NWRT Final Progress Report
Submitted November 15, 2020

1. NWRT PROJECT NUMBER: 03-19-14

2. PROJECT TITLE: Long-term Monitoring of Arctic Char (*Salvelinus alpinus*) Migrations, Dispersal and Habitat Preference in the Cambridge Bay Region of Nunavut Through the Use of Acoustic Telemetry

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4. SUMMARY

Arctic char is central to food security in the Canadian north as it is the most harvested species in Nunavut, utilized by every community in the territory. Its importance as a commercial resource has also been realized and fisheries of this type have now existed for decades. The Cambridge Bay region of Nunavut is also home to the largest commercial fishery for this species, harvesting close to 70,000 kg annually and employing dozens of Nunavummiut on an annual basis. Thus, effective management ensuring the long-term sustainability of this resource is paramount and this is evidenced by the establishment of first Integrated Fisheries Management Plan (IFMP, DFO 2014) for Arctic char in Canada. Within this plan, there are long-term objectives identified to guide the management of the fishery categorized under stock conservation, ecosystem, shared stewardship, and social, cultural and economic objectives. Within stock conservation, improving knowledge of Arctic Char biology, is identified as a key knowledge gap. Specifically, there are still many unknowns pertaining to the migratory ecology and habitat use of harvested Arctic char in the area.

In the Cambridge Bay region, we have been operating the longest uninterrupted acoustic telemetry array that has monitored more than 100 stations and over 400 individual Arctic char. This work has spanned both marine and freshwater environments and through this initiative we have started painting a clearer picture of migratory ecology and habitat use in this species, although a long-term perspective is still lacking. As such we, propose to continue studying the long-term migratory ecology of searun (anadromous) Arctic char from the Cambridge Bay region of Nunavut, which supports the most important commercial fishery for this species in Canada. This continued work will address key challenges in the current management of this

important fishery relating to dispersal and stock mixing, provide information on critical fresh water and marine habitats, provide detailed information on the timing of migrations between these areas and provide critical information on marine survival, all of which will provide important baselines in the face of climate change. The aim is to continue the acoustic monitoring for ten consecutive years ending in 2022, providing a long-term ecological data set that will be crucial for current and future forecasting efforts.

5. PROJECT OBJECTIVES

Through the continued use and re-deployment of our acoustic array in the Cambridge Bay region we aim to address unknowns that still remain pertaining to the anadromous migratory ecology of this species while identifying critical habitat for population persistence in both fresh and marine waters. There still remain a number of unknowns pertaining to the environmental variables that drive the timing of migrations in this species, the environmental and habitat variables that are important for dictating marine feeding, spawning and overwintering and how these all vary annually with temporal variation in environmental and climactic conditions. Thus, to address these unknowns, the specific objectives of the present study involve:

1. MARINE ACOUSTIC ARRAY MAINTENANCE - Retrieving and re-deploying the majority of our marine acoustic receivers (N=25). These Vemco receivers (VR2Ws) have been used to track marine migrations of adult Arctic char throughout the region. Migrations will be linked to oceanographic variables that have been collected since 2013 as part of an annual research cruise conducted by R/V Martin Bergmann.
2. VPS LAKE RETRIEVAL – In 2018, we initiated the first known Vemco Positioning System (VPS) study to track the fine-scale movements of acoustically-tagged adult char in two known spawning lakes using the VPS technology. In 2019 we are required to retrieve our acoustic receivers that were deployed in the two VPS lakes in 2018. (N=38). These receivers will be vital for identifying spawning and overwintering areas in each lake that will be important for understanding fresh water habitat use for Arctic char in the region. In subsequent years, these specific habitats will be ground-truthed and habitat will be quantified, allowing predictions to be made regarding critical and important areas in other lakes.
3. ACOUSTIC TAGGING - Tagging an additional 40 anadromous Arctic char in the marine environment. We will tag char with acoustic transmitters with a life of five years. This will ensure there are char that can be detected by our marine acoustic receivers when they are actively using the marine environment. This will bring us to the end of our marine acoustic work in the region that will wind down in 2022. This ten year perspective will be paramount for linking changes in climactic and environmental conditions to changes in marine habitat use, run timing and straying and mixing of stocks in the region.

6. MATERIALS AND METHODS

Description of the acoustic array – Our proposed work takes advantage of an extensive acoustic array already established in the Cambridge Bay region that has been operating since 2013 thanks to the ongoing support of the Ekaluktutiak HTO and NWMB. The intent is to operate the array at least until 2022 (10 years) providing the longest known temporal perspective of movement and habitat use in this species which is missing in current forecasting efforts but is absolutely essential for understanding how these aspects of char biology change with changing climactic conditions. We briefly describe our marine array below.

The marine acoustic array, now including 40 receivers, (VEMCO model VR2W and VR2AR; www.vemco.com), is specifically designed to test several hypotheses and build upon the six years of experience we have accumulated operating the array in the region. Each mooring is attached to an Edgetech SPORT MFE Push Off Release Acoustic Transponder (www.edgetech.com). The acoustic releases allow the moorings to remain below the ice and to be recovered the following year using the Edgetech Portable Acoustic Command System (www.edgetech.com). Once deployed, the array is continuously recording data. Annually, all acoustic receivers need to be recovered and redeployed in order to download the data and to perform maintenance and battery changes on the units. The marine acoustic array will be deployed with the help of local boat/field guides hired through the Ekaluktutiak HTO.

This passive acoustic telemetry technology used records the presence of tagged fish swimming within range of the acoustic receivers (approximately within 500-750 m). Receivers are currently deployed through four distinct types of locations. (1) A receiver is being placed at the mouth of each of the six Arctic char-bearing rivers in the Wellington Bay/Dease Strait region (six receivers). These receivers will allow the detection of strays (i.e., individuals that do not return to their natal/tagging site), and observe the timing of migrations to and from freshwater. (2) A series of 'gates' (i.e. pairs of receivers) are distributed along the shores (twelve receivers) to capture movement of char, which tends to be mostly coastal. (3) An array has been established in Cambridge Bay to detect those fish tagged in 2018 as part of the VPS study (4). Two VPS arrays have been established in two lakes in the Greiner system close to the community of Cambridge Bay (described below). Overall marine and fresh water movements and habitat use will be described upon subsequent years of acoustic receiver retrieval, data collection and analysis.

Description of the surgical procedure that has been used to surgically implant transmitters– Tracking of movements has been accomplished by surgically implanting over 400 individuals (VEMCO V16 acoustic transmitters, www.vemco.com) since 2013. The intent is to tag and additional 40 Arctic char in 2019, ensuring tagged fish remain until the end of the study on 2022. Individuals for acoustic tracking were captured using continuously monitored gill nets in late summer when spawning individuals can be clearly identified (Kristofferson (2002) sampled between 15 August and 10 September). Captured individuals were then released from the nets immediately by cutting the mesh to minimize injuries. Only individuals longer than 400 mm were selected for surgery. Selected individuals were then anaesthetized by immersion in a 75 ppm tricaine methane sulfonate (MS-222) solution. Anaesthetized fish were provided with a constant stream of a weaker maintenance bath solution (50 mg L-1 MS-222) over the gills. An incision was made on the ventral side of the fish, anterior to the pelvic fins and just to the left of the fish's center, exposing the peritoneal cavity. The transmitter was then be inserted into the body cavity through the incision. Simple interrupted stitches (3-0 curved needle, monofilament) were used to close the incision and the total amount of time for surgery throughout the course of this study is typically less than 5 minutes. Upon completion of the surgery, fish will be placed in freshwater and observed and released once fully recovered. Survival to surgical procedures is very high and survival after one summer was estimated at approximately 95%. All procedures have been approved by the Freshwater Institute's Animal Care Committee and conform to all animal care laws in Canada, and extensive community consultations in Cambridge Bay have confirmed local approval. A picture is taken of every tagged fish and a tissue sample for subsequent genetic analysis was preserved in 95% ethanol. Furthermore, biological information such as fork length, weight, sex and maturity was recorded for every fish.

VEMCO Positioning System and oviduct transmitter implantation – In 2018 we aimed to track the fine-scale movements of acoustically-tagged adult char in known spawning lakes using the VEMCO positioning system (VPS). The premise of the VPS is that simultaneous detections of a single acoustic transmission by three or more acoustic receivers allows the location (e.g., <10 m precision) of transmitters (at time of transmission) to be estimated using the principle of time difference of arrival (TDOA), in a process known as hyperbolic positioning. Simply put, arrays of VR2W receivers with overlapping detection ranges will permit the triangulation of a fish's true location with an accuracy of a few meters, and will provide continuous tracks of fish movement within the array. Using fish positions, areas with dense concentrations of fish during the spawning season will be inferred. Acoustic tagging this year took place in two lakes within the Grenier Lake System as part of our VPS study (Inuhuktok and Nakyulik lakes). A total of 24 Arctic Char and 21 Lake Trout were tagged (following the procedures described above) at these locations and a total of 35 receivers were used as part of the array across both lakes (Appendix 2 and Appendix 3). All fish were caught using angling, surface set gillnets. Additionally, to confirm the position of spawning, we used a newly developed technique involving the insertion of transmitters in the oviduct of gravid females. The transmitter will be shed with eggs, marking the spawning location within the VPS array. This innovative technique is superior to traditional positional telemetry requiring the assumption that a fish at a given location during spawning season has spawned at that location. These areas will then be ground-truthed at a later date and all habitat and environmental variables will be quantified. In 2019, through the assistance of local field guides, we will recover all VPS lake receivers (these will not be re-deployed this year).

Inuit Qaujimajatuqangit - Inuit Qaujimajatuqangit was used specifically to determine the lakes for the VPS study described above. Through consultations with the EHTO and local resource users we identified several candidate spawning lakes for the VPS study. Two of these lakes in the Greiner system were selected as local knowledge indicated they harboured spawning Arctic char and had sufficient depths to moor our equipment. Overall, we have relied heavily on IQ for several aspects of this overall research program including in the design of our marine acoustic array and for determining specific tagging locations and the timing of when we should be there.

In 2019, we will rely heavily on IQ for timing and travel to our acoustic receivers for retrieval and also for the timing of fish capture for our acoustic tagging. We will also incorporate IQ into camp locations and general field safety considerations.

Data analysis for marine survival
Between 2013 and2 018, 187 adult Arctic Char (fork length > 400 mm) were captured and surgically implanted with acoustic transmitters and mark-recapture methods were used to estimate survival probabilities over six years. The Cormack-Jolly-Seber (CJS) model was used for the analysis of the individual encounter histories (Williams et al. 2002). The apparent survival probability (φ) (hereafter, survival) and the recapture (or re-encounter) probability (p) of each tagged individual were estimated by maximum likelihood with MARK (see supp. mat. for explanation of how probabilities are calculated) (White and Burnham, 1999) using the RMark package (Laake 2013) in R (White and Burnham, 1999; Laake, 2013; R Development Core Team, 2008). We formulated 21 candidate models to test our biological hypotheses (Table 1). We considered the date of sea ice melt, the temperature, the sex and the time (year) as the parameters influencing φ. We also considered the interaction between sex and temperature and the interaction between sex and time. For the recapture probability, we considered the number of receivers (effort) and the time (year). The global model fit was assessed with the fletcher-ĉ and it showed some low overdispersion ($\hat{c}$ = 1.06). Therefore, we used model selection and multimodel inference based on Akaike's information criterion corrected for small samples and overdispersion (Burnham and Anderson 2002).

<u>7. RESULTS</u>

Recoveries
In 2019, we recovered and redeployed all marine and freshwater acoustic stations for a recovery rate of 100 % (**Figure 1**). Additionally, all receivers were recovered from both VPS lakes (**Figure 2** (Inuhuktok) and **Figure 3 (**Nakyulik)). These recoveries were done from small boats hired directly in the community, and with four days of recoveries via float plane.

Marine Tagging
Acoustic tagging this year took place at the Lauchlan River in 2019. A total of 30 Arctic Char and were tagged at this locations. All fish were caught using angling, surface set gillnets. Genetic samples were also taken from all tagged fish. These fish will be tracked for the duration of our marine telemetry program in the region.

Marine Habitat Use For the marine portion of this work, data extracted from this study so far includes approximately 16,388,301 individual detections of fish movements. For detailed description of some of the marine acoustic results, see Moore et al. (2016, 2017) and Harris et al. (2020). Our most recent paper (Harris et al. 2020) summarizes four years of data on depth and temperature preference of Arctic Char while swimming in the ocean. Specifically, we used acoustic telemetry to document marine habitat use and depth/temperature preference of 26 anadromous Arctic char within the Kitikmeot Sea region over four years (2013-2016). We determined that most detections (~70%) were within the top three meters of the water column and most were in estuarine (72.6%) vs. marine (27.4%) habitats. Arctic char preferred deeper waters later in the summer, yet the temperature they occupied remained relatively constant throughout the marine feeding season (~5-8ºC). Most Arctic char exhibited some degree of repetitive diving behaviour with individuals diving to 35 m. Diving activity increased later in the summer marine feeding season and is likely a response to the seasonal transition of their preferred prey to deeper waters as the marine feeding season progresses. Finally, Arctic char preferred deeper waters with less ice-cover and during the day, the latter suggesting potential diel patterns to marine habitat use. Finally, year-to-year variation in Arctic char depth and temperature use was very modest despite differences in climatic and ice conditions.

Survival in the Marine Environment

The annual survival probability of the Arctic Char from the Ekalluk River was high and did not show marked interannual variation (range: 0.79 ± 0.10 (2015) to 0.88 ± 0.10 (2017), **Figure 4**). The recapture probability was also high with values ranging from 0.64 ± 0.21 (2019) to 0.90 ± 0.10 (2014), suggesting that our acoustic array was effective at detecting Arctic Char with acoustic transmitters in the marine area. The most parsimonious model included the effect of date at which sea ice melted on the survival probability, but with a constant recapture probability. This model had most of the support (Akaike weight = 0.59) and was 5.9 times better than the second-ranked model consisting of constant survival probability and recapture probability varying across years. However, multimodel inference indicated that survival probability did not vary with the date of sea ice melt (model-averaged estimate: -0.24, 95% confidence interval: [-0.72, 0.23]). Several of the top models included the effect of year on the recapture probability. However, recapture probability did not differ among years. Models with the sex of the individuals or temperature had little support, suggesting no effect of these variables on survival (Akaike weight ≤ 0.05).

Fine-scale Positioning

As a final tagging aspect of our overall telemetry program in the Cambridge Bay region, in 2019 we also aimed to track the fine-scale movements of acoustically-tagged adult Arctic char and lake trout in spawning condition in one known spawning lake using the Vemco Positioning System technology (VPS) technology. The premise of the VPS is that simultaneous detections of a single acoustic transmission by three or more acoustic receivers allows the location (e.g., <10 m precision) of transmitters (at time of transmission) to be estimated using the principle of time difference of arrival (TDOA), in a process known as hyperbolic positioning. Simply put, arrays of VR2W receivers with overlapping detection ranges will permit the triangulation of a fish's true location with an accuracy of a few meters, and will provide continuous tracks of fish movement within the array. Using fish positions, areas with dense concentrations of fish during the spawning season will be inferred.

The initial proposal planned to tag Arctic Char in a lake locally known as Spawning Lake located in the Ekalluk River watershed. The very difficult wind conditions in the summer of 2018 forced us to modify our plans and to move the location of the study to the Grenier Lake watershed nearer the community of Cambridge Bay. To choose the new locations of the tagging study, we enlisted the help of Richard Ekpakohak, an Inuit harvester and expert that has provided valuable knowledge throughout the duration of the study and over the years he has been an invaluable resource. Through consultation with Richard and subsequently with the EHTO, it was suggested we move the study to two lakes that he knew were deep and contained Arctic Char and Lake Trout throughout the winter. Two lakes known locally as Inuhuktok and Nakyulik indeed met all the criteria as candidate lakes for our VPS study (both harboured Arctic char and lake trout in spawning condition). This proved to be extremely valuable information and made it possible to succeed with our field work despite the inclement weather. We captured and acoustically tagged 24 Arctic Char and 21 Lake Trout across both lakes

In 2018 a total of 38 acoustic stations were incorporated into the VPS arrays across both lakes (Nakyulik Lake N= 24, Inuhuktok Lake N = 14) and, as mentioned above, all of these receivers were recovered.

In Nakyulik Lake, there were 4,856,054 animal tag detections logged over the course of the data collection period (Start: 2018-08-27 19:20:46 UTC and End: 2019-07-24 20:05:00 UTC). There were 51 unique animal tags detected; of these, total detections ranged from 2 (transmitter 27531) to 299,468 (transmitter 27522). Overall, 61.3% of animal tag transmissions were detected on at least 3 receivers, and each animal tag transmission was detected 4.0 times on average. A total of 636,178 sync tag positions and 633,757 animal tag positions were calculated by the VPS. Positions were calculated for 50 different animals; of these, yields ranged from 1 position (transmitter 4958) to 39,005 positions (transmitter 27522).

In Inuhuktok Lake, there were 2,690,138 animal tag detections logged over the course of the data collection period (Start: 2018-08-20 20:37:54 UTC and End: 2019-07-27 18:44:00 UTC). There were 23 unique animal tags detected; of these, total detections ranged from 54 (transmitter 6201) to 271,233 (transmitter 27512). Overall, 54.2% of animal tag transmissions were detected on at least 3 receivers, and each animal tag transmission was detected 3.3 times on average. A total of 334,897 sync tag positions and 350,053 animal tag positions were calculated by the VPS. Positions were calculated for 22 different animals; of these, yields ranged from 2 positions (transmitter 6201) to 38,475 positions (transmitter 27512).

To this point only vertical habitat space use patterns have be analyzed and a brief description of some preliminary results is provided below. We are currently, however, collaborating with a PostDoctoral Research Fellow at the University of Windsor to analyze our VPS data set. As such, more in depth analyses and results will be available in the future.

In Inuhuktok, Arctic char and Lake trout body temperature dropped drastically starting in mid-September (**Figure 5**). Relatively constant body temperature were maintained throughout the winter and started increasing in June of the flowing year. This decrease and increase undoubtedly relates to the onset of cold weather and ice associated with fall/winter and the increases in temperature and melting of ice associated with spring/summer. Overall, Arctic char had a narrower range of body temperature compared to Lake Trout. Anadromous Arctic char are suspected not to feed while overwintering in freshwater whereas Lake Trout would be actively foraging in the winter months. This likely explains the differences in body temperature profiles as the Lake Trout are likely using much more of the lakes habitat both vertically and horizontally while foraging. Thus, they likely experience a much wider range of temperatures throughout the winter months. Mean temperature throughout the duration of the study in Inuhuktok was 1.55°C (± 1.36 SD) and 2.55°C (± 2.07 SD) for Arctic char and Lake Trout respectively.

Arctic char also appeared to use slightly deeper water throughout the winter months in comparison to Lake Trout (Figure 5). Early in the study Arctic char were deeper and then moved closer to the surface in late-September and early October. We interpret this to be a move from deeper spawning locations to depths just below the ice for overwintering. Other than that, depth occupied by both species was relatively constant throughout the study. Mean depth throughout the duration of the study was 2.67 m (± 0.86 SD) and 1.79 m (± 0.88 SD) for Arctic char and Lake Trout respectively.

Body temperature and depth profiles for Nakyulik Arctic char and Lake Trout are shown in **Figure 6.** Similar to the body temperature profiles observed In Inuhuktok, Arctic char and Lake trout body temperatures in Nakyulik also dropped drastically starting in mid-September, remained relatively constant throughout the winter and started increasing in June of the flowing year. Unlike in Inuhuktok, Arctic char had a wider range of body temperature compared to Lake Trout. We attribute this to the potential of tagging some resident char (those that do not go to see). Resident char would still be feeding in freshwater over winter and possibly avoiding lake trout predation and therefore should be using much more of the lakes habitat both vertically and horizontally while foraging and avoiding predation compared to their anadromous counterparts. Mean temperature throughout the duration of the study in Nakyulik was 2.40C (± 1.58 SD) and 2.39°C (± 1.55 SD) for Arctic char and Lake Trout respectively.

Lake trout appeared to sue deeper water in the beginning months of the study whereas Arctic char appeared to use slightly deeper water throughout the latter winter months in Nakyulik (**Figure 6**). Both species also appeared to have a wider range of depth use in comparison to fish from Inuhuktok. As mentioned above, if resident char were tagged they likely use much more of the lakes habitat both vertically and horizontally while foraging and avoiding predation compared to their anadromous counterparts. The wider depth range exhibited by lake trout could relate to actively chasing resident Arctic char when foraging. More work would have to be done to truly test this. Mean depth throughout the duration of the study was 2.53 m (± 0.1.25 SD) and 1.79 m (± 0.88 SD) for Arctic char and Lake Trout respectively.

8. DISCUSSION/MANAGEMENT IMPLICATIONS

Arctic char represent the most vital fish species in Nunavut particularly because of its subsistence importance in every community in the territory but also for its commercial significance. The latter contributes to a multi-million dollar industry and thus ensuring the effective management for this species where it is harvested is not only important for ensuring traditional lifestyles and food security are maintained but also for ensuring the livelihoods of those employed through the commercial fishing industry are protected. Ensuring sustainable removal levels for priority fisheries is the most integral part in doing so. This is especially true for the Cambridge Bay Arctic char commercial fishery, the largest in the world, that employees dozens of Nunavummiut on an annual basis. Indeed, ensuring the sustainable exploitation of commercially harvested Arctic char and continued refinement of the Integrate Fisheries Management Plan (DFO 2014) for this fishery have both been identified as regional priorities within the Kitikmeot Region of Nunavut. On a larger scale, the NWMB has identified the establishment of safe harvest levels for priority species, development of wildlife management plans, identification of wildlife management zones that might warrant protection and advice on marine areas all as wildlife priorities at the territorial level. Thus, it is clear that the results of our long-term telemetry program in the Cambridge Bay region will be valuable for furthering our understanding of the biology and ecology of Arctic char in the region; result that will help make informed and appropriate management decisions. We detail some of these below.

Changes in environmental conditions could impact Arctic char recruitment, spawning biomass, abundance (Criddle et al. 1998; Power et al. 2000) and potentially fishing revenue for the residents who commercially fish for this species. Therefore, marine and fresh water habitat use, migration timing and the temperature and depth preferences of this species in the region provides important information for assessing how Arctic char will continue to adjust in a warming Arctic marine environment which will undoubtedly be integral for ensuring the long-term sustainability of this key resource. For example, our marine telemetry results have already shown marine habitat se n Arctic char habitat use is relatively fixed and may reflect their thermal and osmoregulatory physiology, which has important implications for forecasting the impacts of a changing Arctic on this economically valuable species. These our current and future data will provide unique knowledge on the ecology of Arctic Char in marine waters, but will also provide managers with a crucial scientific basis to inform decisions, especially in the face accelerated Arctic climate change.

The information/data collected as part of this work will also directly inform fisheries management of commercially harvested Arctic char in the Cambridge Bay region by furthering our understanding of critical habitat use (such as those used for spawning, foraging and over wintering). Despite the importance of Arctic char wherever it occurs, knowledge regarding critical habitats important for spawning, feeding, rearing and overwintering is limited for this species across most of its northern range. This is also true for Arctic char exploited in Cambridge Bay commercial fisheries even though these fisheries have been prosecuted for over half a century. In order to plan and manage the conservation of these population stocks, knowledge of marine habitat use within the population’s range is essential and a variety of case studies have emerged have emerged highlighting the use of acoustic telemetry for delineation of management zones or areas of consideration for future protection. Thus, improving our understanding of marine habitat use will emerge as a key source of information that may be considered should the need arise for the identification and establishment of marine protected/management areas for Arctic char in the Kitikmeot region. Additionally, our freshwater and VPS work will provide novel insights into the spawning and overwintering habitats that are important for char survival in the area. Habitat characteristics of these areas will be described in order to identify critical environmental variables determining spawning and overwintering habitat suitability. Thus these results could be important for predicting and identify the suitability of critical habitats in other freshwater systems and for protecting spawning areas in systems identified through this work.

Additionally, discrete populations or stocks of fishes often occur in sympatry or intermix while exploiting habitats critical to their survival such marine habitats used for foraging and freshwater habits used for overwintering. Given that it is often not known which stocks, specifically, are being harvested and to what degree, mixed-stock fisheries can severely complicate management. Thus, disentangling contributions of discrete stocks to commercial, subsistence and recreation fisheries has important implications for fisheries management and the sustainability of fisheries resources. In the Cambridge Bay region, the degree to which populations mix during commercial harvest remains unknown. For example, if it is clear that a mixture of populations are harvested at discrete fishing locations based on acoustic telemetry, quota transfers among locations could be implemented if the quota is not filled at one location. Such an approach could provide increased yield and thus value for the commercial fishers without compromising the sustainability of the stocks. Additionally, updated information such as proportional contributions to harvest of discrete stocks may be integral for refining/updating stock assessment models aimed at resolving sustainable harvest and removal levels.

All told, our overarching telemetry program specifically collects information on marine and freshwater habitat use, the timing of migrations between these areas, stock mixing and demographic independence of spawning populations of Arctic char from the Cambridge Bay region. As highlighted in the IFMP and the approved DFO science plans for these fisheries, data are still lacking on habitat use, demographic independence of harvested populations and the overall role of char in the ecosystem. Indeed, one of the primary objectives for the commercial fishery outlined in the IFMP aims to improve knowledge of Arctic Char biology and stock discrimination. This work will therefore fill in important knowledge gaps on many aspects of char biology in the region that will be key for informing effective management aimed at ensuring the long-term sustainability of the resource thereby helping to also fulfill key objectives in the management plan for this fishery.

9. REPORT BY INUIT PARTICPIPANTS

Attached as a separate document.

10. REPORTING TO COMMUNITY RESOURCE USERS

Numerous telephone and email communications took place with the EHTO manager (Beverly Maksagak) and the EHTO president (Bobby Greenley) to discuss the project and as a means to incorporate local knowledge into the timing of sampling at the Lauchlan River and field camp logistics. Meetings in Cambridge Bay occurred in February 2019 where we discussed and presented this project at the at the EHTO annual general meeting. Approval for the project was also received at that time. Additionally, we met with the HTO in June 2019 as part of our pre-season fishing meetings and we met with board members multiple times throughout the summer while in Cambridge Bay when we were conducting our field work. The results of our

2019 field season were also presented at the Kitikmeot Regional Wildlife Boards annual general meeting (AGM) in September 2019 and to the community of Cambridge Bay at the Polar Knowledge Canada Science Days community feast held in March 2020. Summary reports for the Ekaluktutiak HTO and residents of Cambridge Bay have also been distributed.

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FIGURES

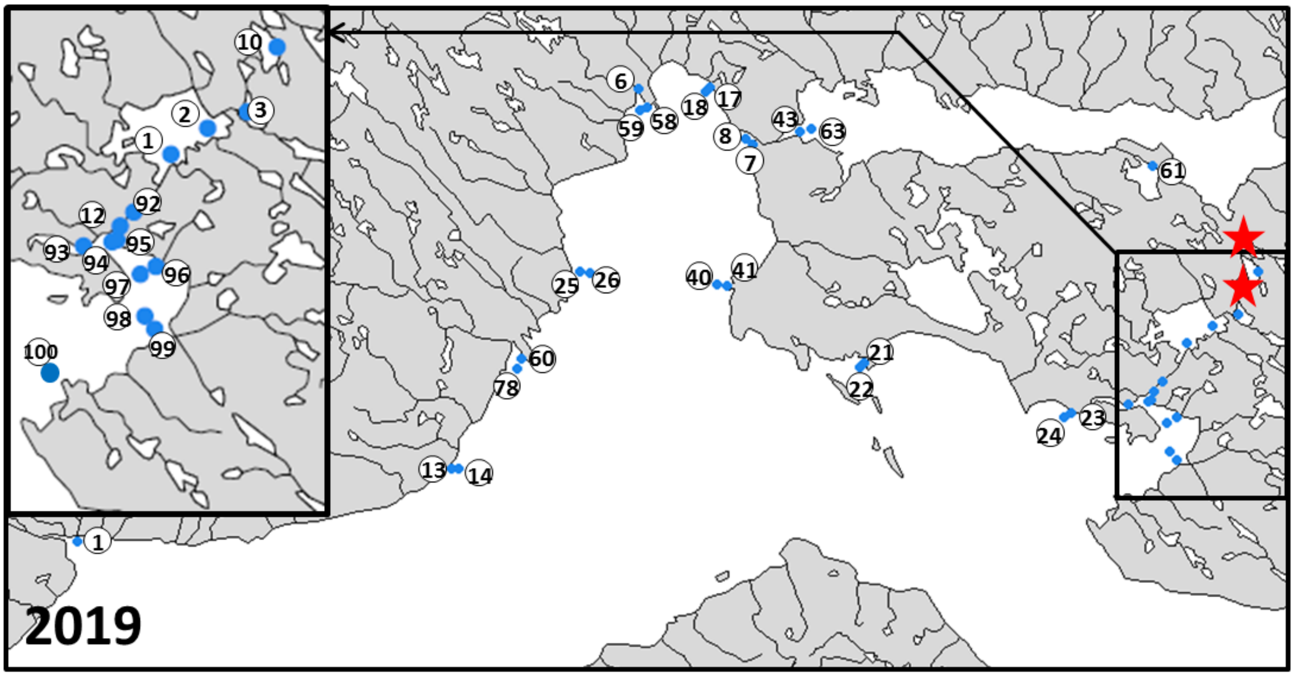
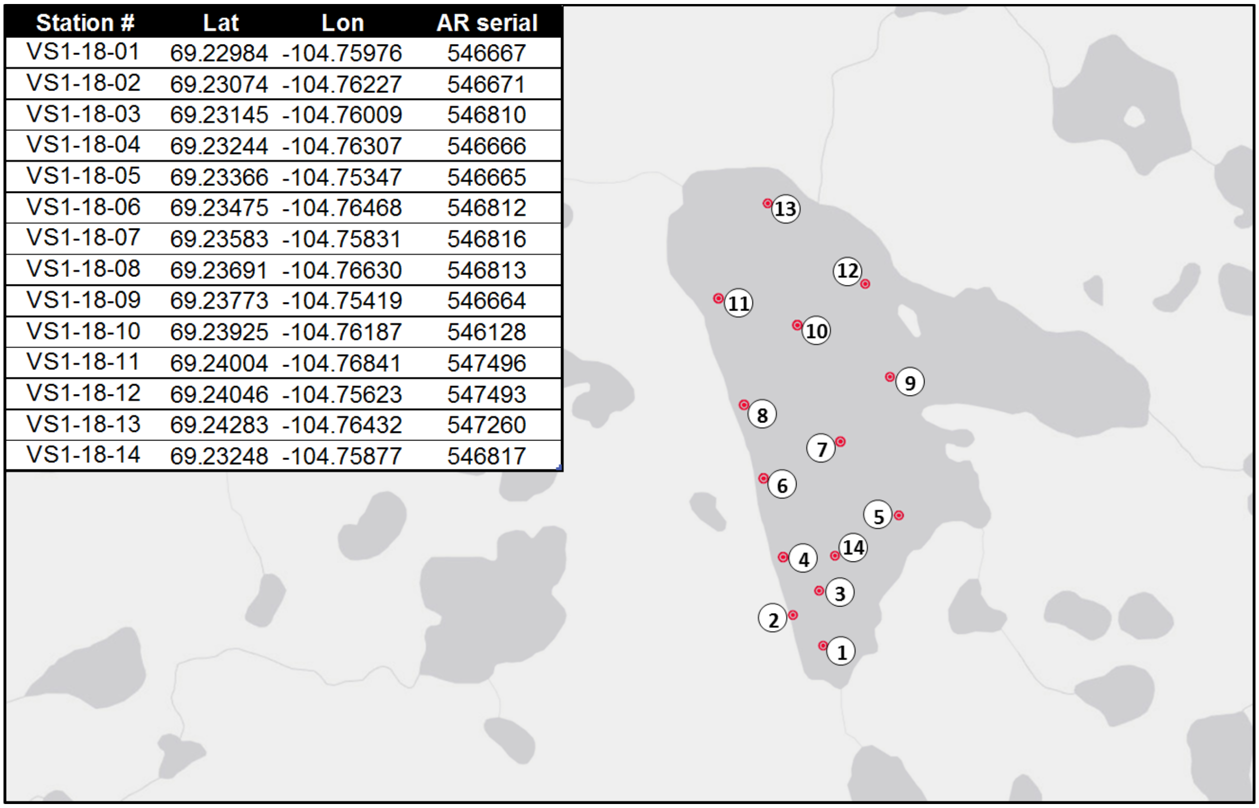


Figure 1. Locations of the acoustic receivers used for tracking Arctic Char in the Kitikmeot Sea near Cambridge Bay that were redeployed in 2018. All of these receivers were recovered in 2019. Note the freshwater focus of our program has transitioned to the Greiner watershed near the community of Cambridge Bay. The location of the two lakes where the Vemco Positioning System (VPS) was implemented are shown with red stars (see also Figures 2 and 3).



Station #	Lat	Lon	AR serial
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VS1-18-04	69.23244	-104.76307	546666
VS1-18-05	69.23366	-104.75347	546665
VS1-18-06	69.23475	-104.76468	546812
VS1-18-07	69.23583	-104.75831	546816
VS1-18-08	69.23691	-104.76630	546813
VS1-18-09	69.23773	-104.75419	546664
VS1-18-10	69.23925	-104.76187	546128
VS1-18-11	69.24004	-104.76841	547496
VS1-18-12	69.24046	-104.75623	547493
VS1-18-13	69.24283	-104.76432	547260
VS1-18-14	69.23248	-104.75877	546817

Figure 2. Locations of the acoustic receivers used for tracking Arctic Char and Lake Trout as part of our VPS study in Inuhuktok Lake.

Station #	Lat	Lon	AR serial
VS2-18-01	69.27121	-104.69470	547256
VS2-18-02	69.27198	-104.70628	546814
VS2-18-03	69.27301	-104.69128	547257
VS2-18-04	69.27466	-104.70256	547495
VS2-18-05	69.27463	-104.71579	547258
VS2-18-06	69.27662	-104.69294	547263
VS2-18-07	69.27849	-104.69723	546668
VS2-18-08	69.27837	-104.71182	546129
VS2-18-09	69.28181	-104.71484	546053
VS2-18-10	69.28265	-104.70706	546054
VS2-18-11	69.28663	-104.70532	546055
VS2-18-12	69.28637	-104.71873	546092
VS2-18-13	69.28578	-104.73395	547254
VS2-18-14	69.28861	-104.72882	546091
VS2-18-15	69.28918	-104.74059	547255
VS2-18-16	69.29006	-104.71541	254262
VS2-18-17	69.29248	-104.73261	547494
VS2-18-18	69.29231	-104.74902	546815
VS2-18-19	69.29451	-104.75799	547492
VS2-18-20	69.29581	-104.74314	547259
VS2-18-21	69.29741	-104.75388	546670
VS2-18-22	69.29823	-104.76458	547497
VS2-18-23	69.29881	-104.73607	547261
VS2-18-24	69.29501	-104.73028	546811

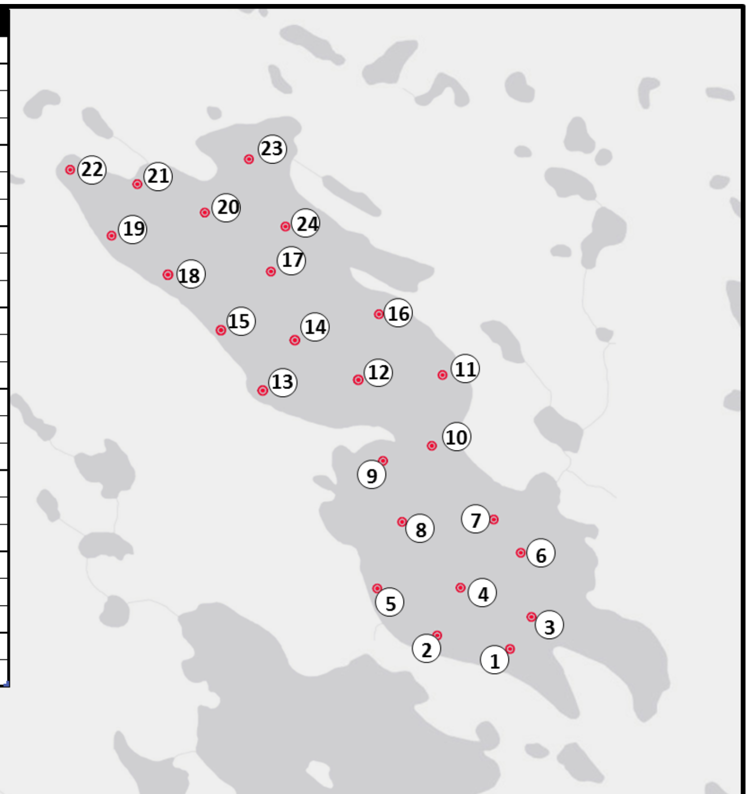

Figure 3. Locations of the acoustic receivers used for tracking Arctic Char and Lake Trout as part of our VPS study in Nakyulik Lake.

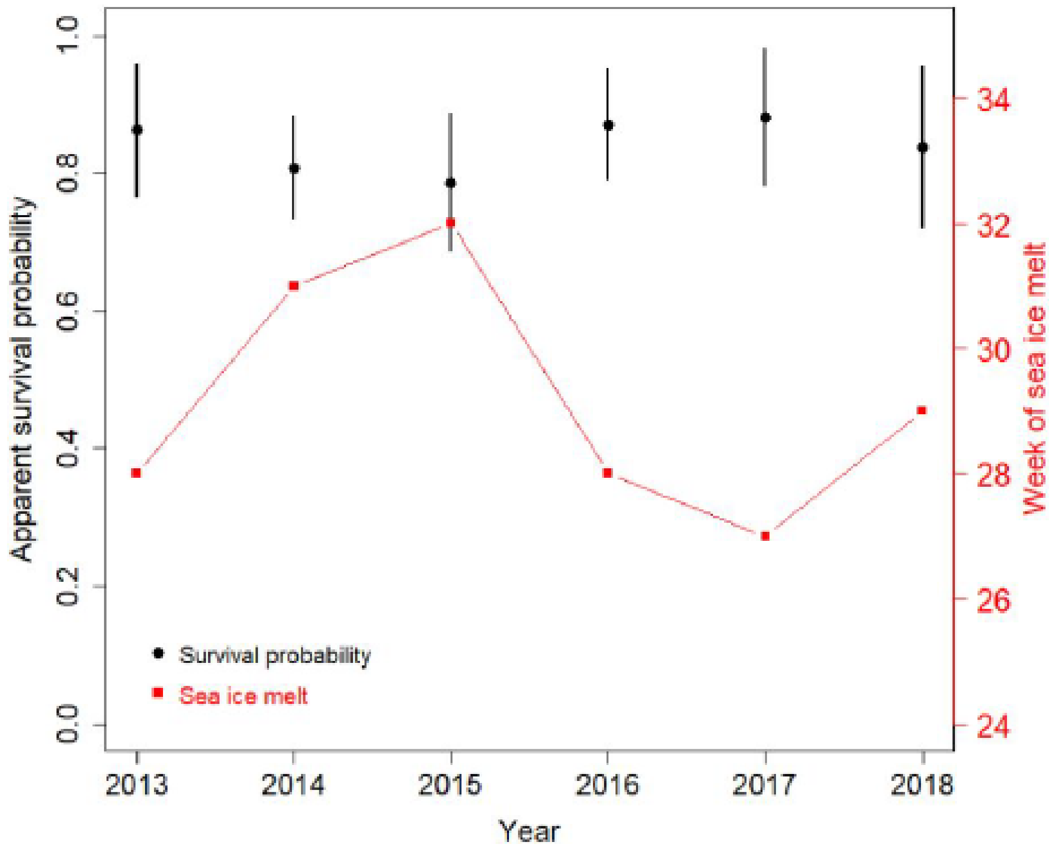

Figure 4: Apparent survival probabilities of Arctic Char (Salvelinus alpinus) acoustically tracked between 2013 and 2019 in Cambridge Bay (n = 187 individuals). Estimates obtained with multimodel inference on the entire set of candidate models. The vertical lines denote 95% confidence intervals. The red squares represent the week of sea ice melt.

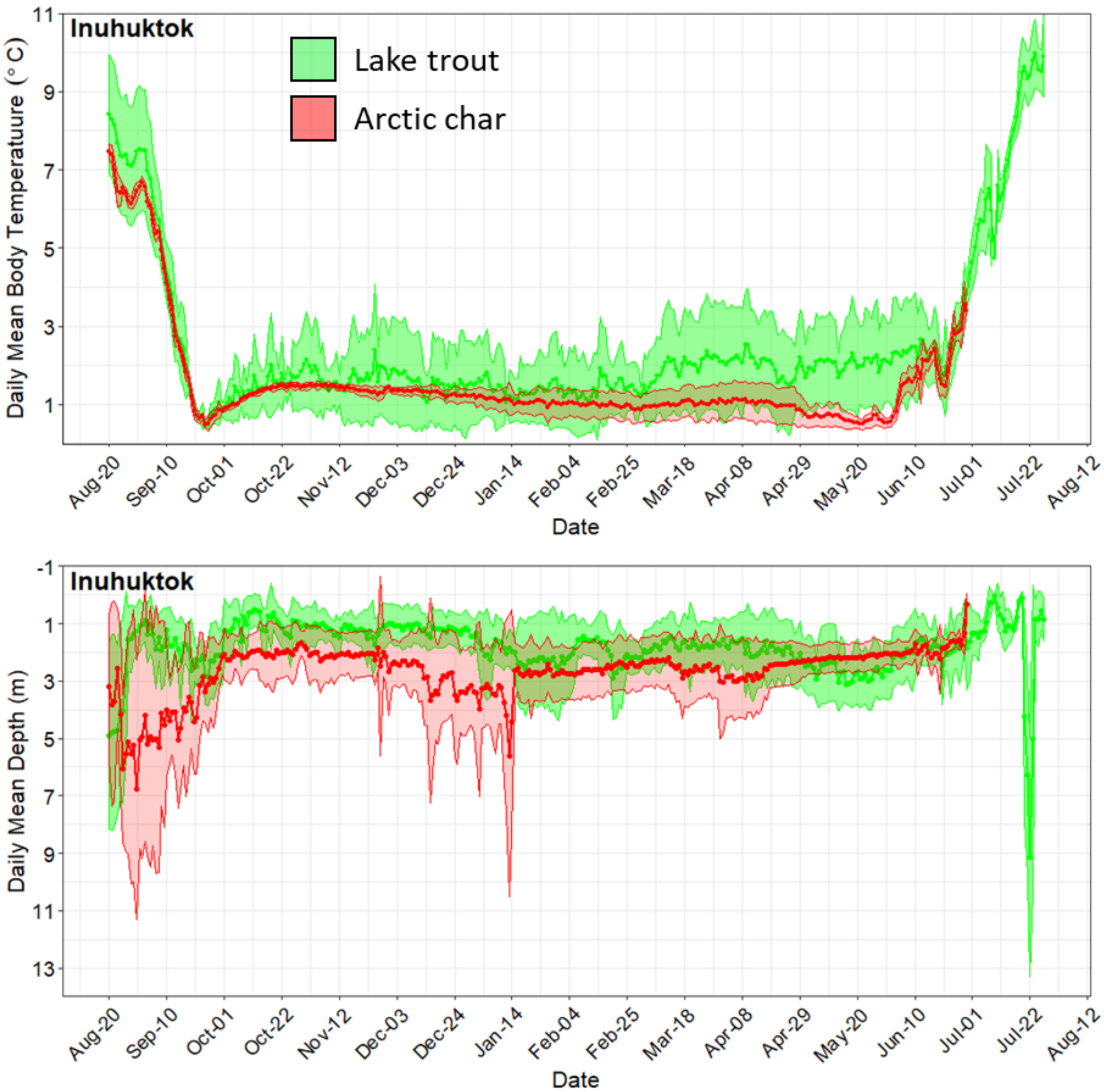
Inuhuktok
Lake trout
Arctic char
Daily Mean Body Temperatuure (° C)
11
9
7
5
3
1
Aug-20
Sep-10
Oct-01
Oct-22
Nov-12
Dec-03
Dec-24
Jan-14
Feb-04
Feb-25
Mar-18
Apr-08
Apr-29
May-20
Jun-10
Jul-01
Jul-22
Aug-12
Date
Inuhuktok
Daily Mean Depth (m)
-1
1
3
5
7
9
11
13
Aug-20
Sep-10
Oct-01
Oct-22
Nov-12
Dec-03
Dec-24
Jan-14
Feb-04
Feb-25
Mar-18
Apr-08
Apr-29
May-20
Jun-10
Jul-01
Jul-22
Aug-12
Date

Figure 5:

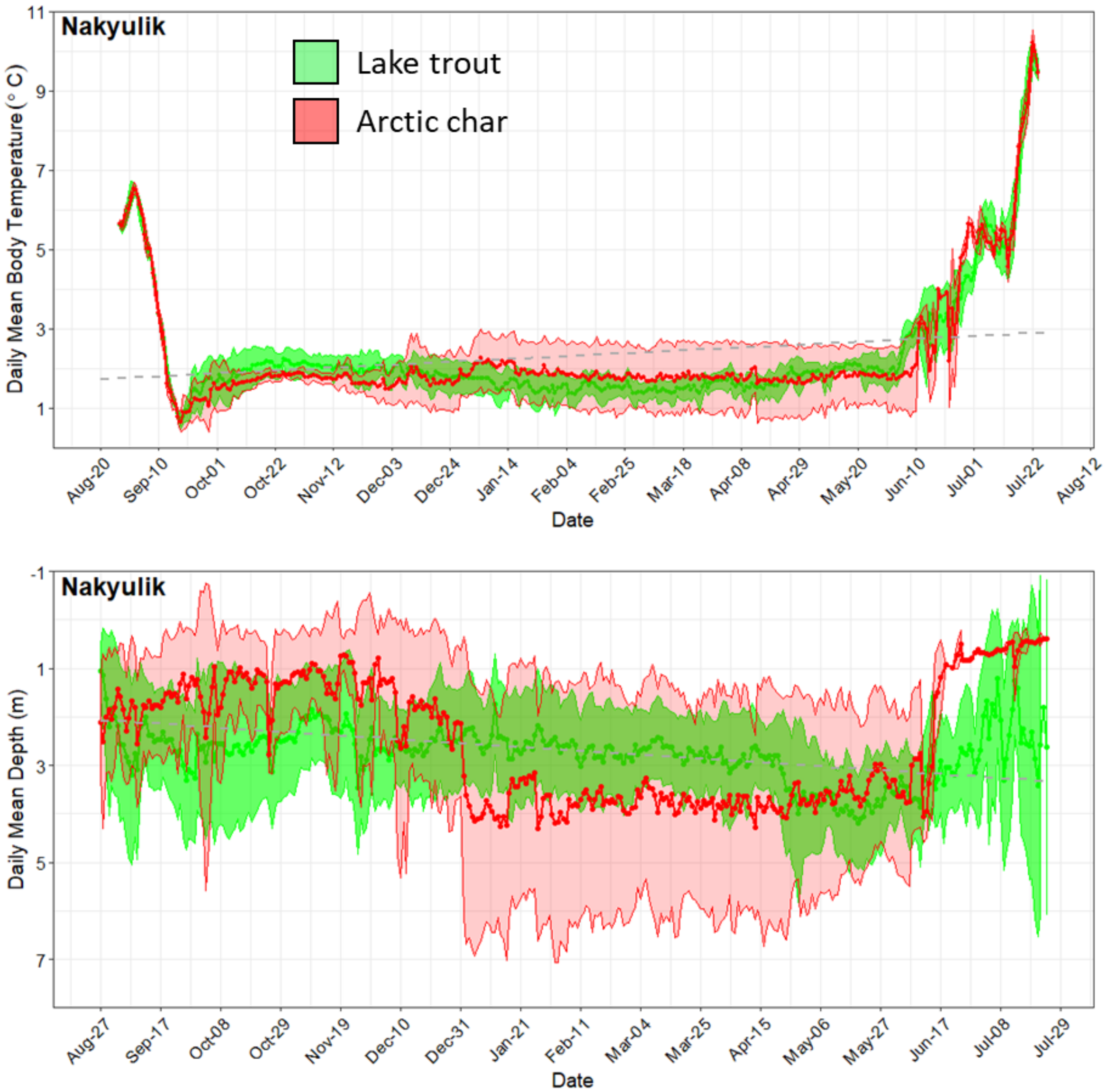
Nakyulik
Lake trout
Arctic char
Daily Mean Body Temperature (° C)
11
9
7
5
3
1
Aug-20
Sep-10
Oct-01
Oct-22
Nov-12
Dec-03
Dec-24
Jan-14
Feb-04
Feb-25
Mar-18
Apr-08
Apr-29
May-20
Jun-10
Jul-01
Jul-22
Aug-12
Date
Nakyulik
Daily Mean Depth (m)
-1
1
3
5
7
Aug-27
Sep-17
Oct-08
Oct-29
Nov-19
Dec-10
Dec-31
Jan-21
Feb-11
Mar-04
Mar-25
Apr-15
May-06
May-27
Jun-17
Jul-08
Jul-29
Date

Figure 6.