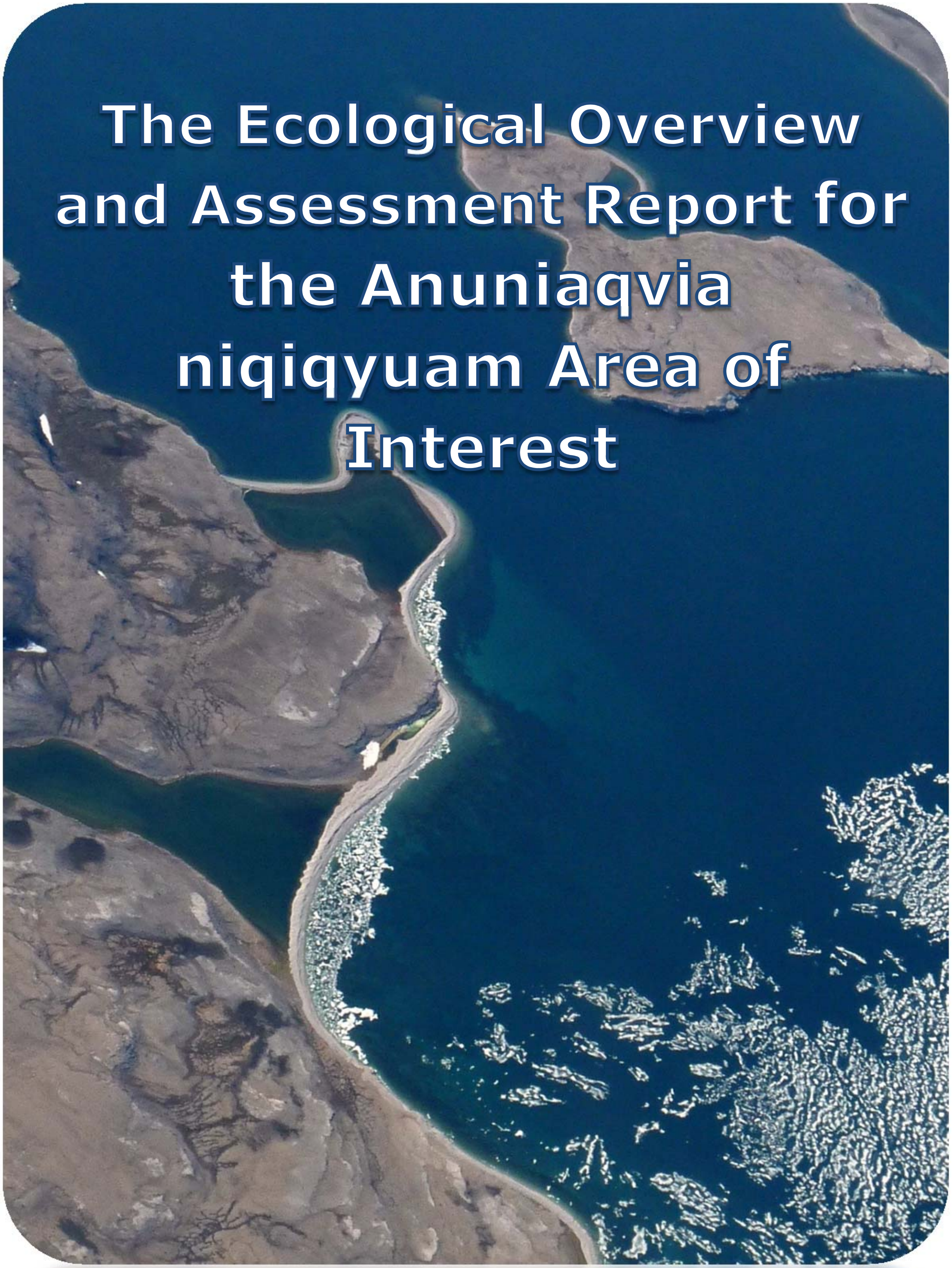
The Ecological Overview and Assessment Report for the Anuniaqvia niqiqyuam Area of Interest



THE ECOLOGICAL OVERVIEW AND ASSESSMENT REPORT FOR THE ANUNIAQVIA NIQIQYUAM AREA OF INTEREST

2012

A Report Prepared
for

Department of Fisheries and Oceans Canada

by

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EXECUTIVE SUMMARY

Fisheries and Oceans Canada (DFO) is in the process of creating a national system of Marine Protected Areas (MPAs) under Canada's *Oceans Act* (1996). The creation of an MPA is one of several tools used by DFO in order to protect and conserve important marine species and their habitat, particularly in the Canadian Arctic. In 2009 DFO, along with territorial government (NT, YT) organizations and local communities, nominated the Paulatuk/Darnley Bay area for consideration as an MPA. The area, referred to as the Anuniaqvia niqiqyuam Area of Interest (AOI), is located in the Western Canadian Arctic near Paulatuk, NT. The AOI is a highly productive region, supporting a variety of Arctic species year-round. During the open-water season, the AOI provides migratory and feeding habitat for fish, marine mammals and birds in nearshore and offshore waters. In winter, the sea ice provides breeding and feeding habitat for Polar Bears and seals, while polynyas offer critical feeding areas and promote aggregations of marine mammals and their prey.

Though not well studied, the AOI supports a number of important ecosystem components within four key habitat areas; the Darnley Bay Nearshore Migration and Feeding Corridor; the Cape Parry Offshore Marine Feeding Habitat; the Darnley Bay Offshore Ice-edge Habitat; and Kelp Beds. Key ecosystem components identified within the AOI include:

- nearshore migration and feeding corridor for Arctic Char;
- freshwater inputs from the Hornaday and Brock rivers;
- deep holes in the channels within the Hornaday River estuary where Arctic Char overwinter;
- seabird colonies (Thick-billed Murres and Black Guillemots) unique to the Beaufort Sea Large Ocean Management Area (LOMA) and associated marine habitat;
- sea duck staging area near Cape Parry and Booth and Canoe islands;
- enhanced tidal flows at Cape Parry;

- upwelling at Pearce Point and along the ice bridge across the mouth of Darnley Bay;
- ice-edge habitat during spring; and
- kelp beds, potentially unique to the Beaufort Sea LOMA, in Argo and Wise bays and perhaps elsewhere in Darnley Bay.

DFO identified several other potential ecosystem components, although further scientific research is necessary to determine their significance within the AOI.

The Anuniaqvia niqiqyuam AOI also is culturally important. In addition to subsistence harvests of Arctic Char, Beluga, birds and other species, the community of Paulatuk utilizes portions of the AOI for travel and education. Due to its importance to resource users, conservation efforts must continue to allow culturally important activities while maintaining the health and integrity of marine organisms and their habitat.

Several options are available for the protection and conservation of an AOI, from the creation of a national park to smaller scale management plans or stewardship programs. Due to the nature of the Anuniaqvia niqiqyuam AOI and its resources, protection through the creation of an *Oceans Act* MPA appears to be the most appropriate. DFO and the Inuvialuit Regional Corporation (IRC) (2010) recognized that the creation of an MPA would provide a more flexible management strategy, minimizing negative impacts while allowing activities that do not impact the environment. Addition of the Anuniaqvia niqiqyuam AOI to the national MPA network also will serve to link areas of Beluga use and increase conservation efforts for this species within the Beaufort Sea LOMA. Migratory species (e.g., Beluga, Arctic Char and birds) will receive additional protection through existing management programs that operate within and outside of the MPA boundaries (Paulic et al. 2012).

DFO and IRC (2010) identified three types of activities that could hinder conservation efforts and negatively impact marine species and/or their habitat within the AOI; large scale commercial fishing for any species; mine development; and increased shipping traffic. Consequently, the authors recommended that these activities not be permitted within the MPA.

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1.0 INTRODUCTION

Creation of a Marine Protected Area (MPA) is one of the tools used by Fisheries and Oceans Canada (DFO) to improve the health, integrity and productivity of Canada's marine ecosystems (DFO 2012). The Federal Marine Protected Areas Strategy defines a marine protected area as, "any area of **intertidal** or **subtidal** terrain, together with its overlying water and associated **flora** and **fauna**, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (DFO 2005). DFO is in the process of creating a national system of Marine Protected Areas under Canada's *Oceans Act* (1996). The purpose of establishing MPAs is to protect and conserve important fish and marine mammal **habitat**s, **endangered** marine species and their habitats, unique features and areas of high biological **productivity** or **biodiversity** (Paulic et al. 2012). Four steps are involved in the establishment of an MPA:

1) Select the AOI;

2) Conduct an overview and assessment of the AOI;

3) Develop regulatory intent and documents; and

4) Manage the MPA.

The Health of the Oceans initiative, launched in 2007, provided funding in order to establish six new MPAs. The Anuniaqvia niqiqyuam AOI, located in the Western Canadian Arctic near Paulatuk (NT), was proposed for consideration as an MPA in 2009 (Paulic et al. 2012).

DFO conducts an overview and assessment for each AOI in order to determine:

- the value and importance of the AOI;
- whether or not the AOI meets the criteria necessary for establishing an MPA; and
- impacts from human activities on the area and its local ecology.

DFO, the Inuvialuit Regional Corporation (IRC) and the community of Paulatuk together produced a series of documents for use in the assessment process for the Anuniaqvia niqiqyuam AOI. This report provides a synthesis of the available information to assist government and aboriginal decision-makers in the assessment of the Darnley Bay area as a potential MPA. Included in the report is a description of the Anuniaqvia niqiqyuam AOI, including information on the physical and biological environments, recommendations for the proposed MPA and existing knowledge gaps.

2.0 THE ANUNIAQVIA NIQIQYUAM AOI

Darnley Bay is a large productive bay located within the Beaufort Sea LOMA and the Inuvialuit Settlement Region, near the community of Paulatuk (Figure 1). The bay opens into Amundsen Gulf, with the Beaufort Sea to the west and the Northwest Passage to the east. The Anuniaqvia niqiqyuam AOI includes waters along the western coastline of Darnley Bay, from the most northern point of the Parry Peninsula (Cape Parry) south to the community of Paulatuk (Paulic et al. 2012).

In 2006, DFO Science identified twenty ecologically and biologically significant areas (EBSAs) within the Beaufort Sea LOMA, including two in Darnley Bay; Pearce Point (identified due to its importance for Bowhead and Beluga and their habitat) and Hornaday River (identified due to its importance for Arctic Char and their habitat) (Paulic et al. 2009; Figure 2). Subsequently, in 2009 the DFO Oceans Program and a Site Selection Advisory Committee[1] selected the Paulatuk/Darnley Bay area for consideration as an MPA in collaboration with members from the communities of Paulatuk, Ulukhahtok and Sachs Harbour (KAVIK-AXYS 2012; Paulic 2012).

Criteria considered by the communities included (DFO and IRC 2010):

1) Presence of culturally important species in the area;
2) Identification of the area in a Community Conservation Plan;
3) Ecological importance of the area;
4) Level of biodiversity within the area;
5) Level of productivity within the area;
6) Presence of threats to the area and how immediate such threats are;
7) Possibility of future conflicts with stakeholders; and
8) Contributions of the area to social and cultural values.

[1] The Site Selection Advisory Committee was formed with representatives of the Fisheries Joint Management Committee (FJMC), Inuvialuit Game Council (IGC), Inuvialuit Regional Corporation (IRC) and DFO in September 2008.

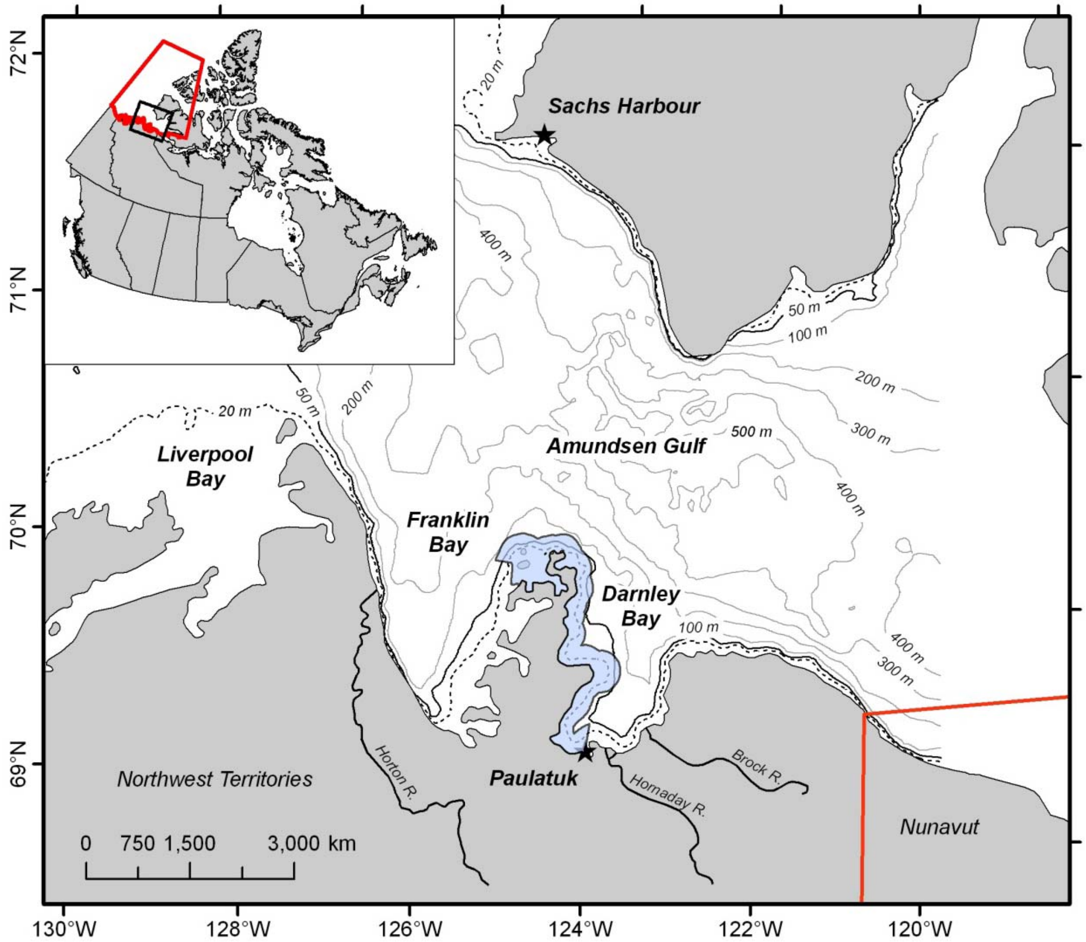

Figure 1. Anuniaqvia niqiqyuam AOI indicated by the blue shaded area within the Inuvialuit Settlement Region and Beaufort Sea LOMA (indicated by red lines within inset map). **Bathymetry** data for this area were obtained from the General Bathymetric Chart of the Oceans (GEBCO). From Paulic et al. 2012.

Additional criteria used by the Site Selection Committee included:

1) Whether or not a similar type of habitat was protected elsewhere;
2) Existence of related management plans or other managed areas associated with the potential candidate area;
3) Amount of information available for the area;
4) Potential economic benefits from protection; and
5) Feasibility of establishing an MPA in the candidate area.

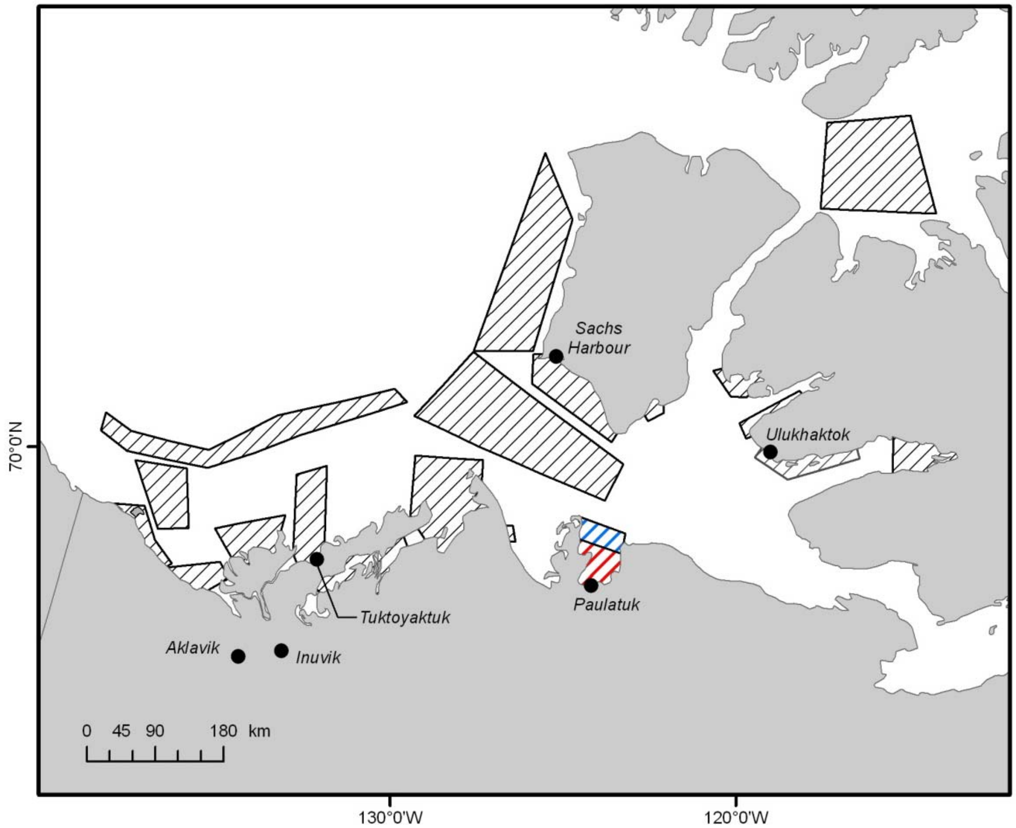

Figure 2. EBSAs identified in the Beaufort Sea LOMA. The blue corresponds to the Pearce Point EBSA. The red corresponds to the Hornaday River EBSA. From Paulic et al. (2009).

Feasibility criteria included that the area:

1) Be close to a community;
2) Have existing monitoring activities or be possible to monitor;
3) Have no jurisdictional conflicts;
4) Be suitable for zoning, providing flexibility in management options if required; and
5) Would contribute to other wildlife and habitat conservation measures (e.g., adjacent to migratory bird sanctuary, national park, Beaufort Sea Beluga Management Plan, char management plans).

2.1 MANAGEMENT PLANS IN THE ANUNIAQVIA NIQIQYUAM AOI

Three separate management plans operate within the Anuniaqvia niqiqyuam AOI; the Beaufort Sea Beluga Management Plan, the Paulatuk Community Conservation Plan and the Paulatuk Char Management Plan (DFO and IRC 2010). Various programs (e.g., Important Bird Areas, DFO EBSAs) also have identified portions of the AOI as conservation priorities (Paulic et al. 2012). Currently, no areas within the AOI receive formal protection under legislation, though a land-based Migratory Bird Sanctuary occurs adjacent to the AOI (DFO and IRC 2010).

Beaufort Sea Beluga Management Plan

The Beaufort Sea Beluga Management Plan was developed by the Fisheries Joint Management Committee (FJMC) to ensure the responsible and effective, long-term management of beluga by the Inuvialuit and DFO (FJMC 2001). The Plan designates most of the AOI (with the exception of the area north of the Brock River **estuary**) as Beluga Management Zone 1B, defined as an occasional or potential beluga harvesting area (FJMC 2001). According to the Plan, Zone 1 areas (including 1B's) must be considered protected areas when reviewing development proposals, and as a result, restrictions are placed on the types of development permitted within these zones. For example, Zone 1B areas should not be subject to exploration or exploitation of **hydrocarbon**s by the oil and gas industry. In addition, evaluations of the potential impacts from developments such as **hydroelectric** or mining projects (e.g., effects on water quality and quantity or the salinity and integrity of ice) are mandatory. Commercial fishing is highly regulated with regard to Beluga food species within these areas.

Paulatuk Community Conservation Plan

The Paulatuk Community Conservation Plan (Community of Paulatuk et al. 2000) is a community-based planning document prepared by the Paulatuk Hunters and Trappers Committee, Paulatuk Community Corporation and Paulatuk Elders Committee. The Plan identifies important habitats, harvesting areas and cultural sites in the Inuvialuit Settlement Region and Paulatuk region, and makes recommendations for their management. Due to its presence in Beluga Management Zone 1B, the Conservation Plan identifies most of the Anuniaqvia niqiqyuam AOI as Management Category E. Category E areas are recommended for the highest degree of protection. They are lands and waters where cultural or renewable resources are of extreme significance and sensitivity. The Conservation Plan recommends that there be no development in these areas. The remainder of the AOI is designated as Category C, which provides resources for a wider range of purposes. Category C areas are lands and waters where cultural or renewable resources are of particular significance and sensitivity during specific times of the year. The Conservation Plan recommends that these areas be managed in order to eliminate, to the greatest extent possible, potential damage and disruption (Community of Paulatuk et al. 2000).

Cape Parry Important and Protected Bird Habitat

Important Bird Areas are internationally agreed-upon sites that are significant to one or more bird species (e.g., threatened, **restricted-range**, **migratory** or **congregatory** species) identified as a priority for conservation (BirdLife International 2009; DFO and IRC 2010). Canada's science-based Important Bird Area program identifies, conserves and monitors sites that provide essential habitat for Canada's bird populations (Important Bird Areas of Canada 2004). One of these sites exists at Cape Parry, located at the northern-most point of the Parry Peninsula.

The Cape Parry Important Bird Area includes the cape and surrounding offshore waters. The limestone cliffs of the cape and the **polynya** and **upwelling** currents around the cape represent important bird habitat (DFO and IRC 2010). This area supports the only breeding colony of Thick-billed Murres (*Uria lomvia arra*) in the western Canadian Arctic and large numbers (up to 20,000) of King Eiders (*Somateria spectabilis*), Common Eiders (*S. mollissima*) and Long-Tailed Duck (or Oldsquaw; *Clangula hyemalis*) that stage in the offshore open water in the spring (Important Bird Areas of Canada 2004). Breeding by Black Guillemots (*Cepphus grylle*) in the area also is suspected (Important Bird Areas of Canada 2004).

In 1961, the federal government established the 200 hectare Cape Parry Migratory Bird Sanctuary under the *Migratory Birds Convention Act* (Canadian Wildlife Service 2005; Figure 3). Sanctuaries are designed to conserve migratory bird populations by regulating hunting, monitoring, maintaining or improving habitat and providing protection from disturbance during migration and nesting (Environment Canada 2007).

Paulatuk Char Management Plan

In 1998, the FJMC, the Paulatuk Hunters and Trappers Committee and DFO created the Paulatuk Char Management Plan (Paulatuk Char Working Group 2003). The primary objective of the Management Plan is to maintain healthy stocks of Arctic Char (*Salvelinus alpinus*) in the Hornaday River and other locations in the Paulatuk area by

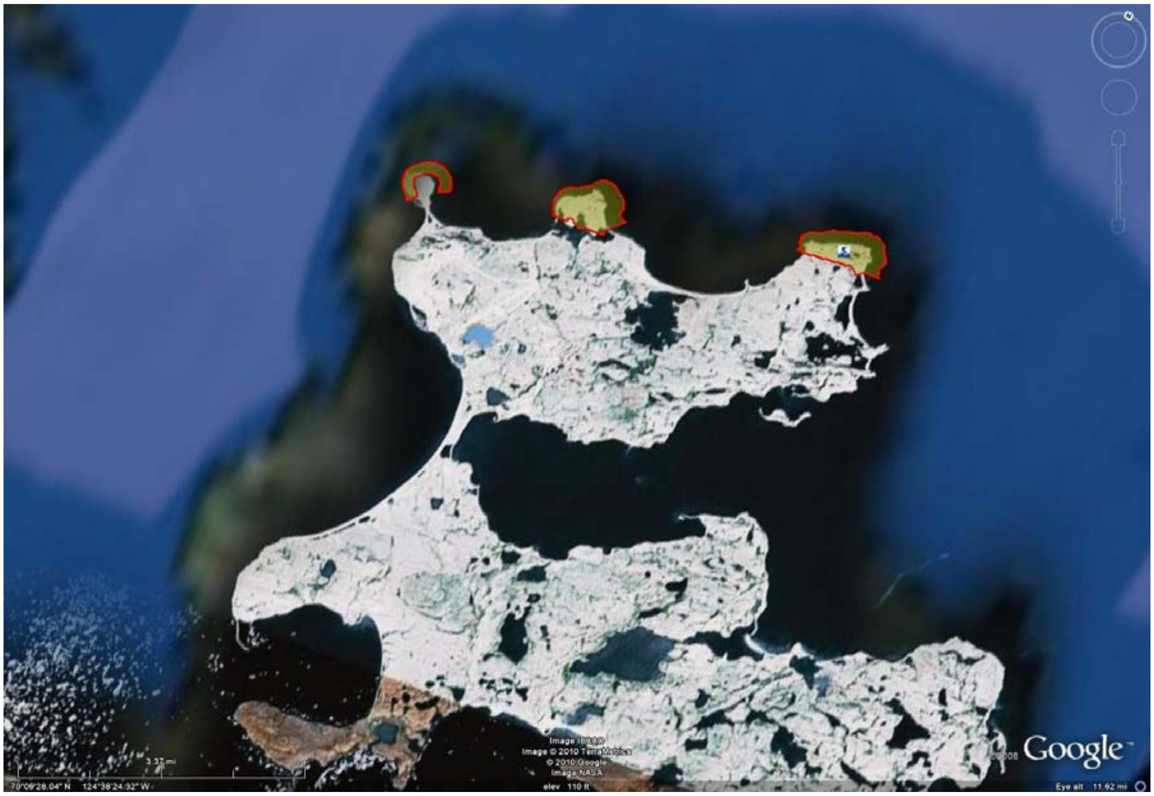

Figure 3. Cape Parry Bird Sanctuary. Modified from Google Maps (2010).

preserving and protecting habitat, while managing and conserving the population to meet **subsistence** needs. A community-based program monitors the char harvest on an annual basis. The Paulatuk Char Working Group uses the results of this monitoring program to make decisions on the next edition of the Management Plan, making recommendations on the areas open to fishing, gear choice, location of capture, and size of harvest. For example, the Management Plan allows a harvest limit of no more than 1,700 fish from the Hornaday River, which represents a 30% reduction in take from years before the Plan was in place. The working group last updated the Management Plan for the period 2007-2010. Results of the monitoring program indicate that since implementation of the Plan, average size of fish caught and catch-per-unit-effort have steadily increased. This suggests that the status of the Hornaday River char population is improving.

Ecologically and Biologically Significant Areas

DFO identifies ecologically and biologically significant areas as part of their **ecosystem-based management** of LOMAs. EBSAs are areas important to the structure and function of some component of the marine environment or to a particular **ecosystem** (DFO and

IRC 2010). Though EBSAs are not regulated, DFO recommends that their significant properties be managed with a great degree of risk aversion. In the Beaufort Sea LOMA, DFO identifies EBSAs through a combination of scientific research and traditional knowledge (TK) (Paulic et al. 2009).

Two EBSAs are located in the Anuniaqvia niqiqyuam AOI: Hornaday River and Pearce Point (Cobb et al. 2008; Paulic et al. 2009; Figure 2). The Hornaday River EBSA, which includes the coastal estuary in southern Darnley Bay and the Hornaday and Brock River systems, and provides important habitat for Arctic Char. The Pearce Point EBSA, located in northern Darnley Bay between Pearce Point and Cape Parry, provides important Bowhead and Beluga whale habitat (Cobb et al. 2008).

3.0 CLIMATE

The Anuniaqvia niqiqyuam AOI is located in the Arctic climatic zone. This zone is often described as harsh or severe due to its long, cold winters, short, cool summers and a dry climate (DFO and IRC 2010; Paulic et al. 2012). The sun remains above the horizon (constant daylight) from late May to mid-July and remains below the horizon (constant darkness) from the beginning of December to early January (Cobb et al. 2008).

Daily average temperatures range from -28.4°C in February to 6.2°C in July (Figure 4). Between 1971 and 2000, the minimum and maximum temperatures observed for the region were -47.2°C in January 1975 and 23.9°C in July 1973 (Environment Canada 2011).

Amundsen Gulf strongly affects climate in the Anuniaqvia niqiqyuam AOI, exerting a maritime influence on the region which results in increased precipitation (Paulic et al. 2012). Prevailing winds are from the east (Environment Canada 2011). Though monthly average wind speeds range from 17.6 to 22.1 km/hr, maximum hourly wind speeds can exceed 100 km/hr (Environment Canada 2011). Most precipitation and fog occur during the summer months, while large continental Arctic air masses predominate in the winter, bringing cold temperatures with little moisture (Parks Canada 2007). Warmer temperatures and precipitation occur with the movement of maritime air masses over the region (Parks Canada 2007).

Rainfall occurs from April to October, typically peaking in August (22.3 mm; Figure 5). However, average rainfall for much of that time period is less than 1.5 mm (Environment Canada 2011). Most snowfall occurs in October (on average 26.8 cm), while the remaining months see between 8 and 16 cm per month on average (Environment Canada 2011). Though snow may fall at any time throughout the year, average snowfall during summer is less than 3 cm per month (Environment Canada 2011). Average monthly accumulations of precipitation (1971-2000) are presented in Figure 5.

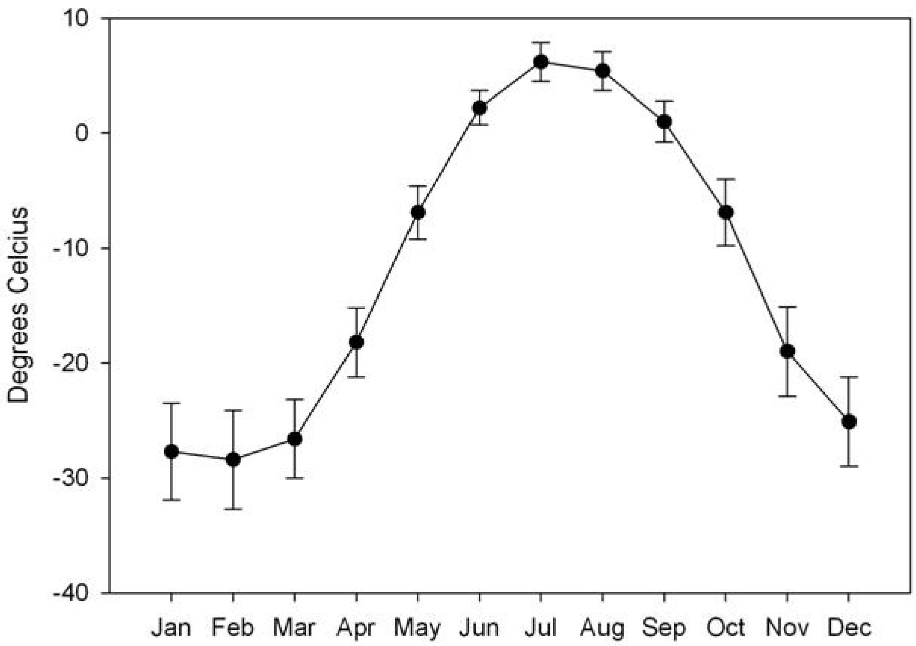

Figure 4. Mean air temperatures ± standard deviation by month collected from the meteorological station located at Cape Parry, NT (http://climate.weatheroffice.gc.ca/climate_normals/stnselect_e.html). From Paulic et al. (2012).

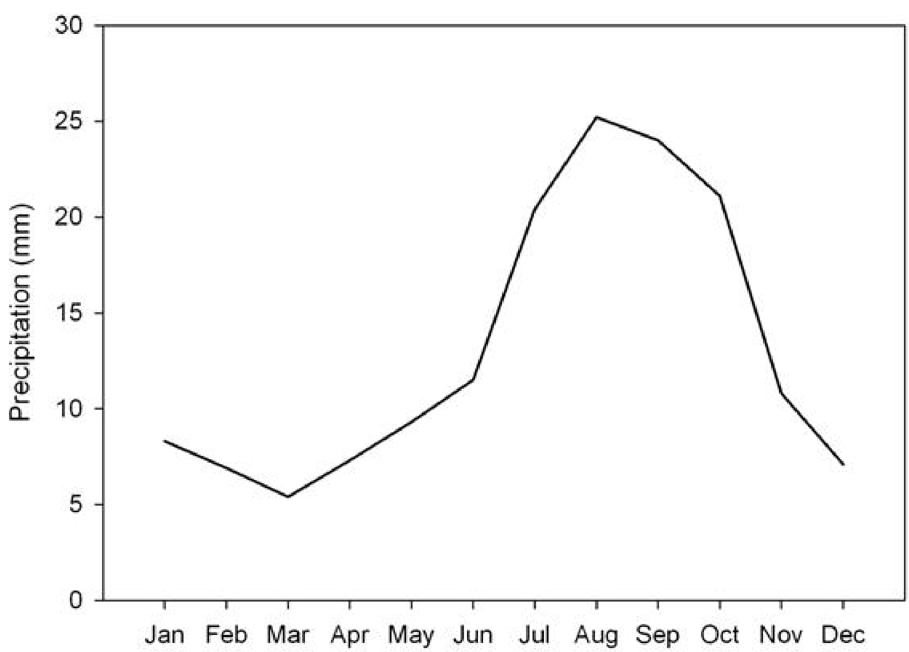

Figure 5. Average accumulation of precipitation by month collected from a meteorological station located at Cape Parry, NT (http://climate.weatheroffice.gc.ca/climate_normals/stnselect_e.html). From Paulic et al. (2012).

4.0 GEOLOGY/BATHYMETRIC

Darnley Bay is approximately 45 km long and 32 km wide at its mouth (Paulic et al. 2012). Two rivers drain into the bay; the Hornaday and Brock (Figure 1). Though relatively small, both rivers are locally important (Paulic et al. 2012). The largest of the two is the Hornaday River, which is approximately 360 km in length with a drainage basin of 14,900 km^2 (Parks Canada 2007).

The coastline of Darnley Bay is complex. Throughout the bay, hundreds of smaller bays and inlets are interspersed with sand and gravel beaches (Figure 6; Paulic et al. 2012). The Parry Peninsula is scattered with ponds and small lakes containing little vegetation. Limestone outcrops at Cape Parry form coastal cliffs rising approximately 20 m above sea level (Canadian Wildlife Service 1992). Bedrock cliffs dominate both the northeast and northwest coasts of Darnley Bay, while large delta complexes and barrier beaches characterize the southern coast near the two major river systems (Paulic et al. 2012). Copper, nickel and platinum deposits exist under the coastal waters of Darnley Bay, within what is called the “Darnley Bay Gravity Anomaly”. Land-based exploration also produced a number of diamond-bearing **kimberlite** samples (Darnley Bay Resources 2010).

Changes in water depth can influence the physical and chemical processes of the ocean (e.g., temperature, salinity, water movement). Because of this, depth is a key determinant of physical oceanography in the region (Paulic et al. 2012). Bathymetry data for the Darnley Bay area is limited, particularly for water depths less than 20 m (Figure 1). However, in 2003 and 2009 researchers aboard the Canadian Coast Guard Ship (CCGS) Amundsen collected detailed data for depths between 50 and 100 m.

The composition of sediments along the sea floor of Darnley Bay is not well studied. However, sampling in 2008 led scientists from the CCGS Nahidik and ArcticNet (Ocean Mapping Group) to conclude that the sea floor surface is composed primarily of silt and clay (R. Bennett and K. MacKillop unpubl. data, cited in Paulic et al. 2012). Surface sediments of the outer bay are made up of a harder **glacial till** covered by a thin, uneven layer of silty clay (R. Bennett, pers. comm., cited in Paulic et al. 2012).

Ice scouring is caused by the movements of pressure ridges and glacial ice along the seabed (Paulic et al. 2012). In the Beaufort Sea, trenches caused by ice scouring are present, and usually about 2 m in depth (up to 7 m; Dome Petroleum Ltd. et al. 1982). Most scouring occurs at water depths less than 50 m; however, the most intensive

Figure 6. Satellite image of the Parry Peninsula and Darnley Bay, NT on September 7, 2010 obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS) from NANA's Aqua satellite (http://rapidfire.sci.gsfc.nasa.gov/). Modified from Paulic et al. (2012).

scouring generally takes place at 20-25 m depths (Blasco et al. 1998). Though glacial ice scouring does not occur in Darnley Bay, data collected by the Ocean Mapping Group in ArcticNet reveals some ice scours and relict glacial features at water depths from 50 to 100 m (Paulic et al. 2012). Though ice scouring creates harsh conditions for existing fauna, the disruption of sediments creates new habitat for some organisms (Lewis and Blasco 1990).

5.0 OCEANOGRAPHY

5.1 WATER MASSES AND GENERAL CIRCULATION

Physical oceanography in the Amundsen Gulf and Darnley Bay is not well known. Three primary water masses are present within the Gulf (Carmack and Macdonald 2002); a relatively fresh polar-mixed layer (0-50 m depth) having lower salinities (26-31 psu) as a result of large river inputs from North American and Eurasian rivers; the Pacific Halocline layer (50-200 m depth; ~32-34 psu) comprised of Pacific Ocean water that has flowed through the Bering Strait; and the more saline (≥34 psu) Atlantic-origin waters of the Arctic Ocean (>200 m depths). Garneau et al. (2008) describe an additional layer within the halocline at approximately 30-40 m depth that is distinguished by a sharp increase in temperature. Seasonal variations in salinity and temperature patterns occur throughout the region as a result of the vertical movement of water masses within the water column (Garneau et al. 2008).

The circulation of water masses within Amundsen Gulf is under examination. Lanos (2009) determined that surface waters generally enter the Gulf near Banks Island and exit near Cape Bathurst; however, where the surface water circulation loop closes remains unknown (Barber et al. 2010). Below 50 m water depth, the Beaufort Undercurrent carries both Pacific- and Atlantic-origin waters eastward along the slope of the Beaufort Sea into the Amundsen Gulf, circulating in the reverse direction of surface waters (Carmack and Macdonald 2002, Ingram et al. 2008, Lanos 2009).

Though no circulation studies have been conducted within Darnley Bay, circulation patterns in nearshore areas are highly variable and controlled by wind direction and intensity, sea-floor topography, water depth and freshwater discharge (W. Williams, pers. comm., cited in Paulic et al. 2012).

5.2 RIVER DISCHARGE

The Brock and Hornaday rivers empty into Darnley Bay, creating estuaries through the mixing of marine water, fresh water and nutrient inputs (DFO and IRC 2010). Environment Canada has collected ten years of flow data for the Hornaday River (http://www.wsc.ec.gc.ca/staflo/index_e.cfm?cname=flow_daily.cfm) (Figure 7). No flow data are available for the Brock River (Paulic et al. 2012).

Annual freshwater inputs into Darnley Bay (2.0-2.5 km^3/year; W. Williams, pers. comm., cited in Paulic et al. 2012) are relatively small compared to those in other areas of the Beaufort Sea (e.g., 330 km^3/year discharged from the Mackenzie River; Macdonald et al. 1998), but are significant in relation to the small area of the Bay. The inner portion of Darnley Bay (Figure 6) into which the Brock and Hornaday rivers empty encompasses an area of roughly 1,440 km^2, and represents approximately 3% of the total area of the Canadian Beaufort Shelf.

Flow from the Hornaday River is near zero during winter, and increases dramatically during the spring **freshet**, which starts at the beginning of June (Paulic et al. 2012). River flow peaks before mid-June and decays by the end of the month (Figure 8). June discharge generally accounts for 75% of the annual total discharge from the Hornaday River (Paulic et al. 2012). There is an occasional secondary peak later in the year as a result of increased precipitation (Figure 8, Paulic et al. 2012).

Parks Canada maintains a water gauge on the Hornaday River within Tuktut Nogait National Park and river flows have remained consistent over the last 24 years (Parks Canada, pers. comm., cited in Paulic et al. 2012).

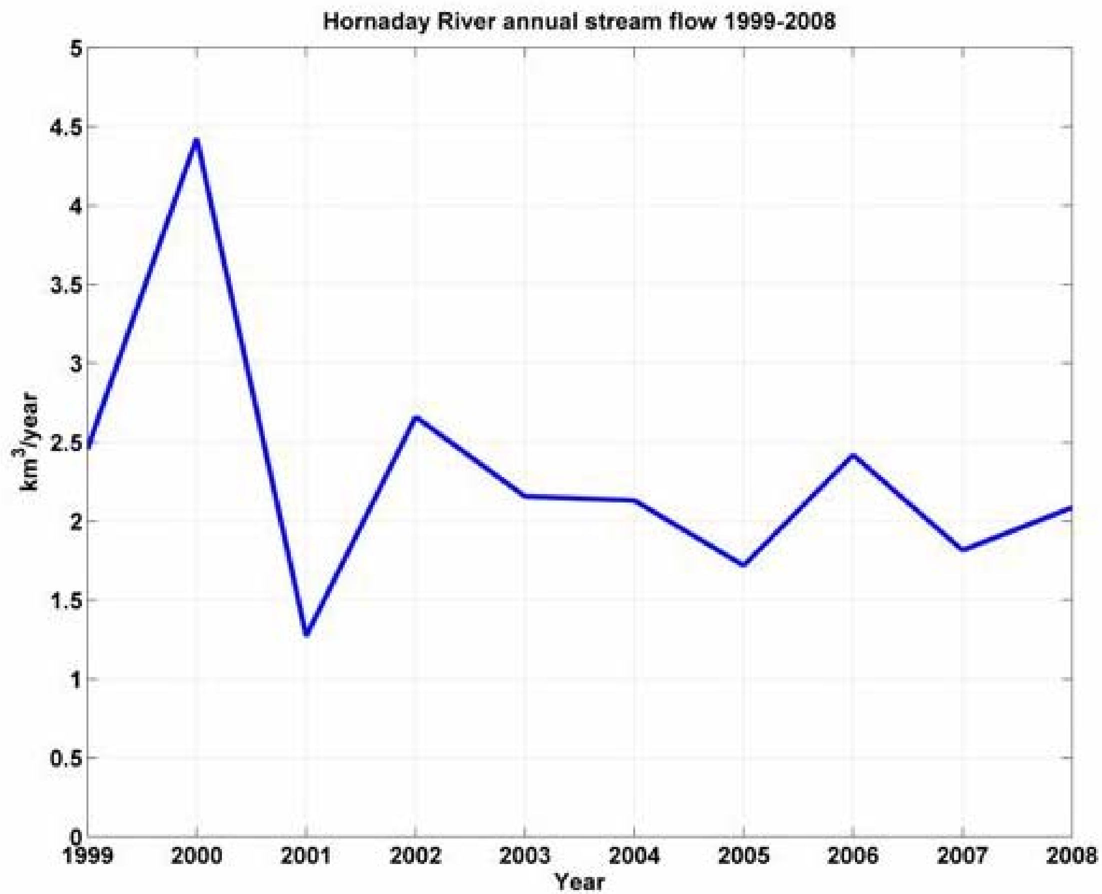

Figure 7. Hornaday River annual stream flow from 1999-2008 http://www.wsc.ec.gc.ca/staflo/index_e.cfm?cname=flow_daily.cfm). From Paulic et al. (2012).

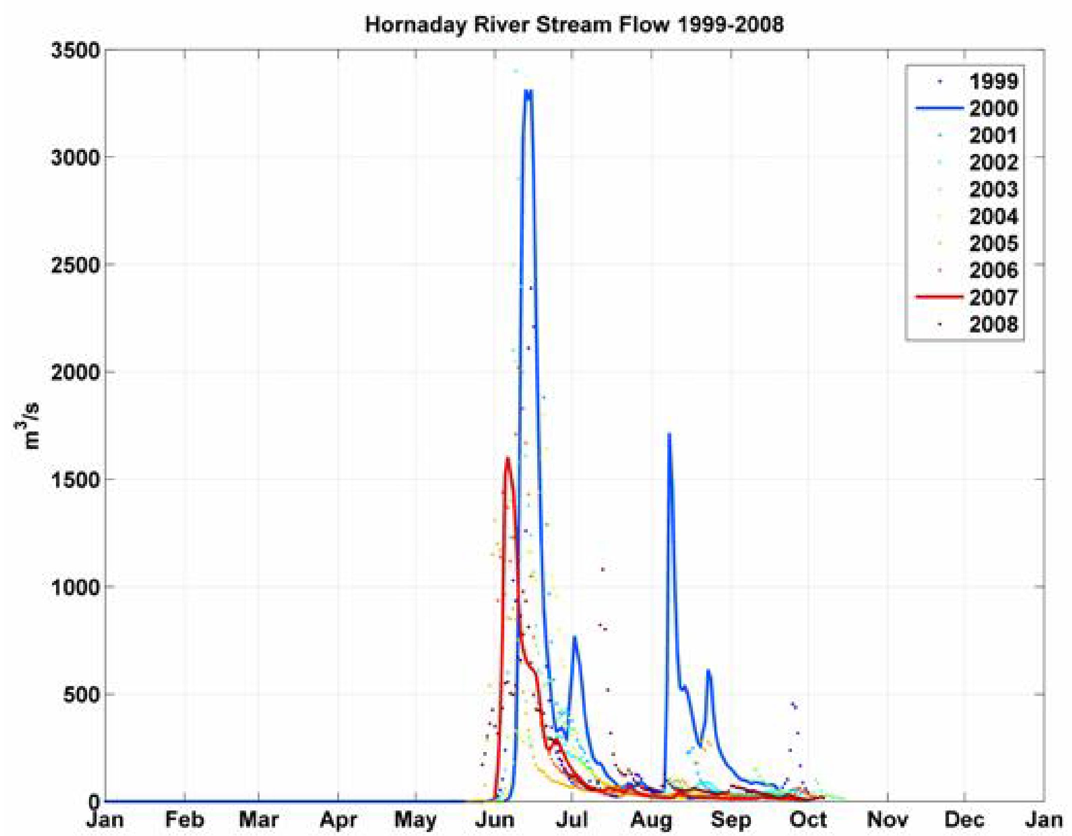

Figure 8. Water gauge data for the Hornaday River stream flow from 1999 to 2008. The 2007 year (in red) was selected as a 'typical' year. The year 2000 (in blue) was selected as an extreme high flow year with both a large spring freshet in June and a large secondary freshet in August due to precipitation on the watershed (http://www.wsc.ec.gc.ca/staflo/index_e.cfm?cname=flow_daily.cfm). From Paulic et al. (2012).

5.3 RIVER PLUME

Low tidal energy (i.e., weak tide) in Darnley Bay is responsible for the creation of **delta**s and **barrier island**s in the estuaries of the Hornaday and Brock rivers, and reduces the mixing of river water with ocean water (Paulic et al. 2012). These characteristics, combined with the large spring freshet, produce a relatively fresh and buoyant river plume that spreads out over the surface of the bay (Paulic et al. 2012).

Landfast ice is present in the bay for much of the year (Figure 9), shielding the plume from wind forcing. As a result, a **brackish** plume created by the June freshet likely accumulates under the ice, adding up to 1 m of fresh water to Inner Darnley Bay (Paulic et al. 2012). By mid-July, when ice concentrations in Darnley Bay are low, wind forcing likely causes rapid displacement of the river plume. Because Darnley Bay is small, wind events are able to push much of the plume out of the bay. The nature of river flow into the bay may favour a counterclockwise circulation in summer under the influence of the **Coriolis Effect** (Paulic et al. 2012).

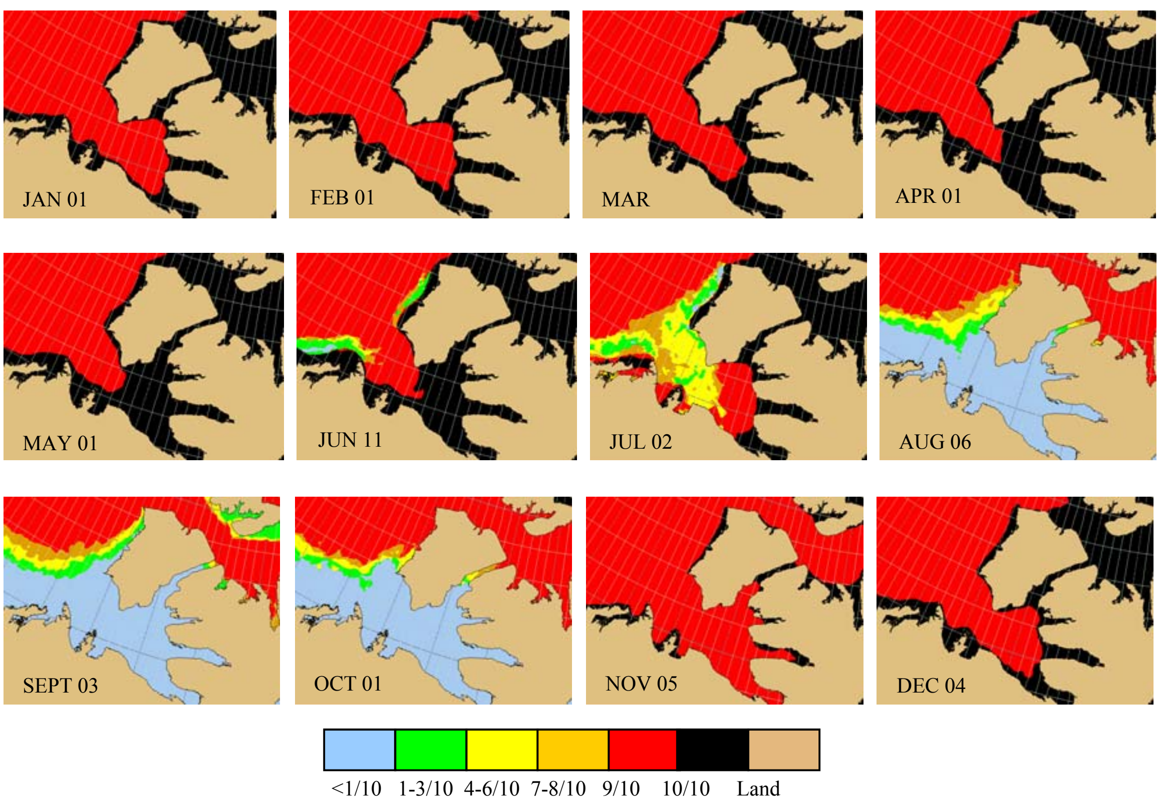

Figure 9. Median ice concentrations for Darnley Bay – Amundsen Gulf based on Canadian Ice Service (CIS) data for 1971 – 2000 (CIS 2002). From Paulic et al. (2012).

5.4 TEMPERATURE AND SALINITY

Though information is limited for Darnley Bay, salinity and water temperature distributions may vary seasonally as a result of sea ice formation and melting, freshwater inputs from the Brock and Hornaday rivers, surface heat fluxes and movements due to wind action (called wind forcing) and ice motion (Paulic et al. 2012). In August 2008, researchers aboard the CCGS Nahidik collected temperature and salinity samples throughout Inner Darnley Bay and Cape Parry. During that time, Cape Parry waters were stratified, with warmer, less saline waters at the surface (0 - 20 m) and cooler, more saline waters below (>20 m; Figure 10). Less stratification occurred in nearshore waters compared to those offshore, suggesting that mixing occurs near the cape as a result of tides and/or wind-driven flow (Paulic et al. 2012). Results indicated that water temperatures are higher in Darnley Bay than at Cape Parry and decrease in surface waters with distance from shore (Figure 10). Circulation occurs in a cyclonic pattern in which flows vary with depth (called baroclinic cyclonic circulation) (Paulic et al. 2012). This type of circulation results from differences in temperature and pressure, which affect the density (i.e., mass per unit volume) and flow of water. As temperature increases the density of sea water decreases, while the reverse is true for pressure. As a result, warm waters of low pressure will rise to the surface, while colder waters of higher pressure will sink below the surface. This division of water layers, in which density decreases with depth, is called a density gradient. Because density affects water flow, circulation will also vary along the gradient.

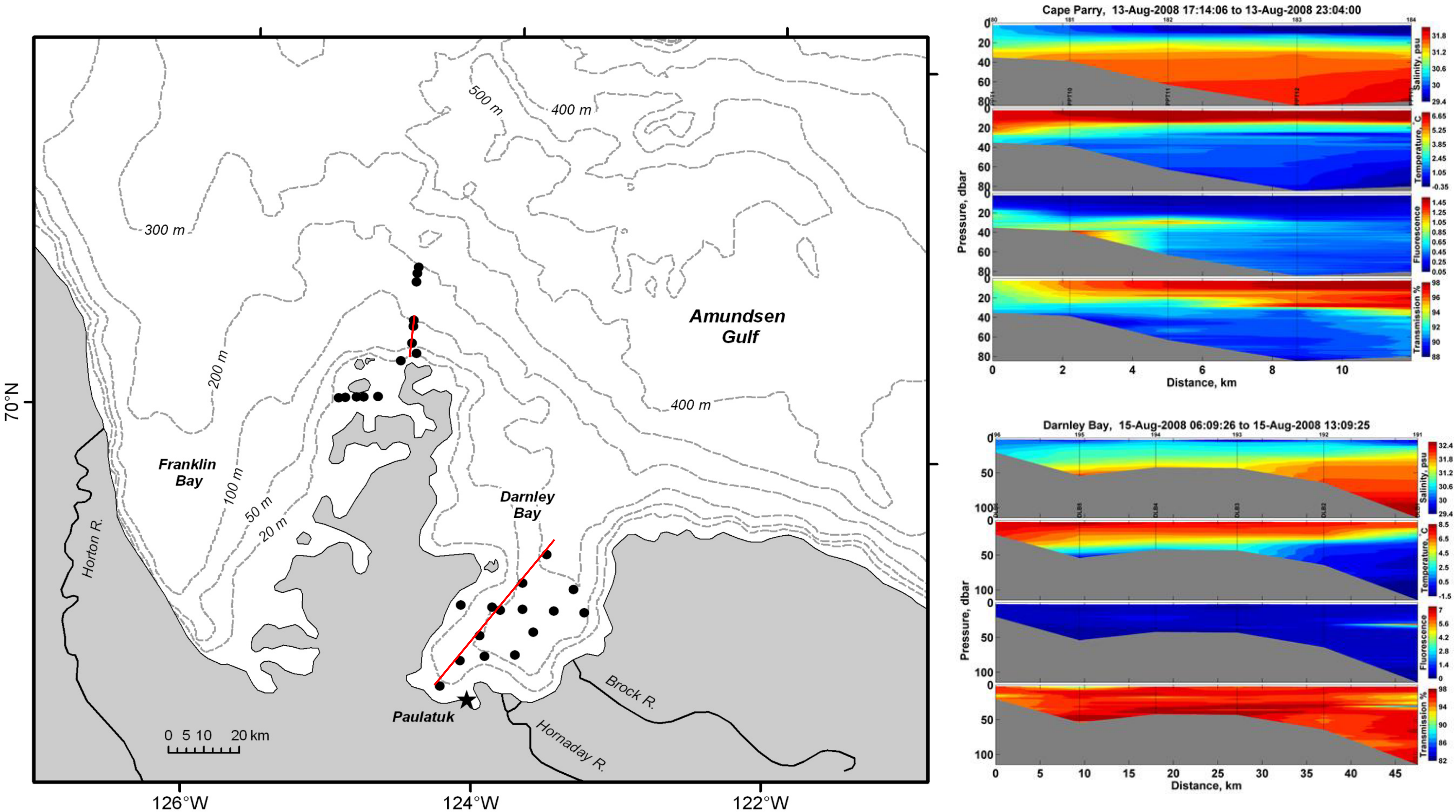

Figure 10. Cross-sectional profiles for transmission (%), fluorescence (ftSP), temperature (°C) and salinity (psu) along the Cape Parry transect (top) and the Darnley Bay transect (bottom) in August 2008 (W. Williams unpubl. Data). Pressure (dbar) can be interpreted as an approximate water depth (m). From Paulic et al. 2012.

5.5 WIND DRIVEN UPWELLING/DOWNWELLING

Wind patterns and storms can influence the movement of water masses, resulting in changes to both water temperature and salinity distributions (Paulic et al. 2012). Upwelling events driven by tides and winds are relatively common throughout the Amundsen Gulf (Barber et al. 2010), occurring along the shelf break, at the coast and along ice-edges (Mundy et al. 2009). Upwellings also are generated as a result of topography (i.e., surface features) (Williams and Carmack 2008).

During an upwelling event in the Arctic, saltier, nutrient-rich waters below the surface move upward, replacing the generally nutrient-poor surface waters (Paulic et al. 2012). In summer, these upwelled waters tend to be cold relative to the surface waters, whereas in winter the surface water is close to the freezing point so upwelled water is relatively warm (Paulic et al. 2012). A Sea Surface Temperatures satellite image from July 2008 reveals what appears to be upwelling along the northeastern coast of Darnley Bay near Pearce Point and slightly cooler temperatures in the immediate vicinity of Cape Parry (Figure 11). Further research is needed in order to determine the frequency and consistency of upwelling events in and around Darnley Bay.

Along the southern coast of the Beaufort Sea LOMA, easterly winds favour upwelling and westerly winds favour **downwelling** (Paulic et al. 2012). During upwelling events, easterly winds direct surface waters offshore toward the west. During downwelling events, westerly winds direct surface waters toward the shore and to the east. An example of near-surface circulation under downwelling-favourable (westerly) wind is shown in Figure 12. Water is first moved onshore and then travels rapidly along the shoreline to the east, taking only four days to move from Cape Bathurst to Darnley Bay (Paulic et al. 2012).

It is important to note that the scenario described above is a simplistic one and likely does not take into account conditions within the Amundsen Gulf or the complicated coastline of a much smaller area such as Darnley Bay (W. Williams, pers. comm., cited in Paulic et al. 2012).

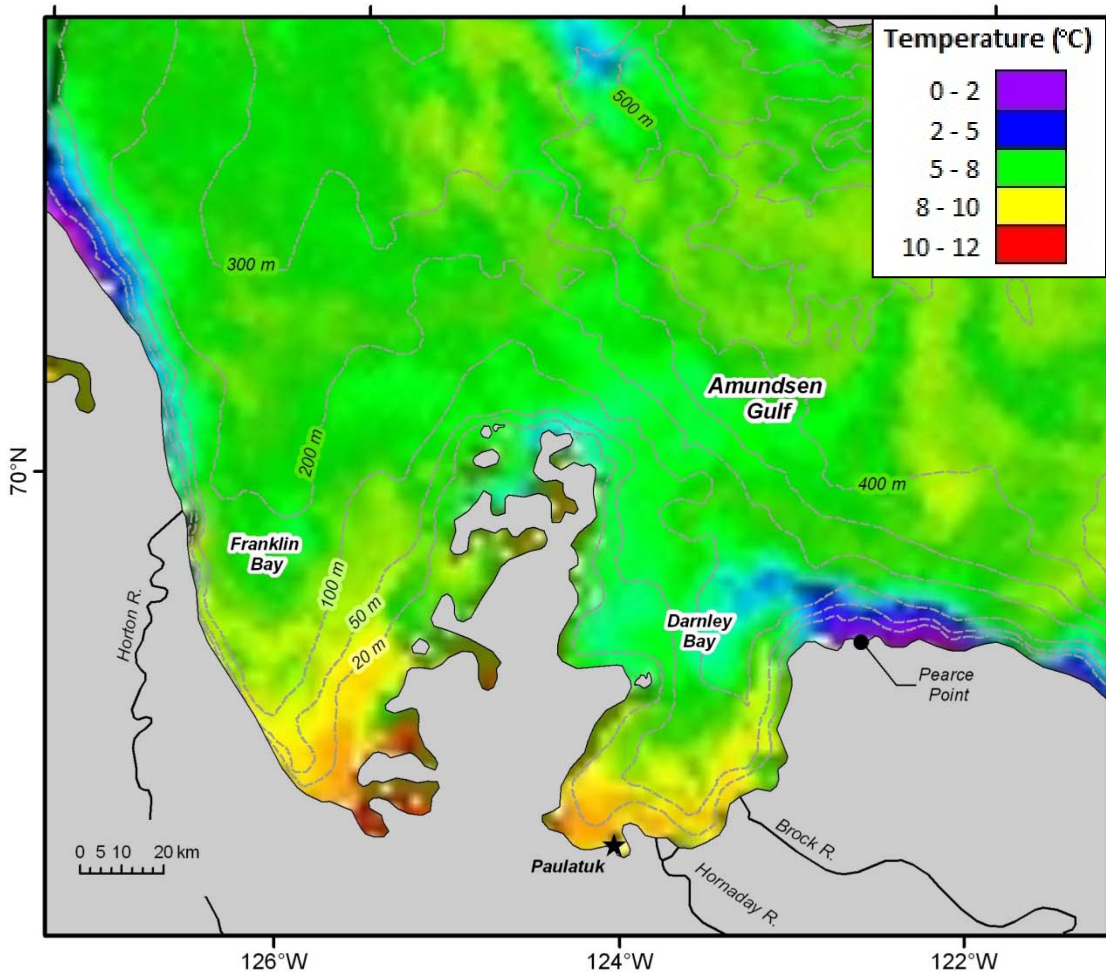

Figure 11. Sea surface temperatures for Darnley and Franklin bays on July 28, 2008 (courtesy of T.J. Weingartner and G.M. Schmidt[2]). Temperature values shown in the legend are approximate. From Paulic et al. (2012).

[2]Weingartner, T.J. and G.M. Schmidt. SeaWiFS and MODIS/Aqua data obtained from: Ocean Color Data Processing Archive NASA/Goddard Space Flight Center, Greenbelt, MD – USA.

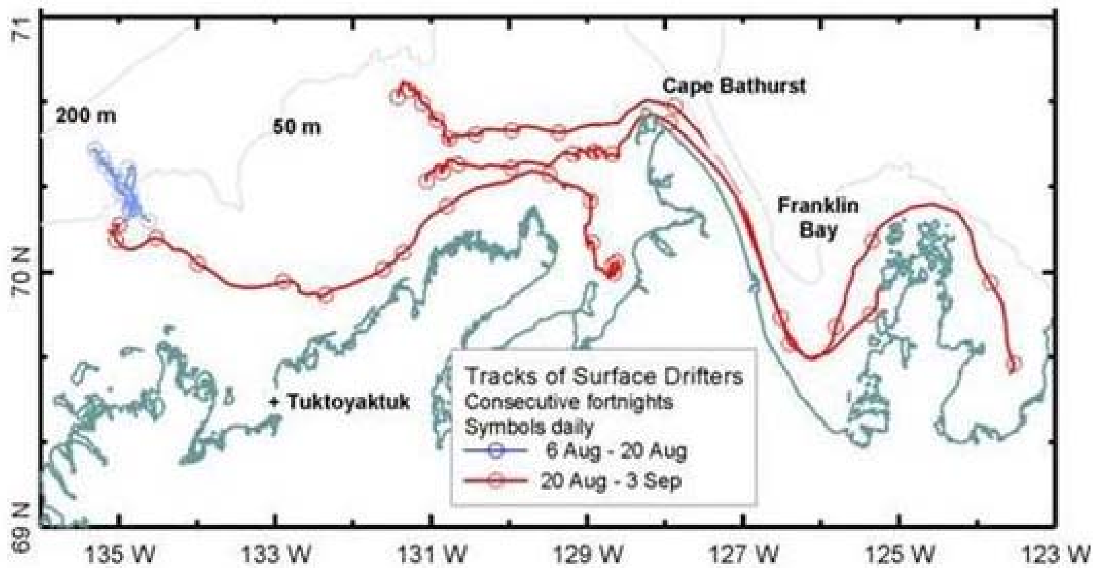

Figure 12. Surface drifter tracks moving from west to east under a downwelling-favourable (westerly) wind in August 1987 (Humfrey Melling, pers. comm., cited in Paulic et al. (2012); Williams and Carmack 2008). From Paulic et al. (2012).

5.6 TIDES

Tidal energy in the Beaufort Sea and Amundsen Gulf is low. Tidal heights are typically less than 0.5 m in the Beaufort Sea (Cobb et al. 2008), and are similar in the Darnley Bay/Amundsen Gulf region (Hannah et al. 2008). The WebTide Tidal Prediction Model[3] produced by the Bedford Institute of Oceanography (2012) determined that tides move at a rate (velocity) of approximately 4 cm/s in Amundsen Gulf, 10 cm/s at Cape Parry and only 1 cm/s in Darnley Bay (Paulic et al. 2012). These velocities are small compared to those in many mid-latitude coastal locations; however, increases in wave height (i.e., amplification) at Cape Parry may cause additional mixing (Paulic et al. 2012).

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http://www.bio.gc.ca/science/research-recherche/ocean/webtide/index-eng.php [3]

6.0 ICE

Sea ice is a key factor in physical oceanography of the Beaufort Sea and is important to the structure and function of the Arctic ecosystem (DFO and IRC 2010; Paulic et al. 2012). In addition to providing a base for **primary production** within and underneath the ice, it provides foraging (i.e., food-gathering) and rearing habitat for mammals such as seals and Polar bears (Dunbar 1981). In Darnley Bay, ice begins to form in mid-October, with complete coverage of the bay before the end of November (Natural Resources Canada 2009; Paulic et al. 2012; Figure 9). The bay freezes completely, with 10/10 (i.e., 100 %) coverage of landfast ice, from December to late June when ice begins to melt and open water is present north of Cape Parry (Dumas et al. 2005; KAVIK-AXYS Inc. 2012; Paulic et al. 2012; Figure 9). Landfast ice is sea ice that forms along the coast and progresses seaward, and in Darnley Bay reaches maximum thickness in May (DFO and IRC 2010). Ice break-up occurs in July (Cobb et al. 2008; KAVIK-AXYS Inc. 2012; Paulic et al. 2012; Figure 9).

At the edge of the landfast ice, ice rubble forms in areas where landfast and drifting ice meet (DFO and IRC 2010). This area is the Stamukhi Zone, and beyond it a flaw polynya (i.e., a polynya that forms between **pack ice** and land-fast ice) occurs. Beyond the flaw polynya lies the drifting polar ice pack (Cobb et al. 2008). The Cape Bathurst polynya is located in the Amundsen Gulf, though its exact location varies from year to year. The polynya forms in summer as the flaw polynya begins to melt and widen and remains open for four months (Cobb et al. 2008). The flaw leads of the Canadian Beaufort Shelf, Banks Island Shelf and Amundsen Gulf meet at the Cape Bathurst Polynya (Figure 13). A flaw lead is long, linear crack in the sea ice and is associated with pack ice deformation or the separation of landfast and mobile pack ice (Martin 2001; Paulic et al. 2012). Leads are typically smaller than polynya and are not restricted to a particular location (Martin 2001). The Cape Bathurst polynya and associated flaw leads represent some of the most important habitats in the Beaufort Sea LOMA, attracting large numbers of birds, **benthic** organisms and marine mammals (Harwood and Stirling 1992, Dickson and Gilchrist 2002, Conlan et al. 2008). Polynyas and flaw lead systems can be open for months before the annual melt begins, allowing for the early availability of light and increased availability of nutrients through upwellings and horizontal transport (i.e., circulation) (Paulic et al. 2012). Increases in light and nutrient availability results in earlier and enhanced productivity within the Arctic marine environment. In Darnley Bay, leads in the ice begin to form in May and Paulatuk residents indicate that their locations are the same every year (KAVIK-AXYS Inc. 2012). Regularly occurring leads form outside of

Brown's Harbour, across Darnley Bay and from the sand spit near Paulatuk westward towards the Fish Lake area (Figure 14).

A variety of environmental factors such as ocean currents, wind strength and direction, temperature, seasonal climate changes and the movement of multi-year ice influence the timing of freeze-up and break-up, as well as the distribution of sea ice, leads and polynyas (Stirling et al. 1993, Stirling 2002). Formation of sea ice within the Amundsen Gulf is highly variable from year to year. For example, strong easterly winds in 2008 resulted in large-scale movement of ice which prevented the formation of fast ice throughout most of the Amundsen Gulf (Barber et al. 2010). In the fall, rubble ice fields are created in Darnley Bay as a result of easterly winds (KAVIK-AXYS Inc. 2012). Rubble ice fields also are formed offshore of Cape Parry as a result of strong currents and westerly winds and mark the boundary between landfast ice and pack-ice (KAVIK-AXYS Inc. 2012; Figure 14). The formation of flaw leads is dependent on both the formation and timing of landfast ice edges and the motion of the mobile offshore pack ice (Barber et al. 2010).

Though receding (melting) ice-edges represent sites of high potential productivity, the amount of productivity in these areas is highly variable over time and space (Smith and Nelson 1986). For example, wind-induced upwelling along ice-edges can bring nutrient-rich waters to the surface and promote extensive **phytoplankton blooms** (Alexander and Niebauer 1981). This process occurred along the landfast ice edge of Darnley Bay in early June 2008 as a result of upwelling-favourable easterly winds (Mundy et al. 2009).

Residents of Paulatuk report that ice conditions in Darnley Bay have changed over time and that permanent ice has not been observed in the bay since 1995 (KAVIK-AXYS Inc. 2012). Residents also note that freeze-up occurs later in the year and that the area between Cape Parry and Nelson Head (Banks Island) rarely freezes over now as it did in the past. During spring break-up, winds typically force the ice out of Darnley Bay; however, community members indicate that in recent years the ice has melted in the bay rather than being forced out by wind. Ice is said to be thinner (often less than 1.5 m as opposed to 2-2.5 m in previous years), making it more difficult for residents to travel long distances over the ice (KAVIK-AXYS Inc. 2012).

Figure 13. Diagram of the Amundsen Gulf polynya (dark gray) and flaw lead system (light gray). From Galley et al. (2008).

Figure 14. Ice features within Darnley Bay as defined by participants at the Traditional and Local Knowledge Workshop for the Anuniaqvia niqiqyuam AOI, March 2011. From KAVIK-AXYS Inc. (2012).

7.0 HABITAT

DFO identifies four primary habitats that are important to ecosystem structure and function within the Anuniaqvia niqiqyuam AOI: Darnley Bay nearshore migratory and feeding corridor; Cape Parry offshore feeding habitat; Darnley Bay offshore ice-edge habitat; and kelp beds (Paulic et al. 2012). Each habitat type supports one or more species at various life cycle stages and is necessary to their survival.

7.1 DARNLEY BAY NEARSHORE MIGRATORY AND FEEDING CORRIDOR

The Darnley Bay nearshore environment is critical for the feeding and coastal migration of Arctic Char (Paulic et al. 2012). Char typically feed at depths between 5 and 10 m along coastline; however, climatic and oceanographic conditions can influence water mass movements within Darnley Bay, affecting the movements of char and their prey (e.g., Capelin [*Mallotus villosus*]) (Paulic et al. 2012). As a result, Arctic Char also may occupy the lower salinity portion of the water column further from shore (Paulic et al. 2012).

Freshwater input from the Brock and Hornaday rivers is the primary factor influencing the nearshore environment of Darnley Bay (Figure 15). Fresh river water combines with marine waters of the bay to produce brackish conditions that are critical to the physiology of Arctic Char. Although this species can tolerate high salinities, they must undergo gradual salinity changes in order to acclimatize their body to marine waters (Paulic et al. 2012). In addition to providing habitat suited to their unique physiology, the corridor represents important feeding, migratory and overwintering habitat for Arctic Char. The Hornaday River delta may be critical to the survival of the overwintering population, although to what extent remains unknown (Paulic et al. 2012).

Paulic et al. (2012) recommends that the Nearshore Migration and Feeding Corridor for Arctic Char in Darnley Bay be given highest priority for protection, as any environmental degradation in the area would likely have serious fitness consequences to populations in Darnley Bay. Arctic Char is an Ecologically Significant Species in the Beaufort Sea LOMA due to its importance to the marine ecosystem. The authors also suggest that protection of this habitat would aid in the conservation of a number of other non-commercial fishery resources.

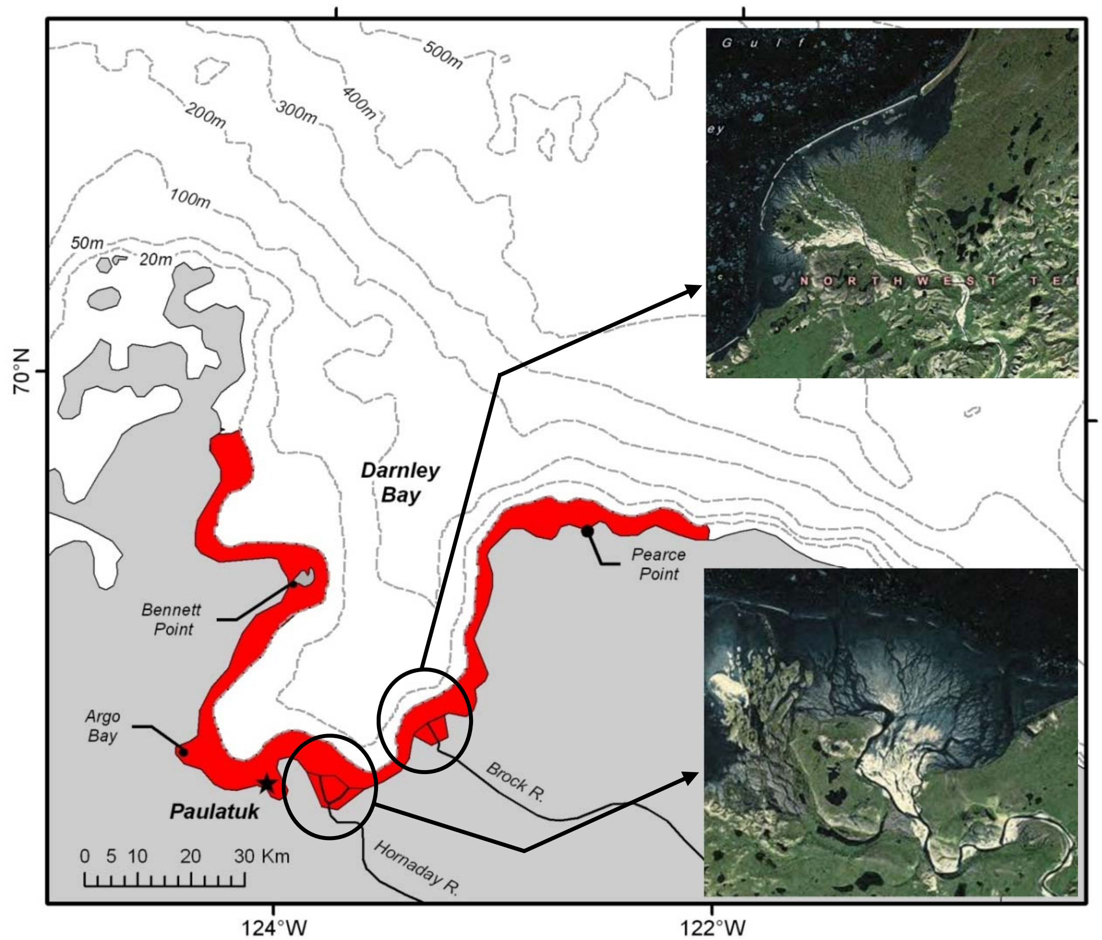

Figure 15. Darnley Bay Nearshore Migration and Feeding Corridor. Inset maps show detailed estuary images for the Brock (top) and Hornaday (bottom) rivers. From Paulic et al. (2012).

Paulic et al. (2012) recommended that the MPA boundaries for the corridor begin at the low water mark to a water depth of 20 m, from the area just north of Bennett Point to the area just east of Pearce Point (Figure 15). This includes brackish waters at the mouths of the Hornaday and Brock rivers. The defined area covers approximately 940 km^2 and is based on tagging data and habitat similarities. The authors suggest that designation of this habitat for marine protection could be used in combination with existing management plans (e.g., Paulatuk Community Conservation Plan, Beaufort Sea Beluga Management Plan, Paulatuk Community Arctic Char Fishery Management Plan).

7.2 CAPE PARRY OFFSHORE MARINE FEEDING HABITAT

The offshore habitat adjacent to Cape Parry is an area of high productivity (Paulic et al. 2012). The marine currents, tides and variable bathymetry result in frequent upwellings that produce a nutrient-rich environment and provide important habitat for many species (Paulic et al. 2012). During late winter and spring the polynya and sea ice provide a structural platform for marine mammal hunting and feeding (e.g., Polar Bears, Ringed and Bearded Seals), promote aggregations of prey species, and provide important feeding areas for other key species (e.g., Beluga, Bowhead) (Paulic et al. 2012). Both TK and scientific collections indicate that squid frequent the area just off Cape Parry (DFO and IRC 2010; KAVIK-AXYS Inc. 2012). This is the only known location in the Beaufort Sea in which this species occurs (DFO and IRC 2010).

The Cape Parry offshore area also represents valuable habitat for marine birds. A unique nesting area for Thick-billed Murres and Black Guillemots exists within the Cape Parry Migratory Bird Sanctuary and in late summer the area is used by sea ducks (e.g., King Eider, Common Eider) for staging and moulting (Paulic et al. 2012). Although suitable Thick-billed Murre nesting habitat is available elsewhere (Nelson Head, NT), the Cape Parry colony is the only one present in the Beaufort Sea LOMA (Paulic et al. 2012). In late spring and summer, when the survival of Murres relies heavily on the success of adult foraging, the productive offshore marine habitat at Cape Parry provides a reliable and abundant source of food (Paulic et al. 2012). Mallory and Fontaine (2004) reported that although a substantial amount of foraging occurs within 30 km of the colony, Thick-billed Murres can forage as far as 200 km away.

Fisheries and Oceans Canada recommends giving the polynya and sea-ice habitat off Cape Parry the second highest priority for protection (Paulic et al. 2012). Available research suggests that the conservation and protection of the habitat features within this area also would protect non-commercial fishery resources as well as assisting other management plans (e.g., Beaufort Sea Beluga Management Plan, Paulatuk Community Conservation Plan) within the area (Paulic et al. 2012). In addition, a number of species considered Endangered or Special Concern (COSEWIC 2008, 2009) potentially utilize this habitat, including Bowhead (Special Concern, COSEWIC 2009), Polar Bear (Special Concern; COSEWIC 2008) and the Ivory Gull (Endangered; COSEWIC 2006). DFO posits that conservation and protection regulations may provide additional protection to these species, particularly in circumstances where local activities may affect habitat quality (Paulic et al. 2012).

Exact boundaries for the Cape Parry Offshore Marine Feeding Habitat are difficult to define due to lack of scientific data. However, in the eastern Canadian Arctic, seabirds travel a median distance of 30 km from their nests to feed and evidence suggests that such is the case for seabirds at Cape Parry (Mallory and Fontaine 2004). Paulic et al. (2012) recommended that the protected area is sufficiently large enough to accommodate the oceanographic and ecological processes that produce the rich marine environment there, in addition to the species that depend on it. Consequently, the recommended area included a minimum 30 km radius centred on Cape Parry (Figure 16). The defined area covers approximately 3,000 km^2 (Paulic et al. 2012).

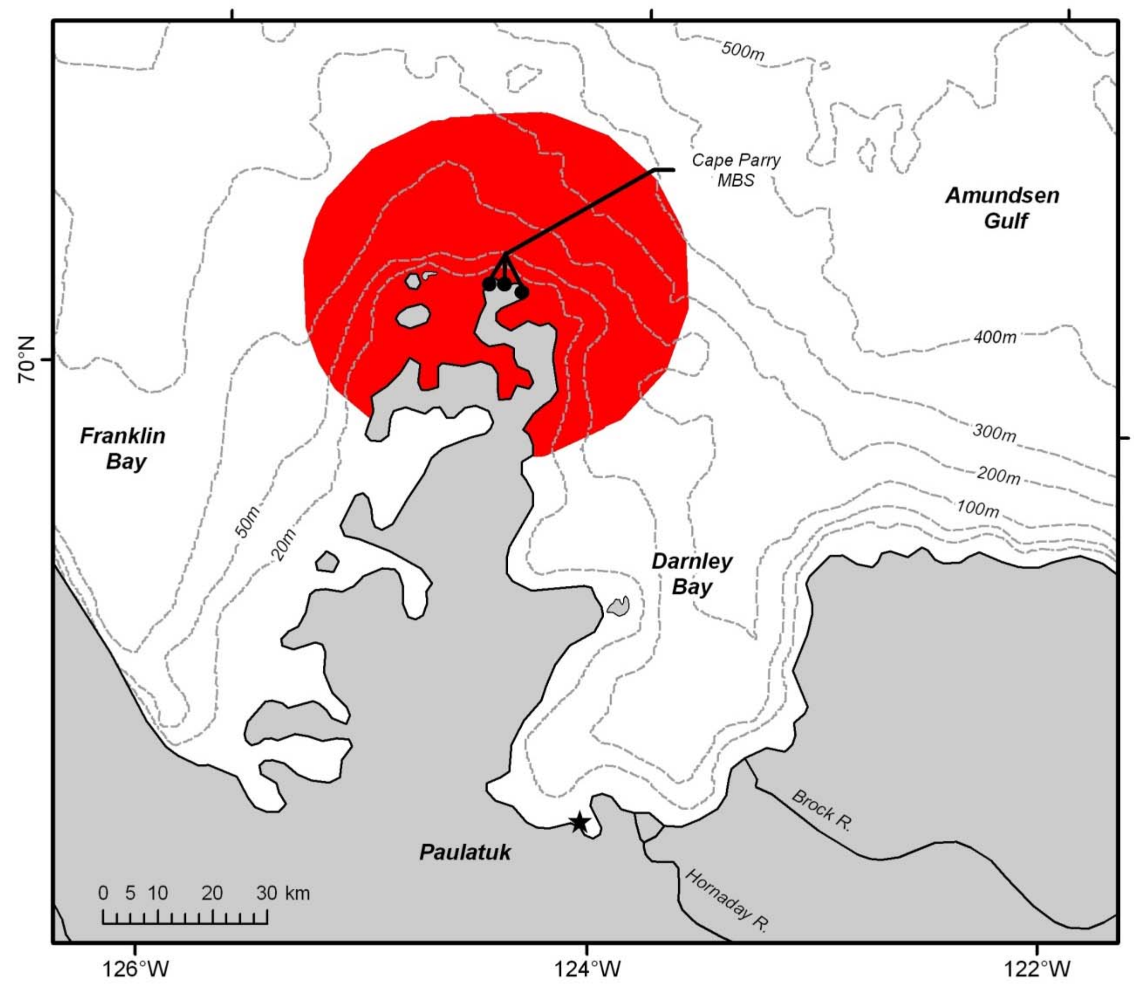

Figure 16. Cape Parry Offshore Marine Feeding Habitat. From Paulic et al. (2012).

7.3 DARNLEY BAY OFFSHORE ICE-EDGE HABITAT

The Amundsen Gulf polynya and associated flaw leads offshore of Darnley and Franklin bays is a highly productive area between late winter and spring (Paulic et al. 2012). The receding fast-ice edge habitat supports greater productivity (Smith and Nelson 1986) and wind-induced upwelling along the sea-ice edge promotes aggregations of prey and their predators (e.g., Arctic Cod [*Boreogadus saida*], Beluga, Bowhead) (Paulic et al. 2012).

In the spring, wind and bathymetry (i.e., differences in depth) can promote inconsistent upwellings. This type of upwelling occurs along the continental coast near Pearce Point (W. Williams, pers. comm., cited in Paulic et al. 2012). Though not unique to the Beaufort Sea LOMA, these upwellings are important as they bring nutrient-rich waters to the surface and allow for additional primary production in the region (Williams and Carmack 2008). However, since they are seasonal features, the timing and distribution of productivity are highly variable (Paulic et al. 2012).

Bowhead and Polar Bears (Special Concern; COSEWIC 2008, 2009) use the Darnley Bay offshore ice-edge for foraging and hunting (Paulic et al. 2012). Ivory Gulls (Endangered; COSEWIC 2006) also may be present in the area.

The Darnley Bay Offshore Ice-edge Habitat encompasses approximately 5,500 km^2. Paulic et al. (2012) concluded that boundaries for the area are difficult to define due to its high degree of inter-annual and seasonal variability. However, the authors determined boundaries based on the approximate location of the fast-ice edge (CIS 2002; Figure 17) and observations made during Bowhead aerial surveys conducted in the region (Paulic et al. 2012).

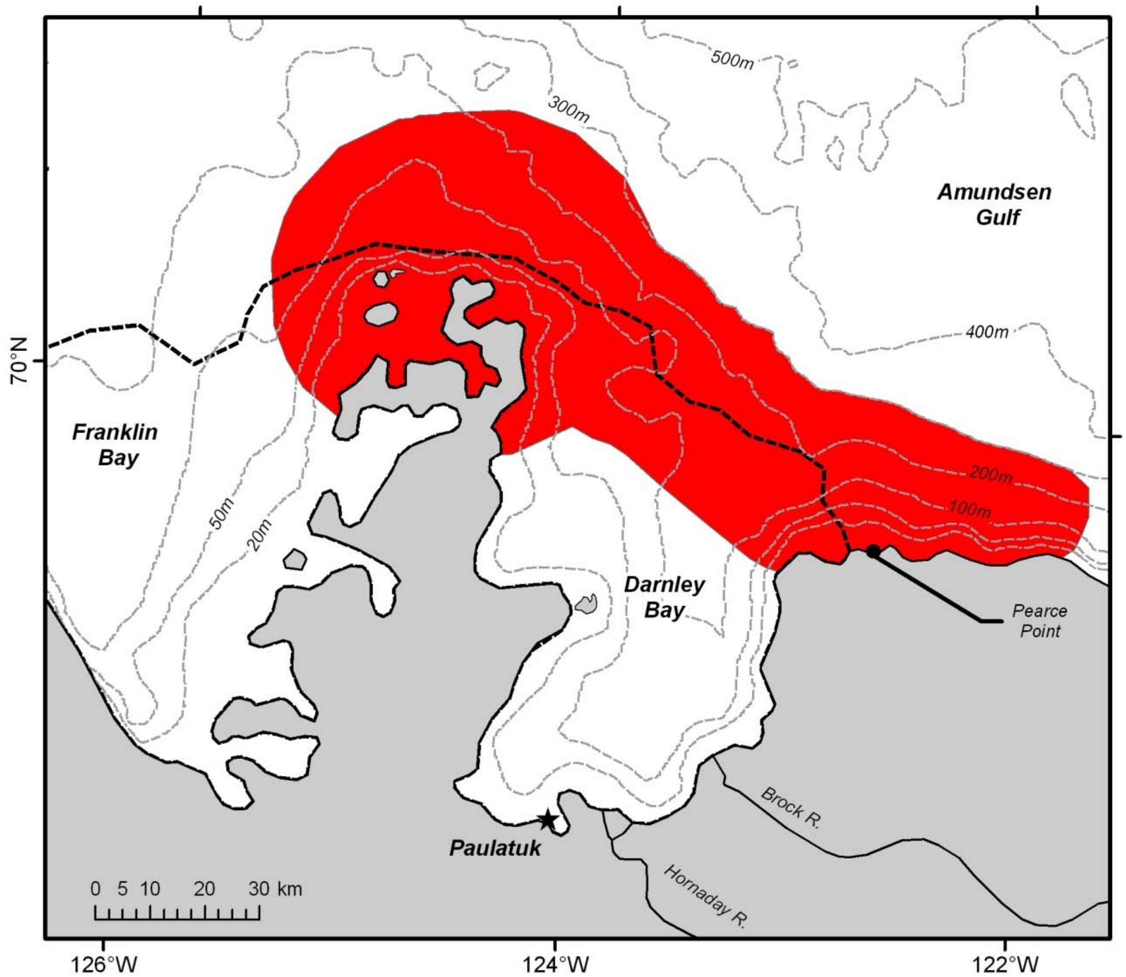

Figure 17. The Darnley Bay Offshore Ice-edge Habitat. Dashed line shows approximate location of the fast ice edge (CIS 2002). From Paulic et al. (2012).

7.4 KELP BEDS

Kelp beds within the Beaufort Sea LOMA are rare and unique (Paulic et al. 2012). Traditional knowledge indicates that beds exist near Argo Bay, in Wise Bay (Figure 18) and potentially other areas along the coast of Darnley Bay (KAVIK-AXYS Inc. 2012; Paulic et al. 2012). The closest comparison is in Alaska at Stefansson Sound (Boulder Patch) and areas within the Canadian Eastern Arctic (e.g., Resolute, Igloolik). Though little information is available for the Beaufort Sea LOMA, kelp beds are known to provide space, protection and food for potentially unique and/or diverse communities in other oceans (Paulic et al. 2012). Kelp beds also may serve as important spawning or nursery habitat for some species of fish. Paulic et al (2012) concluded that identification

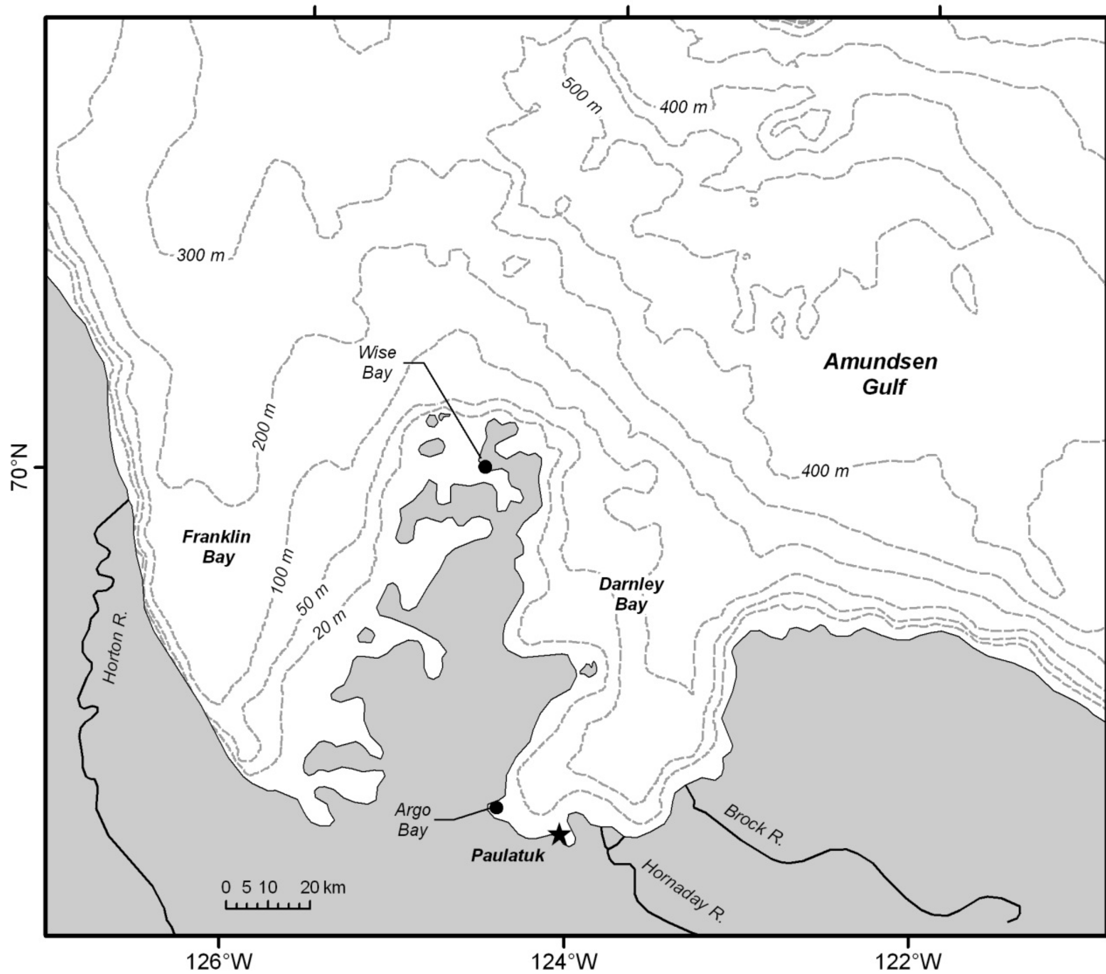

Figure 18. Locations of kelp beds, in Argo and Wise bays, based on Traditional and local knowledge from the community of Paulatuk. From Paulic et al. (2012).

of the exact location and species of kelp in Darnley Bay is necessary for consideration as a key component of an MPA under the *Oceans Act*.

8.0 PRODUCTIVITY

Primary producers form the base of the food web, using energy from the sun to convert carbon dioxide and water into organic matter (DFO and IRC 2010; Paulic et al. 2012). Several different types of primary producers may exist in nearshore Arctic waters, including phytoplankton, **ice algae**, benthic **micro-** and **macroalgae** and aquatic **macrophyte**s (Cobb et al. 2008).

The timing and yield of phytoplankton blooms determine the connection (or coupling) between primary production and the **heterotroph**ic food web (e.g., zooplankton, fish, birds, marine mammals; Legendre 1990) (Paulic et al. 2012). Both are important to the success of higher trophic levels (i.e., organisms that occupy higher feeding positions within the food web, such as carnivores). For example, low phytoplankton growth may lead to low food availability and decreased success of zooplankton populations, which will affect higher trophic levels that depend on zooplankton for food. Alternatively, warmer temperatures and earlier ice break-up can lead to earlier phytoplankton production which peaks before zooplankton have emerged. As a result, zooplankton populations and those of higher trophic levels may be less successful.

Light and nutrient availability control the growth of primary producers (Grainger 1975). The absence of the sun during the winter months (polar night) inhibits growth. When the sun returns in spring, light availability controls the timing (or beginning) of phytoplankton production, while nutrient availability determines the overall amount of production during the growing season (Carmack et al. 2004). Snow-covered ice and shading by the growth of sea-ice algae limits the amount of light available for under-ice production (Grainger 1975). As a result, polynyas and edges of retreating sea-ice become important areas of production during the winter months (DFO and IRC 2010).

Phytoplankton Production

Overall, phytoplankton production in the Beaufort Sea is low (Macdonald et al. 1989), although increased levels of production may occur in nearshore regions and at localized sites (e.g., Arrigo and van Dijken 2004). In addition to open-water areas, primary production also occurs within and under sea ice by ice algae and bacteria (Cobb et al. 2008; Mundy et al. 2009). Primary production within the ice contributes an estimated 25% of total Arctic production and is the principal form of primary production in winter and spring (Horner and Schrader 1982). Production by ice algae plays an important ecological role as it is the first available food source to planktonic grazers (Michel et al. 1996). Ice algal blooms occur in spring due to increasing periods of daylight and nutrient concentrations (e.g., Campbell 1981). Mundy et al. (2009) suggest that ice edge upwelling events are important to local primary production, and Buckley et al. (1979) propose that these types of events may attract a number of ice-associated grazers.

Though little is known about primary production and plankton in Cape Parry and Darnley Bay, information is available for the Beaufort Sea LOMA (e.g., Cobb et al. 2008). Mundy et al. (2009) found that in June 2008, easterly winds (upwelling-favourable wind event) in Darnley Bay forced cooler (-1.5°C), saline (32.5 ppt) waters to be transported from approximately a 40 m depth to the upper 10 m of the water column (Figure 19). This allowed phytoplankton to make use of the nutrient-rich waters within the upper water layer (i.e., **euphotic zone**), triggering an increase in phytoplankton **biomass** (measured as chlorophyll *a*) in the upper 50 m of the water column (Figure 19). Annual estimates of primary production based on the upwelling period in June 2008 exceed earlier estimates (10 to 15 g C m^{-2} a^{-1}; Carmack et al. 2004) by a factor of two (Mundy et al. 2009). This suggests that the fast-ice edge across the mouth of Darnley Bay is an important feature where periodic, localized increases in primary production can occur (Paulic et al. 2012).

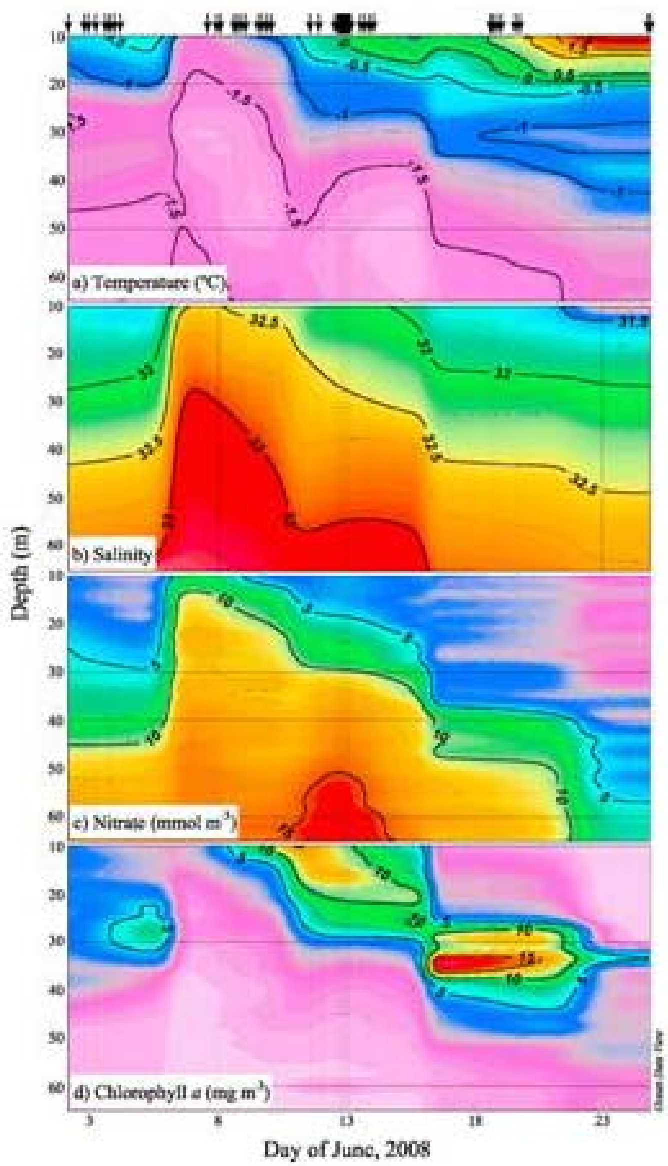

Figure 19. Interpolated time series for a sampling station in Darnley Bay in June 2008 showing a) temperature, b) salinity, c) nitrate concentration and d) chlorophyll *a* concentration (Mundy et al. 2009). From Paulic et al. (2012).

9.0 MARINE VEGETATION

Several factors influence the distribution of macrophytes in the marine Arctic environment, including sea ice dynamics (ice scouring), light availability (sea ice and suspended sediments) and the availability of suitable substrates for attachment (Paulic et al. 2012). Limited information is available regarding marine macrophytes in Darnley Bay and throughout the Western Arctic (Paulic et al. 2012); however, local residents describe several forms of marine vegetation within the Anuniaqvia niqiqyuam AOI (KAVIK-AXYS Inc. 2012).

Kelp beds and other areas of marine vegetation are relatively small and scattered throughout the AOI (KAVIK-AXYS Inc. 2012; Paulic et al. 2012). Traditional knowledge indicates that kelp beds occur near Argo Bay and in Wise Bay (Section 7.4; Figure 18) (KAVIK-AXYS Inc. 2012; Paulic et al. 2012). No other areas with kelp are known from the Beaufort Sea LOMA, although kelp beds may exist in Brown’s Harbour (KAVIK-AXYS Inc. 2012), Liverpool Bay and near Sachs Harbour (Cobb et al. 2008).

Kelp beds are ecologically important as they provide space, protection and food for a variety of organisms. For example, kelp beds may represent important habitat for some fish species, providing suitable conditions for spawning as well as cover and food for juvenile life stages (Paulic et al. 2012). The presence of kelp in Darnley Bay is potentially important to overall ecosystem structure and function (Paulic et al. 2012).

Paulatuk residents report that marine vegetation in the AOI is most prevalent between Paulatuk and Bennett Point and is generally found in areas of sandy **substrate** (KAVIK-AXYS Inc. 2012). Residents describe a kelp-like seaweed having blades that are approximately 2 feet (0.61 m) in length and six inches (0.15 m) across. Blades were described as being as thick as cow hide (approximately 1/8 inch or 0.32 cm) with a bulb on the end, similar to *Laminaria* sp. (KAVIK-AXYS Inc. 2012). Residents observed this seaweed in shallow, sandy areas and in 6 feet (1.83 m) of water underneath the surface. Traditional knowledge indicates that mussels are associated with the kelp-like beds (KAVIK-AXYS Inc. 2012). Paulatuk residents also describe grass-like marine vegetation which grows in small patches in shallow waters (KAVIK-AXYS Inc. 2012). Figure 20 illustrates areas of marine growth identified by Paulatuk residents.

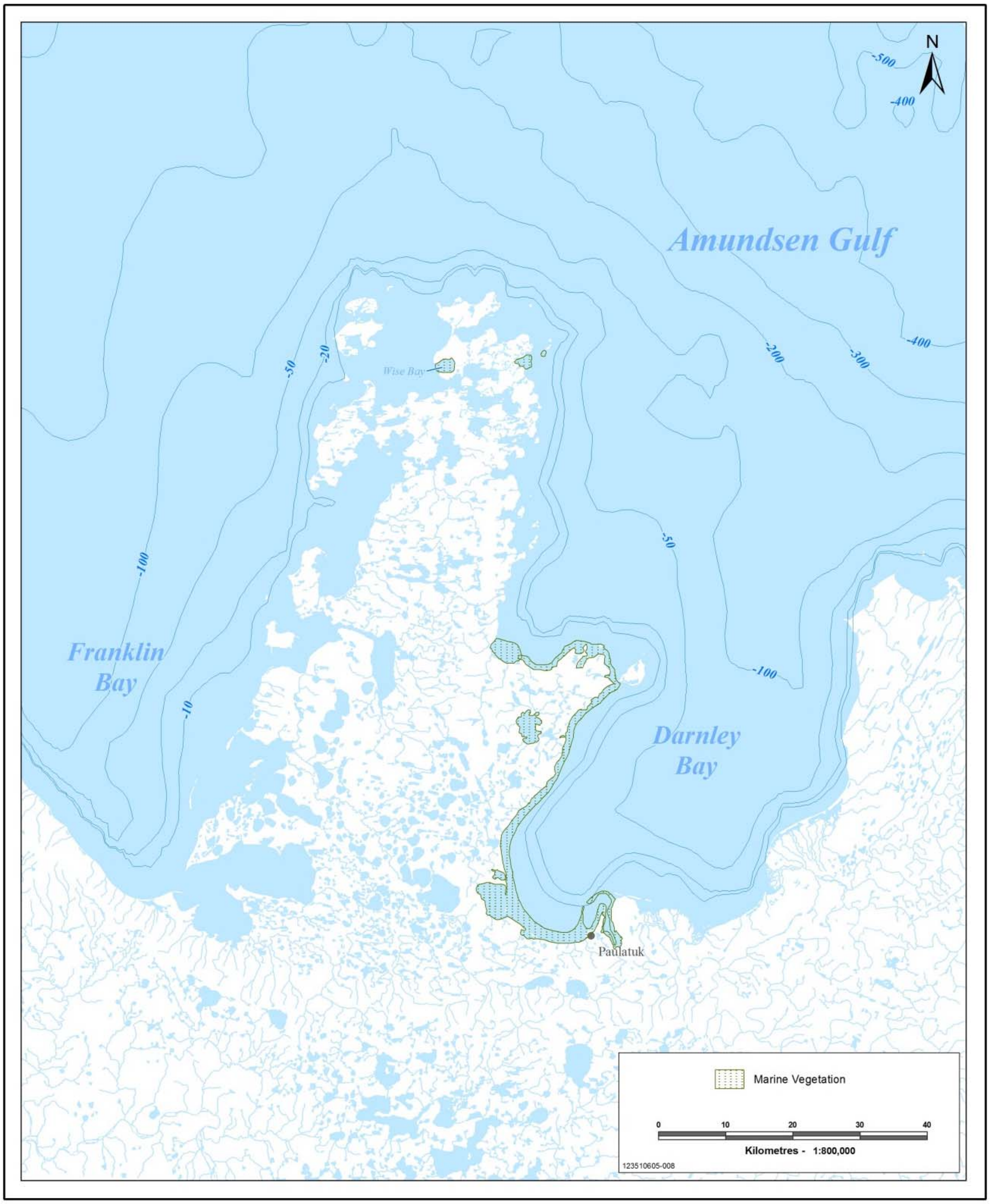

Figure 20. Areas of marine vegetation as determined by participants at the Traditional and Local Knowledge Workshop for the Anuniaqvia niqiqyuam AOI, March 2011. From KAVIK-AXYS Inc. (2012).

10.0 MARINE INVERTEBRATES

10.1 ZOOPLANKTON

Zooplankton are floating or weakly swimming animals in the water column, and represent the primary link in the food web between phytoplankton and higher trophic levels (e.g., fish, whales, birds) (Paulic et al. 2012). Several factors influence the abundance, distribution and community structure (i.e., species present in the community) of zooplankton in the marine environment. These include: movements of water masses; physical-chemical properties of water (e.g., temperature, salinity); and the differences in the life histories of each species (e.g., growth, reproduction) (Paulic et al. 2012).

Zooplankton in Darnley Bay are not well studied. However, Darnis et al. (2008) and Walkusz et al. (2010) found that Arctic copepods (small crustaceans of the subclass Copepoda) dominate zooplankton communities in the Beaufort Sea. Despite the dominance of copepods throughout the system, different assemblages (or communities) exist in different oceanographic regions such as the shelf, slope, polynya and offshore areas (Auel and Hagen 2002, Darnis et al. 2008, Walkusz et al. 2010). For example, the zooplankton community along the shelf (called the shelf assemblage) occupies the shallow (43-182 m), relatively cold, low salinity waters of Kugmallit Canyon, the Mackenzie Shelf and Franklin Bay (Darnis et al. 2008) (Figure 21). Dominated by the copepod species *Pseudocalanus* spp., this assemblage maintains a lower diversity and **species richness** than the offshore assemblage. Results indicate that this shelf assemblage extends around the northern portion of Cape Parry.

Darnis et al. (2008) found that biomass of the polynya assemblage (5.91 g DW m^{-2}) was higher than that of the shelf and slope assemblages (1.98 and 2.59 g DW m^{-2}, respectively), due mainly to a three-fold increase in the abundance of the large **indicator species**, *C. hyperboreus* (Darnis et al. 2008). Zooplankton production in Darnley Bay is significantly less than in neighbouring regions such as Franklin Bay (Hop et al. 2011), with biomass measurements ranging from 0.01 - 0.04 g DW m^{-2} (W. Walkusz, unpubl. data, cited in Paulic et al. 2012).

Zooplankton is not limited to small organisms and can include larger species such as jellyfish (Cnidaria). Paulatuk residents indicate that jellyfish are relatively common throughout the AOI and that declining numbers observed in recent years may indicate that the population fluctuates over time (KAVIK-AXYS Inc. 2012).

Figure 21. Areas occupied by the Beaufort Sea shelf zooplankton assemblage; Mackenzie Canyon, Kugmallit Canyon and Franklin Bay. Modified from Google Maps (2012).

10.2 BENTHIC INVERTEBRATES

Benthic organisms (or benthos) are those living on or within the seabed. Depending on the habitat they occupy, benthos belong to one of two groups: epifauna and infauna (Thorson 1957). Epifauna are organisms that inhabit the upper surface of the seabed substrate and can either be **sessile** (e.g., sea anemones) or mobile (e.g., opossum shrimps). Infauna are organisms found within the bottom sediments and are usually sedentary (e.g., clams, bristle worms). Substrate type, water depth, the presence and dynamics of sea ice (e.g., ice scouring), physical-chemical properties of the water column and food availability all influence the distribution of benthic organisms along the ocean bottom (Paulic et al. 2012). As a result, differences in distribution generally occur along two gradients: onshore to offshore and/or west to east (Paulic et al. 2012).

Scientific information on benthos in Darnley Bay is incomplete. However, collections made from the CCGS Nahidik in 2008 suggest that benthic organisms in the bay respond to environmental conditions in a similar way as those in the Beaufort Sea and Amundsen Gulf (K. Conlan, pers. comm., cited in Paulic et al. 2012). Conlan et al. (2008) found that **macrofauna**l abundances for the Beaufort Shelf and Amundsen Gulf were within the range of those in the Bering and Chukchi seas. Water depth strongly influenced regional variations in abundance for the Beaufort Sea and Amundsen Gulf. Abundance and biomass values at Cape Parry and Darnley Bay were similar to those observed in the western region of the Canadian Beaufort Sea (Figure 22). Mean abundances were higher at Cape Parry (6,410 individuals m^{-2}) than in Darnley Bay (1,375 ± 545 individuals m^{-2}), but highest at Cape Bathurst (>30,000 individuals m^{-2}). Upwellings are common at Cape Bathurst, promoting increased production and macrofaunal abundance. Conlan et al. (2008) identified this area as an important biological hotspot.

Biomass estimates showed similar patterns as those observed for abundance. Biomass measurements at Darnley Bay and Cape Parry (3.9 – 29.8 g m^{-2}; Figure 23) were comparable to those from other western locations on the Canadian Beaufort Sea Shelf but were lower compared to Cape Bathurst and areas west that were influenced by wind-driven upwelling events (117.4 – 245.7 g m^{-2}; Figure 23). Though Darnley Bay and Cape Parry had similar variations in biomass, values measured at Cape Parry were higher due to the presence of large **mollusc**s in samples (Figure 23).

Conlan et al. (2008) reported that although considerable variation occurs, species richness for benthos in the AOI declines from east to west, with particularly low numbers west of Cape Bathurst. Species richness was low in Darnley Bay (7.5 ± 0.5 species m^{-2}) and

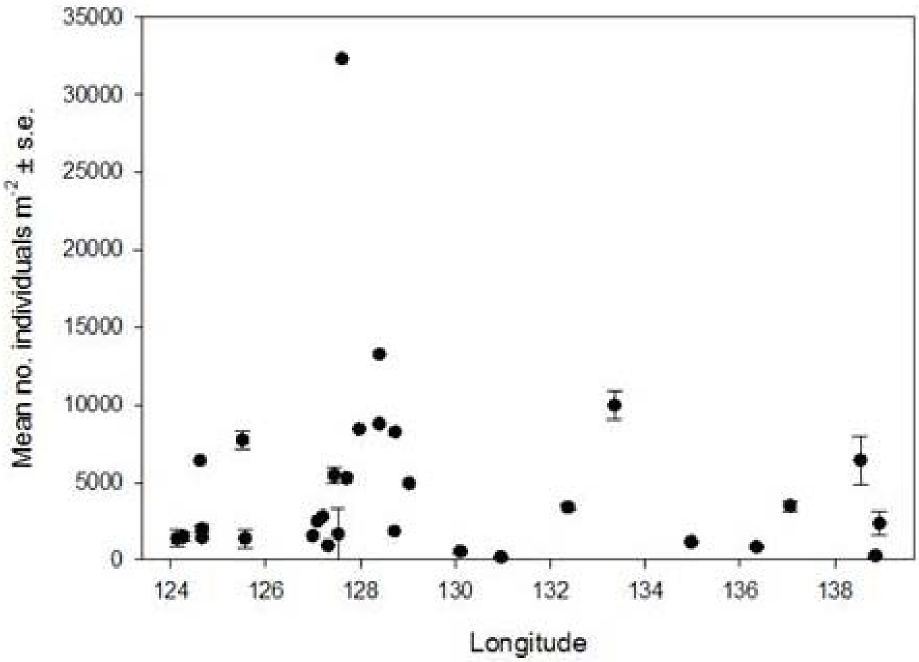

Figure 22. Mean abundance of macrofauna by longitudal location from Darnley Bay (124°W) west to Herschel Basin (138.9°W). The hotspot at Cape Bathurst (128°W) is due to large numbers of **cumacean**s, **ostracod**s, **isopod**s, **tanaid**s and **ophiuroid**s. Further analysis of the data will likely reveal large numbers of the **amphipod** *Ampelisca macrocephala* and **polychaete** *Barantolla americana*. Macrofauna analyzed for this report include **crustaceans**, **echinoderms**, **priapulids**, **sipunculids** and others. Abundances of **Amphipoda**, **Polychaeta** and **Mollusca** have not been completed (K. Conlan, unpubl. data). From Paulic et al. (2012).

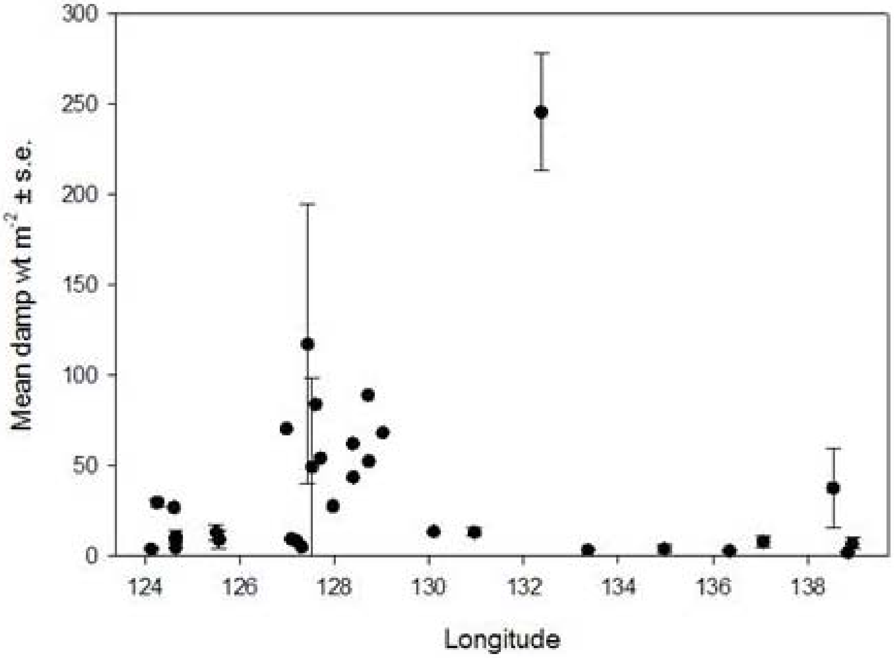

Figure 23. Mean biomass of polychaetes, molluscs, crustaceans, echinoderms, priapulids, sipunculids and others by longitudal location from Darnley Bay (124°W) west to Herschel Basin (138.9°W). (K. Conlan, unpubl. data). From Paulic et al. (2012).

increased toward Cape Parry (32 species m^{-2}; Figure 24), reflecting the general pattern of increasing richness from inshore to offshore areas (Conlan et al. 2008). A similar gradient is present in other regions of the Beaufort Sea LOMA (e.g. Mackenzie River). However, data from the AOI are incomplete and it is possible that upon completion of all species identifications, this gradient of increasing richness toward offshore areas may be less apparent (K. Conlan, pers. comm., cited in Paulic et al. 2012). Based on available information, the high abundance of benthos at Cape Bathurst appears to be more important than species richness to ecosystem structure and function in the Beaufort Sea LOMA (K. Conlan, pers. comm., cited in Paulic et al. 2012).

Species composition of benthic communities in Darnley Bay and at Cape Parry appears similar to that of the western Canadian Beaufort Sea Shelf (Conlan et al. 2008). Residents in the Anuniaqvia niqiqyuam AOI report sea urchins, clams, mussels, crabs, shrimp and other

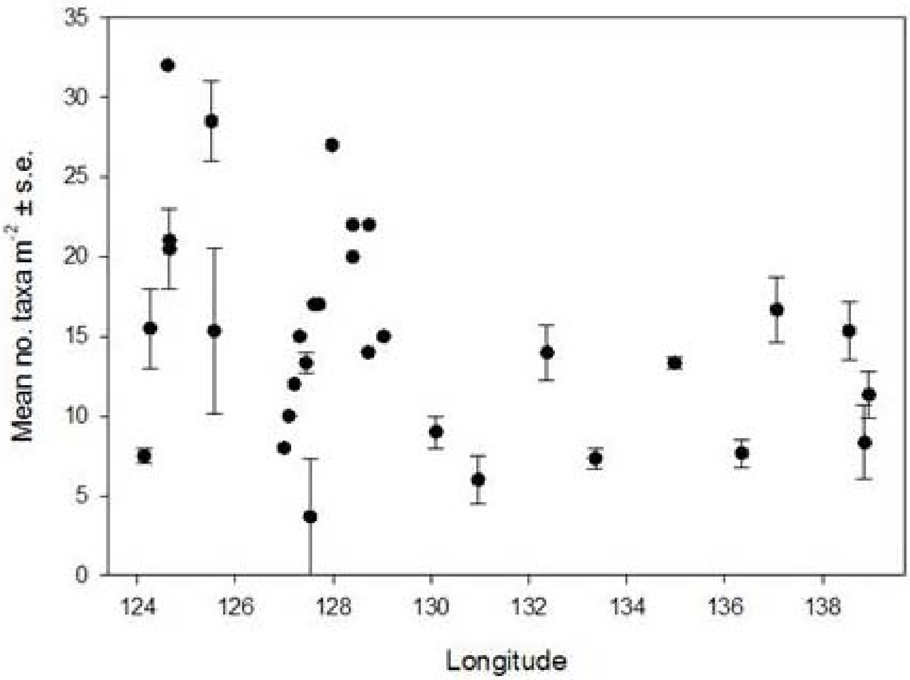

Figure 24. Mean species richness of crustaceans, echinoderms, priapulids, sipunculids and others by longitudinal location from Darnley Bay (124°W) west to Herschel Basin (138.9°W). Lacking are abundances of amphipods, polychaetes and molluscs (K. Conlan, unpubl. data). From Paulic et al. (2012).

benthic crustaceans present along the coast of Darnley Bay and Cape Parry (KAVIK-AXYS Inc. 2012). Residents most frequently encounter crabs at Tipititiuyak, Argo Bay, the area east of the Paulatuk Peninsula and Fish Camp (KAVIK-AXYS Inc. 2012). Shrimp (particularly larger shrimp) are typically found in deeper waters off Kamakaq (Kamakark) and Johnny Green Bay (Figure 25), while mussels are most often associated with kelp or marine grass beds (KAVIK-AXYS Inc. 2012).

Underwater video taken during the CCGS Nahidik seabed survey indicates that Darnley Bay consists primarily of soft sediments with high abundances of brittle stars and burrowing organisms (V. Kostylev, pers. comm., cited in Paulic et al. 2012; Figure 26). This is consistent with benthic habitat observed along the western Canadian Beaufort Shelf (Paulic et al. 2012). The shallow habitats off Cape Parry are very different, consisting of coarser substrate and a higher richness of **megabenthos** (V. Kostylev, pers. comm., cited in Paulic et al. 2012; Figure 26).

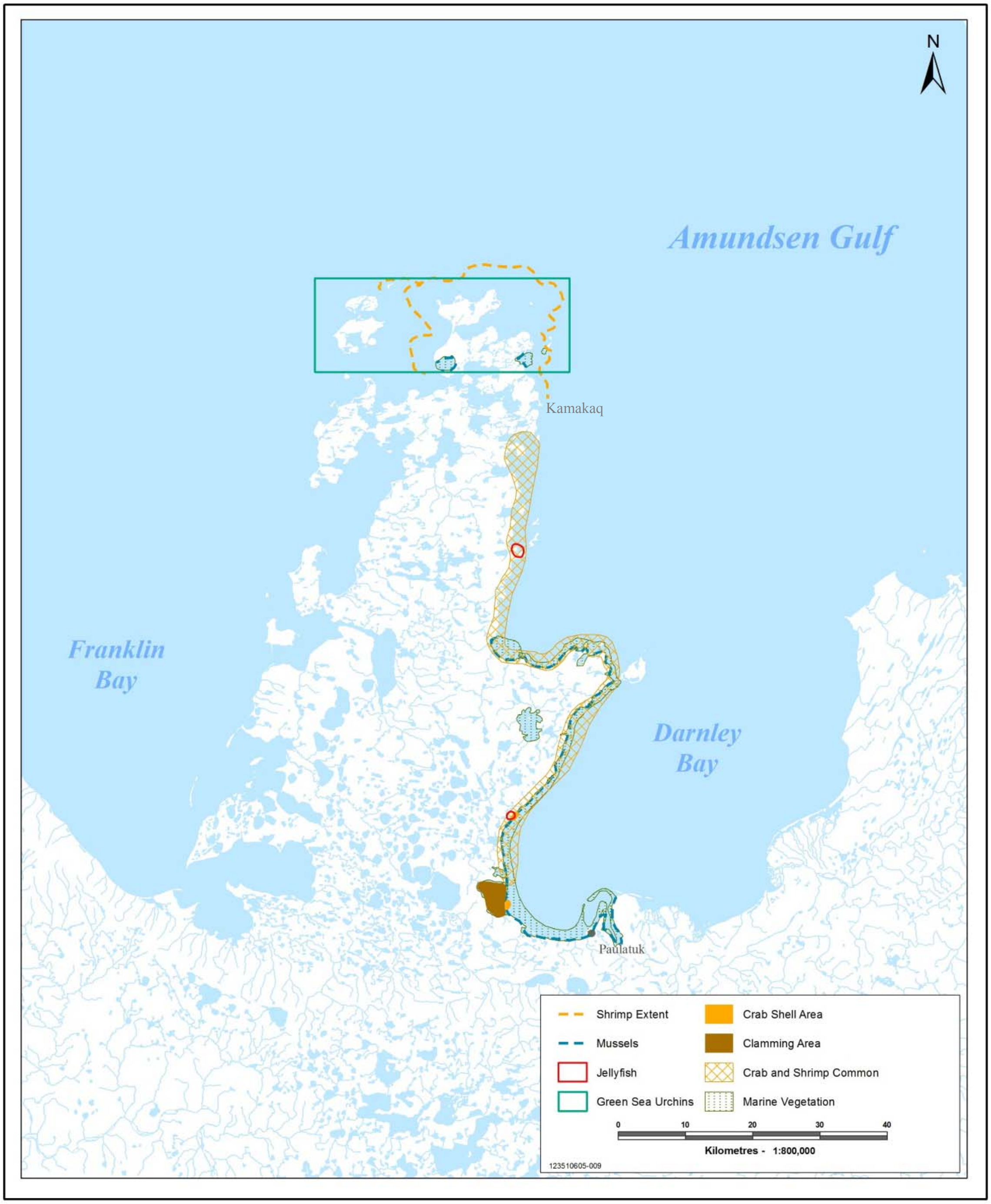

Figure 25. Marine **invertebrate** locations as determined by participants at the Traditional and Local Knowledge Workshop for the Anuniaqvia niqiqyuam AOI, March 2011. Modified from KAVIK-AXYS Inc. (2012).

In the Arctic, benthic communities represent an important food resource for a variety of marine mammals (e.g., Walrus [*Odobenus rosmarus*], Bearded Seals [*Erignathus barbatus*]; Frost and Lowry 1984) and diving sea birds (Dickson and Gilchrist 2002; KAVIK-AXYS Inc. 2012). Although human use of benthic invertebrates is not extensive, local residents collect clams in some areas (e.g., Argo Bay) for food (KAVIK-AXYS Inc. 2012).

Benthic communities can be slow to recover from disturbances to the seabed (Paulic et al. 2012). Though disturbances such as ice scouring can significantly decrease species diversity, it also can favour organisms that are capable of rapidly recolonizing (Conlan and Kvitek 2005). Ice scouring is likely to be a common source of disturbance to benthic communities in Darnley Bay (Myers et al. 1996). Variations in abundance and diversity inshore would likely reflect major benthic disturbances such as storms or variations in salinity, temperature and/or turbidity).

a)

b)

Photo 1. a) Crab, b) Shrimp. Photos by Frances Wolki. From KAVIK-AXYS Inc. (2012).

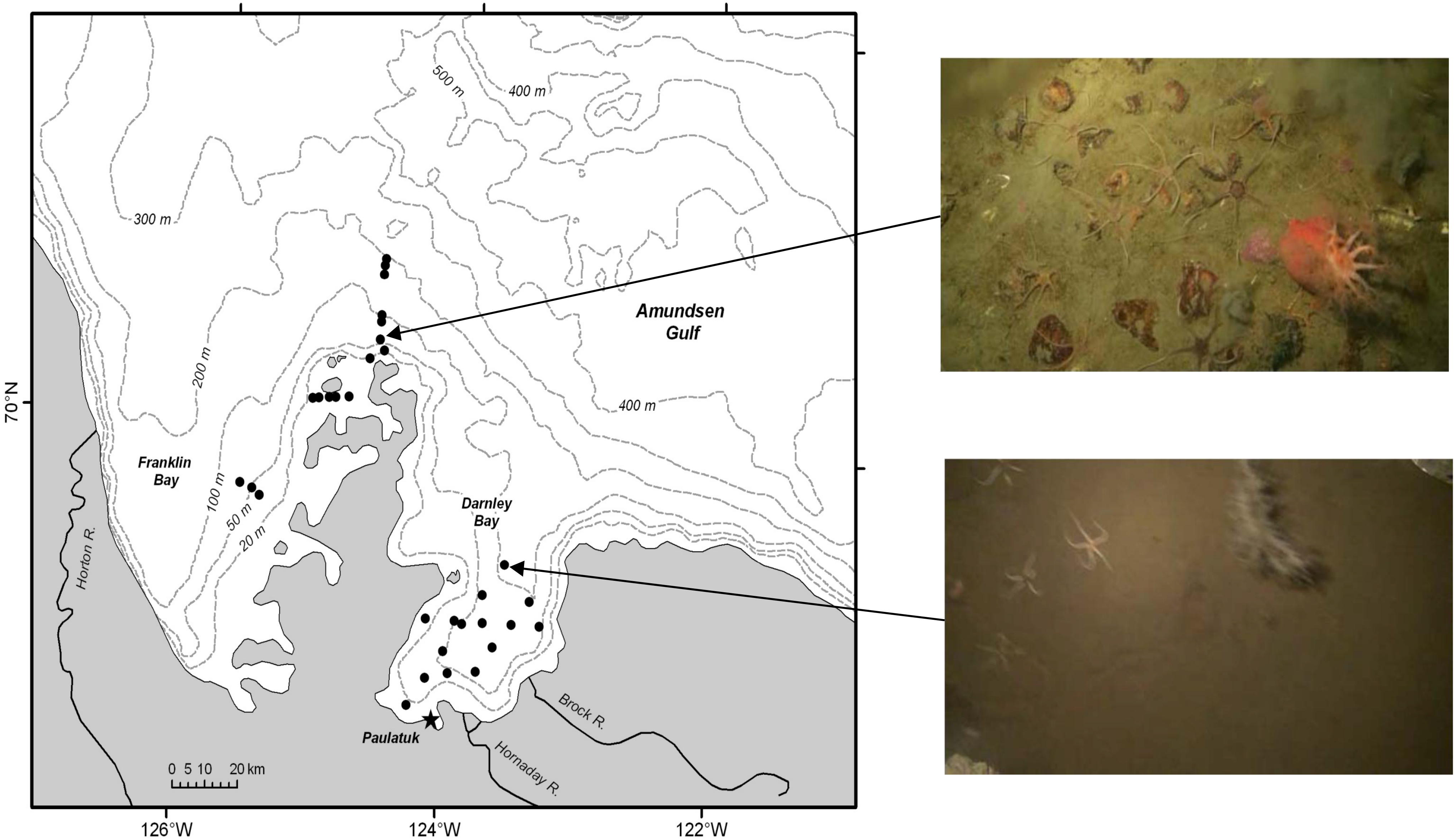

Figure 26. Video images of megabenthos at a selected station within Darnley Bay (below) and at Cape Parry (top) from a 2008 CCGS Nahidik survey, showing differences in sediment and species abundances (V. Kostylev, unpubl. data). From Paulic et al. (2012).

11.0 FISH

The Anuniaqvia niqiqyuam AOI supports a variety of fish species, including Arctic Char, Arctic Cisco (*Coregonus autumnalis*), Arctic Cod, Capelin, herring and flounder (DFO and IRC 2010; Paulic et al. 2012). Three key habitat types occur within the Darnley Bay-Amundsen Gulf area, each one possessing a unique set of conditions that support a distinct fish community (Paulic et al. 2012): 1) freshwater habitat located at the mouth of the major river systems; 2) warmer, brackish waters located in the nearshore coastal region; and 3) colder, offshore marine waters (Paulic et al. 2012). The freshwater rivers and streams and brackish nearshore waters provide habitat for **anadromous** fishes such as Arctic Char, while the offshore waters are used year-round by marine species such as Arctic Cod (Craig 1984).

Fish play a critical role in the marine food web. They act as a link between lower and higher trophic levels and are an important food source for marine mammals, birds and other fish. Coad and Reist (2004) report that, of the fishes identified from the Beaufort Sea, 51 marine and 27 freshwater and anadromous species are likely present in the Darnley Bay - Amundsen Gulf region. Use of the area by marine species is difficult to determine due to their complex seasonal movements; however, changes in temperature, salinity and biological requirements such as spawning or feeding may influence use (Paulic et al. 2012).

Offshore marine habitat in the Beaufort Sea LOMA is not well studied (Paulic et al. 2012). Knowledge of fish resources in Darnley Bay also is limited, though some information on nearshore species is available due to their importance (cultural and/or economic) to local residents. Paulatuk residents use lakes and rivers along the Parry Peninsula as well as the coastal waters of Darnley Bay for subsistence harvesting of fish species such as Arctic Char, Broad Whitefish (*Coregonus nasus*) and Pacific Herring (*Clupea pallasii pallasii*) (Community of Paulatuk et al. 2000; KAVIK-AXYS Inc. 2012; Paulic et al. 2012; Figure 27).

In 1990, the Paulatuk Hunters and Trappers Committee, with assistance from DFO and funding from the FJMC established a long-term, community-based monitoring program for the Arctic Char fishery in the Hornaday River (Paulic et al. 2012). In addition to collecting information on the Arctic Char fishery, this program provides valuable insights into fish species composition in the nearshore coastal region of Darnley Bay.

Nearshore monitoring indicates that the fish community along the coast of Darnley Bay is similar to that of the Beaufort Shelf. For example, both areas contained large numbers of Starry (*Platichthys stellatus*) and Arctic (*Liopsetta glacialis*) flounders (K. Howland, pers. comm., cited

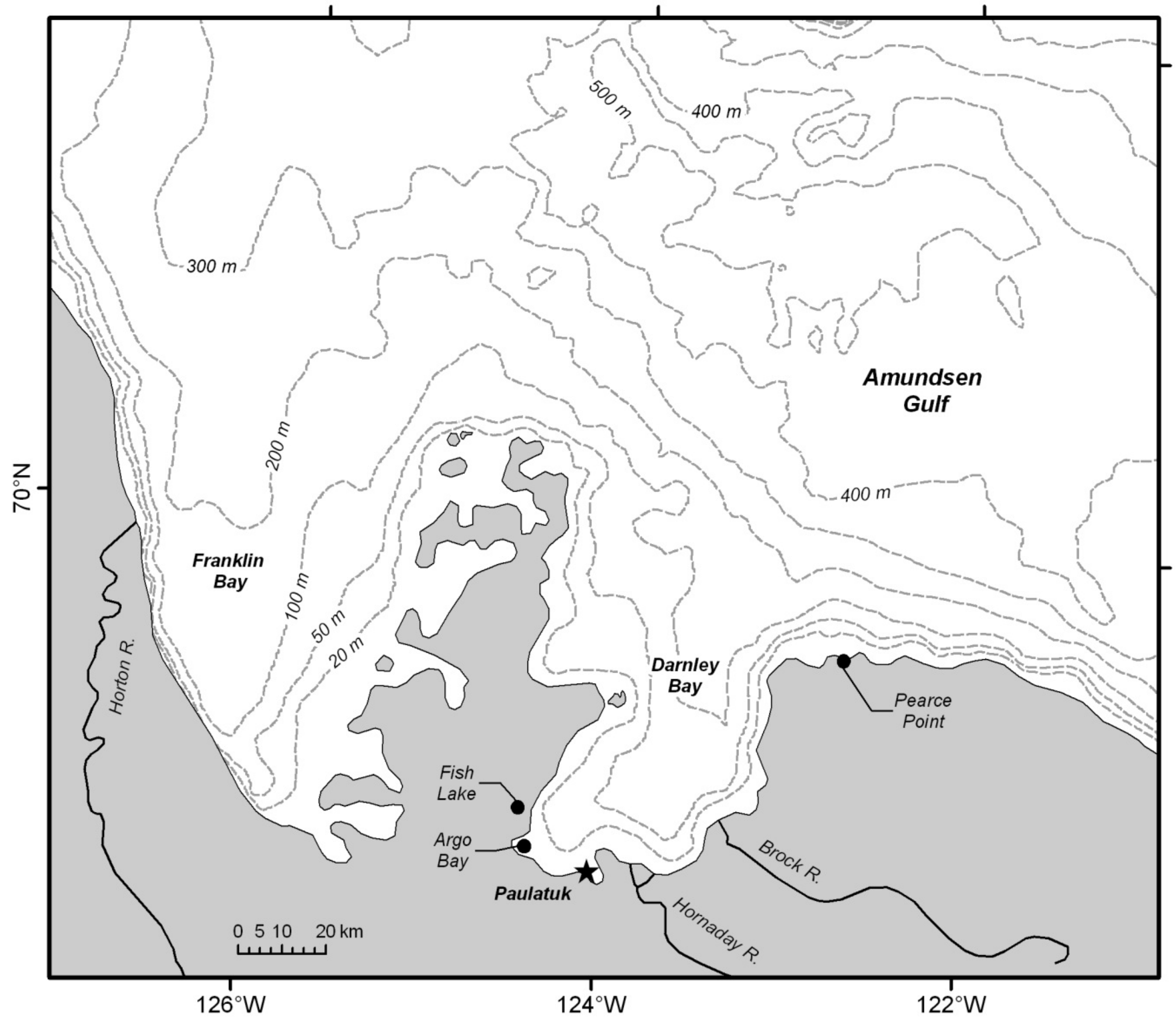

Figure 27. Important areas for marine fish and areas identified by community members as important fishing locations. Coastal waters throughout Darnley Bay represent important habitat for marine fishes. In particular, Argo Bay and Pearce Point were identified as important fishing areas. Fish Lake, and the Hornaday and Brock rivers were identified as important fishing areas for anadromous species such as Arctic Char and Broad Whitefish. Approximate location of Fish Lake indicated on map. From Paulic et al. (2012).

in Paulic et al. 2012). The nearshore fish community in Darnley Bay is unlike other Arctic nearshore communities due to the absence of sculpins (J. Reist, pers. comm., cited in Paulic et al. 2012). Sculpins prefer rocky bottoms rather than the sandy bottom that occurs in nearshore areas of Darnley Bay, which may explain their absence (J. Reist, pers. comm., cited in Paulic et al. 2012). Paulatuk residents report that Argo Bay is an important area for Rainbow Smelt (*Osmerus* *mordax*), Pacific Herring and Broad Whitefish (KAVIK-AXYS Inc. 2012; Paulic et al. 2012; Figure 27).

11.1 ARCTIC CHAR (*Salvelinus alpinus*)

Arctic Char is a cold-water, anadromous species belonging to the salmon family. They are present throughout the eastern part of the Beaufort Sea and are an important resource to many Arctic communities (KAVIK-AXYS Inc. 2012; Paulic et al. 2012). Arctic Char populations exist in several freshwater systems in the Paulatuk area, including the Hornaday, Brock and Horton rivers and possibly Fish Lake (Harwood 2009; Figure 27). The AOI contains particularly important feeding and migratory habitat for the Hornaday River Arctic Char population, as their freshwater spawning areas flow directly into the AOI (DFO and IRC 2010).

Arctic Char spawn every two to three years (DFO and IRC 2010). The young hatch in spring and spend the first 3-4 years of their lives in freshwater (Scott and Crossman 1973). In the spring, beginning at age four or five, char migrate from rivers and lakes to the sea in order to feed in the nearshore coastal marine waters. They remain there throughout the summer and return to freshwater in late September or October (Scott and Crossman 1973).

The subsistence fishery at the Hornaday River is the largest in the Anuniaqvia niqiqyuam AOI, and has existed since the 1940s (DFO and IRC 2010; Paulic et al. 2012). Commercial fishing on the river occurred between 1968 and 1986 but was closed due to population decline (DFO and IRC 2010; Paulic et al. 2012). Recreational (sport) fishing in the area is limited (DFO and IRC 2010; Paulic et al. 2012). Harwood (2009) provides the best available population estimate for the Hornaday River (16,000 individuals); however, this number is based on data from 1986 and does not include spawning individuals (Harwood 2009). The Hornaday River Arctic Char population is managed under the Paulatuk Char Management Plan (Paulatuk Char Working Group 2003). Monitoring indicates that the annual harvest has decreased over time, from 2,483 fish (1988-1997) to 1,691 fish (1998-2001) (Paulatuk Char Working Group 2003). Some Paulatuk residents have stopped fishing for char in the Hornaday River, preferring other systems such as the Brock River (K. Howland, pers. comm., cited in Paulic et al. 2012). This may be due to declining catches in the Hornaday River estuary, which may be related to infilling (**sedimentation**) of channels (K. Howland, pers. comm., cited in Paulic et al. 2012).

Subsistence harvests for Arctic Char from other regions in the AOI are uncommon and low (e.g., <100 fish per year; Paulatuk Char Working Group 2003). Paulatuk residents fish for char along the east and west coasts of Darnley Bay, in Argo Bay, Fish Lake, Hornaday and Brock rivers and north along the coast to Pearce Point (Paulic et al. 2012; Figure 27). Residents fish for char along the coast during July and August, but indicate that fishing seasons are longer now as a result of a later freeze-up (KAVIK-AXYS Inc. 2012).

Arctic Char feed primarily on amphipods, **mysid**s and fish (Sprules 1952, Scott and Crossman 1973; KAVIK-AXYS Inc. 2012). Capelin (*Mallotus villosus*) are important in the diets of Hornaday River char (L. Harwood, pers. comm., cited in Paulic et al. 2012). Though further study is needed for confirmation, schools of Capelin may be present near Pearce Point, approximately 100 km northeast of the Hornaday River (L. Harwood, pers. comm., cited in Paulic et al. 2012). Though Arctic Char use the entire coastline of Darnley Bay as a feeding and migration corridor, Pearce Point is a particularly important summer feeding area for the species (DFO 1999; L. Harwood, pers. comm., cited in Paulic et al. 2012; Figure 27). Residents of Paulatuk report that Arctic Char are common along the coast of Parry Peninsula but most prevalent between Bennett Point and Argo Bay (KAVIK-AXYS Inc. 2012).

In spring, the timing of river ice break-up determines when char can access their migration routes to the ocean. The spring freshet typically occurs between June 2 and 21 (Harwood 2009). Both Walsh (2008) and Harwood (2009) attribute the increasing growth rates of Arctic Char observed since 2002 to earlier ice break-up resulting in increased prey abundance and quality.

11.2 ARCTIC COD (*Boreogadus saida*)

Arctic Cod (also referred to as Rock Cod) is an Ecologically Significant Species in the Beaufort Sea LOMA (Cobb et al. 2008). They have a **circumpolar** distribution and occur in all Arctic marine waters (e.g., Hunter 1979; Welch et al. 1993; Bradstreet et al. 1986; Benoit et al. 2008). This small, short-lived species feeds on **calanoid** copepods (Lowry and Frost 1981; Walkusz et al. 2011) and is an important link between zooplankton and top consumers such as marine mammals and birds (e.g., Bradstreet et al. 1986; Welch et al. 1993). Because of its importance to ecosystem structure and function, Arctic Cod is a keystone species (Cobb et al. 2008). A keystone species is one that plays a critical role in the community and if removed from the system, would lead to a breakdown in community structure. Despite its importance, the ecology of this species is not well-studied, particularly in the offshore environment (Paulic et al. 2012).

Arctic Cod are often associated with ice cracks and edges and are either found dispersed throughout the water column or in large, dense schools (Welch et al. 1993; Crawford and Jorgenson 1996; Benoit et al. 2008). Large aggregations of Arctic Cod frequently appear in nearshore coastal areas of the Canadian Arctic, often in the depressions of bays (Welch et al.

1993, Benoit et al. 2008). Based on results of their Beluga habitat selection study, Loseto et al. (2008a,b) suggested the possibility that there are two Arctic Cod sub-populations existing in the Beaufort Sea LOMA. Results indicated that offshore Arctic Cod fed on organisms higher in the food web relative to nearshore Arctic Cod (Loseto et al. 2008b).

The movement of large water masses can influence the distribution of Arctic Cod. For example, Benoit et al. (2008) reported that Arctic Cod were passively carried from the Amundsen Gulf into Franklin Bay during the winter of 2003/04. During that study, the cod aggregated in deeper waters, likely to avoid predators (e.g., surface-feeding seals) and/or to take advantage of the warm Pacific waters. Benoit et al. (2008) estimated that total cod biomass in Franklin Bay during that year (11.23 kg m^{-2}) would have fulfilled the nutritional needs of all mammal and bird predators in the area (Benoit et al. 2008).

The larvae and juveniles of Arctic Cod are epipelagic, inhabiting the upper portion of the water column. They tend to concentrate at depths less than 50 m on the Beaufort Shelf (Hunter 1979; Ponton et al. 1993; Chiperzak et al. 2003a,b,c; Sareault 2009) and are abundant in the warmer waters of annually recurring polynyas (Michaud et al. 1996). Within the AOI, Arctic Cod occur at a number of locations in Darnley and Franklin Bays and the Amundsen Gulf (Paulic et al. 2012; Figure 28). Marine upwellings, recurrent polynyas, flaw lead features and ice-edges are likely important habitat for Arctic Cod (Paulic et al. 2012). The open ocean and deep depressions within Darnley Bay are likely also important. Paulatuk residents capture Arctic Cod around Cape Parry (KAVIK-AXYS Inc. 2012), although their importance to the community is undetermined.

11.3 OTHER FISH SPECIES

Other fish species that are known to occur in the Anuniaqvia niqiqyuam AOI include: Arctic Cisco, Arctic Flounder (*Liopsetta glacialis*), Broad Whitefish, Capelin, Greenland Cod (*Gadus ogac*), Pacific Herring, Saffron Cod (*Eleginus gracilis*), sculpin (Family Cottidae) and Starry Flounder (DFO and IRC 2010; KAVIK-AXYS Inc. 2012; K. Howland, pers. Comm., cited in Paulic et al. 2012; Paulic et al. 2012).

Saffron (also referred to as Tom Cod) and Greenland Cod also occur throughout the Anuniaqvia niqiqyuam AOI. Local residents indicate that Saffron Cod may have been abundant in Summers Harbour in the past but no current information is available. Residents often fish for cod in Argo Bay (KAVIK-AXYS Inc. 2012).

Paulatuk residents frequently capture large Broad Whitefish (known locally as Argo Bay whitefish) in nearshore waters along the Darnley Bay coast to Bennett Point (KAVIK-AXYS

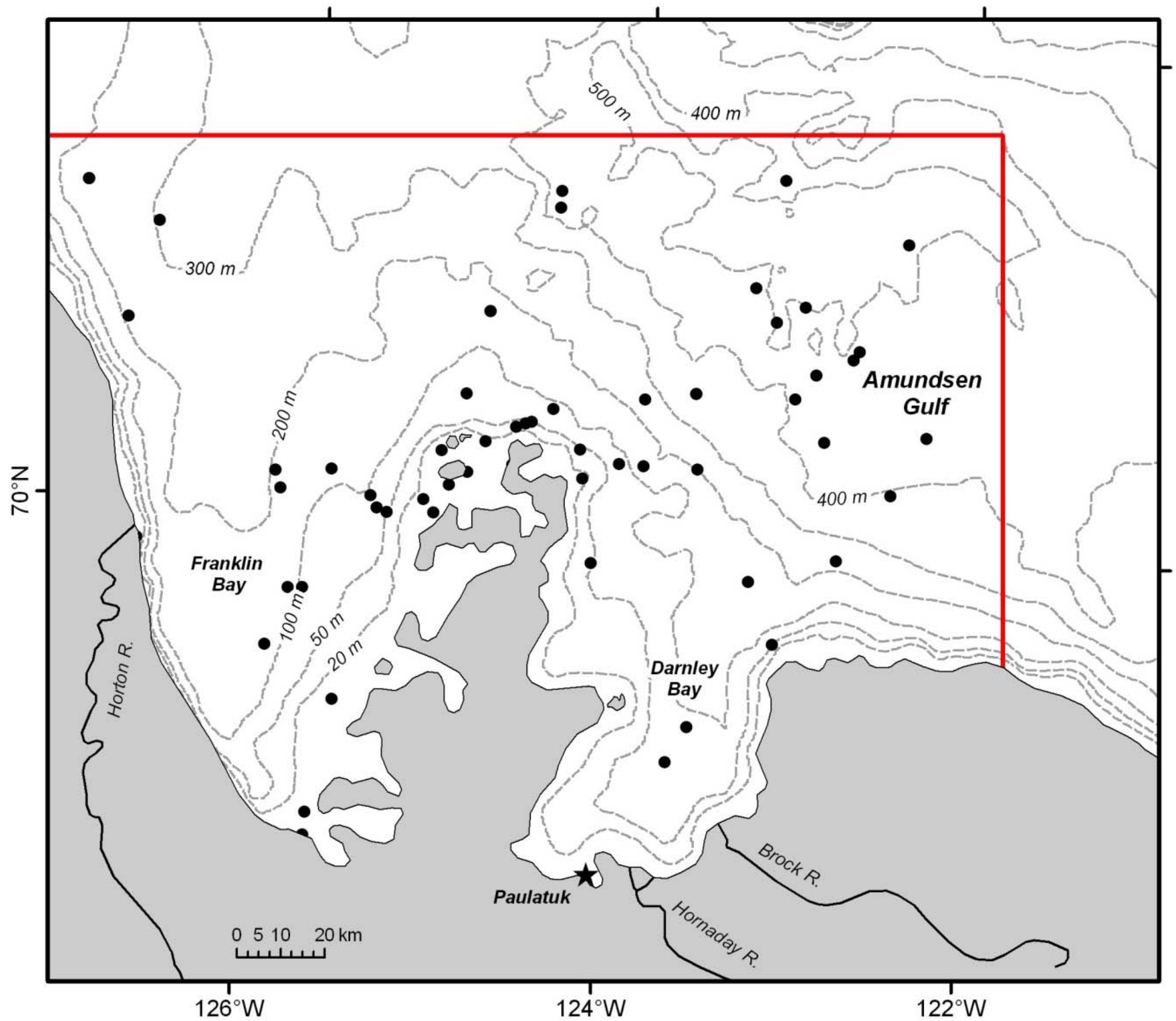

Figure 28. Locations within the red boundaries where Arctic Cod have been sampled. From Paulic et al. (2012).

Inc. 2012). This anadromous species begins its spring migration immediately after the ice moves out of the bay, and residents report their presence in coastal waters by mid-June (KAVIK-AXYS Inc. 2012). Broad Whitefish are abundant at Tipititiuyak as late as September (KAVIK-AXYS Inc. 2012). Paulatuk residents note that whitefish colour varies depending on their environment. For example, whitefish residing in freshwater often have darker (almost black) backs compared to those that migrate to the coast.

Pacific Herring is a small, widely distributed fish species that occurs along the Darnley Bay coast and Cape Parry (KAVIK-AXYS Inc. 2012; Paulic et al. 2012). Paulatuk residents describe black clouds of small herring-like fish along the shorelines of Paulatuk and Egg Island, speculating that spawning may take place during these nearshore aggregations (KAVIK-AXYS Inc. 2012).

However, residents have not observed these events for 4-5 years. Traditional and local knowledge indicates that Arctic Char feed on herring when available (KAVIK-AXYS Inc. 2012).

Sculpin (also referred to as bullhead; Photo 3) are present in the AOI (KAVIK-AXYS Inc. 2012) despite their relatively low numbers along the coast. Though Fourhorn Sculpin (*Myoxocephalus quadricornis*) is the only species described from in the AOI, others likely occur both in coastal and offshore waters. Community residents do not use sculpin, but accidentally capture them while fishing for other species (KAVIK-AXYS Inc. 2012).

Flounder are present in all coastal areas within the AOI (KAVIK-AXYS Inc. 2012). The Arctic and Starry flounders are generally smaller than halibut and occur in relatively large numbers. Paulatuk residents capture flounder in Argo Bay, typically in shallow waters and towards the middle of the bay (KAVIK-AXYS Inc. 2012). Residents also note that flounder occur just beyond the Paulatuk Peninsula and at the mouth of the Hornaday River (KAVIK-AXYS Inc. 2012; Figure 29).

Paulatuk residents describe two unknown fish species from the AOI. One species, referred to as ocean-run char or blue char, is much larger than Arctic Char, and has different physical characteristics (e.g. caudal fin shape, head size). For example, residents describe the meat to be bright red, rich tasting and greasier than that of Arctic Char. Paulatuk residents note that this species is present at Tipititiuyak from early to late July and may move up rivers such as the Hornaday and Brock (KAVIK-AXYS Inc. 2012). The species began to appear in fish catches approximately 20 years ago. Currently, no other information is available for this species.

Traditional and local knowledge indicates that an eel-like fish species occasionally utilizes Pearce Point and Letty and Brown's harbours (KAVIK-AXYS Inc. 2012). Described as having long fins and a bluish body colour, some residents believe it may be Sand Lance (*Ammodytes americanus*). Though Sand Lance have a bluish silver eel-like body, their fins are small and transparent. Consequently, the identity of this species remains unknown.

Traditional and local knowledge indicates that the Greenland Shark (*Somniosus microcephalus*) may occasionally inhabit marine waters of the AOI (KAVIK-AXYS Inc. 2012). Anecdotal evidence exists of large sharks in the Beaufort Sea by some residents in the outlying communities of the Inuvialuit Settlement Region.

Photo 2. Fourhorn Sculpin (*Myoxocephalus quadricornis*). Photo by Frances Wolki. From KAVIK-AXYS Inc. (2012).

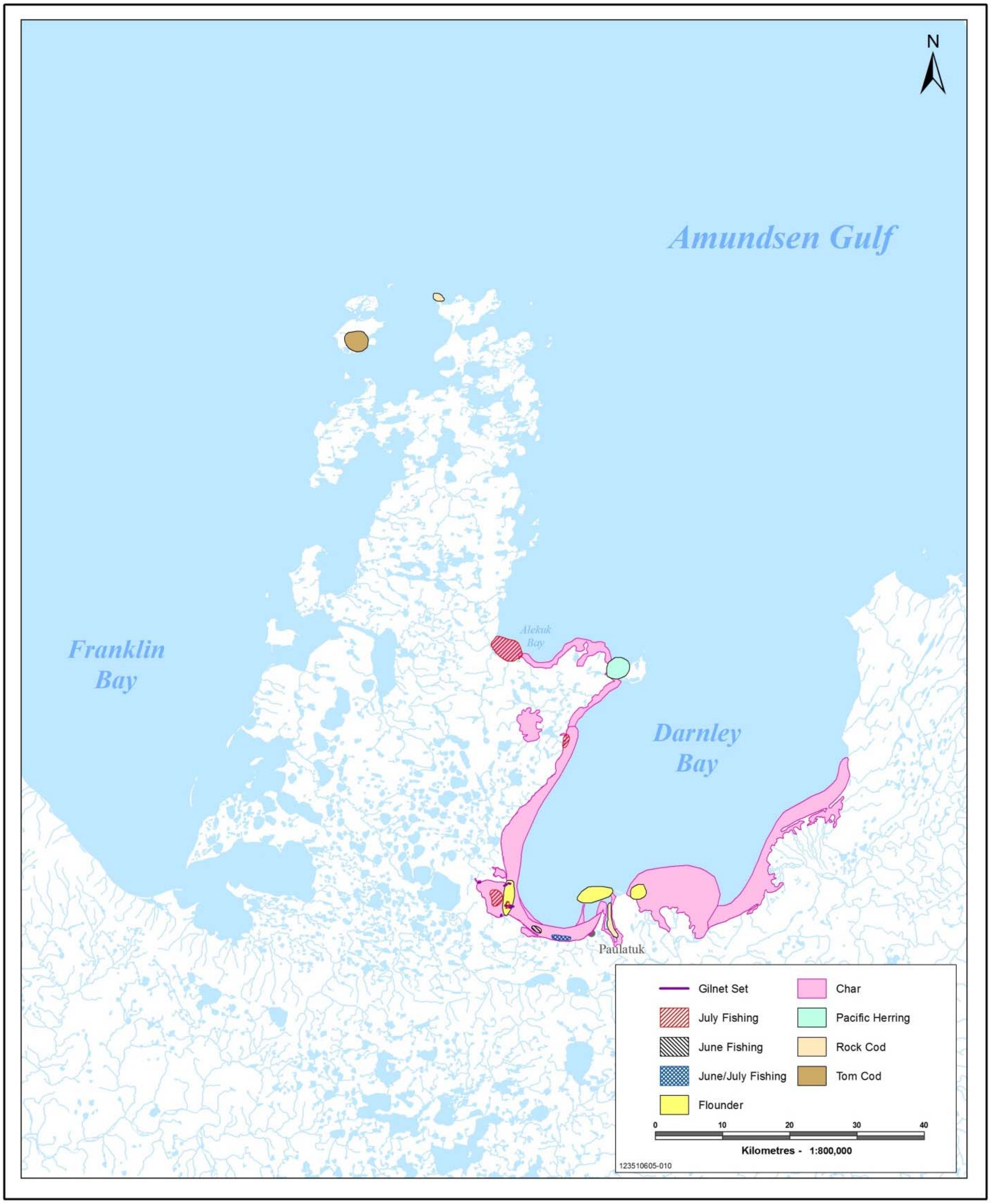

Figure 29. Location of key fish species and fish harvesting areas as determined by participants at the Traditional and Local Knowledge Workshop for the Anuniaqvia niqiqyuam AOI, March 2011. From KAVIK-AXYS Inc. (2012).

12.0 MARINE MAMMALS

The Canadian Beaufort Sea offers both seasonal and year-round habitat for a number of marine mammals (DFO and IRC 2010). The most common marine mammals within the AOI include: Beluga, Bowhead, Ringed Seal (*Phoca hispida*), Bearded Seal, and Polar Bear (*Ursus maritimus*) (DFO and IRC 2010; Paulic et al. 2012). Other species are relatively rare. For example, Gray Whales (*Eschrichtius robustus*) occasionally enter the Beaufort Sea, but few occur east of Point Barrow (e.g., Harris et al. 2008). Narwhal (*Monodon monoceros*; Geist et al. 1960; Smith 1977) and Walrus (Harwood and Borstad 1985) also are uncommon, having distributions considered to be outside of the Beaufort Sea LOMA (e.g., Reimnitz et al. 1994; Stewart 2008). Residents of Paulatuk note that walruses occurred with more regularity in Brown's Harbor in the 1960's and 1970's (KAVIK-AXYS Inc. 2012). Killer Whales (*Orcinus orca*) migrate to the Chukchi Sea during summer and can appear as far east as Cape Bathurst (Higdon 2009). Paulatuk residents occasionally harvest Harp Seals within the AOI (KAVIK-AXYS Inc. 2012).

12.1 BELUGA (*Delphinapterus leucas*)

The Beluga is the most abundant and common whale observed in the Anuniaqvia niqiqyuam AOI (KAVIK-AXYS Inc. 2012). The Eastern Beaufort Sea Beluga population is one of the largest in Canada, estimated at approximately 40,000 (Harwood et al. 1996; COSEWIC 2004). In spring, the whales begin migrating from their winter habitat in the Bering Sea to the Beaufort Sea through offshore leads along the northern coast of Alaska (Fraker 1979; Richard et al. 1997). By late spring, Beluga reach the west coast of Banks Island and offshore waters at Cape Bathurst in time for ice break-up in May and June (Fraker 1979). After ice break-up, Beluga move in a southwest direction, following the edge of the land-fast ice along the Tuktoyaktuk Peninsula (Norton and Harwood 1986). Beluga typically arrive in the Mackenzie River Estuary by late June or early July, but timing depends on ice conditions (Byers and Roberts 1995; Figure 30). In the Mackenzie River Estuary, whales congregate in the thousands, representing one of the largest known summering groups of Beluga (Fraker 1979).

Beaufort Sea Beluga utilize several different habitat types and locations, including offshore waters, areas near or beyond the shelf break and the polar pack ice of the Mackenzie River Estuary, Amundsen Gulf, M'Clure Strait and Viscount Melville Sound (Richard et al. 2001; Figure 30). Their movements are affected by ice conditions and whales will generally not enter waters containing an abundance of ice (KAVIK-AXYS Inc. 2012). For example, Paulatuk

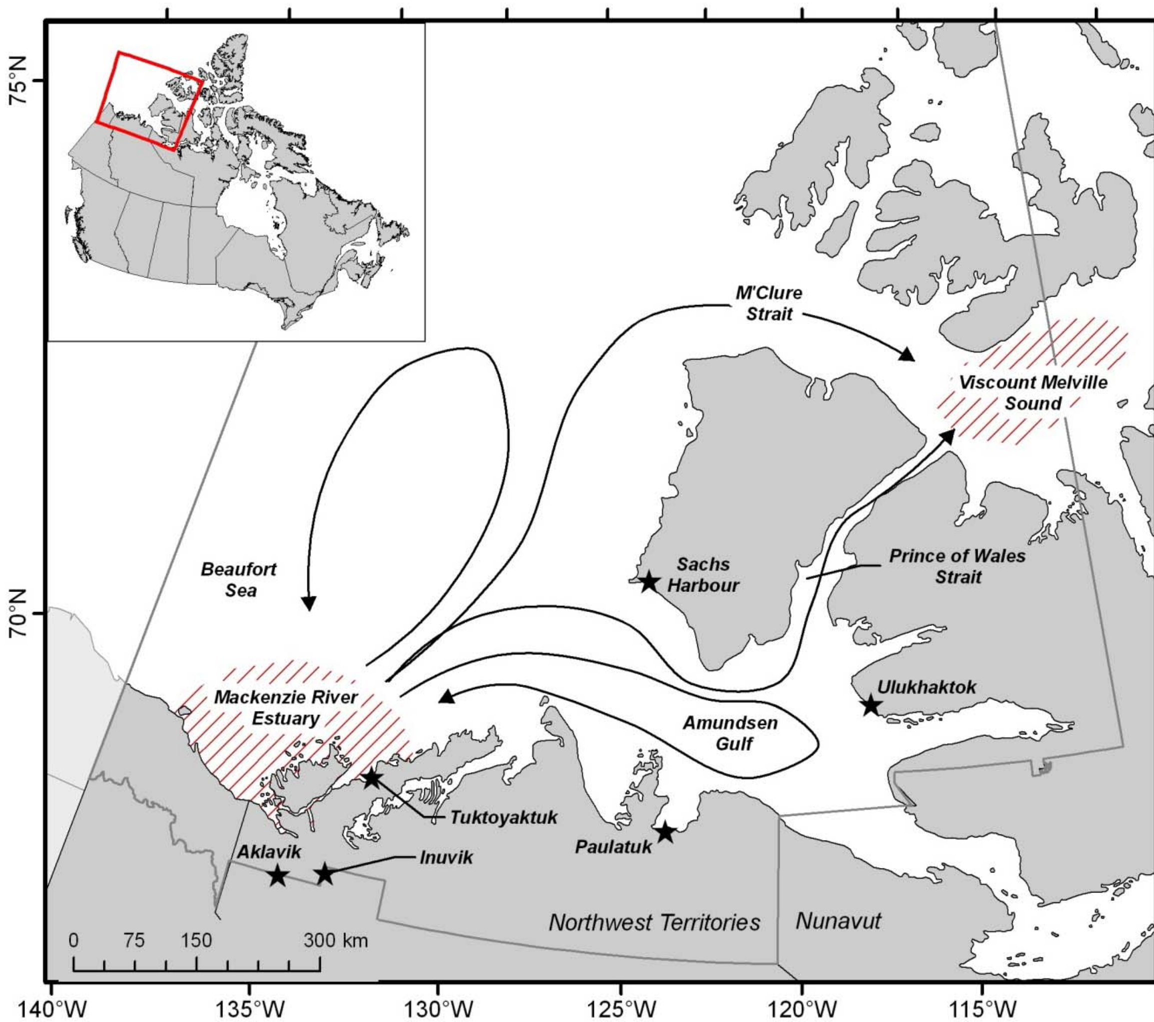

Figure 30. Distribution of eastern Beaufort Sea Beluga during spring, summer and fall, showing aggregation areas and seasonal movements. Beluga distribution range occurs throughout the Beaufort Sea LOMA, however regions identified by red hatching are areas where densities are typically higher (From Paulic et al. 2012; modified from DFO 2000).

residents indicate that Beluga will only enter Darnley and Argo bays after the majority of ice has moved out (KAVIK-AXYS Inc. 2012). Tagging results from 1993 and 1995 indicate that some Beluga travel from the Mackenzie Estuary into the Amundsen Gulf (Richard et al. 2001). Whales in that study typically remained there for 2-3 weeks following a clockwise pattern through the Gulf (Richard et al. 2001; Figure 30). Paulatuk residents indicate that females have already given birth to their calves before entering into Darnley Bay (KAVIK-AXYS Inc. 2012). In mid-August and early September, Beluga begin their westward autumn migration back into Alaskan waters following the mainland coast or offshore area, sometimes under heavy pack ice conditions (DFO

2000; Figure 30). Loseto et al. (2006) reported that use of late summer to early fall habitat differs with Beluga size and sex. From this, researchers were able to identify three habitat use groups within the Beaufort Sea LOMA based on length, sex and reproductive status:

1) females (with and without calves) and small males (< 4 m) selected shallow open water near the mainland;

2) medium-length males (3.8 - 4.3 m) and some females (>3.4 m) without calves selected the sea ice edge; and,

3) the largest males (4.0 - 4.6 m) selected heavy sea ice concentrations in deep, offshore waters.

Paulatuk residents also indicate that Beluga males and females often occupy different habitat. Community observations suggest that females with calves move into nearshore areas while males tend to stay in deeper water (KAVIK-AXYS Inc. 2012). Scientists have developed two hypotheses that could explain why Beluga segregate into groups: the Predation Risk Hypothesis, which suggests that segregation occurs as a result of predator avoidance by reproductive females (i.e., sexually mature females) (Main et al. 1996); and the Forage Selection Hypothesis, which suggests that the larger sex forages for food more often or differently, leading to segregation (Clutton-Brock et al. 1982; Conradt 1998). Results of the segregation study suggest that Beluga have a complex social structure (Paulic et al. 2012).

Segregation of the Beluga population also has implications for mercury (Hg) exposure as it relates to differences in feeding requirements (Stevick et al. 2002). Beluga harvested in Darnley Bay are generally smaller in size, have lower mercury levels and likely feed at lower trophic levels than larger whales that tend to travel in deep water and heavy ice concentrations (Paulic et al. 2012). However, because hunting effort and preference for certain whale sizes may influence which whales hunters take during the harvest, these results are interpreted with caution. Paulatuk residents indicate that Beluga found in the coastal waters of Darnley Bay appear to be younger males and females with calves, and that those harvested in the Paulatuk area are smaller than those harvested in Tuktoyaktuk (KAVIK-AXYS Inc. 2012). A genetic study is underway to determine if the Beluga returning annually to harvesting areas in the Beaufort Sea LOMA are from the same families. If this is correct, it would mean that Beluga within Darnley Bay represent a unique group of whales that show fidelity to the region (i.e., return every year). One study suggests that Beluga in the Paulatuk area differ from those near Tuktoyaktuk; the Paulatuk whales had lower concentrations of mercury, were generally shorter and showed differences in feeding patterns than their western counterparts (Loseto et al. 2008a).

Spring surveys of Beluga in the Amundsen Gulf between 1975 and 1979 suggest that, despite variable sea ice concentrations and extent, Beluga habitat selection is relatively consistent from year to year (Asselin et al. 2011). Beluga distribution in the spring (mid-late June) is mainly influenced by sea ice concentration, bathymetry and seafloor slope. In general, Beluga preferred heavy ice (8/10 to 10/10) regions characterized by 200-500 m water depths and higher seafloor slope (Asselin et al. 2011). These preferences are similar to those of Beluga in other Arctic regions, such as the Alaskan Beaufort Sea (Moore et al. 2000; Mahoney et al. 2007). In the spring, Beluga prefer landfast ice edge habitat and coastal areas only when pack-ice is not present (Asselin et al. 2011). Landfast ice edge habitat may become increasingly important habitat for Beluga in the Amundsen Gulf in light of declining sea ice concentrations in the Canadian Arctic in recent years and further declines expected in the future (DFO and IRC 2010; Paulic et al. 2012). It is unknown whether spring habitat use by Beluga has changed over time (DFO and IRC 2010; Paulic et al. 2012).

Foraging success may influence the spring distribution of Beluga (Asselin et al. 2011). For example, in some instances Beluga appear to select habitats that contain aggregations of preferred prey such as Arctic Cod (Asselin et al. 2011; KAVIK-AXYS Inc. 2012). Paulatuk residents indicate that Beluga are often present in areas where large schools of fish 5-10 cm in length are present (KAVIK-AXYS Inc. 2012). Arctic Cod are important in the diets of some Beluga populations (Dahl et al. 2000; Seaman et al. 1982; Welch et al. 1993; Loseto et al. 2008a,b), though other fish species such as Arctic Cisco, Burbot and Broad Whitefish also are consumed (DFO 2000). The diet of Beluga in the Bering and Chukchi seas includes Arctic Cod, Saffron Cod, sculpins, Pacific Herring, Rainbow Smelt (*Osmerus mordax*), Capelin, Arctic Char, octopus and shrimp (Frost and Lowry 1990), which suggest that diet depends on population and habitat (Paulic et al. 2012).

In general, larger sized Beluga tend to prefer offshore Arctic Cod, whereas smaller sized Beluga feed on prey in the nearshore habitats (which also contain Arctic Cod) (Loseto et al. 2008 a,b). Data suggest that two sub-populations of Arctic Cod (offshore and nearshore) may exist within the Beaufort Sea LOMA. Offshore Arctic Cod tend to feed on organisms at higher trophic levels than nearshore cod and have higher mercury levels (Loseto et al. 2008b). Though further research is required, it appears that benthic (bottom-dwelling) prey for Beluga is generally lacking in the AOI (Loseto et al. 2008b).

The Paulatuk Community Conservation Plan indicates that the mouth of the Horton River and Franklin Bay are important summer feeding areas for Beluga (Community of Paulatuk et al. 2000). The coastal areas of the Parry Peninsula and Franklin and Darnley bays also are important feeding areas, while Amundsen Gulf and the northern portion of Darnley Bay provide a main migration route (Community of Paulatuk et al. 2000). Females and young typically use the Amundsen Gulf area north of the AOI (Richard et al. 2001). Beluga are observed in Argo Bay, Browns Harbour, Letty Harbour, Langton Bay, and as aggregations at the mouths of the Horton, Hornaday and Brock rivers (Paulic et al. 2012; Figure 31). Beluga often aggregate in estuaries and shallow nearshore waters during summer for unknown purposes which may include feeding, favourable conditions (e.g., warmer waters), socializing and/or **moult**ing (DFO and IRC 2010). Paulatuk residents observe Beluga rubbing themselves against the bottom of Argo Bay and in the mouth of the Horton River. The substrate at these locations likely consists of small rocks and pebbles. Rubbing against this type of substrate may aid in the moulting process (KAVIK-AXYS Inc. 2012).

In addition to the Zone 1B area of the Beaufort Sea Beluga Management Plan, residents of Paulatuk harvest Beluga at the mouths of the Horton, Hornaday and Brock rivers, as well as Cape Parry, Brown’s Harbour, Letty Harbour, Argo Bay and Langton Bay (Community of Paulatuk et al. 2000; Figure 31). Paulatuk residents identify several groups of Beluga within the AOI. A large group of primarily older and larger adult Beluga remains in offshore waters of the Parry Peninsula and does not enter into the coastal waters of Darnley Bay, while a second group enters the nearshore area and various bays (KAVIK-AXYS Inc. 2012; Figure 32). The nearshore group splits into two and while one group moves into Franklin Bay, the other moves into Brown’s Harbour, continues down the Parry Peninsula towards Argo Bay and returns. This group typically arrives in Argo Bay by July 22nd or 23rd, and appears to consist of younger males (20%) and females with calves (80%). A third group, referred to as stragglers, enters Argo Bay and continues north along the coast of the Parry Peninsula. This group is primarily comprised of larger males, though residents also observe some females with calves (KAVIK-AXYS Inc. 2012). Residents believe that stragglers remain in areas longer than other beluga groups.

Beluga are important to Inuvialuit diet, tradition and culture and are harvested annually by hunters from all six Inuvialuit communities within the Beaufort Sea LOMA, including Paulatuk (DFO and IRC 2010; Paulic et al. 2012). DFO (2000) determined that the total number of Beluga harvested annually in the Inuvialuit Settlement Region is well below the level which might negatively affect the population. Harvest data for 1990 to 1999 indicate that an annual average of 111 Beluga per year are landed in Canada from the Eastern Beaufort Sea stock (DFO 2000), though Harwood et al. (2002) estimates that the average may be as high as 131. This average is significantly lower than in the past (DFO 2000).

Residents of Paulatuk primarily hunt Beluga off the Parry Peninsula and at the mouth of the Horton River in Franklin Bay (Norton and Harwood 2001; KAVIK-AXYS Inc. 2012). Important

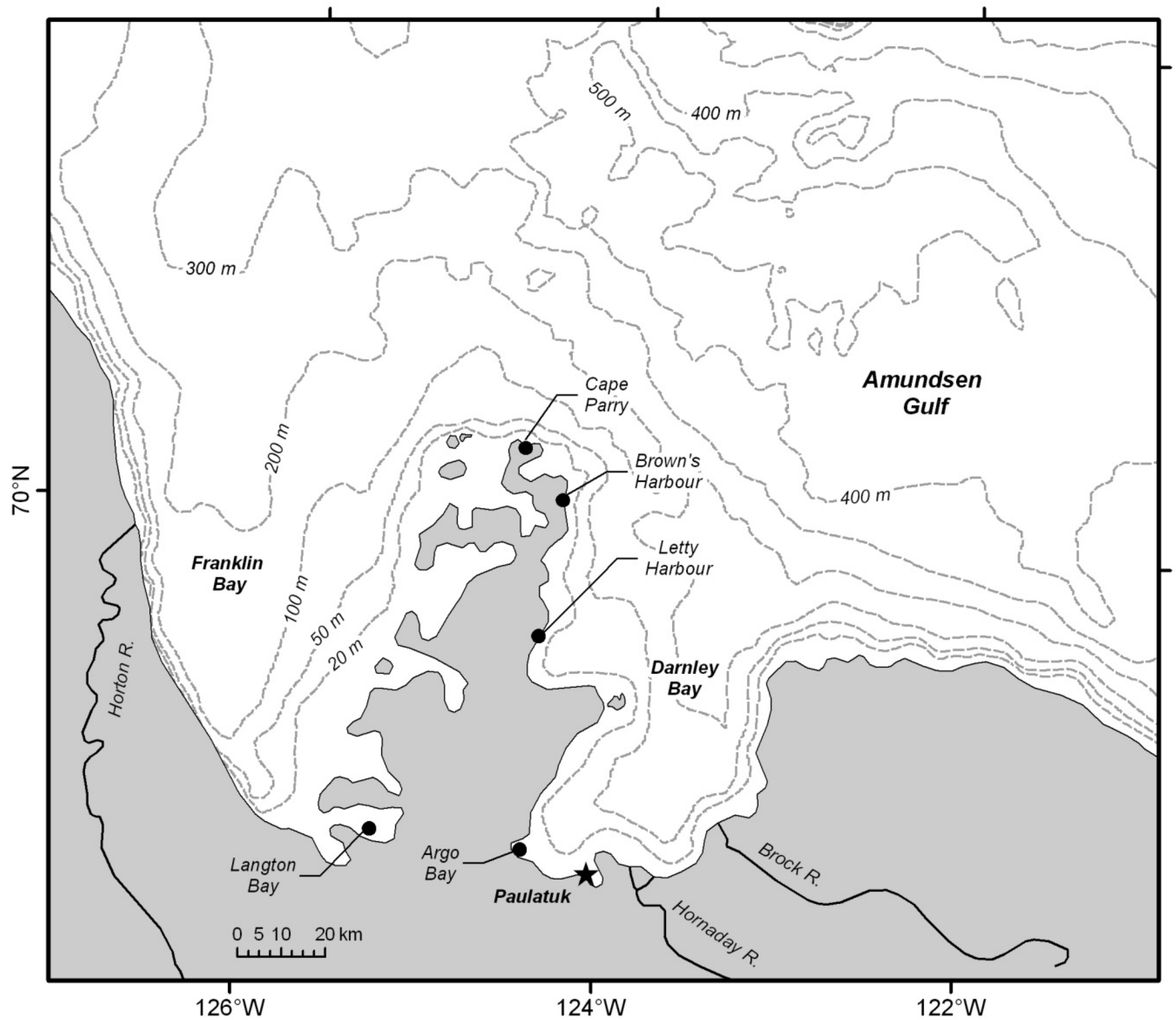

Figure 31. Important Beluga areas within Darnley and Franklin bays and the Amundsen Gulf identified by residents of Paulatuk. From Paulic et al. (2012).

Beluga harvesting areas and migration routes within Darnley Bay are illustrated in Figure 32. Paulatuk reported the harvest of four Beluga in 1966, three in 1985, one in 1987 (Strong 1989), and a total of 91 whales for the period between 1990 - 1999 (DFO 2000; Table 1). The hunter-based Beluga Harvest Monitoring Program has been in place at Paulatuk since 1989 to collect hunt information, biological data and samples (DFO 2000). Paulatuk residents typically harvest between 0 and 25 Beluga annually from July 1 to August 21 (Community of Paulatuk et al. 2000; DFO 2000). The landed catch is highly variable and depends on a combination of Beluga distribution, hunting conditions (e.g., weather and ice conditions), and the number of hunters available to participate (DFO 2000). Total Beluga landed by Inuvialuit harvesters from 2000-

Figure 32. Beluga whale migration routes and harvest areas as determined by participants at the Traditional and Local Knowledge Workshop for the Anuniaqvia niqiqyuam AOI, March 2011. From KAVIK-AXYS Inc. (2012).

2010 are presented in Table 2. In addition to humans, Polar Bears may prey on Beluga (KAVIK-AXYS Inc. 2012), though how common this occurs is unknown.

Table 1. Number of Beluga struck, landed and lost by Inuvialuit harvesters during a ten year period (1990-1999). Numbers in brackets are the additional number of whales struck but lost. This was pooled for all communities (DFO 2000). From Paulic et al. (2012).

Year	**Number of Beluga Landed**				
	Aklavik	**Inuvik**	**Tuktoyaktuk**	**Paulatuk**	**Total**
1990	31	29	27	0	87 (19)
1991	17	34	49	16	116 (28)
1992	17	38	48	18	121 (9)
1993	20	42	45	3	110 (10)
1994	26	50	57	8	141 (8)
1995	26	46	46	11	129 (14)
1996	19	35	41	25	120 (19)
1997	12	44	51	7	114 (9)
1998	13	31	40	2	86 (7)
1999	8	36	41	1	86 (16)
Total	**189**	**385**	**445**	**91**	**1,110 (139)**

Table 2. Number of Beluga struck, landed and lost by Inuvialuit harvesters from the community of Paulatuk during a ten year period (2000-2010; J. Malone, pers. comm., cited in Paulic et al. 2012). From Paulic et al. (2012).

Year	**Struck**	**Lost**	**Landed**
2000	2	n/a	2
2001	0	n/a	0
2002	0	n/a	0
2003	22	2	20
2004	28	3	25
2005	30	0	30
2006	11	0	11
2007	17	0	17
2008	5	0	5
2009	1	0	1
2010	18	0	18
Total	**134**	**5**	**129**

12.2 BOWHEAD (*Balaena mysticetus*)

Bowhead in the western Canadian Arctic are considered to be part of the Bering Sea population (also known as the Bering-Chukchi-Beaufort population) (Burns et al. 1993; COSEWIC 2009) which represents more than 90% of the world's Bowhead whales (George et al. 2004). Designated as Special Concern under the *Species at Risk Act* (January 2008) and by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC 2009), the most recent estimate of stock size is 10,545 based on census data at Point Barrow in 2001 (George et al. 2004; Zeh and Punt 2005).

Bowhead occur in Arctic and **subarctic** marine waters, in conditions ranging from open water to extensive (but unconsolidated) pack ice[4] (COSEWIC 2009). The whales generally prefer marginal ice fronts and polynyas (Braham et al. 1980). Bowhead overwinter in the Bering Sea, migrating each year in early spring through the Bering Strait and eastward to the Beaufort Sea. They generally pass Point Barrow in April and May (Clark and Johnson 1984; George et al. 1989), continuing east through the offshore southeastern Beaufort Sea to Amundsen Gulf (Moore and Reeves 1993; Marko and Fraker 1981).

Bowhead demonstrate age segregation during migration as well as on summering grounds. For example, large numbers of adults (>13m long) and sub-adults (>11m long) occur in the Amundsen Gulf, while juveniles tend to prefer the Yukon coast (Davis et al. 1982; Cubbage et al. 1984; Davis et al. 1986; Cobb et al. 2008). Bowhead are typically widely distributed in offshore areas of the Beaufort Sea by July (Davis et al. 1982; Harwood and Borstad 1985), and begin to form large, loose feeding aggregations as the season progresses (Harwood and Smith 2002; Richardson et al. 1987). These aggregations form in recurring offshore areas where prey are concentrated (Harwood and Smith 2002, Richardson et al. 1987). Though most are found within the main portion of the Beaufort Sea, some smaller aggregations occur in Amundsen Gulf (including Darnley Bay), Viscount Melville Sound and McClure Strait (Paulic et al. 2012).

The Bowhead is a baleen whale, i.e., one that has baleen plates used for filtering food from the water. Bowhead feed mainly on zooplankton (DFO and IRC 2010; Paulic et al. 2012), the majority of which is made up of copepods (*Limnocalanus macrurus*, *C. hyperboreus*, *C. glacialis*), amphipods (primarily of the families Gammaridae and Hyperiidae), **euphausiid**s, mysids and isopods (LGL Ltd. 1988; W. Walkusz, pers. comm., cited in Paulic et al. 2012). Winds, currents and bathymetry act together to influence the distribution and abundance of these

[4] Satellite Tracking of Western Arctic Bowhead Whales from the Alaska Department of Fish and Game website: http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.whaleresearch.

prey species (Thomson et al. 1986), resulting in concentrations of zooplankton in the same areas within the southeastern Beaufort Sea and Amundsen Gulf every year (Paulic et al. 2012). Bowhead regularly use five areas of the southern Beaufort Sea: along the Yukon North Slope; the shallow waters offshore of the Tuktoyaktuk Peninsula; Mackenzie Canyon; Kugmallit Canyon; and certain areas of Amundsen Gulf (Davis et al. 1982; L. Harwood, pers. comm., cited in Paulic et al. 2012). The offshore area along the Tuktoyaktuk Peninsula appears to be the most attractive and supports the largest aggregation of Bowhead (>50% of whales in the region are present there at any one time) in August (Harwood 2010; Figure 33). This is in general agreement with Traditional and local knowledge, which indicates that nearshore waters off Cape Bathurst and in Franklin Bay are important habitat for Bowhead (Community of Paulatuk et al. 2000). Paulatuk residents report that within the AOI, Bowhead feed in waters near Kamakaq (Kamakark), Brown’s Harbour, and the area northeast of Paulatuk offshore from the mouth of the Hornaday River (KAVIK-AXYS Inc. 2012; Figure 34).

During aerial surveys in 2010, Harwood (2010) observed Bowhead aggregations (i.e., >5 surfaced Bowhead/100 km^2 surveyed) north of Cape Parry and along the northeastern coast of Darnley Bay (2.5-5 whales/100 km^2) near Pearce Point during late May (Figures 35 and 36). Satellite-tagged whales also occasionally entered Darnley Bay in July and August between 2006 and 2009 (Quakenbush et al. 2010). Paulatuk residents report that in recent years, Bowhead are observed in the nearshore region of Darnley Bay in late summer rather than in areas where they are typically observed (i.e., Amundsen Gulf) (Paulic et al. 2009). Traditional and local knowledge indicates that Bowhead enter Darnley Bay every year and feed in groups of up to 12 individuals in July and August (KAVIK-AXYS Inc. 2012).

Use of the AOI by Bowhead appears to be occasional rather than frequent (Hazard and Cubbage 1982). Although Darnley Bay is not a unique feeding area used regularly by large numbers of Bowhead, some whales frequent the area for a period of weeks in some years (Paulic et al. 2012). Available information suggests that use of the area by Bowhead may be increasing (KAVIK-AXYS Inc. 2012; Paulic et al. 2012); however, Paulatuk residents suggest that increasing air traffic may be preventing whales from entering the bay (KAVIK-AXYS Inc. 2012).

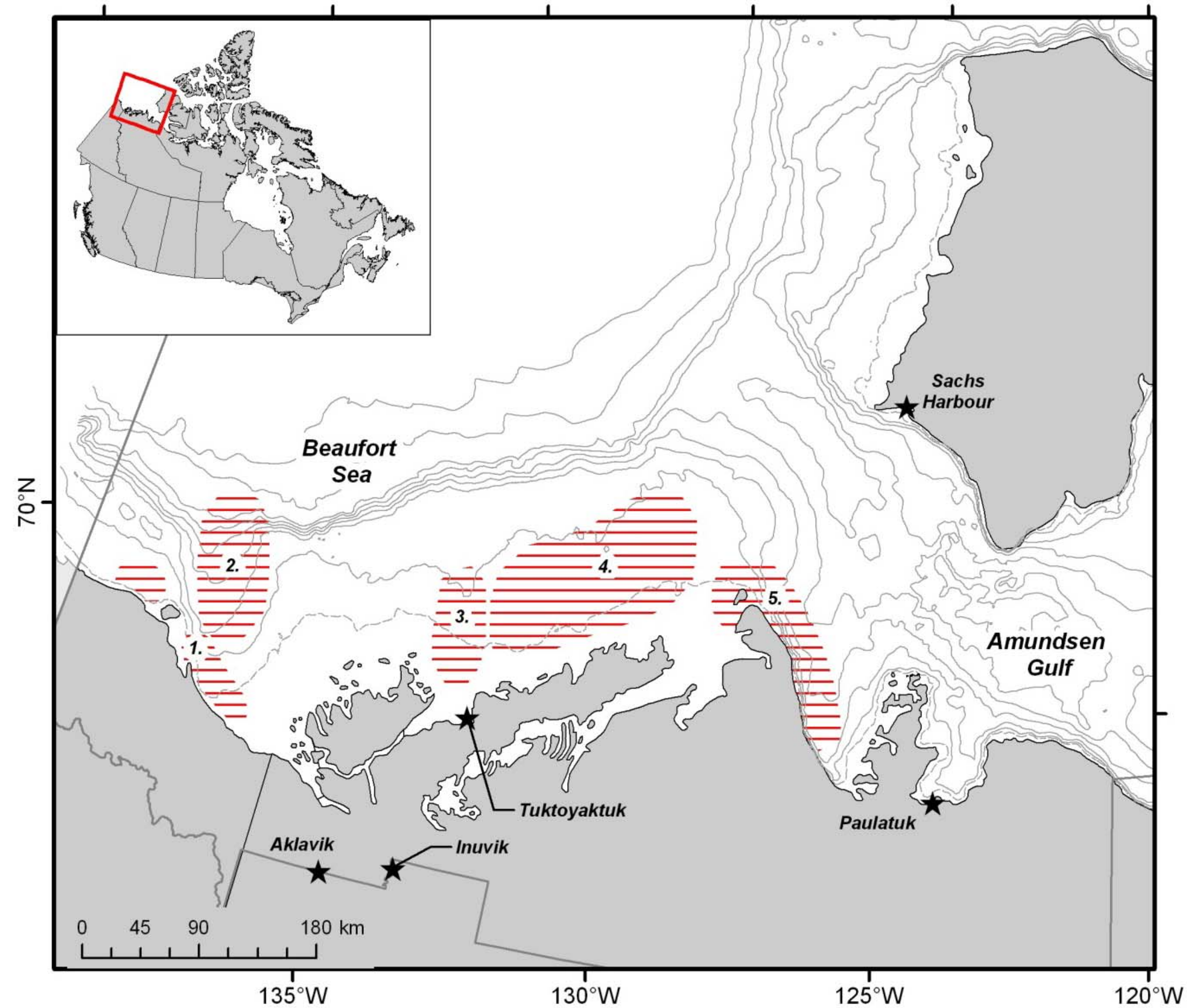

Figure 33. Approximate locations of typical summer Bowhead aggregation areas in the southern Beaufort Sea and Amundsen Gulf region labelled left to right: 1. Yukon North Slope, 2. Mackenzie Canyon, 3. Kugmallit Canyon, 4. Tuktoyaktuk Peninsula and 5. Cape Bathurst (L. Harwood, pers. comm., cited in Paulic et al. 2012). From Paulic et al. (2012).

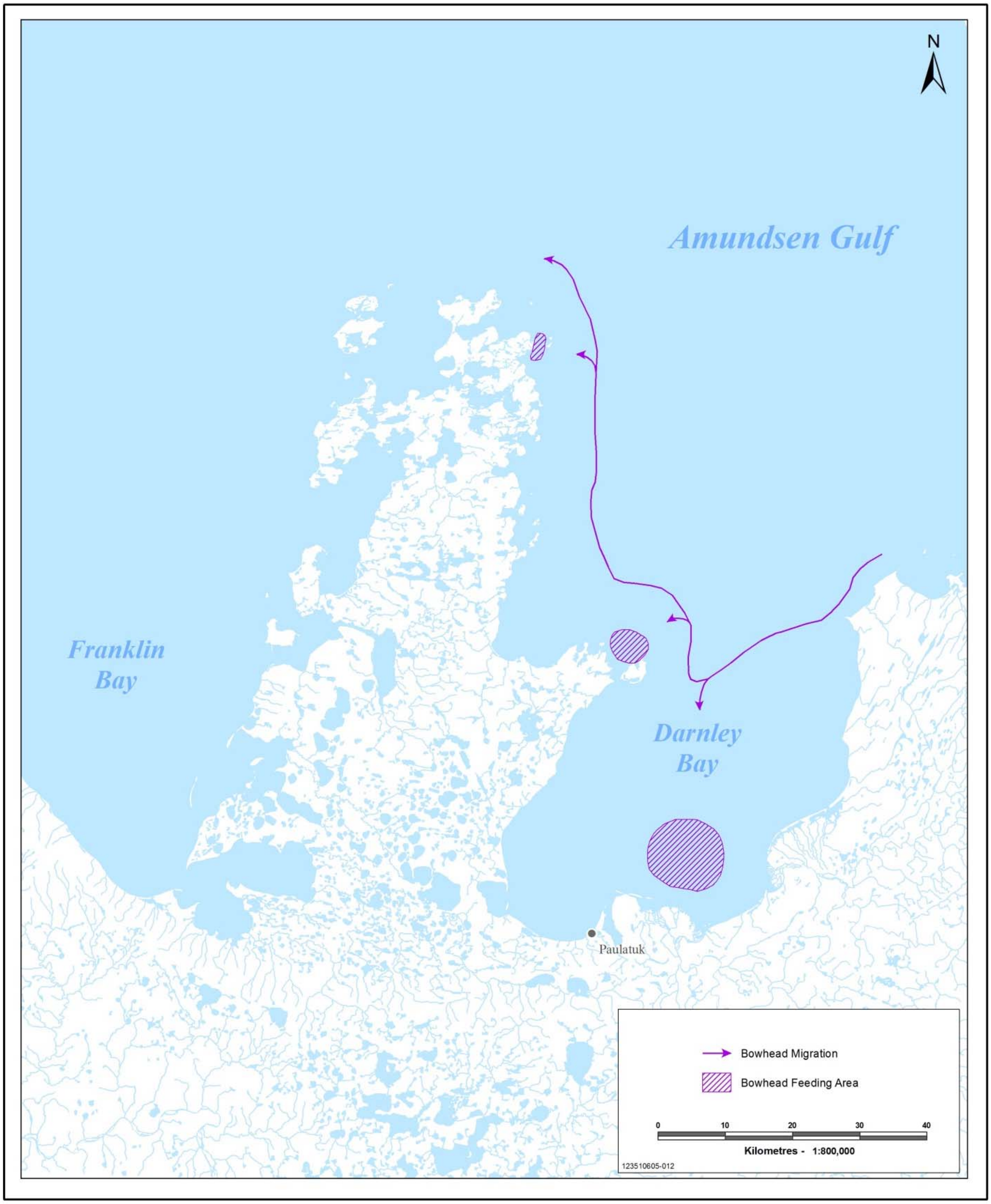

Figure 34. Bowhead whale migration routes and feeding areas as determined by participants at the Traditional and Local Knowledge Workshop for the Anuniaqvia niqiqyuam AOI, March 2011. From KAVIK-AXYS Inc. (2012).

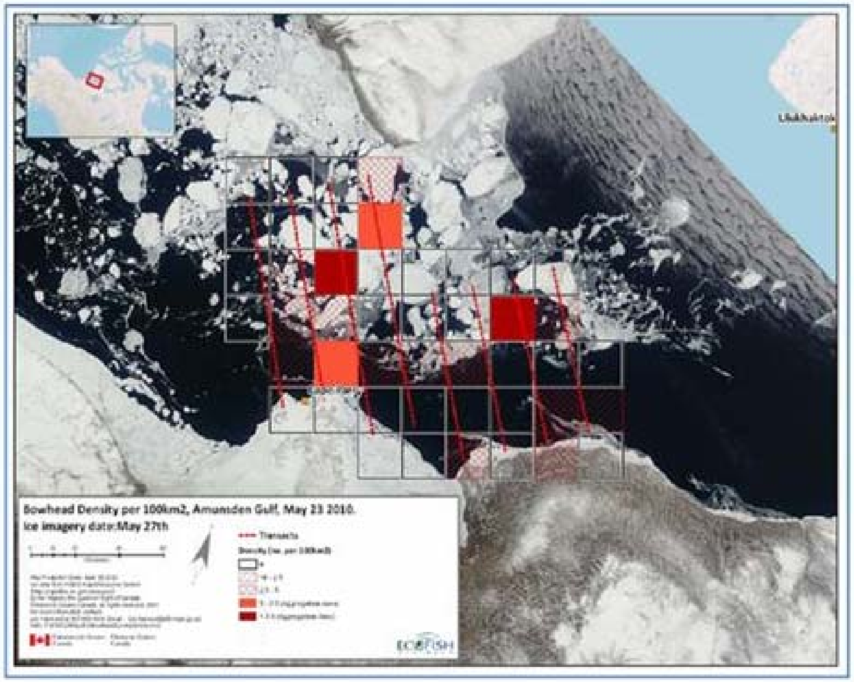

Figure 35. Observed grid cell densities of surfaced Bowhead in western Amundsen Gulf, 23 May 2010 (Harwood 2010). From Paulic et al. (2012).

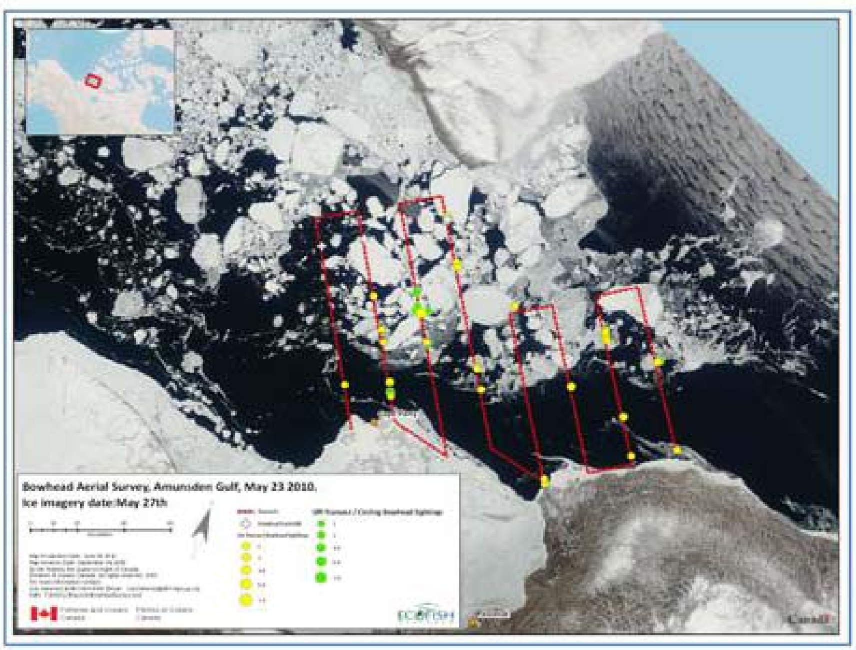

Figure 36. Locations of Bowhead sighted in western Amundsen Gulf, 23 May 2010 (Harwood 2010). From Paulic et al. (2012).

12.3 RINGED SEALS (*Phoca hispida*)

Ringed Seals have a circumpolar distribution and are one of the most abundant marine mammals in the Western Canadian Arctic (Smith 1987). This species plays a key role in the Arctic marine food web, both as predator and prey. It is the primary prey of Polar Bears, a valuable food source for Arctic Foxes (Cobb et al. 2008; Smith 1976; Stirling 2002), and an important predator of marine fish and invertebrates.

Ringed Seals occur year-round in the Beaufort Sea, both within and adjacent to the AOI (KAVIK-AXYS Inc. 2012; Paulic et al. 2012). Amundsen Gulf and Darnley Bay provide breeding habitat for Ringed Seals (Cobb et al. 2008), where most mating occurs between mid-May and mid-June (DFO and IRC 2010). During the spring breeding season, females construct lairs (snow caves) within the landfast ice and give birth to a single pup (Smith 1987). Traditional and local knowledge indicates that seals have their pups in late April and May in Darnley Bay (Steering Committee for the proposed Darnley Bay MPA 2010a; KAVIK-AXYS Inc. 2012). Ringed Seals haul out on the ice in late June before ice break-up begins in order to moult (DFO and IRC 2010; Paulic et al. 2012). Cape Parry has one of the highest densities of Ringed Seal haul-out sites in the southern Beaufort Sea, though other high density areas occur along the Yukon coast, near Cape Bathurst, and along the southwest coast of Banks Island (Stirling et al. 1982).

Several environmental factors influence the distribution of Ringed Seals, including: the distribution of shore leads; polynyas and areas of annual multi-year ice; and variations in the pattern of freeze-up and break-up (Stirling 2002). In spring, seals disperse at low densities throughout the region. In summer, they can travel large distances and often form large, loose aggregations (Harwood and Borstad 1985; Smith 1987; Harwood and Stirling 1992; KAVIK-AXYS Inc. 2012). The locations of these aggregations vary from year to year, occurring most regularly in the area north of the Tuktoyaktuk Peninsula (Harwood and Stirling 1992; Figure 37). High density aggregations also form in Amundsen Gulf off Cape Parry (Cobb et al. 2008). Traditional and local knowledge indicates that fall aggregations commonly occur near Bennett Point on the north side of Clapperton Island and feed in groups near river mouths and channels (e.g., Hornaday River) (KAVIK-AXYS Inc. 2012). The locations of summer and fall aggregations depend largely on the distribution and abundance of zooplankton (Harwood 1989; Smith 1987; KAVIK-AXYS Inc. 2012). For example, Harwood (1989) found that mean densities of euphausiids and copepods were significantly greater in seal aggregation areas than in non-aggregation areas in the southeast Beaufort Sea. Smith (1987) found similar aggregations in the Amundsen Gulf.

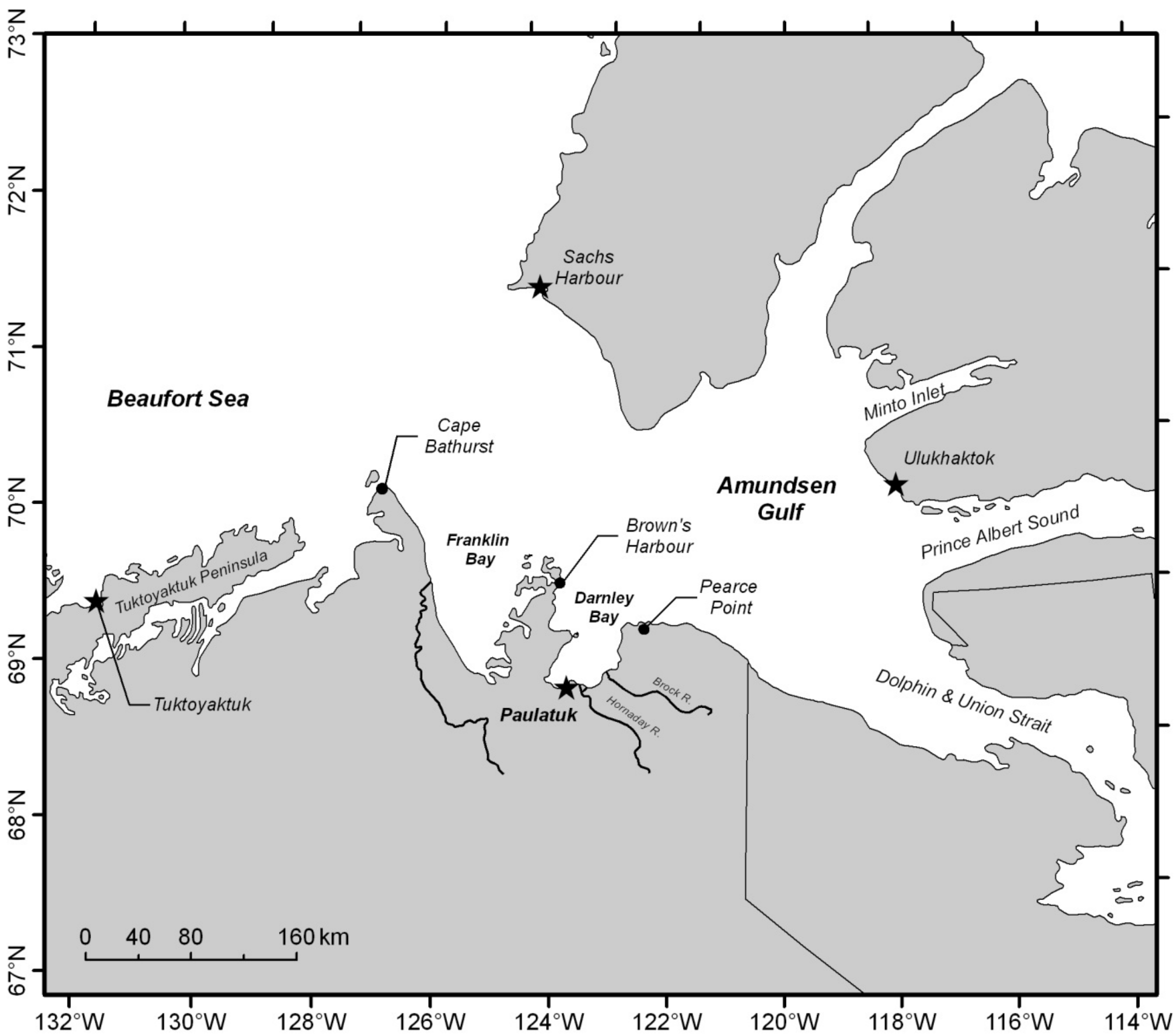

Figure 37. Areas in the Beaufort Sea LOMA where Ringed Seals commonly occur at different times in the year (L. Harwood, pers. comm.). Loose aggregations occur north of the Tuktoyaktuk Peninsula in summer and prime overwintering and spring breeding areas include Franklin and Darnley bays, Prince Albert Sound, Minto Inlet and Dolphin and Union Strait. From Paulic et al. (2012).

As the ice begins to form in late fall, Ringed Seals may undertake localized and large-scale movements within the region (e.g., Stirling et al. 1977; Smith 1987; L. Harwood, pers. comm., cited in Paulic et al. 2012). Smith (1987) discovered that seals in the eastern Amundsen Gulf seasonally redistributed by age class, likely in response to food availability. Summer and fall feeding is particularly important to Ringed Seals in order to build fat reserves for the winter and for pregnant females to support growing offspring (Smith 1987). Smith (1987) suggested that fall migrations and age class segregation may be the result of territorial exclusion of younger animals

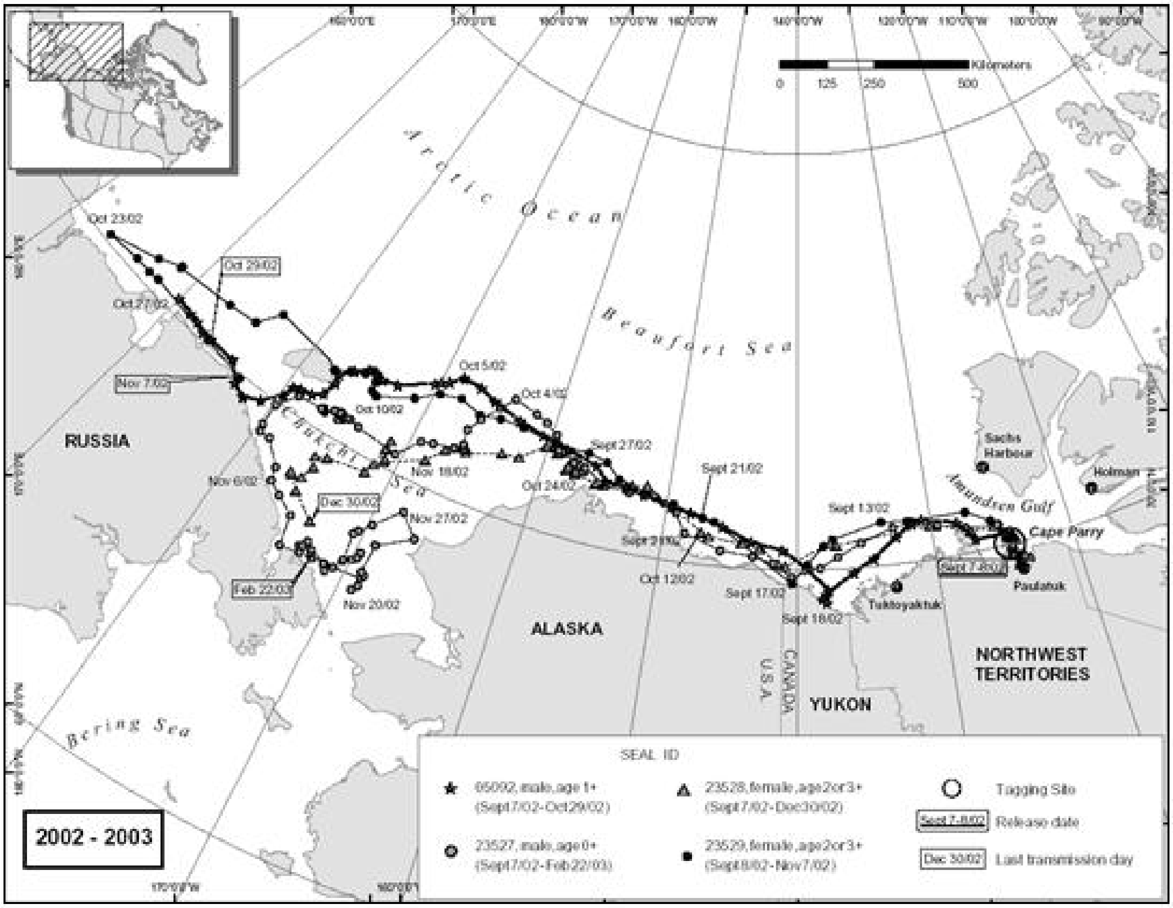

Figure 38. Seal telemetry results for Ringed Seals tagged at or near Cape Parry in September 2002 (www.beaufortseals.com/telemetry.htm). From Paulic et al. (2012).

to reduce feeding competition. In Amundsen Gulf, young seals migrate westward past Cape Parry each fall, moving as far west as the Chukchi Sea (Paulic et al. 2012; Figure 38). At the same time, established adult seals move into coastal areas of stable landfast ice in order to create breeding territories. Important breeding areas within the Beaufort Sea LOMA include Franklin and Darnley bays, Prince Albert Sound, Minto Inlet and Dolphin and Union Strait (L. Harwood, pers. comm., cited in Paulic et al. 2012; Figure 37).

In general, Ringed Seals favour the shallow productive waters of the continental shelf (Stirling et al. 1982). Though preferred Ringed Seal habitat exists elsewhere in the Beaufort Sea LOMA (e.g., Prince Albert Sound; L. Harwood, pers. comm., cited in Paulic et al. 2012), several types of sea-ice within the AOI represent important Ringed Seal habitat (Stirling et al. 1993). For example, the inner portion of Darnley Bay provides stable landfast ice with drifts, while the offshore region near Cape Parry contains moving ice (Stirling et al. 1993). Sea ice habitat in the offshore region between Banks Island and Cape Parry varies between years, depending on the distribution of leads and the size of the Cape Bathurst polynya (Stirling et al. 1993). Important Ringed Seal habitat also exists in areas of pressure ridges along the coastline of the Parry Peninsula, where the ocean bottom drops quickly to depths of approximately 50 m at Cape Parry (Stirling et al. 1993).

Population estimates for Ringed Seals in the Beaufort Sea vary from year to year (DFO and IRC 2010; Paulic et al. 2012). Though Ringed Seals are relatively abundant throughout the AOI, some residents of Paulatuk report that the population has declined since the 1970s (KAVIK-AXYS Inc. 2012). Residents speculate that this decline could have resulted from a decrease in hunting pressure and/or intense sampling in the 1960s and 1970s for research purposes (KAVIK-AXYS Inc. 2012). Some residents suggest that declines in hunting pressure lead to a significant increase in seal numbers and intense competition for food. This competition, in turn, may have led to the decline or dispersal of seals in the region (KAVIK-AXYS Inc. 2012).

Heavy ice conditions may negatively impact Ringed Seal populations by causing a decline in food availability and/or reproductive success (Cobb et al. 2008; Harwood and Stirling 1992). Heavy ice conditions can lead to decreases in **primary** and **secondary productivity** which, in turn, reduce the numbers of prey species or cause them to disperse (Harwood and Stirling 1992). Harwood and Stirling (1992) observed Ringed Seal population declines following years of heavy ice conditions, as evidenced by decreased densities and a reduction in the number of pups. A decrease in Ringed Seal numbers may lead to similar declines in Polar Bear and Arctic Fox populations due to their dependency on seals for food (Cobb et al. 2008).

Though limited ice cover and the early break up of land-fast ice enhances productivity and the availability of food sources, these conditions also may negatively impact Ringed Seals. For example, declines in ice cover limit the amount of breeding habitat available to seals and may force pups to abandon their platform prior to the end of their normal nursing period (Smith and Harwood 2001). An interruption in the lactation period can affect the growth and body condition of unweaned pups, resulting in high mortality (Harwood et al. 2000). Traditional and local knowledge indicates that an early spring in 2010 resulted in the premature melting of seal lairs, possibly leading to high pup mortality (KAVIK-AXYS Inc. 2012).

Ringed Seals eat a variety of invertebrates and fish (Cobb et al. 2008). Crustaceans (e.g., copepods, mysids and amphipods) and Arctic Cod are the most common food items, though Saffron Cod also are important (Smith 1987; Community of Paulatuk et al. 2000). Prey species vary seasonally and depend on availability, water depth, and distance from shore (Smith 1987). For example, one study conducted in Prince Albert Sound found that the stomach contents of older Ringed Seals in June were either empty or contained Arctic Cod (Smith and Harwood 2001). Pups in that study primarily consumed invertebrates, but also fed on Arctic Cod (Smith and Harwood 2001). In fall and winter, fish are most important in the diets of all age classes (Cobb et al. 2008). Acoustic data indicate that Ringed Seals in Franklin Bay dive up to 200 m to feed on schools of Arctic Cod (Benoit et al. 2010). In addition, residents of Paulatuk report fall aggregations of Ringed Seals feeding on Arctic Char at the mouth of Hornaday River and along its channels (KAVIK-AXYS Inc. 2012).

Ringed Seals represent an important resource of the Inuvialuit, who harvest them for subsistence, dog food, and pelts (Community of Paulatuk et al. 2000). Traditional and local knowledge identifies important Ringed Seal areas in Darnley Bay along the nearshore coasts east and west of Paulatuk, Pearce Point, and the Brown's Harbour area (Community of Paulatuk et al. 2000; KAVIK-AXYS Inc. 2012; Figures 37 and 39).

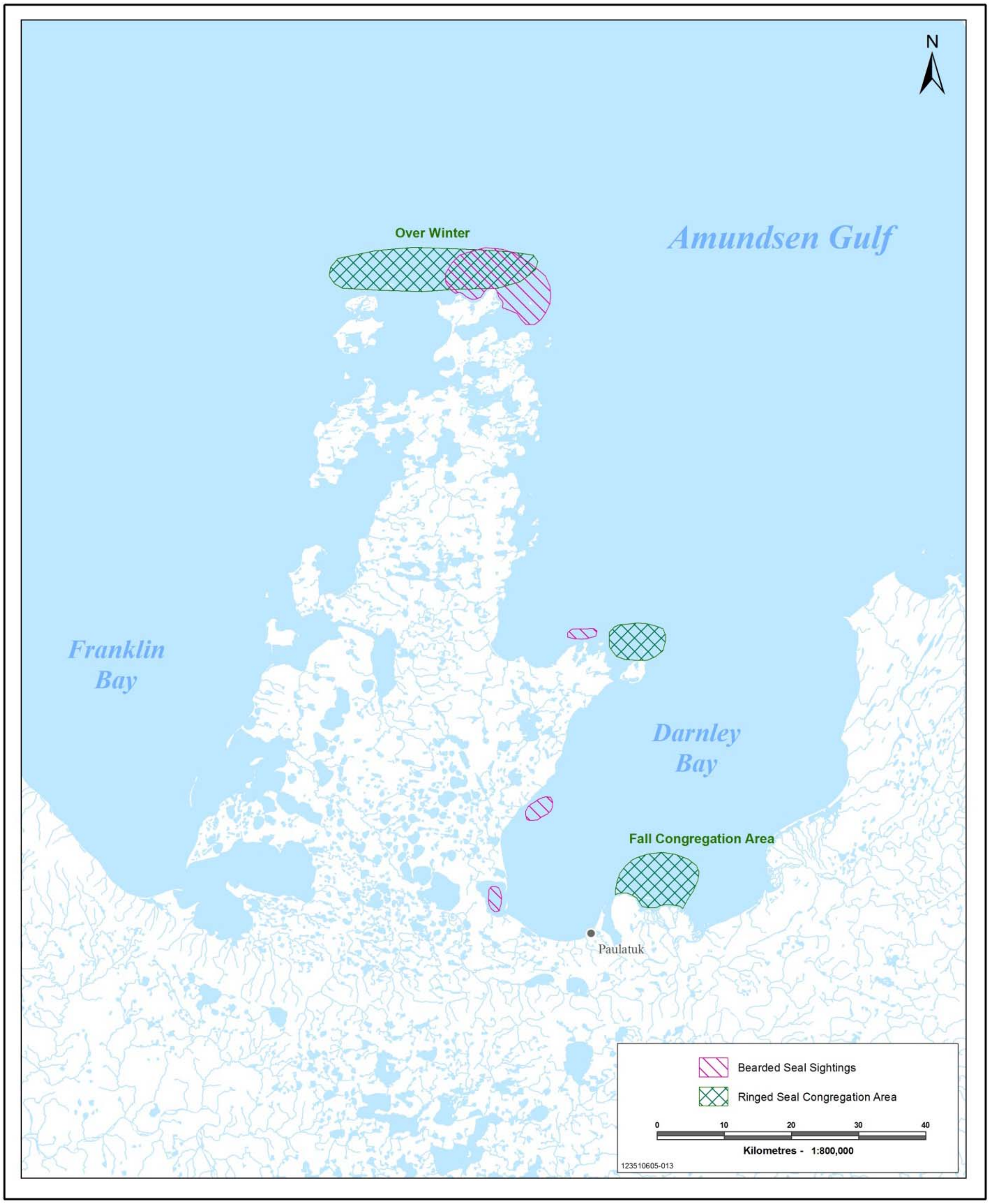

Figure 39. Seal areas of importance as determined by participants at the Traditional and Local Knowledge Workshop for the Anuniaqvia niqiqyuam AOI, March 2011. From KAVIK-AXYS Inc. (2012).

12.4 BEARDED SEALS (*Erignathus barbatus*)

Bearded Seals are widely distributed throughout the Arctic but are considerably less abundant than Ringed Seals (Stirling et al. 1982; Parks Canada 1995; Stephenson and Hartwig 2010; KAVIK-AXYS Inc. 2012). Bearded Seals have a patchy distribution and are usually solitary (Smith 1981), preferring the floe-edge and areas with moving ice (Stirling et al. 1993).

As with Ringed Seals, the Bearded Seal population in the Beaufort Sea fluctuates from year to year (DFO and IRC 2010). Water depth, prey biomass and ice conditions appear to strongly influence their distribution (Stirling et al. 1977). In the Beaufort Sea and Amundsen Gulf, Bearded Seals prefer shallow (25-75 m) shelf waters that are seasonally ice-covered (Stirling et al. 1977; Stirling et al. 1982). Results of aerial surveys conducted between 1974 and 1979 indicate that Bearded Seals were 1/16th as common as Ringed Seals in the southeastern Beaufort Sea (Stirling et al. 1982).

Bearded Seals are generalists, feeding on a wide variety of benthic organisms including shrimp, clams, crabs, other benthos and fish (Stirling et al. 1982; Dehn et al. 2007). Though one study concluded that Bearded Seal in the Canadian Arctic feed primarily on fish such as Arctic Cod (Finley and Evans 1983), several others report varying occurrences and proportions of clams, shrimp, crabs, benthic invertebrates, and fish in seal stomachs (Burns and Frost 1979; Lowry et al. 1980; Anotonelis et al. 1994; Hjelset et al. 1999; Dehn et al. 2007). This suggests that Bearded Seal diets are area specific, reflecting the local distribution and availability of prey (Dehn et al. 2007). Residents of Paulatuk report that some Bearded Seals within the AOI also feed on squid (KAVIK-AXYS Inc. 2012).

Though Bearded Seals occur within the AOI and surrounding areas (Cobb et al. 2008; KAVIK-AXYS Inc. 2012; Figure 39), information regarding their population structure, abundance or productivity is limited (Paulic et al. 2012). Bearded Seals occur along offshore leads and polynyas north of the coast from the Alaska/Yukon border east to the Baillie Islands, in the region of the Cape Bathurst polynya, and along the western and southern coastlines of Banks Island (Parks Canada 1995; Cobb et al. 2008). Traditional and local knowledge also identifies important Bearded Seal habitat in the Amundsen Gulf (west) and Franklin Bay, the nearshore region of Darnley Bay, Pearce Point and Brown's Harbour (Community of Paulatuk et al. 2000; KAVIK-AXYS Inc. 2012; Figures 39 and 40). Residents of Paulatuk indicate that the western portion of Amundsen Gulf contains important pupping habitat in late April and early May, and that Bennett Point is a common location where Bearded Seals haul-out (Community of Paulatuk et al. 2000; Figure 40).

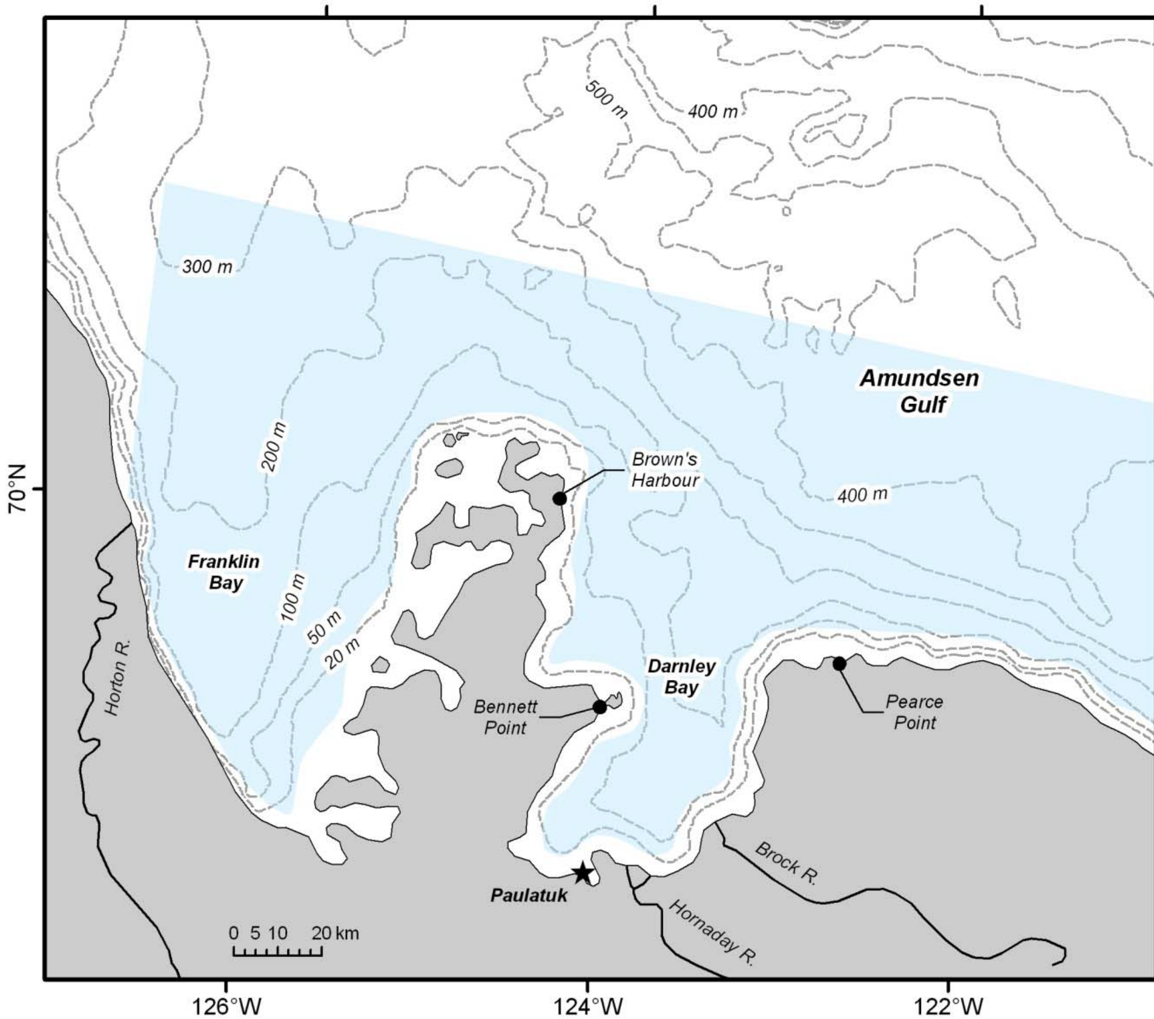

Figure 40. Areas identified as important Bearded Seal habitat (blue) in the study area by Traditional and local knowledge (Community of Paulatuk et al. 2000). From Paulic et al. (2012).

Photo 3. A youth with a bearded seal. Photo by Frances Wolki. From KAVIK-AXYS Inc. (2012).

13.0 POLAR BEARS (*Ursus maritimus*)

Beaufort Sea Polar Bears are divided into northern and southern subpopulations. Polar Bears occurring in Franklin and Darnley bays belong to the Southern Beaufort Sea subpopulation, which extends from west of Wainwright, Alaska (approx. 160°W) to just east of Pearce Point (approx. 125°W; Paulic et al. 2012; Figure 41). The most recent estimates for the Southern Beaufort Sea indicate a population size of approximately 1,526 (± 315) (Regehr et al. 2006, 2007). This number is slightly less than 2002 estimates of 1,800 (COSEWIC 2002; Brower et al. 2002), but is higher than those for the northern subpopulation (1,200; COSEWIC 2002; Brower et al. 2002).

Polar Bear management and harvest levels in the Canadian Southern Beaufort Sea fall under the jurisdiction of the Government of the Northwest Territories guided by the joint commissioners of the Inuvialuit-Inupiat Polar Bear Management Agreement (the Agreement) in the Southern Beaufort Sea (Paulic et al. 2012). Inuvialuit hunters of Canada and Inupiat hunters of Alaska ratified The Agreement in 1988 (Paulic et al. 2012). This Agreement ensures the sustainable harvest of Polar Bears by providing annual quotas, defining hunting seasons, and providing protection for denning bears and females with young-of-the-year cubs (Brower et al. 2002). The current harvest level is set at 80 bears/year (40 in Canada and 40 in Alaska), but is being reviewed in light of recent population studies by Regehr et al. (2006), Regehr et al. (2007) and Hunter et al. (2007) (Paulic et al. 2012). COSEWIC is currently considering the Polar Bear as a species of Special Concern (COSEWIC 2008).

Polar Bears are among the most ice-dependent of all Arctic marine mammals (Amstrup 2003; Laidre et al. 2008). The sea ice provides a platform for movement, mating and maternal denning as well as access to their primary prey (Ringed and Bearded seals) (Stirling 2002). Variation in sea ice habitat availability and the distribution and abundance of prey species determine Polar Bear distribution and seasonal movements (Smith 1980; Regehr et al. 2010). Ringed Seals (young-of-the-year) are the primary prey for Polar Bears in the Southern Beaufort Sea, though bears also feed on Bearded Seals and Beluga (Stirling 2002; Theimann et al. 2008).

Polar Bear movements mainly reflect their need to remain on ice for as long as possible (Stirling et al. 1993) and are influenced by the distribution of their prey (Parks Canada 1995). Polar Bears can travel long distances over the course of the year, but demonstrate seasonal fidelity to certain locations (Stirling 2002). In summer, when sea ice is minimal, the majority of bears from the Southern Beaufort Sea subpopulation either move offshore into the multi-year pack ice or north along the coast of Banks of Banks Island and the mainland (Stirling 2002; Figure 42). Recently, however, more bears are spending the summer onshore in Alaska (Schliebe et al. 2008).

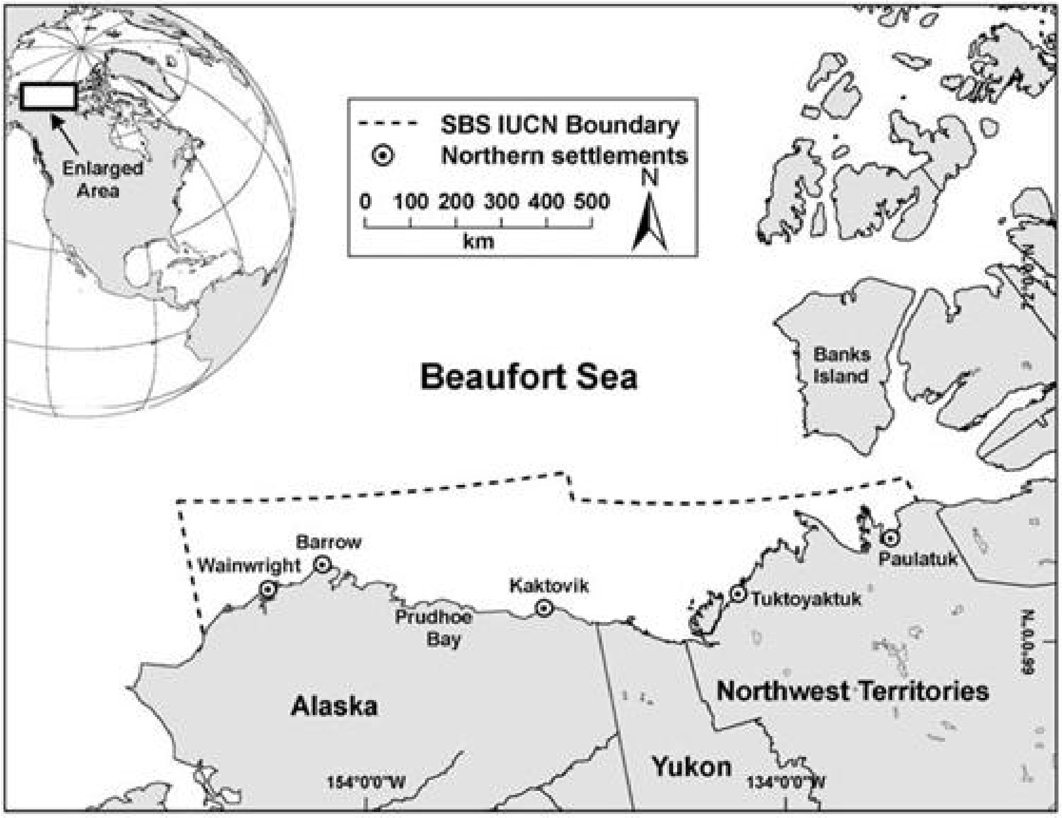

Figure 41. Map of the Southern Beaufort Sea Polar Bear management unit established by the International Union for the Conservation of Nature and Natural Resources Polar Bear Specialist Group (Regehr et al. 2007). From Paulic et al. (2012).

Although Polar Bears can fast for long periods of time while on land, hunting success in spring and early summer is important in maintaining body condition and ensuring survival of individuals for the remainder of the year (Stirling 2002).

In the fall, bears that have remained onshore (primarily in Alaska) wait for the landfast ice to reform before moving into winter feeding areas (Stirling 2002). Those that have traveled north with the retreating sea ice begin to move south from Banks Island toward the mainland coast and Amundsen Gulf (Stirling 2002; Figure 42), occupying preferred habitats over the continental shelf (Durner et al. 2009).

Polar Bears use a variety of sea ice types, from stable landfast ice with drifted pressure ridges to areas near the floe edge and moving active ice (Stirling et al. 1993). In late winter and spring, Polar Bears occur in highest densities near the floe edge and in areas of moving active ice

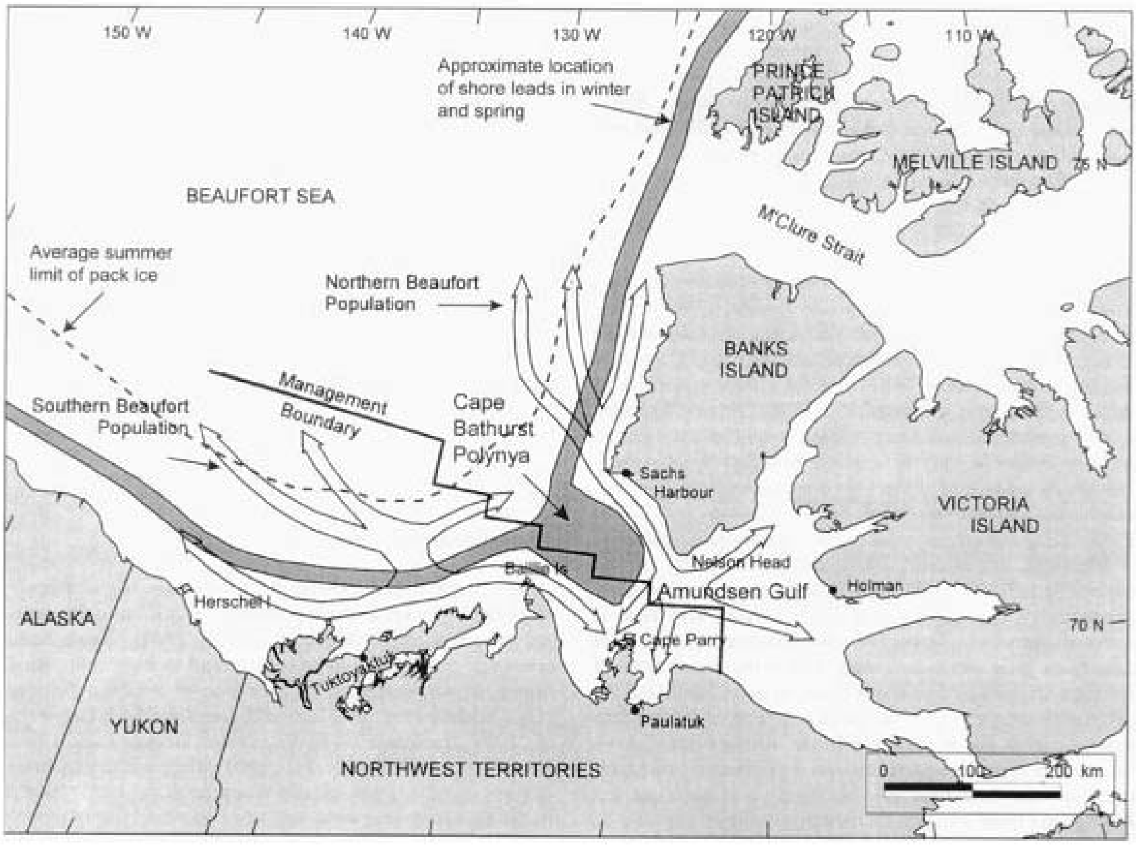

Figure 42. Map of the Beaufort Sea indicating the distribution and seasonal movements of Polar Bears in relation to sea ice, leads and the Cape Bathurst polynya. The arrows indicate the southerly and easterly movement of bears during ice formation in the fall and in a northerly and westerly direction during ice break-up in the spring and early summer (From Paulic et al. 2012; modified after Stirling 2002).

(Stirling et al. 1993). Stirling et al. (1993) found that adult and sub-adult males, lone females and females with two-year-old cubs preferred these types of habitats for two possible reasons: ease in finding a mate (April-May); or seal abundance and accessibility (Stirling et al. 1993). These preferred habitat types exist within the AOI, particularly in the area just north of Cape Parry (Paulic et al. 2012). Here, oceanographic and meteorological conditions help form and maintain the Cape Bathurst polynya. The floe edge in this region of the Beaufort Sea typically extends along the mainland coast in Amundsen Gulf and west towards Alaska (Paulic et al. 2012; Figure 42). Moving active ice is generally located north of the floe edge in the northern portion of both Franklin and Darnley bays and Amundsen Gulf (Paulic et al. 2012; Figure 42). This area represents important spring feeding habitat for Polar Bears and appears to be a mating area (Paulic et al. 2012). In addition, the area from Baillie Island east toward Cape Parry and north toward Nelson Head on Banks Island can be an important travel route for bears as they move north during the spring melt (Figure 42). However, its usefulness as a travel route is dependent upon current oceanographic conditions (Paulic et al. 2012).

Females with cubs typically prefer landfast ice associated with drifted pressure ridges rather than the floe edge or areas of moving active ice (Stirling et al. 1993). Stirling et al. (1993) suggested that these habitats may be important to cub survival by preventing cubs from swimming in open water (i.e., areas with active leads) and/or decreasing contact with other bears, specifically males which are a threat to cubs. Although the southern portion of Darnley Bay contains stable fast ice, the extent to which females with cubs-of-the-year use this area is unknown (Paulic et al. 2012). Field notes and unpublished data from long term research in the Southern Beaufort Sea indicate that pregnant female bears den on the Cape Bathurst Peninsula and Baillie Islands, utilizing the landfast ice in Franklin Bay to hunt Ringed Seals in the spring (Paulic et al. 2012).

Polar Bears differ from other bears in that only pregnant females that use maternity dens for reproduction experience winter dormancy (Ramsay and Stirling 1990). Female Polar Bears typically use snow dens to give birth to and nurture their young (Paulic et al. 2012). These dens provide warmth from ambient temperatures and are important for the survival and development of cubs (Blix and Lentfer 1979). Maternity dens in the Beaufort Sea are common along the western and southern coasts of Banks Island (Stirling and Andriashek 1992), along the coast of Parry Peninsula (KAVIK-AXYS Inc. 2012), along the mainland coast of Alaska (Durner et al. 2001; Durner et al. 2006) and Canada (Stirling and Andriashek 1992; E. Richardson, unpubl. data), and to a lesser extent on the multi-year ice pack (Amstrup et al. 1986; Amstrup and Gardner 1994). Several factors influence the distribution of maternity dens, including: the availability of suitable denning habitat (i.e., snowdrifts); sea ice conditions; den site fidelity and anthropogenic (human) influences (Harington 1968; Schweinsburg 1979; Belikov 1980; Lentfer and Hensel 1980; Hansson and Thomassen 1983; Stirling and Andriashek 1992; Amstrup 2003). Though denning information for the Darnley Bay area is limited, TK suggests that females may show fidelity to a particular den (KAVIK-AXYS Inc. 2012). Pregnant females enter maternity dens in late October and the cubs are usually born between November and early January (Derocher et al. 1992).

The Community of Paulatuk outlined the importance of Darnley Bay and Amundsen Gulf to Polar Bears through their identification of Polar Bear spring and winter harvesting areas (Community of Paulatuk et al. 2000; KAVIK-AXYS Inc. 2012; Figure 43). Both subsistence harvesting and sport hunting occur within the region (Paulic et al. 2012). Subsistence harvesting in the AOI occurs between December and April, typically along leads in the ice, while sport hunts are generally limited to the Cape Parry area (KAVIK-AXYS Inc. 2012). The community of

Paulatuk identifies important Polar Bear habitat in the offshore areas of Pearce Point, Canoe, Booth and Bear Islands, Cape Parry and along the eastern coastline of the Paulatuk planning area (Community of Paulatuk et al. 2000). This information is supported by field studies conducted by the Canadian Wildlife Service, which found increases in the use of identified areas by bears in the spring (Paulic et al. 2012). The community of Paulatuk has raised concerns with regard to the disturbance of sea ice habitat by climate warming and commercial activity (e.g., tanker traffic) and their impacts on Polar Bears (Community of Paulatuk et al. 2000).

Overall, the area north of Cape Parry, in association with the Cape Bathurst polynya, represents important habitat for Polar Bears from late spring to early summer. Landfast ice in Darnley and Franklin bays are likely important for females with cubs-of-the year (Paulic et al. 2012).

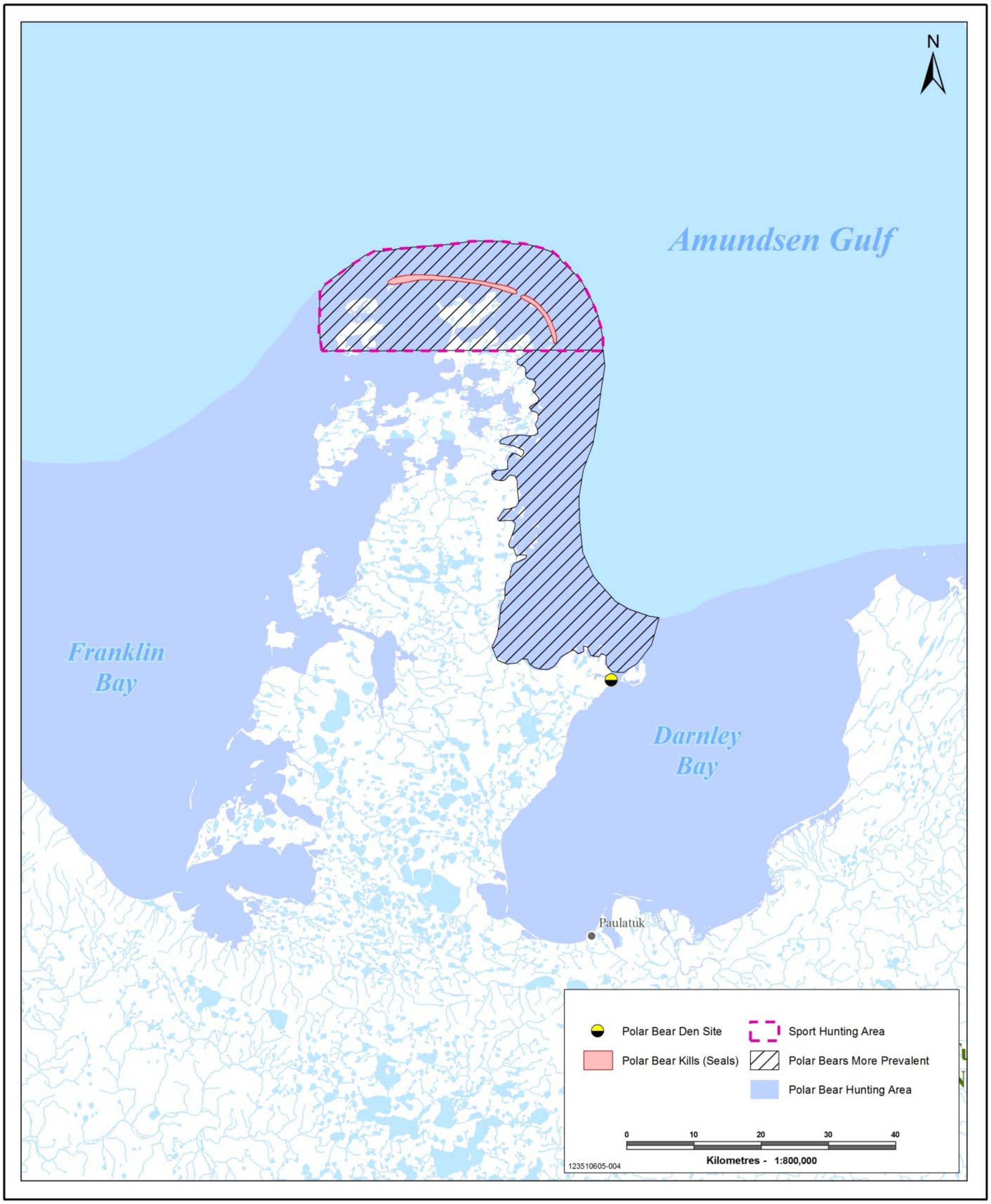

Figure 43. Polar bear harvest and denning area as determined by participants at the Traditional and Local Knowledge Workshop for the Anuniaqvia niqiqyuam AOI, March 2011. From KAVIK-AXYS Inc. (2012).

14.0 MARINE BIRDS

The Canadian Arctic is home to a wide variety of bird species that depend on marine habitat for at least part of their life cycle (e.g., breeding, feeding, migration, moulting; Mallory and Fontaine 2004). Species such as ducks, geese, swans, murres, guillemots, gulls, terns, jaegers, loons and shorebirds (Cobb et al. 2008) are widespread throughout the Arctic and occur in high densities within coastal, nearshore and offshore waters (Johnson and Herter 1989). Open-water lead systems are particularly important, providing migration and staging habitat for a large number of birds (Alexander et al. 1997; Latour et al. 2008). For example, recurrent leads in the Canadian Beaufort Sea serve as important migration corridors and staging areas for populations of King Eiders (*Somateria spectabilis*), Common Eiders (*Somateria mollissima*), Long-tailed Ducks (*Clangula hyemalis*), Glaucous Gulls (*Larus hyperboreus*) and Yellow-Billed Loons (*Gavia adamsii*) (Barry and Barry 1982; Alexander et al. 1988; Community of Paulatuk et al. 2000; KAVIK-AXYS Inc. 2012). The Canadian Wildlife Service (Environment Canada) identifies the area immediately north of Cape Parry as a key marine habitat due to its importance to bird species (Mallory and Fontaine 2004; Figure 45).

In addition to providing valuable staging areas and migration corridors, the marine habitat north of Cape Parry is a known feeding area for species that nest in the terrestrial portion of Cape Parry (Paulic et al. 2012). Though nesting colonies of Thick-billed Murres (*Uria lomvia*) occur in other areas of the Canadian Arctic (e.g., Coburg Island, NU), the coastal cliffs of Parry Peninsula at Cape Parry support the only nesting colony of the subspecies *Uria lomvia arra* in Canada (Mallory and Fontaine 2004). Murres lay only one egg per year (Gaston and Hipfner 2000), which makes this species particularly susceptible to disturbance. Because of its importance to murres, the Canadian Wildlife Service identified the Cape Parry area as key terrestrial habitat, designating it as a Migratory Bird Sanctuary in 1961 (Canadian Wildlife Service 2005). The Cape Parry Migratory Bird Sanctuary covers approximately 232 hectares (2.32 km^2) and comprises three separate nesting sites on the Peninsula: 1) Police (West) Point; 2) Devon (Central) Point; and 3) East Point (Canadian Wildlife Service 1992; Figure 45).

A colony of Black Guillemots (*Cepphus grylle*) also nests at Cape Parry and is one of only two known colonies of the species in the western Arctic (Johnson and Ward 1985; Latour et al. 2008). Other species nesting at Cape Parry include Common Murres (*Uria aalge*; Johnson and Ward 1985), eiders, gulls, brant and Canada geese (Parks Canada 1995; Community of Paulatuk et al. 2000).

Pelagic seabirds often use cliff habitat for nesting in order to avoid terrestrial predators. Although this type of habitat exists at two locations in the southeastern Beaufort Sea (Cape Parry

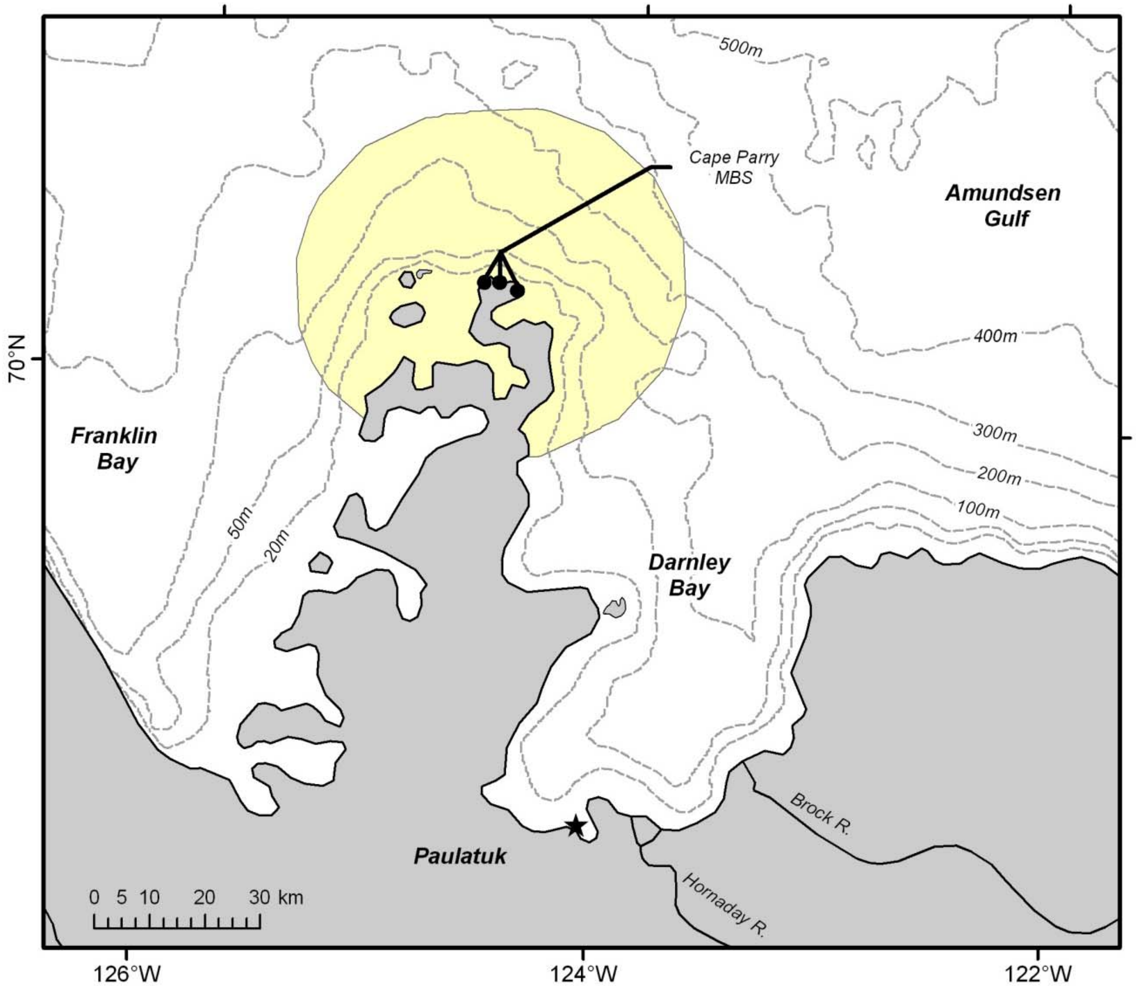

Figure 44. Key Marine Habitat for Migratory Birds indicated in yellow and the Cape Parry Migratory Bird Sanctuary indicated in black as identified by the Canadian Wildlife Service, Environment Canada. From Paulic et al. (2012).

and Nelson Head), cliff-nesting seabirds only occupy the cliffs at Cape Parry (Dickson and Gilchrist 2002). Dickson and Gilchrist (2002) suggested that this preference for Cape Parry cliffs may be a function of prey availability. While adult seabirds often feed on invertebrates at sea (Bradstreet 1982), their chicks require fish to speed their growth rates during the short breeding season (Dickson and Gilchrist 2002). Thick-billed Murres can forage as far as 200 km from the colony, but typically feed within a 30 km radius of their nesting sites (Mallory and Fontaine 2004). This species can forage underwater to depths of 200 m (Croll et al. 1992; Falk et al. 2000). Their prey typically includes small fishes, squid and large zooplankton (Gaston and Bradstreet 1993; Gaston and Hipfner 2000). Gaston and Nettleship (1981) reported that in the eastern Arctic, Arctic Cod is the primary fish prey for seabird chicks.

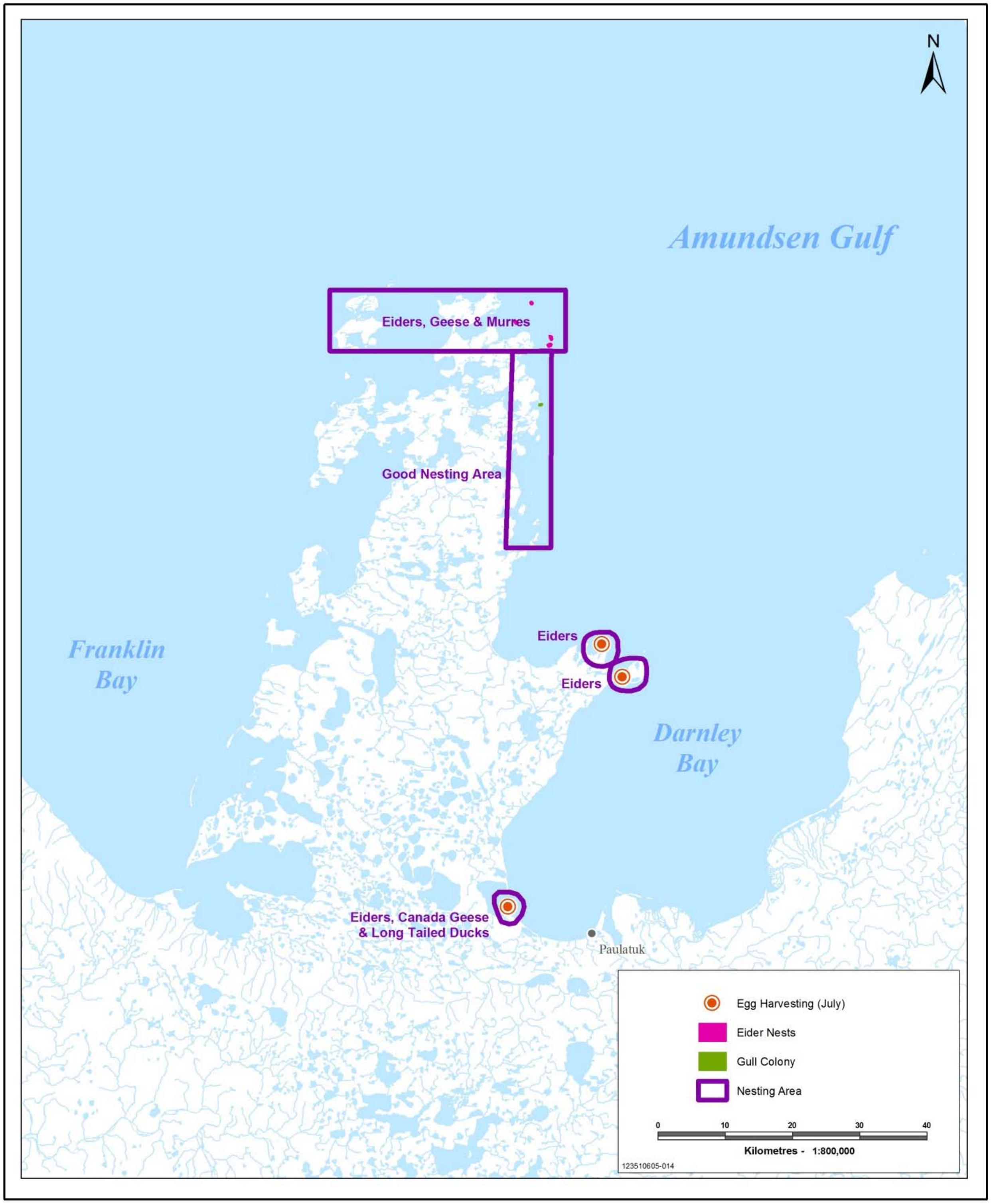

Figure 45. Seabird nesting and egg harvesting areas as determined by participants at the Traditional and Local Knowledge Workshop for the Anuniaqvia niqiqyuam AOI, March 2011. From KAVIK-AXYS Inc. (2012).

However, changes in oceanographic and sea ice conditions often trigger shifts in the distribution of fish populations (Gaston et al. 2003). As a result, the dominance of particular fish species in the diets of sea birds can vary. Murre diets also may vary among colonies (Gaston and Bradstreet 1993).

The community of Paulatuk harvests the eggs of marine birds for food (KAVIK-AXYS Inc. 2012). The eggs of eiders, Canada geese and Long-Tailed Ducks are collected in June at Egg Island, which is a known nesting area located between Argo and Darnley bays (KAVIK-AXYS Inc. 2012). Other areas for egg harvesting occur in the Clapperton Island area (eiders) and at Cape Parry (eider, Canada geese, murres) (KAVIK-AXYS Inc. 2012).

Some Paulatuk residents report that fewer eiders and Arctic Terns (*Sterna paradisaea*) occur within the AOI compared to past years (KAVIK-AXYS Inc. 2012).

15.0 SPECIES AT RISK

The only species known to be present in the AOI and listed on Schedule 1 of the *Species at Risk Act* is the Bowhead Whale. The *Act* currently lists the Bering-Chukchi-Beaufort population of Bowhead as a species of Special Concern, which is the lowest level of threat issued under the *Act* (Canadian Wildlife Service 2009). COSEWIC is currently considering the Polar Bear as a species of Special Concern (Paulic et al. 2012). Though no data are available, Paulic et al. (2012) speculate that the Ivory Gull may frequent high productive areas in the AOI (such as polynyas) in late winter and spring. The Ivory Gull is currently listed as Endangered under the *Species at Risk Act*.

16.0 RECOMMENDATIONS

16.1 CONSERVATION OBJECTIVES

Insufficient information regarding the structure and function of the Darnley Bay ecosystem limits DFO's ability to determine conservation objectives for the Anuniaqvia niqiqyuam AOI (Paulic et al. 2012). In addition, the Darnley Bay region exhibits a high degree of variability from one year to the next and is currently experiencing changes due to climate warming (Paulic et al. 2012). This type of variability can affect the relative importance of key habitat features within the region at any given time (Paulic et al. 2012). Despite the knowledge gaps and environmental variability, DFO identified a number of key ecosystem components in the AOI, located within the four important habitat areas described in Section 7.0 (Paulic et al. 2012):

- nearshore migration and feeding corridor for Arctic Char;
- freshwater inputs from the Hornaday and Brock rivers;
- deep holes in the channels of the Hornaday River estuary where Arctic Char overwinter;
- seabird colonies (Thick-billed Murres and Black Guillemots) unique to the Beaufort Sea LOMA and associated marine habitat;
- sea duck staging area near Cape Parry and Booth and Canoe islands;
- enhanced tidal flows at Cape Parry;
- upwelling at Pearce Point and along the ice bridge across the mouth of Darnley Bay;
- ice-edge habitat during spring; and
- kelp beds, potentially unique to the Beaufort Sea LOMA, in Argo and Wise bays and perhaps elsewhere in Darnley Bay.

Although scientific data confirming their importance are lacking, DFO identified several other features as possible key ecosystem components within the AOI (Paulic et al. 2012):

- Beluga that appear to exhibit a distinct foraging strategy and may show fidelity to the area;
- Arctic Cod, an Ecologically Significant Species, in the Beaufort Sea LOMA (Cobb et al. 2008);
- potentially important habitat for Bearded Seals at Bennett Point and Cape Parry;
- potential presence of Ivory Gulls (*Pagophila eburnean*), a rare Arctic seabird; and
- important sea-ice habitat for Polar Bears.

The primary objective of establishing MPAs in Canada is the conservation and protection of marine resources. Section 35 (1) of the *Oceans Act* states that…

A marine protected area is an area of the sea that forms part of the internal waters of Canada, the territorial sea of Canada or the exclusive economic zone of Canada and has been designated under this section for special protection for one or more of the following reasons:

a) the conservation and protection of commercial and non-commercial fishery resources, including marine mammals, and their habitats;
b) the conservation and protection of endangered or threatened marine species and their habitats;
c) the conservation and protection of unique habitats;
d) the conservation and protection of marine areas of high biodiversity or biological productivity; and,
e) the conservation and protection of any other marine resource or habitat as is necessary to fulfill the mandate of the Minister.

The four habitat areas identified by DFO appear to provide critical and/or important habitat for a number of species within the AOI. In order of priority, these areas and their conservation objectives are (Paulic et al. 2012; Figures 15-18):

- **Darnley Bay Nearshore Migration and Feeding Corridor** to ensure the quality and quantity of nearshore habitat and estuaries, including overwintering channels and freshwater inputs, for Arctic Char.
- **Cape Parry Offshore Marine Feeding Habitat** to maintain the integrity of the marine environment offshore of Cape Parry for the protection of staging sea ducks and feeding seabirds and marine mammals.
- **Darnley Bay Offshore Ice-edge Habitat** to maintain the integrity of the Amundsen Gulf polynya and ice-edge ecosystem offshore of Darnley Bay for the protection of biological productivity and feeding habitat.
- **Kelp Beds** to maintain the integrity of kelp bed communities in Argo and Wise bays and elsewhere in Darnley Bay.

DFO contends that the designation of any one of these priority areas would, to varying extents, serve the combined purposes as described in Section 35 of the *Act* (Paulic et al. 2012; Table 3).

Table 3. Purpose(s) for which each of the four identified areas meet rationale for MPA designation under the *Oceans Act* (1996). From Paulic et al. (2012).

Purpose Under Section 35	Darnley Bay Nearshore Migratory and Feeding Corridor	Cape Parry Offshore Marine Feeding Habitat	Darnley Bay Offshore Ice-edge Marine Feeding Habitat	Kelp Beds
a)	✓	✓	✓	✓
b)		✓	✓	?
c)	✓	✓		✓
d)		✓	✓	?
e)	✓	✓	✓	✓

16.2 DARNLEY BAY AS AN MPA

While the protection of an AOI and its resources can be achieved in several ways (e.g., creating protected areas under other legislation or management plans), the creation of an *Oceans Act* MPA appears to be the most appropriate choice for the Paulatuk/Darnley Bay area (DFO and ICR 2010). The AOI does not require the level of protection afforded by either a National Park with a marine component or a National Marine Conservation Area, nor does it meet the requirements for Species at Risk Critical Habitat (DFO and IRC 2010). An *Oceans Act* MPA provides a level of flexibility, protecting an area and its resources from negative impacts while allowing no-impact, properly planned activities to continue (DFO and IRC 2010). Though valuable in itself, an *Oceans Act* MPA in the Darnley Bay area also would contribute to the national MPA network by linking areas of Beluga use in the Beaufort Sea LOMA (e.g., Tarium Niryutait MPA) (DFO and IRC 2010).

While creating an MPA can enhance biological productivity and attract species to an area, it does not address impacts to migratory populations outside of the MPA (Paulic et al. 2012). In those cases, DFO recommends species management through other jurisdictional programs combined with habitat management within the MPA (Paulic et al. 2012). For example, depending on its location, the MPA could expand or provide legal protection already offered by the Cape Parry Migratory Bird Sanctuary, the Inuvialuit Beaufort Sea Beluga Management Plan, the Paulatuk Community Conservation Plan and/or the Paulatuk Char Management Plan (Paulic et al. 2012).

Several important habitat features require protection within the Anuniaqvia niqiqyuam AOI (Section 16.1). DFO and IRC (2010) identified three types of activities that could hinder conservation efforts and negatively impact one or more of these features; large scale commercial fishing for any species; mine development; and increased shipping traffic. Consequently, the authors recommended that these activities not be permitted within the MPA. DFO and IRC (2010) also recommended that due to its cultural importance, careful consideration be given to ensure that an MPA designation does not inappropriately limit future opportunities for local economic development.

16.3 BOUNDARIES

The Anuniaqvia niqiqyuam AOI includes waters along the western coastline of Darnley Bay, from the northern-most point of the Parry Peninsula (Cape Parry) south to the community of Paulatuk (Paulic et al. 2012; Figures 1 and 46). It extends 5 km from the coastline into the bay (Paulic et al. 2012). Boundaries of the AOI were determined based on the presence of two EBSAs (Pearce Point and Hornaday River; Figure 2) and important habitat areas (Section 7.0) as well as information provided by the community of Paulatuk (i.e., key species and locations, migration routes, nesting areas, ice features, harvest areas, trails, camp locations, traditional sites; KAVIK-AXYS Inc. 2012). Though DFO raised the possibility of extending the AOI to 15 km off the coastline rather than 5 km, some participants raised concerns with regard to creating an MPA that was too large to properly manage (KAVIK-AXYS Inc. 2012).

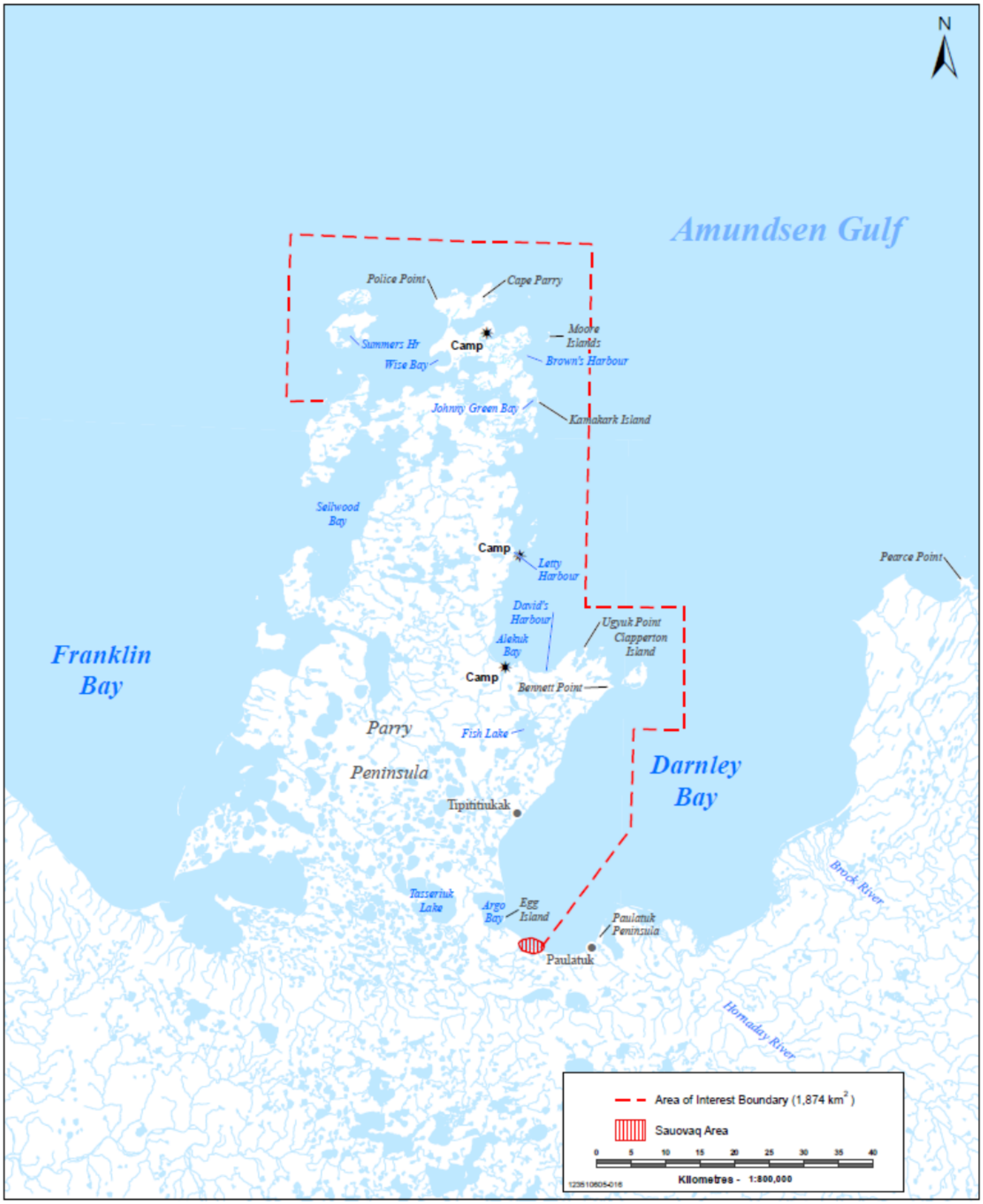

Figure 46. Proposed boundary for the Anuniaqvia niqiqyuam AOI as determined by participants at the Traditional and Local Knowledge Workshop for the Anuniaqvia niqiqyuam AOI, March 2011. From KAVIK-AXYS Inc. (2012).

17.0 KNOWLEDGE GAPS

Scientific research within the Anuniaqvia niqiqyuam AOI is limited and literature available for the Beaufort Sea LOMA is restricted to a few areas during the open-water season. As a result, conditions within Darnley Bay are often inferred using knowledge obtained from the Beaufort Shelf (Paulic et al. 2012). Existing research and monitoring programs within the AOI mainly focus on Arctic Char and Beluga stocks, or the Cape Parry Migratory Bird Sanctuary. More recent studies provided additional information on upwelling events and phytoplankton production within the bay (Mundy et al. 2009) as well as preliminary sediment, benthos, temperature and salinity data (CCGS Nahidik; Paulic et al. 2012). Traditional knowledge for the Darnley Bay area also has been a valuable tool in understanding the local distribution and movements of species within the AOI (DFO and IRC 2010; KAVIK-AXYS Inc. 2012; Paulic et al. 2012).

Paulic et al. (2012) identified several environmental components for which further research is required:

- wind patterns (i.e., occurrence of upwelling-favourable winds), water current patterns, tides (e.g., degree of vertical mixing caused by tidal patterns), freshwater inputs and areas of upwelling, freshwater retention in Darnley Bay;
- deep water mass movements in Amundsen Gulf on a seasonal basis;
- extent and inter-annual variation of the freshwater plume from the Hornaday River during summer and winter;
- detailed bathymetry for Darnley Bay, particularly at depths less than 20 m;
- morphological changes in the estuary channels of the Hornaday River;
- ice-scouring, ice-ridging and sea-ice habitat type in Darnley Bay;
- detailed information on the location of the ‘deep-holes’ in the Hornaday River and the degree to which Arctic Char use and rely on them as overwintering habitat;
- Arctic Char summer feeding habitat;
- abundance, distributions and habitat use of fishes;
- locations of Capelin aggregations and description of their ecology (e.g., spawning locations);
- diet and range of feeding from the colony for Thick-billed Murres and Black Guillemots at the Cape Parry Migratory Bird Sanctuary;
- location and ecological significance of kelp beds;
- abundance and genetic relationships of Beluga in Darnley Bay and more specifically in Argo Bay and how and why they use that area; and

- abundance, distribution, diet and habitat use of Darnley Bay by Bearded Seals.

Developing baseline knowledge for each of these components is necessary to understand the structure and function of the local ecosystem (Paulic et al. 2012). DFO and IRC (2010) recommended that studies focusing on the potential effects of anthropogenic noise (e.g., shipping traffic) on marine mammals in Darnley Bay and Amundsen Gulf also are necessary in light of current and potential increases in ship traffic.

18.0 CONCLUSION

The Anuniaqvia niqiqyuam AOI is a highly productive area containing significant habitat for a number of species. In the open-water season, nearshore waters provide migratory and feeding habitat for Arctic Char and other anadromous fish species, while offshore areas support a variety of marine invertebrates, fish, mammals and birds. During winter, the sea ice provides breeding and feeding habitat for Polar Bears and seals, while polynyas offer critical feeding areas and promote aggregations of marine mammals and their prey (Paulic et al. 2012). Though not well studied, the AOI supports four key habitat areas and a number of valuable ecosystem components that require protection (Paulic et al. 2012). The Anuniaqvia niqiqyuam AOI also is culturally important (DFO and IRC 2010). In addition to subsistence harvests of Arctic Char, Beluga, birds and other species, the community of Paulatuk utilizes portions of the AOI for travel, education and other activities.

Due to the nature of its resources, protection of the Anuniaqvia niqiqyuam AOI is best suited to an *Oceans Act* MPA. Creation of an *Oceans Act* MPA will provide a more flexible management strategy, minimizing negative impacts while at the same time allowing no-impact activities within its boundaries (DFO and IRC 2010). Designation as an MPA will link the Anuniaqvia niqiqyuam AOI to the national MPA network, increasing conservation efforts for species within the Beaufort Sea LOMA, while the operation of broader management plans within the MPA will provide a degree of protection to migratory populations outside of the MPA (Paulic et al. 2012).

19.0 DEFINITIONS

Amphipod/Amphipoda: a crustacean of the Order Amphipoda, commonly known as scuds.

Anadromous: organisms that live their lives in the sea and migrate to freshwater to spawn.

Barrier Island: relatively narrow strips of land that are parallel to the mainland coast. Typically occurring in chains, these islands form a barrier to water flow.

Bathymetry: the area and water depth of oceans, seas, or other bodies of water.

Biodiversity: the number of different species living in a particular ecosystem.

Biomass: the amount of living matter in a given habitat; expressed either as a weight of organisms per unit area or as the volume of organisms per unit volume of habitat.

Brackish: water that is more saline than fresh water, but not as saline as seawater; usually the result of mixing freshwater (e.g., river input) and marine water.

Catch-per-unit-effort (CPUE): an indirect way of measuring species abundance, in which the total number of fish captured is divided by the effort used to harvest the catch. Calculation of effort varies with harvesting method (e.g., gill nets, angling, trawling).

Circumpolar: located in or near one of the earth's polar regions.

Congregatory species: species that, in at least one portion of their life-cycle, a significant portion of world population gathers in one place.

Copepod: small marine or freshwater crustaceans of the Subclass Copepoda.

Coriolis Effect: the deflection of an object or water mass due to the Earth's rotation; this force is responsible for the clockwise movement of ocean currents in the northern hemisphere, and counterclockwise movement in the southern hemisphere.

Crustacean: a large group of arthropods (invertebrates having an external skeleton called an exoskeleton) of the Subphylum Crustacea. This group includes animals such as crabs, lobsters, crayfish, scuds, shrimp, krill and barnacles.

Cumacean: a small crustacean of the Order Cumacea. Commonly referred to as hooded shrimp.

Cyclonic: counterclockwise circulation.

Delta (river delta): a landform at the mouth of a river where the river flows into an ocean, sea, estuary, lake or reservoir. Formed from the build-up of sediment deposition carried by river flow.

Downwelling: the downward movement of fluid.

Echinoderm: marine invertebrates of the Phylum Echinodermata. The group includes star fish, brittle stars, sand dollars, sea urchins and sea cucumbers.

Ecosystem-based management: an oceans management approach in which the health of the surrounding ecosystem (i.e., a community of living organisms and their environment) is taken into account when managing human activities that affect marine and coastal areas. This type of management is designed to ensure that the ecosystem is not significantly impacted by human activities over time.

Endangered: a wildlife species facing extirpation (e.g., extinction at a local level) or extinction within a relatively short period of time.

Estuary: a partly enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea; forms a transition zone between river environments and ocean environments and are subject to both marine and riverine influences.

Euphotic zone: the depth of the water in an ocean or other waterbody that is exposed to sufficient sunlight for photosynthesis to occur.

Fauna: the animals of a particular region or habitat.

Flora: the plants of a particular region or habitat.

Forage: the act of searching for food.

Freshet: the flood of a river from heavy rain or melted snow; a rush of fresh water flowing into the sea.

Glacial till: unsorted rock debris and sediment that is carried or later deposited by a glacier; usually a mixture of all particle sizes from clay to boulder.

Habitat: the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilized by) a species population; often related to a function such as breeding, spawning, feeding, etc.

Heterotroph: a consumer; an organism that cannot make its own food but obtains it from other sources.

Hydrocarbon: an organic compound consisting entirely of hydrogen and carbon.

Hydroelectric: electricity produced by converting the energy of falling water into electrical energy (i.e., at a hydro generating station).

Ice algae: algal species found in annual and multi-year ice.

Indicator species: a species whose presence, absence, or relative well-being in a given environment is used to measure the health of its ecosystem as a whole.

Intertidal: the area of the shoreline that is covered at high tide and uncovered at low tide.

Invertebrate: an animal that lacks a backbone.

Isopod: a crustacean of the Order Isopoda. Commonly referred to as sea roaches.

Landfast ice: ice that forms a continuous and stationary sheet of ice from the coast. Also referred to as ‘fall time ice’ or ‘fast ice’.

Kimberlite: volcanic rock often containing diamond deposits.

Macroalgae (seaweed): a term used to describe macroscopic (measureable, visible), multicellular (i.e., more than one cell), benthic marine algae.

Macrofauna: benthic organisms that are 0.5 mm or larger.

Macrophyte: an aquatic plant that grows in or near water.

Microalgae (microphyte): microscopic, unicellular (i.e., single cell) algae which exist individually or in chains or groups.

Migratory species: as species for which a significant proportion of members cyclically and predictably cross one or more national jurisdictional boundaries.

Moult: (of Beluga) to shed the skin.

Mollusca/Mollusc: organisms of the Phylum Mollusca; includes snails, slugs, clams, mussels, squid and octopi.

Mysid: a crustacean of the Order Mysidacea, commonly referred to as opossum shrimps.

Ophiuroid: echinoderms of the Class Ophiuroidea. The group includes basket stars, brittle stars and snake (or serpent) stars.

Ostracod: a small crustacean of the Class Ostracoda. Commonly referred to as seed shrimp.

Pack ice: floating sea-ice composed of ice fragments of varying size and age that converge to cover the sea surface with little or no open water.

Pelagic: inhabiting the upper layers of the water column.

Phytoplankton: plankton consisting of photosynthetic (i.e., produce their own food through photosynthesis) free-floating algae, protists (free-living or colonial organisms of the Kingdom Protista) and cyanobacteria (blue-green algae).

Phytoplankton bloom: A high concentration of phytoplankton in one area; typically caused by increased phytoplankton reproduction as a result of increased sunlight and nutrient availability.

Polychaete/Polychaeta: marine worms of the Class Polychaeta, commonly called bristle worms.

Polynya: an area of persistent open water and thin ice surrounded by sea ice.

Priapulids: predatory marine worms of the Phylum Priapula. Priapulids are known for their spiny proboscis, or elongated appendage at their head, which is used for feeding.

Primary productivity: the productivity of autotrophs (animals that produce their own food) through photosynthesis (i.e., the process of converting light energy to chemical energy in the form of sugars) or chemosynthesis (e.g., the process of converting chemicals, such as ammonia, to energy through the addition of oxygen).

Productivity: the rate of formation of organic matter over a defined period; this can include the production of offspring.

psu: practical salinity measurement: A unit of measurement of salinity similar to part per thousand (ppt).

Restricted-range species: species that have a total historical breeding range of less than 50,000 square kilometres.

Secondary productivity: the productivity of heterotrophs (e.g., animals).

Sessile: permanently attached to a base (e.g., ocean bottom) or structure.

Sipunculids: unsegmented marine worms of the Phylum Sipuncula, commonly known as peanut worms or shore worms.

Species assemblage: the collection of species making up any co-occurring community of organisms in a given habitat.

Species richness: the number of species present in a community.

Sedimentation: the deposition or production of sediment.

Subarctic: latitudes immediately south of the Arctic Circle.

Subsistence: the source from which food and other items necessary to exist are obtained.

Substrate: a layer that underlies or serves as a basis or foundation. In oceanography, this term is used to describe the ocean bottom.

Subtidal: that part of the ocean, lake or river bottom that is close to the shore, below the level of low tide. The subtidal zone typically extends to a depth of 200 m and is often referred to as the littoral zone.

Tanaid: a crustacean of the Order Tanaidacea.

Upwelling: the upward movement of fluid.

20.0 ACRONYM PAGE

AOI	Area of Interest
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Department of Fisheries and Oceans Canada
EBSA	Ecologically and Biologically Significant Area
FJMC	Fisheries Joint Management Committee
LOMA	Large Ocean Management Area
MPA	Marine Protected Area
TK	Traditional Knowledge

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