

## Key issues affecting coastal aquatic ecosystems and changing coastal conditions in Nunavut:

A comparative assessment of five communities in the Kitikmeot region

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## Executive Summary

The Coastal Restoration Nunavut (CRN) project draws on Inuit Qaujimagatuqangit (IQ) to document and address the health and condition of marine species and their habitats. The objective of the research project is to identify and implement physical interventions to mitigate the stressors impacting aquatic species in each of Nunavut's 25 communities. Under the Oceans Protection Plan (OPP), the Government of Canada has identified coastal restoration as a key priority to address threats to aquatic ecosystems and marine biodiversity loss. "Coastal restoration" is defined as the action of returning something to its former condition; improving its current condition; or protecting it from further or future harm. "Coastal" refers to any area where marine and terrestrial processes meet and interact.

This technical report presents the findings of the CRN team visits to the five communities (Cambridge Bay, Gjoa Haven, Kugaaruk, Kugluktuk, Taloyoak) in the Kitikmeot region. In each of the communities, team members held participatory mapping workshops with the Hunters and Trappers Association, Hamlet staff, elders, and other resource users requesting to share their knowledge on coastal health and changing coastal conditions. The data collected represents a snapshot in time and are not a comprehensive inventory of all the coastal issues or priorities within a community.

A scan of the literature identified the following coastal topics as being relevant to the Kitikmeot region. These topics were 1. Sea and freshwater ice, and permafrost issues (including multi-year sea ice issues, glacier melt, and decreasing freshwater levels), 2. Marine mammal populations and health (seals, walruses, and whales), 3. Seasonal events and weather, 4. Fisheries, and 5. Polar and grizzly bear populations. Literature sources used in this review include the Nunavut Coastal Resource Inventories (Government of Nunavut, various dates), Arctic Corridors and Northern Voices reports (Carter et al., various dates), government documents and websites, and news articles.

The most noted change has been the decrease in water levels (31 mentioned accounts). This change has impacted communities by limiting access to key fishing sites. Decreasing water levels has similarly impacted the migratory routes of key species such as Arctic char. Residents also described an increase in exposed rocks as water levels lowered.

An increase in erosion was the second most frequently mentioned change (12 mentioned accounts). For example, Cambridge Bay knowledge holders noted that their graveyard was eroding, and water was washing out the road to the airport. Although culverts have been recently installed, they were too small. In Kugaaruk an island had disappeared years ago due to erosion. Kugluktuk knowledge holders also noted erosion of areas, e.g., Emnalokyoak riverbanks (Coppermine River), and other examples of roads being washed out due to erosion.

Species changes (7 mentioned accounts) were noted in Kugaaruk and Taloyoak. For example, in Kugaaruk, knowledge holders mentioned that the Kellet River was closed to commercial fishing because char were getting smaller (or there were more juveniles and not enough adults), whereas in Taloyoak knowledge holders noted a decline in lake trout at Krusenstern Lake and at Middle Lake, and that the fish were much smaller and less abundant.

Residents were also concerned about human impacts on the environment. Key issues raised included coastal and river pollution from garbage and ghost nets, and overfishing. In Cambridge Bay, community members reported that key habitats and migration routes were being disturbed by ATV crossings. Coastal habitats and migratory routes were also being impacted by the current placement (and limited) anchorage sites for cruise ships and other recreational vessels.

Community perspectives on actions needed to address coastal restoration priorities included: 1. The cleanup of contaminated sites, focusing on debris and garbage, 2. Environmental research and monitoring on water quality and fish health, and 3. Management interventions relating to fisheries, including stock assessments.

The report concludes with a section that describes several examples of projects, guidelines, research, and reports from Nunavut and other Canadian provinces and territories that focus on similar issues as those identified by the Kitikmeot communities during the CRN team visits. Based on the findings in this section, there are already quite a few strong initiatives in Nunavut that could be replicated and/or built upon. Moving forward, it will be important to share these examples with other communities and learn from the implementation of these initiatives to further build on our current knowledge base.

## 1.0 Introduction

Under the Oceans Protection Plan (OPP)<sup>1</sup>, the Government of Canada has identified coastal restoration as a key priority to address threats to aquatic ecosystems and marine biodiversity loss. Established in 2017-2018, the Coastal Restoration Fund (CRF) is a five-year grants and contributions program focusing on projects that (a) address the impacts of historical development; (b) mitigate the results of increased marine shipping; (c) contribute to the recovery of species that are considered threatened, endangered or at risk; and (d) build local capacity to restore and maintain coastal habitats<sup>2</sup>. In this context, “Coastal restoration” is defined as the action of returning something to its former condition; improving its current condition; or protecting it from further or future harm. “Coastal” refers to any area where marine and terrestrial processes meet and interact.

The Coastal Restoration Nunavut (CRN) project draws on Inuit Qaujimagatuqangit (IQ) to document and address the health and condition of marine species and their habitats<sup>3</sup>. In collaboration with communities, the objective of the research project is to conduct feasibility studies to identify and mitigate the stressors impacting aquatic species in each of Nunavut’s 25 communities. The project is committed to implementing at least three physical interventions identified as priorities by communities, one in each administrative region within the territory. The project also aims to strengthen capacity at the community level via local training; to document IQ; and to support each community in environmental restoration and stewardship initiatives.

The project builds on the successful baseline and monitoring programs developed and delivered by the Government of Nunavut, such as the Nunavut Coastal Resource Inventory (NCRI) and the Nunavut Community Aquatic Monitoring Program (N-CAMP).

Nunavut has three administrative regions (Figure 1) - Kitikmeot (Cambridge Bay, Gjoa Haven, Kugaaruk, Kugluktuk, Taloyoak); Kivalliq (Arviat, Baker Lake, Chesterfield Inlet, Coral Harbour, Nauyasat, Rankin Inlet, Whale Cove); and Qikiqtaaluk (Arctic Bay, Kinngait, Clyde River, Grise Fiord, Sanirajak, Iqaluit, Igloolik, Pangnirtung, Pond Inlet, Qikiqtarjuaq, Resolute, Sanikiluaq).



Figure 1: The three administrative regions of Nunavut

<sup>1</sup> <https://tc.canada.ca/en/initiatives/oceans-protection-plan>

<sup>2</sup> <https://www.dfo-mpo.gc.ca/ae-ve/evaluations/20-21/crf-frc-eng.html>

<sup>3</sup> For further information visit <https://www.coastalnunavut.ca/>

The purpose of this summary is to present a comparative analysis of the findings of the CRN team visits to the five communities in the Kitikmeot region. In each of the communities, team members held participatory mapping workshops with the Hunters and Trappers Association (HTA), Hamlet staff, elders, and other resource users requesting they share their knowledge on coastal health and changing coastal conditions. Community workshops and meeting discussions sought to learn more about the knowledge holders' perspectives on the following:

1. What are the coastal restoration priorities and needs in your community?
2. What coastal areas, if any, show historical or potential signs of degradation and/or contamination?
3. How have your social, economic, and cultural activities and practices been impacted by changes to the coastal environment?
4. What should be done to address these impacts?

Based on the knowledge shared during these workshops, community driven restoration projects were identified, feasibility studies conducted, and coastal restoration activities funded, following the recommendations presented in the feasibility studies.

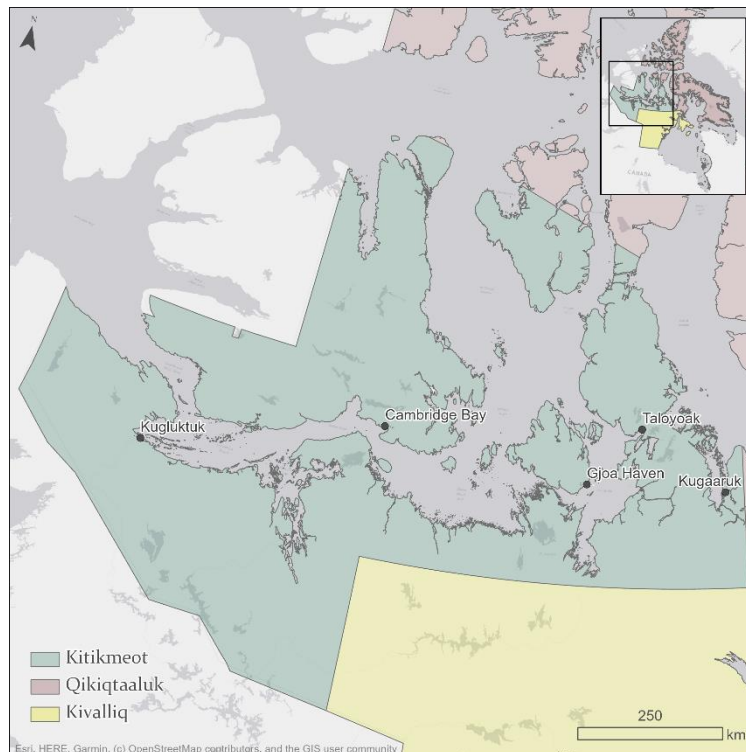
## 2.0 Kitikmeot region overview

Kitikmeot is one of three administrative regions of Nunavut, Canada. Prior to 1999, the Kitikmeot Region existed as part of the Mackenzie District of the Northwest Territories. The Kitikmeot Region consists of the southern and eastern parts of Victoria Island with the adjacent part of the mainland as far north of the Boothia Peninsula, together with King William Island and the southern portion of Prince of Wales Island. The regional hub is Cambridge Bay. **Table 1** provides a brief overview of the Kitikmeot region and **Figure 2** shows the location of the five communities.

**Table 1:** Overview of Kitikmeot region

Community	Population (2016)	Location	Elevation	Other details
Cambridge Bay	1,902	Latitude: 69°6'N Longitude: 105°08' 14.0" W	31m	Rolling plateau that rises from steep coastal cliffs. Lakes, ponds, and rivers are abundant.
Gjoa Haven	1,398	Latitude: 68° 37' N Longitude: 95° 52' W	47m	Flat coastal tundra. Substrate of sand, gravel, sandstone, boulders, limestone bedrock.
Kugaaruk	1,180	Latitude: 68°32'26.00" N Longitude: 89°47'50.00" W	17m	Coastal mountains and vast expanses of rugged, boulder-strewn tundra with many lakes, rivers, and streams.
Kugluktuk	1,517	Latitude: 67° 49' N Longitude: 115° 07' W	23m	Rocky hills surround the Hamlet, which is situated at the mouth of a large river
Taloyoak	1,146	Latitude: 69° 32'12" N Longitude: 93°31'37" W	28m	Vast expanses of rolling dark-tundra with boulders scattered along the coast. Numerous lakes and rivers.

**Source:** Travel Nunavut (<https://travelnunavut.ca/>) and Statistics Canada (<https://bit.ly/2QM84JI>)



**Figure 2: Communities in the Kitikmeot region**

**Cambridge Bay (ᐱᐆᐆᐆᐆᐆᐆ, Iqaluktuuttiaq, “Good fishing place”):** The community is located on the southeastern coast of Victoria Island, situated between Queen Maud Gulf and Dease Strait. The hunting and fishing area covers the Bathurst Inlet, southeast Victoria Island, Queen Maud Gulf, Victoria Strait, and Coronation Sound. Important species for food and income include arctic char, seals, geese, caribou, and muskoxen. The culturally and ecologically significant Ovayok Territorial Park is about 15km east of there. Southwest of Victoria Island is the Queen Maud Gulf (Ahiak) migratory bird sanctuary (Environment & Climate Change Canada, 2019).

**Gjoa Haven (ᐱᐆᐆᐆᐆᐆᐆ, Uqsuqtuuq, “Place of plenty blubber”):** Gjoa Haven is located on the southeast coast of King William Island. The community’s hunting and fishing area spans 100 km from Gjoa Haven in all directions, and extends into Rasmussen Basin, Chantrey Inlet, and Simpson Strait. The area is known to be a nesting place for many arctic birds, including migratory seabirds, ducks, and geese. Many freshwater lakes are important fishing areas for arctic char, lake trout, and lake whitefish. Coastal waters contain seals, bowhead whales, narwhal, and beluga whales. Polar bears are also present in the region (Government of Nunavut, 2018). The Northwest Passage Territorial Park is located on King William Island. Beginning at the Natilik Heritage Centre in Gjoa Haven, the park consists of six areas that show in part the history of the exploration of the Northwest Passage.

**Kugaaruk (ᐱᐆᐆᐆᐆᐆᐆ, “Little stream”):** The community is located on the southwest shore of the Simpson Peninsula, on the east side of Pelly Bay. The community’s hunting and fishing area covers approximately 1790km from north to south, and 1450km from east to west (Government of Nunavut, 2015a). Important coastal resources include bowhead whales, narwhals, seals, polar bears, and arctic char with residents sometimes travelling long distances to reach hunting and fishing grounds (Government of Nunavut, 2015a). Currently there are no national or territorial parks located near Kugaaruk, however, several fishing and hunting camps exist nearby (Travel Nunavut, n.d).

**Kugluktuk: (ᐱᐆᐆᐆᐆᐆᐆ, “Place of moving water”):** Kugluktuk is the furthest western community and is located close to the border with the Northwest Territories, where the Coppermine River empties into the Coronation Gulf along the southernmost route of the Northwest Passage (Travel Nunavut, n.d). Wildlife is very important both culturally and economically. Key species include Arctic char and whitefish, ringed seals, caribou, moose, muskoxen, wolverines, foxes, and grizzly bears (Government of Nunavut, 2010). Kugluk Territorial Park is located 13km southwest of Kugluktuk and has a long history of use by Dene and Inuit cultures. Onoagahiovik, a traditional campsite area in the park, is known to be a very good place to fish (Travel Nunavut, Kugluktuk, n.d).

**Taloyoak (ᑕᑭᑦᑲᑦᑲᑦ, “Large caribou blind”):** Taloyoak is the northernmost community on the Canadian mainland, situated northeast of Gjoa Haven and northwest of Kugaaruk. The community’s hunting and fishing area includes both coasts of the Boothia Peninsula and many inland lakes, extending from Franklin Lake on the Back River system to areas around the Prince of Wales and King William islands. The area includes the Bellot Strait, and Kuugaruk to Fort Ross, with the most harvesting use occurring in Lord Mayor Bay (Government of Nunavut, 2014).

### 3.0 Literature review synthesis

A brief literature review with references (Appendix 1) identified the following coastal topics as being relevant to the Kitikmeot region. These topics were **1.** Sea and freshwater ice, and permafrost issues (including multi-year sea ice issues, glacier melt, and decreasing freshwater levels), **2.** Marine mammal populations and health (seals, walruses, and whales), **3.** Seasonal events and weather, **4.** Fisheries, and **5.** Polar and grizzly bear populations. Literature sources used in this review include the Nunavut Coastal Resource Inventories (Government of Nunavut, various dates), Arctic Corridors and Northern Voices reports (Carter et al., various dates), government documents and websites, and news articles. The following section is a synthesis of the topics, providing first a summary, followed by examples of potential and current impacts on social, economic, and cultural activities and practices.

#### 3.1 Sea and freshwater ice, and permafrost issues.

**Summary:** Changes in sea and freshwater ice are a major issue for the Kitikmeot region. Examples of these changes include: a shorter duration of freshwater ice, less snow cover, a decrease in sea ice, sea ice forming later and breaking up earlier, not being as thick as previous years, less multi-year ice, more icebergs and rough ice, and longer ice-free seasons. Permafrost subsistence and land lift are also of concern due to glacier retreat, specifically in the Kugaaruk and Taloyok areas. Appendix 1 provides a detailed reference list.

##### **Impacts on social, economic, and cultural activities/practices:**

- Permafrost and land uplift have impacts on building foundations as these may need to be retrofitted to accommodate changing ground conditions. Land uplift is also lowering freshwater levels in lakes and rivers, which is affecting access to lake trout and Arctic char resources.
- Reduced ice thickness, a shorter ice season, and an increase in variable and unpredictable weather have impacts on the ability for people to travel and hunt safely. There may also be impacts to species and on habitats such as polar bear denning areas.

#### 3.2 Marine mammal populations and health (seals, walruses, and whales).

**Summary:** In some areas ringed seal, whales, and walrus populations have increased in size. For example, Taloyoak residents have noted that walrus populations appear to be increasing, with the most sightings reported on the west side of the Boothia Peninsula. Belugas and narwhal appear to be changing their migration routes in this area. However, belugas are not abundant in the Eastern Beaufort Sea but are occasionally present in the Coronation Gulf. Appendix 1 provides a detailed reference list.

##### **Impacts on social, economic, and cultural activities/practices:**

- In Gjoa Haven, seal abundance has increased in some areas and decreased in others. Given the importance of this species for food and other cultural uses, the community is interested in knowing more about seal health and abundance in the area.
- There are fewer whales in Gjoa Haven compared to other regions, but some areas around King William Island are important for whale harvesting, as migratory routes pass through here.
- Narwhals are common in the Kugaaruk area and are hunted by community members.
- In Kugluktuk, some residents thought that seals were getting smaller, thinner, and less healthy, i.e., when cut open, animals had visible blisters and infections.

#### 3.3 Seasonal events and weather

**Summary:** Overall, summers are getting warmer and longer, with more intense heat from the sun. The weather in the region also appeared to be more variable and unpredictable with increased annual occurrences of hail and thunderstorms. Earlier snow melts with a faster melt time have been reported. Changes in the strength and direction of



winds, and the increased frequency and intensity of storms are also noted by community members. Appendix 1 provides a detailed reference list.

**Impacts on social, economic, and cultural activities/practices:**

- Cambridge Bay residents are concerned about bacterial growth and water contamination in Water Lake (the main water source) due to warmer temperatures attracting or sustaining new species.
- Kugaaruk residents have witnessed more freezing rain, which covers ground vegetation in an ice layer. This can prevent caribou from foraging, which can lead to their starvation and death. Other community members have reported increased difficulty in predicting weather, which poses safety risks to hunting and fishing activities.
- Kugluktuk residents have observed changes in temperatures, as well as an apparent increase of species more typical of southern regions. These changes have impacted seasonal harvest patterns, i.e., the timing and distribution of species.
- Taloyoak community members reported that in 2013/2014 limited snowfall resulted in a shortage of available country foods that year. There has also been an increase in unpredictable weather, which poses risks to the safety of the community since they are less able to predict when extreme storm events may occur. Changes in wind patterns and precipitation also have an impact on the abundance and composition of species.

### 3.4 Fisheries

**Summary:** Arctic char is an important food and economic source for the Kitikmeot region. For example, Kugaaruk members noted that Arctic char is abundant in Pelly Bay and several lakes and rivers near the community. Cambridge Bay residents typically fish Arctic char between March and December, travelling in the spring and fall to catch fish through the ice of freshwater lakes, and in the summer to string nets along the southern shore of Victoria Island. Taloyoak residents indicated that several lakes appeared to have abundant fish populations that could support current subsistence harvesting, in addition to commercial quotas for the community. For example, Netsilik Lake and Middle Lake were identified as having abundant sources of sea-run Arctic char. Appendix 1 provides a detailed reference list.

**Impacts on social, economic, and cultural activities/practices:**

- Gjoa Haven residents reported changes in the taste and color of Arctic char, which may suggest a shift in the species diet (i.e., likely due to an increase in caplin). Other members have seen diseased char in the area. Studies currently underway include assessments on the overall health, quality, abundance, and distribution of fish, and the viability of developing a co-operative processing plant for the community.
- Kugaaruk community members have observed reddish spots on the skin of Arctic char, especially in areas with higher densities of fish. Fish also seem to taste different, and the skin of char seemed to be getting thinner each year.
- Kugluktuk residents observed that the health of some fish species was deteriorating, for example they were seeing boils, scratches, and parasites on the skin of the fish. Species were also getting smaller, which was attributed to having too many nets in the water, or nets with smaller mesh size than recommended. These changes were also linked to lower water levels in lakes/rivers, and pollutants from mining. For example, Arctic char, often harvested from the lower portion (16km) of the Coppermine River, used to be moderately larger than what fishers catch now.

### 3.5 Polar and grizzly bear populations.

**Summary:** In general, most of the communities in the Kitikmeot region have reported an increase in polar bears in their areas. Cambridge Bay community members have seen an increase in bears between 2005 and 2015, compared to earlier years. However, normally, polar bears are a rare occurrence but due to the abundance of seals they are sometimes attracted to the area. Similarly, Kugluktuk residents reported that polar bears are less common but appeared to be more abundant around the Beaufort Sea and Amundsen Gulf area, where ice conditions allow for productive seal hunting. Taloyoak members have also reported an increased presence of polar bears on the east side of the peninsula, specifically in the Lord Mayor Bay and Thom Bay areas. Kugaaruk residents have also seen polar bears on the western side of the Gulf of Boothia from Committee Bay to the northern part of the Boothia Peninsula, and throughout Pelly Bay. Appendix 1 provides a detailed reference list.

### Impacts on social, economic, and cultural activities/practices:

- Cambridge Bay residents noted that grizzly bears had been spotted in the area with an increased presence and aggressive behavior. Some bears appeared to be denning on the island (Government of Nunavut, 2015b).
- In 2011, Gjoa Haven residents had observed that the polar bear size and population around King William Island was growing larger, and they wanted more polar bear tags to increase hunting.
- Grizzly bears are common in the Kugluktuk area and are a general nuisance to people. Hunters believed they are gradually moving northward.
- Taloyoak residents noted that polar bears appeared to be more abundant near the community than in the past. The bears were also spending less time on the coast and ice where they used to be commonly found.

### 3.6 Other topics

Sea-level rise (SLR) and localised erosion were also noted in the literature. In Cambridge Bay, a study by the Nunavut Climate Change Secretariat indicated that the sea level was estimated to probably not fall more than 35cm, nor rise more than 50cm by 2100 (James, et al., 2011). SLR is dependent on how the mean sea level in the Arctic Archipelago relates to the global mean, how fast the land is rising in this region, and the effects of ice melt from glaciers and ice caps, including the Greenland and Antarctic ice sheets (Stern & Gaden, 2015). Whereas in Kugluktuk, SLR could be exacerbated by storm surges, leading to potential flooding and saltwater intrusion, both impacting local water supply (Manson et al., 2004). Gjoa Haven residents have identified an area of coastline around the town that could be prone to erosion. Infrastructure that could be impacted include residential properties, roads, trails, recreational areas, and the sealift dock and stockpile area.

### 3.7 Approaches to address these issues.

Drawing in general from the NCRI workshops conducted in the Kitikmeot region, the following three areas were identified as acceptable and respectful approaches for addressing coastal issues:

- Using Inuit Qaujimagatuqangit (IQ) and Western science to assess changing sea ice conditions and increasing vessel traffic, leading to the development and implementation of effective management strategies.
- Incorporating IQ into community climate change education.
- Methods to foster IQ knowledge transfer and increase the number of Inuit knowledge studies on key ecosystems and species, land use patterns, and climate change in the area.

Research needs identified by communities can be grouped into the following categories: baseline and monitoring programs, contaminated area assessments, coastal erosion surveys, economic development studies, and shipping and transportation monitoring. Community-specific needs and approaches are summarized as follows:

#### Baseline and monitoring programs

- **Cambridge Bay:** More research on the population status and health of species hunted and consumed in the community such as caribou, Arctic char, and ringed seals (Government of Nunavut, 2015b).
- **Gjoa Haven:** Water quality of major rivers pre-mining activities or pollution (particular concern around heavy metals and fish health). Research on the health and abundance of seals, fish, and caribou species (Government of Nunavut, 2018).
- **Kugaaruk:** Monitoring the health and population status of marine mammals and fish in the region using Inuit Qaujimagatuqangit and Western science (Government of Nunavut, 2015a).
- **Kugluktuk:** Research focusing on the health and abundance of species such as Arctic char, including an assessment of spawning areas and whether habitat ranges are changing (Evans et al., 2015). Impacts of pollutants from mining operations, and an assessment of water quality and impacts on fish species is also needed (Government of Nunavut, 2010). Assessments should be guided and informed by cultural knowledge / IQ.

#### Contaminated area assessments:

- **Gjoa Haven:** King William Island has many lakes and regions with permafrost and wetlands, which are expected to have increased concentrations of methylmercury as a result of warming (Government of Nunavut, 2018). Bioaccumulation of mercury in fish and other seafood is a risk. There are only a few published studies that focus

specifically around Gjoa Haven or King William Island. Residents are interested in learning which lakes have the highest mercury concentrations (Stern et al. 2011).

#### Coastal erosion surveys

- **Kugluktuk:** Identification of areas that are susceptible to erosion, particularly areas with existing infrastructure, or areas regularly accessed by residents. Previous restoration work to reduce erosion on Kugluktuk’s northern shore is now being undercut and destabilized by wave-induced erosion (Smith, 2014).

#### Economic development studies:

- **Gjoa Haven:** Marine tourism is a potential opportunity. However, marine stressors have been identified as a concern, including the impact of increased tourism and other vessel traffic on wildlife, increased waste going into the local landfill, potential marine pollution and the risk of oil spills (Carter et al., 2017).
- **Kugaaruk:** Research on commercial fisheries and implementing feasibility assessments for the most suitable species to use for commercial harvest. An exploratory study to assess a turbot fishery is needed (Government of Nunavut, 2015a).
- **Taloyoak:** Residents have expressed an interest in establishing a commercial fishery for arctic char and lake trout (Coastal Restoration Nunavut, 2014).

#### Shipping and transportation monitoring:

- **Kugaaruk:** Updated and improved Arctic waterway charts and increased mapping of Canada’s Arctic to prevent accidents and protect important coastal resources (George, 2019, May 2). Studies on potential impacts from Canadian Coast Guard vessels on seals, fish, and other coastal resources (Government of Nunavut, 2015b).
- **Taloyoak:** Concerns regarding the increase in shipping, and the impacts this may have on wildlife (Carter et al. 2017).

## 4.0 Methods

**Data collection:** In each community, one focus group was conducted at the HTO and/or Hamlet council, and one-on-one interviews were conducted with Hamlet staff and HTO members with each participant list approved by the HTO board of directors beforehand. The interviews were conducted in person, with all interviews and the selection of knowledge holders coordinated through the community HTO. Focus groups and focus group attendees were coordinated through the respective HTO and Hamlet. Communication between the CRN team and engaged communities began at least two months in advance of travel. Flexibility on behalf of the research team was required to adapt to scheduling conflicts and/or availability changes on the ground. The CRN research team was composed of a lead interviewer, as well as a local note taker and interpreter when possible. The data collected represents a snapshot in time and are not a comprehensive inventory of all the coastal issues or priorities within a community. Table 2 provides a summary of the data collection.

**Table 2:** Summary of data collection details

Community	Team visit	No. of Knowledge holders	Session length
Cambridge Bay	February 2019	8	1 hour
Gjoa Haven	February 2019	7	2 hours
Kugaaruk	March 2019	6	2 hours
*Kugluktuk	February 2019	8	1 hour
Taloyoak	March 2019	7	1 hour

\*Two focus groups were held in Kugluktuk, but there was no data collection during one, so this only captures the one.

**Data analysis (participatory maps):** Using participatory mapping and semi-structured interviews, knowledge holders were asked to identify changes, damages and risks to species, habitats and coastal activities over time, and the causes of and impacts from said changes. These questions lead to community-identified restoration priorities and/or potential interventions. Information from the interviews was then coded and themed by the data collection team.

**Data analysis (themes):** Using the codes created for the maps and assigned field notes, the information was then themed into the following four categories: general observations; changes to habitats, environment, and species; causes for these changes; and actions that are needed to address key coastal restoration issues. Table 3 provides a summary of the primary data sources used to address specific research questions.

**Table 3:** Research questions, sources for themes, and theme categories

Research questions	Source for themes	Theme categories
1. What are the community perspectives on coastal restoration needs?	Community field notes	<ul style="list-style-type: none"> <li>Coastal restoration actions needed in the Kitikmeot region (Priorities and needs)</li> </ul>
2. What coastal areas, if any, show historical or potential signs of degradation and/or contamination?	Mapping codes and community field notes	<ul style="list-style-type: none"> <li>Environment and ecological changes and causes</li> </ul>
3. How have socio-economic and cultural activities been impacted by changes to the coastal environment?	Mapping codes and community field notes	<ul style="list-style-type: none"> <li>Environment and ecological changes</li> <li>Coastal restoration actions needed in the Kitikmeot region (Priorities and needs)</li> </ul>
4. What should be done to address these impacts?	Community field notes	<ul style="list-style-type: none"> <li>Coastal restoration actions needed:               <ul style="list-style-type: none"> <li>Management interventions - fisheries</li> <li>Cleanup of contaminated sites</li> <li>*Environmental research and monitoring</li> <li>Restoration of key fishing areas, and</li> <li>**Ecological research and monitoring.</li> </ul> </li> </ul>
***Setting the context	Mapping codes	<ul style="list-style-type: none"> <li>General observations</li> </ul>

**Notes:**

\* Environmental research and monitoring are actions that focus on water quality, fish health due to contamination sources, and physical and/or chemical environmental assessments.

\*\* Ecological research and monitoring focuses on species abundance, migration patterns, habitat changes, etc.

\*\*\* Setting the context was not a research question but was used to describe mapping codes/information that did not fall into any of the other themes.

**Lessons learned:**

From a data collection perspective, lessons learned include prioritizing open, transparent, translated, and weekly communication with the respective communities before and after the research takes place; additional review of data, map locations and place names prior to departure; and receipt of contact details from all knowledge holders in case follow-up information is needed.

From the data analysis perspective, having an ongoing working code book developed after the first few visits have been completed can help in standardizing the information being collected. Debriefing meetings after visits also contribute to clearer interpretation of the data and highlight the potential to adjust approaches if needed. Also ensuring that there is a clear understanding and documentation of the methods being used by team members collecting the data and those doing the analysis (if different) help to ensure a smooth transition in the event of changes in team personnel. From a project management perspective, clear definitions for team member roles are essential, especially for new personnel taking on positions held by previous team members.

## 5.0 Findings

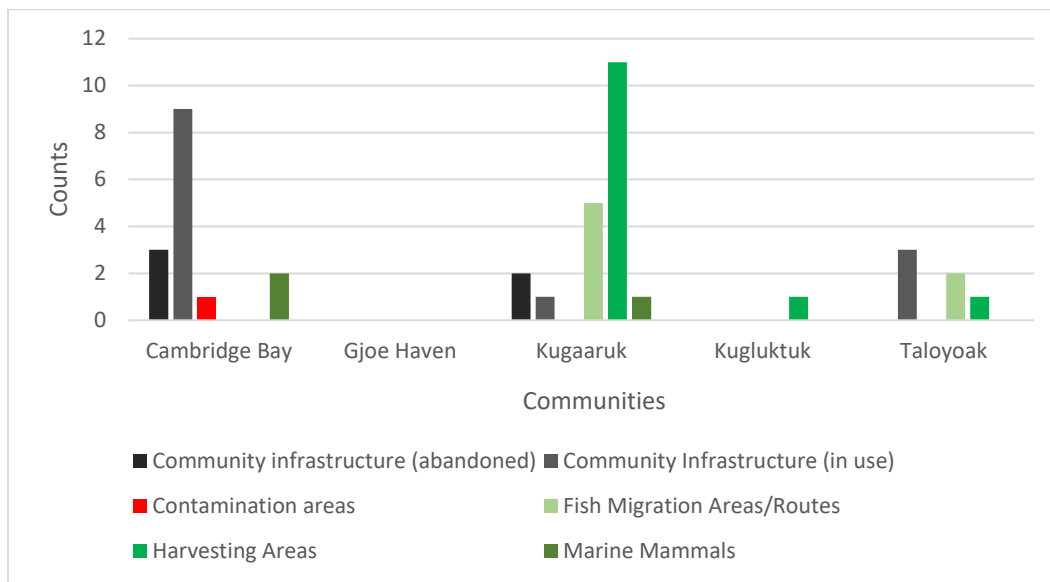
### 5.1 General observations

This category represents information drawn from the mapping codes and themed as “*general comments*” about specific areas, species, and infrastructure. In most instances comments are neither positive nor negative, but more a statement of what is there and the potential relevance to the person providing that information. Based on the approach taken for

this thematic analysis, none of the information collected from Gjoa Haven fell into this category. Figure 3 presents the themes that related to general observations.

The two most mentioned themes related to community infrastructure (currently in use) and harvesting areas. Examples of community infrastructure included bridges, cabins, roads, culverts, new graveyard, tank farm, and old runway. Harvesting areas focused on abundant areas for lake trout and sea-run Arctic char, and other fish species in general, and fish weir and gillnetting locations. One observation also noted hunting grounds for caribou and berry-picking areas.

Abandoned community infrastructure mainly shacks, boats, and barrels. The one contaminated area that was commented on referred to a site where water was green and near the dump and sewage lagoon (Cambridge Bay). Fish migration areas and routes describe sites where Arctic flounder congregate, whereas other areas are noted for char migrations from the Kugaaruk river to the lakes. Sightings of marine mammals related to seals, with one comment noting the abundance of the animals at the mouth of the Kugaaruk river.



**Figure 3:** General areas of interest (42 responses)

## 5.2 Environment and ecology changes to the coastal areas of the Kitikmeot region

This category represents information drawn from the mapping codes and field notes, and themed as “*environment and ecological changes*”. Changes were noted to have occurred within the lifetime of the person describing the event, species, or area. Figure 4 describes the main environment and ecological changes to the coastal environments of the Kitikmeot region. Appendix 2 contains community-specific maps depicting the spatial extent of related observations.

### 5.2.1 Physical and ecological changes

The most noted change has been the decrease in water levels (31 mentioned accounts). This change has impacted communities by limiting access to key fishing sites (e.g., boats are not able to navigate or pass through a channel). Decreasing water levels have similarly impacted the migratory routes of key species such as Arctic char and in some cases, fish are stuck at certain points along the river system. Knowledge holders also described an increase in exposed rocks as water levels lowered. Specific examples include:

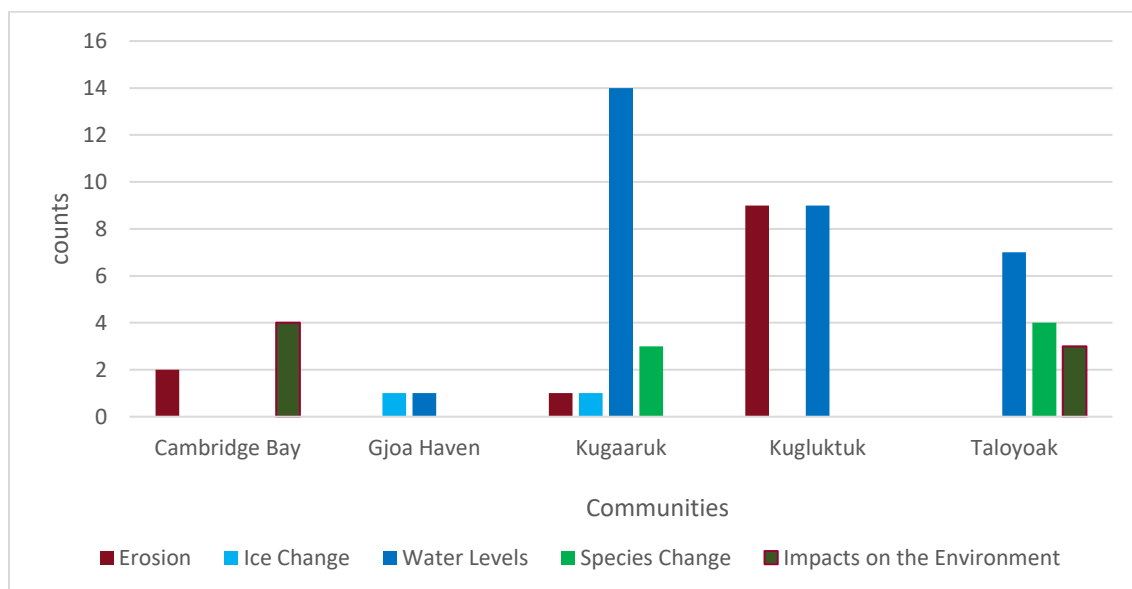
- Gjoa Haven – Due to decreasing water levels in the river there is a need for a deeper channel, as water feeds into Koka (Quuqa) Lake, which is a key fishing site for the community.
- Kugluktuk – Currently, specific areas (Kakotalik, Tikigak, Avalikgonik) are too shallow for boat navigation.
- Taloyoak – The river that connects to Redfish Lake is drying up and is very shallow at the mouth of the river. This is an important char migration route so deepening of the river needed as it also feeds into Lord Mayor Bay.

For more details about these sites, please refer to Appendix 2.

An increase in erosion was the second most frequently mentioned change (12 mentioned accounts). For example, Cambridge Bay knowledge holders noted that their graveyard was eroding, and water was washing out the road to the airport. Although culverts have been recently installed, they were too small. In Kugaaruk an island had disappeared years ago to erosion. Kugluktuk knowledge holders also noted erosion of areas, e.g., Emnalokyoak riverbanks (Coppermine River), and other examples of roads being washed out due to erosion.

Species changes (7 mentioned accounts) were noted in Kugaaruk and Taloyoak. In Kugaaruk, knowledge holders mentioned that the Kellet River was closed to commercial fishing because char were getting smaller (or there were more juveniles and not enough adults). In Simpson Lake, parasites were noted on char, which were also much thinner than in the past. Crab legs and mussels were also noted in the stomachs of bearded seal but were not seen along shorelines. Taloyoak knowledge holders noted a decline in lake trout at Krusenstern Lake. At Middle Lake, the fish were much smaller and less abundant. Overall, char seemed to be much longer and thinner now, which may also be a result of lowering water levels.

Ice changes were noted in Gjoa Haven (ice blocking entranceway of the bay) and Kugaaruk (Committee Bay is packed with multi-year ice every summer).



**Figure 4:** Environment and ecological changes in the coastal areas (55 responses)

### 5.2.2 Human impacts on the environment.

Taloyoak knowledge holders were concerned about impacts on the environment. Overall, there were too many gill nets and the over-netting of fish was having an impact on local fisheries and the environment. For example, at Panikto Lake, residents have noticed a decline in lake trout populations, which was attributed to over-netting in this area. The river system was also being heavily polluted with lots of garbage and ghost nets.

In Cambridge Bay, knowledge holders noted river crossings where ATVs drive directly into the water, disturbing habitats and migration routes. Other issues related to the current placement (and limited) anchorage sites for cruise ships (such as the Crystal Serenity in 2016), sailboats, and yachts.

### 5.3 Community perspectives on coastal restoration in the Kitikmeot region (Priorities and Needs).

This category represents information drawn from the field notes and themed as “*coastal restoration priorities*”. Table 4 provides a summary of the main coastal restoration priorities identified by the communities.

**Table 4:** Summary of the main coastal restoration priorities identified by the communities.

Communities	Main priorities and comments
Cambridge Bay	When the team visited the community, there were no urgent coastal restoration priorities identified. However, improvements in culvert design are needed to enhance water flow in some areas, which may reduce changes in fish behavior, such as the avoidance of migratory routes.
Gjoa Haven	<ol style="list-style-type: none"> <li>1. The restoration of access areas for key fishing sites (e.g., deepen river mouth/channel or rearrange boulder garden).</li> <li>2. Remediation of contaminated areas - which is a concern as some sites require increased and ongoing monitoring of contaminants and others require the physical removal of old gill nets.</li> </ol>
Kugaaruk	<ol style="list-style-type: none"> <li>1. The restoration of key fishing rivers and monitoring of water quality and fish health in local waterbodies, as water levels are too low and rivers are drying up so remediation action and new infrastructure will be required.</li> <li>2. Observed changes in water quality and fish health in some areas have been noted for a while. Community-led water quality and fish health monitoring programs should be put in place.</li> </ol>
Kugluktuk	<ol style="list-style-type: none"> <li>1. A gill net exchange and river restoration work at various sites.</li> <li>2. Reducing the impacts of erosion on current and future infrastructure is a priority.</li> </ol>
Taloyoak	<ol style="list-style-type: none"> <li>1. The restoration of key fishing rivers and the monitoring of fish health in local waterbodies. Water levels are currently too low, and rivers are drying up; therefore, remediation and new infrastructure will be required.</li> <li>2. Changes in fish appearance and abundance have also been observed and long-term, community-led fish health monitoring programs need to be implemented.</li> </ol>

Community perspectives on coastal restoration actions emerged from the mapping codes that were themed under the category – “*action needed to address coastal restoration priorities*”, The information was further sub-themed into the following five sub-categories:

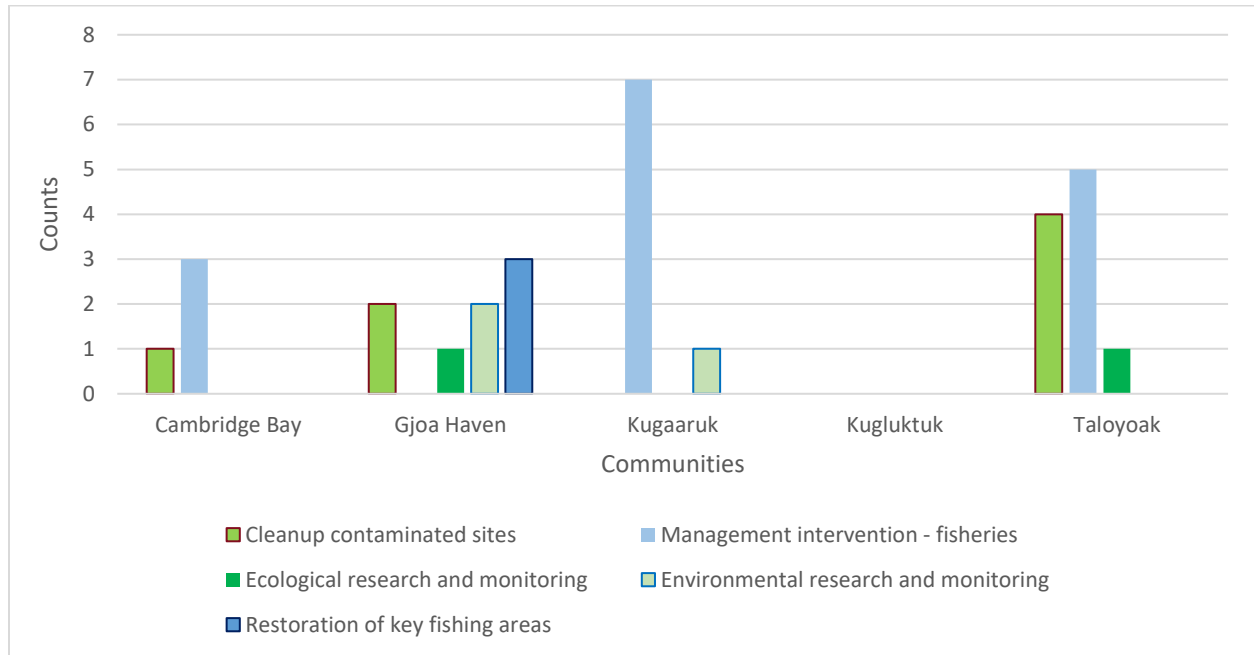
1. **Cleanup of contaminated sites** including garbage, discarded fishing gear, and assessments on the impacts on fish and habitats from contaminants.
2. **Environmental research and monitoring** – focused on water quality and fish health due to mining activities and the presence of mercury levels in lake trout and the environment.
3. **Ecological research and monitoring** on the health of char and other species at specific lakes and rivers.
4. **Management interventions – fisheries** relating to stock assessments, fishing quotas, gear, and regulations of boats and planes that were preventing access to key fishing areas.
5. **Restoration of key fishing areas** due to decreasing water levels and the impacts on access to fishing sites and species migration routes.

Based on the approach taken for this thematic analysis, none of the coded mapping information collected from Kugluktuk fell into the “action needed” category. However, based on the field notes (Table 4), community knowledge holders identified one management intervention related to fisheries (gill net exchange) and the need for river restorations at various sites. Another action, which could fall under environmental research and monitoring is the ongoing assessment of erosion, specifically around current and future infrastructure. Figure 5 summarizes the coastal restoration actions needed, as described by the knowledge holders.

**Cleanup of contaminated sites** were noted by three communities (Cambridge Bay, Gjoa Haven, and Taloyoak). In Cambridge Bay, knowledge holders mentioned that there was a lot of garbage en route to cabins. Knowledge holders

from Gjoa Haven mentioned the presence of gill nets frozen into the ice that need to be removed, and lots of garbage, metal, and plastic from old dump sites south of community. Knowledge holders also wanted to know how hazardous the garbage/sewage lagoon was, and what impact this might have on contaminating fish, land, and water.

**Ecological research and monitoring** studies were identified by Gjoa Haven and Taloyoak knowledge holders. In Gjoa Haven communities wanted to monitor the health of fish at Swan lake, which is a key community fishing site. Whereas for Taloyoak, the community wished to monitor the health of char populations at Red lake.



**Figure 5:** Coastal restoration actions needed (30 responses)

**Environmental research and monitoring** - requested studies for Gjoa Haven residents focused on water quality and fish health due to mining activities where there might be high mercury levels in lake trout. The presence of a nearby gold mine caused concern, and the community would like baseline water quality testing. The Water Board used to monitor this area when Nunavut was still NWT. Water monitoring typically falls under GN Health but only if the water is a potable water source, i.e., dedicated source of community drinking water. Kugaaruk was also requesting mercury testing at a key fishing site.

**Management interventions – fisheries** were the most mentioned theme (15 accounts). For Kugaaruk and Taloyoak most of the comments were centered around char fishing quotas. In Kugaaruk, there was also a call for char stock assessments. Whereas in Taloyoak, the request was for a commercial char quota for Netsilik and Lord Lindsay lakes. For Cambridge Bay, interventions were needed to manage gill net fishing at key sites and the regulation of boats and planes that were preventing access to these sites.

**Restoration of key fishing areas** was identified by Gjoa Haven knowledge holders, specifically because of decreasing water levels, and there was a need to deepen channels or rearrange boulder gardens. For example, at the Iqalummiut River, the mouth is too shallow now from drifting sand and some parts are only a foot deep or even shallower.

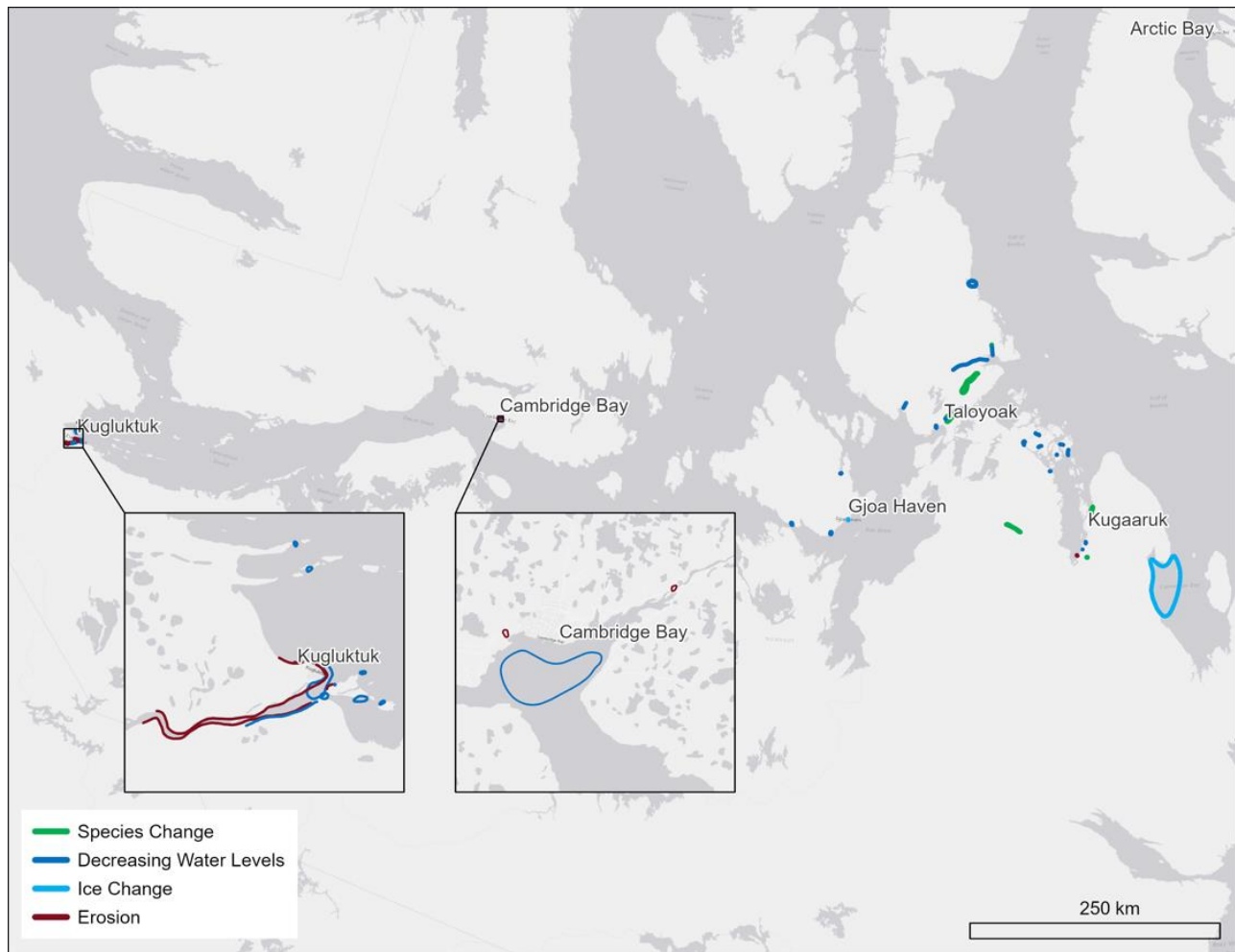


## 6.0 Synthesis and discussion.

### 6.1 Community coastal restoration priorities.

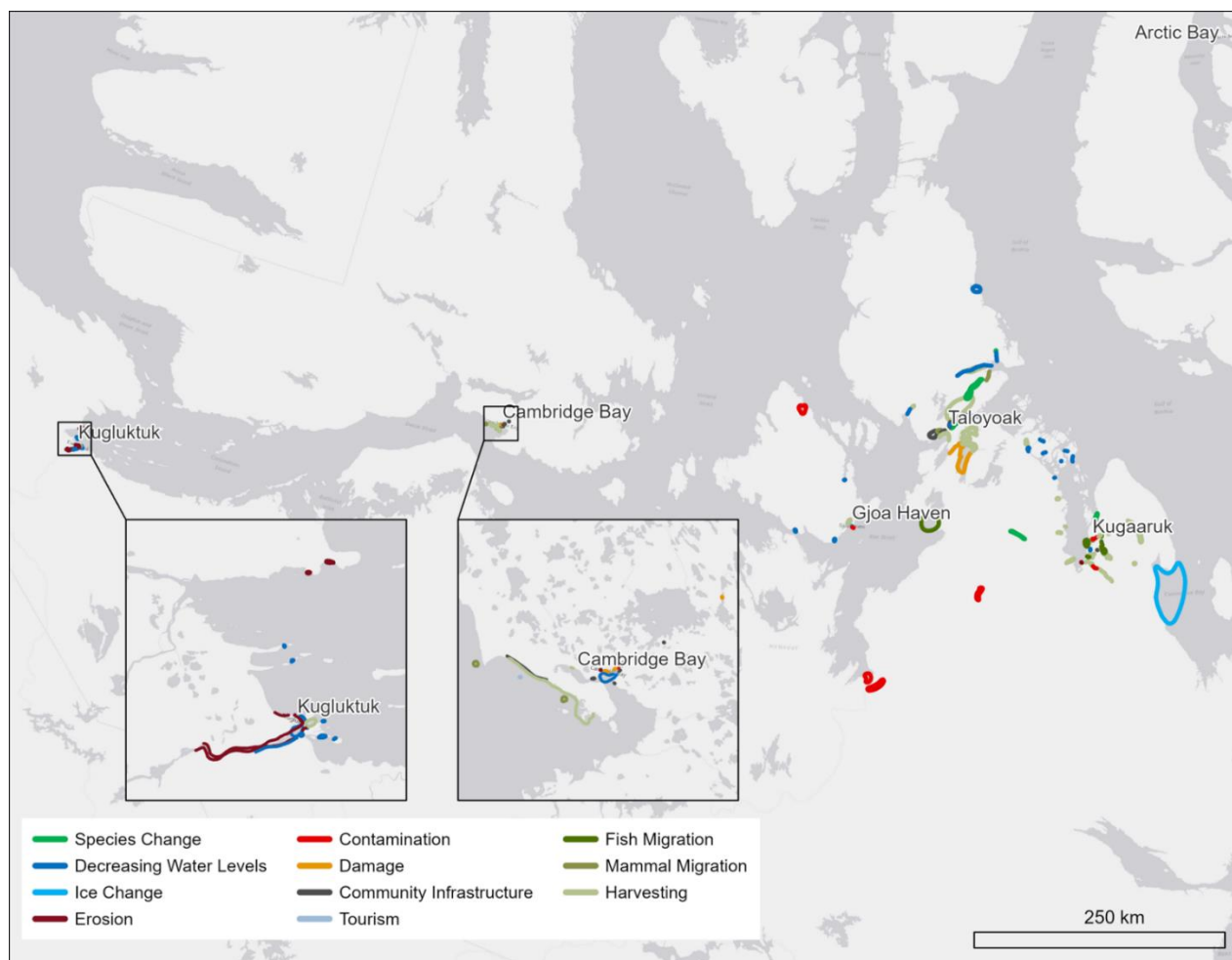
From the perspective of the communities, the major coastal issue was the lowering of water levels, followed by increased erosion, and changes to species and habitats (Figure 6).

Communities also identified human impacts to the environment, including overfishing, river pollution from garbage, and abandoned gillnets (ghost nets), and anchorage issues from visiting cruise ships, yachts, and other pleasure crafts (Figure 7).



**Figure 6:** Kitikmeot coastal areas showing historical or potential signs of degradation and/or contamination related to decreasing water levels, erosion, species and habitat changes and ice changes.

Drawing from the literature, changes in sea and freshwater ice are a major issue for the Kitikmeot region. Other concerns noted were changes in seasonal events and weather, and the health and abundance of marine mammals and fish species. Sea-level rise and localized erosion were also identified as a concern. Although there were only a few comments from the communities specific to ice issues, the interconnectedness of the hydrological system and the broader influence of weather patterns and seasonal events suggest that this will be a major ongoing and complex management issue to address.



**Figure 7:** Representation of the extent and type of spatial observations in the five communities in the Kitikmeot region.

## 6.2 Impacts on social, economic, and cultural activities/practices.

Table 5 summarizes the most important concerns for the Kitikmeot region, and the impacts that these issues are having on social-economic and cultural activities and practices. Numbers 1-5 summarizes the community perspectives, whereas points 6-11 are drawn from the literature.

**Table 5:** Coastal concerns and impacts on social, economic, and cultural activities and practices.

Coastal Issue – Community perspectives	Impacts on social, economic, and cultural activities/practices
1. Decrease in water levels - Disrupted migratory routes of key species, e.g., Arctic char.	<ul style="list-style-type: none"> <li>Limiting access to key fishing sites (boats not able to navigate shallow waters).</li> </ul>
2. Increased erosion.	<ul style="list-style-type: none"> <li>Erosion of graveyards.</li> <li>Road and culvert washouts.</li> <li>Land/islands disappearing.</li> </ul>
3. Species and habitat changes <ul style="list-style-type: none"> <li>Arctic char getting smaller and thinner.</li> <li>More juveniles, less adults.</li> <li>Parasites and other lesions noticed on char.</li> <li>Ice blockages and increased coverage of multi-year ice.</li> </ul>	<ul style="list-style-type: none"> <li>Food security concerns, including community health from eating contaminated species.</li> <li>Changes in texture and taste of species (e.g., Arctic char)</li> <li>Navigation and travelling safety issues.</li> </ul>
4. Overfishing using gill nets (including smaller mesh sizes) and increase in abandoned ghost nets.	<ul style="list-style-type: none"> <li>Food security from declining fish populations.</li> <li>Pollution from nets and other garbage in the rivers and water systems.</li> </ul>

<p>5. Other human impacts</p> <ul style="list-style-type: none"> <li>• River crossings where ATVs drive directly into the water.</li> <li>• Current placement (and limited) anchorage sites for cruise ships, sailboats, and yachts.</li> </ul>	<ul style="list-style-type: none"> <li>• Disturbance to habitats, including haul outs, and migration routes.</li> </ul>
<p><b>Coastal Issue – Literature review</b></p>	<p><b>Impacts on social, economic, and cultural activities/practices</b></p>
<p>6. Changes in sea and freshwater ice, and permafrost issues.</p>	<ul style="list-style-type: none"> <li>• Permafrost and land lift are impacting building foundations.</li> <li>• Land uplift is lowering freshwater levels, which is affecting access to lake trout and Arctic char resources.</li> <li>• Reduced ice thickness and a shorter ice season has safety impacts on travelling and hunting.</li> </ul>
<p>7. Sea level rise (SLR) and localized erosion</p>	<ul style="list-style-type: none"> <li>• Kugluktuk: SLR could be exacerbated by storm surges, leading to potential flooding and salt-water intrusion impacting local water supply.</li> <li>• Gjoa Haven: identified area of coastline around the town that could be prone to erosion and could impact important infrastructure.</li> </ul>
<p>8. Changes in marine mammal populations and health (seals, walruses, and whales).</p>	<ul style="list-style-type: none"> <li>• Fluctuating populations of marine mammals are of concern as these species are important for food security and cultural practices.</li> </ul>
<p>9. Seasonal events and weather</p> <ul style="list-style-type: none"> <li>• Summers are warmer and longer.</li> <li>• Weather more variable and unpredictable.</li> <li>• Earlier snow melts and faster melt time.</li> <li>• Increased frequency and intensity of storms.</li> </ul>	<ul style="list-style-type: none"> <li>• Bacterial growth and water contamination in Water Lake (Cambridge Bay)</li> <li>• More freezing rain, which covers ground vegetation in an ice layer and can prevent caribou from foraging.</li> <li>• Increase of species more typical of southern regions has an impact on seasonal harvest patterns, i.e., the timing and distribution of resident species.</li> <li>• 2013/2014 (Taloyoak) limited snowfall resulted in a shortage of available country foods that year.</li> <li>• Unpredictable weather, which poses risks to the safety of the community since they are less able to predict when extreme storm events may occur.</li> <li>• Changes in wind patterns and precipitation also have an impact on the abundance and composition of species.</li> </ul>
<p>10. Fisheries</p> <ul style="list-style-type: none"> <li>• Diseased and injured char (e.g., parasites, boils, scars, and other blemishes) and thinner skins.</li> <li>• Changes attributed to contamination from mines, lowering water levels, and overfishing with gill nets and/or using smaller sized mesh nets.</li> </ul>	<ul style="list-style-type: none"> <li>• Changes in the taste and color of Arctic char, which may suggest a shift in the species' diet (i.e., due to an increase in caplin).</li> <li>• Food security and health concerns from eating contaminated fish.</li> </ul>
<p>11. Polar and grizzly bear populations</p> <ul style="list-style-type: none"> <li>• Increase in bear sightings (could be due to the abundance of seals) and population numbers.</li> <li>• Aggressive behaviour and moving closer to communities.</li> </ul>	<ul style="list-style-type: none"> <li>• Safety issues with more bears, i.e., they are coming closer to community dwellings.</li> <li>• Potential to increase hunting (issuing of more tags).</li> </ul>

### 6.3 Addressing impacts on coastal areas, and social, economic, and cultural activities/practices.

This section provides a brief overview of projects, guidelines, research, and reports from Nunavut and other Canadian provinces and territories that address the main issues identified by Kitikmeot communities during the CRN team visits. Approaches to address these issues are grouped into five main areas: 1. Cleanup of contaminated sites; 2 Ecological research on population changes in Arctic char and other important food species; 3. Environmental research, specifically on water quality and fish contamination from mining activities; 4. Fisheries management interventions, including stock assessments, fishing quotas, gear, and regulations of boats and planes that were preventing access to key fishing areas; and 5. Restoration of key fishing areas.

As noted in section 3.7, several important study areas for specific communities were also identified in the literature. These included baseline and monitoring studies for important food species, water quality, and habitat changes, contamination assessments, coastal erosion monitoring and remediation, economic development studies, and research and policy interventions due to the increased shipping and maritime transportation in the region. Human interventions for the restoration of key fishing areas could include deepening river mouths and channels and establishing and/or arranging boulder gardens. Boulder gardens are sets of large stones placed in the stream channel to provide fish habitat (LCSMC, 2002). Other examples are presented below.

#### **A Cleanup of contaminated sites.**

Waste management at the community level usually addresses municipal solid waste, referred to as “recyclables and compostable materials, and includes garbage from homes, businesses, institutions, and construction and demolition sites” (Environment & Climate Change Canada, 2017). The Government of Canada also defines a contaminated site as “one at which substances (usually a petroleum product or a metal) occur at concentrations (1) above background (normally occurring) levels and pose or are likely to pose an immediate or long-term hazard to human health or the environment, or (2) exceeding levels specified in policies and regulations” (Treasury Board of Canada Secretariat, n.d.). Based on the responses from the knowledge holders, the focus of this section will be mainly on waste management for debris and garbage. Examples of regulations that are relevant to this issue include: the Canadian Environmental Protection Act, the Transportation of Dangerous Goods Act, the Fisheries Act, the Arctic Waters Pollution Prevention Act, the National Fire Code, and the Explosives Act. Provincial and territorial governments each have their own legislation and regulations relating to environmental protection, water resources, municipalities, public health, and sanitation (Oceans North, 2021; Song, 2016).

Nunavut does not have legislation that pertains directly to solid waste management, nor is there a specific strategy for solid waste management (Oceans North, 2021). However, several regulations provide guidance on waste management (Song, 2016). These include: The Nunavut Agreement that establishes the Nunavut Water Board; Nunavut Waters and Nunavut Surface Rights Tribunal Act, SC 2020c10 (use of water and disposal of waste in waters in Nunavut); Arctic Water Pollution Prevention Act, RSC 1985cA-12 (deposit of waste in Arctic waters); Fisheries Act, RSC 1985, cF-14 (activities harmful to fish, disposal of prejudicial/deleterious substances in waters where fishing is conducted); Environmental Protection Act, RSNWT 1988, c E-7, s.5 (discharge of contaminant into the environment); General Sanitation Regulations R.R.N.W.T 1990, c. P-16 Public Health Act (insanitary conditions, accumulation and deposit of garbage, municipalities responsibilities); and various environment guidelines issued by the Nunavut Department of Environment pertaining to the disposal of various types of waste (Song, 2016).

In 2014, a fire, dubbed Dumpcano, engulfed the 150 m<sup>2</sup> dump. The fire lasted for four months and cost the city \$3 million to extinguish. It also created up to 2000°C of heat and released chemicals into the air, resulting in health warnings and the closure of schools for several days (WWF, 2020). In July 2018, the city announced a new waste management plan that involves closing the old site and creating a new waste transfer station that aims to reduce landfill waste by 44 per cent through recycling of tires and scrap metal, among other waste diversion initiatives (Oceans North, 2021). In 2021, Iqaluit began constructing a new landfill, with additional plans to develop a recycling and eco-centre and alternative collection methods for residential, commercial, and industrial waste (WWF, 2020).

Other examples of reports, guidelines, and programs addressing solid waste management are provided in Table 6.

**Table 6:** Examples of reports, guidelines and programs addressing solid waste management.

Province/ Territory	Summary	Contact/Reference Links
QU	<p><b>Practical guide for the dismantlement, clean-up, and remediation of outfitting camps on the JBNQA/NEQA territory.</b> The Kativik Regional Government, northern Quebec (2019) has produced a practical guide for the dismantlement, clean-up, and remediation (DCUR) of outfitting camps in the James Bay and Northern Québec Agreement territory. These guidelines focus on safely and effectively conducting DCUR activities, in accordance with applicable laws, regulations, funding agreements and contracts, reducing threats to ecosystem and human health, treating contaminated areas, removing debris and hazardous materials, and transferring knowledge through the participation of Nations and their communities.</p>	<p>For more information see: <a href="https://bit.ly/3gottRk">https://bit.ly/3gottRk</a></p>
NFL, NWT, NU, QU	<p><b>Towards a Waste-Free Arctic:</b> This report provides an overview of waste management in Inuit Nunangat (Inuvialuit Settlement Region - NWT, Nunavut, Nunavik - northern Quebec, and Nunatsiavut - northern Labrador). Highlights of the report note that although Inuit communities do not accumulate more waste than communities in other parts of Canada, they are faced with managing similar quantities of waste with inferior infrastructure, limited services and programming, extremely poor access to eco-alternatives and fewer economic, educational, and capacity resources to develop lasting solutions. The report provides recommendations for how the private sector, civil society and all levels of government can address these issues.</p>	<p>For more information see: Oceans North (2021) <a href="https://bit.ly/2SoJsXD">https://bit.ly/2SoJsXD</a></p>
NU, NWT, YT	<p><b>Solid waste management for northern and remote communities: planning and technical guidance document.</b> Focusing on managing residual waste in a landfill cell within the community’s solid waste facility, the guidelines provide a four-step continuous approach to waste management planning: 1. Conduct a community waste assessment; 2. Set waste management priorities for the community; 3. Identify and evaluate options, and develop a plan; and 4. Implement, evaluate, and improve the plan.</p>	<p>For more information see Environment and Climate Change Canada (2017). <a href="https://bit.ly/3pAg8JW">https://bit.ly/3pAg8JW</a></p>
National	<p><b>The Great Canadian Shoreline Cleanup</b> presented by Loblaw Companies Limited and Coca-Cola Canada is one of the largest direct action conservation programs in Canada. Netsilik School (Taloyoak, Nunavut) has been organising clean-ups since the early 90’s. In 2016, Taloyoak was one of the top 5 clean-up communities with the largest number of knowledge holders. The organiser of the event noted that “Avatittinnik kamatsiarniq” or “environmental stewardship” is a key value of Inuit Qaujimatuaqangiit (IQ) and it is important that the youth realize from a young age that they need to carry on the tradition of looking after the land, water and air for generations of humans and animals to come.</p>	<p>For more information see: <a href="http://www.ShorelineCleanup.ca">www.ShorelineCleanup.ca</a> Netsilik School story: <a href="https://bit.ly/3w8OohV">https://bit.ly/3w8OohV</a></p>

**B Ecological research on population changes in Arctic char and other important food species**

Arctic char is an important fishery for Nunavut. In 2015, over 72,000 kg of char were caught commercially for a market value of \$1.8 million (Department of Environment, Fisheries and Sealing Division, 2016). The Truly Wild Arctic Char brand and valued-added products such as char candy and char jerky are well known within and outside of Nunavut. Communities such as Naujaat, Coral Harbour, Igloodik, and Qikiqtarjuaq fish more in the winter, whereas Pond Inlet, Whale Cove, Rankin Inlet and Cambridge Bay fish in the summer months. Most fishing is done using gill nets, but at two

rivers in the Cambridge Bay area, fishing is done with weirs. The Kitikmeot communities are the only region to use air transport to move char to the processing plant as fishers in other regions transport their catch to town by snowmobile and qamutik, or by boat (Department of Environment, Fisheries and Sealing Division, 2016). Other examples of community-led projects addressing ecological research on Arctic char population changes are provided in Table 7.

**Table 7:** Community-led projects addressing ecological research on Arctic char population changes.

Province/ Territory	Summary	Contact/Reference Links
QU	<p><b>Community-based monitoring of Arctic char from the Nepihjee river system and other areas.</b> Makivik Corporation is the legal representative of Quebec's Inuit, established in 1978 under the terms of the James Bay and Northern Quebec Agreement. This monitoring program includes direct counting, measuring, and monitoring of Nepihjee River Arctic char to estimate the size of the population, understand size structure and growth over time, and track movement and migration patterns. Recently, the research branch secured \$62,416.25 from the Indigenous Community-Based Climate Monitoring program for 2020-2021.</p>	<p>For more information see: <a href="https://bit.ly/3zfScQE">https://bit.ly/3zfScQE</a></p>
NU	<p><b>Science and Inuit Qaujimajatuqangit join forces to better understand iqalukpiit / Arctic char in the Kitikmeot region.</b> In 2013, a collaborative project between Fisheries and Oceans Canada and the Ocean Tracking Network was initiated to utilize acoustic telemetry to track the migrations of Arctic char (marine and freshwater) in the region. Local youth were trained to conduct semidirected ethnocartographic interviews to document the IQ of nine individuals from the community. In August 2016, a week-long Elder-youth knowledge exchange camp that also included biologists and social scientists was held at Ekalluk River (an archaeological site used for over 4,000 years) to exchange and share knowledge about Arctic char.</p>	<p>For more information see: Thorpe, et al., 2018 <a href="https://bit.ly/3gpiHPb">https://bit.ly/3gpiHPb</a></p>
NFL, NWT, NU, QU	<p><b>Linking Inuit and scientific knowledge and observations to better understand Arctic char (<i>Salvelinus alpinus</i>) community monitoring.</b> The research explored community-based monitoring factors and parameters across Inuit Nunangat that is needed to provide information for local resource users and decision-makers to make informed choices for managing Arctic char populations. This research is helpful in that it identifies Arctic char environmental parameters that could be monitored for species and habitat health. What is also interesting about this research is the exploration of different aspects of community-based Arctic char monitoring, including the establishment of the programs, monitoring schedules and parameters, partnerships, funding, inclusion of IQ, and knowledge dissemination.</p>	<p>For more information see: Knopp, 2017 <a href="https://bit.ly/359CkB7">https://bit.ly/359CkB7</a></p>

**C. Environmental research, specifically on water quality and fish contamination from mining activities**

The Northern Contaminated Sites Program<sup>4</sup>, under Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC), and the Northern Contaminants Program<sup>5</sup> (NCP) are two of the most relevant federal programs pertaining to this issue. The objective of the Northern Contaminated Sites Program is to manage contaminated sites to reduce or eliminate, where possible, risks to human and environmental health, and to decrease the federal environmental liability associated with contaminated sites in the North. Policies associated with the Northern Contaminated Sites Program include the Northern Affairs Program Environment, Health and Safety Policy; the Mine Site Reclamation Policy for the Northwest Territories; and the Mine Site Reclamation Policy for Nunavut.

At the territorial level, the Nunavut General Monitoring Plan (NGMP)<sup>6</sup> provides for the collection, analysis, and reporting of information on the long-term conditions of Nunavut’s environment, people, communities, and economy. General monitoring is a requirement under the Nunavut Agreement, and is founded within the Nunavut Agreement and the Nunavut Project Planning and Assessment Act (NuPPAA). The NGMP is managed and operated by the NGMP Secretariat and overseen and governed by the NGMP Steering Committee, consisting of representatives from the Nunavut Planning Commission (NPC), Nunavut Tunngavik Inc. (NTI), the Government of Nunavut (GN), and Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) on behalf of the Government of Canada. The NGMP Secretariat is housed within CIRNAC.

Selected projects funded and/or supported by these three programs include the Tłıchq Aquatic Ecosystem Monitoring Program, Understanding and predicting fish mercury levels in the Dehcho region, and the Community-based monitoring program for the Baker Lake/Chesterfield Inlet Ecosystem (Table 8).

**Table 8:** Community-led environmental research, specifically on water quality and fish contamination from mining activities.

Province/ Territory	Summary	Contact/Reference Links
NWT	<p><b>Tłıchq Aquatic Ecosystem Monitoring Program (TAEMP).</b> The Wek’èezhii Renewable Resources Board (WRRB) is a wildlife co-management authority established by the Tłıchq Agreement. The TAEMP is implemented by the WRRB and has the objective of building and developing a successful community-based monitoring program that meets the needs of the Tłıchq people in determining whether fish, water, and sediment quality are changing, and whether fish and water remain safe to consume. The program started in 2010, with the most recent report produced in 2018.</p>	<p>For more information see: <a href="https://www.wrrb.ca/about-wrrb">https://www.wrrb.ca/about-wrrb</a></p>
NWT	<p><b>Understanding and predicting fish mercury levels in the Dehcho region.</b> The focus of this project is to better understand why fish mercury levels are relatively low in some lakes yet not elsewhere, and why fish mercury levels are increasing in some lakes, but stable in others. This study builds on previous work by the University of Waterloo in partnership with the Dehcho First Nations. Fish, water, other small animals, and plants were sampled from eight Dehcho lakes between 2013 and 2015, and it was found that some fish mercury levels can be predicted from water quality measurements and fish age.</p>	<p>For more information see: Swanson &amp; Low, 2017 <a href="https://bit.ly/2Te8hWg">https://bit.ly/2Te8hWg</a>  Online open access Dehcho Region water quality data set (2019) (<a href="https://bit.ly/2R6u1To">https://bit.ly/2R6u1To</a>)</p>

<sup>4</sup> <https://www.rcaanc-cirnac.gc.ca/eng/1100100035301/1537371472183>

<sup>5</sup> [https://science.gc.ca/eic/site/063.nsf/eng/h\\_7A463DBA.html](https://science.gc.ca/eic/site/063.nsf/eng/h_7A463DBA.html)

<sup>6</sup> <https://www.ngmp.ca/eng/1363792048577/1363792058944>

Province/ Territory	Summary	Contact/Reference Links
NU	<p><b>Community-based monitoring program for the Baker Lake and Chesterfield Inlet ecosystem and other areas.</b></p> <p>The Baker Lake and Chesterfield inlet ecosystem is a three-year project (2019-2021) funded by the Nunavut General Monitoring Plan. The project is being implemented by ARCTICconnexion, a community science group. This project focuses on the development of local capacity to monitor water quality and quantity, fish, shipping activities, and the presence of marine and terrestrial wildlife to collect independent and community-owned information that can guide future actions. The communities also perform landscape and watershed analysis with satellite imagery. Local observations and perspectives are documented in the communities through mapping and group discussions.</p>	<p>For more information see: Nunavut General Monitoring Plan <a href="https://bit.ly/3v47Xqp">https://bit.ly/3v47Xqp</a> ARCTICconnexion <a href="https://arcticonnexion.ca/">https://arcticonnexion.ca/</a></p>

#### D Fisheries management interventions

Fisheries and Oceans Canada (DFO) and the Canadian Coast Guard are responsible for fisheries management and the safeguarding of Canadian waters<sup>7</sup>. A number of acts support and guide these responsibilities, including the *Oceans Act*, *Fisheries Act*, *Species at Risk Act*, *Coastal Fisheries Protection Act*, *Canada Shipping Act, 2001* (which is led by Transport Canada), and the *Fishing and Recreational Harbours Act*. Other initiatives that fall under DFO, which might be of interest to communities are the Integrated fisheries management plans (IFMP), Aboriginal aquatic resource and oceans management (AAROM) program, and the Sustainable fisheries solutions and retrieval support contribution program, or Ghost gear fund.

The purpose of the IFMPs is to guide the conservation and sustainable use of marine resources, support the management of sustainable fisheries, and combine science and Indigenous knowledge on fish species with industry data to determine best practices for harvest<sup>8</sup>. The IFMP is not a legally-binding instrument, cannot form the basis of a legal challenge, can be modified at any time, and does not fetter the Minister's discretionary powers set out in the Fisheries Act. The AAROM Program<sup>9</sup> supports Indigenous groups to establish and maintain aquatic resource and oceans management departments that can provide fisheries, habitat, science, and oceans related services along a watershed. The program also supports community participation in advisory and co-management processes and decision-making related to aquatic resources and oceans management. The ghost gear fund<sup>10</sup> focuses on actions to reduce plastic in the marine environment through four main areas: 1. ghost gear retrieval, 2. responsible disposal, 3. acquisition and piloting of available technology, and 4. international leadership. Other examples of fisheries management interventions are provided in Table 9.

**Table 9:** Examples of fisheries management interventions

Province / Territory	Summary	Contact/Reference Links
AB	<p><b>Native Trout Recovery Program</b></p> <p>Alberta's Native Trout Recovery Program is a comprehensive, long-term fish conservation initiative aimed at monitoring and recovering populations of native trout and whitefish in the watersheds of the Eastern Slopes. The Native Recovery Program's focus is to recover the species through understanding the threats to its survival, through co-ordinated action, and through the support of stakeholders,</p>	<p>For more information see: <a href="https://bit.ly/2Spdhax">https://bit.ly/2Spdhax</a></p>

<sup>7</sup> <https://www.dfo-mpo.gc.ca/about-notre-sujet/mandate-mandat-eng.htm>

<sup>8</sup> <https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/index-eng.html>

<sup>9</sup> <https://www.dfo-mpo.gc.ca/fisheries-peches/aboriginal-autochtones/aarom-pagrao/index-eng.html>

<sup>10</sup> <https://www.dfo-mpo.gc.ca/fisheries-peches/management-gestion/ghostgear-equipementfantome/programme/projects-projets-eng.html>



	the public, and multiple levels of government. As a component of the integrated provincial fisheries management approach, the recovery program focuses on Westslope cutthroat trout, bull trout and Athabasca rainbow trout recovery planning processes; a watercourse crossings remediation program; and Whirling disease and invasive species management.	
NU	<p><b>Integrated Fishery Management Plan (IFMP) - Cambridge Bay Arctic Char, <i>Salvelinus alpinus</i>, Commercial Fishery, Nunavut</b></p> <p>The Arctic Char commercial fishery addressed in this plan occurs on Victoria Island, near the community of Cambridge Bay. The IFMP was developed to be relevant over a long period of time and has no fixed end date. Through regular reviews by the IFMP Working Group and stakeholders, updates and amendments will be provided to the NWMB and Minister of Fisheries and Oceans for approval, as required. The IFMP was made effective in 2014, with a 2021 review currently underway. Examples of best practices that are currently in place in the commercial fishery focus on the reduction of any potential impact to spawning populations. These include measures such as the release of spawners if captured in the gillnet fishery if still alive, all spawning char released in a manner that causes them the least harm, and when encountered in a weir fishery, all spawners should be released unharmed.</p>	For more information see: <a href="https://bit.ly/3g6GgsY">https://bit.ly/3g6GgsY</a>
NU	<p><b>Coastal Restoration Nunavut</b></p> <p>The communities of Kugluktuk, Taloyoak and Kugaaruk have requested assistance with a community-wide net exchange. All the communities identified the need for strategic fishing methods to support the health and sustainability of the subsistence char fishery, which is mostly fished by gill net. A successful net exchange was first implemented by the community of Kugluktuk in the nineties to prevent high stock exploitation and a potential recruitment failure due to diminished stock size. To conduct a net exchange, fishers exchange old nets with nets of a larger mesh size. One objective of the mesh size approach is to influence the sustainable yield in the long-term. Other reasons are to protect juvenile fish from capture and to ensure that enough fish survive to maturity.</p>	For more information see: <a href="https://www.coastalnunavut.ca/">https://www.coastalnunavut.ca/</a> or email <a href="mailto:crn@dal.ca">crn@dal.ca</a> .
NWT	<p><b>Paulatuk Char Fisheries Management Plan</b></p> <p>The Paulatuk Char Working Group (PCWG) was formed in 1996 with the goal to establish a community fishing plan for Arctic char from the Hornaday River population. The community was concerned about the numbers and size of Arctic char and saw the need for a fisheries management plan. Voluntary community-based harvest surveys were conducted to enumerate fish and marine mammal subsistence harvests. These measures continue to support sustainable management of Arctic char populations in the area.</p>	For more information see: Lee, 2020: <a href="https://bit.ly/3w6Zc0h">https://bit.ly/3w6Zc0h</a> Paulatuk community conservation plan: <a href="https://bit.ly/3pBzj63">https://bit.ly/3pBzj63</a>

## E Restoration of key fishing areas

On February 6, 2018, Fisheries and Oceans Canada introduced proposed amendments to restore lost protections and incorporate modern safeguards into the Fisheries Act. On June 21, 2019, the new Fisheries Act received royal assent and became law<sup>11</sup>. Prior to 2012, the Fisheries Act provided broad protection for fish and fish habitat throughout Canada. In 2012, changes were made so that only fish and habitat related to a commercial, recreational, or Aboriginal fishery were protected. Some of the key elements of the modernised Fisheries Act include the protection against the ‘death of fish, other than by fishing’ and the ‘harmful alteration, disruption or destruction of fish habitat’, requirements that Indigenous knowledge must inform habitat decisions, consideration of the adverse effects of decisions on the rights of Indigenous peoples, the protection for Indigenous knowledge when provided in confidence to the Minister, and the ability to enter into agreements with Indigenous governing bodies and any body established under a land claims agreement, as well as provinces and territories (Fisheries and Oceans Canada, 2021, April 14). Specifically focused on

<sup>11</sup> <https://www.dfo-mpo.gc.ca/campaign-campagne/fisheries-act-loi-sur-les-peches/introduction-eng.html>

coastal restoration, the Coastal Restoration Fund, launched in 2017, is part of the national Oceans Protection Plan. Appendix 5 provides a broad overview of projects that have been funded under this program.

One often cited example of coastal restoration work in Nunavut is the Bernard Harbour project in Kugluktuk. Historical evidence describes large char runs in the summer and significant Inuit use of Bernard Harbour (Golder Associates Ltd., 2014). However, community members noted declines due to low water and ‘blockages’ in the creek. The Kugluktuk Hunters and Trappers Association (HTA) originally proposed stream restoration initiatives at Bernard Harbour beginning in the early 2000s and since then the HTO has since worked closely with Golder Associates and other partners (e.g., Environment Canada, GN Department of Environment) to advance this work. From 2010 to 2013, Golder designed, coordinated, and led a study to address community concerns and collect novel scientific information on char at Bernard Harbour. Community involvement was a crucial component of the project and was accomplished through the incorporation of Inuit knowledge and local expertise, and the engagement of HTO summer students and residents of Kugluktuk to facilitate youth education and encourage community stewardship (Golder Associates Ltd., 2014). In June 2014, an agreement to complete stream restoration work as a mining offsetting project was signed with Sabina (Sabina Gold & Silver Corp., 2015). Other examples of coastal restoration initiatives are provided in Table 10.

**Table 10:** Examples of coastal restoration initiatives.

Province / Territory	Summary	Contact/Reference Links
QU	<p><b>The Nepihjee river Arctic char fishway restoration project.</b>            The organisation is conducting a project to continue the minor restoration work initiated in 2019. The objective of this project is to remove debris in the river, allowing for a clear path for Arctic char to migrate upriver. The project is being funded by a \$46,157.96 grant from the Climate Change Preparedness in the North program for 2020-2021. Another project is focused on the restoration of fish habitat affected by mining activities in the north, in collaboration with MiraNor.</p>	<p>More information about these projects can be obtained by contacting the Makivik Corporation <a href="https://www.makivik.org/contact/">https://www.makivik.org/contact/</a></p>
NFL	<p><b>Parker’s Brook restoration.</b>            In 2020 the Pistolet Bay Parker’s Brook char association partnered with WWF-Canada to organize the Parker’s Brook: Then and Now workshop. The event brought together community members, resource managers, and science and engineering experts to share information on the Parker’s Brook aquatic system and its ecologically unique population of Arctic char, Atlantic salmon, and brook trout. The project encouraged community engagement in the planning of restoration actions and long-term stewardship of the river and its aquatic resources.</p>	<p>Several resources can be found on the association’s website: <a href="https://bit.ly/3yW2ipM">https://bit.ly/3yW2ipM</a></p>
NU	<p><b>Preserving Arctic char habitat and Indigenous fisheries in Western Hudson Bay.</b>            This project addresses issues such as isostatic rebound that has reduced water levels resulting in the emergence of physical obstacles like rocks that impede fish migration. Climate change has also impacted these areas and has increased the risk of permafrost slumping which may create new barriers (either physical or chemical) in the future. The plan includes simple, mechanical methods to improve migration opportunities (e.g., pry bars and come alongs) following examples of other similar restoration initiatives such as those used to successfully restore Nulahugyuk Creek near Bernard Harbour. Inuit will be trained to collect data inputs to habitat occupancy modeling during restoration activities in year two (2020), and as part of follow up monitoring in year three (2021).</p>	<p>For more information see:            Nesbitt et al., 2019  <a href="https://bit.ly/3xa6C2I">https://bit.ly/3xa6C2I</a></p>

Province / Territory	Summary	Contact/Reference Links
NU	<p><b>Coastal Restoration Nunavut - Restoration projects in Clyde River &amp; Coral Harbour.</b> The community of Clyde River (Qikiqtaaluk Region) is located on the northern shore of Patricia Bay, Baffin Island. The mouth of the Clyde River enters the bay to the east of the community. An old road crosses the river about 2,000 m upriver from its mouth. A boulder riprap (human-built structure) had been placed in the river to reduce the water depth and allow traffic to cross. Community members noted that Arctic char were impacted by these changes, as it restricted their migration routes from the ocean to freshwater. In 2018, a plan to remove the riprap structure and return the river to a more natural flow was put into place. Working with the assistance of Dalhousie University, and the Government of Nunavut, the HTO has also developed an upstream migration monitoring plan to assess and share information about the river and char runs. This plan includes a counting fence structure and a video recording system to reduce stress on the fish.</p> <p>The community of Coral Harbour (Kivalliq Region) is on Southampton Island in Hudson Bay. Residents have noted that Coates Island rivers are drying up and getting too shallow to dock. A rockslide occurred on Canyon River in 2017 and the community wished to remove boulders from the area to free the channel, as there is less fish in the lakes. Commercial fishing for Arctic char occurs in the lakes as well as year-round subsistence fishing, but due to the rockslide, fishing sites are difficult to access. Harvesters also hunt seals and beluga there. Six members from the Aiviit Hunters and Trappers Association (HTO) travelled to the site in spring 2020 and restored approximately 10 m<sup>2</sup> of the river habitat. This work supports local fish populations, habitat health, and subsistence fishing and food sovereignty. Work continued in spring 2021 to maintain this important area. An additional 10 m<sup>2</sup> was restored.</p>	<p>For more information see:  <a href="https://www.coastalnunavut.ca/">https://www.coastalnunavut.ca/</a> or email <a href="mailto:crn@dal.ca">crn@dal.ca</a>.</p>
NWT	<p><b>Beaufort Sea Coastal Restoration Project, Northwest Territories.</b> This study focuses on sites in the Galiptat Area, Imnaqpaluk, and Tuktoyaktuk Island. The sites were chosen in consultation with the Tuktoyaktuk Hunters and Trappers Committee. The objectives of the study are to use historical aerial photographs and satellite imagery to map the progression of coastal erosion and thaw slumping (1967 to 2004 to 2018), study the progression of thaw slumping at these three sites, examine these effects on water quality and run-off into the Kugmallit Bay, and investigate methods by which plant species native to Tuktoyaktuk region can be used to restore disturbed coastline.</p>	<p>Further details on the approach and preliminary results can be found on the project's website:  <a href="https://nwtresearch.com/beaufort-sea-coastal-restoration-project">https://nwtresearch.com/beaufort-sea-coastal-restoration-project</a>.</p>
General	<p><b>Aquatic Habitat Canada</b> is a national network supporting aquatic habitat protection and restoration. Aquatic Habitat Canada works to encourage and assist governments, local communities, Indigenous organizations, industry stakeholders and conservation organizations to protect and restore aquatic ecosystems to ensure they are healthy, resilient to the effects of changing climate and environmental conditions and provide ecosystem services to their full potential more effectively. Four core themes of the network are: 1. Restoration planning and prioritization, 2. Resources and capacity-building, 3. Knowledge synthesis and transfer, and 4. Policy and program. In addition to technical guides and success stories, other useful resources include a 2020 review of aquatic habitat restoration regulations and policies under the Fisheries Act, and funding opportunities, both Canada-wide and province specific.</p>	<p>More information can be found on the network's website:  <a href="https://aquatichabitat.ca/">https://aquatichabitat.ca/</a>.</p>

## 7.0 Conclusion.

This technical report presents the findings of the CRN team visits to the five communities (Cambridge Bay, Gjoa Haven, Kugaaruk, Kugluktuk, Taloyoak) in the Kitikmeot region. During these workshops, knowledge holders shared their knowledge on topics relating to coastal restoration priorities, ecological and habitat changes, and impacts on their social, economic, and cultural activities and practices. Community members also identified approaches that could help address these impacts.

The most noted change, and hence the top coastal priority is the decrease in water levels, which has impacted the migratory routes of key species such as Arctic char and limited community access to key fishing sites. Erosion impacts such as eroding graveyards, loss of land area and riverbanks, and road washouts were reported from Cambridge Bay, Kugaaruk, and Kugluktuk. Species changes, specifically Arctic char were noted in Kugaaruk and Taloyoak, as knowledge holders observed fish were smaller, less abundant, and cohorts with more juveniles than adults.

Knowledge holders were also concerned about human-induced effects on the environment. Key issues raised included coastal and river pollution from garbage and ghost nets. Overfishing (gill netting) in specific areas, such as Panikto Lake in Taloyoak, was also an issue. In Cambridge Bay, community members reported that key habitats and migration routes were being disturbed by ATV crossings. Coastal habitats and migratory routes were also being impacted by the current placement (and limited) anchorage sites for cruise ships and other recreational vessels.

There were no specific responses to the issue of decreasing water levels, which is most likely a systematic impact of climate change, and beyond the control of the communities. However, knowledge holders identified key actions that could still allow access to key fishing sites and maintain important migratory routes. These interventions included: 1. The cleanup of contaminated sites, focusing on debris and garbage, 2. Environmental research and monitoring on water quality and fish health, and 3. Management interventions relating to fisheries, including stock assessments. Other interventions that could positively influence the continuation of social, economic, and cultural activities and practices were environmental research, specifically on water quality and fish contamination from mining activities, and river restoration projects and programs.

The brief overview of regulations and policies relating to coastal priorities reveals the siloed governance approach to addressing these issues. Projects and programs tended to be more holistic and integrated both the social and ecological components into activities such as char monitoring, river restoration, and environmental monitoring. Most if not all projects and programs included an Inuit-centered approach and a coming together of Inuit and Western science knowledge. However, policies and regulations are shifting towards a similar approach as seen in the development of the integrated fisheries management plans and waste management guidelines. Based on the findings in section 6.3, a few strong initiatives in Nunavut have emerged that could be replicated and/or built upon. Moving forward, it will be important to share these examples with other communities, learn from the implementation of these initiatives, and further build on our current knowledge base.

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## Appendix 1: Overview of the literature

### 1. Sea and freshwater ice and permafrost

Cambridge Bay residents have noticed that spring starts earlier and sea ice forms later, taking up to two months longer before it is safe to travel on<sup>6</sup>. The extent of sea ice in the Victoria island region is decreasing steadily over time and the trend to a later freeze-up, and earlier melt is expected to continue<sup>5</sup>. Residents have also noticed a shorter duration of freshwater ice and snow, thinner and less multi-year ice, and a longer ice-free season in the area<sup>3</sup>.

Gjoa Haven community members have observed that the sea ice is forming later and breaking up earlier in the year, when compared to pre-1970s<sup>2</sup>. For example, break-up seems to be occurring in mid- to early-July (compared to August), and safe ice for travel is forming after mid-November to early-December (compared to October or early November in the past)<sup>4</sup>. Sea ice is also not as thick as it used to be and there seems to be less snow than 30+ years ago, resulting in more dangerous travel conditions and impacts to species habitats (e.g., polar bear denning areas)<sup>4</sup>.

Kugaaruk residents have noticed longer ice-free seasons, less MYSI and increased unpredictability of conditions<sup>4</sup>. In 2015 the sea ice appeared to be getting thinner compared to previous years, and cracks in the ice appear to be getting wider<sup>2</sup>. Residents have also reported an increase in 'rotten ice' or ice in an advanced stage of break-up<sup>6</sup>. Others have noted that they saw more icebergs and rough ice in 2015 that made it difficult to hunt<sup>4</sup>. Some members also reported that the permafrost is melting<sup>4</sup>, which may have impacts on freshwater levels, and that sea levels appear to be declining in the region<sup>4</sup>. Land uplift is also leading to lower freshwater levels in lakes and rivers, which is affecting access to lake trout and arctic char resources<sup>6, 7</sup>.

In Kugluktuk, typically, the ice season lasts from late October to July, and the Coronation Gulf often remains mostly ice-covered into mid-July<sup>5</sup>. This marks a change from the past, where freeze-up used to occur in late August-September and break-up occurred later than it does presently<sup>6</sup>. Overall, reduced ice thickness and a shorter ice season have been observed around the community, which has impacts on the ability for people to travel and hunt<sup>6</sup>.

Taloyoak community members have reported that the sea ice in their area is becoming thinner and there is less multi-year ice<sup>4</sup>. Community members have also noticed a longer ice-free season (earlier break-up and later freeze-up) and an increase in variable and unpredictable weather<sup>4</sup>. Permafrost subsistence is a concern in the community and building foundations may need to be retrofitted to accommodate changing ground conditions<sup>6</sup>. Due to glacial retreat in this area, the land is rebounding to its former height, resulting in what appears to be declining sea levels. Like Kugaaruk, land uplift is also affecting freshwater levels in lakes and rivers, impacting the health and abundance of fish such as arctic char<sup>4</sup>.

### 2. Marine mammal populations and health (seals, walruses, and whales)

Ringed seals are abundant in the Cambridge Bay area and are an important part of the local economy<sup>6</sup>. Bearded seals are also present in the area and are abundant in the spring and summer when the ice is breaking up and there is an abundance of prey e.g., capelin<sup>6</sup>. Beluga sightings have increased from 2005 to 2015 and are seen consistently in the area from 2010 to 2015<sup>6</sup>. Since 2013, narwhals and orcas have also been observed in the area<sup>6</sup>.

In Gjoa Haven, surrounding King William Island, ringed seals are found year-round. Bearded seals are also present, although in less abundance<sup>2</sup>. Seal abundance has increased in some areas and decreased in others, and there is interest in knowing more about seal health and abundance in the area<sup>2</sup>. There are fewer whales compared to other regions but some areas around King William Island are important for whale harvesting as migratory routes pass through here<sup>2</sup>.

Kugaaruk residents have noted that ringed seals and bearded seals are found throughout Pelly Bay<sup>2</sup>. Ringed seals are also found in Lord Mayor Bay and Committee Bay where they form large groups when the ice melts<sup>2</sup>. Bearded seals enter Pelly Bay in early summer and stay through winter, utilizing solid land-fast ice areas as haul-out locations<sup>4</sup>. Narwhals are common and are hunted by community members<sup>4</sup>. In the summer, bowhead whales also enter Pelly Bay from the north<sup>2</sup>. Beluga whales are less common but are now starting to come into this area<sup>2</sup>.

Kugluktuk community members note that seals are common in the area, with ringed seals often found occupying land-fast coastal ice, and bearded seals found in shallower water<sup>2</sup>. Residents thought that some seals were smaller, thinner,

and less healthy looking<sup>6</sup> with some observed as having blisters, or even infections when cut open<sup>10</sup>. Belugas are not abundant in the Eastern Beaufort Sea but occasionally visit the Coronation Gulf<sup>8</sup>.

Taloyoak residents have noted that walrus populations appear to be increasing, with most sightings reported on the west side of the Boothia Peninsula<sup>3</sup>. Community members have also observed an increased presence of walrus in the Franklin Strait area and that they are gradually moving closer to the community<sup>3</sup>. Other residents reported an increase of ringed seal populations on the east side of the Boothia Peninsula near Lord Mayor Bay. Whereas bearded seals appeared to be more abundant on the west side near King William Island<sup>3</sup>. Residents are also seeing a substantial increase in whales, with an unusually high numbers of beluga and narwhal passing near the community every few years. Belugas and narwhal also appear to be changing their migration routes<sup>3</sup>.

### **3. Seasonal events and weather changes**

Cambridge Bay residents are concerned about bacterial growth and water contamination in Water Lake (the main water source) due to warmer temperature species<sup>5</sup>. People have noticed warmer and longer summers, more intense heat from the sun, shorter winters, and less snowfall or later snowfall<sup>3</sup>. Weather in the region appears to be more variable and unpredictable with increased annual occurrences of hail and thunderstorms<sup>5</sup>.

Similarly, in Gjoa Haven, residents have observed warmer temperatures (or more extreme temperatures) in the summer, and longer summers overall<sup>5</sup>.

Kugaaruk community members have observed earlier snow melts and/or this happens quicker, and there is a shorter duration of freshwater ice<sup>4</sup>. Residents have also witnessed more freezing rain, which covers ground vegetation in an ice layer and can prevent caribou from foraging, which can lead to their starvation and death<sup>4</sup>. Other community members have reported increased difficulty in predicting weather, which poses safety risks to hunting and fishing activities. Other changes include the strength and direction of winds, and the increase in frequency and intensity of storms<sup>4</sup>.

Kugluktuk residents have observed changes in temperatures, as well as an apparent increase of species more typical of southern regions<sup>2</sup>. This impacts seasonal harvest patterns i.e. the timing and distribution of species.

Taloyoak community members reported that winters are warmer, there is less snowfall, and an increase in unpredictable weather patterns. Summers seems longer, snow melts earlier or quicker than before, and there is a shorter duration of freshwater ice<sup>4</sup>. In 2013/2014 limited snowfall resulted in a shortage of available country foods that year. There has also been an increase in unpredictable weather, which poses risks to the safety of the community since they are less able to predict when extreme storm events may occur. Changes in wind patterns and precipitation also have impacts on the abundance and composition of species<sup>5</sup>.

### **4. Fisheries**

Arctic char is an important food and economic source for Cambridge Bay residents, and the species are typically fished between March and December<sup>6</sup>. Residents travel in the spring and fall to catch char through the ice of freshwater lakes, and in the summer to string nets along the southern shore of Victoria Island<sup>6</sup>.

Gjoa Haven residents report changes in the taste and color of Arctic char, which may suggest a shift in the fish's diet. Others have noticed seeing diseased Arctic char in the area<sup>2</sup>. Studies are currently focusing on the overall health, quality, abundance, and distribution of fish, and the viability of developing a co-operative processing plant for the community<sup>6,7</sup>.

Kugaaruk members have noted that Arctic char is abundant in Pelly Bay as well as several lakes and rivers near the community<sup>2</sup>. Changes to the char include having reddish spots on their skin, mostly in areas with higher densities of fish<sup>4</sup>. Fish also seem to taste different, and the skin of char appears to be getting thinner each year<sup>2</sup>.

Kugluktuk residents report that some fish species health is deteriorating, for example boils, scratches, and parasites on the skin. Other changes include being smaller in size, which was attributed to having many nets in the water, or nets with smaller mesh size than recommended. These changes were also linked to lower water levels in lakes/rivers, and pollutants from mining<sup>2</sup>. For example, Arctic char, often harvested from the lower 16 km of the Coppermine River<sup>9</sup> used to be moderately larger than what they are now.



Taloyoak residents have noted that several lakes have an abundance of fish that could support current subsistence harvesting, in addition to commercial quotas for the community. For example, Netsilik Lake and Middle Lake were identified as having abundant sources of sea-run Arctic char<sup>3</sup>.

## 5. Polar and Grizzly bears.

Cambridge Bay residents note that polar bears are usually a rare occurrence but due to the abundance of seals they are sometimes attracted to the area. Community members have seen an increase in bears between 2005 and 2015, compared to the past<sup>6</sup>. Grizzly bears had also been spotted in the region with an increased presence and aggressive behavior. Some bears appeared to be denning on the island<sup>6</sup>.

In 2011, Gjoa Haven residents had observed that the polar bear size and population around King William Island was increasing, and they wanted more polar bear tags to increase hunting<sup>2</sup>.

Kugaaruk community members have seen polar bears on the western side of the Gulf of Boothia from Committee Bay to the northern part of the Boothia Peninsula, as well as throughout Pelly Bay<sup>2</sup>.

Kugluktuk residents report that polar bears are less common but seem to be more abundant around the Beaufort Sea and Amundsen Gulf area where ice conditions allow for productive seal hunting<sup>2</sup>. Grizzly bears are common in the area and are a general nuisance to people. Kugluktuk hunters believed they are gradually moving northward<sup>2</sup>.

Taloyoak members reported an increased presence of polar bears on the east side of the peninsula, specifically in the Lord Mayor Bay and Thom Bay areas. Bears also appeared to be more abundant nearer the community than in the past and were also spending less time on the coast and ice where they used to be commonly found<sup>3</sup>.

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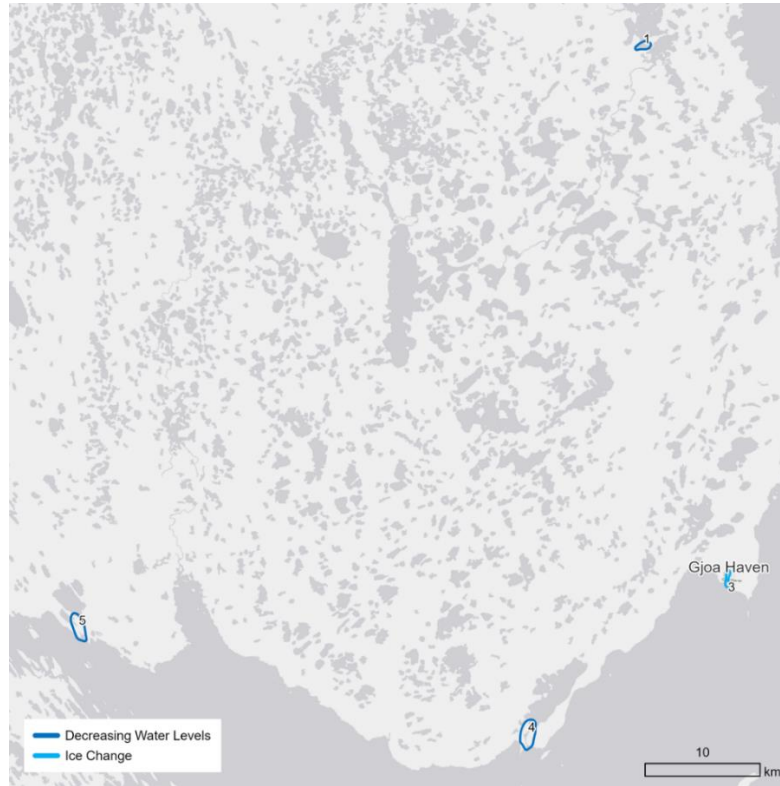
## Appendix 2: Community observations of environmental and ecological change

These maps show community-specific observations of the most frequently noted factors contributing to environmental and ecological coastal change. These maps represent what was recorded by participating individuals, and do not reflect the full extent of potential coastal change in the region.

**Figure 2a: Cambridge Bay**

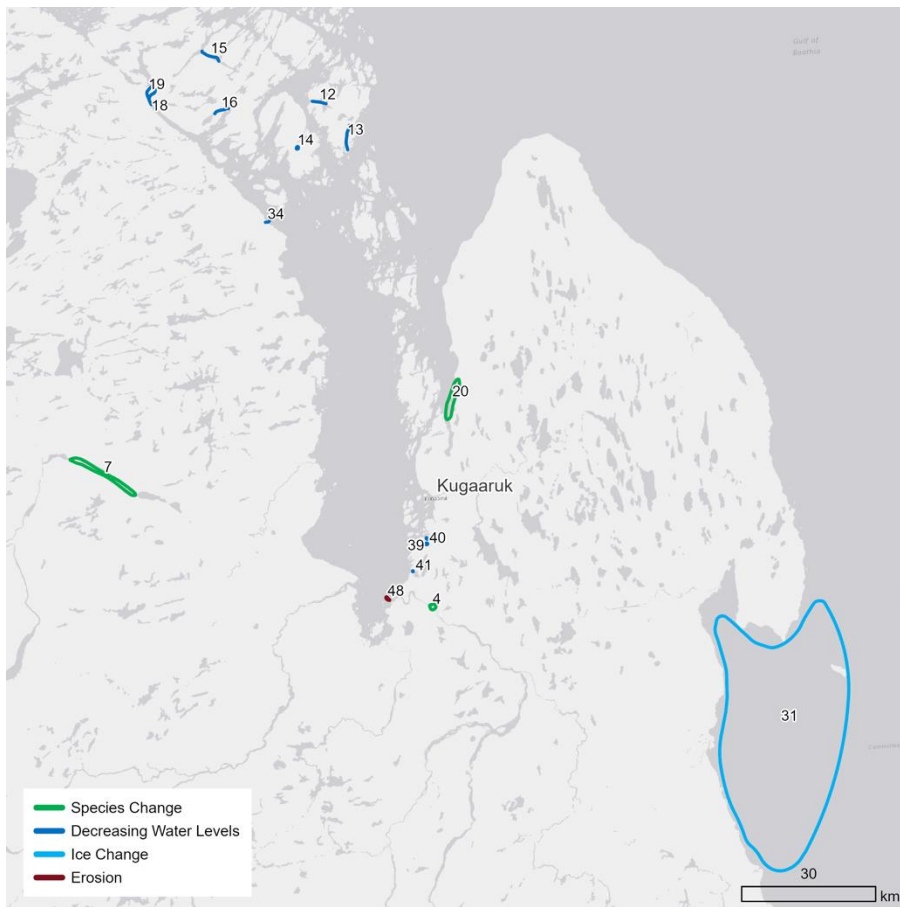


**Figure 2b: Gjoa Haven**



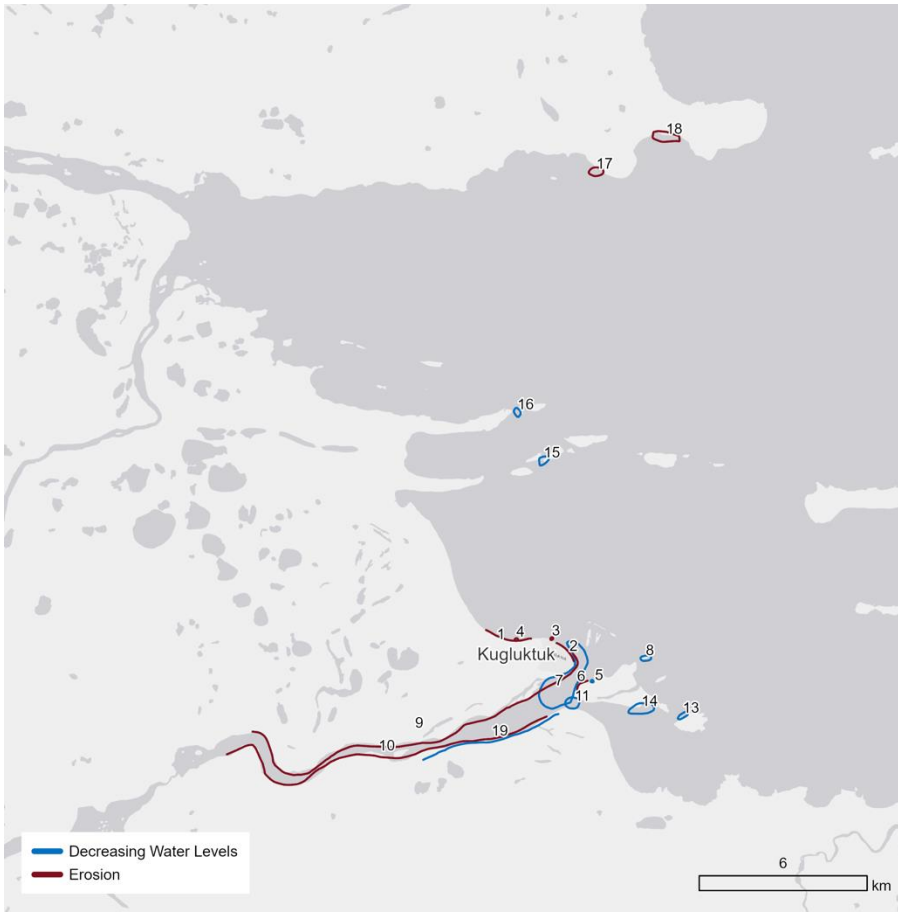
- 1 Decreasing water levels, deepen channel or rearrange boulder garden
- 3 Ice blocks entrance way of the bay
- 4 Decreasing water levels, deepen channel; feeds Koka (Quuqa) Lake, key fishing site for the community
- 5 Decreasing water levels, deepen mouth or rearrange boulder garden; (Iqalumiut River)

**Figure 2c: Kugaaruk**



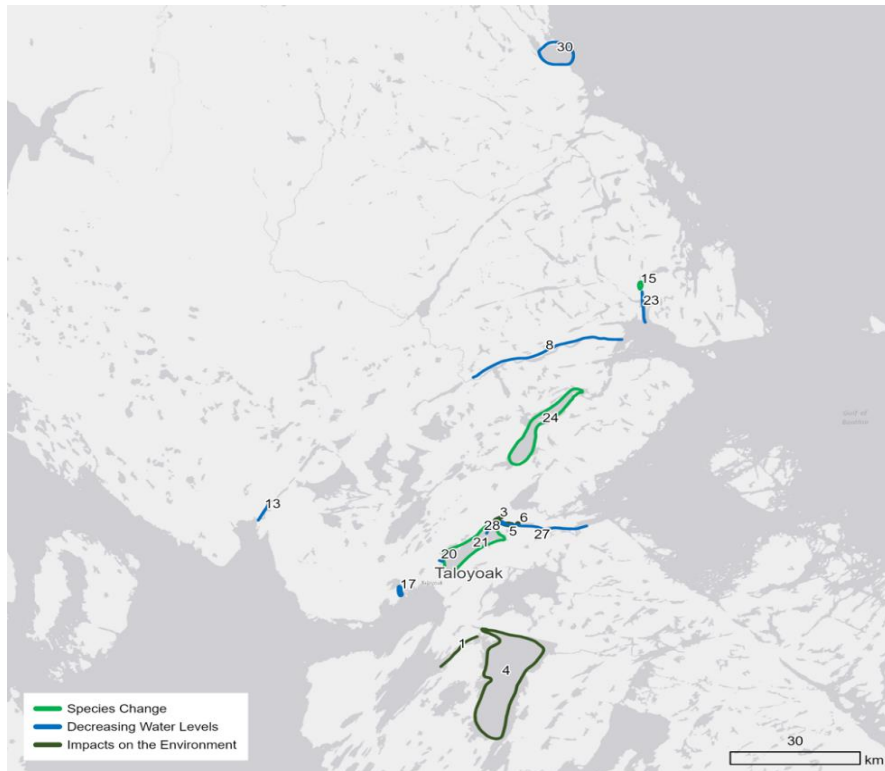
- 4 Kellet River: closed to commercial fishing because char were getting smaller (or more juveniles, not enough adults)
- 7 Simpson Lake: parasites and skinny char
- 12 River drying up; char migration route; big char
- 13 River drying up; char migration route; big char
- 14 Water levels decreasing
- 15 River drying up; char migration route
- 16 River drying up; char migration route
- 18 River drying up; char migration route
- 19 River drying up; char migration route
- 20 Crab legs and mussels in stomachs of bearded seal (not seen along shoreline, only in stomachs)
- 31 Committee Bay: Packed with multi-year ice every summer
- 34 River drying up
- 39 Too many rocks
- 40 Too many rocks
- 41 Fish get stuck
- 48 Island disappeared years ago due to erosion

**Figure 2d: Kugluktuk**



- 1 Erosion
- 2 Erosion
- 3 Road washed out due to erosion
- 4 Road washed out due to erosion
- 5 Exposed rock now; boats no longer anchor here
- 6 Erosion
- 7 Boats can't pass channel anymore, too shallow; key char spawning area
- 8 Too shallow to access by boat now (Avalikgonik)
- 9 Erosion of riverbanks (Coppermine River)
- 10 Erosion of riverbanks (Coppermine River)
- 11 Too shallow for navigation by boat
- 13 Too shallow to access by boat now
- 14 Too shallow to access by boat now
- 15 Too shallow for navigation by boat (Kakotalik)
- 16 Too shallow for navigation by boat (Tikigak)
- 17 Erosion (Emnalokyoak)
- 18 Erosion
- 19 Too shallow for navigation by boat

**Figure 2e: Taloyoak**



- 1 River system heavily used, lots of garbage; ghost nets
- 3 Ghost net clean-up needed
- 4 Netsilik Lake; ghost net clean-up completed
- 5 Ghost net clean-up needed
- 6 Ghost net clean-up needed
- 8 Char migration route; river drying up so difficult for char to swim upstream
- 13 Char migration route; decreasing water levels
- 15 Changes in char: longer and skinnier now
- 17 River drying up (connects to Redfish Lake); very shallow at mouth of river
- 20 Water crossing
- 21 Lake Trout are smaller now and less abundant (Middle Lake)
- 23 Char migration route; key fishing site but drying up
- 24 Krusenstern Lake; decline in Lake Trout
- 27 Char migration route; river drying up; deepen river feeding into Lord Mayor Bay
- 28 Very shallow river crossing
- 30 low water levels; skinnier char

## Appendix 3: Examples of projects funded under the Oceans Protection Plan.

Location	Project title and details	Lead agency	Aim	Activities	Website/references examples
Nunavut, Kugluktuk	Restoration of anadromous Arctic char ( <i>Salvelinus alpinus</i> ) and Dolly Varden ( <i>Salvelinus malma malma</i> ) near Kugluktuk.  <b>Time frame:</b> 5 years. <b>Fund allocation:</b> \$1,261,890	University of Waterloo, Heidi Swanson	To identify migratory patterns and overwintering habitats used by Arctic char and/or Dolly Varden in the Coppermine and adjacent river systems. It will also develop restoration plans for 1-2 high-priority streams which support these species fisheries and are subject to low-flow events and fish stranding.	<ol style="list-style-type: none"> <li>1. Fish tagging</li> <li>2. Placement of acoustic telemetry receivers</li> <li>3. Water samples</li> <li>4. Collection of otoliths</li> <li>5. Collection of fin clips</li> </ol>	Nunavut impact review board ( <a href="https://bit.ly/3b3fzSW">https://bit.ly/3b3fzSW</a> ) CBC news article: <a href="https://bit.ly/2QN4uPa">https://bit.ly/2QN4uPa</a>
Hudson Bay and James Bay	Hudson Bay and James Bay strategic planning for coastal habitat restoration <b>Time frame:</b> 2 years <b>Fund allocation:</b> \$220,000	Arctic Eider Society	The goal of this project is to work through the collaborative framework of the Hudson Bay Consortium to coordinate on identifying restoration priorities and planning for coastal ecosystems in the Greater Hudson Bay and James Bay region	Activities between 2017-2020 <ul style="list-style-type: none"> <li>• Forums, working groups, identified priority areas, and actions.</li> </ul>	Project site: <a href="https://hudsonbayconsortium.com/">https://hudsonbayconsortium.com/</a> HBC – 2020 progress report ( <a href="https://bit.ly/33fVwMN">https://bit.ly/33fVwMN</a> ) Focus is on coastal restoration, stewardship, research, and monitoring.
Nunavut	Assessment of the current state of coastal restoration needs across Nunavut.  <b>Time frame:</b> 5 years <b>Fund allocation:</b> \$2,129,522	Dalhousie University Lucia Fanning	This project will conduct community consultations and feasibility studies to identify and mitigate the stressors impacting aquatic species in each of Nunavut's 25 communities.	It will be followed by working with Nunavut communities to develop coastal restoration plans on a case-by-case basis. At least 3 restoration projects will be implemented over the 5-year funding period.	Project site: <a href="https://www.coastalnunavut.ca/">https://www.coastalnunavut.ca/</a>
Nunavut	Addressing existing migratory barriers that increase stress on culturally and economically important Arctic char populations in the Kivalliq Region. <b>Time frame:</b> 3 years <b>Fund allocation:</b> \$420,000	Kivalliq Inuit Association	Aim to address existing migratory barriers that increase stress on culturally and economically important Arctic char populations in the Kivalliq Region.		News article <a href="https://bit.ly/3eN4CG0">https://bit.ly/3eN4CG0</a>

**Appendix 3 cont.:** Relevant Projects funded under the Oceans Protection Plan.

Location	Project title and details	Lead agency	Aim	Activities	Website/references examples
Northwest Territories and Yukon	The Inuvut, Inikputlu Project  <b>Time frame:</b> 3 years  <b>Fund allocation</b> \$680,000	Dalhousie University Claudio Aporta	To conduct community consultations and feasibility studies to identify: important aquatic species for local communities within the Inuvialuit Settlement Region; the stressors impacting each of these aquatic species; culturally important coastal areas impacted by environmental degradation; and potential mitigation strategies for each of the communities.	Uses an approach to coastal restoration that focuses on the relationships that connect people with their environment rather than on discrete and biophysical spaces that have typically been the focus of coastal restoration projects.	Project site: <a href="https://inuvutinikputlu.ca/">https://inuvutinikputlu.ca/</a>
Newfoundland and Labrador	Riverbank restoration Miawpukek First Nation  <b>Time frame:</b> 2 years  <b>Fund allocation:</b> \$404,100	Mi'kmaq Alsumk Mowimsikik Koqoey Association	Restoration of riverbank and stabilization of embankment toe on the Conne River	The area has been severely eroded by extreme weather conditions and a lack of total ice cover in winter. The work will help prevent sediment, tree roots and debris from previous development activities from falling into the water. The project will benefit Atlantic salmon as the area is a known migration route for the species.	News article: <a href="https://bit.ly/3b4CcGx">https://bit.ly/3b4CcGx</a>
Newfoundland and Labrador	Stewarding coastal habitats monitoring and restoration for priority species  <b>Time frame:</b> 5 years  <b>Fund allocation:</b> \$3,789,720	WWF-Canada	Its goal is to identify data gaps on coastal habitats for priority species, particularly capelin, but including salmon, trout, and char.	The project will build on the momentum of a successful restoration of capelin habitat at Ship Cove, NL by the WWF.	Nunatukavut site <a href="https://bit.ly/3eIXWjr">https://bit.ly/3eIXWjr</a> News article <a href="https://bit.ly/3uqiooM">https://bit.ly/3uqiooM</a>
Northwest Territories	Beaufort Sea coastal restoration: Using native plant species to stabilize coastline affected by permafrost thaw slumping.  <b>Time frame:</b> 5 years  <b>Fund allocation:</b> \$410,000	Aurora College Aurora Research Institute Erika Hille	This project will examine the effects of thaw slumping on the nearshore waters of the Beaufort Sea coast, with a focus on the region of Kugmallit Bay. It will use this research to create a plan to mitigate these effects using native plant species.	The Aurora Research Institute will work closely with the community of Tuktoyaktuk and the Tuktoyaktuk Hunters and Trappers Committee, who play a pivotal role in the study design. Local Indigenous knowledge will be used to identify study sites close to significant fishing locations.	Project site: <a href="https://bit.ly/3teLNRg">https://bit.ly/3teLNRg</a> CBC news article <a href="https://bit.ly/3un1RSr">https://bit.ly/3un1RSr</a>