

**1. Project Title:** What comes next: phase 2 of Char and Cod research near Kugluktuk NU.

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**3. Summary:** The Kugluktuk Angoniatit Association Hunters and Trappers Organization (HTO) has annually identified priority concerns around declines in fish numbers and climate change impacts on subsistence fisheries within the Coronation Gulf (i.e., waters where the community of Kugluktuk spend time assessing country foods). From 2019 to 2023, a team-based approach was formed between the HTO, University of Waterloo and Fisheries and Oceans Canada to start examining issues on two targeted subsistence fisheries: 1. Chars (Arctic Char and Dolly Varden Char) and 2. Cods (Greenland Cod and Arctic Cod). Original research undertaken by graduate students to address questions on char movements and species identification via telemetry, morphometrics and meristics, Inuit Qaujimajatuqangit, and genomics, have been interpreted by all partners and have led to development of the next phase of research questions. We have recently confirmed that there are two species of chars were identified in the Coppermine River with Dolly Varden being the predominate species found within subsistence harvesters catches. While acoustic telemetry results have allowed us to understand fish movements in the marine environment and identified that some fish overwinter below Kugluk Falls in the Coppermine River, new telemetry approaches are needed to identify more specific spawning and overwintering habitats, and if the two species of char (newly confirmed) differ in the habitats used for spawning and overwintering. Inuit Qaujimajatuqangit interviews in addition to morphometry and meristics have also demonstrated two types of char and specific physical characteristics to distinguish visually. Further, research to date on cod declines using community monitoring samples is demonstrating a reduction of larval hatch size for Greenland Cod and connection to environmental variables.

During the 2023 HTO/Science board meetings (February and October), HTO board members requested that we continue science research in the region. HTO board members specifically wanted research gaps to be addressed such as 1.) where do char spawn and overwinter in the Coppermine, and does it differ between Dolly Varden and Arctic Char; 2.) do marine movements differ between Arctic Char and Dolly Varden; 3.) what can we further learn from community based fish collections specifically focused on marine fishes? Moving forward in 2024, research will be focused on addressing research gaps using 1.) radio-telemetry and radiotracking of fish in fresh water environments, 2. continued monitoring of marine acoustic telemetry arrays, with addition of genetics on as many tagged fish as possible and 3. continued community fish collections.

**4. Project Objectives:** Research Questions Addressed Since 2018:

1.) Where do chars overwinter and spawn within the Coppermine River?

- 2.) Do chars congregate in feeding areas in the marine environment or do they disperse randomly?
- 3.) What species of char exists in the Coppermine River and how does this relate to migration timing in the run?
- 4.) What do we know about marine species (focused on cods) in Coronation Gulf?
- 5.) Which species have seen an increase in occurrence in recent years and what do we know about these fish (i.e., wolffish)?

Research questions and objectives pursued in 2024:

- 1.) Do Arctic Char and Dolly Varden differ in their overwintering and spawning habitat use in the Coppermine River, and where are these habitats?
- 2.) Do Arctic Char and Dolly Varden differ in their marine movements?
- 3.) Use community-based fish collections to increase knowledge on marine fishes, including "unusual" fishes, such as Bering Wolf fish, and new species of fish in the area, including Pacific salmon species.

## **5. Materials and Methods:**

**Objective 1(Char spawning areas):** To examine freshwater char movement, fish are being implanted with a radiotag (best suited for freshwater tracking) then tracked in the fall spawning period via fixed wing or helicopter areal surveys of the Coppermine River. A pilot project was initialized in 2023 to assess feasibility and success, and the HTO is very keen for this technique to be continued and expanded. Fish were captured (gillnets, angling, dipnets), assessed for health, anesthetized, surgically implanted with tags, held for a period time to recover (15 minutes), and then released back into the natural environment. Tagging locations were determined by the Inuit researchers on our team. In 2023, 17 fish were radiotagged. Nine of these fish were detected in two primary locations in the Coppermine River in October 2023. In 2024, we will increase the number of radio tags to 30, and collect data on water and habitat features of systems/locations where radio tagged fish are detected. We are also initializing winter patrols for radio tags (undertaken entirely by the Inuit researchers), as we have recently confirmed that the radiotags can be heard through the ice.

**Objective 2 (Marine Movements):** Char Movement Studies (Acoustic telemetry and otolith isotope and element analysis, community fish harvest collection program): To examine marine char movement an array of listening devices (n=75; see Smith 2020 for a list of specific equipment) was installed both within the Coppermine River and marine/coastal waters adjacent to Kugluktuk, NU. The array design was developed from local knowledge of char behavior, scientific observations from other Arctic Char tagging studies (i.e., Spares et al. 2015; Moore et al. 2016,2017; Harris et al. 2020), costing of array equipment (i.e., number of listening devices that could be purchased), and safety of installing the listening devices. Subsequent to installing the listening array, char were tagged in the summer fishing season over a 2-year period. Fish were captured (gillnets, angling, dipnets), assessed for health, anesthetized, surgically implanted with acoustic tags, held for a period time to recover (15 minutes), and then released back into the natural

environment (see Smith 2020 for a detailed discussion of tagging methods). Tagging locations were determined through consultation with local community members and consent from the HTO. In total ~200 chars have been tagged. In addition, the listening array was set up to parallel and function similarly with 2 other telemetry studies in the region (potentially detect any straying fish from other locations such as Cambridge Bay and Uluhaktok). The listening array was maintained at the beginning and end of each field season to download data, replace batteries, and complete any other maintenance required for them to function. When possible the array was left in the water throughout all seasons. Statistical methods for acoustic telemetry involves the detection data being imported into VUE software (VEMCO) where the file editor can be used to account for receiver clock drift and to correct recorded times (see Smith 2020 for detailed methodologies). VUE False detection Analysis Tool will be used to identify errors in signal detection (Smith 2020). Network analysis, general linear models and mixed effects models, maximum likelihood estimation were used to model the date of fall freshwater entry and will also be used when examining marine fish movements (Smith 2020). QGIS will be used to map acoustic data detections. Otoliths (i.e., ear bones in fish) are also collected each year as part of a community fish harvest collection program (i.e., sharing of fish heads) for a \$25 monetary reward. Due to concerns of fish declines in numbers and regular subsistence harvesting for chars, no scientific gillnetting surveys for dead sampling fish were considered for the program. Otoliths are extracted from fish heads, cleaned, embedded into epoxy resin, sectioned in half with an isomet slow speed saw to expose the nucleus center, embedded into circular rings, polished (30 micron, 9 micron, 0.5 micron), and ultrasonically cleaned before being analyzed for strontium isotopes and trace elements. We are using a split stream Laser-Ablation-Induced-Coupled-Mass Spectrometer (LA-ICPMS) that allows for simultaneous analysis isotope ratios (Thermo Neptune multi-collector) and trace elements (Thermo XSeries 2 quadrupole) in the same transect line on the otolith (see Loewen2016 for general/similar otolith analytical methodologies and applications; <https://uwaterloo.ca/groundwater-geochemistryremediation/laboratories/clean-room-analytical-laboratory>). Otoliths, in conjunction with acoustic tags, will provide information on migration timing (i.e., age at first migration and frequency of migration; total strontium element) and juvenile rearing location (strontium isotopes). Additionally the use of otolith elements and isotopes allows for an understanding of historical stocks of origin and migration timing from archived samples (periodic collections from 1980's to present). Statistical methods for otolith isotope and element analysis will include multi-variate analyses such as Principle Component Analysis, Random Forest Analysis (Loewen et al. 2015) and descriptive statistics on binned trace element data for each annuli (Loewen 2016). Binning data involved digitizing and marking otolith annuli across the elemental scan line, developing R statistical code create element bins foreach annuli and to run descriptive statistics. Environmental data (trace elements and strontium isotopes in freshwater) were collected in association to otolith studies (since elements and isotopes from the environment are incorporated into otolith structures, Loewen et al. 2016). Helicopter surveys of the Copeprmine, Rae, Richardson, Napaaktoktok, Asiak, Kugaryuak, and Tree rivers allowed for the collection of water trace element and strontium isotope analysis to accompany otolith studies. Water samples were collected (30 sites) from the surface water of the river in acid washed bottles then preserved with hydrochloric

acid (strontium isotopes) or nitric acid (trace elements) (see Loewen et al. 2015 for methodologies) over a period of 3 years during the summer season.

**Objective 3 (Marine Fish/Community Monitoring program):** A community fish collection program for whole marine fish (5 focused species : Greenland Cod, Saffron Cod, Arctic Cod, Freshwater Cod, and Wolffish) with financial reward of \$25 per fish has been established in Kugluktuk. All fish collected are assessed for species identification, photographed, and sampled for biological parameters (i.e., length, weight, sex, maturity stage). Tissues are collected for stable isotope analysis, and stomach contents are recorded. Fish carcasses are returned to community members (or HTO) when biological sampling can occur within the community. Life history characteristics are examined for marine fish species through descriptive statistical analysis of biological data and age determination (otoliths) (see Loewen et al. 2010 for fish biological collection and age determination methodologies). Stomach content analysis and tissue stable isotope analysis (Carbon and Nitrogen) will address feeding ecology for marine fish species (see Brewster et al. 2016 for methodologies on stable isotope analysis and Chambers 2009 for stomach content analysis). Stable isotope ratios will be analysed using general linear models, and overlap/discrimination in isotopic niches will be explored through nicheROVER (Swanson et al. 2015). Otolith trace element analysis preparation, data collection, and statistical analysis is the same as described above for chars. Marine biodiversity is assessed and compared to existing science and Inuit knowledge. Incorporation of Inuit Qaujimagatuqangit has occurred at all steps of our research program. The project has been developed based on the HTO's concern of fish decline within the community and subsequent research has been co-developed to address these concerns. All field research is led by Inuit researchers. Inuit researchers also participate in laboratory analyses both in the community and during visits to southern labs.

## **6. Results:**

**Objectives 1 and 2:** A total of 48 acoustic listening receivers were set out in the marine and freshwater environment in Coronation Gulf and some adjacent rivers draining into the region (i.e. Coppermine River). A total of tagged 5 Arctic Char and/or Dolly Varden Char were successfully tagged over the course of the summer field season. Data is presently being downloaded and analyzed for the 2023 summer field season.

Research on Char otolith elements and isotopes is also being pursued to assist with understanding fish movements and natal origins. To date, 1465 samples have been collected from char heads (all years of sample collection) and 595 char have been aged so far. The oldest char is 15 years and the youngest captured was 3 years. Otolith isotope and element analysis is ongoing and not available for presentation for this report.

In 2024, R. Smith published research findings entitled "Migration timing and marine space use of an anadromous Arctic fish (Arctic Char, *Salvelinus alpinus*) revealed by local spatial statistics and network analysis" in the journal ***Movement Ecology*** (<https://doi.org/10.1186/s40462-024-00455-z>).

**Objective 3:** A total of 350 Char heads, and numerous other whole fish were collected as part of the community monitoring program including Saffron Cods, Greenland Cods, whitefish, flatfish, and any other fish that the HTO deemed of interest to the community for collection. As the program continues, awareness of the program within the community is increasing. Char heads were processed in Kugluktuk with T. Loewen and community members that were trained to collect tissues, otoliths and samples. The summer fish collections have been sent to the Freshwater Institute for further processing. The fish have been processed for biological data collection.

Bering Wolffish is one species we are collecting as part of community programming. Presently, we are examining biological characteristics, age, sex, maturity, stomach contents/isotopes/ecology, and parasitology. To date (all years of collection) we have fully sampled 10 fish and data was presented to the Kugluktuk HTO in Feb. 2023. To date, the lifespan of wolfish is known to be 6-7 years of age, with a sex ratio of 5 males: 2 females that have been in a non-reproductive condition with round weights ranging from 652-1930 g and a length of 446-660 mm. All fish have been processed for biological data collection.

Presently stable isotopes, age estimation, stomach content analysis are being completed. A comprehensive report covering multi-years is being developed to provide a summary of all information collected in the community monitoring program.

**Coastal Cods research** is currently being done to examine climate change impacts to Greenland Cods in the marine coastal environment. The research conducted has shown that larval hatch size of Greenland Cods is directly related to overall total length archived as adults. Over the last 13 years - larval hatch size of Greenland Cod has decreased and thus the adult size of Greenland Cod has also declined overtime. Work is presently being done to compare these results to climate change variables. The research paper and presentation of these findings have been discussed with Amanda Dumond at the Kugluktuk HTO and will be presented to the HTO board during the next consultation meeting. This research paper is in a draft manuscript form presently and will be submitted for publication in 2024.

**7. Discussion/Management Implications:** The Kugluktuk HTO has identified a conservation concern for the long-term viability of subsistence harvesting of both chars and cods near Kugluktuk, NU. The research undertaken will help to address the management of both fisheries through increased monitoring and understanding of habitat use (marine and/or freshwater), assistance to predict and manage the effects of climate change, human disturbance, and management of subsistence fisheries for food security. Our research suggests that two species of chars inhabit the river systems in Coronation Gulf. A stronger understanding of Dolly Varden and Arctic Char habitat use and presence in overwintering areas will help to support the management of char fisheries in the region.

Dolly Varden Char have been listed as a species of special concern by COSEWIC. Our research (genomics, morphology, and local knowledge studies) will help to

confirm the identification and verify the first presence of Dolly Varden Char in Nunavut waters. Our research will feed into Dolly Varden Char designatable unit calculations, overall population numbers for the species, and potentially modify the species distribution map for Canada.

Presently S. Weinstein has published a paper entitled: "Gill raker and pyloric caeca counts differ between Arctic char (*Salvelinus alpinus*) and Dolly Varden (*S. malma*) populations across their ranges" in the journal ***Fish Biology***. Additional research papers are in review and should be published by 2025 timeframe.

**9. Report by Inuit participants:** Amanda Dumond has been a strong participant and organizer of the community collection program. Amanda has indicated that the community collection report is collecting fish species seen within the community fisher's nets. She wanted to manage and monitor when and how many fish are collected from each fisher. She has indicated it is challenging to ship the fish due to the large workload that the HTO has on various programs and thus we have hired E. Hitkolok to assist with this task so that the HTO freezer is not overwhelmed and at capacity constantly. There are competing interests for Amanda's time presently. Amanda will receive this report and provide comment.

**10. Reporting to the communities/resource users:** T. Loewen and H. Swanson met with the HTO board in February, 2023 to provide research updates. In addition, R. Smith and S. Weinstein set up community booths to provide further information on science programs focused telemetry findings and IQ/species identification topics. A letter of support for the NWRT 2023-24.

The HTO is generally positive about the progress made and were particularly interested in: the high proportion of fish that are genotyping out to be Dolly Varden Char, the otolith microchemistry work (both the approach, and temperature reconstruct), and the wolffish. The HTO is interested in taking a broad approach to the community collection program with some focus on char, whitefish, cod, and wolffish. In 2023, The HTO board was asked for future direction and inputs into research moving forward - the board indicated that they were happy with progress and wanted to continue to focus on the research questions already developed.