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RESEARCH REPORT
2016-2020

Nunavut

Introduction

Photo from Pierre-Yves Daoust, Canadian Wildlife Health Cooperative

Fisheries play an important role in the social and economic wellbeing of Nunavummiut. They provide employment opportunities while also increasing food security in local communities. The sustainable development and management of Nunavut's fisheries is essential to ensuring their ability to continue to benefit future generations. Sustainability is built on informed decision making and requires an understanding of the ecology of the populations that are being harvested, and how they may be changing in response to human induced pressures such as climate change. Over the past five years the Fisheries and Sealing Division, hereafter referred to as the Division, has worked to support research which improves our understanding of Nunavut's aquatic resources through the collection of Inuit Qaujimajatuqangit (IQ) and the employment of innovative scientific methodologies.

The summaries herein provide a general overview of this research. Some of the projects presented were led directly by Division staff, while others were conducted by university partners or other organization with funding, guidance, or other indirect forms of support from the Division. All were either started or completed under the Department of Environment, prior to the Division's move to the Department of Economic Development and Transportation in April 2020.

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Photo from the Government of Nunavut

Photo from Arctic Stock

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GN	Government of Nunavut
GC	Government of Canada
DFO	Department of Fisheries and Oceans Canada
IQ	Inuit Qaujimajatiqangit

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Improving Research Methodologies

Research in Nunavut is continually evolving, not only with advances in technology but with developments in better research practices. Alongside the recent progress that has been made in Western science to improve methodologies and equipment to better suit the Arctic environment, great strides have been made in the recognition and valuation of Inuit Qaujimajatuqangit (IQ) in the world of research. Inuit possess a vast wealth of knowledge about their natural resources and environment, gathered over many generations of living on the land. Nunavut has committed to a system of co-management which incorporates both Western science and IQ. In recognition of this commitment, the Division has worked to support research that is not only at the forefront of science but that meaningfully incorporates IQ and actively seeks to improve our practices for engaging communities.

While many of the studies summarized in this report exemplify these qualities, the following work focused specifically on improving research methodologies and engagement practices in Nunavut.

Fisheries Western and Indigenous Knowledge Systems (Fish-WIKS)

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Timeline:
2012 to 2019

Fish-WIKS, which stands for Fisheries Western and Indigenous Knowledge Systems, was a multi-partner research initiative which sought to explore the ways in which indigenous knowledge systems could be utilized alongside western knowledge systems to improve fisheries management in Canada. The project, which took place between 2012 and 2019, was led by the Assembly of First Nations (AFN) and Dalhousie University with partners from the Unama'ki Institute of Natural Resources, the British Columbia First Nations Fisheries Council, the Division, and researchers from Vancouver Island, Toronto, and Guelph universities. With funding from the Social Sciences and Humanities Research Council the project emphasized the importance of a multidisciplinary perspective on resource management and policy. Focusing on four communities from different regions of Canada (Tla-o-qui-aht, BC, Eskasoni, NS, Nipissing, ON, and Naujaat, NU) the research examined commonalities and differences in how knowledge is gained, used, and transmitted between different Indigenous knowledge systems as well as between these systems and the more frequently recognized Western knowledge system. The Division supported Fish-WIKS as an Arctic partner and had an active role on the projects' steering committee.

The portion of the project conducted in Nunavut explored the incorporation of IQ in the co-management of fisheries resources as defined by the Nunavut Agreement and the relationship between Western and Inuit knowledge systems in research being conducted within the territory. A case study in Naujaat brought to light the ways in which the

existing quota-based management system for narwhal has changed the traditional atmosphere around the hunt and the harvesters' interactions with one another and the resource. Through interviews with community members, it was determined that the hunt is now more competitive due to the introduction of the quota system and that the patience and thoughtfulness that once went into determining when and if to harvest is less present. The community felt that to support the inclusion of IQ into the decision-making process in a meaningful way, better communication is needed between the different levels of management, and that Inuktitut should be incorporated into the communication structure. Additional work involving field research in Naujaat, Iqaluit, Pond inlet, and Igloolik emphasized the need for a new way of creating knowledge in Nunavut that is truly co-produced by western and Inuit scholars with the intent of decolonization at its core. The Fish-WIKS team held it's final fisheries policy workshop and webinar in Ottawa in March 2019, at which they presented their finding to DFO senior officials.

Photo from Sivummut Solutions

For more information check out the Fish-WIKS website: https://www.dal.ca/sites/fishwiks.html

Towards a Sustainable Fishery for Nunavummiut: Knowledge Coevolution

Photo from Dr. Virginia K. Walker

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Timeline:
2015 to Present

Towards a Sustainable Fishery for Nunavummiut (TSFN) is a large scale, collaborative project funded by the Government of Canada through Genome Canada, as well as many other supporters including the Ontario Ministry of Research and Innovation, CanNor, Polar Knowledge Canada, and the Government of Nunavut. The project consists of a number of small-scale research initiatives which all contribute to the goal of sustainable fishery development in Nunavut. These projects were done in collaboration with the Division and the residents, fishers, and youth apprentices of Gjoa Haven.

The TSFN team put community collaboration at the forefront of their research and emphasized capacity building as much as the valuation and inclusion of IQ. They sought to create an

environment in which there could be knowledge coevolution, or the generating information through which both Indigenous knowledge and Western science are joined in an inclusive and interactive way. Through community-led research and the reinforcement of each distinct knowledge system, they found both systems were strengthened and co-management was improved. While this approach was both rewarding and demanding for the team, it allowed them to learn important lessons about the challenges associated with Northern collaborative research. They recommend that funding agencies place more value, and thus budgetary priority, on activities related to ongoing consultation, engagement, dissemination, and implementation of project outcomes. Through their publications they have shared their experiences and knowledge coevolution framework with other researchers and organizations in an effort to improve research practices in Nunavut.

For more information check out:

S. Schott et al. (2020) https://cdnsciencepub.com/doi/pdf/10.1139/as-2019-0011

Towards a Sustainable Fishery for Nunavummiut: Software for in the Field labeling

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Dr. Stephan Schott, Associate Professor at Carleton University, stephan.schott@carleton.ca

Timeline:
2015 to Present

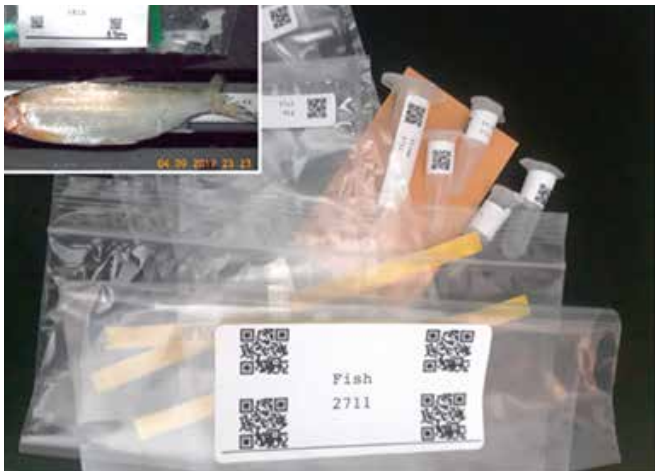

Photo from Dr. Virginia K. Walker

In addition to their larger scale work on knowledge coevolution, the TSFN team also sought to address some of the smaller, practical challenges of conducting research in Nunavut. The team knew it would be difficult to track all of their samples, from more than 500 fish over the 2500 km2 study area under challenging Arctic conditions even with experienced and reliable fishers from Gjoa Haven directing fishing efforts. They needed a way to track each and every fish sample (including fin clips, otoliths, organ biopsies, gonads, skin mucous, intestinal sections, parasites, scales), as well as the data associated with each sample, such as geographic location, date, name of fisher, net size, net set hours, species, sex, weight, length, and photograph. Commercial software was not suitable for the task so they created "baRcodeR". The software makes fish-specific digital 2D barcodes on waterproof paper and vinyl labels. The use of the "PyTrackDat" workflow, an online data collection and tracking system, has worked well in accompaniment. Both are now available as open source for use by other researchers in the Arctic and elsewhere. The team hopes that the use of digital barcodes as well as their archived fish samples will allow more data sharing between researchers, making research more efficient and reducing the quantity of fish needed to be sampled.

For more information check out:

Wu et al. (2020) besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210X.13405

Cambridge Bay Arctic Char and Lake Trout Research: Acoustic Surveying in Marine and Freshwater Environments

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Timeline:
2012 – Present

The acoustic tracking program in Cambridge Bay has been monitoring Lake trout and Arctic char migration and habitat use for more than seven years. It represents one of the most significant, long term data sets of its kind. The program uses an acoustic telemetry system to locate fish along the Southern edge of Victoria Island as well as within the Ekalluk River Watershed. The system consists of transmitters implanted into the body cavity of individual fish and receivers anchored near the bottom of the water column. Each transmitter emits unique sound pulses, or pings, while each receiver records these pings when a fish passes by. This system allows the team to track individual fish throughout the freshwater system and into the marine environment. In 2018 the team began using an even more precise technique for acoustic tracking known as the VEMCO Positioning System (VPS), in which receivers are placed more closely together. VPS uses the time it takes a ping to reach at least three nearby receivers to triangulate the position of a fish and can deliver more exact positions, which helps to determine habitat use at a finer scale. This information on habitat use and freshwater movements within the water shed will contribute to the informed management of both the Arctic char and Lake trout fisheries.

Ringed Seal Population Trends Inferred from Genetics

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Timeline:
2015-2018

Like most marine mammals, Ringed seals can be challenging to monitor, as they have wide distribution ranges and spend much of their time in difficult to access environments. While most population estimates, for the species are made using aerial surveying techniques, this may not provide an accurate picture of their true abundance. Aerial surveys are best conducted when the highest proportion of seals are hauled out on land and can be visually counted, however the ideal timing for this changes each year depending on sea ice break up, making the maintenance of consistency between surveys difficult. Accurate population estimates are an important part of the informed and sustainable management of Ringed seals in Nunavut as underestimates may elicit unnecessary conservation regulations, but overestimates may risk the health of the population.

Kyle Ritchie, and the team at the University of Manitoba, set out to determine if genetic methods for estimating population trends could serve as an alternative and more accurate means of monitoring Nunavut's Ringed seal populations. Tissue and jaw samples (containing a tooth used for aging the seal) were collected from Ringed seals harvested in Arviat between 1980 and 2011. Sample sizes varied between 3 – 45 per year for a total of 503 samples. The effective number of breeders (Nb) was estimated for each year using genetic analysis, then compared to population estimates from years in which aerial surveys had been taken. While effective number of breeders should have a direct relationship to effective population size, no relationship was detected between the estimates made using genetic analysis and those made using

aerial surveys. This could be due to a number of different factors as the relationship between the two population variables can sometimes be complex and both methodologies have their biases. However, it does suggest that at least one method is flawed in its population estimates.

In addition to comparing methodologies for estimating population size, the team explored the relationship between their estimates and different environmental variables which may explain changes in the population over time. Determining how environmental conditions may affect Ringed seal population size will help to predict population changes due to climate change and warming Arctic conditions. The team's analysis showed that the amount of spring rainfall, snow depth, and the timing of fall sea ice freeze up had a larger influence on Nb than the timing of spring ice breakup. Increases in spring rainfall seemed to decrease Nb in later years while increases in snow depth and later fall freeze up times seemed to increase Nb. This may be because increased snow depth provides more protection for pups and a later sea ice freeze up date delays polar bear predation while spring rain can cause pupping lairs to collapse exposing the pups to predation and harsh weather. There was a time lag between 5 and 7 years between each variable and its effect on Nb, but this is likely due to the time it takes a pup to reach maturity and be included in the number of breeders estimates. While inconclusive on the effectiveness of genetic methodologies for estimating population size, this work highlights the need for further investigation to determine the accuracy of current estimation techniques. It also provides interesting incite into environmental factors which may influence Ringed seal populations in the future.

EFFECTIVE NUMBER OF BREEDERS DEFINED:

Effective number of breeders is the number of individuals within a population that are of breeding age at a given time. The number of breeders within a population can sometimes be a more informative measure of population health and genetic fitness than total population size as it represents the number of individuals contributing to the next generation.

For more information check out:

Ritchie (2018): https://mspace.lib.umanitoba.ca/bitstream/handle/1993/33393/Ritchie_Kyle.pdf?sequence=1&isAllowed=y

Learning More About Our Fisheries Resources and Ecosystem

Thanks to the progress being made in northern research methodologies our knowledge of Nunavut's fisheries resources continues to grow! From learning where and when different populations of char spawn to exploring how Ringed seals are responding to changes in the presence of prey species, the Division, researchers, and communities are continuously working to improve our understanding of the biology and life history of the aquatic species on which so many Nunavummiut depend. This knowledge helps to inform sustainable fisheries management and ensure the health and prosperity of local populations.

Ecosystem

All of Nunavut's freshwater and marine species live in a delicate balance with one another and their environment. However, the effects of climate change as well as increases in population and development within the territory may be causing this balance to shift. Gathering information about the current state of Nunavut's wildlife and aquatic environment in addition to consistent long-term monitoring will be crucial for determining the impacts of this shift and ensuring adaptive resource management.

Nunavut Coastal Resource Inventory (NCRI)

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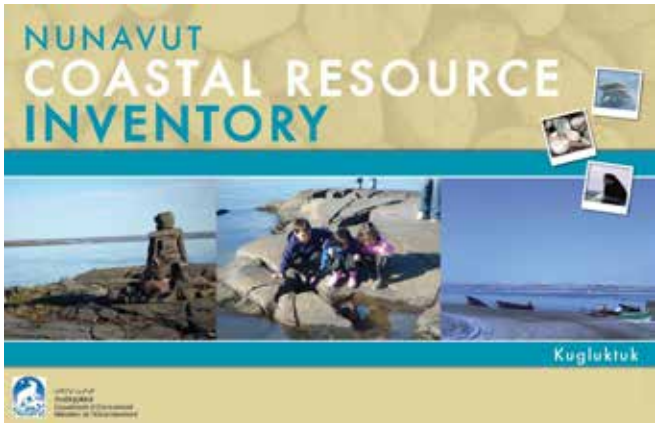
Timeline:
2007 – 2020



Images from Nunavut Coastal Resource Inventory

Resource inventories can provide important baseline data for future research or resource development. In Nunavut, they also serve an additional and equally important purpose in gathering and preserving Inuit Qaujimajatuqangit (IQ). IQ represents both traditional and contemporary knowledge and is an invaluable resource in the assessment and informed management of coastal species and environments. With the growing development of tourism and fishing industries in Nunavut and the effects of climate change, knowledge of the current and past states of coastal resources is of critical importance as a baseline to measure against future changes.

The Nunavut Coastal Resource Inventory (NCRI) was started by the Division in 2007, with a pilot project in Igloolik. Since then, inventories have been conducted in all Nunavut communities. In each community the project team met with 8-12 expert fishers, hunters, and knowledge holders of varying ages to conduct participatory mapping interviews. While the process was led by the project team, local interpreters and youth interviewers were engaged in each community. Interviews followed a general structure as a guide but each

was unique as the team adapted the conversation to the information being provided by the interviewee. Data was gathered on fish, marine mammals, aquatic plants, invertebrates (clams, crabs, etc.), birds, travel routes, camp areas, and other important coastal sites.

Reports have been published for each inventory with maps and descriptions based on the details provided by participants. Additionally, an interactive online atlas was released for the project in March 2020. The atlas is a joint initiative between the Division and the Geomatics and Cartographic Research Centre (GCRC) at Carleton University. It brings together all the data gathered throughout the project, roughly 27,000 pieces of information, in a central location where it can be explored by species, community, or different types of human use. This ensures the information is easily accessible to all community members. Though the project is complete for the time being, the information gathered will continue to serve communities and the Division in future resource development and project planning.

For PDF versions of NCRI reports check out:

www.gov.nu.ca/economic-development-and-transportation/information/nunavut-coastal-resource-inventory

To view the NCRI atlas head to:

www.ncriatlas.org/index.html

Wager Bay (Ukkusiksalik National Park) and Chesterfield Inlet Baseline Study

Image from Dr. Zou Zou Kuzyk

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Timeline:
2016

The ecological impacts of increased shipping traffic in the waters around Nunavut are of growing concern for local communities. However, evaluating these impacts can often be difficult as baseline environmental data against which to compare is lacking for most regions. In 2016 the Division and the Parks Canada Agency initiated and funded a marine baseline study for Wager Bay and Chesterfield Inlet. The multidisciplinary project involved researchers from the University of Manitoba, Memorial University of Newfoundland, and the Université du Québec à Rimouski. With each group specializing in a different area, the team worked to provide a fuller picture of environmental conditions, from benthic communities to water column chemistry.

In Chesterfield Inlet multibeam mapping surveys were conducted from the R.V. Nuliajuk around the community harbor and at potential scallop beds between Fairway Island and Promise Is-

R.V. NULIAJUK?

The R.V. Nuliajuk is a 65' research vessel owned and operated by the GN, and the largest of it's two inshore research vessels.

Images from Zou Zou Kuzyk

land. In Wager Bay mapping took place from both the R.V. Nuliajuk and a Park's vessel throughout the Narrows (connection between Wager Bay and the Roes Welcome Sound), around Palak Island and Silia lodge, and on the shoreline near the Douglas harbour. Tide gauges were also placed in Wager Bay to record changes in height over time. Water samples were collected for both locations to analyse salinity, colored dissolved organic matter, strontium and oxygen 18 isotopes, particulate organic carbon and nitrogen, chlorophyll a, CTD profiles, and nutrients. Samples were also taken to evaluate environment DNA in Chesterfield Inlet. For both locations, plankton samples were collected within the water column while benthic invertebrate surveys were conducted along the marine floor to gather information on the composition of the two communities. Sediment samples were collected at both sites to evaluate their recent sedimentary record (roughly 100 years) and their concentrations of contaminants including poly aromatic hydrocarbons (PAH), n-alkanes, metals, and mercury.

This work provides the first ever baseline data on the marine environment of Wager Bay and will provide important insight for future research in both regions. A final overview of the study's results is expected to be released in the near future.

WHAT ARE PAH AND N-ALKANES?

PAH and N-Alkanes are environmental pollutants. PAH's come primarily from the burning of natural materials such as coal, oil, or petrol while n-alkanes are generated from petroleum products.

ENVIRONMENTAL DNA (eDNA) DEFINED:

Environmental DNA (eDNA) is genetic material collected from environmental samples, such as water or soil. These samples can contain DNA from many different organisms and are used to give researchers a better idea of the organisms present in a specific area.

Towards a Sustainable Fishery for Nunavummiut: Gjoa Haven Food Security

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Timeline:
2015 to Present

Image from Jamie Desautels

Country food is an important part of the diet of most Nunavummiut. As part of the "Towards a Sustainable Fishery for Nunavummiut" (TSFN) project (see "reference to introduction of project in section 1") research was conducted to better understand country food access and affordability in Gjoa Haven. The TSFN team conducted a series of surveys, focus groups, and meetings between August 2017 and March 2020. Data was collected from elders, youth, adults, hunters, the HTA, schools, the health centre, the local conservation officer, the wellness centre, the Government of Nunavut Department of Health, and other organizations that provide country food as a part of their services or programs. Data is currently in the process of being validated and analyzed, the results of which will be collated into a report that shares the community's unique perspective on access to country food and the challenges they face. Through the Government of Nunavut Department of Health, this research hopes to inform a future Kitikmeot food security strategy that will improve country food availability and affordability in Gjoa Haven and other communities in the region.

Arctic Char

Arctic char are one of the most well-known fish species in Nunavut and are harvested in almost every community. They support prominent commercial fisheries in each of the territory's three regions and are the focus of many small-scale development initiatives. To balance both the commercial potential of the species and local subsistence fishing needs, managers will require detailed information about the life history and biology of Nunavut's many char populations.

Cambridge Bay Arctic Char and Lake Trout Research

Image from iStock

The Arctic char fishery in Cambridge Bay (Ekaluktiak) is the largest for the species in Canada and is both Oceanwise certified and Clean Fish recommended. The fishery began in 1960 and has always considered community knowledge and concerns in its management, but a formal Integrated Fisheries Management Plan was put into place in 2014. This plan, a first of its kind, was developed by a community-based working group which included the Ekaluktiak Hunters and Trappers Organization alongside the DFO, and was approved by the Nunavut Wildlife Management Board. As part of the management plan, a multi-year stock assessment design was created which would include both fishery dependent and independent sampling. With the support of university researchers, the Division, and

other fisheries development organizations, the initial monitoring plan has grown to include extensive research on the biology and ecology of Arctic char in the area. These data will help to inform the long-term management of the fishery as the environment continues to change in the North.

Alongside Artic char research, additional work is also being done to monitor Lake trout within the watershed. While there is no established commercial fishery for Lake trout in the region, they do support an important subsistence fishery, the informed management of which contributes to increased food security for the community.

Warm Temperature Tolerance Study

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Timeline:
2016 - Present

Since 2016 Matthew Gilbert, a member of Dr. Anthony Farrell's research group at the University of British Columbia, has been working with the DFO and other researchers in Cambridge Bay to better understand the response of Arctic char to the warming water conditions being experienced in the Arctic due to climate change. Char are specially adapted to cold conditions but their ability to cope in warmer environments is still unknown. Through use of a mobile research lab provided by the Arctic Research Foundation, the team has been able to test the effects of temperature on the aerobic metabolism (the ability of the body to produce energy) and maximum heart rate of char, both of which serve as indicators of char's ability to perform and recover from a strenuous task such as upstream migration. While the research is ongoing, early results suggest that warm water conditions, between 18° and 20° Celsius, can impair heart function in char, which may reduce their ability to migrate. River temperatures in this range have been recorded in warm years and their frequency may increase in the future. The team is now working to determine the effect of acclimation time on temperature tolerance as char may be able to better deal with these conditions if they are given enough time to adjust. This research will be crucial to sustainable management of the populations long term and helps to fill an important knowledge gap in the understanding of Arctic char biology.

MOBILE RESEARCH LAB?

The Arctic Research Foundation has built mobile laboratories which are housed in discarded shipping containers to facilitate research in the Arctic. The one used in this study was equipped with 15×305 W solar panels, 2×1.1 kW wind turbines, a backup 10 kW diesel generator, 24×2 V batteries and 2×6.8 kW inverter and charging systems. This made it possible to run the 450-L temperature-controlled fish holding system needed for the study.

Microplastic Contaminates

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Timeline:
2019 - Present

In 2019 the Rochman lab from the University of Toronto joined the Cambridge Bay research team. They have begun work to explore the occurrence and makeup of microplastic pollution (synthetic particles less than 5mm in size) in Arctic char from the Lauchlan River. Microplastic pollution is a

growing concern worldwide and has been documented in the Arctic environment and associated wildlife. These small particles differ in make up depending on their source and researchers are still exploring their impacts. However, some may release or transport chemical contaminates and are therefor of concern for wildlife and environmental health. Most research to date has focused on larger body mammals and birds in the Arctic and very little information is known about the occurrence and effects of microplastic pollution on Arctic fish. The team is working to help fill this gap while providing information relevant to the fishery and the Cambridge Bay community. 130 digestive tracts and muscle samples have been collected thus far along with sediment and surface water samples and are being processed to form a baseline assessment for further work.

For more information check out some of the project's publications at:
https://www.researchgate.net/project/Arctic-Char-environmental-physiology-and-migratory-ecology-in-a-rapidly-changing-north

Arctic Char Stock Assessments for Multiple Water Bodies

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Timeline:
Ongoing

The use of quantitative mathematical models of Arctic char stocks and their ecosystem can help to provide information for decision makers on the current and future sustainability of char fisheries. Models also help to focus research efforts by identifying what data is needed to understand the system. While the distribution of Arctic char over a large area makes it challenging to generate information for modeling population and ecosystem dynamics, collaborative efforts between the DFO and local processing plants have made it possible for select water bodies near Cambridge Bay and Pangnirtung.

Data for this project was gathered from fishery dependent and independent sources. Fisheries contributed data on catch per unit effort, fish size, and structures to determine fish age (otoliths). These data provide information on harvest pressure (catch totals), a relative index of abundance (catch per unit effort), total mortality estimates, and growth rates (size and age data combined). Fishery independent data was used to compliment the data provided by commercial fisheries. These data were collected using a sci-

Image from Dr. Ross Tallman

entific Survey design and helped to provide a fuller picture of the population (catches of all sizes, ages and locations). In both cases data for the project was collected by local samplers, providing additional employment opportunities for communities.

Full stock assessments were completed for two major stocks in the Cambridge Bay commercial fishery, Jayko Lake and Halovik, and three major stocks for the Pangnirtung commercial fishery, Ijaruvung Lake, Iqalujjuaq Fiord and Irvine Inlet. Both assessments were reviewed by community members, DFO researchers, and external reviewers and all stocks were found to be fished in the "Healthy Zone" of the DFO Precautionary Approach Framework. This suggests that current commercial quotas are considered to be sustainable. A shallow but consistent trend of declining stock size was however noted in each Cambridge Bay stock. These stocks will require on-going monitoring to ensure continued sustainability.

Using the ECOPATH-ECOSIM model, the Cumberland Sound ecosystem was described for the first time. This will provide decision makers with information on how Arctic char fit in the overall ecosystem and can be used for predicting the indirect effects of other fisheries, climate change, and other habitat concerns in the system. Additionally, catch-maximum sustainable yield modeling for the Cumberland Sound was used to fully develop a precautionary approach framework for the three stocks in accordance with international standards. The results from these models could provide powerful support for the eco-certification of these fisheries in the future.

As the Arctic char fishery in Cumberland Sound also relies on many exploratory fishery licences, data was also collected for a number of exploratory stocks in the area. Fisheries in Kipisa, Qasigiyat, Iqaluit, Isuituq, Nauliniavik Lake, and Ikaluit Lake have had stock assessment reviews while fisheries in Avituajuit (Chidlak Bay), Qasigialiminiq Lake, Tagioyuk Lake, Millut Bay, Anaktuayuit, Opingavik Lake, and Kanayuktuk (Ikpit Bay) are in the process of collecting additional data to prepare for formal stock assessment. Stock assessment data collection has also been initiated in Pond Inlet for two Arctic char stocks (Koluktoo Bay and Satuut). Pond Inlet is redeveloping its Arctic char fisheries and the local fishers have put in great effort to collect biological samples in accordance with their exploratory fishing licence. To provide a complete and well executed stock assessment analysis, fishery independent baseline biological data is

Image from Dr. Ross Tallman

also required. This involves collecting both baseline biological data and local knowledge on these stocks. Stock assessments require gathering data for several years so this work will continue into the future.

For more information check out:

Ijaruvung Lake, Iqalujjuaq Fiord and Irvine Inlet - DFO (2018) https://waves-vagues.dfo-mpo.gc.ca/Library/40726174.pdf

Qasigiyat Lake - DFO (2013) https://science-catalogue.canada.ca/record=4019880~S6

Isuituq – DFO (2010) https://waves-vagues.dfo-mpo.gc.ca/Library/341883.pdf

Kipisa - DFO (2005) https://science-catalogue.canada.ca/record=4061514~S6

Ikaluit Lake – DFO (2003) https://waves-vagues.dfo-mpo.gc.ca/Library/276468.pdf

Tallman et al. (2019) https://www.intechopen.com/books/biological-research-in-aquatic-science/migration-dispersal-and-gene-flow-of-harvested-aquatic-species-in-the-canadian-arctic

Coronation Gulf Arctic Char - Diversity, Habitat, and Conservation

Image from Dr. Heidi Swanson

Contact
Dr. Heidi Swanson, Associate Professor and University Research Chair
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Timeline:
2017 - Present

Kugluktuk community members have been observing declines in their fall catches of anadromous (i.e., sea-run) Arctic char, as well as changes in char migration timing and locations. In response to community concerns, research was begun on the subsistence char fishery in the Coppermine River and Coronation Gulf in 2017. The project is a collaborative effort and includes partners and funders from the Kugluktuk Hunter and Trappers Organization, University of Waterloo, DFO (Coastal Restoration Fund, Species at Risk Fund, Northern Operations), NSERC (Discovery, Northern Research Supplement), Polar Continental Shelf Program, Government of Nunavut, Environment and Climate Change Canada (Indigenous Guardians Program), Polar Knowledge Canada (Northern Scientific Training Program), and the W. Garfield Weston Foundation.

With the help of the community, the research team set out to investigate the diversity of char in the Coppermine River by studying genetic and morphological differences from samples provided by local subsistence fishers. Utilizing acoustic telemetry, they have also begun to track char movements through both the Coppermine River and Coronation Gulf, in order to characterize the migration patterns of char in the area, including winter habitat use, fall migration destination, and the potential use of streams and rivers other than the Coppermine River. While analyses are ongoing, preliminary results show that a diversity of morphotypes and migration strategies exist in Arctic char that use the Coppermine River watershed. Data from acoustic tags support local knowledge and suggests that a subset of char overwinter within the lower reaches of the Coppermine River despite unfavourable winter conditions, and that some individuals enter the marine environment under the sea ice before break-up in the spring. In combination with telemetry data, otolith (fish ear bone) microchemistry is being used to identify the age of first ocean migration, frequency of skipped migrations, and use of overwintering habitats. So far, otoliths have been sampled from over 700 fish heads donated by local fishers, and otolith microchemistry will be analyzed in 2021. Strong community relationships and involvement in the project has allowed the research to continue even during times of travel restrictions. Community priorities along with the team's research results will inform the restoration of 1-2 streams that support char in the region.

WHAT ARE MORPHOLOGICAL DIFFERENCES?

Morphological differences are differences in appearance, form, or structure between individuals. A morphotype is used to describe a group of individuals with similar morphologies.

Sylvia Grinnell Arctic Char Stock Assessment

Contact
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Timeline:
2015 - Present

Arctic char in the Sylvia Grinnell River are an important subsistence and cultural resource to the community of Iqaluit. This stock experienced two brief commercial fisheries between the 1940s and 1960s, but commercial efforts were halted due to a large decrease in catch. While only subsistence and recreational fishing have continued in the area, catch rates and fish size have not returned to those perceived to be representative of the pre-commercial fishery.

Image from Sivummut Solutions

In 2015, DFO began a five-year plan to update and acquire new data on Sylvia Grinnell Arctic char abundance, migration timing, and other biological characteristics. Biological and catch data on Arctic char were collected through experimental gill netting and angler surveys with collaboration from the Amaruq Hunters and Trappers Association. Creel surveys were conducted in 2017 and 2019 and data on migration timing and patterns as well as fish abundance was recorded using DIDSON sonar and netting surveys during the summers of 2015-19. The research team

WHAT DOES DIDSON STAND FOR?

"DIDSON" stands for Dual Frequency Identification Sonar and is a device that allows researchers to detect individual fish in turbulent water. The sonar emits sound waves which reflect off the fish and return to the device. The measurement of returned waves allows researchers to count the number of fish in the area at a given time.

hopes to characterize and describe the Arctic char migration in relation to tides and other environmental variables that were recorded (e.g., water velocity, temperature and salinity).

Data analysis is currently being completed for the study and will result in an updated stock assessment on Sylvia Grinnell Arctic char. This work will help to understand how this Arctic char stock is recovering from being fished to near depletion in the 1940s and 1960s, and broaden our understanding to better managing Arctic char in northern Canada.

Towards a Sustainable Fishery for Nunavummiut: Bioprospecting from Arctic Char

Image from Dr. Virginia K. Walker

Contact
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Dr. Stephan Schott, Associate Professor at Carleton University, stephan.schott@carleton.ca

Timeline:
2015 to Present

WHAT IS A MICROBIOME?

An organism's microbiome is the community of microorganisms, such as bacteria, fungi, and viruses, that live on or in it. (Merriam-Webster Dictionary) These microorganisms often contribute to the function of the organism in some way, such as gut bacteria which helps maintain healthy digestion.

Many northern populations of Arctic char are anadromous, migrating annually to freshwater lakes and rivers to escape sub-zero ocean temperatures. When char migrate, they have to adapt to the changes between marine and freshwater environments, and so do their microbiomes. As part of the TSFN program, residents from Gjoa Haven were hired to catch fish in the waters on and surrounding King William Island. Local youth were trained in sampling bacteria from the char caught, which were analyzed for differences based on seasonal habitat use. Utilizing an on-site lab to ensure that there was no contamination of samples, mucus associated microbes were collected from the fish skin and intestines. Through DNA sequencing, bacteria were identified that included cold-adapted species and some that are involved in the nitrogen cycle that have potential to improve

fish farm management practices. If possible to cultivate, these bacteria could be used in microbial supplement applications or probiotic therapies in aquaculture. The bacteria differed depending on where the fish were caught, whether the water was brackish or fresh, as well as the time of year. Gut intestinal communities from brackish waters were similar to other salmon-type fish. However, gut microbiota from freshwater-caught char were more diverse and variable, possibly because these char do not eat when they are overwintering. Seasonal habitat was the strongest influence on the composition of the bacterial communities. This suggests that climate change could affect relationships between Arctic char and their symbionts by way of its effect on both water temperature and migratory behaviour.

Images from Dr. Virginia K. Walker

Greenland Halibut (Turbot)

Greenland halibut (turbot) is a deep sea flat fish that supports important commercial and subsistence fisheries in Nunavut and internationally. They are harvested both offshore and inshore, most notably in Baffin Bay and Cumberland Sound. However, other communities have been working to develop turbot fisheries in their nearby waters. An understanding of population connectivity, seasonal movement patterns, and areas of high abundance will be crucial to the sustainability and prosperity of these fisheries.

Multi-Species Survey in Baffin Bay

Contact
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Timeline:
1999 - Present

The creation and reference of long-term data provides important information on the biology and population structure of species of interest, as well as how they are responding to harvesting pressure. Annual surveying in areas of commercial harvest help to build a fuller picture of the populations of interest and compliment fishery dependent data by providing information on catches of all sizes and ages and at a wider range of locations.

Multispecies bottom trawling surveys have been conducted in NAFO DIV 0A South and DIV 0B since 1999, though annual surveying only began for both divisions in 2014. These surveys collect data needed to establish age structure and estimated population abundance, biomass, and recruitment for Greenland halibut and shrimp. In addition, these surveys also collect oceanographic data, and data to estimate abundance and biomass for other species of commercial or conservation

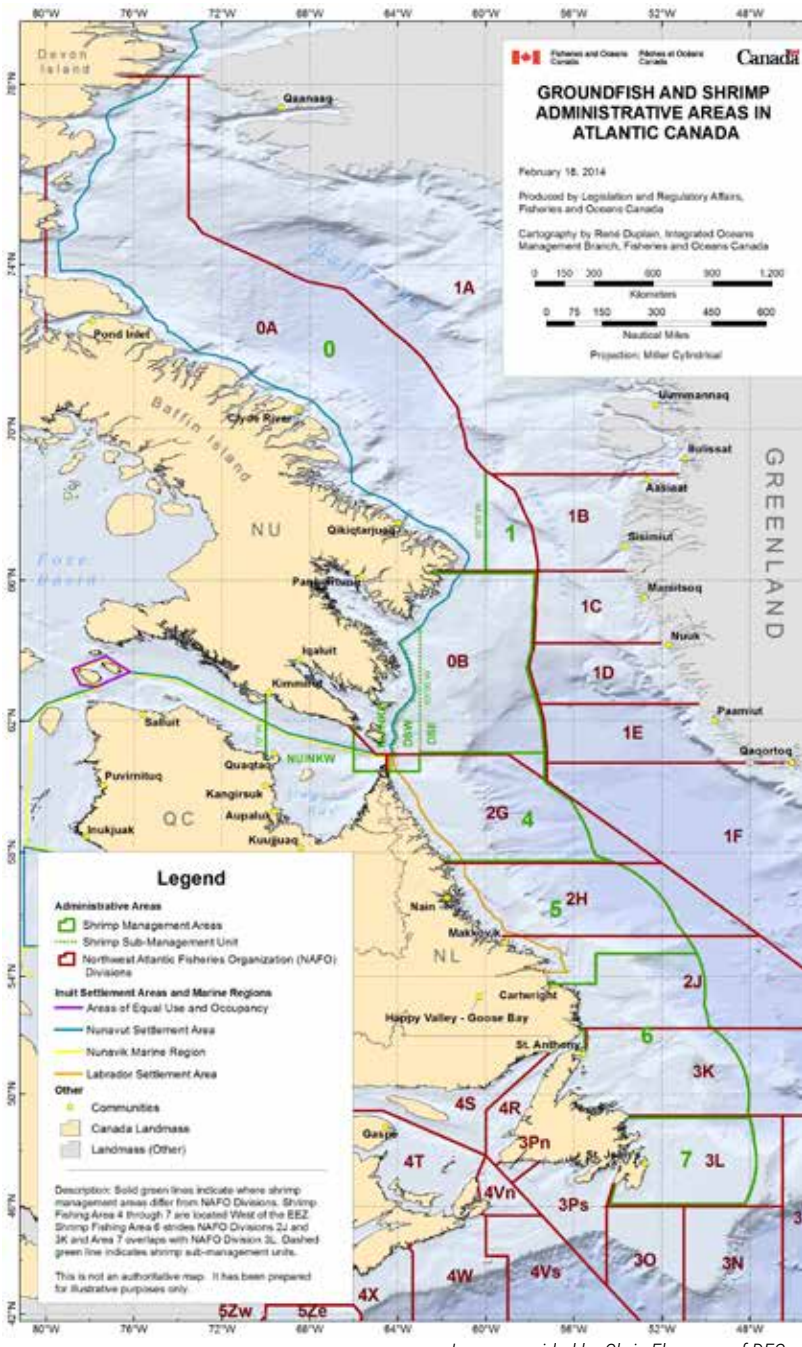

Image provided by Chris Flanagan of DFO

interest.

In 2016 bottom trawl surveys were conducted between October and November for depths ranging between 400 and 1500 meters in both divisions. While catches contained multiple species, the percentage of species other than Greenland halibut were relatively low. The results of the surveys suggest that in DIV 0A South, both Greenland halibut biomass and abundance estimates increased from previous years with a corresponding increase in halibut between 40 and 60 cm in length. In DIV 0B, biomass and abundance estimates also increased from those obtained in 2015. This research helps to support the sustainable management of the Subarea 0A Greenland halibut fishery. Since 2017, the annual survey has been fully funded by the DFO.

For more information check out:

Northwest Atlantic Fisheries Organization (NAFO) website, https://www.nafo.int/ and search DIV 0A and 0B.

WHAT IS NAFO?

The Northwest Atlantic Fisheries Organization (NAFO) is an organization made up of multiple participating governments, including Canada as well as other countries, that is responsible for the management of fisheries within the Northwest Atlantic Ocean. Their area of management is split into smaller units known as divisions (DIV). DIV 0A and OB make up Nunavut's offshore region.

BOTTOM TRAWLING SURVEYS?

Bottom trawling surveys utilize a large net which is towed from a vessel along the sea floor to catch fish and other organisms.

WHAT IS OCEANOGRAPHY?

Oceanography is the study of the ocean and its different properties such as temperature and chemical composition.

Acoustic Monitoring of Greenland Halibut and Principal By-catch Species

Contact
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Timeline:
2011 – Present

Advances in telemetry technology have greatly expanded research capabilities in the North and are helping fisheries, both developed and emerging, better understand the resources they harvest. This is especially true for deep water species such as the Greenland halibut (turbot) and their principal by-catch species, the Greenland shark and the Arctic skate.

As part of a long-term collaboration between the Arctic Ocean Tracking Network at the University of Windsor, DFO, the Government of Nunavut, the Nunavut Fisheries Association, and local communities, a telemetry network consisting of 140 receiver moorings has been set up across Baffin Bay. The network first provided information on Greenland halibut movements in the Cumberland Sound in 2011, but is now helping to inform the development of fisheries near the communities of Pond Inlet, Clyde River, and Qikiqtarjuaq. While receivers have been maintained in Scott inlet since 2012, and near Qikiqtarjuaq since 2015, 20 new receivers were added to the network in 2018 in a grid across the Eclipse Sound with a gate between the Sound and Baffin Bay. Roughly 80 additional fish were also tagged with acoustic transmitters

WHAT IS BY-CATCH?

By-catch are species or individuals caught unintentionally when fishing. In Nunavut's Greenland halibut fishery, Greenland halibut are the target species, but Greenland shark and Arctic skate are often unintentionally caught on long lines or in gill nets while fishing. Greenland shark and Arctic skate are of no commercial or subsistence interest, but play important roles in the Arctic ecosystem, and are considered some of the primary by-catch species for the Greenland halibut fishery.

in this area. This array configuration allows for the monitoring of fish movements within the Sound as well as an evaluation of population connectivity between inshore and offshore. This receiver arrangement is also used in both Clyde River and Qikiqtarjuaq and a similar design has been proposed for future work in Cumberland Sound.

Data gathered by these arrays have suggested that connectivity tends to be high between inshore and offshore populations and that Greenland halibut exhibit distinct timing in their movements, with some individuals returning to the same location yearly, and others being more transient. Not only does this information contribute to local management plans but the continuity across sites helps provide insight into the behaviour of the species overall.

Two additional mooring gates have been installed across the NAFO (Northwest Atlantic Fisheries Organization) boundaries between divisions 0A and 0B, and 0B and 2G. These arrays will help to explore fish movement and rate of exchange between the North Atlantic and Baffin Bay. 125 Greenland halibut were tagged with acoustic transmitters in each 0B and 2G divisions in 2018 and 2019. Collected data are currently being analyzed and could have important implications for offshore quota management.

In addition to Greenland halibut, over 190 Greenland sharks have been tagged with acoustic transmitters for monitoring. Data gathered from receivers in Scott Inlet have revealed that it may be the first known habitat for juvenile Greenland sharks. While juveniles seem to remain in the inlet

ACOUSTIC RECEIVER MOORING (LISTENING DEVICES)?

In its base form an acoustic receiver mooring consists of an anchor, to hold the device to the sea floor, and an acoustic receiver which listens for and records “pings” from acoustic transmitters (tags) which have been implanted into the specie(s) of interest. To make them more functional they usually also include a float, which sits at the surface of the water and keeps the equipment afloat within the water column, and a release device which allows researchers to be able to retrieve the receivers to download data. The moorings in the Baffin Bay Network also include marine mammal hydrophones and oceanographic sensors to gather further information about the environment and the other species which inhabit it.

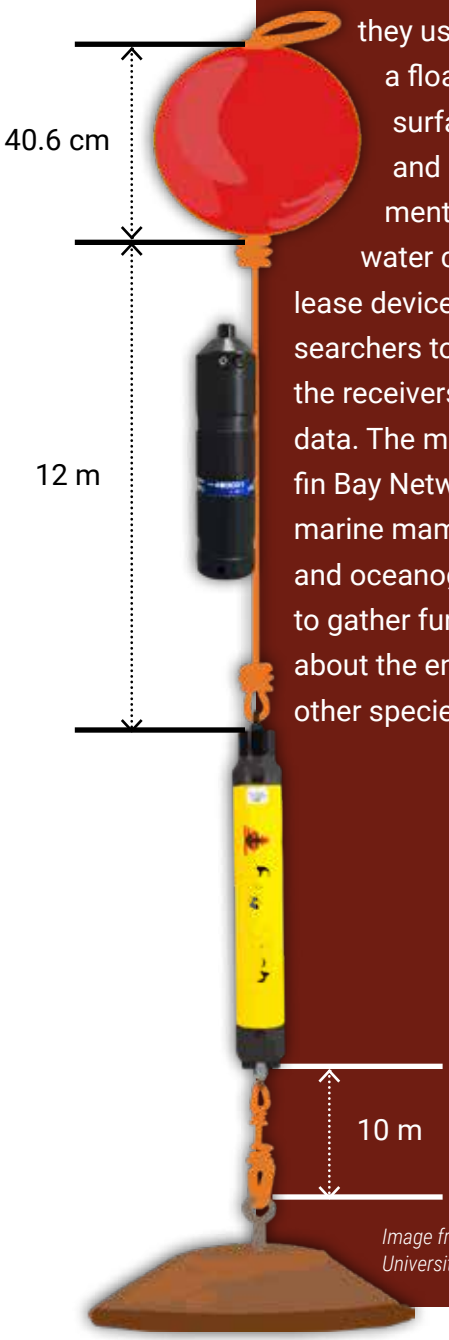

Image from Amanda Barkley from the University of Windsor

for long periods of time, adult sharks seem to primarily be present in coastal regions during the summer open water periods and are rarely detected in the Inlet in the winter. These data are supported by offshore moorings which detect tagged adult sharks in higher numbers during the winter than the summer. An additional 30 sharks have received pop up archival satellite tags which allow researchers to explore their vertical space movements. Preliminary results suggest that Greenland sharks commonly inhabits spaces between 300 and 500 meters deep and their habitat use overlaps with that of Greenland halibut.

Arctic skate monitoring also takes place across the network but is focused near Clyde River and Pond Inlet. Data has shown the species to be highly mobile across coastal fishing areas. However, there are clearly defined hotspots in which they overlap with Greenland halibut in high numbers.

These findings highlight the need for the development of effective by-catch strategies. Additional research by the team has shown by-catch reporting to be limited in community-based fisheries in Nunavut, despite the fact that it is required by DFO. As by-catch species are often misidentified, further work is being done by the team to develop clear species identification guidelines which may help to improve reporting.

Ringed Seal

Ringed seals are a very important species in Nunavut, ecologically, culturally, and economically. As one of the most abundant marine mammals in the territory they have provided Inuit with food, clothing, and other resources for generations. In today's wage-based economy they also provide Nunavummiut economic opportunity as seal skins and seal skin products are sold both nationally, and internationally. Continued research and monitoring in multiple aspects of Ringed seal health and ecology is crucial for the sustainable management of healthy populations in the Arctic.

Ringed Seal Inuit Qaujimajatuqangit (IQ) Study

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Timeline:
2015 – Present

Photo by Maha Ghazal

In an effort to facilitate the collaborative use of IQ in Ringed seal research and management, the Division is compiling baseline information from knowledge holders in Nunavut communities. Between 2015 and 2017 semi structured interviews were held in 15 different communities: Arviat, Cambridge Bay, Chesterfield Inlet, Clyde River, Gjoa Haven, Kugaaruk, Naujaat, Pond Inlet, Qikiqtarjuaq, Rankin Inlet, Pangnirtung, Sanikiluaq, Igloolik, Kimmirut, and Arctic Bay. Between 2 and 11 experienced Ringed seal hunters were interviewed in each community for a total of 72 participants. Information was gathered on Ringed seal ecology including seasonal behavior, abundance, distributions, movement patterns, threats, and their interactions with other species, as well as the ways in which these variables may be changing over time. Additional data on the hunter's experience harvesting and selling Ringed seal skins was also collected to help the Division identify and address factors which may be contributing to the decline in sales to the Fur purchasing program. By ensuring the sale of each pelt, this program helps to maintain traditional and sustainable harvesting practices which support food and economic security for community members. Once all the information regarding Ringed seal ecology and the factors influencing harvest have been reviewed and curated, a book will be published and made readily available to communities, the public, and other relevant organizations within the territory.

Ringed Seal Feeding Ecology

Contact
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Timeline:
2016 – Present

Maha Ghazal and the team at the University of Manitoba, began research to better understand Ringed seal feeding ecology in 2016. The study utilized both stomach content analyses and local Inuit knowledge gathered from Pangnirtung, Pond Inlet, and Arctic Bay. Stomach samples were obtained from seals through a DFO program and their analysis will explore differences in diet between northern (Pond Inlet and Arctic Bay) and southern (Pangnirtung) regions. Factors like age, sex, year harvested, and time of year harvested will also be analyzed. As generalist predators, changes in Ringed seal diet can be indicative of changes to the overall Arctic food web. These changes may be due to fluctuations in prey species and other competing predators within the system.

Inuit Qaujimajatuqangit (IQ) tends to cover a larger time and spatial scale than Western science, as people gain extensive knowledge on species through a lifetime of interaction. So, to compliment the stomach content analysis, 23 semi structured interviews were conducted with Ringed seal hunters and knowledge holders in the three study communities. These interviews gather data on Ringed seal biology, behavior, and habitat use and included open-ended questions on hunting, feeding, stomach contents, movement, behaviour and environmental change. The relatively open interview structure allowed for further discussion unique to the knowledge and comfort of each participant. These interview data are currently being analyzed and will be reported in the near future.

Assessment of Exposure of Ringed Seal Populations to Contaminants

Contact
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Timeline:
2016-2019

Ringed seals (nattiq) continue to be a very important wildlife resource for communities in Nunavut. However, reliance on animals for food always carries with it the potential for exposure to infectious agents that can be transmitted from animals to humans and cause disease (zoonotic pathogens). In addition to infection, accumulation of some contaminants in wild animals also represents a potential hazard to humans who consume their meat. It is therefore important to know the prevalence of these infectious agents and contaminants in hunted wild populations. Enooyaq Sudlovenick and James Simonee, with guidance from Pierre-Yves Daost from the University of Prince Edward Island, sought to better understand the extent of these hazards. The team worked closely with hunters in Pond Inlet and Iqaluit to collect samples from the seals that they harvested. The studies in each community were identical and carried out in the same time period, providing an opportunity to compare results in these two distant regions of Qikiqtaaluk. In addition, interviews were conducted with local knowledge holders in Iqaluit to gather IQ about nattiq health and harvesting.

Photo from Dr. Pierre-Yves Daoust

Infectious agents were tested for using blood, feces, muscle and liver samples from approximately 50 seals in each region. In Frobisher Bay (Iqaluit) and Eclipse Sound (Pond Inlet), the proportions of seals with serum antibodies were, respectively: 20.5% and 37% for Brucella; 21% and 11% for Ery-

sipelothrix; 93% and 100% for Leptospira; and 10% and 27% for Toxoplasma. The presence of these antibodies indicates that seals were exposed to these pathogens at some point in their life. However, they do not indicate that these animals were actual carriers of the pathogens at the time of sampling. Virulence factors associated with Escherichia coli (known to cause human intestinal disease) were found in feces of 17% of the seals from Frobisher Bay and 12% of the seals from Eclipse Sound. Salmonella was isolated from the feces of eight seals from Eclipse Sound during the span of 1 week in June 2017. Interestingly, this coincided with the spring return of large numbers of greater snow geese to Bylot Island, suggesting that these birds may have brought this bacterium in their digestive tract from the south and contaminated the water of Eclipse Sound. Listeria was not isolated from any of the fecal samples, and Trichinella was not found in any of the muscle samples in either Frobisher Bay or Eclipse Sound. Most pathogens whose presence in the seals' environment was identified in this study can be avoided by using standard hygienic methods when butchering the animals and preparing their meat. Toxoplasma may require extra precaution, but its destruction can be easily achieved by freezing the meat.

Concentrations of the four heavy metals studied were comparable in Frobisher Bay and Eclipse Sound. The amount of arsenic in all muscle and liver samples was below the detection limit. Most levels of lead were below the maximum acceptable level as advised by Health Canada. A few samples were above this level, particularly in muscle, but the possibility that some of these samples would have been contaminated by fragments from the bullets cannot be ruled out. If so, this supports the effort to seek affordable non-toxic alternatives for ammunition. Levels of cadmium in muscle samples from all seals were below the maximum acceptable level as recommended by the World Health Organization (WHO). Levels in livers of a large proportion of the seals were above WHO recommended levels.. High concentrations of cadmium in liver have also been observed in several other animal species. Levels of mercury in only a few muscle samples were above the maximum acceptable level as advised by Health Canada. Conversely, the level of mercury was above this level in a large proportion of the liver samples. There did not appear to be a substantial difference in levels of cadmium and mercury in the liver between young seals and other age groups.

Results of interviews with local knowledge holders indicated that hunters have a very good understanding of the health of harvested animals and that they assess this health in a manner comparable to that of health specialists. Neither source of information raises any specific alarm from a public health perspective. These studies though serve to remind hunters and their communities about the importance of proper precautionary measures when handling any type of food, particularly that coming from animals, which is consistent with the guidelines provided by the Nunavut Department of Health. When the detailed analysis of this study is complete, it will be published as a journal article and made available to the public.

For more information check out:

Sudlovenick (2019) https://www.islandscholar.ca/islandora/object/ir%3A23043/datastream/PDF/view

Diet Studies on Harp Seals and Ringed Seals

Contact
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Timeline:
2015 - 2018

Image from Dr. Steven Ferguson

Harp seals have been observed in increasing numbers in Nunavut recent years. While they have long been present during the open ice season, there has been concern that growing numbers for longer periods throughout the year may pose a competitive risk to resident Ringed seals. Wesley Ogloff, under the supervision of Steven Ferguson at the DFO, and the Davoren Lab at the University of Manitoba explored the diet of Harp and Ringed seals within the Cumberland Sound to determine trophic niche overlap between the two species.

Stomach, muscle, and liver samples were collected from both Ringed and Harp seals harvested by the community of Pangnirtung in the Cumberland Sound between 2007 and 2016 for stomach content and stable isotope analysis. The study determined that while Harp and Ringed seals do eat much of the same prey, harp seals eat a higher percentage of fish than Ringed seals, and that the fish they consume tend to be larger. Ringed seals were more generalist in their prey consumption and ate more squid, decapods, amphipods, krill, and other invertebrates. This may allow Ringed seals to shift their diet more easily in response to competition from Harp seals for larger fish prey. Additionally, the stable isotope analysis suggested that the two seals differ in foraging location when in the same area, with Harp seals foraging deeper in the water column than Ringed seals. These differences lessen the likelihood of direct competition.

TROPHIC NICHE?

A species trophic niche relates to what it eats and what eats it. When two species occupy the same area and the same trophic niche, competition for resources can lead to the exclusion of one of the two species.

It is important to note that the samples collected for this study came from harvesters and were naturally influenced by harvester preference, with the majority of the Ringed seals sampled being juveniles while the majority of Harp seals sampled were adults. Some of the observed differences in diet may therefore be due to differences in age between the two sample groups, as younger seals are thought to be more opportunistic in their foraging. Continued monitoring will be essential to fully understanding the long-term effect these changes in the ecological community will have on resident species such as the Ringed seal.

WHAT IS A STOMACHCONTENT ANALYSIS?

Stomach content analysis provides a snapshot of what an individual was feeding on in the hours prior to its death, while muscle and liver samples, which are utilized for stable isotope analysis, provide a look at what an individual has been consuming over a period of months. The use of both analyses in compliment allows for a fuller picture of overall diet.

For more information check out:

Ogloff et al. (2019) https://link.springer.com/article/10.1007/s00227-019-3549-6

Images from Steven Ferguson

Capelin

Capelin were once considered rare in the waters around Baffin Island, but in recent years they have been observed in higher numbers. These small forage fish are culturally and economically important for many communities along Canada's North Eastern coast, and act as a keystone species, feeding larger animals such as Harp seals and Greenland halibut. Despite their importance, much remains unknown about their population structure. Defining population units and understanding the degree of gene flow between them will be crucial to the sustainable management of capelin in Canadian waters and internationally.

Diet Studies on Capelin

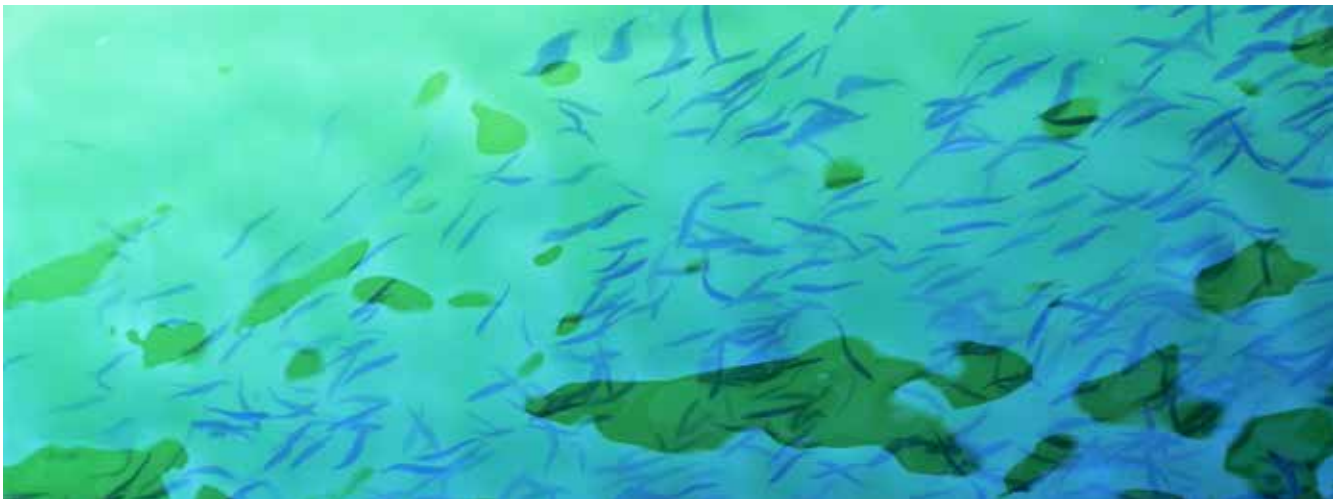

Photo from Steven Ferguson

Contact
Steven Ferguson, Research Scientist Fisheries and Oceans Canada and Adjunct Professor University of Manitoba, steve.ferguson@dfo-mpo.gc.ca

Timeline:
2015 - 2019

The open water season is becoming longer as temperatures increase in the Arctic and communities are starting to see a rise in the species that migrate to the North during this time. Once rare species are also being observed in larger numbers as these conditions allow for the range expansion of more temperate animals. In recent years capelin have been observed shoaling in the Cumberland Sound and near the community of Pangnirtung. It is unclear if more favorable conditions are allowing small resident populations to grow, or if southern populations are moving further north, but the increase in capelin is bringing new resources to the local food web. While this could be beneficial for predators that feed on forage fish, it may also alter the delicate balance held by resident species.

In addition to their work on Ringed and Harp seal diets (see Diet Studies on Harp Seals and Ringed Seals), Wesley Ogloff and the Davoren Lab team explored

the diet of capelin in the Cumberland Sound using stomach content and stable isotope analysis. 206 stomach samples and roughly 280 muscle samples were collected from capelin of different sizes and maturity prior to and during spawning in 2015 and 2016. These samples were used to determine what the capelin were feeding on, how this differed between individuals of differing sizes, and how this might compare to the diet of other local species. Their results showed that as body size increased in individuals so did the size of their prey. This slight change in diet between groups of different sizes may help to alleviate intraspecific (within the same species) competition. The overall diet, which included 23 different kinds of prey, seemed to overlap with the diets observed in the literature for other artic forage fish such as polar cod and to some degree Arctic char. While this suggests that there could be some competition between the species as capelin numbers increase in the Arctic, the team determined that more information would be needed to fully understand the breadth of overlap between them, as differences in foraging habits or overall prey availability may help to alleviate this.

For more information check out:

Ogloff et el. (2020) https://link.springer.com/article/10.1007/s00300-020-02707-1

Population Genomics of the Capelin in the Northwest Atlantic

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Timeline:
2016-2019

Photo from Dr. Louis Bernatchez

In 2016 a team from the Université Laval set out to study the population structure of capelin around Canada's east coast and Greenland. They started by assembling the full 490 million base pair genome for the species. 1,310 capelin collected from 31 spawning sites in Kuururjuaq, Labrador, Newfoundland, Quebec, Nunavut, and Greenland were genotyped. Three major genetic clusters were identified from the samples, each of which showed a very distinct geographic distribution, one in the Northwest Atlantic, one in the Arctic (Nunavut), and one in Greenland. By reconstructing the history of these three distinct genetic groups, the team was able to determine that they likely separated from one another from 3.8 to 1.8 million years ago. The deep time of separation and very limited genetic exchanges that was observed between the groups strongly suggest that these three clusters may actually correspond to three distinct, so-called "cryptic" species, or species that cannot be easily distinguished based on their external morphology. Within each of the three genetic groups, population sizes were healthy with a high degree of gene flow among populations from different spawning sites and spawning habitats. Despite this, the analysis showed evi-

dence for genetic adaptation within populations to local environmental factors such as temperature, productivity (chlorophyll), and spawning habitat (beach vs. demersal). This provides support for the hypothesis that while capelin populations are weakly genetically differentiated overall, they are nevertheless adapted to their local reproductive habitat conditions. Beyond it's direct contribution to the understanding of capelin population structure, this study highlights the benefits of genetic exploration for the complex task of defining management units for marine fish with high dispersal capabilities.

Photo from Dr. Louis Bernatchez

For more information check out:

Cayuela et al. (2020) https://www.researchgate.net/publication/341918940_Shared_ancestral_polymorphism_and_chromosomal_rearrangements_as_potential_drivers_of_local_adaptation_in_a_marine_fish

Photo from Dr. Louis Bernatchez

WHAT IS A GENOME?

An organism's genome is made up of it's DNA, and acts as the building instructions for the organism's form and function. DNA is formed of different chemical base pairs, and the order in which these base pairs occur differs between individuals. There are enough similarities in the DNA of individuals of the same species that researchers can assemble species specific genomes, as they have here.

Lake Whitefish and Cisco

Lake whitefish, Arctic cisco, and sardine cisco are all cousins to the Arctic char in the family Salmonidae. Though they are not as widely harvested as char in Nunavut whitefish and cisco species do support subsistence fisheries in many communities. A further understanding of their biology will help to inform their sustainable long term management.

Towards a Sustainable Fishery for Nunavummiut: Skin- and Intestine-Associated Microbial Communities

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Dr. Stephan Schott, Associate Professor at Carleton University, stephan.schott@carleton.ca

Timeline:
2015 to Present

In the Kitikmeot, Lake whitefish and their "sister" species, Arctic cisco and sardine cisco, can be anadromous, migrating annually between freshwater lakes and the Arctic Ocean. As part of the "Towards a Sustainable Fishery for Nunavummiut" project (see page 9) Gjoa Haven fishers netted hundreds of these fish and with the help of community youth, sampled them for bacteria living on their skin and in their intestines. These bacteria contribute to the function and health of the fish and can be sensitive to environmental changes. Bacterial communities associated with Lake whitefish changed seasonally and were distinct from the more stable communities found in ciscoes. These results suggest that ciscoes are better adapted to these northern waters. Bacterial communities were also sampled from Artic char (see Section 3: Bioprospecting from Arctic Char) for comparison.

Even though Arctic char and the related lake whitefish travel through the same waters, their gut communities were different. Lake whitefish had more bacteria that could cause disease to the fish. Geography and feeding also seemed to have a greater impact on whitefish gut microbiota. Lake whitefish in this region of the Kitikmeot are at the northern limits of their range and grow slowly. Therefore, it is possible that both the fish and their associated bacteria are more vulnerable than the better-adapted Arctic char, which are the most northerly distributed of any freshwater fish. The prospect of additional stress on the more vulnerable whitefish is of concern since they are an important food fish for the residents of Gjoa Haven. This work may inform approaches to Lake whitefish health in fisheries and aquaculture that are important for subsistence and economic interests in these resources.

Towards a Sustainable Fishery for Nunavummiut: Contaminant Testing in Food Fish

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Timeline:
2015 to Present

The identification of food fish bearing contaminants from human activity is one of many priorities for Nunavummiut. In direct response to requests from the community of Gjoa Haven the TSFN team assessed, in some cases for the first time, mercury, arsenic and persistent organic pollutants including polychlorinated biphenyls (PCBs) in more than 500 fish including Arctic char, Lake trout, Lake whitefish, and ciscoes. Mercury levels in fish from sites on King William Island were generally higher than from mainland sites. However, average concentrations were generally below advisory guidelines, except for Lake trout. Lake trout were also highest in arsenic, but this likely includes non-toxic arsenobetaine from ocean prey. PCB levels were within advisory guidelines but were highest in Lake trout and Arctic char. PCB analysis showed signatures consistent with the legacy of cold-war distant early warning stations.

These results have been submitted for publication and include community member authors that not only contributed traditional knowledge but were co-grant holders on a Northern Contaminant Community Project. These results have also been shared with the Department of Health, Government of Nunavut.

Photos from Dr. Virginia K. Walker

Seabirds

Nunavut is home to a number of migratory seabird breeding colonies, including those of the northern fulmar, which flock to the coasts along the Davis straight during the summer months. Northern fulmars are a noted by-catch species in the NAFO divisions 0A and 0B Greenland halibut fishery, but little is known about the impact these mortalities have on local populations. The assessment and mitigation of seabird by-catch in Arctic fisheries has been identified as a top priority under the Arctic Migratory Bird Initiative (AMBI) and will be necessary for the environmentally sustainable management of Nunavut's growing fisheries.

Addressing Seabird By-catch in Arctic Fisheries

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Timeline:
2016 - Present

Photo by Dr. Jennifer Provencher from the Canadian Wildlife Service

Through a collaboration between the Nunavut Fisheries Association, federal and territorial government departments, Nunavut land claim organizations, academia, and non-government organizations research has begun to fill the knowledge gap on northern fulmar by-catch. Recent work used published demographic data for northern fulmars to assess the levels of their by-catch in the offshore Baffin Bay-Davis Strait Greenland halibut fishery, while also exploring how breeding populations may respond to increases in by-catch levels as the fishery continues to grow. Data gathered by at-sea-observers between 2011 and 2015 were used to approximate annual by-catch for the fishery. Factors were then varied within a model to reflect different possible scenarios such as fishery growth, differences in population of origin for the fulmars caught, and changes in by-catch reporting. It was determined that at its current rate, by-catch could cause an 11.7% decline in nearby colonies over a period of 3 generations (66 years) though continued fishery growth could result in decreases as high as 33.3%. Data deficiencies however make a reliable evaluation of the situation difficult and it was noted that much of the uncertainty in the models could be addressed with improved and standardized data collection by at-sea-observers. Currently most observers do

not receive detailed training on seabird identification and the reporting requirements across different regions vary greatly. The study recommended that Nunavut develop its own observer program that provides better training and requires more detailed data recording, such as mortalities caused by gear outside of those included in net hauls.

The study also highlighted the need for more information on which breeding colonies the by-catch fulmars originate from, as the mortalities may have a less drastic impact if they are spread out across multiple populations. However, new genetic analysis from the project shows that this may be difficult to determine. The work, which used samples from 127 northern fulmars from six different breeding colonies across the Atlantic, found there to be only weak genetic differentiation between the breeding colonies. A mostly homogenous population across the Atlantic makes it challenging to determine with certainty which breeding populations by-catch belong to. While proximity can likely give some indication, northern fulmars can travel long distances to feed and are known to do so even during breeding season. A continued and coordinated approach will be needed to further understand and improve the management of northern fulmar by-catch in Nunavut fisheries.

Exploring New Economic Opportunities

In compliment to the work being done to improve our understanding of well-established fisheries, the Division has made it a priority to support research into new economic opportunities for Nunavummiut. In some cases, this has meant exploring ways to develop new fisheries for species that already have an established market, like char. In other cases, it has meant investigating the commercial potential of less well-known species like soft shell clam and sea cucumber. In addition to bringing money into communities these small-scale commercial fisheries can help to increase local food security while also providing important employment and capacity building opportunities for Nunavummiut.

Nunavut-wide Opportunities

Nunavut Community Aquatic Monitoring Program (N-CAMP)

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Timeline:
2012 – Present

Photo from the Government of Nunavut

The Division has provided communities with exploratory fishery sampling and aquatic monitoring training through the Nunavut Community Aquatic Monitoring Program (N-CAMP) since 2012. The program, which emphasizes hands-on learning, provides a mix of classroom and land-based training that helps to build capacity and confidence within communities so they can take ownership of their aquatic resources and play an active role in their monitoring and development. The program was piloted in the communities of Igloolik, Coral Harbour, and Kugluktuk in 2014 and has since been delivered in Pond Inlet, Iqaluit, Gjoa Haven, and Cape Dorset, resulting in a total of 65 graduates thus far!

With a desire to develop an exploratory Greenland halibut fishery, participants in Pond Inlet received training in related biological sampling and catch recording techniques, as well as long lining fishing from an experienced commercial fisher from Pangnirtung. The community is still actively harvesting to fulfil their exploratory license requirements and have developed an operational fishing plant.

In Iqaluit the N-CAMP team partnered with the Nunavut Arctic College and involved second year students from the Environmental Technology Program. Since then, a number of program graduates have been employed by DFO to conduct similar sampling work.

For N-CAMP delivery in Gjoa Haven the program collaborated with the "Towards a Sustainable Fishery for Nunavummiut" team (see page 9) to train participants to sample both Arctic char and whitefish. This put them at the forefront of the field-based research underway in their community. Participants were a crucial part of the studies completed and now have the skills to conduct their own independent sampling.

In 2020 the structure of N-CAMP was re-evaluated to determine how it could better support communities and promote small scale fishery development throughout the territory. The new evolution of the program focuses solely on fishery development, rather than general aquatic monitoring, but provides participants with more well-rounded training and support throughout the entire 5-year exploratory process. The Division hopes to put the new curriculum into action starting in 2021!

Photos from the Government of Nunavut

Assessment of the Current Coastal Restoration Needs Across Nunavut

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Timeline:
2017-Present

Photo from Jade Owen

In 2017 Dalhousie University, in partnership with the Division, received funding under the Government of Canada's Ocean Protection Plan for a 5-year research project to assess the current coastal restoration needs of Nunavut communities. Since 2018 the project team has conducted participatory mapping interviews in 18 communities with the members of the local HTO and Hamlet staff to identify habitats and species of concern. Feasibility studies are now being put together to determine how each communities' needs might be addressed. The first pilot restoration project was conducted in 2018-2019 on the Nilaqtarvik River (near Clyde River) to restore a char fishing site and has since served to inform projects being developed in other communities. In 2020 rubble was removed on the Canyon River near Coral Harbor from a rockslide in the area and net exchanges took place in Kugluktuk, Taloyoak, and Kugaaruk. The team plans to visit the remaining seven communities to conduct interviews in the winter of 2021, travel restrictions permitting. The work being done through this project helps to ensure the persistence and health of Nunavut's coastal fisheries for future generations.

Sea Cucumber Research

Photo from iStock

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Timeline:
2019 – Present

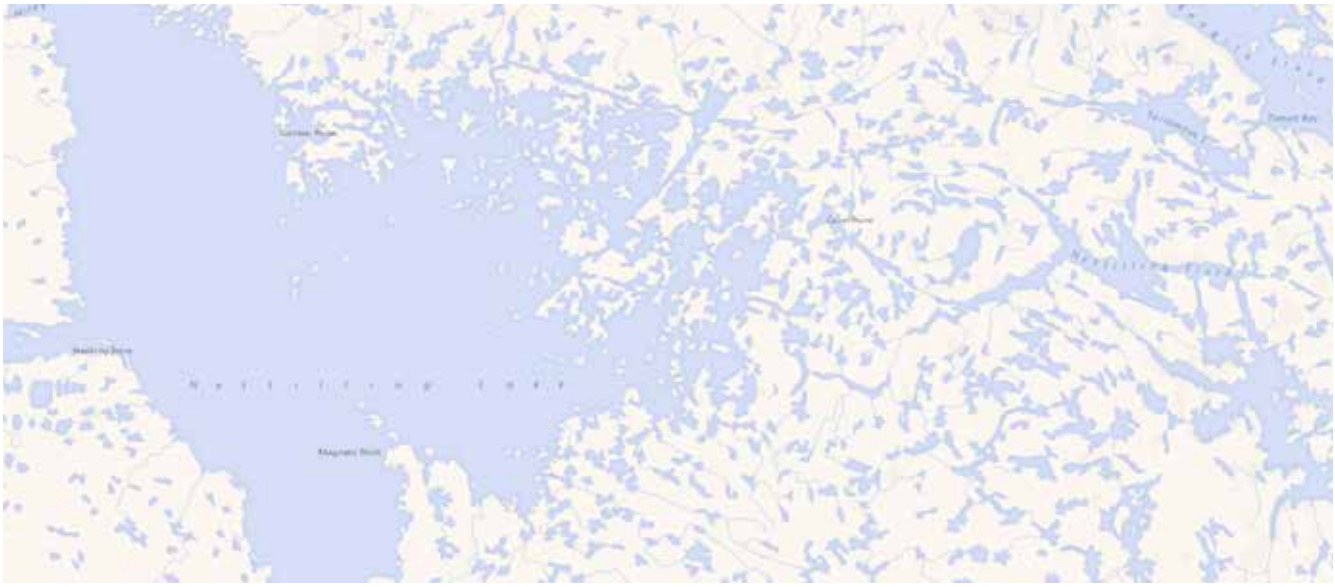
Nunavut's waters are rich not only in fish and marine mammals, but in marine invertebrates, such as the sea cucumber. Though not as well known for their harvest as char or turbot, sea cucumbers do support subsistence fisheries in some Nunavut communities and may have the potential for small scale commercial development. In 2018 the Sanikiluaq HTO expressed interest in learning more about the health of their local sea cucumber populations and what kind of harvest they may be able to sustain. In response to this interest the Division coordinated a meeting between the HTO and an expert in sea cucumbers, Dr. Annie Mercier. The Mercier lab at Memorial University has extensive experience in the stock assessment, monitoring, and successful economic development of sea cucumbers in Northern communities as well as other environments. After an initial meeting with the Sanikiluaq HTO in March 2019 to discuss the community's research needs, the Mercier team met

with HTOs in Coral Harbour, Kimmirut, and Iqaluit to gage community interest and determine if there were productive sea cucumber populations in these areas.

Sea cucumber samples and underwater videos were collected by DFO and World Wildlife Foundation Canada in Kimmirut and Sanikiluaq during the summer of 2019 and are currently being analyzed to determine population metrics, spatial patterns, and chemical composition. To further this research in coming years, the Division has provided the team with an Arctic capable underwater drone that can record video and collect biological samples. Its high portability and ease of use (it can be piloted by a single person) will greatly facilitate the team sampling populations throughout Nunavut.

Qikiqtaaluk

Arctic Char Fishery in the Nettilling/Amadjuak Lake System



Map fromGovernment of Canada - Indigenous and Northern Affairs Canada, Nunavut Map Viewer

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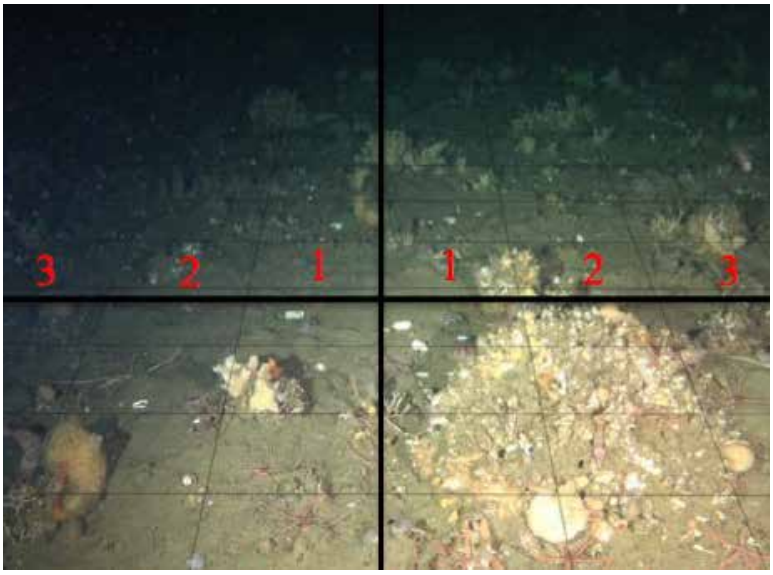
Timeline:
2014-Present

Nettilling Lake is the largest lake in Nunavut and it carries the largest single commercial quota for Arctic char in the territory at 22,000kg. It is connected to Amadjuak Lake via the north-flowing Amadjuak River which also bears sea-run char. Various fisheries have been attempted in the area to take advantage of the resource but most have proven unviable. In the 1970s there was a fly-in fly-out fishery catching char on their way inbound from Hudson's Bay in the Fall. However, other attempts to harvest the quota by air have proven too costly, due to the high price of chartering planes. In 2011 the Division began looking at models of harvesting char by snowmobile from Iqaluit and Pangnirtung. With support from Arctic Net and in partnership with the Ocean Tracking Network and the Department of Fisheries and Oceans Canada, the Division

initiated an acoustic telemetry research project in 2014. The goals of the project were to determine the timing and southern extent of the seasonal migration of char in the Amadjuak River as well as to study the biological diversity of char in the water system. Additionally, the Division has employed fishers from both Iqaluit and Pangnirtung to conduct exploratory test fisheries within the system in the winter, in an effort to improve understanding of the viability of fishing the resource. In 2018/19 the team began a radio-tagging study with the objective of pinpointing different overwintering locations of sea run char in the system. As a first step 10 radio tags installed at different depths were tested near one of the known overwintering sites. To provide shelter for winter fishers the team built a weather haven near a productive fishing site in 2019 and has since added a small shed for scientific equipment storage, reducing research costs. Analysis of project data gathered over the past 6 years will be used to inform any further development efforts in the Nettilling Lake System.

Marine Fisheries Resource Assessment around Iqaluit and Kimmirut



Photos from Dr. Scott Grant

Contact
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Timeline:
2016 - Present

Small scale fishery development can provide important economic opportunities for communities in Nunavut and help increase local food security. However, for many communities, the presence or abundance of commercial species in adjacent waters is unknown. With support from the Division, a team of researchers from Memorial University's Center for Sustainable Aquatic Resources (CSAR) has been working in partnership with the communities of Kimmirut and Iqaluit to conduct resource assessments for their nearby waters. These surveys are helping to determine the presence of species of commercial interest and whether or not the harvest of such species can be done in an ecologically and economically viable way. The research plan combines surveying, limited harvesting, and consistent mon-

itoring to inform the responsible and timely development of local fisheries.

Multispecies Survey in Frobisher Bay and near Kimmirut

In 2017 the CSAR team began their research with a multispecies potting and underwater video survey to explore the presence and abundance of species in the nearshore waters, as well as the most effective way to harvest them. This survey effort has continued in the years following.

The potting surveys were conducted from the RV Papiruq and utilized three main pot types: conical single entrance welk pots, small three entrance circular shrimp pots, and large seven entrance circular shrimp pots. Circular shrimp pots were observed to be more effective and less environmentally damaging in catching welk than the conical pots. However, many small whelks were caught in the large circular pots which could pose a risk for overharvesting immature individuals. The team is currently examining specimens gathered during the 2019 potting survey to determine a size at maturity for the species in Nunavut. This will help inform a minimum catch size and the best mesh size or escape mechanism to use for pots.

While B. hydrophanum, which is a species of whelk, was the most abundant species of commercial interest caught in the potting survey, the video surveys revealed slightly different results. In the video surveys sea urchins and sea cucumbers were the most abundant species of interest observed, while whelks appeared to have one of the lowest abundance measures. Though sea urchins were caught with some frequency in the potting surveys, very few sea cucumbers were caught. The difference in results between the two surveys highlights the importance of gathering both fishery dependent and fishery independent data. Video surveys can provide information on presence and abundance of species independent of harvesting and may avoid biases caused by harvesting technique or gear type.

Multispecies Survey off the South Coast of Baffin Island

In 2018 the CSAR team expanded their surveying effort to include deep water trawl surveys in the Hudson Straight. In October of 2018 and 2019 surveys were carried out from the R.V. Nuliajuk. The majority of the tows were made up of fish, basket stars, sea urchins, and shrimp. Of the fish

DID YOU KNOW?

Prior to the acquisition of the R.V. Nuliajuk, the smaller, 27-foot R.V. Papiruq was the Fisheries and Sealing Division's main inshore fishery research platform. The Papiruq served for 2 years in Frobisher Bay and the Cumberland Sound before it's retirement in 2009. However, in 2016 the vessel was reassessed as a cost-effective option to support inshore fishery development. The Papiruq was retrofitted and returned to service in 2017 with the ability to deploy a variety of fishing gear, high-tech underwater video technologies, multi-beam sonar and the most up to date electronics and navigation equipment. It also received a Blue Decal certification from Transport Canada. CSAR was at the forefront of the R.V. Papiruq's refitting and have since been putting it to good use in resource assessment surveys in Frobisher Bay and near Kimmirut.

species caught two were most dominant, Greenland halibut and Arctic cod. While Greenland halibut are of commercial interest, most of the individuals caught were below the minimum size requirement for a commercial fishery, suggesting the Hudson Straight may act as a nursery ground for juveniles. The team gathered samples from the Greenland halibut caught and hope that future genetic work may be able to help answer questions on where the juveniles originated and where they will go as adults. Arctic cod are not thought to have any commercial value at this time.

Sea urchins, another species of interest, seemed plentiful in some areas, but the depth of these areas would necessitate specialized equipment for their harvest. Additionally, they are typically harvested for their roe during spawning, which is known to occur in the early spring for southern populations. If northern populations follow a similar spawning schedule harvesting would have to take place under the ice, which could only be done by divers if the location is in a shallow area. Multiple shrimp species were also caught during surveying in both years, but further studies are needed to determine if any of the populations could support a viable commercial fishery.

Soft Shell Clam Resource Assessment

The presence of soft-shell clams near Kimmirut and Iqaluit is already well known due to their subsistence harvest. However, little is known about their life history in the Arctic, an understanding of which is important to their sustainable management. In addition to the multispecies surveys, CSAR began a resource assessment of soft-shell clams in 2018. Clams were collected from two sites within the inner Frobisher Bay and three sites near Kimmirut. During their first year the team was able to determine the size at maturity for both male and female clams and found evidence to suggest that local clam populations spawn in the autumn. They also determined that dry body weight was the best measurement for comparing body condition between individuals. The 2019 surveys showed clams to be in better condition at the end of September than in early August or early September which could help inform the time of best harvest. The team also found that there was little difference in the weight of clams sampled between 2018 and 2019 in Frobisher Bay despite the late occurrence of ice break up in 2019.

In addition to excavation surveys the team tested the effectiveness of an inexpensive drop camera at estimating abundance of clams in the intertidal zone. If successful, this camera could have helped communities to conduct their own population assessments. However, the water from the high tide, which is needed to access the intertidal zone by boat, disturbed much of the fine substrate in the area causing many of the clams to retract their siphons. The disturbed substrate quickly filled the holes left by the siphons and made it very difficult to accurately count the number of individuals present. It was therefore determined that drop cameras are not suitable for this task. The team is continuing to work with community members to develop gear that will help make the clams more accessible.

Seaweed Resource Assessment

Seaweed is another resource that already sustains subsistence harvests in Kimmirut and Iqaluit. However, its commercial potential has yet to be explored. Nearshore seaweed is an easily harvestable resource that could help to improve food security within communities and provide economic opportunities in local and international markets. Seaweed also provides important habitats for burrowing species, such as the soft-shell clam. The development of either resource will therefore require baseline knowledge of the degree of seaweed abundance in different areas.

The CSAR team began work exploring ways to assess seaweed cover in areas near Iqaluit in 2019 using aerial drones. The team set out to determine the optimal height from which to survey as well as the effectiveness of two different types of camera for identifying areas of submerged seaweed. A 4K multispectral camera, which produces images using wavelengths outside of those normally visible to the human eye, was compared to a 4K RGB camera, which produces the type of color images we are more used to seeing. Multispectral cameras are becoming more popular in scientific research as machine learning software can be utilized to recognize patterns in multispectral images. However, the survey results showed that the RBG camera was more effective for locating submerged seaweed. The team also determined that maps created using images from flights at 90 m was ideal.

In addition to exploring abundance, the team gathered samples of seaweed for trace metal and lead testing. Not only is this important nutritional information but it serves as a good measure of concentrations of metal within the surrounding environment. Seaweed are good bioindicators because they accumulate environmental metals in their tissues and are easy to collect and identify. Samples were collected from four species of edible macro seaweed: spiral wrack, broadleaf kelp, winged kelp, and dulse. The most prominent trace metals detected in the seaweed were arsenic, cadmium, copper, nickel, and zinc. While most were found in similar concentration to what has been reported in the Canadian Total Diet Study for fish and shellfish, higher concentrations of cadmium were found in broadleaf kelp and spiral wrack, of nickel in dulse and spiral wrack, and of lead in dulse. Continued monitoring will be needed to see if and how these concentrations change overtime in response to increased coastal development and population growth within communities.

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