NWRT Final Progress Report
Submitted September 30, 2021

1. NWRT Project Number: 3-20-08

2. Project Title: Cambridge Bay Arctic Char Research: Fishery Independent Sampling of Cambridge Bay Arctic Char with Emphasis on the Lauchlan River Stock: Year 3 of 5

Revised to: Community-based sampling of Arctic Char at the Gravel Pit Area Near the Community of Cambridge Bay

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4. Summary

The intent of this project was to conduct the third year of fishery independent sampling of Arctic Char from the Lauchlan River, NU using multi-mesh research gill-nets. Consistent with previous years, multi-mesh gill nets will be used to capture a representative sample of Arctic Char from this system that will be sampled for a suite of biological characteristics (i.e., length, weight, age, sex and maturity). These data will be compared to those collected as part of the commercial plant sampling program (that typically over-represents larger and older fish) and will be added to the time series of fishery-independent data from this system. Catch and effort information will also be collected and combined, these data will be key for exploring and applying data-limited models that will permit the estimation of biological reference points and sustainable harvest rates for this fishery. This is critical given the Lauchlan River is only recently being commercially harvested again and thus is being fish at a reduced quota (5000 kgs)

recommended by the Integrated Fisheries Management Plan Working (IFMP) Group for this Fishery and as approved by the NWMB. Given the paucity of data it is unknown whether harvest at this level is sustainable or if harvest can be increased to reach maximum sustainable yield that would be more economically viable. Finally, we will again collect 200 Arctic Char stomachs and tissue samples to be subsequently analyzed for micro-plastics and contaminants, respectively. All told, the results of this work will add to the time series of data that will be key for assessing the sustainability of the Lauchlan River Arctic char stock while contributing to our overall collective understanding of char biology in the region and impacts of potential contaminants that would impact stock health and population productivity.

5. Project Objectives

In response to the above knowledge gaps, the **INITIAL** objectives of this proposed research are to:

1. Continue the collection of fishery-independent data from Lauchlan River Arctic char to establish a time series of biological (including, length, weight and age) and catch-effort data from this system. This will be done in tandem with the fishery-dependent data collection program in the region.
2. Collect stomach, tissue and genetic samples from all captured char. These will specifically be used for (1) assessing the frequency and prevalence of microplastics in the stomachs of Lauchlan River Arctic char, (2) investigating trends in mercury concentrations (and metals) in sea-run (anadromous) Arctic char in the region (3) stable isotope analyses aimed at understanding the trophic relationships of char within the marine food web, and (4) assessing contributions of discrete stock to harvest in the mixed-stock fisheries in the region.
3. After five consecutive years, use these data to assess the sustainability of the Lauchlan River fishery and to set total allowable harvests for this location that will be incorporated into an updated version of the IFMP for Cambridge Bay Arctic char.

Unfortunately as a result of COVID-19 and the subsequent travel restrictions, coupled with no float planes being in Cambridge Bay during the Lauchlan River downstream Arctic char run, that aspect of our field program was cancelled. We therefore transitioned the focus of the work to be completed in 2020 to a community-based sampling initiative at the area locally known as Gravel Pit. The Gravel Pit area is important to Cambridge Bay residents for the subsistence harvest of Arctic char throughout the summer. Despite this, there has been very limited sampling at Gravel pit and there is limited knowledge regarding the char harvested at this location. Therefore the revised objectives of the 2020 field season were to:

1. Hire a community-based subsistence harvester to fish for Arctic char throughout the marine feeding season.
2. Collect biological data (length, weight and age) of Arctic char harvested at Gravel Pit throughout the marine feeding season, and to establish a time series of biological data (including, length, weight and age).

3. Collect stomach, tissue and genetic samples from all captured char. These will specifically be used for (1) assessing the frequency and prevalence of microplastics in the stomachs of Kitikmeot Region Arctic char, (2) investigating trends in mercury concentrations (and metals) in sea-run (anadromous) Arctic char in the region, and (3) assessing contributions of discrete stock to harvest in the mixed-stock fisheries in the region.

6. Materials and Methods

Please note that Materials and Methods used in the 2020 field season were revised from the initial proposal to reflect the transition to the Gravel Pit community-based sampling initiative for Arctic char.

In 2020, DFO through the Ekaluktutiak Hunters and Trappers Organization (EHTO) hired a community-based field technician to sample their subsistence harvest of Arctic char at Gravel Pit (**Figure 1**) throughout the summer marine feeding season. DFO supplied sampling kits to the local harvester that included everything needed to sample their subsistence catch for biological data and for preserving the stomachs and a piece of flesh. Fish were captured using 5.5 inch gillnets, similar to those used for the subsistence harvest of Arctic char in the region. The fork length, round weight, gonad weight, sex and maturity stage were recorded for each fish. Additionally, structures for determining the age and stomach contents of each fish were all taken as well as tissues were collected for contaminants (mercury and radium) and for future molecular assessments. Ages of sampled fish are in the process of being determined by embedding, sectioning and reading the aging structures (i.e., otoliths). At the end of the summer fishing season, these sample kits will all be returned to DFO for processing. Diet (and potentially stable isotope) analyses will subsequently be performed to determine preferred prey items and potential trophic positioning of Arctic Char in the region. Samples will also be sent to the University of Toronto for assessments of marine microplastics.

Diet Analyses

All stomachs were preserved for subsequent diet analyses. Stomachs were weighed and stomach linings were weighed subsequent to diet items being removed. The degree of fullness (F = Full (distended); PF = partially full (obvious contents, not completely distended); NE = near empty (few contents); or E = empty) and state of digestion (I = Intact; PD = partially digested; D = digested (individual stomachs may include some intact and some digested prey items) were both recorded. Individual stomach contents were then identified to the lowest taxonomic level and contents were enumerated and weighed.

Marine Microplastics Assessments:

In 2019 Arctic char stomachs, marine water and sediment samples were collected to 1) quantify microplastic concentration across a range of environmental matrices (i.e. sediment, water, Arctic char; 2) determine concentrations of PCBs/PBDEs in these environmental and biological matrices; 3) investigate the relationship between PCBs/PBDEs and microplastic concentration across all matrices; and 4) investigate congener and concentration patterns between microplastics and PCB/PBDEs identified in the char gut and muscle tissue.

The char samples will be analyzed for PCB/PBDE and microplastic concentrations using Pyrolysis-Gas Chromatography Mass Spectrometry (Pyro-GC/MS0). The char samples will be divided into three different sample types: gut lining, gut contents, and muscle tissue. All three samples will be homogenized separately using a tissue homogenizer (Fischer and Scholz-Böttcher 2019, 2017), extracted using microwave assisted extraction (MAE) and analyzed via Pyro-GC/MS. Here, samples will be split in two to determine microplastic concentrations (via Pyro) and PCB/PBDE concentrations (via GC/MS).

Sediment samples will be subsampled for PCB/PBDE concentrations using a single-point Tenax extraction method (adapted from Harwood and Nutile 2020; Sinche et al., 2017). The remaining sediment samples will be analyzed for microplastic concentration via density separation and stereo microscopy. Once identified a representative sub-sample of suspected microplastics will be chemically identified using Raman Spectrometry. Water samples will also be quantified via stereo microscopy, and chemically identified using Raman Spectrometry.

Data Analyses:

Weight-length relationships for Arctic Char harvested at Gravel Pit will be described using a linear regression model. The weight-length relationship,

$$W_i = aL_i^b$$

will be transformed into its logarithmic form expressed as:

$$\log(W_i) = log(a) + b * log(L_i) + \varepsilon_i$$

where *W* is the round weight (g), *L* is the fork length (mm), *a* is the y-intercept, *b* is the slope of the regression and ε_i is a normally distributed error term for the *i*th fish. The parameters *a* and *b* will be calculated by least-squares regression separately for each sampling year.

Arctic char length at age will be modeled using the von Bertalanffy growth function (Beverton and Holt 1957) expressed by the equation:

$$L_t = L_\infty\left(1 - e^{-k(t-t_0)}\right) + \varepsilon_i$$

where L_t is the expected or average length at time t, L_∞ is the asymptotic average length, *k* is the Brody growth rate coefficient, and t_0 is the theoretical length at age 0 (Ricker 1975).

To assess maturity, the length and age at 50% maturity (L_{50} and A_{50} respectively) will be determined using logistic regression. The proportion mature within a given length or age class will be modeled as:

$$x = \frac{log\left(\frac{\mathrm{p}}{1-\mathrm{p}}\right) - \alpha}{\beta_1}$$

where *p* is the proportion mature (0.00-1.00) in length class (x) or age class (x). For determining *x* for 50% maturity, (i.e., *p* = 0.05) the above formula reduces to:

$$x = -\frac{\alpha}{\beta_1}$$

Finally, catch curve data will be used to estimate the total annual survival rate (S), and thus the annual finite mortality (A) and instantaneous (Z) total mortality rates. We will use the method of Chapman and Robson (1960) which is based on the assumption that the descending limb of the curve showing catches at each age follows a geometric probability distribution. Briefly, the natural log of age class frequency will be plotted against age for each year. Least squares regression will then be used to fit a curve to descending limb of the catch curve (from modal year class plus one year to the oldest year class where n>1). Instantaneous mortality rate (Z), annual survival rate (S) and annual mortality rate (A) will then be calculated as follows: Z=positive slope of regression, $S=e^{-z}$, A=1-S (Ricker 1975).

The Chapman-Robson estimate of the annual survival rate is:

$$\hat{S} = \frac{T}{n + T - 1}$$

where *n* is the total number of fished observed on the descending limb of the curve, *T* is the total recorded age of fish on the descending limb of the catch curve. The parameters S and A were calculated as described above for each year of sampling for both fishery-dependant and independent data.

7. Results

Sample sizes

Sampling was initiated on July 15th and continued until September 15th. Community-based monitors only sampled a handful of Arctic char at Gravel pit throughout the summer. In total 55 Arctic char were sampled by the monitors. Of those, 42 samples had sex and maturity information.

Biological Data Summary

Of the 42 Arctic char that were sampled that had associated sex and maturity information, 26 were males and 16 were females. Every Arctic char sampled was mature meaning that they have spawned at least once in their life.

Individual fork lengths ranged from 577 mm to 845 mm, with an average fork length of 760 mm Males were significantly larger than females in 2019 ($t = -2.27$, $df = 21.9$, $p < 0.05$). Individual fork lengths for males ranged from 655 mm to 900 mm, with an average fork length of 773 mm. Fork lengths for females ranged from 577 mm to 815 mm, with an average fork length of 730 mm. The fork length distribution of Arctic char sampled at Gravel Pit in 2019 is shown in **Figure 2**. And appears to be uni-modal. We also calculated the length at 50% maturity (L50) to use as an index for reproductive potential. Length at 50% maturity (L50) could not be calculated given that all individuals sampled were mature.

Individual weights ranged from 1950g to 6300g with an average weight of 4308 g. Males were significantly heavier (mean = 4675 g) than females (mean = 3793 g, $t = -2.84$, $df = 28.72$, $p < 0.05$). Males ranged in weight from 3450 g to 6500 g and females ranged from 1950 g to 5400 g. The weight distribution of Arctic char sampled at Gravel Pit in 2020 is shown in **Figure 3.** Similar to fork length, there appears to be a uni-modal distribution. The relationship between fork length and weight is shown in **Figure 4**. There was not significant difference in the weight-length relationship between males and females ($P > 0.05$).

Mean condition factor (sexes combined) was 0.98 with individuals ranging in condition from 0.62 to 1.36. Males were in slightly better condition than females (1.01 vs. 0.98), a difference that was not statistically significant ($t = -0.98103$, $df = 162.22$, p-value = 0.57). Individual condition factor was highly variable as evidenced by the wide range in values shown in **Figure 5**.

Ages of Arctic char have yet to be determined and are currently in queue at the Freshwater Institute aging lab.

Diet:

Currently the stomachs of Arctic char are still being processed by the consultants and only preliminary results can be discussed. Of the 55 Arctic char stomachs assessed, 5 of these contained no prey items (i.e., they were empty). Unidentified amphipods and fish remains appeared to be the most commonly consumed prey items. Work is still ongoing to identity prey items to lower taxonomic levels.

Unfortunately there are no results to report on marine micropastics in Arctic char collected in 2020. This analysis is ongoing at the University of Toronto. Our previous work in the region assessing Byron Bay Arctic char, however, has shown that microplastics ranged from 3 to 80 particles per individual fish with blue fibers as the most commonly observed morphology. On average, surface water samples ranged from 8.75 particles/L in Byron Bay (estuary) to 3.86 particles/L in the Lauchlan River (freshwater) with fragments as the most commonly observed morphology.

8. Discussion/Management Implications

Unfortunately as a result of COVID-19 travel restrictions, the initial project that aimed to collect fishery-independent biological data from Lauchlan River Arctic char was cancelled. Data collected as part of the initial plan was to be used in a formal quantitative stock assessment evaluating the sustainability for this fishery after five years of data collection. Instead, we transitioned the focus of the work to be completed in 2020 to a community-based sampling initiative at the area locally known as Gravel Pit. Although not a commercial fishery, the Gravel Pit area is important to Cambridge Bay residents for the subsistence harvest of Arctic char throughout the summer. Although data collected as part of this study will not be used in a formal stock assessment, samples and data collected in 2020 will undoubtedly further our understanding of the biology and ecology of char in the region including shedding light on diet. Additionally, results from this project should shed light on how microplastics and legacy contaminants may affect char under changing climatic conditions.

The Cambridge Bay commercial fishery is the first Arctic char fishery in Canada to have an approved Integrated Fisheries Management Plan (DFO 2014) which is a key tool for successful management. An IFMP is both a process and a document, with the primary goal of providing the framework for conservation and sustainable use of fisheries resources, outlining how they will be managed for a given period of time (DFO 2013). The primary objective of the IFMP aims to conserve commercially harvested Arctic char in the Cambridge Bay region through sustainable use and effective fishery management. There are also several other short-term objectives outlined in the IFMP including, among other things, the goal of improving knowledge of Arctic Char biology and ecology in the region. One glaring data gap that still persists surrounds what Arctic char in the region primarily forage on. To date there have been no studies on char diet for Cambridge Bay Arctic char and the results of this community-based sampling program will fill that knowledge gap and will be included in revised IFMPs as they become renewed in the future.

DFO has also adopted a Sustainable Fisheries Framework (SFF) for all Canadian fisheries to ensure that objectives for long-term sustainability, economic prosperity, and improved governance for Canadian fisheries are met. The SFF contains policies for adopting an ecosystem based approach to fisheries management known as ecosystem-based fisheries management (EBFM). Modern approaches to EBFM and sustainable use of marine resources must take into consideration the myriad of pressures (interspecies, human and environmental) affecting marine ecosystems. The network of feeding interactions between and among co-existing species and populations (food webs) are an important aspect of all marine ecosystems and biodiversity. Having an understanding of what char forage on, when they forage on specific items and where foraging occurs will undoubtedly feed into EBFM decisions. Diet analyses to be performed as part of this study will provide important insights into fish feeding patterns and quantitative assessment of food habits is an important aspect of EBFM. Finally, diet information collected as part of this work should prove useful as inputs into ecosystem-based models (i.e., Ecosim, Ecopath) aimed at modelling the temporal and spatial structure of marine food webs and other ecological questions.

Microplastic pollution (synthetic particles < 5 mm) is a widespread contaminant, found in marine and freshwater ecosystems that can be devastating for aquatic species and ecosystems as a whole. Microplastic pollution is a global contaminant of concern and has it has also been identified in the Kitikmeot as regional issue of concern as highlighted in the NWMBs list of regional priorities. Specifically within the Kitikmeot, there is great interest in trying to understand the effects of marine litter and plastics in the marine environment. Since the early 2000s, plastic pollution has been studied in the Canadian Arctic and has since been identified in a variety of wildlife and environmental samples, including seabirds, beluga whales, surface water, sediments, and sea ice. Legacy contaminants have been identified and monitored in the Canadian Arctic for the last 40 years. Plastics have properties that encourage legacy contaminants, like PCBs, to adsorb (or stick) to their surface. This allows plastic pollution to become a vector for the transport of legacy contaminants within an ecosystem. Legacy contaminants and plastic pollution can have adverse effects on wildlife. Given that these particles can transport chemical contaminants, there is a need to understand the chemicals introduced into an ecosystem as well as organisms that ingest these particles. To date, however, there have been no studies directly aimed at understanding the impacts of marine microplastic pollution in Arctic char or the habitats they need to survive.

During the 2020 field season, 30 of the Arctic char were sent to the University of Toronto for assessments of marine microplastics within the stomachs of harvested char. Analysis on all the samples for contaminants is ongoing, however, early results indicate that plastic are indeed present within the summer feeding habitats of Arctic char in the region. We plan to evaluate microplastics and affiliated chemicals in char across the migration and feeding season, both spatially and temporally. Further research is warranted in northern keystone species to better understand the individual and, population and ecosystem level impact of plastic pollution in the changing Arctic. All told, however, the results of this part of our work will undoubtedly help us better understand the presence of microplastics in the region which will be valuable for informing future effects monitoring.

9. Report by Inuit participants:

Attached as a separate document.

10. Reporting to communities/resource users:

Numerous telephone calls and countless email communications took place with the EHTO manager (Beverly Maksagak) and the EHTO president (Bobby Greenley) to discuss the project and to discuss the transition of the project to a community-based sampling initiative. Meetings in Cambridge Bay occurred in March 2020 but at that time it was to present on and discuss the initially proposed project (i.e., Lauchlan River sampling). Approval for the revised project was received in May of 2020. Additionally, we met with the HTO via Zoom in October 2020 after the field season to discuss the project. A follow-up Zoom meeting occurred in March 2021 The results of our 2020 field season were also presented at the NWMB regular meeting in

December 2020. Summary reports for the Ekaluktutiak HTO and residents of Cambridge Bay were prepared and will distributed.

11. References

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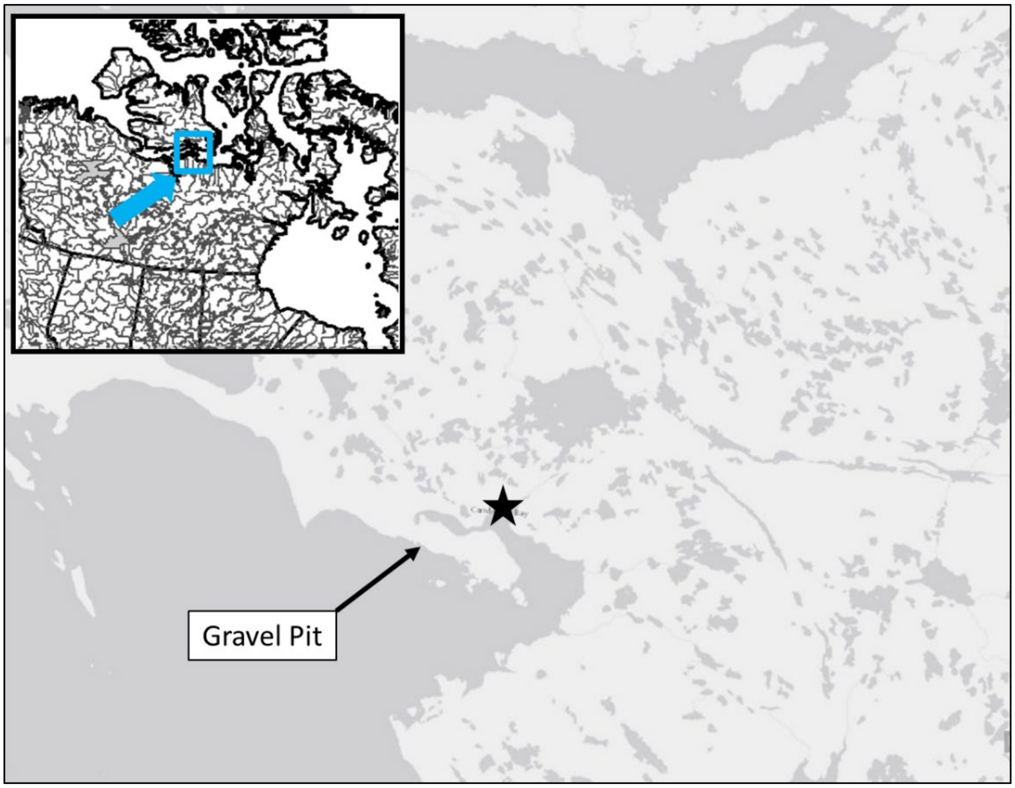

Figure 1. Map of the study area showing the area locally known as Gravel Pit where samples were collected in 2020. The community of Cambridge bay is shown as a black star

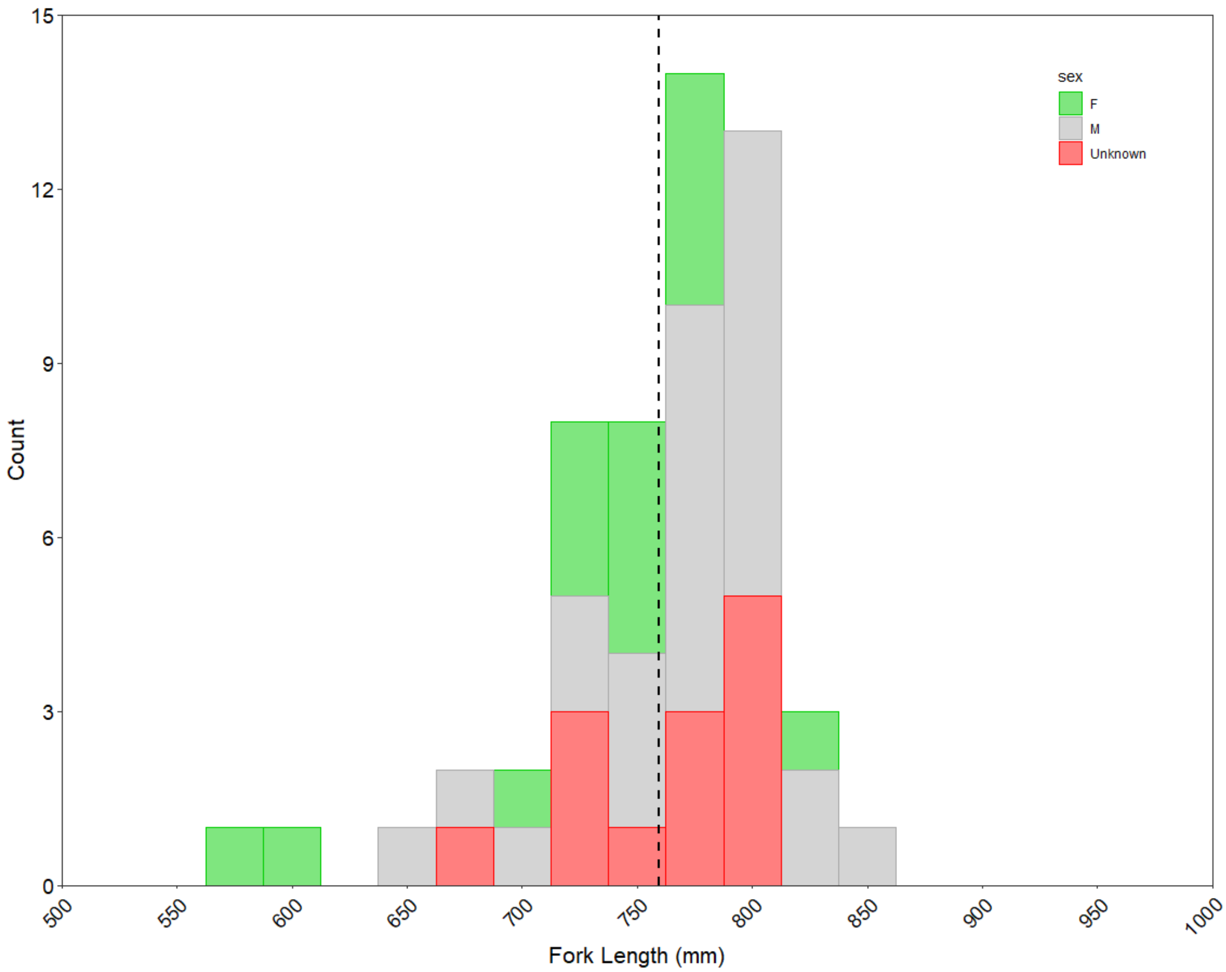

Figure 2. Frequency distributions of fork length (mm) of Arctic char collected from community-based sampling at from Gravel Pit in 2020. Females are shown in green, males are shown in grey and unknown sexes are in red. The mean fork length for each year (sexes combined) is shown as a black dotted line.

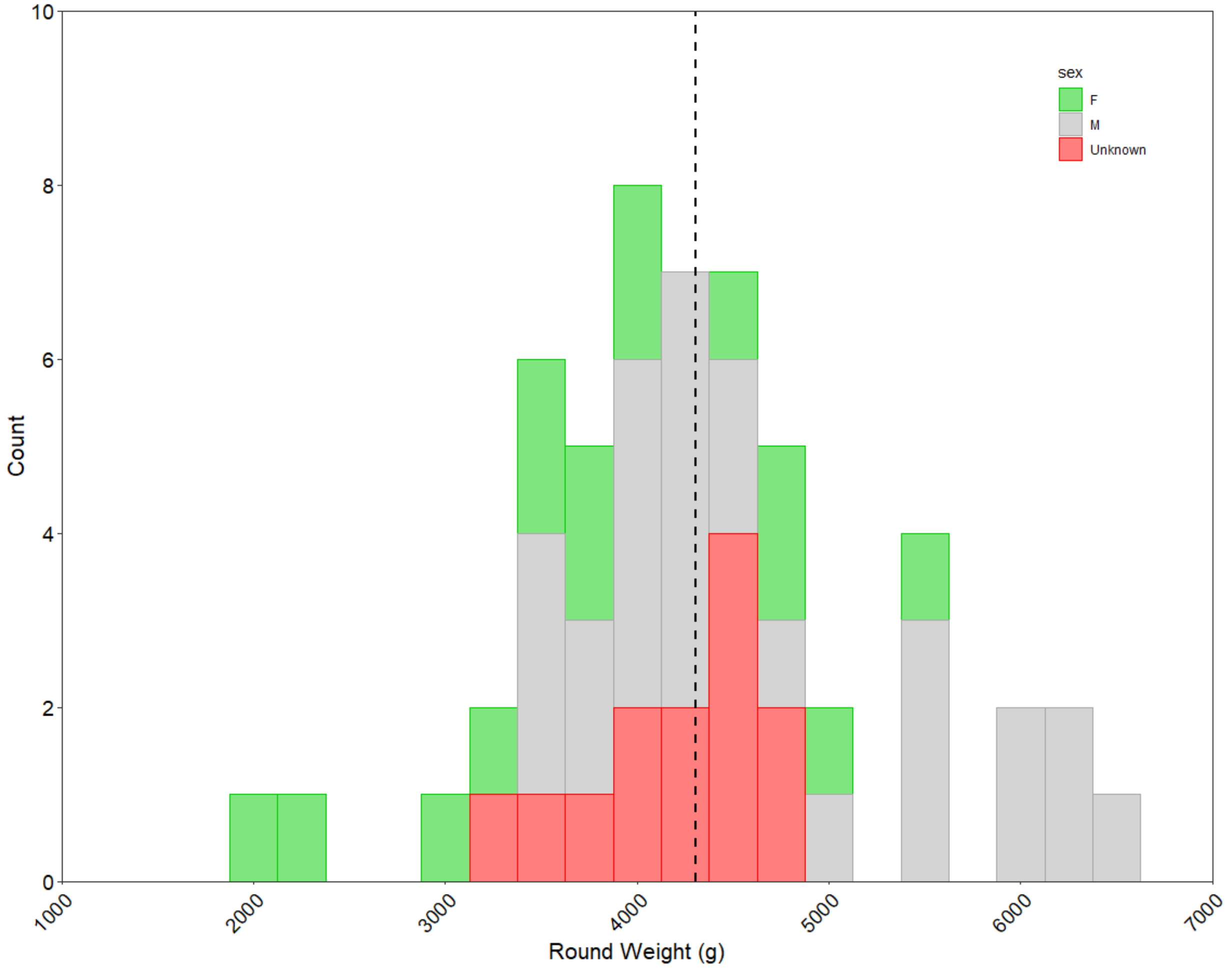

Figure 3. Frequency distributions of round weight (g) for Arctic char collected from community-based sampling at Gravel Pit in 2020. Females are shown in green, males are shown in grey and unknown sexes are in red. The mean weight for each year (sexes combined) is shown as a black dotted line.

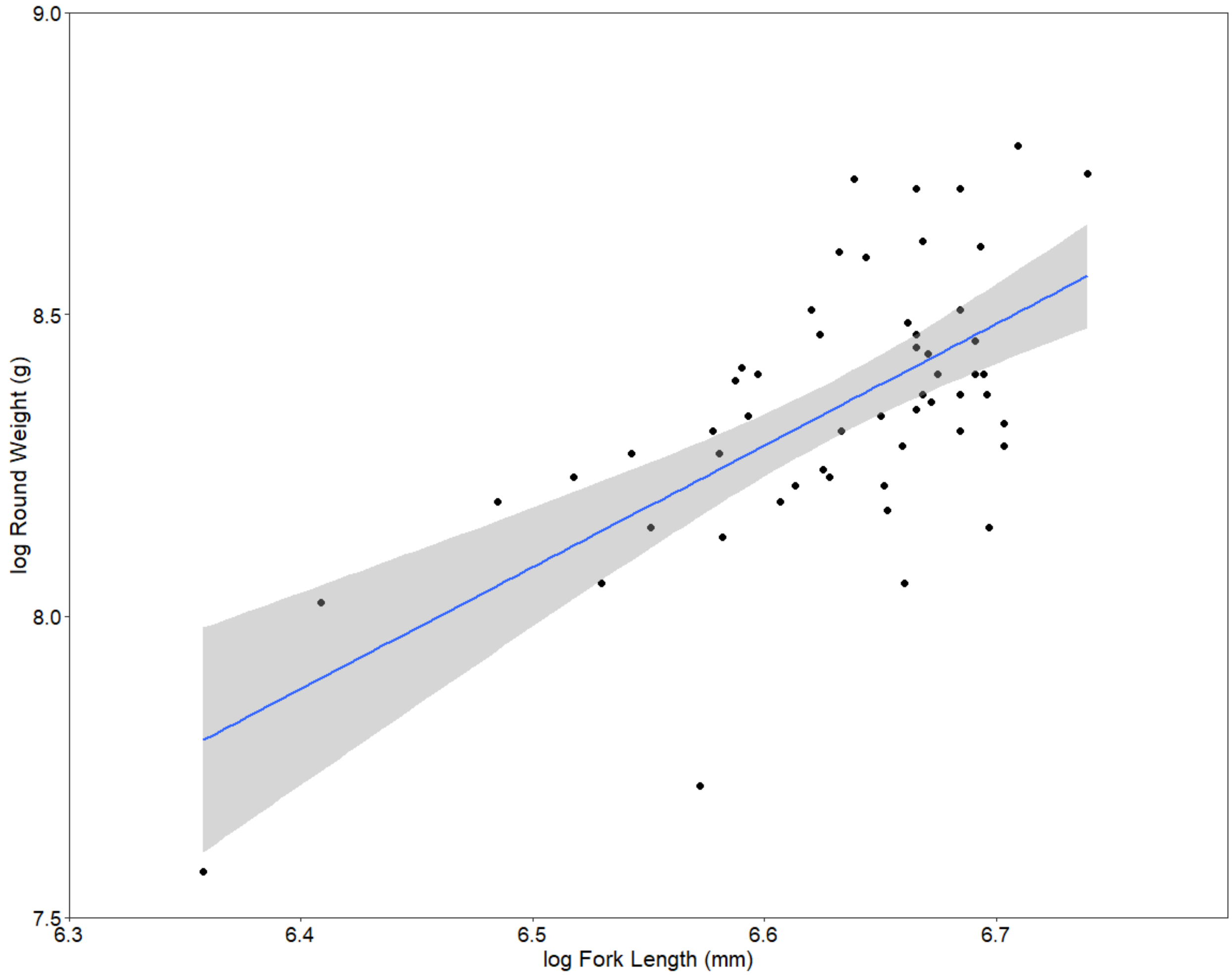

Figure 4. Weight-length relationship (sexes combined) of Arctic char collected from community-based sampling at from Gravel Pit in 2020.

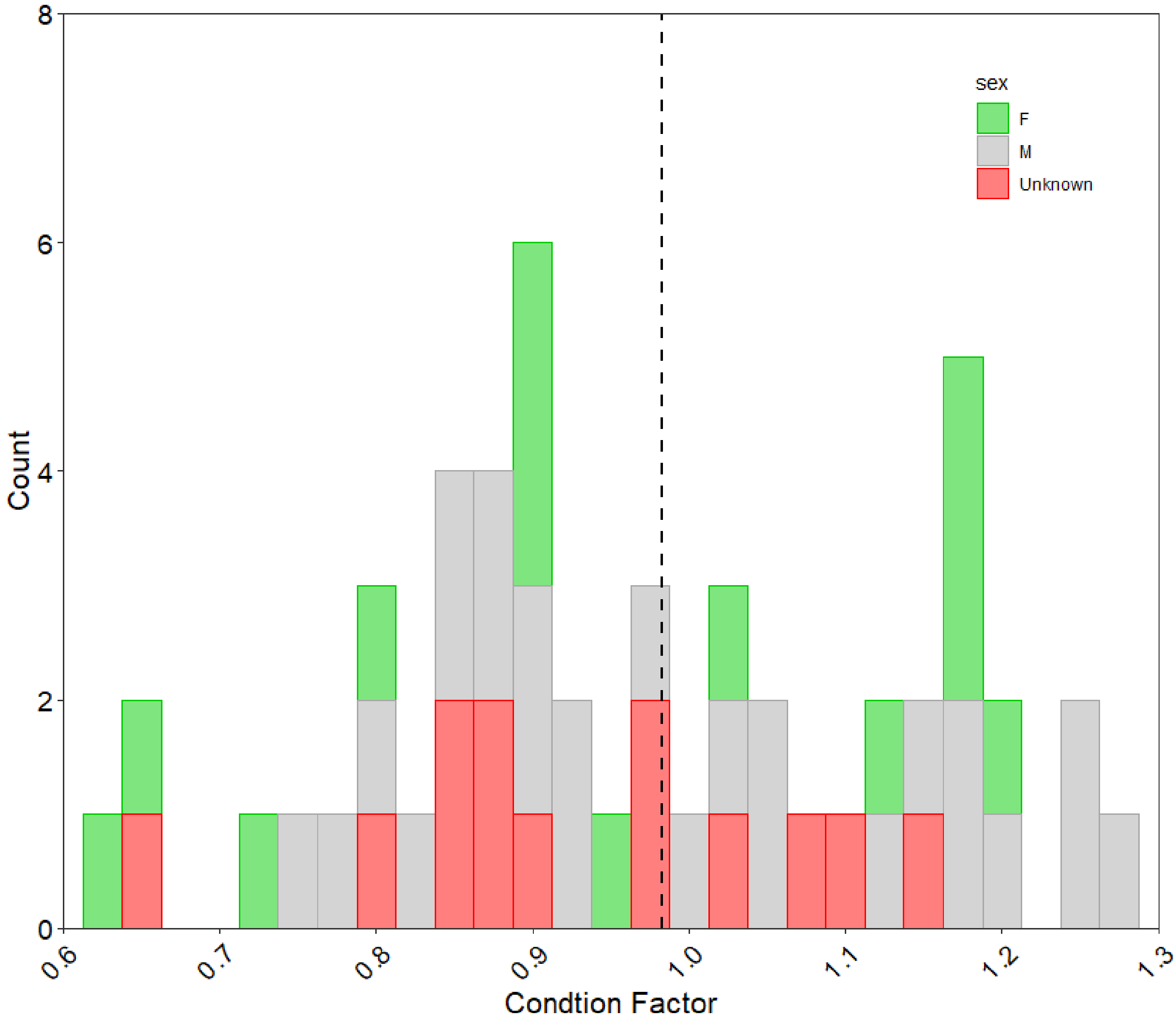

Figure 5. Frequency distributions of condition factor of Arctic char collected from community-based sampling at from Gravel Pit in 2020. Females are shown in green, males are shown in grey and unknown sexes are in red. The mean condition factor for each year (sexes combined) is shown as a black dotted line.