NWRT Final Progress Report
Submitted September 30, 2022

1. NWRT Project Number: 3-21-01

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

3. Project Leaders:

Les N. Harris
Fisheries and Oceans Canada
Freshwater Institute
501 University Cres., Winnipeg, MB, R3T 2N6
Ph: (204) 983-5143
Fax: (204) 984-2403
E-mail: Les.N.Harris@dfo-mpo.gc.ca

Dr. Ross Tallman
Fisheries and Oceans Canada
Freshwater Institute
501 University Cres., Winnipeg, MB, R3T 2N6
Ph: (204) 983-3362
Fax: (204) 984-2403
E-mail: Ross.Tallman@dfo-mpo.gc.ca

4. Summary

The initial 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 were to be used to capture a representative sample of Arctic Char from this system to 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 were also to 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 aimed again to collect 200 Arctic stomachs and tissue samples to be subsequently analyzed for micro-plastics and contaminant 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 were to:

- 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.
- 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.
- 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 once again 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. Similar to 2020, we once again transitioned the focus of the work to be completed in 2021 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. Additionally, this summer, there concern was raised by Cambridge Bay residents over potential cysts and parasites in locally harvested Arctic char. Initially, this came to our attention through social media posts and then subsequently harvesters started reaching out to us directly. As such, this year we will also use a subset of the samples for parasite assessments with the goal of producing an infographic of common parasites in the region.

Therefore the revised objectives of the 2021 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 (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, (3) assessing contributions of discrete stock to harvest in the mixed-stock fisheries in the region and (4) assessing parasites in locally harvested Arctic char.

6. Materials and Methods

Please note that Materials and Methods used in the 2021 field season were revised from the initial proposal to reflect the transition to the Gravel Pit community-based sampling initiative for Arctic char.

In 2021, DFO through the Ekaluktutiak Hunters and Trappers Organization (EHTO), hired a community-based field technician to sample their subsistence harvest of Arctic char and the harvest of other fishers at Gravel Pit throughout the summer marine feeding season. DFO supplied sampling kits to the local monitor that included everything needed to sample their subsistence catch for biological data and for preserving the stomachs and a piece of flesh. At the end of the summer fishing season, these sample kits were returned to DFO for processing. 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). 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. A subset of samples will also be processed for parasites and 30 samples will be sent to the University of Toronto for assessments of marine microplastics.

Diet Analyses

All stomachs were persevered 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 2021, Arctic char stomachs 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 were analyzed for PCB/PBDE and microplastic concentrations using Pyrolysis-Gas Chromatography Mass Spectrometry (Pyro-GC/MS0. The char samples were 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 were 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 7th and continued until September 5th. Community-based monitors only sampled a handful of Arctic char at Gravel pit throughout the summer. In total 63 Arctic char were sampled by the monitors.

Biological Data Summary

Of the 63 Arctic char that were sampled in 2021, 32 were males and 31 were females. Maturity information was not recorded for any Arctic char.

Individual fork lengths ranged from 470 mm to 882 mm, with an average fork length of 642.2 mm. There was no significant difference in length between sexes in 2021 (t = -1.28, df = 56.78, p-value = 0.21). Individual fork lengths for males ranged from 470 mm to 862 mm, with an average fork length of 658 mm. Fork lengths for females ranged from 496 mm to 830 mm, with an average fork length of 626 mm. The fork length distribution of Arctic char sampled at Gravel Pit in 2021 is shown in **Figure 2**. Length at 50% maturity (L50) could not be calculated given that no maturity information was provided.

Individual weights ranged from 1460 g to 7500 g with an average weight of 3346 g. There was no significant difference in length between sexes in 2021 (t = -1.39, df = 51.37, p-value = 0.17). Males ranged in weight from 1480 g to 7500 g and females ranged from 1460 g to 55480 g. The weight distribution of Arctic char sampled at Gravel Pit in 2021 is shown in **Figure 3.** The relationship between fork length and weight is shown in **Figure 4**. There was no significant difference in the weight-length relationship between males and females (P > 0.05).

Mean condition factor (sexes combined) was 1.21 with individuals ranging in condition from 0.73 to 1.47. Females were in slightly better condition than males (1.23 vs. 1.19), a difference that was not statistically significant (t = 1.13, df = 58.66, p-value = 0.26). 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:
The diet data collected from the stomachs of Arctic char have only recently been provided and only general observations are available at this time (more fulsome analyses will be conducted this winter). Of the 60 Arctic char stomachs assessed, 6 of these contained no prey items (i.e., they were empty). The majority of the stomachs were considered partially full or full. Approximately 55 distinct prey taxa were identified in the stomachs of Arctic char, Cottids (Myoxocephalus sp.) dominated the fish prey items and the amphipods *Themisto libellula* and *Onisimus litoralis* were the most common invertebrate prey items. Indeed, *Themisto libellula* was found in all but four Arctic char stomachs assess.

Marine microplastics
Unfortunately there are no results to report on marine micropastics in Arctic char collected in 2021. 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 2021 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. Additionally, we met with the HTO via Zoom in March 2021. We also met with the EHTO almost daily while we were in the community to discuss the project. We intend to present this work at

(1) the EHTO annual general meeting, (2) the Cambridge Bay IFMP working group and at (3) a Kitikmeot Chart workshop that is being planned. Summary reports for the Ekaluktutiak HTO and residents of Cambridge Bay are in prep and will distributed.

11. References

Beverton, R.J H. and Holt, S.J. 1957. On the Dynamics of Exploited Fish Populations, Fishery Investigations Series II Volume XIX, Ministry of Agriculture, Fisheries and Food

Chapman, D.G. and Robson, D.S.1960. The analysis of a catch curve. Biometrics 16:354-368.

DFO (2013). Preparing an Integrated Fisheries Management Plan (IFMP). Fisheries and Oceans Canada. https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/guidance-guide/preparing-ifmppgip-elaboration-eng.htm

DFO (2014). (DFO) Integrated fisheries management plan, Cambridge Bay Arctic Char commercial fishery, Nunavut Settlement area. DFO Central Arctic Region, Resource Management and Aboriginal Affairs, Winnipeg, Canada.

Fischer, M. and Scholz-Bootcher, B.M. 2017. Simultaneous trace identification and quantification of common types of microplastics in environmental samples by Pyrolysis-Gas Chromatography-Mass Spectrometry. Env. Sci. Tech. 51(9): 5052-5060.

Fischer, M. and Scholz-Bootcher, B.M. 2019. Microplastics analysis in environment samples—recent pyrolysis-gas chromatography-mass spectrometry method improvements to increase the reliability of mass-related data. Anal. Methd. 11:2489-2497.

Harwood AD, Nutile SA. 2019. Using Tenax Extractable Concentrations to Determine the Bioavailable Contaminant Fraction in Sediments. New York, NY: Springer US. [accessed 2020 Apr 28]. http://link.springer.com/10.1007/7653_2019_41.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Sinche FL, Nutile SA, Landrum P, Lydy MJ. 2017. Optimization of Tenax extraction parameters for polychlorinated biphenyls in contaminated sediments. Talanta. 164:386–395. doi:10.1016/j.talanta.2016.11.061.

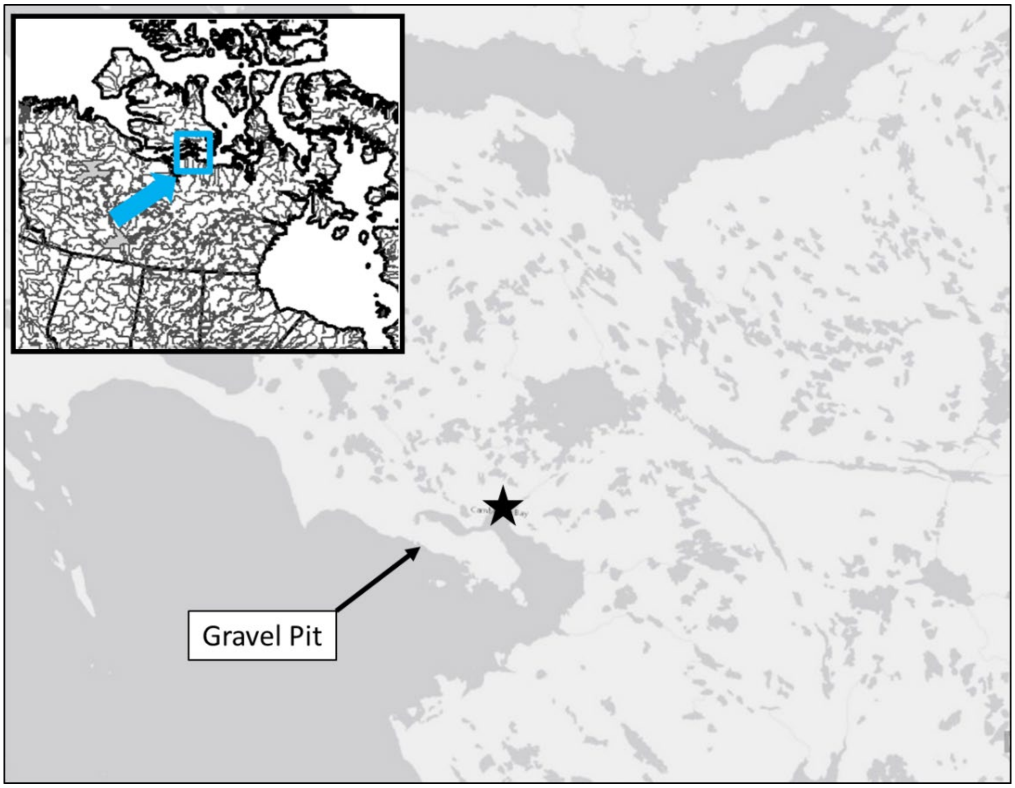

Figure 1. Map of the study area showing the area locally known as Gravel Pit where samples were collected in 2021. The community of Cambridge bay is shown as a black star

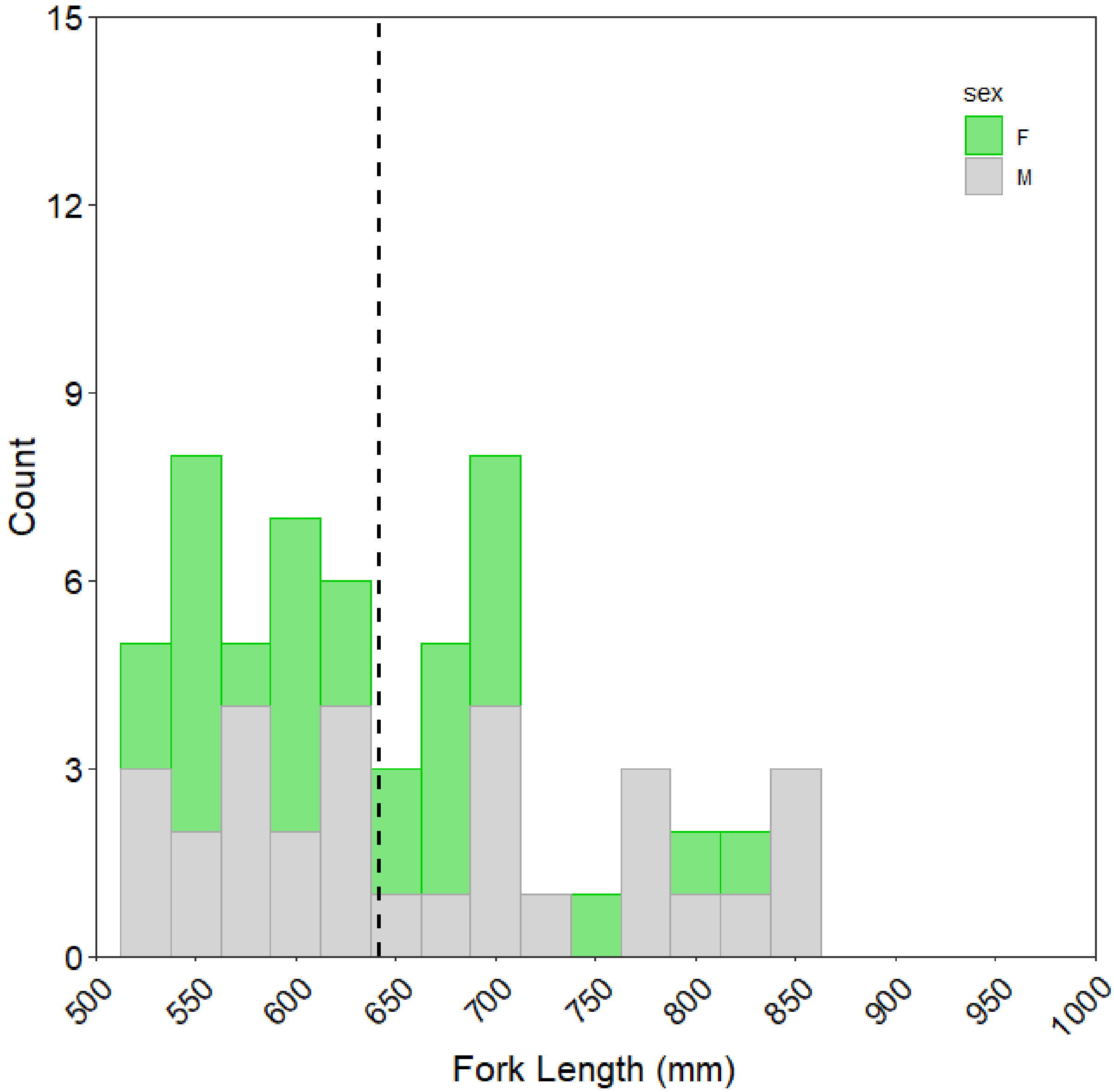

Figure 2. Frequency distributions of fork length (mm) of Arctic char collected from community-based sampling at from Gravel Pit in 2021. Females are shown in green and males are shown in grey. The mean fork length for each year (sexes combined) is shown as a black dotted line.

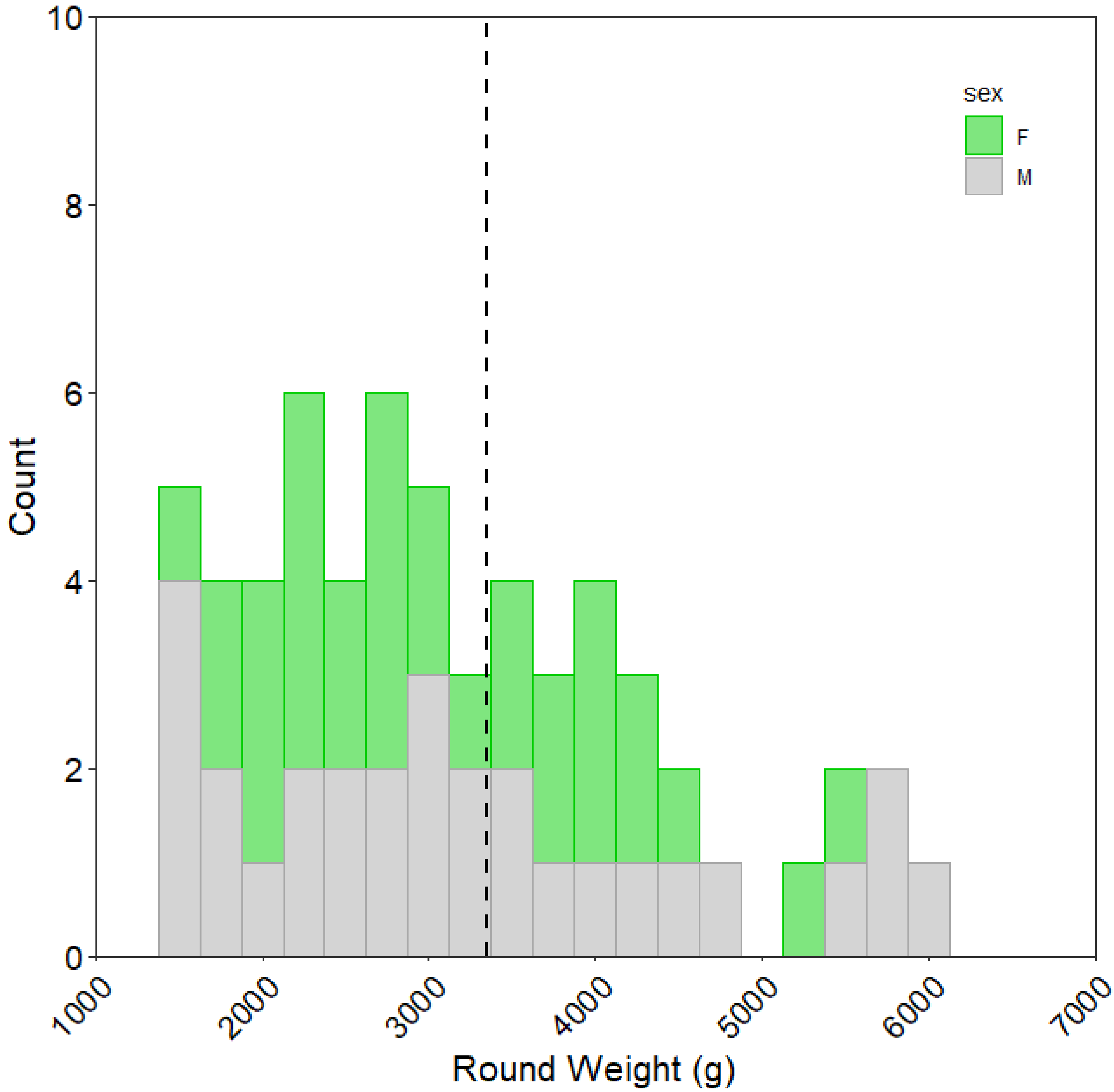

Figure 3. Frequency distributions of round weight (g) for Arctic char collected from community-based sampling at Gravel Pit in 2021. Females are shown in green and males are shown in grey. The mean fork length for each year (sexes combined) is shown as a black dotted line.

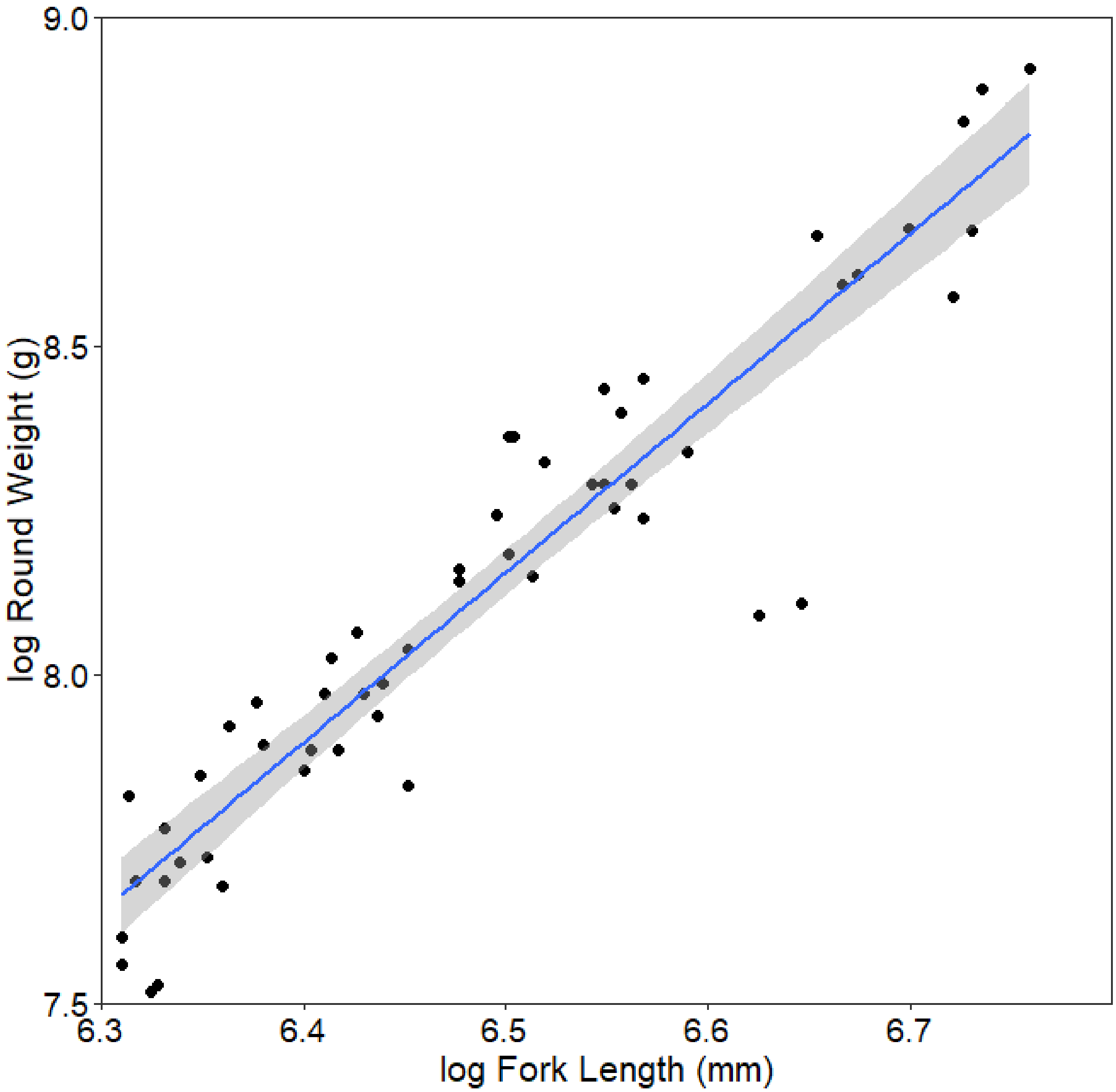

Figure 4. Weight-length relationship (sexes combined) of Arctic char collected from community-based sampling at from Gravel Pit in 2021.

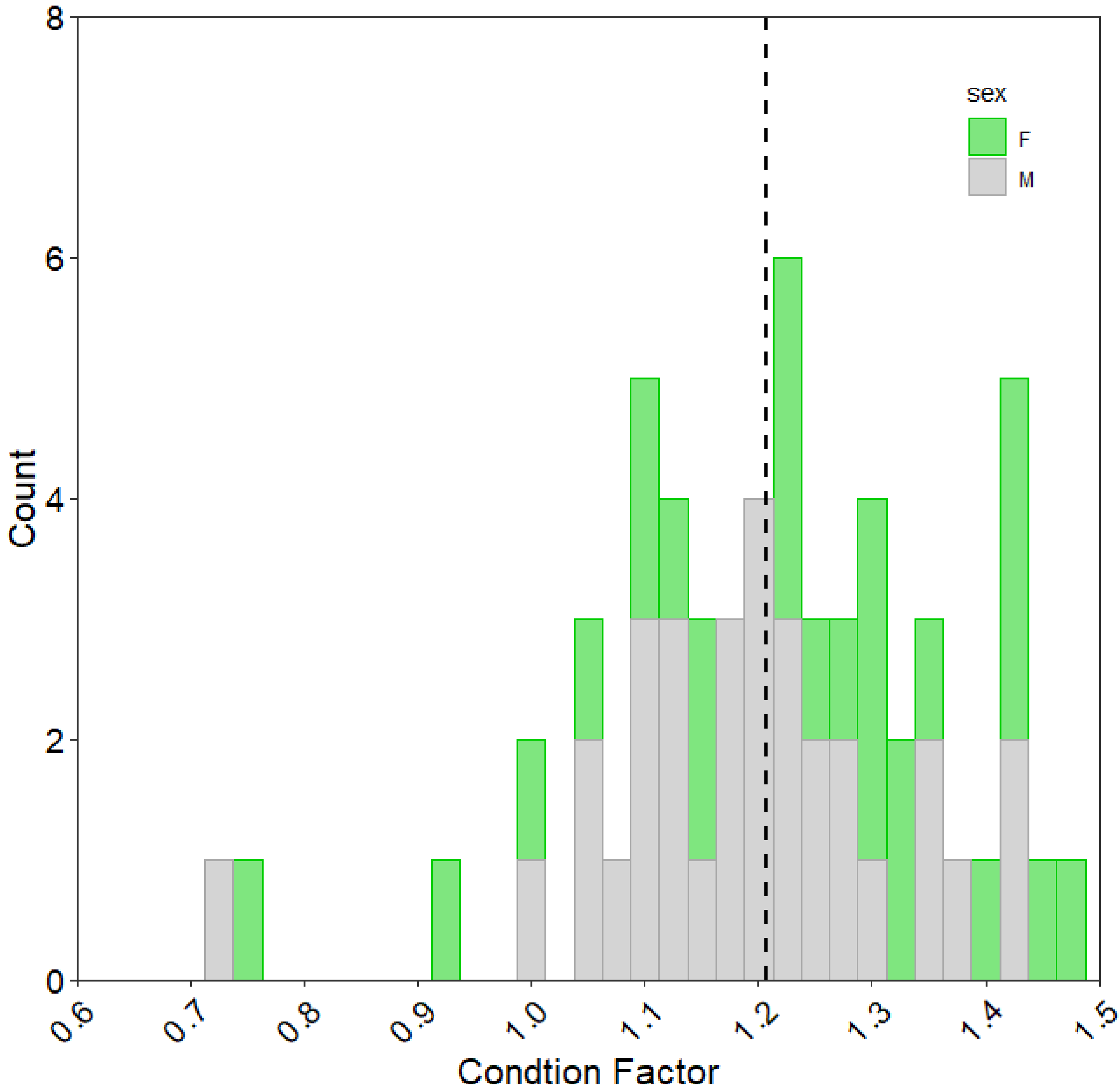

Figure 5. Frequency distributions of condition factor of Arctic char collected from community-based sampling at from Gravel Pit in 2021. Females are shown in green and males are shown in grey. The mean fork length for each year (sexes combined) is shown as a black dotted line.