NWRT Interim Progress Report
Submitted January 15, 2014

1. NWRT Project Number: 3-13-23

2. Project Title: Cambridge Bay Arctic Char Research: Fishery Independent Sampling of Cambridge Bay Arctic Char (*Salvelinus alpinus*) Stocks Including the Weir Enumeration for the Halokvik River Population

3. Project Leaders:

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

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

4. Summary

The purpose of this research is to collect fishery independent biological information/samples from Arctic char harvested in the Cambridge Bay area and to operate a weir at the Halovik River for the purpose of enumerating the upstream run while tagging up to 2000 Arctic char. Despite the long commercial history in the Cambridge By region, virtually all the current data available on this fishery has come from a fishery-dependent, commercial plant sampling program. As such, the majority of biological information on which stock assessments are conducted, and on which present management decisions based, has typically only considered biological/catch information of commercially harvested fish which typically over represents larger and older individuals. Therefore, data that accurately represent all sizes and ages, while including sex and maturity information, are lacking from most of these fisheries or this information is outdated. In recent years, however, consistent fishery-independent surveys have been important for

collecting biological data from Arctic char to compliment that collected as part of the plant sampling program. Combined, these data will be important for providing estimates of abundance/biomass and potentially for resolving sustainable harvest levels that will be recommended to Fisheries Management sector of Fisheries and Oceans Canada (DFO). Furthermore, although fishery-independent data are recently becoming available again, accurate enumerations of abundance of Arctic Char in commercial waterbodies are nearly 30 years outdated. Abundance estimates or weir enumerations are a vital component for resolving sustainable harvest levels and validating current stock assessment models for Arctic char in the region. Through this proposed research, we intend to address some of these knowledge gaps, all of which are identified in the 5-year plan for this fishery. All told, these data will be vital for an upcoming assessment of the Halokvik and Jayko river fisheries as part of a Regional Advisory Process (RAP) currently planned for the spring of 2016.

5. Objectives

The objectives of this research are to:

- Collect fishery independent biological information/samples from Arctic char harvested in the Cambridge Bay area, specifically form the Halokvik (30 Mile, Figure 1) and Jayko rivers
- Collect catch and effort information that will be valuable for understanding how harvest levels are impacting current population status as these data may potentially be used as an index of abundance for these fisheries.
- Operate a weir at the Halokvik River to enumerate the upstream run of Arctic char in this system.
- Tag up to 2000 Arctic char for future mark-recapture estimates and to update information on movements for this species in the region.
- Use these data in upcoming assessments on the health and sustainability of these fisheries facilitated through a Regional Advisory Process (RAP) scheduled for 2016.

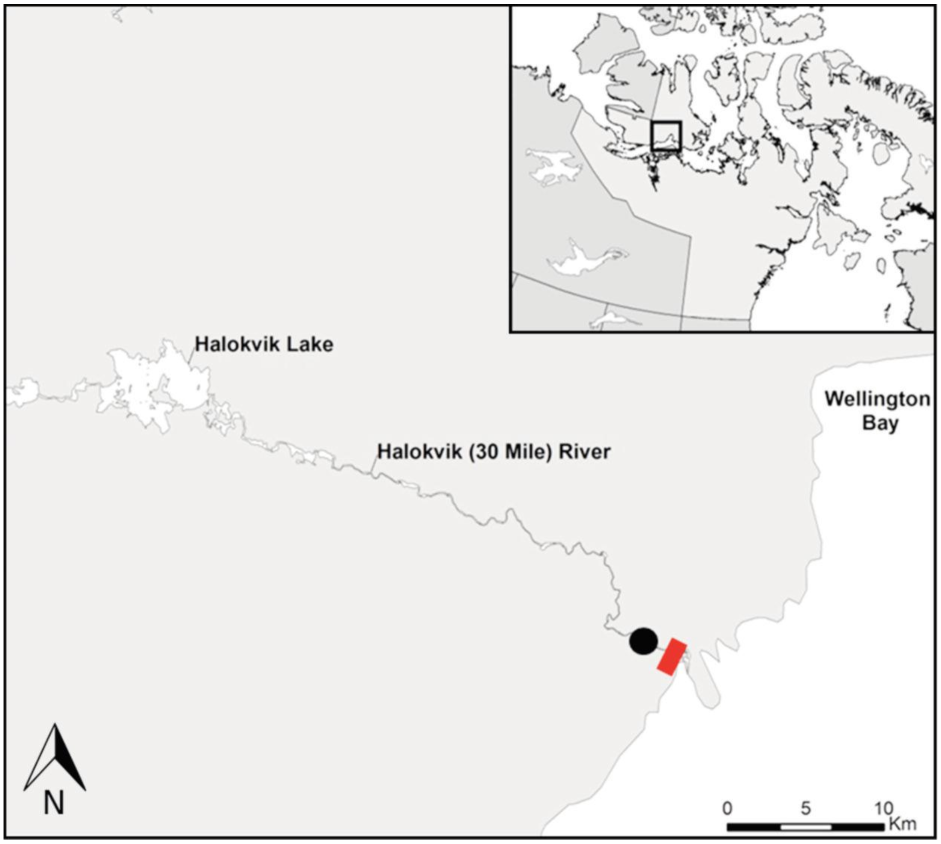

Figure 1. Map of the study area showing the location of the Halokvik River (30 Mile) on Victoria Island, Nunavut. Also shown is the location of the weir constructed in 2013 (red rectangle), the position of the acoustic receiver deployed. The Jayko River was not sampled in 2013.

6. Materials and Methods

Fishery independent sampling

Primarily, work to date has focused on the biological sampling of Arctic char during upstream migrations, typically when this species is commercially harvested. The study was designed and carried out in cooperation with the Ekaluktutiak HTO (EHTO) and four local field technicians chosen by the EHTO assisted with the field component of the work. The field work portion of this project was conducted with little variance from the summary provided in the NWMB application with the exception of the Jayko River sampling (explained below).

Briefly, the collection of biological data from Cambridge Bay Arctic char was conducted as part of fishery-independent surveys at the Halovik (30 Mile) River. Due to a blizzard on August 23-24, 2013 and the inclement weather that followed in the subsequent days, several days of sampling were lost. As such, we were unable to travel to the Jayko River on time allowing us to be consistent with previous sampling dates. Thus, we remained at the Halovik River ensure the work on this system was thoroughly completed thereby postponing sampling at the Jayko River until 2014. This, however, has resulted in the Halovik and Jayko rivers both being on the same sampling schedule (i.e., 2014 will be the fourth year of sampling for both systems).

At the Halovik River, fish were captured using multi-mesh gillnets permitting the capture of Arctic char of all sizes and ages. The aim was to biologically sample two-hundred Arctic char from each location. Location and general environmental data such as position (determined by GPS), time of year, time of day, net depth, water temperature, weather and other environmental conditions were recorded for each net set. To estimate catch-per-unit-effort (CPUE), the net type and soak time were recorded. The fork length (± 1 mm), round weight (± 50 g), 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. Ovaries from any mature individuals were collected and preserved as a means to estimate fecundity (egg number per female) and fish tissues were collected for contaminants (mercury and radium) and for future molecular assessments. Ages of sampled fish will be determined by embedding, sectioning and reading the aging structures (pelvic fins and otoliths) when money becomes available to do so. Preserved eggs will be measured and counted to determine egg size and fecundity of Arctic char. These and the data collected in the field (fork length, weight, sex and maturity) will allow for the assessment of the age and length structure, growth rate, sex ratios, physical condition, age-at-maturity, egg-number-per-female (fecundity), reproductive potential and mortality rates for these Arctic char populations.

Environmental Data Collection

Hobo data loggers were used to record water temperature at five minute intervals. Three data loggers were placed in strategic locations, to monitor temporal fluctuations in temperature throughout the study period. (1. Estuary-: in saline water out from the mouth of the Halokvik River, 2. tidal - brackish water with in the mouth of the Halokvik River, downstream from the weir, 3. weir - placed on the southwest corner of the box of the weir). The Hobo data loggers were set below the water and tethered using zip ties rocks and floats. Daily wind and air temperatures were also taken with a Kestrel temperature and wind reader.

Weir design, operation and enumeration

A weir was operated at the Halovik River with the intent of enumerating the upstream migration of Arctic char in this system. The weir was designed to be functional for both scientific and commercial harvest purposes and followed the methodology described in McGowan (1990, Figures 2 and 3). A location was selected near the mouth of the Halokvik River, where two lower branches of the river join in an upstream location some 50 meters from tidal waters. At this location, stream flow was approximately 0.3 m/s allowing for manageable setup and processing conditions. Water column depth favoured the south side of the weir, where it was up to 80 cm in depth. The weir trap door maintained a depth of approximately 70 cm and the majority of the north side weir wing was set at a 30 cm depth. The weir was completed on 10th of August taking approximately 31 man-hours, requiring 29 A-frames, 58 rails, 2200 conduit pipes, 60 50lb rock bags, two rock retaining walls, 30 yards of chicken wire, and two two king anchors

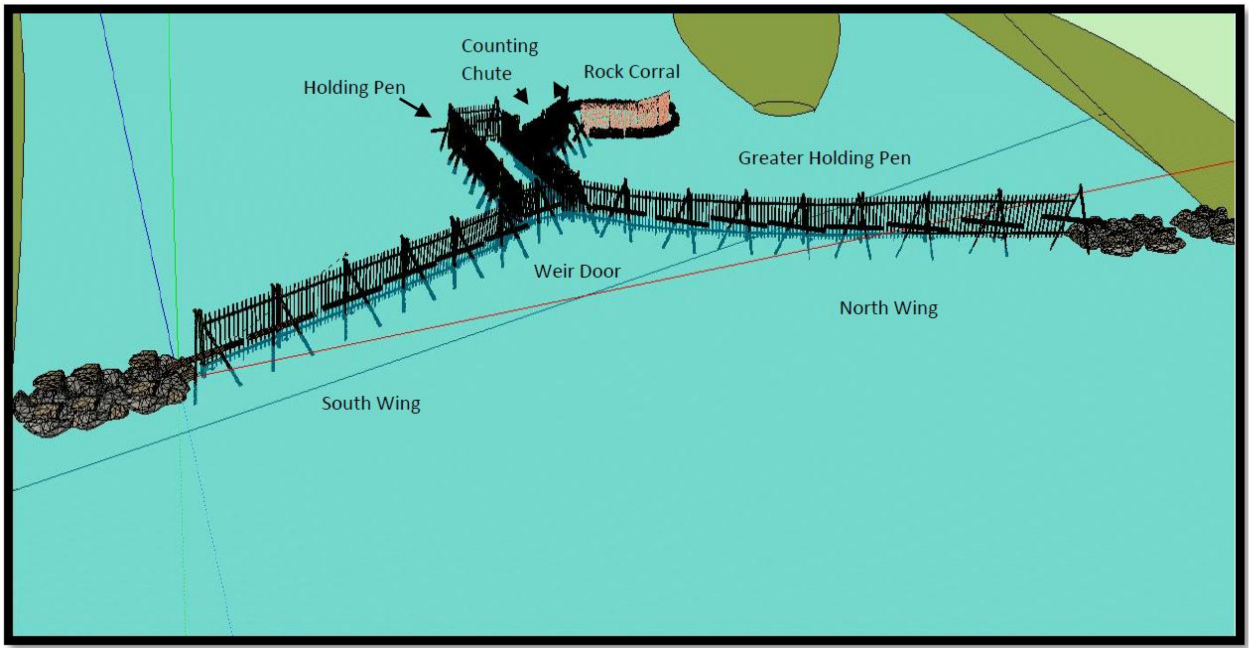

Figure 2. A schematic of the weir constructed on Halokvik River, Nunavut in 2013.

Arctic char were enumerated on a daily basis (including during the commercial harvest). Additionally, 1000 Arctic char were also tagged with T-bar anchor (Floy) tags and rewards are currently being offered for the return of any tags from fish captured in subsequent years to provided data that can be incorporated into a mark-recapture estimate of population size. Fork lengths (± 1 mm) were taken for nearly all the fish during the study with the exception of those that were visually enumerated (i.e., counted as they freely passed through the weir). Additionally a subset of fish were sacrificed and sampled for whole weight (± 50 g). The data collected during the 2013 enumeration were compared to historical data collected in a 1981 enumeration that is reported in McGowan in (1990) to assess temporal differences in the biology and demographic of Arctic char from this system. See also data analysis description below.

<u>*Data analysis*</u>

Condition factor (k) represents the health or robustness of an individual fish and was calculated using the following formula:

$$k = \frac{10^5(W)}{L^3}$$

where W is the round weight (g), L is the fork length (mm).

Figure 2. Aerial view of the weir across the Halokvik River, Victoria Island, Nunavut, used in 2013 as part of an Arctic Char population assessment. The red arrow indicates the upstream direction of migration. Photo courtesy of Denise LeBleu Images

Descriptive statistics (sample sizes, means, and standard deviations) were calculated for whole weights, fork lengths, sex, maturities and condition factors. The weight-length relationships for Arctic Char were described using the linear regression model. The weight-length relationship,

$$W = aL^b$$

was transformed into its logarithmic form expressed as:

$$\log_{10} W = a + b(\log_{10} L)$$

where W is the round weight (g), L is the fork length (mm), a is the y-intercept and b is the slope of the regression. An ANCOVA was used to compare the slopes and y-intercepts of the 1981 and 2013 data.

Two-tailed, paired t-tests were used to compare differences between the 2013 and the 1981 fork lengths, whole weights and condition factors. Frequency distributions were visualized for fork length and Kolmogorov-Smirnov tests (K-S-test) was used to determine if the fork length and whole weight frequency distributions differed between the 2013 and 1981 enumeration years.

7.0 Results

Fishery independent sampling

The Halovik River was the only location in the Cambridge Bay region in 2014 where fishery independent sampling commenced. We were unable to sample at the Jayko River for the reasons described above.

The Halovik River (30 Mile) was sampled from August 22-26, 2013. In total, 175 Arctic char were captured, 93 of which were males and 62 of which were females. Arctic char at this location ranged in fork length from 274 mm to 905 mm for males and 414 mm to 814 mm for females. Round weight ranged from 187 g to 7450 g for males and from 850 g to 6150 g for females. The majority of Arctic char captured in 2013 were in resting condition. Additionally, six least cisco (*Coregonus sardinella*) were also captured.

The data presented here are still preliminary and only general summaries are provided. All data collected as part of this 5-year assessment will be examined in full as part of the assessment for this fishery planned for 2016. Assessments and analyses of the fishery independent data collected from the Halovik and Jayko rivers will continue. These data will be added to the time series collected for these systems and full assessments of stock health will be performed subsequent to five years of data collection. Samples for parasite and genetic assessments are also being organized and contracts for age determination are in progress. All of the above described data will be used to assess trends in stock health (i.e., compared to previous years of fishery-independent sampling) as well as for comparison to those data collected as part of the plant sampling program. Subsequent to five years of data collection, a Regional Advisory Process (RAP) can take place to make recommendations with respect to the sustainability of current commercial quotas for these waterbodies (see Management Implications below).

Weir enumeration

Daily fish counts, during the 2013 Halokvik river enumeration were highly variable ranging from 0 to 568 fish counted per day (Figure 4). Fish counts were not completed on August 22nd and 23rd due to extreme weather and to accumulate fish in the holding pen in anticipation of the commercial harvest. In 2013 a total of 2135 fish were counted which is only a fraction of the 21 214 enumerated in 1981 (Figure 5). The 2013 enumeration total count included, tagged fish, incidental kills, fish sacrificed in the commercial harvest, as well as the fishery-independent samples, which used a gill net for the method of capture. Data from the fish caught in the independent sample were not used in statistical calculations or graphs, as it was not a true comparison to the 1981 weir study. During the 2013 enumeration, a total of 957 Arctic char were successfully floy tagged as a part of the mark and recapture study.

The 2013 and 1981 Halokvik River indicate that, although the total enumeration counts differ between years, the proportional trends are quite similar (Figure 6). The comparison clearly shows that for both years the start of the peak run began approximately August 23rd with the peak daily counts on August 28th.

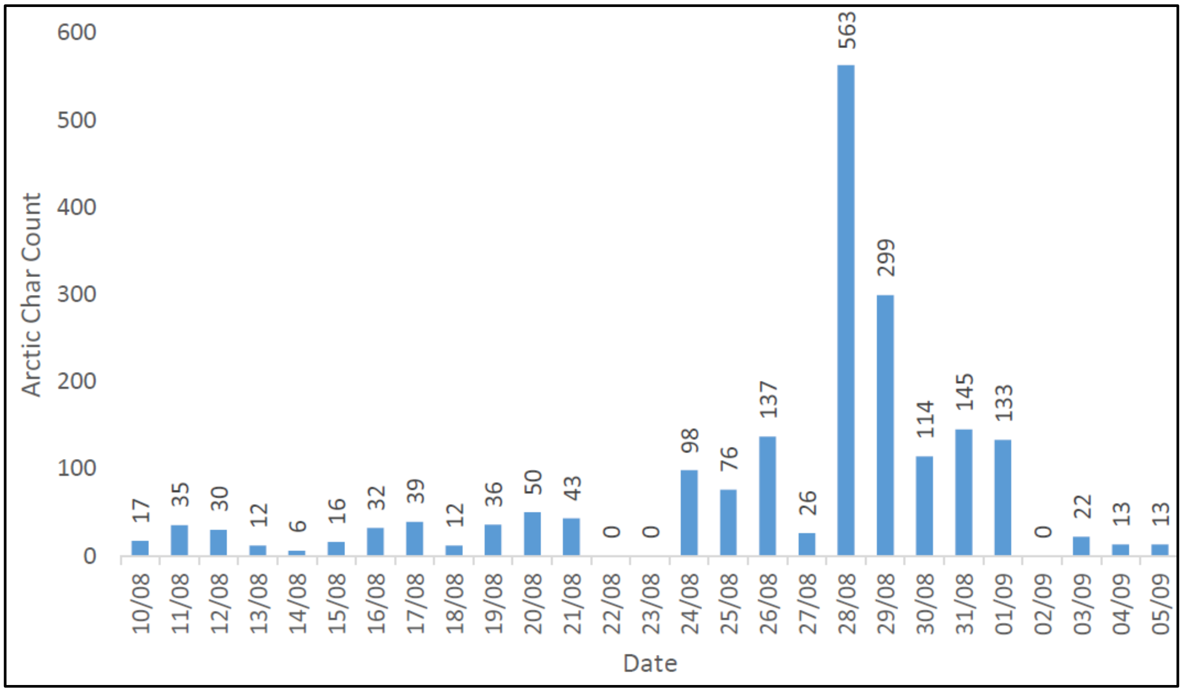

Figure 4. The daily counts of Arctic Char enumerated from the Halokvik River in 2013.

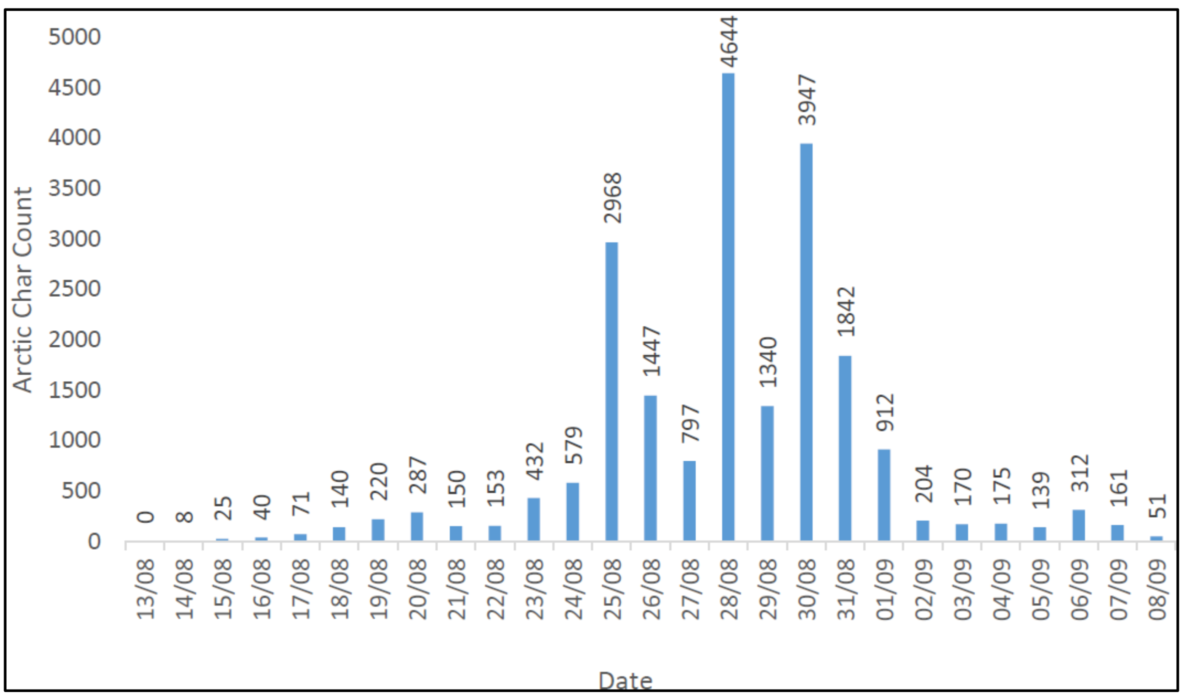

Figure 5. The daily counts of Arctic Char enumerated from the Halokvik River in 1981 (modified from McGowan 1990).

Temperature data collected with HOBO data loggers revealed some important information about the migratory patterns of Arctic char (Figure 6). Major trends over the study period showed temperature changes in all three temperature recorders fluctuated harmoniously. The water temperature dropped 7°C when on the 23rd of August dropping from 7°C to 0°C. This particular decline in temperature coincides with extreme weather which involved freezing temperatures and up to 100km/h winds and the peak run of Arctic char. This particular daily count coincides with an estuary temperatures averaged above 5 °C, whereas the temperatures of the weir and the tidal waters remained slightly above 4 °C.

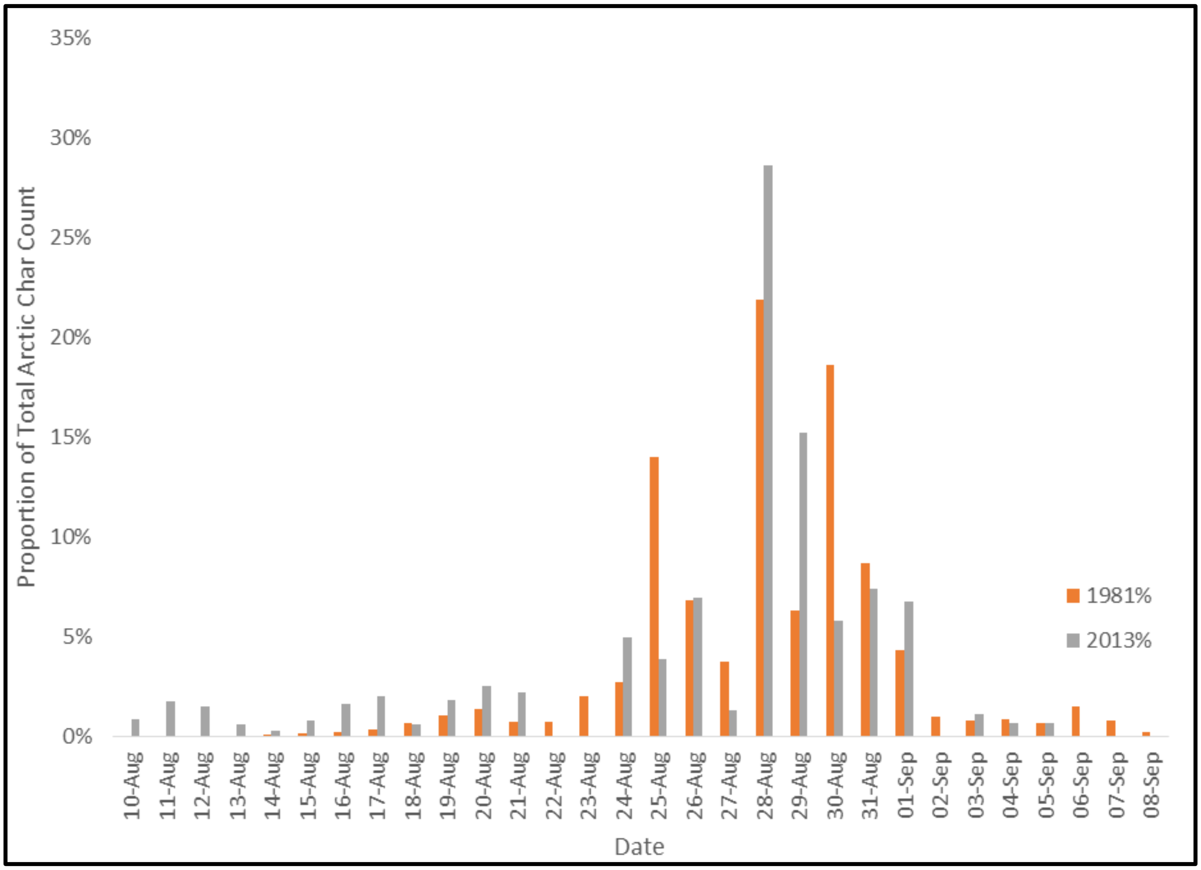

Figure 6. Proportional distributions of Arctic char) daily counts for 1981 (orange) and 2013 (grey) Halokvik river enumerations.

The fork lengths frequency distribution of the 1 424 fish measured in 2013 is shown in Figure 8. No fish less than 250 mm were recorded. The distribution of fork length appears to be normally distributed. The highest number of Arctic char (238) were in the 651-700mm fork length class. The 651-700 mm fork length class also represented the majority of Arctic char in the 1981 enumeration.

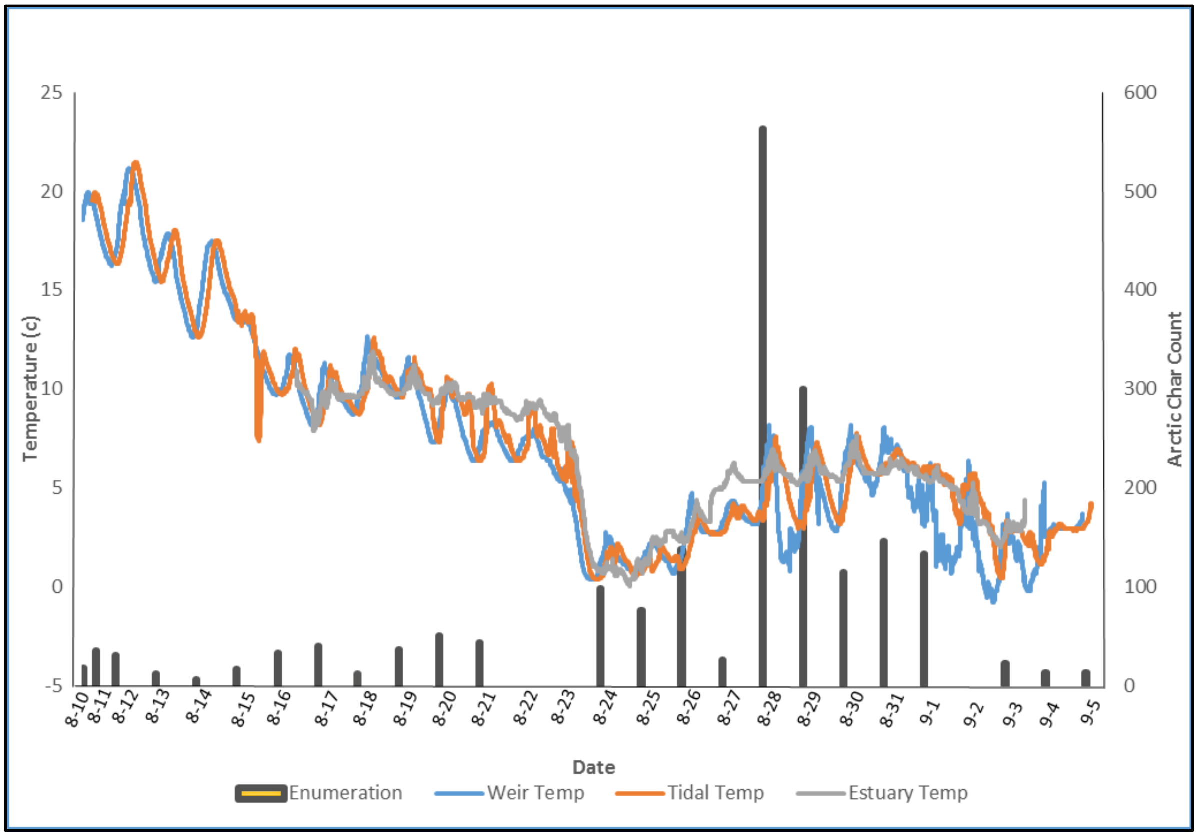

Figure 7. Temporal temperature trends collected from the HOBO data loggers located in the river (in blue), tidal (in orange) and estuarine (in grey) stations. The 2013 Halokvik River enumeration data (daily counts) are also shown.

Mean fork length (P < 0.0001, df=4051, t=29.63), whole weight (P <0.0001, df=3143, t=19.99). and k-factor (P <0.0001, df=3143, t=10.56) were all significantly different between 1981 and 2013. Results of the K-S test indicate that the distributions between the fork length (p<0.0001, d=0.281), and whole weight (p<0.0001, d=0.209) also differed significantly between years.

Overall, the entire sampled population had a mean k-factor of 1.22, which would indicate a generally “good condition” population. Condition factor was also calculated for fish in individual length classes. The best-condition length class in 2013 was the501- 500 mm class (k = 1.34).

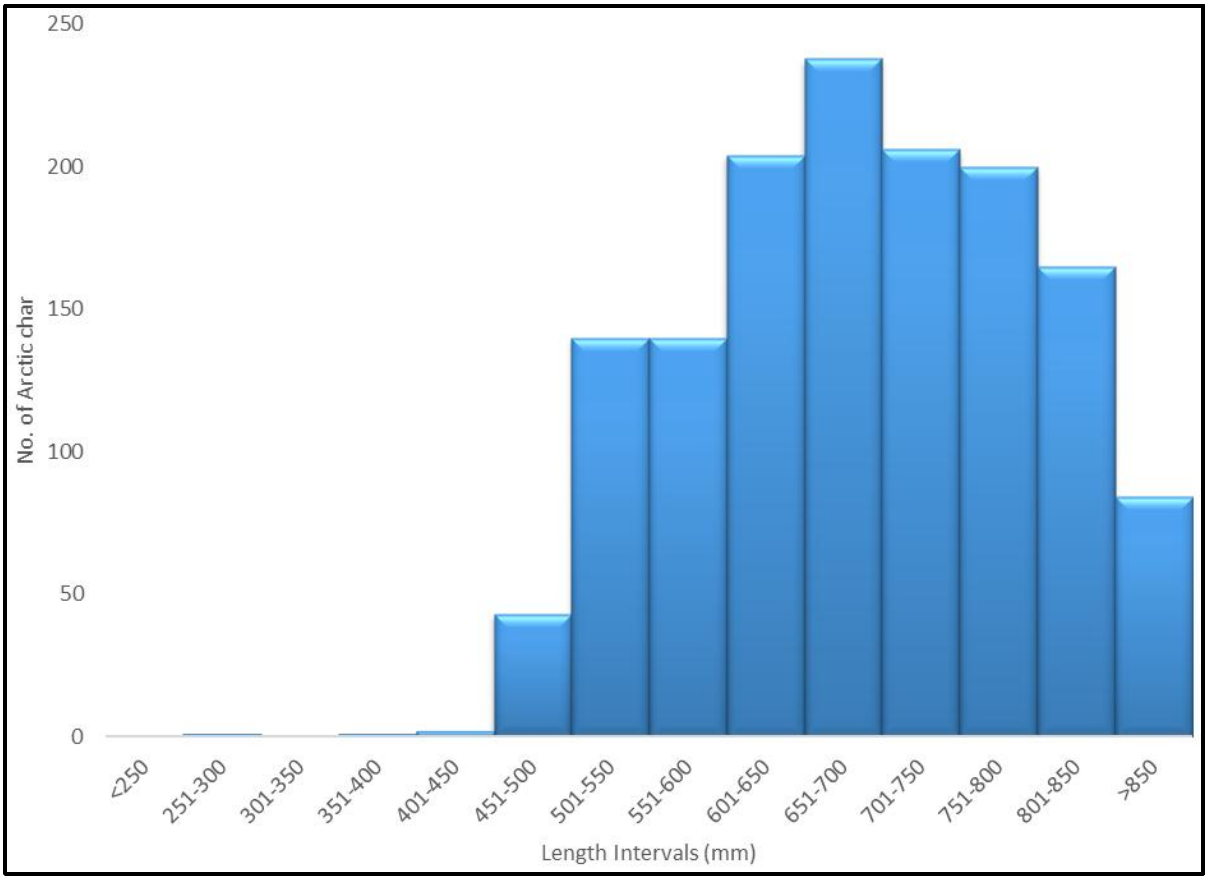

Figure 8. Fork Length frequency distribution for Arctic char captured from the Halokvik River 2013.

Length-weigh regressions for the 2013 Halokvik River samples are shown in Figure 11. The 2013 Halokvik River data produced a linear regression function of: Log (W) = -3.9+2.65(log (L)). The 1981 Halokvik River data (not shown) produced a linear regression function of: Log (W) = -5.77+3.33(log (L)). The ANCOVA found that both the slopes ($p<0.0001$, df=3309), and the y-intercepts and ($p<0.0001$, df=3309) were significantly different.

Discussion/Management Implications

Upon comparison of the 2013 Halokvik River enumeration, to the 1981 Halokvik River enumeration, some similarities were observed. The peak run times were remarkably similar between both years (i.e., August 24- September 1). Although the maximum daily counts for each of the years assessed fell on the same date, there were large differences when comparing the actual counts. For example, the 2013 daily maximum was 568, whereas the 1981 daily maximum was 4650. The 1981 Halokvik River assessment enumerated 21 214 Arctic char (McGowan, 1990) and several factors may explain the marked differences in the number of fish enumerated. First, problems with the weir design may have led to an incomplete count for the entire upstream run. It was observed, prior to the peak of the run that some fish were

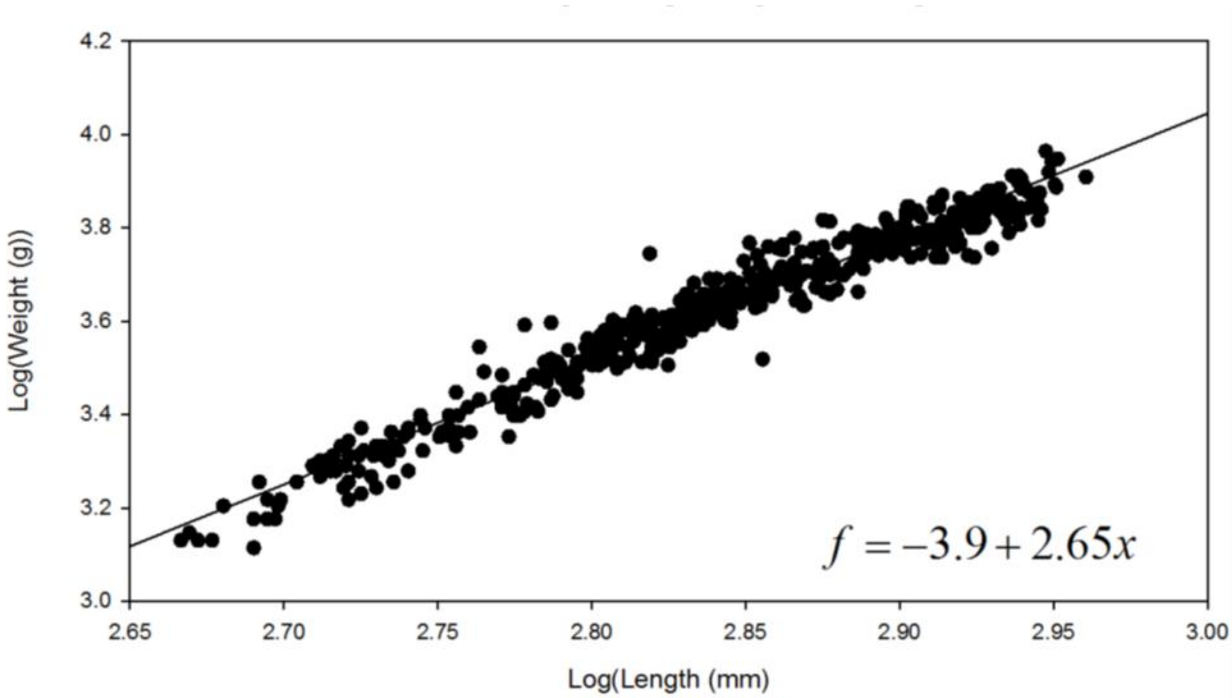

Figure 9. Weight-length relationships of Halokvik River Arctic char sampled during the 2013 weir enumeration.

able to pass through the wings of the weir. The 2013 assessment followed the design used for commercial fishing where conduit pipes were used in every second hole of the rails used for the wings of the weir and fish were clearly able to pass through these. These observations pose a problem for the validity of the enumeration numbers. Second, another theory to explain the difference in the overall enumeration is a behavioural trait in which fish that encounter a barrier to upstream migration may opt to leave that system and migrate up another river in the area. This means the weir may have triggered a reaction that caused them to vacate the Halokvik river system to seek another suitable freshwater river system for spawning and/or overwintering (Kristofferson, 1986). Indeed, Arctic char tagged in the Halokvik River were subsequently recaptured the same fall in the Ekalluk River (Moore and Harris, unpublished data) undoubtedly providing evidence for this behavior. This may not be surprising given most rivers in the region will freeze to the bottom and thus Arctic char not able to migrate to deep, freshwater winter habits will certainly be adversely affected (Lenhart, 2003). The reduced enumeration counts between 1981 and 2013 were likely the result of a combination of the two fore mentioned problems. Regardless, the weir design was modified for the 2014 assessment where upwards of 15 000 Arctic char were enumerated. Data entry for the 2014 study, however, has yet to commence.

In 2013, 957 of the Arctic char enumerated in the Halokvik River were tagged with floy tags. Tags that are recovered will be used as part of a mark and recapture study to update information on migratory patterns and most importantly, population abundance. In 1981, 996 Arctic Char were tagged at the Halokvik River. In subsequent years, 156 tagged Arctic Char were recovered in this system (Dempson and Kristofferson, 1987), 46% of which were previously tagged in this system. The majority of the remaining recoveries were composed of Lauchlan and Ekalluk rivers fish which were, 32%, and 17%, respectfully. This would suggest that the Arctic Char will movements in marine habitats is variable and that there is clear intermixing of stream populations (Kristofferson, 2002). This undoubtedly has important management implications (Kristofferson and Berkes, 2005; Roux et al. 2011).

Environmental data were captured using hobo data loggers. When visual comparisons were made between the enumeration data (i.e., daily counts) and temperature, there was a weak, negative relationship between temperature and abundance. As the water temperature started to decrease significantly on the 23rd of August, the daily fish counts began to increase. This temperature fluctuation could be considered the trigger or the upstream migration but further work is needed to confirm this.

The length-frequency distributions differed between the 1981 and 2013 enumerations. Most noticeably was the lack of smaller sized fish (< 450 mm) in the 2013 sample. There are a number of reasons why class sizes < 450 mm would not be represented in the 2013 enumeration. Most obvious is that smaller sized Arctic char were freely able to pass through the weir. In 1981, conduit pipes were used in every hole of the rails preventing the passage of smaller sized char. In 2014, the weir design was modified and conduit pipes were used in every hole. Second, the absence of small fish may be the result of smaller sized fish not yet migrating to the sea and thus could not be captured in the upstream component of the run. Smaller sized fish may not be able to survive the lengthy migration, and they lack the ability to osmo-regulate in marine water. Previous studies suggest that fish smaller than 200 mm in fork length will not migrate downstream from their freshwater rearing locations (Kristofferson et al., 1985).

The overall condition of the fish sampled in 2013 on Halokvik river suggested that they are in “good condition” (Barnham and Baxter, 1998). This should be expected as these fish should have gained ample body weight subsequent to the exploitation of rich marine food sources. Overall condition in 1981 was slightly lower suggesting that the Arctic char are generally less healthy 32 years later in 2013. This fact may be explained by the larger abundance of fish greater than 800 mm in fork length, which show a lower condition factor than the large proportion of small and mid-sized fish seen in 1981.

As expected, very few fully mature (current year spawning) fish were present during this sampling period. It is probable that mature fish of either sex may attempt to migrate upstream in advance of resting and immature individuals. Indeed, most mature fish observed in the present study migrated prior to the main upstream run. This behaviour could be explained by the need to migrate upstream earlier to find appropriate spawning grounds in their natal freshwater habitat. Immature Arctic char were not observed until the 22nd of August. This may be explained by their desire to forge at sea for a longer duration. The immature fish will not have to allocate energy to reproduction, and therefore should attribute all of their energy to a rapid growth. No obvious differences in sex ratios was observed in the analysis of the temporal data.

Management Implications

The data collected as part of this study (included the data collected in 2014) will have several direct management implications. Ultimately, these results will be used to provide advice to DFO Fisheries Management and the Nunavut Wildlife Management Board on the sustainability of harvest levels for Cambridge Bay Arctic char. This will proceed through a regional advisory process (RAP) for the Halokvik River planned for 2016 (after 5 years of fishery-independent data have been collected). At that time, the health of the fishery will be assessed and recommendations for sustainable harvest levels will be provided and these updates will also be used to revise the current Integrated Fisheries Management Plan (IFMP).

As with most char fisheries in the Canadian Arctic, the Cambridge Bay fishery is recognized as a data-poor fishery. As such, the results obtained from this proposed work will immediately build on our knowledge of the biology, vital rates, abundance and harvest of Arctic char in the Cambridge Bay area. Subsequently, these fishery-independent data and catch and effort information can then be used in future assessments of Cambridge Arctic Char relying on trend analyses (e.g., DFO 2004, Day and de March 2004, Day and Harris, 2013). Furthermore, models (i.e., generalized surplus production models (GSPM)) are currently being developed for these fisheries as a means to resolve precautionary limit reference points (LRPs). It is however noted that the results produced from these initial models should be used cautiously and adjustments should be made to refine the model once new information/data on these fisheries becomes available. Information/data collected (e.g., CPUE, fecundity, etc) as part of this proposed research can be used to support models noted above and to develop age-structured predictive models for the fishery that will be used to ensure the long-term sustainability of the resource.

9. Reporting to communities/resource users:

Numerous telephone and email communications took place with the EHTO manager (Brenda Sitatak) to discuss the project and as a means to incorporate local knowledge into sampling locations. Meetings in Cambridge Bay occurred in January and March of 2013 where the project details were presented and approved. Additionally, meetings were conducted in July 2013 prior to the commencement of field work where project planning was discussed again. Meetings with the EHTO subsequent to the field season also took place in March and Jun 2014 (i.e., through community presentations) to discuss the project progress and current results and to obtain approval for this year’s fishery-independent sampling.

EHTO and community reports and community posters highlighting this work have been distributed throughout Cambridge Bay. Updated posters highlighting results were distributed in 2014.

References

Barnham, C., Baxter, A. 1998. Fisheries Notes: Condition Factor, K, for Salmonid Fish. ISSN 1440-2254, State of Victoria, 3p.

Day, C., de March, B. 2004. Status of Cambridge Bay anadromous Arctic char stocks. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/052. v + 78 p.

Day, A.C., Harris, L.N. 2013. Information to support an updated stock status of commercially harvested Arctic Char (*Salvelinus alpinus*) in the Cambridge Bay region of Nunavut, 1960−2009. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/068. v + 30 p.

Dempson, J.B., Kristofferson, A.H., 1987. Spatial and temporal aspects of the ocean migration of anadromous Arctic Char. Am. Fish. Soc. Symp. 1: 340-357

DFO, 2004. Cambridge Bay Arctic Char. DFO Can. Sci. Advis. Sec. Stock Status Rep. 2004/010

Kristofferson, A.H. 2002. Identification of Arctic char stocks in the Cambridge Bay Area, Nunavut Territory, and evidence of stock mixing during overwintering. Ph. D. Thesis, University of Manitoba. 255 p.

Kristofferson, A. H., Berkes, F. 2005. Adaptive co-management of Arctic char in Nunavut Territory. Pp. 249 *in* F. Berkes, R. Huebert, H. Fast, M. Manseau, and A. Diduck, eds. Breaking ice: renewable resource and ocean management in the Canadian north. University of Calgary Press, Calgary, Canada.

Kristofferson, A.H., D.K. McGowan, and W.J. Ward. 1985. Fish weirs for the commercial harvest of searun Arctic Charr in the Northwest Territories. Can. Ind. Rep. Fish. Aquat. Sci. 174: iv + 31p.

McGowan, D.K. 1990. Enumeration and biological data from the upstream migration of Arctic Charr, *Salvelinus Alpinus* (L.), in the Cambridge Bay area, Northwest Territories. 1979-1983. Can. Data Rep. Fish. Aquat. Sci. 811: iv + 27 p.

Roux, M. J., Tallman R.F., and Lewis, C.W. 2011. Small-scale Arctic charr *Salvelinus alpinus* fisheries in Canada’s Nunavut: Management challenges and options. J Fish Biol 79, 1625-1647