Application: Shipping traffic impacts on fishes of subsistence and ecological importance

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Nunavut Wildlife Research Trust (2024-2025)

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NWRT-2024-0000000007-Harris-Reporting by the EHTO

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1. NWRT Project Number: NWRT-2024-0000000007

2. Project Title: Shipping traffic impacts on fishes of subsistence and ecological importance

3. Project Leader:

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4. Summary:

Climate change in the Arctic is occurring at some of the fastest rates on Earth, nearly four times higher than the global average. This rapid warming, coupled with other anthropogenic stressors such as increased shipping activities, poses clear and significant threats to Arctic aquatic ecosystems and the taxa that inhabit them. Marine and anadromous fishes have been central to Inuit culture, food security, and health for millennia, yet there are still clear knowledge gaps regarding how species of subsistence and ecological importance will respond to changing conditions and accelerated anthropogenic activities such as shipping in Arctic regions. Here, we propose to study the impacts of shipping traffic and noise on Arctic fishes of cultural, subsistence, and ecological importance, including Arctic char, Greenland cod, and fourhorn sculpin. Specifically, we will build on an existing acoustic telemetry array in the Cambridge Bay region to study fine-scale movement patterns and habitat use to assess how shipping activities and noise potentially impact these species. The results of this study should prove valuable for understanding how shipping traffic and noise potentially alter the behavior and habitat use of marine species of importance in addition to identifying key habitats critical to their survival. Furthermore, the results of this work would provide an important baseline of habitat use and behavior in these marine species that could be monitored as shipping traffic continues to increase in the region.

5. Project Objectives:

Because of the unknowns that still remain with respect to understanding the impacts of shipping traffic and noise on marine fishes of subsistence and ecological importance and given the specific knowledge gaps identified above, the objectives of this multi-year study present study involve:

• Acoustically tagging multiple marine and anadromous fishes (Arctic char Greenland Cod and fourhorn sculpin)and expand our existing acoustic telemetry array in Cambridge Bay to (1) quantify potential behavioral shifts related to shipping activity and noise and (2) identify areas of importance in Cambridge Bay while quantifying the environmental characteristics of those habitats.

6. Materials and Methods:

Surgical Procedure: Tracking of movements of Arctic char, Greenland cod and fourhour sculpin will be accomplished using acoustic transmitters been accomplished by surgically implanting over 347 individuals(InnovseaV9, V13 and V16 acoustic transmitters). The transmitters send a series of individually coded 'pings' that are recognized by the acoustic receivers. Some transmitters have also been equipped to record temperature and depth data, thus providing information on habitat use of tagged individuals. There is no external antenna; the entire unit is wholly contained within the fish's body and does not compromise the health or nutritional value of the fish. Individuals for acoustic tracking were captured using continuously monitored gill nets and via angling. Selected individuals will be anaesthetized by immersion in a 150 ppm tricaine methane sulfonate (MS-222)solution. Anaesthetized fish will have a constant stream of a weaker maintenance bath solution (50 mgL-1 MS-222) over the gills. An incision will be 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 will then be inserted into the body cavity through the incision. Simple interrupted stitches (3-0 curved needle, monofilament) will be used to close the incision. We expect the total amount of time for surgery throughout the course of this study to be less than 5 minutes. Upon completion of the surgery, fish will be placed in freshwater and observed and released once fully recovered. 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 will be taken of every tagged fish and a tissue sample for subsequent genetic analysis will be preserved in 95% ethanol. Furthermore, biological information such as fork length, weight, sex and maturity will be recorded for every fish.

Acoustic Telemetry Data Processing. Detection data downloaded from Innovasea/VEMCO receivers will be quality-controlled using VUE and custom R scripts to remove false detections, clock drifts, and tag collisions. Detection histories will be merged with deployment metadata to create a continuous spatiotemporal database for each tagged individual. To estimate residence time and movement paths, we will apply a combination of state-space models and Hidden Markov Models (HMMs) that incorporate detection probabilities and receiver range testing results. Environmental covariates (temperature, salinity, dissolved oxygen) from year-round loggers and CTD casts will be integrated into these models to evaluate how habitat use varies with seasonal and interannual environmental conditions.

Movement and Space-Use Analyses. Home-range and core-area utilization will be quantified using kernel density estimation and Brownian bridge movement models, providing 95 % and 50 % utilization distributions, respectively. Horizontal movement rates will be derived from sequential receiver detections and interpolated tracks, while vertical habitat use will be reconstructed from depth-sensing acoustic tags to estimate diel and seasonal patterns of occupancy. Network analysis of receiver detections will be used to identify movement corridors and connectivity among key habitats, allowing comparisons across species and life-history stages.

Shipping Activity and Noise Exposure. Spatiotemporal overlap between fish positions and vessel traffic will be assessed by integrating vessel-tracking data from the Enhanced Maritime Situational Awareness (EMSA) platform. Metrics will include proximity to vessel tracks, cumulative vessel density, and temporal overlap of detections with shipping events. SoundTrap hydrophones deployed alongside receiver arrays will provide continuous acoustic recordings; these will be processed to calculate broadband sound pressure levels and spectral composition. Generalized additive models (GAMs) and time-lagged cross-

correlations will test whether fish movement, residence time, or vertical distribution change in response to acute or chronic noise exposure.

Additional Analyses and Species Comparisons. To evaluate interspecific differences, multivariate ordination (e.g., non-metric multidimensional scaling) will be used to compare space-use metrics across the multiple marine species tagged. Mixed-effects models will examine the influence of species, size, and environmental variables on home-range size and movement rates. Seasonal habitat "hotspots" will be identified through spatial clustering of high detection densities and validated with bootstrapped resampling. Finally, cumulative impact mapping will integrate acoustic, environmental, and shipping data to highlight priority areas where anthropogenic noise and fish habitat overlap, providing science-based guidance for marine spatial planning and potential mitigation measures.

Use of Qaujimajatuqangit: We will use Inuit Qaujimajatuqangit to determine the locations and timing of fish capture as is done in all years for our fish research in the region. Through consultations with the EHTO and through discussions generated at community open-house presentations that are given several times annually, we identified several additional candidate locations of importance for some of our acoustic moorings. 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. Furthermore, this research was initiated based on concerns we have heard from community members regarding the impacts of shipping (especially the large cruise ships that enter Cambridge Bay) on fish in the region.

Inuit Employment: In 2024, we hired eight local beneficiaries to help support our research in Cambridge Bay. Three of the beneficiaries were youth. The beneficiaries acted as guides on land and water and assisted with sampling, tagging, mooring deployment, and general camp duties.

7. Results

The first full year of receiver recovery yielded a substantial dataset encompassing approximately 28 million acoustic detections across all tagged marine species . Preliminary inspection confirms high detection efficiency throughout the Cambridge Bay array, with consistent year-round functionality of both fixed and fine-scale receivers and minimal data loss from ice or biofouling. Environmental sensors (temperature, salinity, and dissolved oxygen) deployed alongside the acoustic network operated reliably, and repeated RBR CTD casts successfully captured seasonal variability in water column structure. Vessel-tracking information from the Enhanced Maritime Situational Awareness (EMSA) platform and continuous SoundTrap recordings were also retrieved without incident, providing the foundation for integrated analyses of fish movement, shipping activity, and ambient noise.

Although these datasets are exceptionally rich, formal analyses have not yet begun. Quality control of detection files, receiver range testing, and preliminary database construction are underway to ensure a robust analytical framework. Given the volume of detections, dedicated computational workflows are being developed in R to handle large-scale state-space modeling, movement path reconstruction, and noise-exposure metrics.

To lead this effort, a postdoctoral researcher has been recruited and will begin in the upcoming field season. This postdoctoral project will focus on integrating acoustic telemetry, environmental time series, and shipping/noise data to address the study's central questions regarding behavioral responses and habitat use under increasing vessel traffic. Their work will also refine cross-species comparative

analyses and develop spatially explicit “hotspot” models to inform co-management and mitigation strategies.

These preliminary findings demonstrate the success of the field program in establishing a high-quality, long-term acoustic monitoring network and highlight the strong potential of the forthcoming analyses to reveal how Arctic marine fishes respond to environmental variability and anthropogenic disturbance.

8. Discussion/Management Implications

Our preliminary results—nearly 28 million acoustic detections spanning multiple marine species—demonstrate that year-round telemetry monitoring is feasible in Cambridge Bay and capable of capturing fine-scale fish movement relative to shipping and underwater noise. Although formal analyses are still underway, the sheer volume and quality of these data indicate strong potential to identify critical habitats, seasonal migration corridors, and species-specific sensitivities to vessel activity. Such insights are directly relevant to the NWMB’s responsibility to ensure the protection and sustainable use of wildlife while supporting Inuit harvesting rights.

As vessel traffic through the Northwest Passage increases with climate-driven reductions in sea ice, the likelihood of acoustic disturbance, displacement from key habitats, and interactions with subsistence and commercial fisheries will grow. Our planned analyses will quantify how fish respond to noise and ship proximity—information essential for evidence-based guidelines on shipping lanes, seasonal routing measures, and speed restrictions to reduce ecological impacts. Early integration of these findings into regional shipping management plans can help the NWMB and co-management partners proactively address potential conflicts between maritime traffic and Arctic fisheries.

The high-resolution telemetry data will also identify important feeding, spawning, and overwintering areas. Protecting these hotspots through spatial or temporal closures, or by designating them as Areas of Interest for future Marine Protected Area (MPA) consideration, would align with NWMB’s mandate to conserve wildlife and habitat for present and future Inuit use. Importantly, integrating local Inuit Qaujimajatuqangit with telemetry results can ensure that management measures reflect both scientific and traditional knowledge, strengthening community support and long-term stewardship.

Finally, the project’s collaborative framework—including a dedicated postdoctoral researcher and partnerships with local harvesters—provides a template for ongoing monitoring and adaptive management. Continued annual receiver maintenance and periodic data synthesis will allow the NWMB to track trends in fish distribution and shipping activity, enabling responsive decision-making as environmental conditions and human activities evolve.

9. Report by Inuit participants:

Attached/submitted as a separate file.

10. Reporting to communities/resource users:

Numerous telephone and email communications took place with the EHTO manager (Beverly Maksagak) to discuss the project prior to the 2024 field season. Meetings in Cambridge Bay with the EHTO occurred throughout the summer while we were in the community. We also attended an EHTO board meeting to discuss the project and provide updates in August 2024. In November, 2024 we presented

field season results to the EHTO. Summary reports for the Ekaluktutiak HTO and residents of Cambridge Bay are currently being prepared.

Last, we hosted both Science Students on Ice (in May) and a community barbecue ("Char Days" in August). Students on Ice involved inviting the high school science class to join us for one of our field days, where we showed fish capture, our tagging procedure, and general fish sampling. We discussed our research and highlighting the importance of the work being driven by community concerns. In August, we invited the community to attend a BBQ we hosted where we provided food to > 100 residents of Cambridge Bay. This also allowed us to discuss our research with a larger audience, showcase our equipment, materials, and techniques (fish dissections and sampling methods). We intend to make this an annual event.

Reporting by the Ekaluktutiak Hunters and Trappers Organization (EHTO)

Pertaining to Project NWRT Project Number: NWRT-2024-0000000007

Project Title: Cambridge Bay Arctic Char Research: Shipping traffic impacts on fishes of subsistence and ecological importance

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1. Were you involved in the development of the methods? If so, do you feel that your input was considered and applied?

The EHTO was not directly involved in the development of the methods for this project. The EHTO and however, did provide input on personnel for all sampling and field trips.

2. Do you think that the methods of the project were appropriate for the purpose? If not, how could they be improved?

Yes. Tagging and receiver deployment was done in a similar fashion to that outlined in the initial proposal that was approved and supported by the EHTO. We look forward to seeing the results.

3. Did the project effectively incorporate Inuit Qaujimajatuqangit? If not, how could it be improved?

Yes, the specific locations for receivers and the timing and location of tagging were chosen or identified through the use of Inuit Qaujimajatuqangit provided by the EHTO and local field assistants.

4. Were the methods undertaken in the project respectful of wildlife? Would you change anything about the methods of the project?

Yes. Besides the Arctic char that were sacrificed as part of the study, no other wildlife was hurt or disturbed. All harvested fish were made into piffi or kept fresh and retained by the subsistence harvester and in many cases distributed to other members in the community including to the wellness center, to elders and food insecure households.

5. Were you involved in the analysis and interpretation of the project's results? If so, do you feel that your input was considered and applied?

Not directly, however much of the analysis is ongoing. Additionally, the EHTO is intimately involved in contributing to and evaluating the Integrated Fisheries Management Plan for this fishery and the results of this work will be directly relevant for revised IFMPs in the future.

6. How do you think that the results of the project could best be applied to wildlife management in Nunavut?

From the Ekaluktutiak HTO's viewpoint, the telemetry project provides a powerful new source of information to **protect and sustain Cambridge Bay's fisheries and the broader marine ecosystem**. By revealing when and where Arctic Char and other key species move, feed, and overwinter—and how these patterns shift in response to vessel traffic and underwater noise—the results can guide management decisions that safeguard harvesting opportunities for future generations.

7. Is there any information not included in the Final Project Report that you think is important to the outcomes of the project?

The EHTO has long supported the research of DFO and specifically that proposed by Les Harris since 2009. He has been working in the Cambridge Bay region for over a decade where he is very engaged with the community with nearly 50 different beneficiaries hired over that time. His work is very relevant for ensuring Arctic char populations remain sustainable so that these fish will be around for generations to come. We look forward to working with him for many years to come.

Sincerely,

Rose Maksagak
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