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# Ecosystem Overview Report for the Darnley Bay Area of Interest (AOI)

# Aperçu de l'écosystème de la zone d'intérêt de la baie Darnley

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## ABSTRACT

An Area of Interest (AOI) in Darnley Bay of the western Canadian Arctic is being considered for designation as a Marine Protected Area (MPA) under the *Oceans Act*. The AOI was nominated based on the presence of two Ecologically and Biologically Significant Areas (EBSAs). Under the Health of the Oceans Initiative, Fisheries and Oceans Canada (DFO) Science is required to provide advice in support of the identification and prioritization of MPAs following the selection of an AOI. This Research Document forms the basis of the Ecosystem Overview for the Darnley Bay AOI. Though the area is not well studied and is based largely on expert opinion, this overview synthesizes the limited ecological and biological information available (including available traditional ecological knowledge) for the Darnley Bay AOI and surrounding area. The report includes a summary of information and knowledge gaps and provides the technical basis for the science advice and information. Based on this analysis, four areas were identified for marine protection in the following priority: 1) 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 (*Salvelinus alpinus*); 2) 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; 3) 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; and 4) Kelp Beds to maintain the integrity of kelp bed communities in Argo and Wise bays and elsewhere in Darnley Bay. Beluga (*Delphinapterus leucas*), Arctic Cod (*Boreogadus saida*), Bearded Seals (*Erignthus barbatus*), Ivory Gulls (*Pagophila eburnean*) and Polar Bears (*Ursus maritimus*) appear to play an important role in the Darnley Bay region and may benefit from protection of one or more of the priority areas. Since there is likely more detailed local knowledge for the area, local traditional ecological knowledge held by the local community of Paulatuk should be considered when further developing an MPA in the area.

# RÉSUMÉ

Une zone d'intérêt (ZI) dans la baie Darnley, située dans l'ouest de l'Arctique canadien, fait l'objet d'un examen en vue d'être désignée zone de protection marine (ZPM) en vertu de la Loi sur les océans. La ZI a été retenue en raison de la présence de deux zones d'importance écologique et biologique (ZIEB). Dans le cadre de l'Initiative pour améliorer la santé des océans, le secteur des Sciences de Pêches et Océans Canada (MPO) doit formuler un avis à l'appui de la désignation et de la création de ZPM à la suite du choix d'une ZI. Le présent document de recherche forme la base de l'aperçu de l'écosystème pour la ZI de la baie Darnley. Bien que la zone n'ait pas été soumise à un examen approfondi et que cet avis repose en grande partie sur des opinions d'experts, cet aperçu résume les données écologiques et biologiques disponibles mais limitées (y compris les connaissances écologiques traditionnelles) pour la ZI de la baie Darnley et les environs. Le rapport comprend un résumé des lacunes sur le plan des connaissances et des renseignements, et il fournit les notions techniques requises pour formuler l'avis scientifique. À la suite de cette analyse, quatre zones ont été délimitées pour faire l'objet d'une protection marine selon l'ordre de priorité suivant : 1) le couloir de migration et d'alimentation des eaux côtières de la baie Darnley, pour assurer le maintien de la qualité et de la disponibilité des habitats et des estuaires côtiers, y compris les chenaux d'hivernage et les zones d'entrée d'eau douce, pour répondre aux besoins de l'omble chevalier (*Salvelinus alpinus*); 2) l'habitat marin nourricier du large du cap Parry, pour maintenir l'intégrité de l'environnement marin au large du cap Parry en vue de protéger les rassemblements de canards marins et les aires d'alimentation des oiseaux de mer et des mammifères marins; 3) l'habitat constitué par la lisière des glaces au large de la baie Darnley, pour maintenir l'intégrité des polynies du golfe d'Amundsen et de l'écosystème de la lisière des glaces au large de la baie Darnley et ainsi protéger la productivité biologique et les habitats nourriciers; et 4) les lits de laminaires, pour maintenir l'intégrité des communautés de laminaires dans les baies Argo et Wise et ailleurs dans la baie Darnley. Le béluga (*Delphinapterus leucas*), le saïda franc (*Boreogadus saida*), le phoque barbu (*Erignthus barbatus*), la mouette blanche (*Pagophila eburnean*) et l'ours polaire (*Ursus maritimus*) semblent jouer un rôle important dans la région de la baie Darnley et pourraient profiter de la protection d'une ou de plusieurs zones prioritaires. Comme il existe probablement des connaissances locales plus détaillées pour le secteur, le MPO devrait tenir compte des connaissances écologiques traditionnelles de la communauté de Paulatuk lorsqu'il établira une ZPM dans le secteur.

# INTRODUCTION

Fisheries and Oceans Canada (DFO), under the authority of the *Oceans Act* (1996), is authorized to establish a national system of marine protected areas (MPAs) in order to conserve and protect Canada's marine resources. The National Framework for Establishing and Managing MPAs (DFO 1999) describes the four major steps for establishing an MPA as follows: 1) select the Area of Interest (AOI); 2) conduct an overview and assessment of the AOI; 3) develop regulatory intent and documents; and 4) manage the MPA. In 2009, Darnley Bay (NT) was selected by the DFO Oceans Program and a Site Selection Committee for consideration as a MPA. The nominated area is one of four AOIs that are currently being assessed in Canada. Darnley Bay is situated in the Canadian Western Arctic region within the Beaufort Sea Large Ocean Management Area (LOMA) and the Inuvialuit Settlement Region (ISR; Figure 1). The nomination of an area must fulfil the ecological and feasibility criteria outlined in the MPA Practitioners Guide (DFO 2009). DFO Science has been requested to provide advice and support for developing ecological overview reports for AOIs, boundary delineation for areas with high conservation priority and identification of the associated conservation objectives.

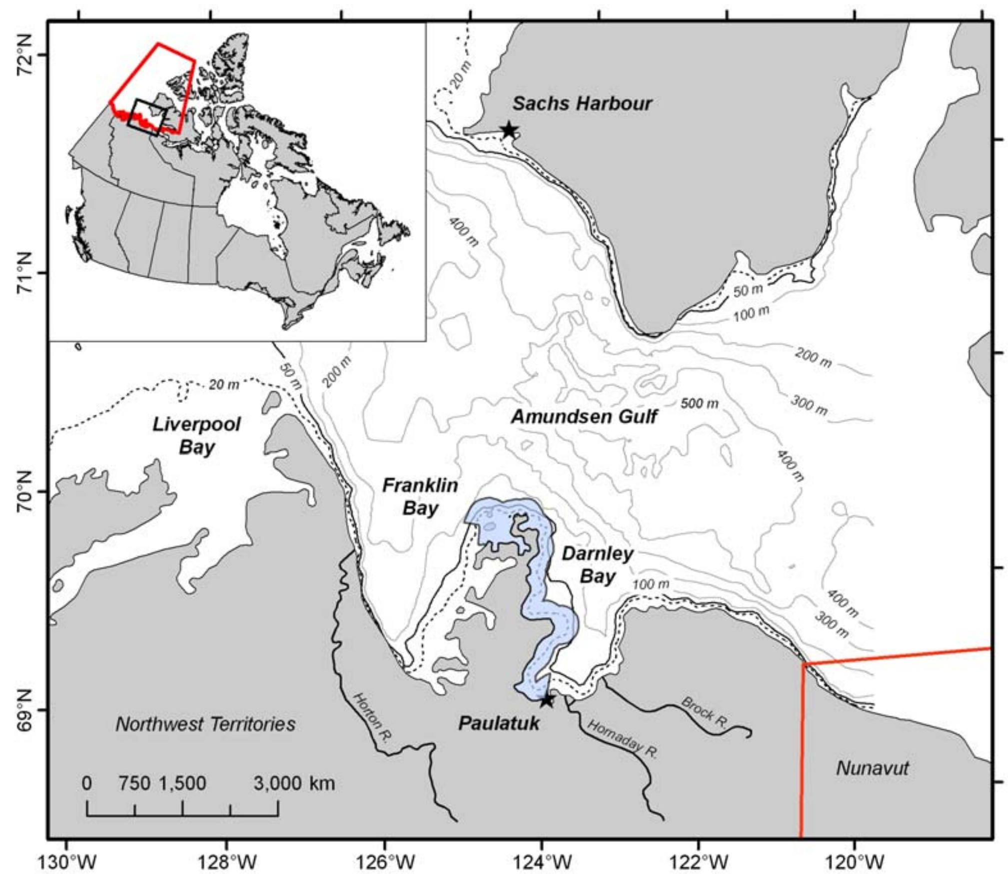


*Figure 1. Darnley Bay AOI indicated by the blue shaded area within the ISR and Beaufort Sea LOMA (indicated by red lines within inset map). Bathymetric data available for this area was from the General Bathymetric Chart of the Oceans (GEBCO[1]).*

In 2006, DFO Science conducted an exercise in which ecologically and biologically significant areas (EBSAs) within the Beaufort Sea LOMA were identified (Paulic et al. 2009). The

[1] http://www.gebco.net/data_and_products/gridded_bathymetry_data/

identification of EBSAs is a tool used in Integrated Oceans Management (IOM) to call attention to areas that have particular ecological or biological significance to facilitate a greater-than-usual degree of risk aversion (DFO 2004). In the LOMA, twenty EBSAs, including two in Darnley Bay (Figure 2), were identified through a series of science and community workshops (Paulic et al. 2009) using a comprehensive set of nationally accepted criteria (DFO 2004). Subsequently, an AOI was nominated in Darnley Bay, which includes portions of the Pearce Point and Hornaday River EBSAs (Figures 1 and 2). The Pearce Point EBSA was identified due to its importance for Bowhead (*Balaena mysticetus*) and Beluga (*Delphinapterus leucas*) and their habitat, and the Hornaday River EBSA for Arctic Char (*Salvelinus alpinus*) stocks and their habitat. Both EBSAs were considered to be data deficient, except the nearshore coastal portion of the Hornaday River EBSA where Arctic Char are harvested and stocks are monitored and managed by the local community. Although there was sufficient traditional knowledge available to conclude the areas are likely EBSAs, there was insufficient scientific information to complete the evaluation.

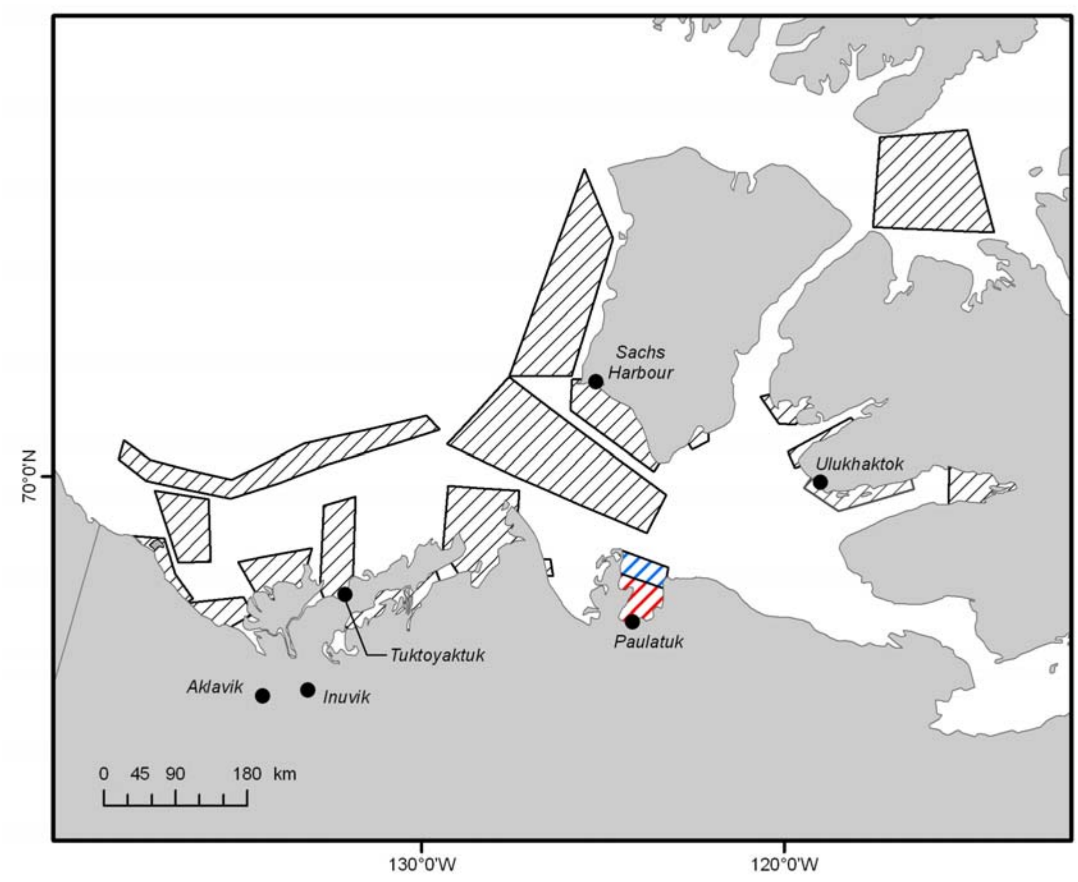


*Figure 2. EBSAs identified in the Beaufort Sea LOMA (from Paulic et al. 2009). The blue corresponds to the Pearce Point EBSA. The red corresponds to the Hornaday River EBSA.*

The characterization and assessment of the AOI is highly recommended and underpins all decisions leading to the establishment of a MPA (DFO 2009). The purpose of this report is to (1) provide more site-specific detail than the broader LOMA-scale information, (2) determine the ecological merits and their relative significance and (3) evaluate the area against MPA criteria listed in the *Oceans Act* Section 35. This assessment is a desktop assessment based on existing information (published and unpubl. reports) and science expert advice. Local community knowledge has been included when available.

This report has been organized as follows:

- **Environmental and Ecological Information** – This section describes the biological and ecological attributes and identifies special features within the Darnley Bay AOI and surrounding area. Traditional knowledge has been integrated into the body of this section from documented sources and community consultations.

- **Information and Knowledge Gaps** – This section attempts to identify areas that are lacking in both scientific and traditional knowledge and where more work is needed (desk analysis or research projects) to understand this ecosystem.

- **Ecological Merits and Significance** – This section identifies and provides a rationale for designation as an *Oceans Act* MPA.

## ENVIRONMENTAL AND ECOLOGICAL INFORMATION

### REGIONAL CONTEXT

The Beaufort Sea LOMA is located in the extreme northwestern corner of the Canadian Arctic, and encompasses the marine portion of the ISR (Figure 1). The Darnley Bay AOI is located in a large bay in the southeastern portion of the Beaufort Sea LOMA near the community of Paulatuk (Figure 1). The AOI includes waters along the western coastline of Darnley Bay from Cape Parry (northern point) south to the community of Paulatuk and extends 5 km from the coastline into the bay (Figure 1). For the purposes of this ecological overview report, the geographical extent (scope) was expanded beyond the current AOI boundaries to include all of Darnley Bay, and portions of Franklin Bay and the Amundsen Gulf. The rationale for extending the geographical scope of the assessment is (1) available scientific information for the AOI is limited, whereas some areas outside the AOI are known to have biological significance, especially for Arctic Char and (2) many of the key species have larger geographic ranges than the Darnley Bay AOI.

### CLIMATE

Darnley Bay is located within the Arctic climatic zone. The relatively short growing season and the cold, dry climate are unique environmental conditions to the Arctic. Climates within this zone are often described as harsh or severe with long, cold winters and short, cool summers. Typical of higher latitudes, the sun is continually above the horizon from late May until mid-July, and below from the beginning of December to early January (Cobb et al. 2008). Environment Canada maintains a weather station at Cape Parry (70° 10’ 00.00N, 124°43’ 00.00W), which provides data for summary reports by station on climate normals or averages by year (Environment Canada 2011). Daily average temperatures range from -28.4°C in February to 6.2°C in July (Figure 3). The extreme minimum temperature observed (for the period 1971-2000) was -47.2°C in January 1975 and an extreme high of 23.9°C observed in July 1973 (Environment Canada 2011).

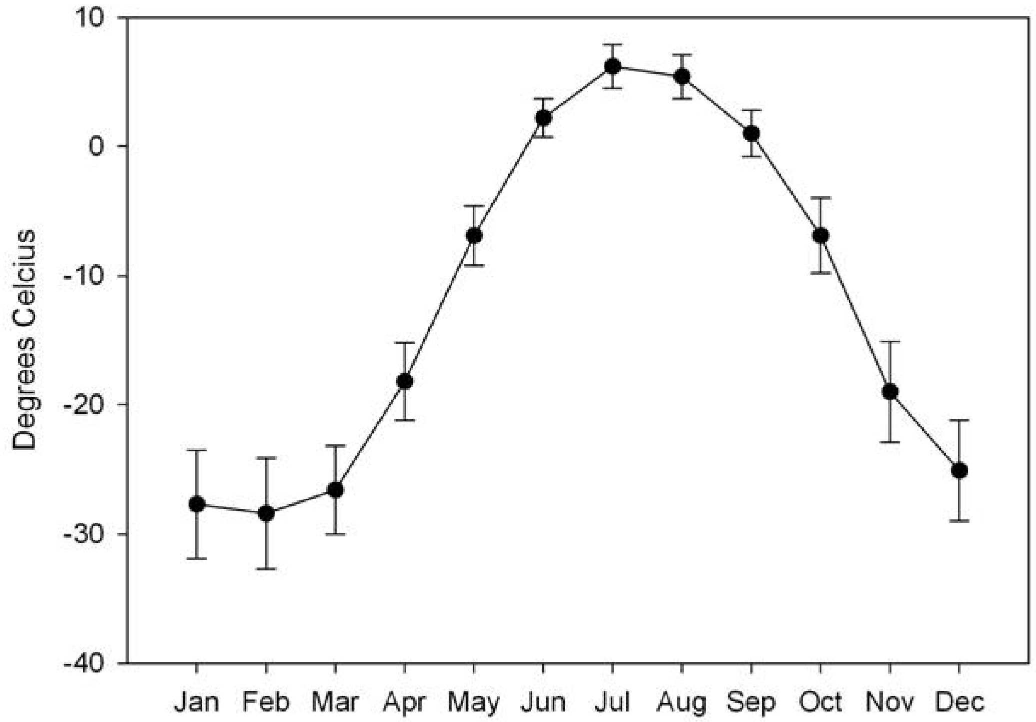


*Figure 3. Mean air temperatures ± standard deviation by month collected from the meteorological station located at Cape Parry, NT (http://climate.weatheroffice.gc.ca/climate_normals/stnselect_e.html).*

The climate is strongly affected by the Amundsen Gulf, which exerts a maritime influence on the region. Prevailing winds are from the east (Environment Canada 2011). Monthly average wind speeds range from 17.6 to 22.1 km/hr and maximum hourly wind speeds range from 65 to 105 km/hr (Environment Canada 2011). Most precipitation and fog occur during the summer, and large continental Arctic air masses are predominant in the winter (Parks Canada 2007). When maritime air masses break through, they bring warmer temperatures and precipitation (Parks Canada 2007). Rainfall occurs from April to October; although average amounts for April, May and October are less than 1.5 mm (Environment Canada 2011). Rainfall typically peaks in August with an average of 22.3 mm (Figure 4). Snowfall may occur at any point during the year however it averages less than 3 cm per month during summer (Environment Canada 2011). The most snowfall occurs in October, averaging 26.8 cm. The remaining months see between 8 and 16 cm per month on average (Environment Canada 2011). Average accumulations of precipitation for a given month (1971-2000) are presented in Figure 4.

## GEOLOGY AND BATHYMETRY

Darnley Bay is a large inlet off the southern side of Amundsen Gulf. The bay is approximately 45 km long and 32 km wide at its mouth. There are two relatively small, but locally important, isolated drainage areas in Darnley Bay: the Hornaday and Brock rivers (Figure 1). These two rivers generally follow the northwest slope of the land, flowing from interior areas to the Bay. The largest river is the Hornaday, which is approximately 360 km in length, with a drainage basin of 14,900 km$^2$ (Parks Canada 2007).

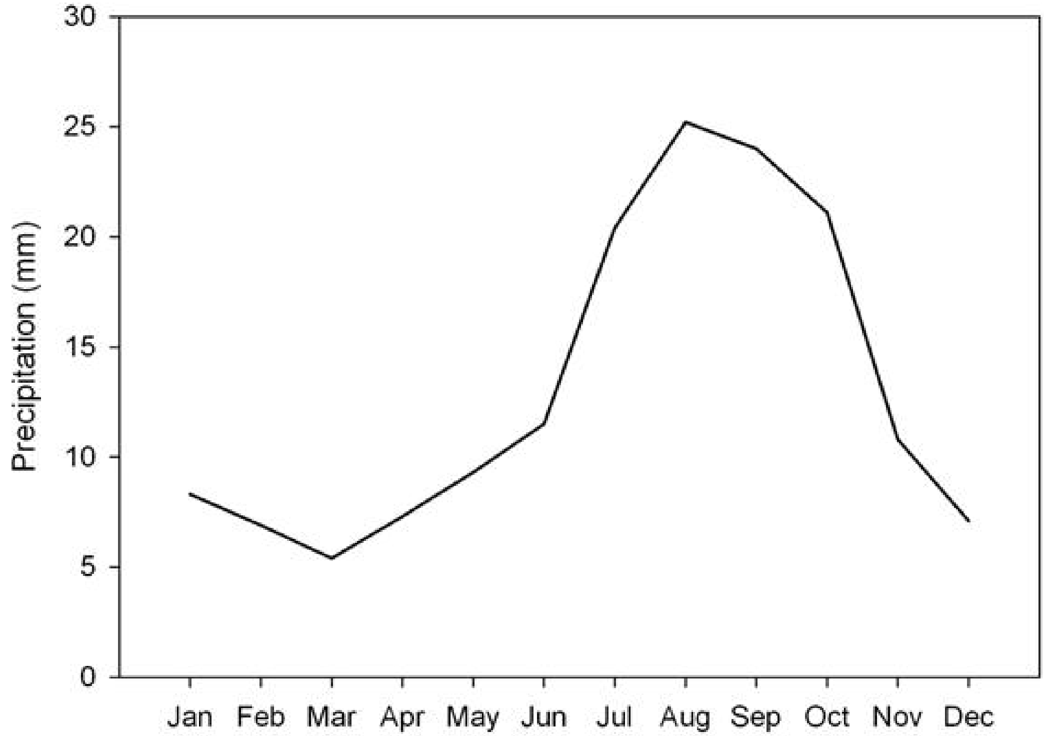


*Figure 4. Average accumulation of precipitation by month collected from a meteorological station located at Cape Parry, NT (http://climate.weatheroffice.gc.ca/climate_normals/stnselect_e.html).*

Changes in depth can influence a number of physical and chemical processes including temperature, salinity and water movement and are therefore a key determinant of physical oceanography in the region. For example, shelf topography can produce areas of upwellings that can allow for additional primary production and ultimately benthic production (Williams and Carmack 2008). Bathymetry data for this area is limited and very little data exists for water depths less than 20 m (Figure 1). In 2003 and 2009, the CCGS *Amundsen* collected data in order to produce a number of multi-beam images for detailed information on depths around 50 - 100 m within Darnley Bay. The bathymetry and backscatter data from these images can be accessed through the Ocean Mapping Group in ArcticNet (www.omg.unb.ca).

Sea floor sediment composition in Darnley Bay has not been extensively surveyed. During a 2008 survey conducted from the CCGS *Nahidik*, researchers sampled and examined push cores (20 cm) at seven stations. The results from this work suggest the surface of the sea floor is composed mainly of silt and clay with varying degrees of bioturbation and mottling (R. Bennett and K. MacKillop unpubl. data). This is consistent with the sub-bottom data collected by the Ocean Mapping Group in ArcticNet[2], which reveals sediments at the surface to likely be composed of marine silty clay in the inner part of the bay and a harder glacial till covered by a discontinuous thin layer of silty clay at the outer part of the bay (R. Bennett, pers. comm.).

Ice scouring is caused by the onshore and long-shore movements of keels of pressure ridges and glacial ice. Scouring as a result of glacial ice is not a presently occurring phenomenon in Darnley Bay. In the Beaufort Sea, trenches caused by ice scouring are usually about 2 m in

[2] www.omg.unb.ca

depth but can reach up to 7 m (Dome et al. 1982). Most scouring occurs in waters that are less than 50 m in depth however, the most intensive scouring tends to occur within about 20-25 m depths (Blasco et al. 1998). The multi-beam images from 2003 and 2009, collected in Darnley Bay by the Ocean Mapping Group in ArcticNet, reveals some ice scours and relict glacial features at water depths around 50 -100 m.

The coastline of Darnley Bay is extremely complex (Figure 5). There are several beaches of sand and gravel which form the coastline and there are hundreds of bays and small inlets. The Parry Peninsula is scattered with ponds and small lakes with sparse vegetation. At the most northern point of the Parry Peninsula, known as Cape Parry, limestone outcrops form coastal cliffs which rise about 20 m above sea level (CWS 1992). The northwest and northeastern coasts of Darnley Bay are defined by bedrock cliffs while large delta complexes and barrier beaches exist along the most southern coast near the two major river systems.


*Figure 5. Satellite image of the Parry Peninsula and Darnley Bay, NT on September 7, 2010 obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS) from NASA's Aqua satellite (http://rapidfire.sci.gsfc.nasa.gov/).*

## OCEANOGRAPHIC SYSTEMS

### Water Masses and General Circulation

Very little is known about the physical oceanography of the Amundsen Gulf. Carmack and Macdonald (2002) describe the primary model of three water masses within the Amundsen Gulf. At the surface (0-50 m) is a relatively fresh polar-mixed layer, defined by salinity values of about

26-31 psu (practical salinity measurement[3]), that is due to the relatively large volumes of river water that flow into the Arctic Ocean from North American and Eurasian rivers. Beneath the polar-mixed layer is the Pacific Halocline layer (~32-34 psu, 50-200 m depths), which is comprised of water from the Pacific Ocean that has flowed though Bering Strait and finally, the Pacific Halocline overlays the Atlantic-origin waters of the Arctic Ocean (≥34 psu, >200 m depths) (Carmack and Macdonald 2002). Garneau et al. (2008) also describe a layer of Pacific-derived waters within the halocline at about 30-40 m depth which was characterized by a sharp temperature maximum. Salinity and temperature profiles within this region reveal deviations from this pattern on a seasonal basis as a result of hydrodynamic events which force water masses to move vertically within the water column (Garneau et al. 2008).

The circulation of these water masses within Amundsen Gulf is still under examination but it is known that the surface waters generally enter the Amundsen Gulf near Banks Island and exit near Cape Bathurst (Lanos 2009). It is currently under debate as to where the surface water circulation loop is closed (Barber et al. 2010). Below 50 m water depth, the Beaufort Undercurrent carries waters of both Pacific and Atlantic origin eastward along the slope of the Beaufort Sea into the Amundsen Gulf and circulates in reverse direction to the surface waters (Carmack and Macdonald 2002, Ingram et al. 2008, Lanos 2009).

Circulation patterns within Darnley Bay are speculative at best, as there have not been any studies conducted to date. Circulation patterns in nearshore areas tend to display considerable variability and are generally controlled by wind direction and intensity, sea-floor topography, water depth and freshwater discharge (W. Williams, pers. comm.).

## River Discharge

There are currently ten years of Hornaday River flow data available online from Environment Canada (http://www.wsc.ec.gc.ca/staflo/index_e.cfm?cname=flow_daily.cfm), however, no flow data has been compiled for the Brock River. A preliminary analysis of the available data indicates there are significant amounts of freshwater input (2.0-2.5 $km^3$/year; Figure 6) into Darnley Bay annually (W. Williams, pers. comm.). Although these values are less than 1% of the annual volume of discharge from the Mackenzie River (330 $km^3$/year; Macdonald et al. 1998), they are significant for a small area such as Darnley Bay. 'Inner' Darnley Bay (south of the latitude of Bennett Point and into which the Brock and Hornaday rivers flow; Figure 5) contains an area of roughly 1440 $km^2$, which represents approximately 3% of the area of the Canadian Beaufort Shelf.

In winter, the Hornaday River appears to have near zero flow. Following winter, the spring freshet starts at the beginning of June when river flow increases dramatically. The flow peaks before mid-June and decays by the end of the month (Figure 7) such that the June discharge is often over 75% of annual total discharge. There is an occasional secondary peak later in the year due to precipitation (Figure 7).

[3] A unit of measurement of salinity similar to part per thousand (ppt).

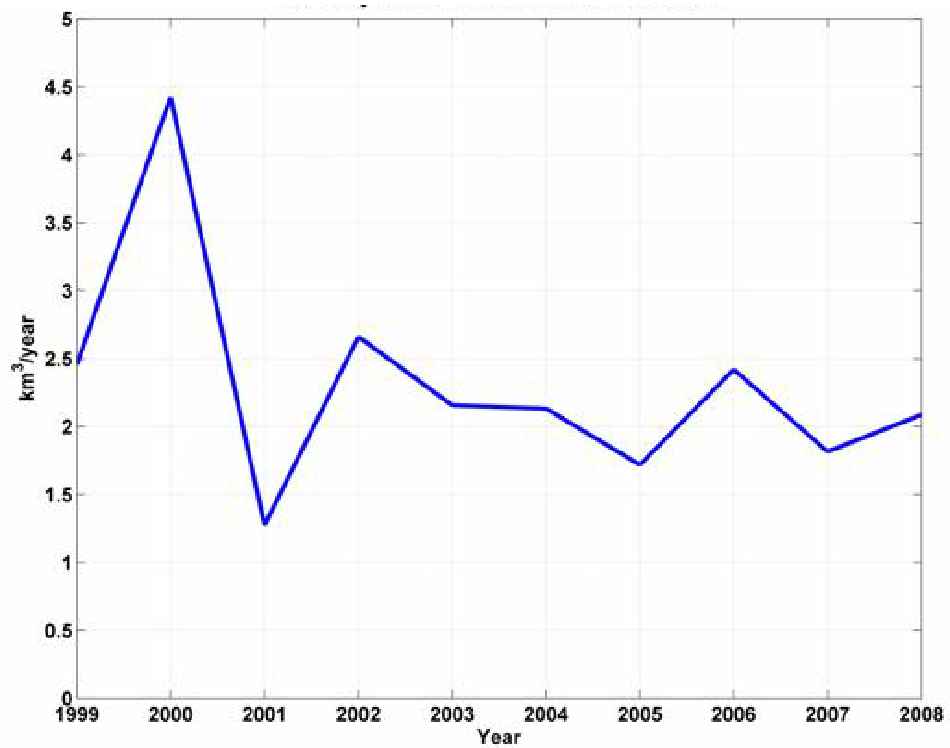


*Figure 6. Hornaday River annual stream flow from 1999 to 2008 http://www.wsc.ec.gc.ca/staflo/index_e.cfm?cname=flow_daily.cfm).*

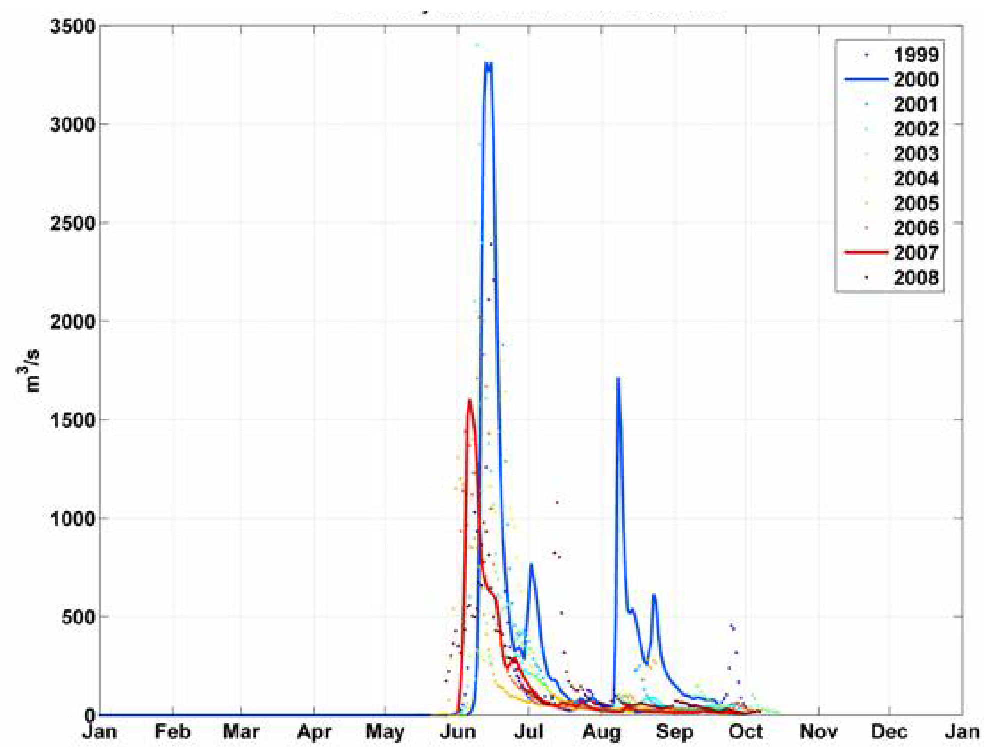


*Figure 7. Water gauge data for the Hornaday River stream flow from 1999 to 2008. The 2007 year (in red) has been selected as a 'typical' year. The year 2000 (in blue) was selected as an extreme high flow year with both a large spring freshet in June and a large secondary freshet in August due to precipitation on the watershed. (http://www.wsc.ec.gc.ca/staflo/index_e.cfm?cname=flow_daily.cfm).*

## River Plume

Low tidal energy in Darnley Bay means that the Hornaday and Brock rivers contain deltas and barrier islands and the river water undergoes much less mixing before reaching the ocean than a river flowing into a tidal estuary. Because of this, the river plume, due to the spring freshet in June, is expected to be relatively fresh and buoyant and to spread out over the surface of the bay. Median ice conditions in June (Figure 8) show that landfast ice is present in the bay, shielding the plume from wind forcing. In these conditions, a brackish plume from the June freshet likely accumulates under the ice, potentially adding 1 m of fresh water to inner Darnley Bay.

By mid-July, when median ice conditions show low concentrations of ice in Darnley Bay (Figure 8), the river plume is likely rapidly displaced by wind-forcing. It is difficult to predict plume movement based on the lack of existing information for the area, but it seems that the small size of the bay makes it likely that wind events could push much of the plume out of the bay. Note also that the inflow of rivers into Darnley Bay may favour a counter-clockwise circulation in summer under the influence of the Coriolis Effect.

## Distribution and Seasonal Ice Patterns

Sea ice is an important structural ecosystem component in the Canadian Arctic. It provides a substrate for primary production within the ice and on the underside of the ice, as well as affording mammals an opportunity to forage and rear young (Dunbar 1981). Ice begins to form in October, with complete coverage in Darnley Bay by November (Figure 8). The Bay is completely frozen, with 10/10 coverage of landfast ice, from December to late June when ice begins to melt and open water is present north of Cape Parry (Figure 8). Break-up of sea ice occurs in July and open water within Darnley Bay is typical by August through until October when the ice begins to form again (Figure 8).

The Cape Bathurst polynya and associated flaw leads are considered to be some of the most important habitats in the Beaufort Sea LOMA, attracting some of the highest densities of birds, benthic organisms and marine mammals (Harwood and Stirling 1992, Dickson and Gilchrist 2002, Conlan et al. 2008). A polynya is an area of open-water or thin-ice in a region that is otherwise ice-covered. A flaw lead is the waterway opening that occurs between the landfast ice and mobile pack ice when the pack ice moves offshore. In Amundsen Gulf, the flaw leads of the Canadian Beaufort Shelf, Banks Island Shelf and Amundsen Gulf all intersect in the Cape Bathurst Polynya which often resembles an enlarged flaw-lead (Figure 9). Polynyas and flaw lead systems can be open for months before the annual melt begins, which allows for early availability of light and increased availability of nutrients through advection and upwellings. Barber et al. (2010) suggests that the flaw lead system in the Amundsen Gulf preconditions the area biologically, thereby enhancing productivity in the marine environment.

The distribution of sea ice, leads, polynyas and the chronology of freeze-up and break-up are determined by marine currents, wind, temperature, seasonal climate changes and the movement of multi-year ice pack (Stirling et al. 1993, 2002). Studies have shown that there is high inter-annual variability in the formation of sea ice within Amundsen Gulf. For example, in 2008, high ice mobility, driven by strong easterly winds, prevented the formation of fast ice throughout most of the Amundsen Gulf (Barber et al. 2010). The formation of the flaw leads is dependent on both the formation and timing of fast ice edges and the motion of the mobile offshore pack ice (Barber et al. 2010). During the period of ice retreat, both temperature and

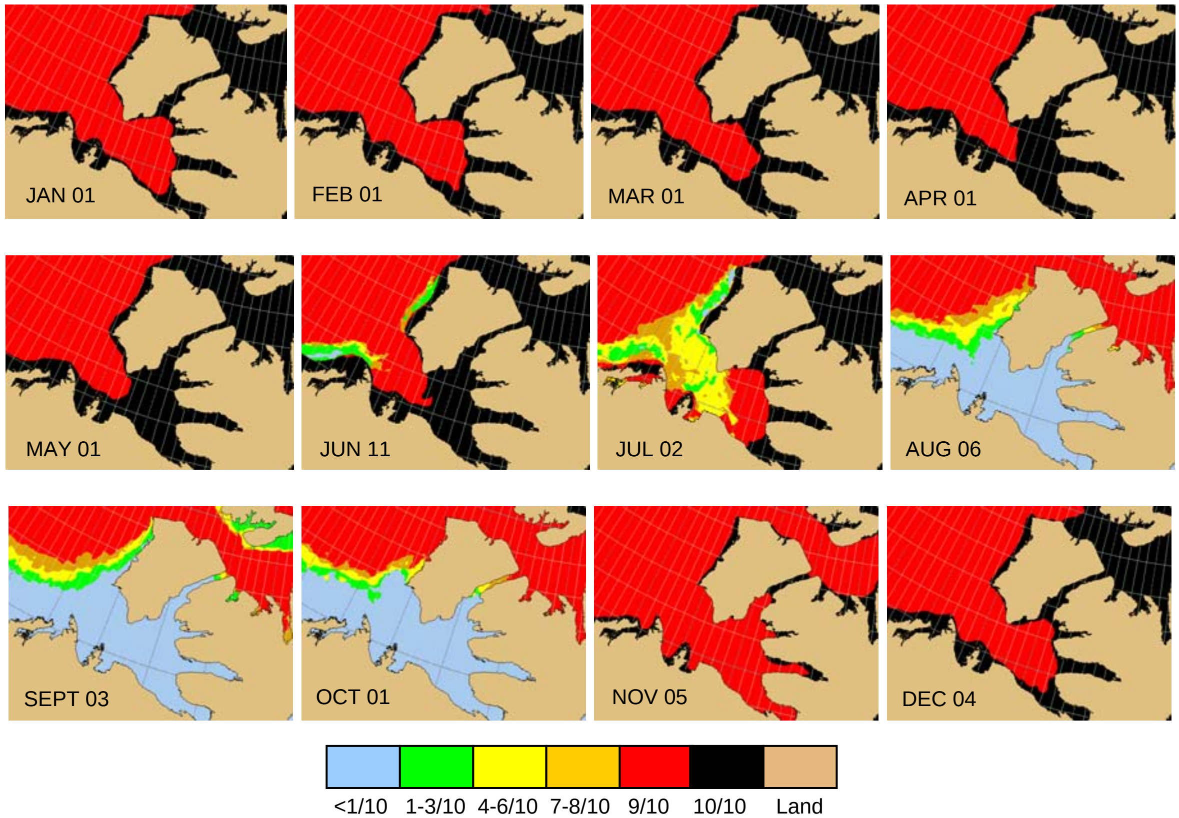


*Figure 8. Median Ice Concentrations for Darnley Bay – Amundsen Gulf based on Canadian Ice Service data for 1971 – 2000 (CIS 2002).*

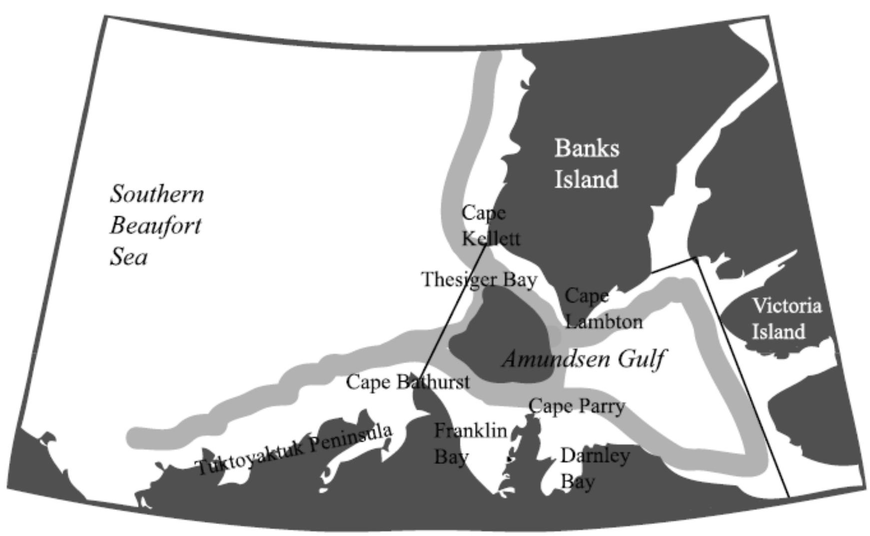


*Figure 9. Diagram of the Amundsen Gulf polynya (dark gray) and flaw lead system (light gray) from Galley et al. (2008).*

wind direction appear to be important drivers in the Amundsen Gulf (Hammill 1987, Peterson et al. 2008). A more comprehensive analysis of sea ice type and distribution/seasonal patterns can be found in Galley et al. (2008), which provides a summary of data for 1980-2004.

Receding (melting) ice-edges have long been recognized as sites of high biological production potential, but are highly variable in production with respect to time and space (Smith and Nelson 1986). The occurrence of wind-induced Ekman upwelling along ice-edges has been shown to bring nutrient-rich waters to the surface and support the development of extensive phytoplankton blooms (Alexander and Niebauer 1981). Mundy et al. (2009) document upwelling and the resulting bloom at the edge of the landfast ice of Darnley Bay in early June 2008 in response to the upwelling-favourable easterly wind. Peterson et al. (2008) found that the landfast ice in Franklin Bay was immobile and ice motion north within Amundsen Gulf was intermittent and often negligible prior to the ice break-up period, however, when the ice did move, it could be explained by wind (Figure 10).

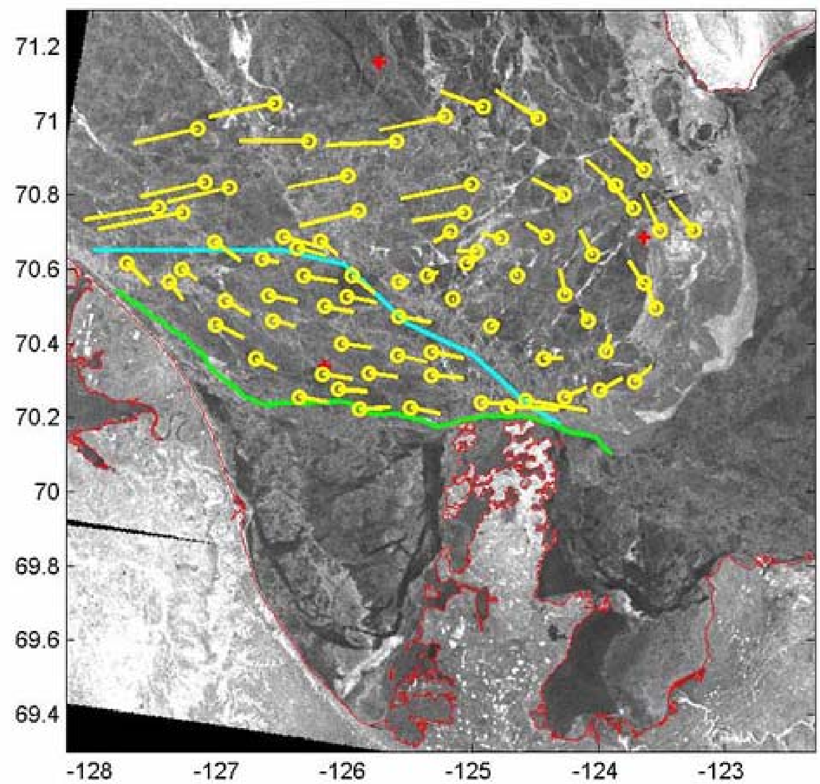


*Figure 10. Ice displacements between 21–22 April and 7 May 2004 from RADARSAT SAR and ENVISAT ASAR data (circles at the start of the displacements). The limits of the compact ice (blue line), and the landfast ice (green line) are also shown. The red crosses indicate the locations of the ice beacon deployments on 8 March. # CSA/ASC 2004 (from Peterson et al. 2008).*

## Temperature and Salinity

The distributions of salinity and water temperature in Darnley Bay will vary seasonally with the formation and melting of sea ice, freshwater inputs from the two main rivers within the bay, surface heat fluxes and forcing from the wind and ice motion. Few studies have taken place within Darnley Bay and most sampling has been conducted during the open-water season (Mundy et al. 2009, W. Williams, unpubl. data). Water temperature and salinity measurements were collected in August 2008 from the CCGS *Nahidik* and results are presented in Figure 11 (W. Williams, pers. comm.). These results along with satellite imagery (July 2008) form the basis for this discussion.

At Cape Parry the waters were stratified at the time of sampling, with warmer, less saline waters at the surface (0 - 20 m) and cooler, more saline waters below (>20 m; Figure 11). The water closest to Cape Parry was less stratified than offshore with isohalines both lifted towards the surface and depressed towards the seafloor. This is suggestive of mixing near the cape, perhaps due to tides or wind-driven flow. In Darnley Bay, there were warmer temperatures at the head of the bay than at Cape Parry and a general decrease in surface water temperatures with distance from shore (Figure 11). There was also an accumulation of freshwater at the head of the bay and, in general, isohalines sloped downward towards the head of the bay across the section, suggesting baroclinic cyclonic circulation in the bay at that time.

**Wind-Driven Upwelling/Downwelling**

Wind patterns and storms can influence the movement of water masses and subsequently result in changes in both water temperature and salinity distribution. The Amundsen Gulf is a location of numerous wind-driven and tidally-driven upwelling events (Barber et al. 2010). Upwelling events can occur along the shelfbreak, at the coast, be topographically-induced (Williams and Carmack 2008) and along ice-edges (Mundy et al. 2009). During an upwelling event in the Arctic, subsurface waters that are saltier and nutrient-rich move up towards the sea surface, thereby replacing the typically nutrient-depleted surface waters. 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. A Sea Surface Temperatures (SST) 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 12). Areas of upwelling are typically linked to areas of increased biological productivity and are considered important for ecosystem structure and functioning (Carmack and MacDonald 2002). The location of enhanced production can however be highly variable and may not always result in increased production. In addition, an increase in production may be delayed (temporal offset between upwelling event and increased growth) and/or growth may be spatially removed (i.e., local currents move the nutrient rich waters). Further research is needed to determine the frequency and consistency of upwelling events in and around Darnley Bay.

Along the southern coast of the Beaufort Sea LOMA, easterly wind (winds coming from the east) is upwelling favourable and westerly wind (winds coming from the west) is downwelling favourable. During an upwelling favourable wind event, the Ekman transport is offshore and the alongshore transport is towards the west. During a downwelling favourable wind event, Ekman transport is onshore, tending to push water against the coast, and the alongshore transport is towards the east. This scenario is quite simplistic and likely does not properly take into account Amundsen Gulf or the complicated coastline of a much smaller area such as Darnley Bay (W. Williams, pers. comm.).

An example of near-surface circulation under downwelling favourable (westerly) wind at the end of August is shown in Figure 13. Surface drifters first moved onshore, presumably in the surface Ekman layer, and then travelled rapidly alongshore to the east, taking only four days to move from Cape Bathurst to Darnley Bay. This demonstrates the connectivity of flows along shelf topography.

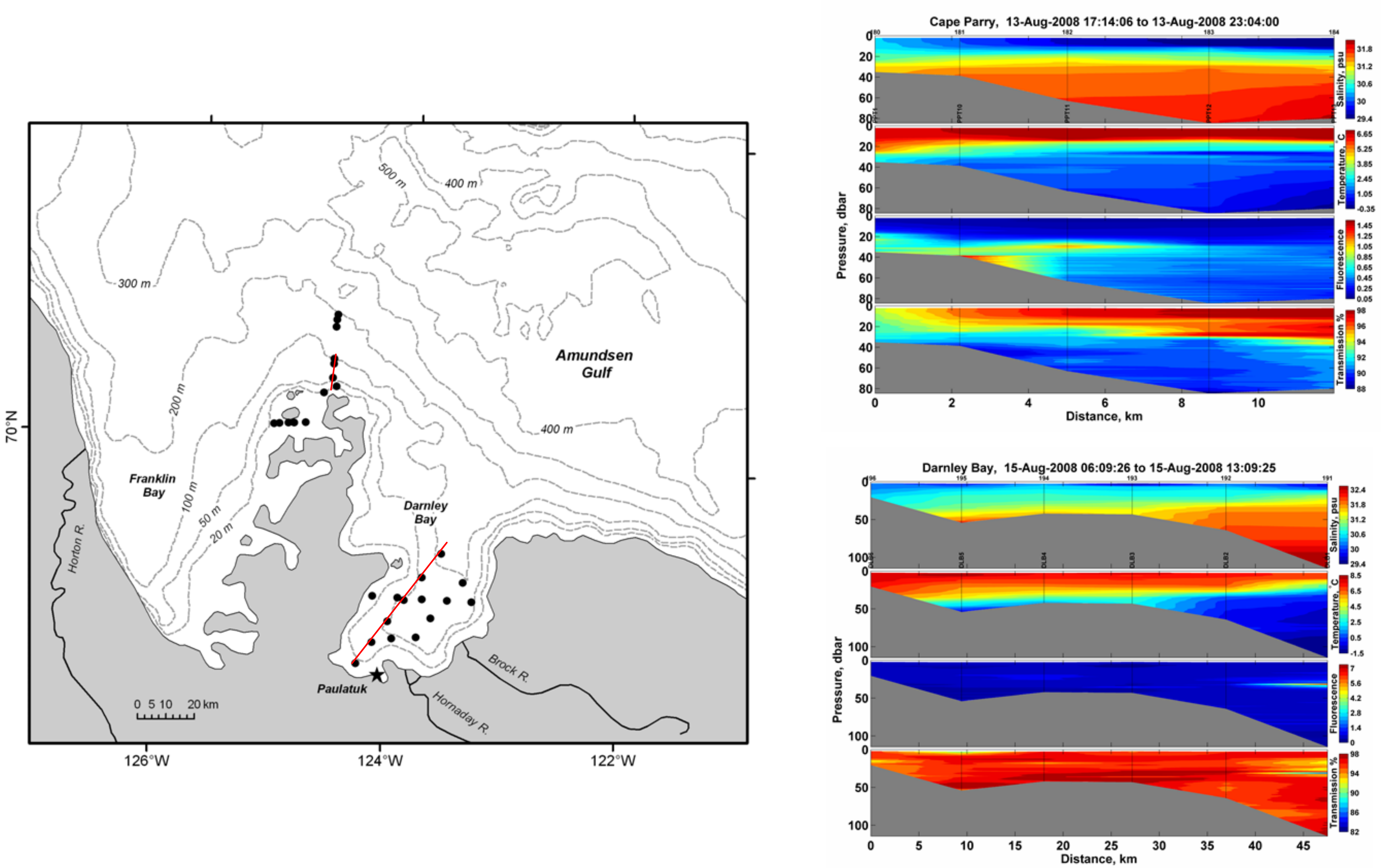


*Figure 11. Cross-sectional profiles for transmission (%), fluorescence (ftSP), temperature (°C) and salinity (psu) along the Cape Parry transect (top) and the Darnley Bay transect (bottom) in August 2008 (W. Williams unpubl. data). Pressure (dbar) can be interpreted as an approximate water depth (m).*

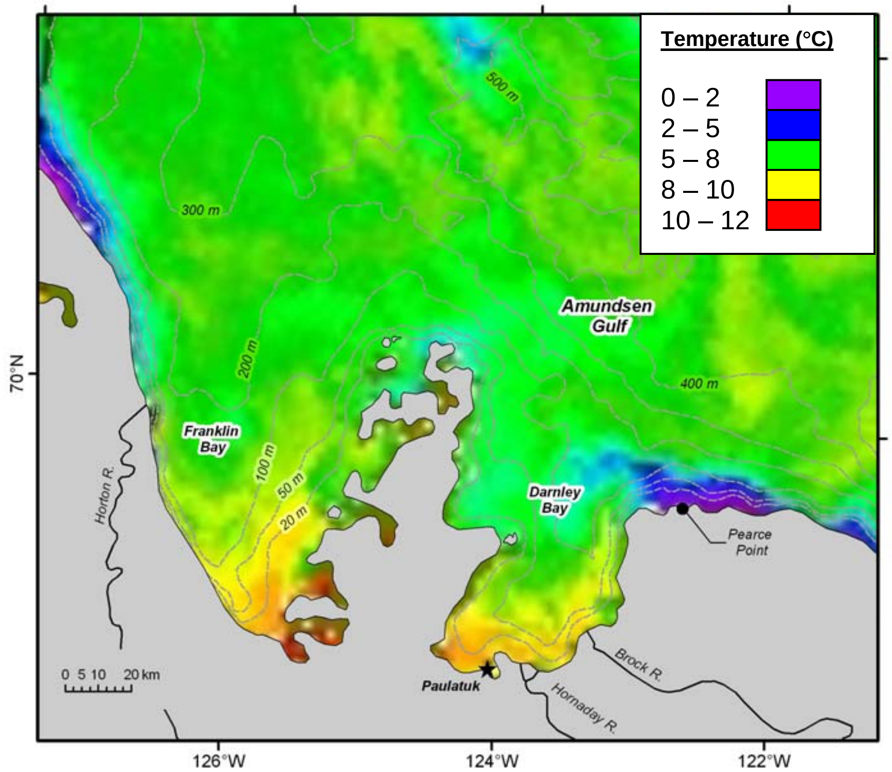


*Figure 12. Sea surface temperatures for Darnley and Franklin bays on July 28, 2008 (courtesy of T.J. Weingartner and G.M. Schmidt[4]). Temperature values shown in the legend are approximate.*

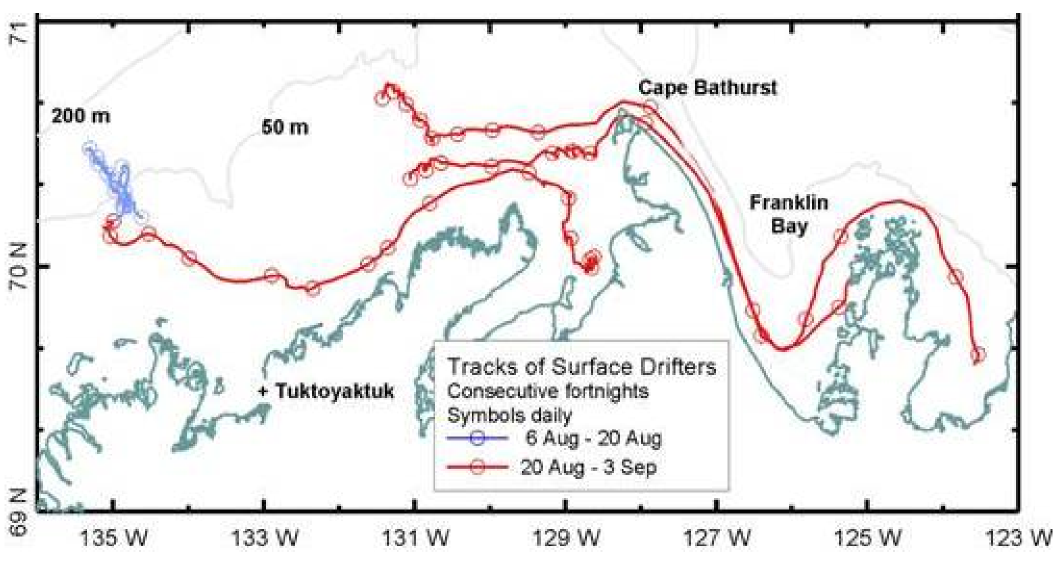


*Figure 13. Surface drifter tracks moving from west to east under a downwelling-favourable (westerly) wind in August 1987(Humfrey Melling, pers. comm., Williams and Carmack 2008).*

[4] 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.

## Tides

Overall tidal heights in Darnley Bay – Amundsen Gulf are generally small in amplitude (Hannah et al. 2008). The WebTide Tidal Prediction Model[5] gives tidal velocities of typically 4 cm/s in Amundsen Gulf, 10 cm/s at Cape Parry and only 1 cm/s in Darnley Bay. These velocities are small compared to many mid-latitude coastal locations, but the amplification at Cape Parry may be enough to cause additional mixing.

## PRIMARY PRODUCTION AND PLANKTON

There are several potential sources of primary production in nearshore arctic waters: phytoplankton, ice algae, benthic micro- and macroalgae and aquatic macrophytes. Primary producers form the base of the food chain, and use the energy from the sun to convert carbon-dioxide and water into organic matter. The timing and yield of phytoplankton blooms determine the coupling between primary production and the heterotrophic food web (e.g., zooplankton and ichthyoplankton; Legendre 1990).

The growth of primary producers is controlled primarily by light and nutrient availability (Grainger 1975). The absence of the sun during the winter months (polar night) inhibits growth. In spring, when the sun returns, the availability of light controls the timing (or beginning) of the 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 growth of sea-ice algae limits the amount of light available for under-ice production (Grainger 1975). Areas of increased overall production are known to typically occur at polynyas and ice-edges (Stirling 1997). While little is known about primary production and plankton in the area of Cape Parry and Darnley Bay, a general overview of knowledge on this subject for the Beaufort Sea LOMA can be found in Cobb et al. (2008). There was also a recent study by Mundy et al. (2009) conducted in Darnley Bay.

## Phytoplankton Production

Overall, phytoplankton production in the Beaufort Sea is low (Macdonald et al. 1989), however, production levels can increase in nearshore regions and at localized sites (e.g., Arrigo and van Dijken 2004). In addition to areas of open water, primary production can also occur within and under sea ice, for example by ice algae (Mundy et al. 2009). Ice algae is estimated to contribute to the majority of primary production during winter and spring (e.g., Horner and Schrader 1982), and plays an important ecological role as the first available food sources to planktonic grazers (Michel et al. 1996). Ice algal blooms occur in spring due to increasing periods of daylight and the presence of nutrient rich waters (e.g., Campbell 1981). Mundy et al. (2009) suggest that ice-edge upwelling events are important to local primary production, while Buckley et al. (1979) propose that these types of events may attract a number of ice-associated grazers as well.

The study by Mundy et al. (2009) was conducted at a station site within Darnley Bay in June 2008. Winds sustained an easterly direction over a 72 h period (upwelling favourable wind event) forcing 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 14). This allowed phytoplankton to make use of the nutrient-rich waters within the upper water layer (i.e., euphotic zone), evidently triggering an increase in phytoplankton biomass (measured as chlorophyll a) to peak values of

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

25 mg m$^{-3}$ integrated over the upper 50 m of the water column (Mundy et al. 2009; Figure 14). 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.

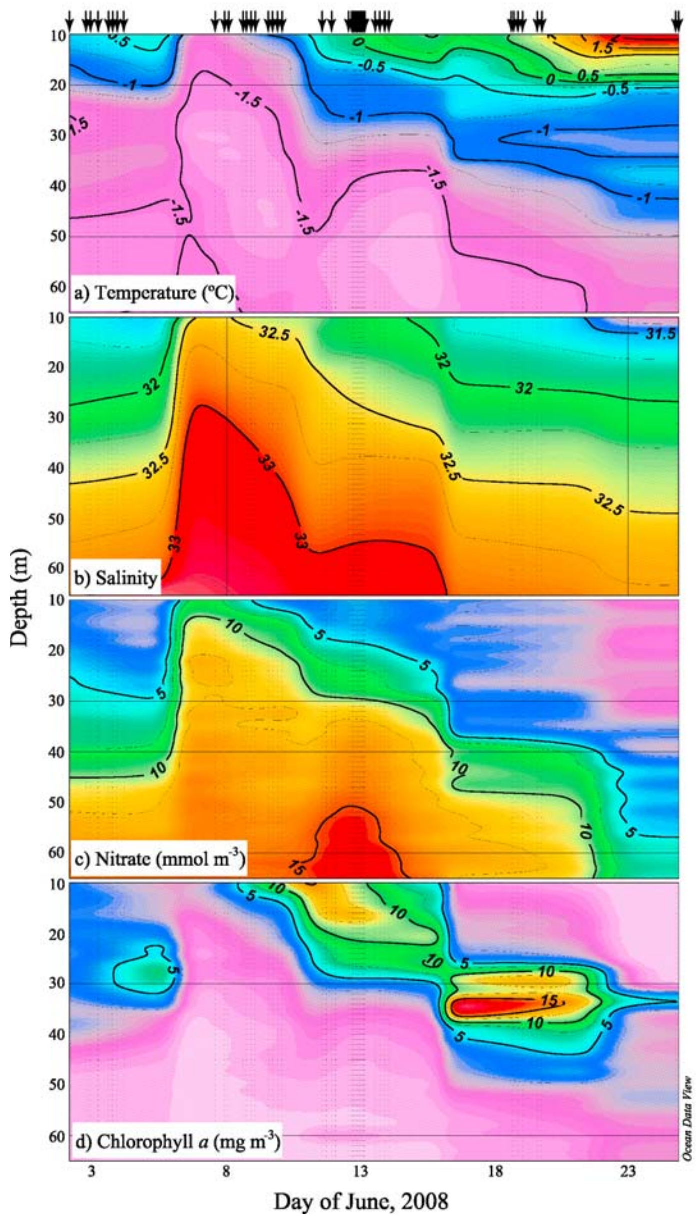


*Figure 14. Interpolated time series for a sampling station in Darnley Bay in June 2008 showing a) temperature, b) salinity, c) nitrate concentration and d) chl a concentration (Mundy et al. 2009).*

## Marine Macrophytes

Knowledge of marine macrophytes in the Western Arctic is poor. The overall distribution of macrophytes within the marine Arctic environment is largely subject to sea ice dynamics (ice scouring), light availability (sea ice and suspended sediments) and suitable substrates for attachment. Detailed studies on macrophytes have been conducted in other Arctic regions (e.g., Stefansson Sound, Alaska and Bridgeport Inlet, Melville Island), however, their distribution in the Beaufort Sea LOMA appears to be limited.

Traditional knowledge indicates there are kelp beds near Argo Bay and in Wise Bay (Figure 15) and suggests there may be others that exist along the coastline of Darnley Bay. In the Beaufort Sea LOMA no other areas with kelp have been identified, although kelp beds may exist in Liverpool Bay and near Sachs Harbour (see Cobb et al. 2008). The closest comparison is in Alaska at Stefansson Sound (Boulder Patch) and areas within the Canadian Eastern Arctic (e.g., Resolute, Igloolik).

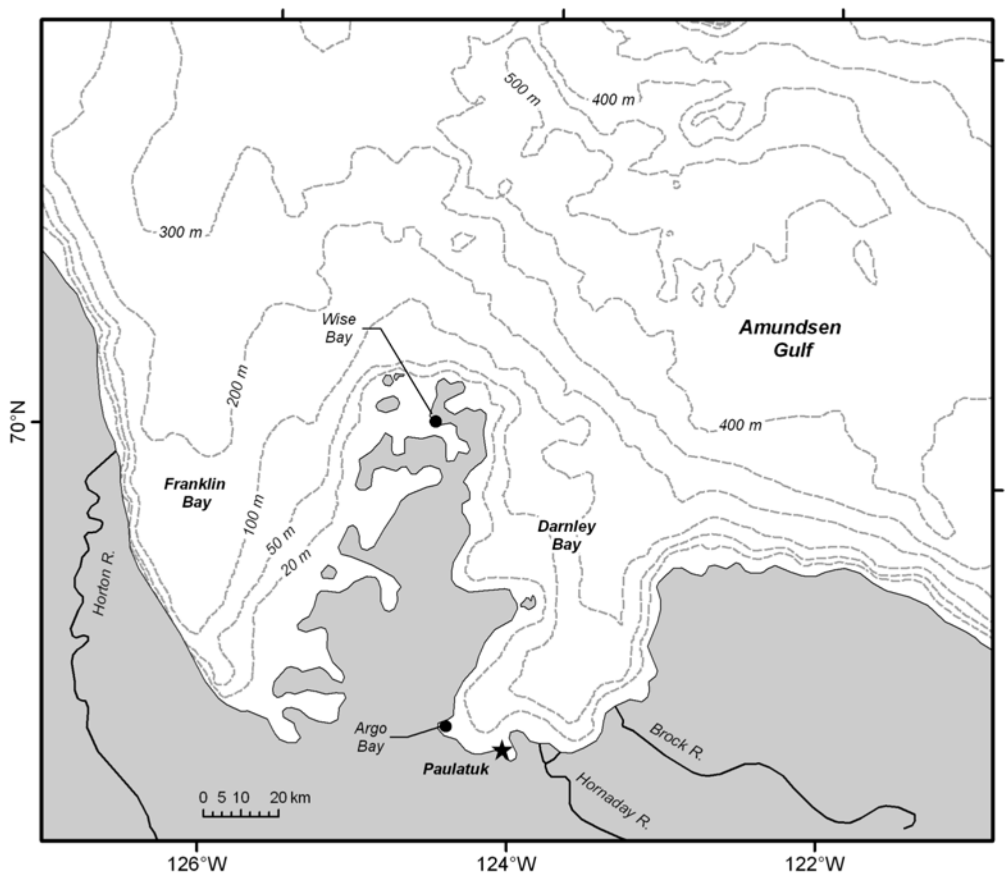


*Figure 15. Locations of kelp beds, in Argo and Wise bays, based on traditional knowledge from the community of Paulatuk.*

Kelp beds are known to fulfill many diverse habitat functions in other coastal oceans, providing three-dimensional space, protection and food for potentially unique and/or diverse communities. They may also serve as important spawning habitat or nursery areas for juvenile life stages for some species of fishes. The presence of kelp in Darnley Bay is potentially important to overall ecosystem structure and function.

**Zooplankton**

Zooplankton are the primary link in the food web between phytoplankton and higher trophic levels (e.g., fish, whales, birds) in the marine ecosystem. Abundance, distribution and community structure (assemblages) of zooplankton are dependent on the movement of water masses, physical-chemical water properties (e.g., temperature, salinity) and the differences in species specific life histories (e.g., development, reproduction).

Zooplankton sampled during the short summer season in the Beaufort Sea is dominated by arctic copepods (Darnis et al. 2008, Walkusz et al. 2010). Zooplankton species composition has not been extensively studied in Darnley Bay with the exception of under-ice work done by Hop et al. (2011) and a recent survey study conducted from the CCGS *Nahidik* during which zooplankton biomass was assessed at two sampling stations (W. Walkusz, pers. comm.).

Distinct zooplankton assemblages appear to correspond to different oceanographic regions (e.g., Auel and Hagen 2002, Darnis et al. 2008, Walkusz et al. 2010). The shelf assemblage, as identified by Darnis et al. (2008), was found in shallow (43-182 m), relatively cold, low salinity waters in Kugmallit Canyon, the Mackenzie Shelf and Franklin Bay. This assemblage was found to have lower diversity and species richness and a predominance of *Pseudocalanus* spp. as opposed to the offshore assemblage (Darnis et al. 2008). This study suggests that this shelf assemblage also extends around the northern portion of Cape Parry.

Darnis et al. (2008) also found that the polynya assemblage had a higher biomass than the shelf and the slope (1.98 and 2.59 g DW $m^{-2}$, respectively, vs. 5.91 g DW $m^{-2}$) due mainly to a three fold increase in the abundance of the large indicator species, *C. hyperboreus* (Darnis et al. 2008). Biomass measurements for Darnley Bay range from 0.01 - 0.04 g DW $m^{-2}$ (W. Walkusz, unpubl. data). Hop et al. (2011) found Darnley Bay significantly less productive in terms of zooplankton when compared to neighbouring Franklin Bay.

**Benthic Community**

Benthos is defined as organisms or communities that live on or within the seabed and are divided into two groups based on the habitat they occupy: epifauna and infauna (Thorson 1957). Epifauna generally inhabit the upper surface of the seabed substrate and are divided into sessile forms (e.g., sea anemones) and mobile forms (e.g., mysids). Infauna organisms are generally found in the bottom sediments and are usually sedentary (e.g., bivalves, polychaetes). Spatial distribution of benthic organisms can be influenced by 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. Differences in distribution are therefore typically observed along two gradients: onshore to offshore and/or west to east. Information on benthic marine invertebrates in the region is based on recent data collected from the CCGS *Nahidik* (2008) on benthic macrofauna and megafauna. The data are incomplete, therefore the patterns presented below may not hold when the complete data are generated in the future (K. Conlan, unpubl. data). It is, however, likely that other faunal groups may respond similarly to the environmental gradients experienced by the faunal groups presented (K. Conlan, pers. comm.).

Macrofaunal abundances for the Beaufort Shelf and Amundsen Gulf were found to be within the range of those in the Bering and Chukchi seas (Conlan et al. 2008). Regional variations in abundance for the Beaufort Sea and Amundsen Gulf were highly correlated with water depth (Conlan et al. 2008). Abundance and biomass values at Cape Parry and Darnley Bay (approximately 124°W) were within the range of what is observed in the western region of the Canadian Beaufort Sea (130°W-138°W; Figure 16). Preliminary results show mean abundances are higher at Cape Parry (6410 ind. $m^{-2}$) than within Darnley Bay (1375 ± 545 ind. $m^{-2}$), but the influence of upwellings at Cape Bathurst is evident (>30,000 ind. $m^{-2}$). The influence of upwellings at Cape Bathurst on macrofaunal abundance is typical of this area and Cape Bathurst is known as an important biological hotspot (Conlan et al. 2008).

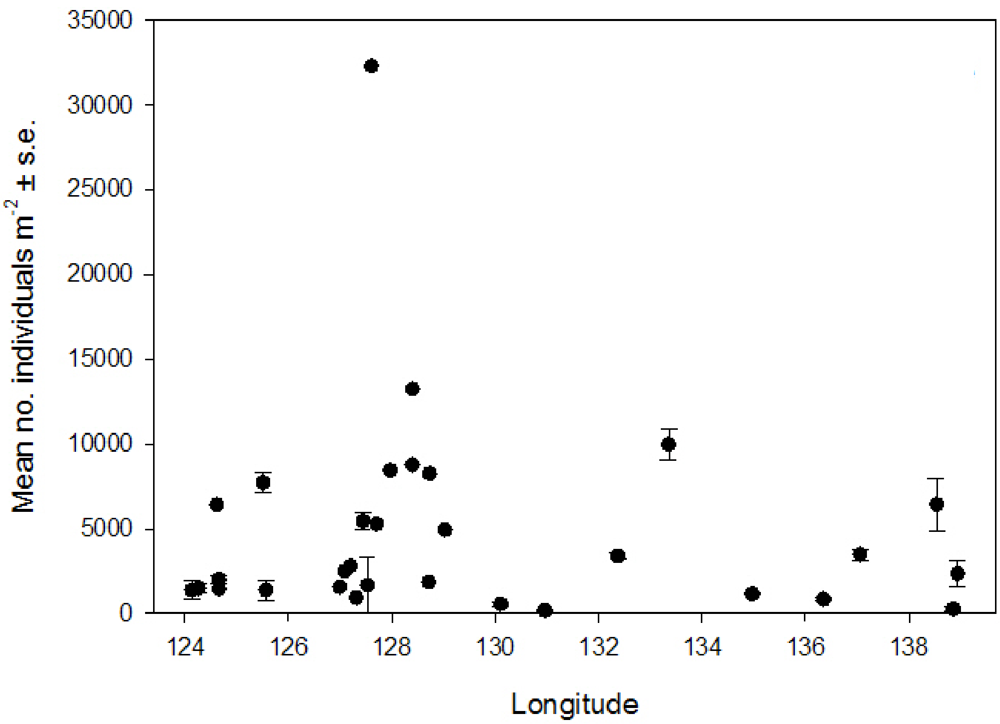


*Figure 16. Mean abundance of macrofauna by longitudal location from Darnley Bay (124°W) west to Herschel Basin (138.9°W). The hotspot at Cape Bathurst (128°W) is due to large numbers of cumaceans, ostracods, isopods, tanaids and ophiuroids. Further analysis of the data will likely reveal large numbers of the amphipod Ampelisca macrocephala and the polychaete Barantolla americana. Data analyzed for this report include crustaceans, echinoderms, priapulids, sipunculids and others. Abundances of amphipods, polychaetes and molluscs have not been completed (K. Conlan, unpubl. data).*

Preliminary results for biomass estimates (g $m^{-2}$) showed similar patterns as for abundance, where values at both Darnley Bay and Cape Parry (3.9 – 29.8 g $m^{-2}$; Figure 17) were similar to those values observed in other western locations on the Canadian Beaufort Sea Shelf, but lower compared to Cape Bathurst and areas west that were influenced by the wind-driven upwelling events (117.4 – 245.7 g $m^{-2}$; Figure 17). Darnley Bay and Cape Parry had similar variations in biomass, however, the larger values observed at Cape Parry were due to a number of large molluscs being captured (Figure 17).

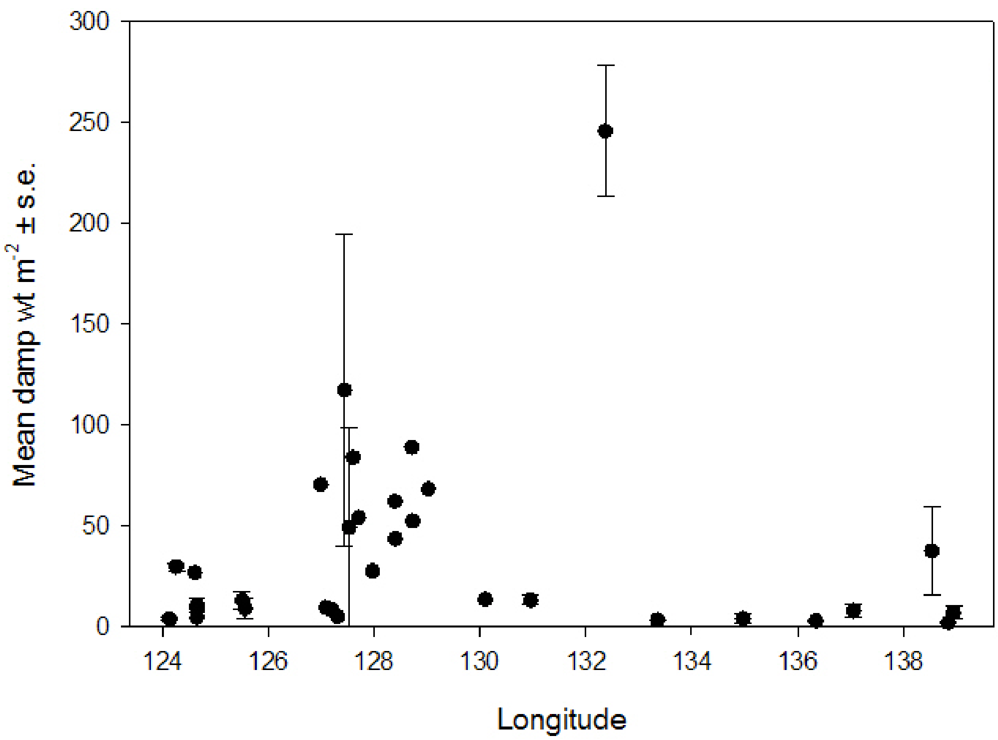


*Figure 17. Mean biomass of polychaetes, molluscs, crustaceans, echinoderms, priapulids, sipunculids and others by longitudal location from Darnley Bay (124°W) west to Herschel Basin (138.9°W). (K. Conlan, unpubl. data).*

Highest species richness was observed at one station near Cape Parry with 32 species $m^{-2}$ (Figure 18). Although there is considerable variation, a broad decline in species richness is evident from east to west, particularly to the west of Cape Bathurst. It is important to note, however, that these observations are based on a taxonomic subset and that often sample locations will influence species composition (K. Conlan, pers. comm.). Samples inshore and close to the Mackenzie River have lower species richness than those offshore (Conlan et al. 2008). Similarly, this was found in the Darnley Bay/Cape Parry region, where species richness was low in Darnley Bay (7.5 ± 0.5 species $m^{-2}$) and increased toward Cape Parry (32 species $m^{2}$; Figure 18).

Species composition, for the faunal subset that was analyzed, is not distinctive in Darnley Bay or at Cape Parry relative to the western Canadian Beaufort Sea Shelf. In addition, although Figure 18 suggests a gradient of species change from Darnley Bay to Cape Parry it would not likely be as prominent once all species identifications have been completed. Based on this analysis, the high abundance of benthos at Cape Bathurst appears to be more important to ecosystem structure and function for the Beaufort Sea LOMA (K. Conlan, pers. comm.).

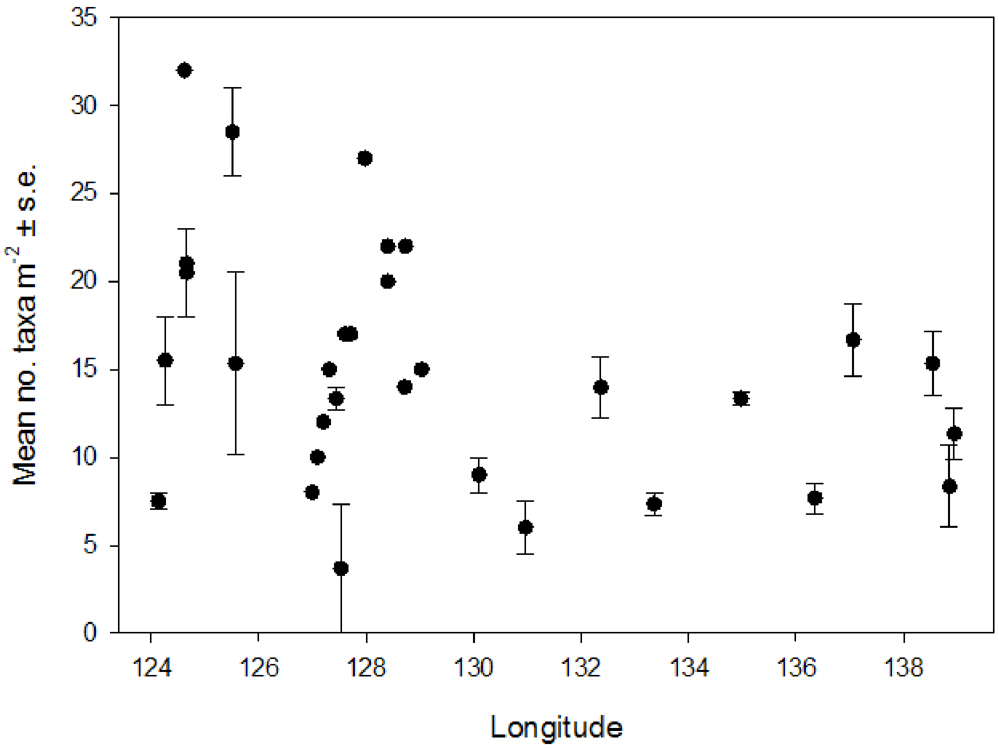


*Figure 18. Mean species richness of crustaceans, echinoderms, priapulids, sipunculids and others by longitudal location from Darnley Bay (124°W) west to Herschel Basin (138.9°W). Lacking are abundances of amphipods, polychaetes and mollusks (K. Conlan, unpubl. data).*

In addition to the box core data presented above, seabed surveys using underwater video were also carried out from the CCGS *Nahidik* in August 2008 (30 stations). Darnley Bay appears to be dominated by soft sediments with high abundances of brittle stars and burrowing organisms (V. Kostylev, pers. comm.; Figure 19). The shallow habitats off Cape Parry are dramatically different from the soft muddy environment of the western Canadian Beaufort Shelf and appear to have more coarse substrate and a higher richness of megabenthos in general (V. Kostylev, pers. comm.; Figure 19).

Arctic benthic communities are important food resources for diving sea birds (Dickson and Gilchrist 2002) and several marine mammals (e.g., Walrus (*Odobenus rosmarus*), Bearded Seals (*Erignathus barbatus*); Frost and Lowry 1984). Benthic communities can be slow to recover from disturbances to the seabed, for example intensive ice scouring can significantly reduce diversity of species. However, this can also favour organisms that are capable of rapidly recolonizing (Conlan and Kvitek 2005). Benthos found in the inshore fast ice and flaw lead zones, such as the Darnley Bay region are likely to be subject to frequent disturbance by ice scouring (Myers et al. 1996). Variation in faunal abundance and diversity inshore would likely reflect major benthic disturbances (e.g., storm effects, variable salinity, temperature and turbidity). Predictive models for zones of ice scour and average percent seabed disturbance in the Beaufort Sea Shelf can be found in Cobb et al. (2008) and applied to the Darnley Bay region in the current absence of data for this region.

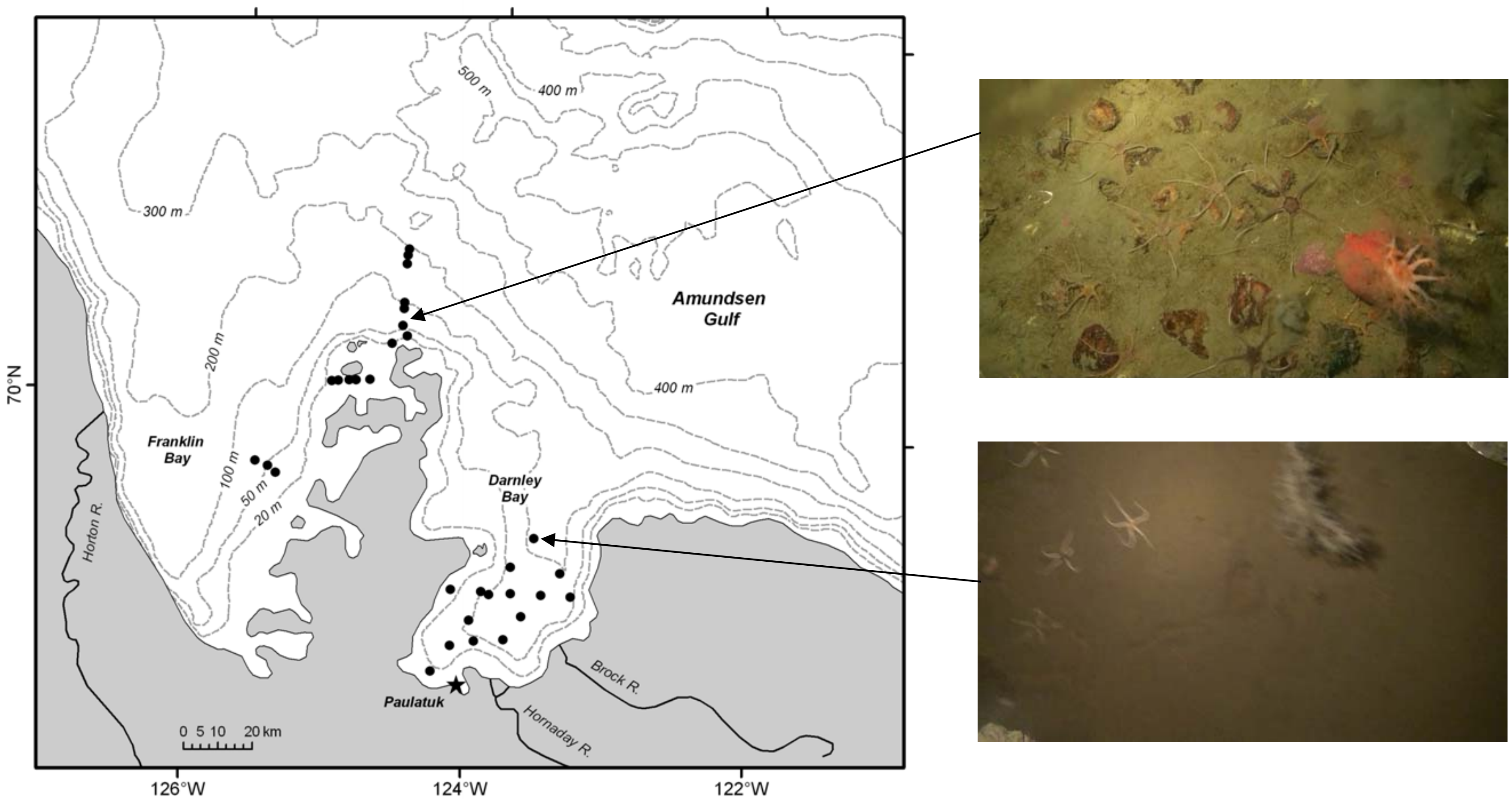


*Figure 19. Video images of megabenthos at a selected station within Darnley Bay (below) and at Cape Parry (top) from a 2008 CCGS Nahidik survey, showing differences in sediment and species abundances (V. Kostylev, unpubl. data).*

## MARINE MAMMALS

There are currently five species of marine mammals that occur regularly in the Canadian Beaufort Sea: Bowhead, Beluga, Ringed Seal (*Phoca hispida*), Bearded Seal, and Polar Bear (*Ursus maritimus*). Gray Whales (*Eschrichtius robustus)* have been sighted occasionally, but only a few enter the Beaufort Sea east of Point Barrow in most years (e.g., Harris et al. 2008). Rare sighting of Narwhal (*Monodon monoceros*; Geist et al. 1960, Smith 1977) and Walrus (Harwood and Borstad 1985) have also been made in the Beaufort Sea, however the typical distribution ranges are not considered to be within the Beaufort Sea LOMA (e.g., Reimnitz et al. 1994, Stewart 2008). Killer Whales (*Orcinus orca*) migrate to the Chukchi Sea during summer and have been sighted in the Canadian Western Arctic as far east as Cape Bathurst (Higdon 2009).

### Beluga (*Delphinapterus leucas*)

The Eastern Beaufort Sea Beluga population is one of the largest in Canada, estimated at approximately 40,000 (COSEWIC 2004). Beluga from this population winter in the Bering Sea, but migrate each spring through offshore leads eastward along the north coast of Alaska into the southeast Beaufort Sea (Fraker 1979, Richard et al. 1997). Whales arrive off the west coast of Banks Island and offshore Cape Bathurst in late spring, coinciding with the onset of ice break-up (May and June; Fraker 1979). Beluga typically move to the southwest, following the seaward edge of the land-fast ice along the Tuktoyaktuk Peninsula (Norton and Harwood 1986), and, depending on ice conditions, arrive in the Mackenzie River Estuary by late June or early July (Byers and Roberts 1995; Figure 20). The congregation at the Mackenzie Estuary are in the thousands, representing one of the largest summering aggregations of Beluga (Fraker et al. 1979). Beaufort Sea Beluga spend time offshore, near or beyond the shelf break and in the polar pack ice of the Mackenzie Estuary, Amundsen Gulf, M'Clure Strait and Viscount Melville Sound (Richard et al. 2001; Figure 20). In 1993 and 1995, Beluga tagging data revealed eleven male Beluga travelled north from the Mackenzie Estuary through either the M'Clure Strait or the Prince of Wales Strait into Viscount Melville Sound (Richard et al. 2001; Figure 20), after which they made their way back south either to begin their migration into Alaskan waters or to return to the southern Beaufort Sea (Richard et al. 2001). In this same study, tagged males (n=7) and females (n=3) late in the season made trips from the Mackenzie Estuary into the Amundsen Gulf. The whales typically remained there for 2-3 weeks following a clockwise pattern, east through the center or northern portion of the Gulf and then westward through its southern portion (Richard et al. 2001; Figure 20). In mid-August and early September, Beluga begin their autumn westward migration back into Alaskan waters either along the mainland coast or far offshore under sometimes heavy pack ice conditions (DFO 2000; Figure 20).

Resource selection function analysis was carried out on Beluga satellite data to better understand Beluga habitat use of sea ice and bathymetry. The late summer to early fall habitat use differed among size and sex classes, demonstrating sexual segregation (Loseto et al. 2006). Within the Beaufort Sea LOMA, three Beluga habitat use groups were defined in relation to 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 a few females (>3.4 m) without neonates selected the sea ice edge; and,
3) the largest males (4 – 4.6 m) selected heavy sea ice concentrations in deep, offshore waters.

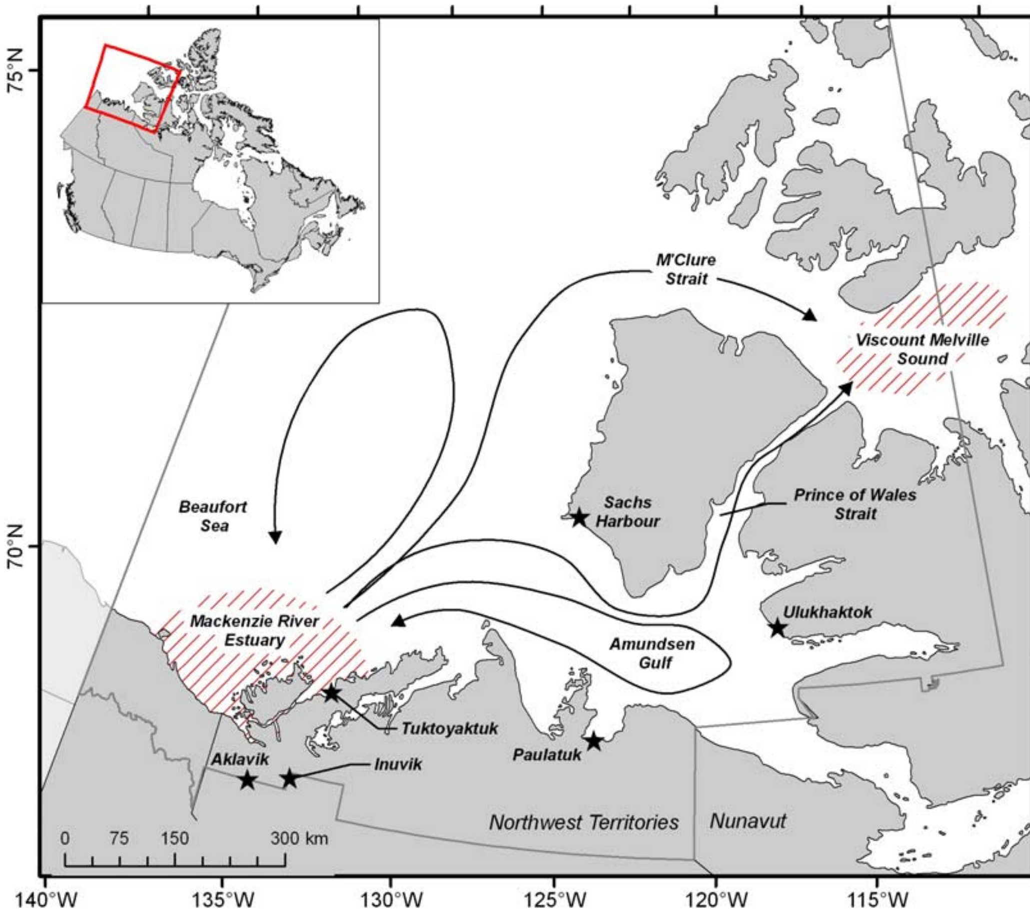


*Figure 20. Distribution of eastern Beaufort Sea Beluga during spring, summer and fall, showing aggregation areas and seasonal movements. Beluga distribution range occurs throughout the Beaufort Sea LOMA, however regions identified by red hatching are areas where densities are typically higher (modified from DFO 2000).*

Such intra-species segregation of habitat use has consequences for feeding ecology and mercury (Hg) exposure, as segregation relates to different requirements over space and time (Stevick et al. 2002). Two common hypotheses of habitat use are the predation risk hypothesis that postulates predator avoidance by reproductive females will segregate the population (Main et al. 1996) and the forage selection hypothesis which is related to size dimorphism where the larger sex will forage more often or differently leading to segregation (Clutton-Brock et al. 1982, Conradt 1998). The results of Beluga habitat use segregation suggested a complex Beluga social structure, as well as indicated where and potentially which food webs the Beluga were feeding on during the summer season in the western Arctic.

Beluga sampled from Paulatuk harvests were analyzed for Hg, stable isotopes and fatty acids. Whales harvested in Darnley Bay were generally smaller in size and had lower mercury levels and diet biomarkers, suggesting that these whales are feeding at lower trophic levels relative to the larger whales that typically travel in the deep water and heavy ice concentrations. However, it is unclear how hunting effort and preference of whale size influence which whales were taken during the harvest. A genetic study is underway to examine kinship groups within the Beaufort Sea Beluga population to determine if the animals that return annually to harvesting areas in the

LOMA are from the same families. If the findings are confirmed this would suggest whales that enter Darnley Bay are unique to the area and show fidelity.

Data collected from spring surveys in 1975-1979 were recently analyzed and published for the Amundsen Gulf (Asselin et al. 2011). These results suggest that Beluga patterns of habitat selection were relatively consistent despite large inter-annual variability in sea ice concentration and extent (Asselin et al. 2011). The three main factors that appear to influence Beluga distribution in spring (mid-late June) are sea ice concentration, bathymetry and seafloor slope. In general, Beluga habitat preference selected heavy ice (8/10 to 10/10) regions characterized by 200-500 m water depths and close proximity to regions with higher seafloor slope (Asselin et al. 2011). These results were similar to those in other Arctic regions, such as the Alaskan Beaufort Sea (Moore et al. 2000, Mahoney et al. 2007). Overall Beluga do not prefer the fast-ice edge habitat or coastal areas in spring during years when pack-ice is present in the region, rather they do appear to select this habitat during years when there is a greater extent of open water (Asselin et al. 2011). With reports of and expected declines in sea ice concentration and extent in the Canadian Arctic, the fast-ice edge habitat may be an increasingly important habitat for Beluga in the Amundsen Gulf. Further research and spring surveys are needed to determine if the same patterns in Beluga spring habitat use from the late 1970s are similar to those observed today, particularly since the methods and logistics of Beluga reconnaissance surveys have improved over time.

Asselin et al. (2011) suggests that the spring distribution may be due to foraging success since Beluga appeared to select habitats that are also thought to be closely associated with the presence of Arctic Cod (*Boreogadus saida*) aggregations. In the Mackenzie Estuary, harvested Beluga have typically been found to have empty stomachs (DFO 2000). Arctic Cod is thought to be an important forage species for some Beluga populations (Dahl et al. 2000, Seaman et al. 1982, Welch et al. 1993); yet there have been some instances when other prey item remains were found, including Arctic Cisco (*Coregonus autumnalis*), Burbot (*Lota Lota*) and Broad Whitefish (*Coregonus nasus*) (DFO 2000). The diet of Beluga in the Bering and Chukchi seas included Arctic Cod, Saffron Cod (*Eleginus gracilis*), sculpins, Pacific Herring (*Clupea pallasii pallasii*), Rainbow Smelt (*Osmerus mordax*), Capelin (*Mallotus villosus*), Arctic Char, octopus and shrimp (Frost and Lowry 1990), which suggest that diet may be population and habitat specific.

Analysis of stable isotopes and fatty acids supports the suggestion that while there are dietary differences among the previously discussed size classes, Arctic Cod was found to be the most important prey item (Loseto et al. 2008 a,b). These results further suggest that larger sized Beluga preferred offshore Arctic Cod, whereas smaller sized Beluga appeared to feed on prey in the nearshore habitats that included nearshore Arctic Cod. This suggests the possibility that there are two Arctic Cod sub-populations that exist within the Beaufort Sea LOMA. The offshore Arctic Cod had higher nitrogen values and mercury levels that supported higher trophic feeding relative to the nearshore Arctic Cod sampled (Loseto et al. 2008b). Results from this same study also revealed the lack of benthic diet sources. Further research is required to determine if the results were influenced by the collection methods (e.g., different years and seasons).

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). Amundsen Gulf and the northern portion of Darnley Bay provide a main migration route, while the coastal areas of the Parry Peninsula and Franklin and Darnley bays are reported to be important feeding areas (Community of Paulatuk et al. 2000). More specifically, Beluga are seen at Argo Bay, Browns Harbour, Letty Harbour, Langton Bay, and as aggregations at the mouth of the Horton, Hornaday and Brock rivers (Figure 21). These areas coincide with the harvesting practices of the residents of Paulatuk and the Zone 1B area of the Beaufort Sea Beluga Management Plan (Community of Paulatuk et al. 2000, FJMC 2001; Figure 21).

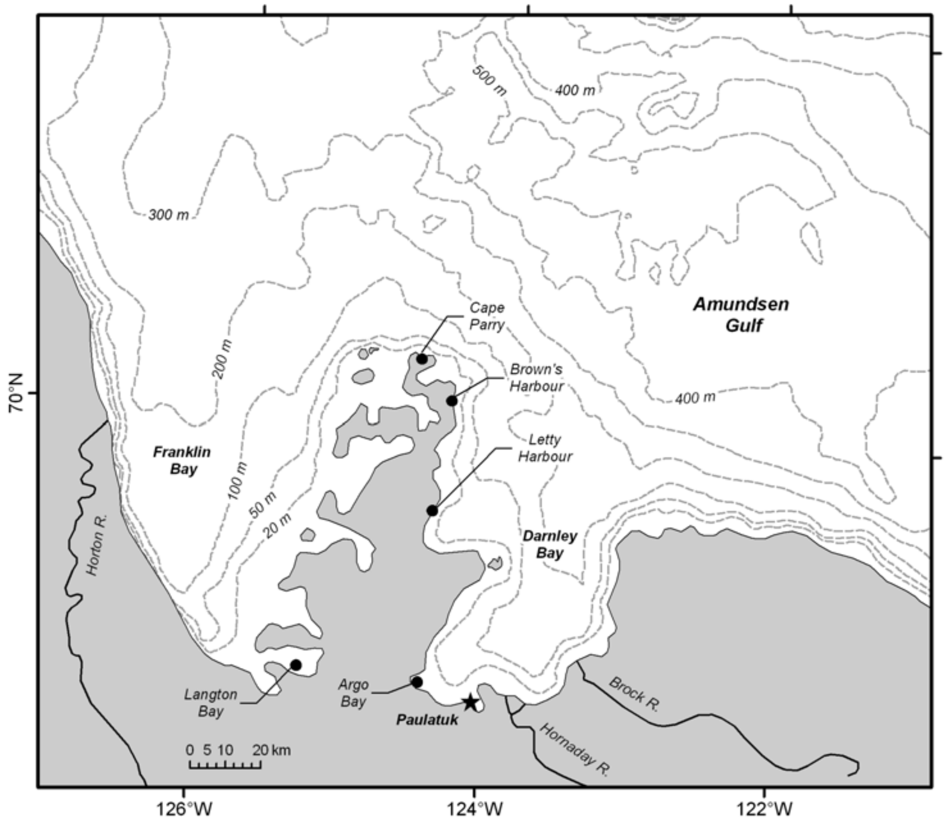


*Figure 21. Important areas identified by the Paulatuk Community Conservation Plan et al. (2000) for Beluga in Darnley and Franklin bays and the Amundsen Gulf.*

Beluga are important to the Inuvialuit diet, tradition and culture and are harvested annually by hunters from all six Inuvialuit communities within the Beaufort Sea LOMA, including Paulatuk. The Beluga harvest season for residents of Paulatuk typically occurs between July 1 and August 31 (Community of Paulatuk et al. 2000). The total number of Beluga harvested annually in the ISR is considered to be well below the level which might negatively affect the population (DFO 2000). 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 (BHMP) has been in place at Paulatuk since 1989 to collect hunt information and biological data and samples; however the results of the harvest vary from year to year depending on hunting conditions (DFO 2000). Based on harvest data analysis from 1990-1999, an annual average of 111 Beluga per year are landed in Canada from the Eastern Beaufort Sea stock (DFO 2000). In general, this average is considered to be significantly lower than in the past (DFO 2000). The landed catch for hunters from Paulatuk has been highly variable, ranging from 0 to 25 animals per year due to a combination of factors including the distribution of whales in any given year, 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 2000-2010 are presented in Table 2.

*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).*

| 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 | 1110 (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.).*

| 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 |

**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). The stock is designated as Special Concern under SARA (January 2008). The status of this population was re-examined and confirmed to be Special Concern in April 2009 (COSEWIC

2009). The most recent estimate of stock size is 10,545 (95% confidence interval 8,200 to 13,500) 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 and in conditions ranging from open water to extensive (but unconsolidated) pack ice[6] (COSEWIC 2009), however they are generally associated with marginal ice fronts and polynyas (Braham et al. 1980). Bowhead migrate annually in early spring through the Bering Strait after wintering in the Bering Sea and continue eastward passing Point Barrow in April and May (Clark and Johnson 1984, George et al. 1989). Whales continue their migration east, travelling through the offshore southeastern Beaufort Sea and arriving in Amundsen Gulf (Moore and Reeves 1993) in early spring (Marko and Fraker 1981). Age segregation is apparent during migration and on the summering grounds. In Canadian waters, the Amundsen Gulf is frequented by adults (>13m long) and subadults (>11m long), and the Yukon coast appears to be most attractive to juvenile whales (Davis et al. 1982, Cubbage et al. 1984, Davis et al. 1986). Whales are typically widely distributed in offshore areas of the Beaufort Sea by July (Davis et al. 1982, Harwood and Borstad 1985). As the season progresses, they begin to form large, loose feeding aggregations in recurrent offshore areas where prey are concentrated (Harwood and Smith 2002, Richardson et al. 1987), mainly in the Beaufort Sea but also including some smaller opportunistic feeding aggregations in Amundsen Gulf (including Darnley Bay), Viscount Melville Sound and McClure Strait.

Bowhead feed predominately on zooplankton. Samples taken in the vicinity of Bowhead feeding in 1986 and 2008 revealed copepods as the predominant prey item (*Limnocalanus macrurus, C. hyperboreus, C. glacialis*), gammariid and hyperiid amphipods, euphausiids, mysids and isopods (LGL Ltd. 1988, W. Walkusz, pers. comm.). The distribution and abundance of zooplankton is driven by winds, currents, and bathymetry (Thomson et al. 1986). These conditions typically concentrate zooplankton in the same areas within the southeastern Beaufort Sea and Amundsen Gulf annually. Five areas consistently attract large aggregations of Bowhead: 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.). The offshore area along the Tuktoyaktuk Peninsula appears to be the most attractive and supports the largest aggregation (>50% of whales in the region present at any one time) in August of all years surveyed in terms of whales sighted (Harwood 2010, Figure 22). This generally corresponds with local traditional knowledge which indicates that nearshore waters off Cape Bathurst and in Franklin Bay are important habitat for Bowhead (Community of Paulatuk et al. 2000).

[6] 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.

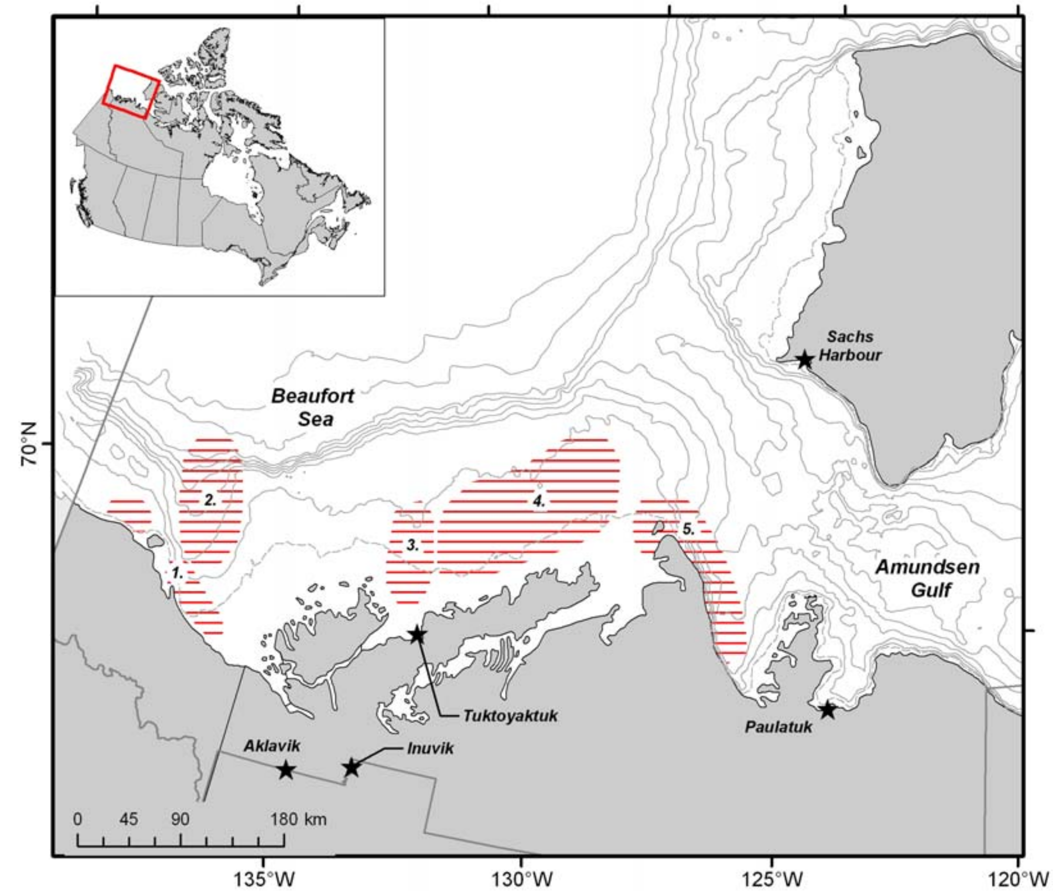


*Figure 22. Approximate locations of typical summer Bowhead aggregation areas in the southern Beaufort Sea and Amundsen Gulf region labelled left to right: 1. Yukon North Slope, 2. Mackenzie Canyon, 3. Kugmallit Canyon, 4. Tuktoyaktuk Peninsula and 5. Cape Bathurst (L. Harwood, pers. comm.).*

During systematic aerial surveys in the Beaufort Sea LOMA, Bowhead were observed in aggregations (i.e., >5 surfaced Bowhead/100 $km^2$ surveyed; Harwood 2010) 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 2010 (Harwood 2010, Figures 23 and 24). During community consultation, residents have reported that in recent years Bowhead have been observed from shore in the nearshore region of Darnley Bay in late summer as opposed to where they are typically observed offshore in Amundsen Gulf (Paulic et al. 2009). Satellite-tagged whales (2006-2009) where also observed to occasionally enter Darnley Bay in July and August (Quakenbush et al. 2010). The available data suggest that although Darnley Bay is not a unique feeding area used regularly by a large portion of the population, it is frequented by Bowhead for a period of weeks in some years, and possibly to a greater extent than was the case decades ago.

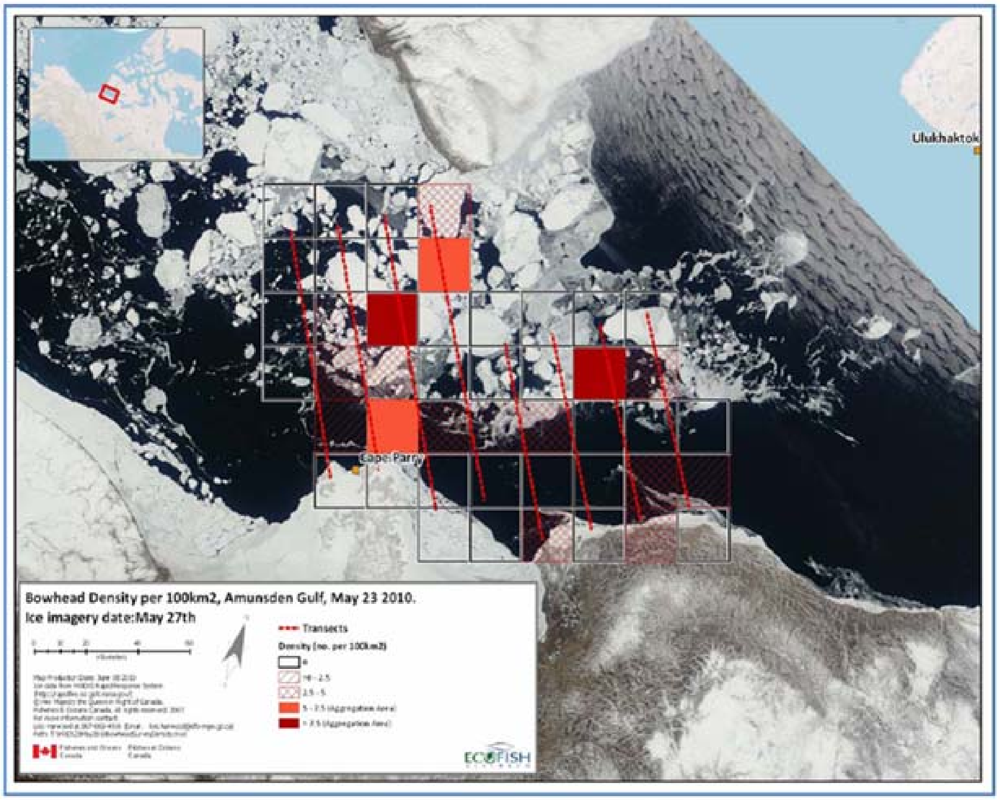


*Figure 23. Observed grid cell densities of surfaced Bowhead in western Amundsen Gulf, 23 May 2010 (Harwood 2010).*

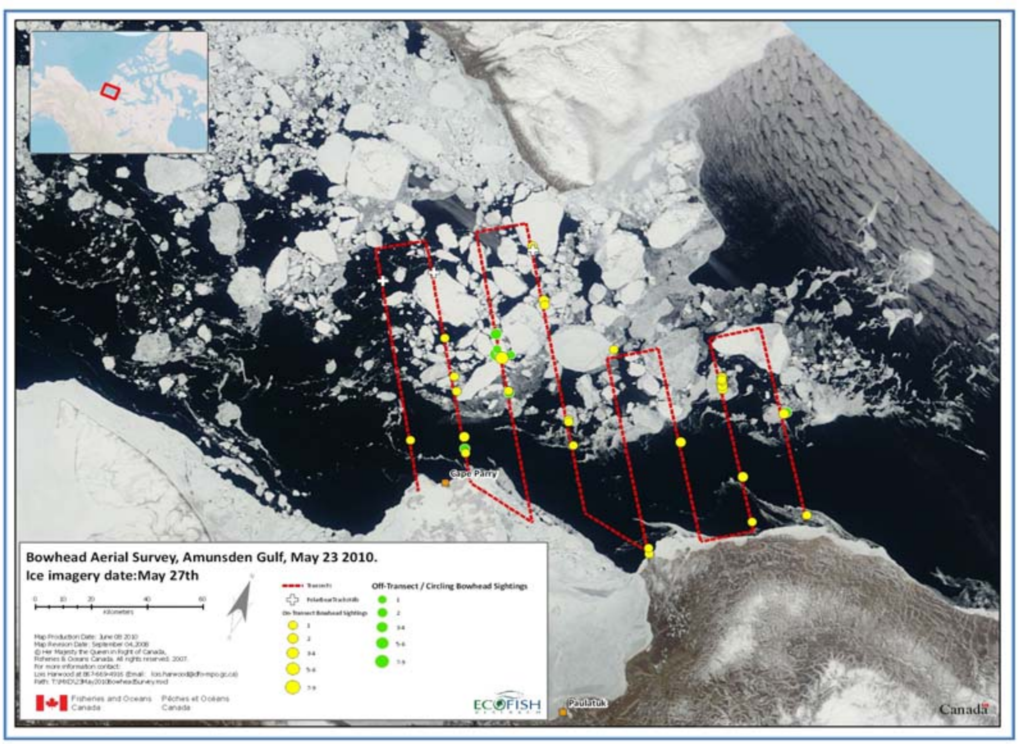


*Figure 24. Locations of Bowhead sighted in western Amundsen Gulf, 23 May 2010 (Harwood 2010).*

**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). They are an important part of the Arctic marine food chain, being the primary prey of Polar Bears and an important source of food for Arctic Foxes (Smith 1976, Stirling 2002).

Ringed Seals occur in the Beaufort Sea year-round. During the spring breeding season, females construct lairs within the thick ice and give birth (Smith 1987). In late June, prior to ice break-up, seals haul out on the ice to moult. Stirling et al. (1982) reports high densities of seal haul-out sites along the Yukon coast, near Cape Bathurst and Cape Parry and along the southwest coast of Banks Island. Ringed Seal distribution is strongly influenced by the distribution of shore leads, polynyas, areas of annual multi-year ice, and the short and long term variations in the pattern of freeze-up and break-up (Stirling 2002). In spring, seals are observed to be typically dispersed at low densities throughout the region, while in summer they can travel large distances and often are found to form large, loose aggregations (Harwood and Borstad 1985, Smith 1987, Harwood and Stirling 1992). These aggregations vary among years but occur most regularly in the area north of the Tuktoyaktuk Peninsula (Harwood and Stirling 1992; Figure 25). Summer aggregations of Ringed Seals are linked to oceanographic conditions that are favourable for production and retention of zooplankton. Harwood (1989) confirmed this by demonstrating that mean densities of euphausiids and copepods were significantly greater in seal aggregation areas than in non-aggregation areas. Similar aggregations were reported by Smith (1987) in the Amundsen Gulf.

As the ice begins to form in late fall, localized and large-scale movements of seals may occur within the area (e.g., Stirling et al. 1977, Smith 1987, L. Harwood, pers. comm.). In particular, a seasonal redistribution by age class has been documented in the eastern Amundsen Gulf, which is likely in response to food availability (Smith 1987). Summer and fall feeding is a particularly important activity to deposit fat reserves for the winter and for pregnant females to support growing offspring (Smith 1987). It is suggested by Smith (1987) that the fall migrations and age class segregation described could be attributed to territorial exclusion of younger animals due to feeding competition. In Amundsen Gulf, young seals migrate westward past Cape Parry each fall. In 2001 and 2002 eight seals, ranging in age from 0-4 years, were tagged in September near the community of Paulatuk. All of the tagged seals moved westward past Cape Parry to the Chukchi Sea (Figure 26). In contrast, established adult seals move into coastal areas of stable landfast ice to establish breeding territories as the fall progresses. Prime 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.; Figure 25).

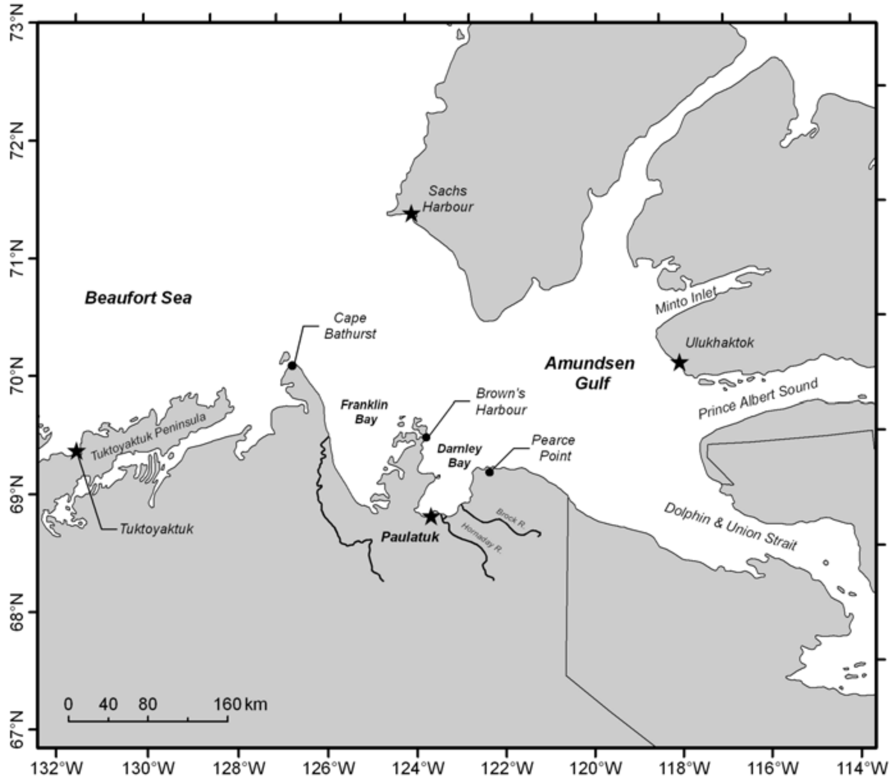


*Figure 25. Areas in the Beaufort Sea LOMA where Ringed Seals commonly occur at different times in the year (L. Harwood, pers. comm.). Loose aggregations occur north of the Tuktoyaktuk Peninsula in summer and prime overwintering and spring breeding areas include Franklin and Darnley bays, Prince Albert Sound, Minto Inlet and Dolphin and Union Strait.*

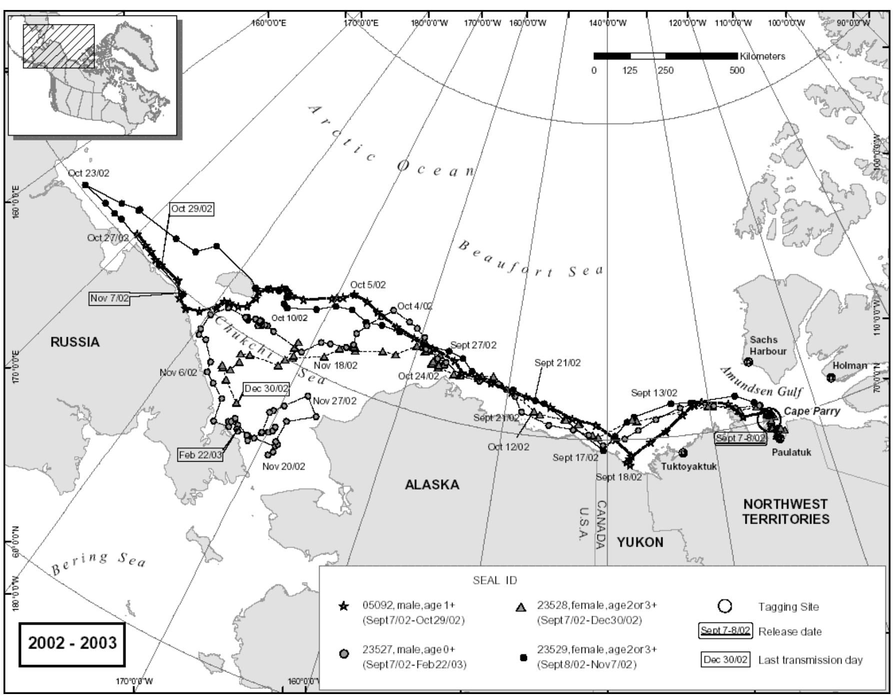


*Figure 26. Seal telemetry results for Ringed Seals tagged at or near Cape Parry in September 2002 ([www.beaufortseals.com/telemetry.htm](www.beaufortseals.com/telemetry.htm)).*

Ringed Seal preferred habitat generally occurs over the shallow productive waters of the continental shelf (Stirling et al. 1982). Stirling et al. (1993) defines suitable habitat for Ringed Seals based on several different sea ice types that can occur within the Beaufort Sea region. Within the Darnley Bay – Amundsen Gulf region, Stirling et al. (1993) defines the inner portion of Darnley Bay as stable fast ice with drifts and the offshore region near Cape Parry as moving ice. Sea ice habitat type within the offshore region between Banks Island and Cape Parry is known to vary between years depending on the distribution of leads and the size of the Cape Bathurst polynya (Stirling et al. 1993). The coastline of the Parry Peninsula is characterised by coastal pressure ridges where the ocean bottom drops quickly to depths of approximately 50 m at Cape Parry (Stirling et al. 1993). All of these areas within Darnley Bay are considered suitable habitat for Ringed Seals and are considered to be relatively important to seals in this area, however preferred habitat exists in a number of alternate locations within the Beaufort Sea LOMA (e.g., Prince Albert Sound; L. Harwood, pers. comm.).

Population estimates of Ringed Seals in the Beaufort Sea vary year to year. Heavy ice conditions can have a negative influence on primary and secondary productivity and reduce the numbers of, or disperse, prey species (Harwood and Stirling 1992). In years following heavy ice conditions, Harwood and Stirling (1992) observed declines in Ringed Seal density and a reduction in the number of pups. In contrast, limited ice cover and the early break up of land-fast ice would enhance productivity and the availability of food sources. However, these conditions would limit the amount of regional breeding habitat and could create circumstances where Ringed Seal pups are obligated to abandon their platform prior to the end of their normal nursing period (Smith and Harwood 2001). An interruption in lactation to pups can, in turn, affect the condition and growth of unweaned pups potentially resulting in high mortality (Harwood et al. 2000).

Ringed Seals eat a variety of invertebrates and fish. The most frequently consumed prey is crustaceans (copepods, mysids and amphipods) and Arctic Cod (Smith 1987, Community of Paulatuk et al. 2000). Species of prey consumed appears to vary seasonally and depend on availability, depth of water, and distance from shore (Smith 1987). 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). The pups examined in this same study were found to have consumed primarily invertebrates and secondly Arctic Cod (Smith and Harwood 2001). In fall and winter, fish are the most important dietary component of all age classes. In a recent study in Franklin Bay, researchers used acoustic technology to observe seals diving up to 200 m to feed on aggregations of Arctic Cod (Benoit et al. 2010).

Ringed Seals are very important to the Inuvialuit, who harvest them for subsistence, dog food, and their pelts which are used for clothing and crafts (Community of Paulatuk et al. 2000). Local traditional 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; Figure 25).

**Bearded Seals (*Erignathus barbatus*)**

Bearded Seals are widely distributed throughout the circumpolar Arctic but are considerably less abundant than Ringed Seals (Stirling et al. 1982, Stephenson and Hartwig 2010). They are usually solitary, have a patchy distribution (Smith 1981) and are typically observed in greater densities where the floe-edge and moving ice habitat occur (Stirling et al. 1993). In the Beaufort Sea and Amundsen Gulf, Bearded Seals show preference for shallow (25-75 m) shelf waters that are seasonally ice-covered (Stirling et al. 1977). Distribution appears to be strongly influenced by water depth, prey biomass and ice conditions (Stirling et al. 1977). During aerial surveys in the southeastern Beaufort Sea in 1974-1979, Bearded Seals were 1/16th as common in the counts as Ringed Seals (Stirling et al. 1982).

Bearded Seals prey on a variety of benthic and epibenthic organisms and can be characterized as generalists (Dehn et al. 2007). Finley and Evans (1983) found that Bearded Seals from the Canadian Arctic had high occurrences of fish, with gadids being most common. However, stomach contents have revealed varying occurrences and proportions of clams, shrimp, crabs, benthic invertebrates, and fish (Burns and Frost 1979, Lowry et al. 1980, Anotonelis et al. 1994, Hjelset et al. 1999, Dehn et al. 2007), suggesting that their diets are area specific, reflecting the local distribution and availability of prey (Dehn et al. 2007).

There is very little known regarding the population structure, abundance or productivity of Bearded Seals in Darnley and Franklin bays or Amundsen Gulf. Typically, aerial surveys that have sighted Bearded Seals in the southeastern Beaufort Sea are rare. Local traditional knowledge however, has identified 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; Figure 27). More specifically, the Amundsen Gulf (west) was identified by the community of Paulatuk as important habitat for pupping in late April and early May (Community of Paulatuk et al. 2000). Bennett Point was also identified by community members as a common location where Bearded Seals haul-out (Community of Paulatuk et al. 2000; Figure 27).

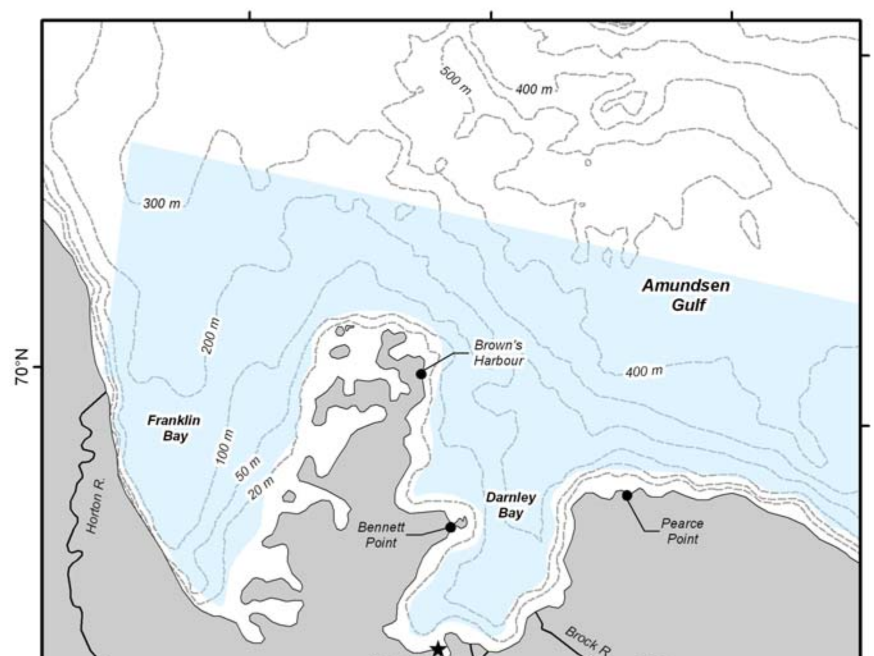


*Figure 27. Areas identified as important Bearded Seal habitat (blue) in the study area by local traditional knowledge (Community of Paulatuk et al. 2000).*

## Polar Bears (*Ursus maritimus*)

Polar Bears occurring in Franklin and Darnley bays belong to the Southern Beaufort Sea (SBS) Polar Bear subpopulation which extends from west of Wainwright, Alaska (approx. 160°W) to just east of Pearce Point, Northwest Territories, Canada (approx. 125°W; Figure 28). Current abundance estimates for the SBS indicate that there were about 1526 (± 315) Polar Bears in the subpopulation in 2006 (Regehr et al. 2006, 2007). Polar Bear management and harvest levels in the Canadian SBS fall under the jurisdiction of the Government of the Northwest Territories and are guided by the joint commissioners of the Inuvialuit-Inupiat Polar Bear Management Agreement (the *Agreement*) in the Southern Beaufort Sea. The *Agreement* was ratified by Inuvialuit hunters of Canada and the Inupiat hunters of Alaska in 1988. This *Agreement* provides annual quotas, defines hunting seasons, protection for denning bears and protection of females accompanied by young-of-the-year cubs (Brower et al. 2002). Brower et al. (2002) noted that the *Agreement* has been successful in ensuring sustainable harvest of Polar Bears. Current harvest levels are set at 80 bears/year (40 in Canada and 40 in Alaska), but are being reviewed in light of recent population information from Regehr et al. (2006), Regehr et al. (2007) and Hunter et al. (2007). Federally the Polar Bear is being considered as a Species of Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2008) and a listing decision from Environment Canada is expected.

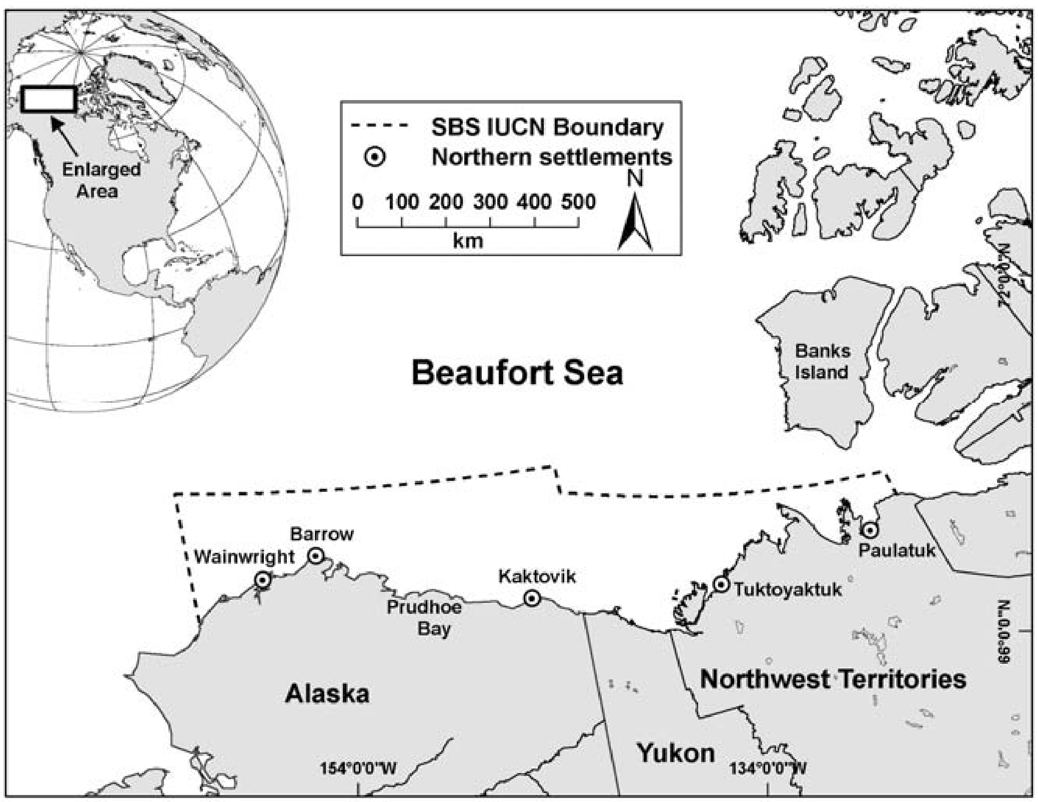


*Figure 28. Map of the SBS Polar Bear management unit established by the International Union for the Conservation of Nature and Natural Resources (IUCN) Polar Bear Specialist Group (Regehr et al. 2007).*

Polar Bears are among the most ice-dependent of Arctic marine mammals (Amstrup 2003, Laidre et al. 2008). Their life history and survival are intimately linked to the sea ice as it provides a platform for movement, mating and maternal denning and access to their primary prey, Ringed and Bearded seals (Stirling 2002). Polar Bear distribution and seasonal movements are determined principally by the variation in the availability of sea ice habitat and the distribution and abundance of their prey (Smith 1980, Regehr et al. 2010). In the SBS, Polar Bears feed predominately on Ringed Seals (young-of-the-year) and, to a lesser degree, Bearded Seals and Beluga (Stirling 2002, Theimann et al. 2008). Movement between geographic areas occur primarily in order to remain on ice for as long as possible (Stirling et al. 1993). Polar Bears can move long distances between geographic areas throughout the year but show seasonal fidelity to areas (Stirling 2002). In summer, when the sea ice is at a minimum, the majority of the bears from the SBS subpopulation either move offshore into the multi-year pack ice or north along the coast of Banks Island and the mainland (Stirling 2002; Figure 29). However, in recent years there has been an increase in the number of bears that spend the summer onshore in Alaska (Schliebe et al. 2008). Although Polar Bears can fast for long periods of time on land, hunting success in spring and early summer plays an important role in determining the condition and survival of individuals through the rest of the year (Stirling 2002). Polar Bears that remain onshore (primarily in Alaska) wait for landfast ice to reform in the SBS in fall, while those bears that have traveled north in summer with the retreating sea ice begin to move south from Banks Island toward the mainland coast and the Amundsen Gulf as the sea ice begins to reform (Stirling 2002; Figure 29) to occupy preferred habitats over the continental shelf (Durner et al. 2009).

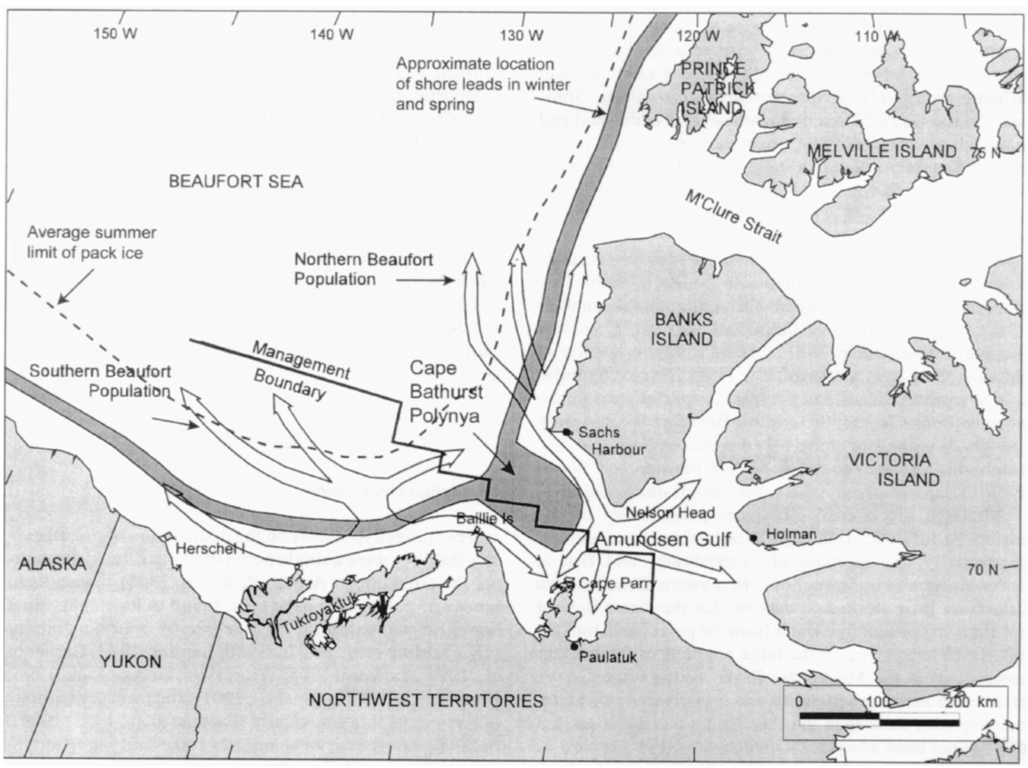


*Figure 29. Map of the Beaufort Sea indicating the distribution and seasonal movements of Polar Bears in relation to sea ice, leads and the Cape Bathurst polynya. The arrows indicate the southerly and easterly movement of bears during ice formation in the fall and in a northerly and westerly direction during ice break-up in the spring and early summer (modified after Stirling 2002).*

Polar Bears use a variety of sea ice types: from stable fast ice with drifted pressure ridges to areas near the floe edge and moving active ice (Stirling et al. 1993). In late winter and spring the densities of Polar Bears in the Beaufort Sea are highest near the floe edge and in areas of moving active ice than any other habitat (Stirling et al. 1993). Adult and sub-adult males, lone females and females with two-year-old cubs showed strong preference for these types of habitat possibly because: 1) it is easier to find a mate during breeding season (April-May); and 2) seals were likely abundant and equally accessible to all groups (Stirling et al. 1993). These preferred habitats for bears exist within the AOI and in particular just to the north of Cape Parry as a result of the oceanographic and meteorological processes that help maintain and form the Cape Bathurst polynya. The floe edge in this region of the Beaufort Sea typically extends along the mainland coast in Amundsen Gulf, west along the coast toward Alaska (Figure 29). Moving active ice is generally located to the north of the floe edge in the northern portion of both Franklin and Darnley bays and the Amundsen Gulf (Figure 29). This area is important for spring feeding for Polar Bears and also appears to be an area where adult male and females mate. In addition, depending on the prevalence of east winds during the spring, 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 29).

Although bears of various sex and age-classes show a preference for the floe edge and areas of active moving ice, similar densities of bears (primarily females with cubs) have been observed in landfast ice in association with drifted pressure ridges (Stirling et al. 1993). Stirling et al. (1993) suggested that these habitats may be important to cub survival by 1) keeping the cubs from swimming in open water (chills) (i.e., areas with active leads); and/or 2) by avoiding other bears, specifically males that may threaten their cubs (Stirling et al. 1993). Stable fast ice occurs in the southern portion of Darnley Bay although it is not known to what degree females with cubs-of-the-year use this area. Field notes and unpublished data from long term research in the SBS indicate that pregnant female bears den on the Cape Bathurst Peninsula and Baillie Islands and make use of the landfast ice in Franklin Bay in the spring to hunt Ringed Seals. The lack of scientific data for the Darnley Bay area should be supplemented by the collection and incorporation of traditional ecological knowledge relating to Polar Bear denning activity and movements with females and cubs-of-the-year in the spring.

Polar Bears differ from other ursids in that overwinter dormancy is limited to pregnant females that use maternity dens for reproduction (Ramsay and Stirling 1990). Over most of their circumpolar range, female Polar Bears make use of snow dens to give birth to and nurture their young. These reproductive sites 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 have been found frequently along the western and southern coasts of Banks Island (Stirling and Andriashek 1992), 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). Pregnant females enter the maternity dens in late October and the cubs are typically born between November and early January (Derocher et al. 1992). The distribution of dens is considered to be a function of several factors including the availability of suitable denning habitat (i.e., snowdrifts), sea ice conditions, den site fidelity and anthropogenic influences (Harington 1968, Schweinsburg 1979, Belikov 1980, Lentfer and Hensel 1980, Hansson and Thomassen 1983, Stirling and Andriashek 1992, Amstrup 2003). Although denning female Polar Bears are susceptible to disturbance there is a current lack of data on the amount of denning that is known to occur in Darnley Bay.

The importance of Darnley Bay and Amundsen Gulf to Polar Bears has been identified by the community of Paulatuk through their identification of Polar Bear harvesting in spring and winter (Figure 30). Subsistence harvesting and sport hunting both occur and quotas are followed according to territorial regulations and user agreements. Habitats specifically identified as important for Polar Bears by the community were areas offshore of Pearce Point, Canoe, Booth and Bear Islands and Cape Parry (Community of Paulatuk et al. 2000). These data are supported by field studies conducted by the Canadian Wildlife Service that have documented increased use of the identified areas by bears in spring. In addition to identifying important areas for Polar Bears, the community has raised concern with regard to the disturbance of sea ice habitat due to tanker traffic and climate warming and the impact on Polar Bears (Community of Paulatuk et al. 2000).

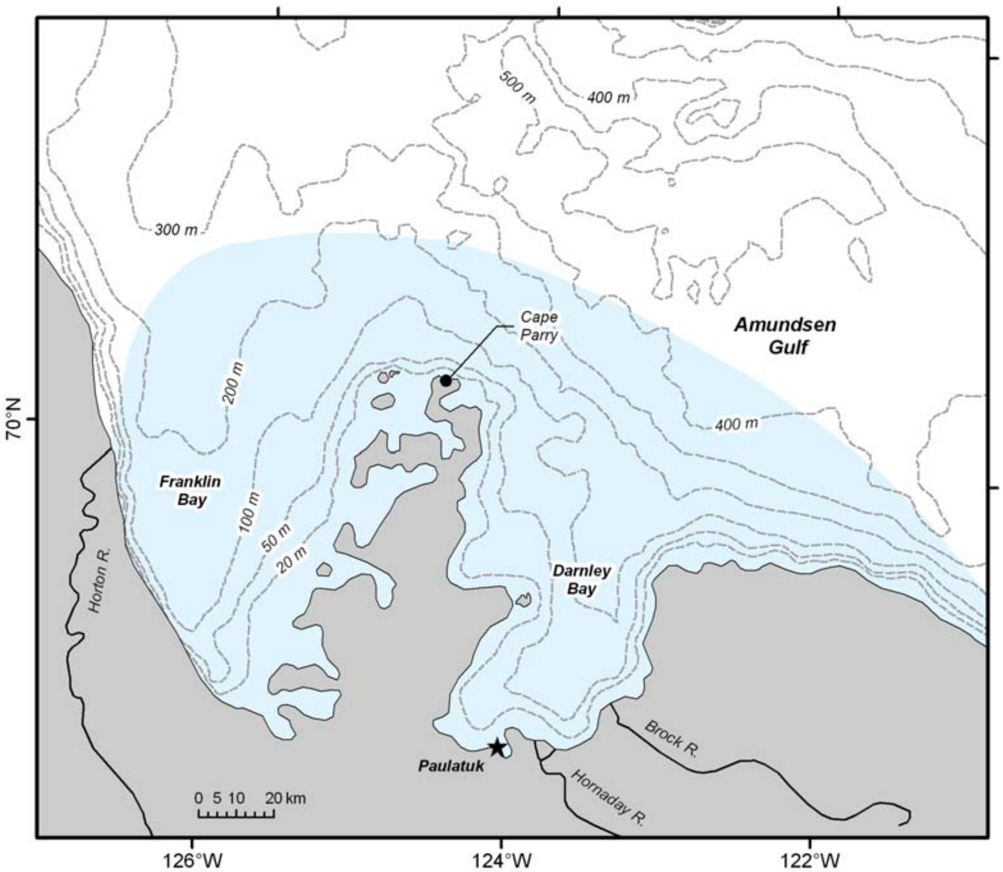


*Figure 30. Important Polar Bear spring and winter harvesting area identified by the Community of Paulatuk et al. (2000).*

Overall the area north of Cape Parry, in association with the Cape Bathurst polynya, represents an important area for Polar Bears from late spring through early summer, while landfast ice in Darnley and Franklin bays also likely represent important habitat for females with cubs-of-the-year.

## FISHES

Three principal aquatic habitat types are identified within the Darnley Bay-Amundsen Gulf area: 1) freshwater located at the mouth of the major river systems; 2) relatively warm, brackish waters located in nearshore coastal waters; and 3) colder marine waters located offshore. Each habitat type provides suitable habitat for distinct assemblages of fish species. The freshwater rivers and streams and the brackish nearshore, coastal waters provide habitat for anadromous fishes, while the offshore waters are used throughout the year by marine species (Craig 1984).

Fish are an important component to the food web, linking lower trophic levels with the higher trophic levels. Numerous marine mammals and birds rely on a variety of fish species as prey.

Several marine fish species inhabit Darnley Bay-Amundsen Gulf, however their seasonal movements and frequency to the area can be complex and are likely influenced by variations in temperature, salinity and species-specific biological requirements. Coad and Reist (2004) report 51 species from 13 families of marine fish and 27 species from 8 families of freshwater and anadromous fishes in the Beaufort Sea region which could also occur within Darnley Bay-Amundsen Gulf.

The offshore marine environment is considered to be a significant data gap in the Beaufort Sea LOMA. Few survey studies have been conducted in the offshore marine habitat for Darnley Bay. Research and fisheries information from Darnley Bay has been mainly focused on nearshore species considered to be of cultural and/or economic importance to local residents. Residents of the community of Paulatuk utilize the coastal waters of Darnley Bay and several identified lakes and rivers within the Parry Peninsula for subsistence harvesting of Arctic Char, Broad Whitefish and Pacific Herring (Community of Paulatuk et al. 2000). In 1990, the Paulatuk Hunters and Trappers Committee (PHTC), with the assistance of DFO and funding from the Fisheries Joint Management Committee (FJMC), established a long-term community-based monitoring program for the Arctic Char fishery in the Hornaday River. Results of this monitoring program have provided some insight into the nearshore fish species composition. As suspected they are similar to results from the Beaufort Shelf, with high numbers of Starry and Arctic flounder (*Platichthys stellatus, Liopsetta glacialis*; K. Howland, pers. comm.). Interestingly, there appears to be a lack of Sculpins present in the nearshore region which is unlike other typical Arctic nearshore communities (J. Reist, pers. comm.). Preferred habitat for flounder is a sandy environment, which is not the case for Sculpins and likely why they are not present in the nearshore environment (J. Reist, pers. comm.). Local traditional knowledge also reports that Langton Bay and Argo Bay are important habitat for Rainbow Smelt, Pacific Herring and Broad Whitefish (Figure 31).

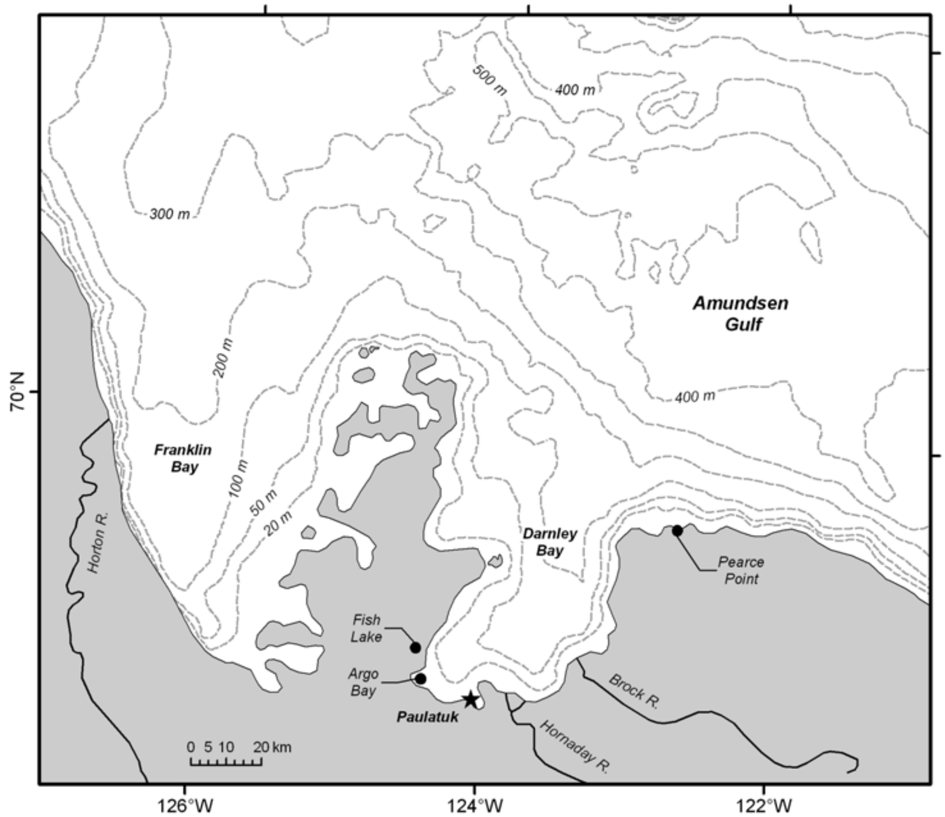


*Figure 31. Important areas for marine fish and areas identified by community members as important fishing locations (approximate location of Fish Lake indicated on map).*

## Arctic Char (*Salvelinus alpinus*)

Arctic Char are widely distributed throughout the eastern part of the Beaufort Sea and are an important subsistence resource to a number of Arctic communities. A number of populations exist within several freshwater systems in the Paulatuk area, including the Hornaday, Brock and Horton rivers and possibly Fish Lake (Harwood 2009; Figure 31). Arctic Char hatch in spring, and spend the first 3-4 years of their lives in freshwater rivers and lakes (Scott and Crossman 1973). In the spring, beginning at about age four or five, they migrate to the sea for the first time to feed in the nearshore, coastal marine environment and remain here throughout the summer months before returning to freshwater in late September or October (Scott and Crossman 1973).

The Hornaday River Arctic Char stock has supported a subsistence fishery since the 1940s. Commercial fishing existed in the area from 1968-1986 but was closed when a reduction in the population was noted. Recreational or sport fishing is limited in the area. Monitoring of the subsistence harvest takes place on an annual basis, primarily in late August during char upstream migration to over-wintering sites (Harwood 2009). The best available estimate of stock size is 16,000 (Harwood 2009). This estimate was extrapolated from data of a weir count conducted in 1986 and does not represent spawners (Harwood 2009). The Hornaday River Arctic Char population is currently managed according to the Paulatuk Char Management Plan (Paulatuk Char Working Group 2003).

Average annual subsistence harvest totals from the Hornaday River has decreased from 2,483 fish (1988-1997) to 1,691 fish (1998-2001) (Paulatuk Char Working Group 2003). Subsistence take of sea-run char from other systems are sporadic and low (e.g., <100 fish per year; Paulatuk Char Working Group 2003). Trends in the annual catch rate were reported to be in decline since 2003 (Harwood 2009), however there are no recent reports to suggest the decline has continued. Families from the community of Paulatuk are known to fish along both 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 (Figure 31). In general, the majority of fishing in the past was conducted in the Hornaday River since it is easily accessible and close to the community, however, there appears to have been a shift in this trend and some residents have adjusted their fishing locations to other systems, such as the Brock River (K. Howland, pers. comm.). This shift may be due to reduced catches in the Hornaday River estuary, which may be associated with infilling (sedimentation) of channels (K. Howland, pers. comm.).

Arctic Char feed predominantly on amphipods, mysids and fish (Sprules 1952, Scott and Crossman 1973). Stomach content analysis of Arctic Char provides evidence that Capelin are an important prey item available for Hornaday River char (L. Harwood, pers. comm.). These Capelin aggregations are thought to be located near the area of Pearce Point, however, this is not confirmed and requires investigation (L. Harwood, pers. comm.). Pearce Point is considered an important summer feeding area, located approximately 100 km northeast of the Hornaday River (L. Harwood, pers. comm.; Figure 31). However, the entire coastline of Darnley Bay is used as a nearshore corridor for migrating and feeding char. In spring the timing of ice break-up in the river determines when char have first access to their migration route to the ocean. This has been monitored in the past by a hydrometric water gauging station established jointly with DFO and Environment Canada from 1999-2007 (L. Harwood, unpubl. data). The median date of the freshet ranges from June 2 - 21 (Harwood 2009). Growth rates of Arctic Char have been increasing since 2002, which are likely related to an earlier date of ice break-up and therefore an increase in quality and quantity of prey (Walsh 2008, Harwood 2009).

**Arctic Cod (*Boreogadus saida*)**

Arctic Cod is considered to be an Ecologically Significant Species (ESS) in the Beaufort Sea LOMA (Cobb et al. 2008). They have a circumpolar distribution and are ubiquitous in arctic marine waters (e.g., Hunter 1979, Welch et al. 1993, Bradstreet et al. 1986, Benoit et al. 2008). Arctic Cod are known to consume calanoid copepods (Lowry and Frost 1981, Walkusz et al. 2011) and are considered to be an important link between zooplankton and top consumers, such as marine mammals and birds (e.g., Bradstreet et al. 1986, Welch et al. 1993). Despite the ecological importance of the species to ecosystem structure and function very little is known regarding their ecology, specifically in the offshore environment.

Arctic Cod are often associated with ice cracks and edges and are found either 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 have been observed nearshore, often in the depressions of bays in the Canadian Arctic (Welch et al. 1993, Benoit et al. 2008). During an over-wintering study in Franklin Bay from December 2003 to May 2004, Benoit et al. (2008) found that Arctic Cod were passively advected from the Amundsen Gulf into Franklin Bay and that aggregations formed at depth, likely to avoid surface-feeding seals and/or to take advantage of the warm Pacific waters. Total cod biomass estimates calculated for Franklin Bay (11.23 kg $m^{-2}$) would have satisfied the nutritional requirements of all mammalian and avian predators in the area (Benoit et al. 2008), demonstrating the ecological significance of this species.

During early life, epipelagic larvae and juveniles are reported to be concentrated at shallow depths <50 m on the Beaufort Shelf (Hunter 1979, Ponton et al. 1993, Chiperzak et al. 2003a,b,c, Sareault 2009) and often found to be abundant in the ice-free and relatively warm waters of annually recurring polynyas (Michaud et al. 1996). Arctic Cod have been sampled at a number of locations within Darnley and Franklin bays and the Amundsen Gulf, based on historical and current fish records (Figure 32).

Although there is limited knowledge specific to the area it is speculated that marine upwellings, recurrent polynyas, flaw lead features and ice-edges are important marine habitat for Arctic Cod. The open ocean and deep depressions within Darnley Bay are also likely important but data deficient.

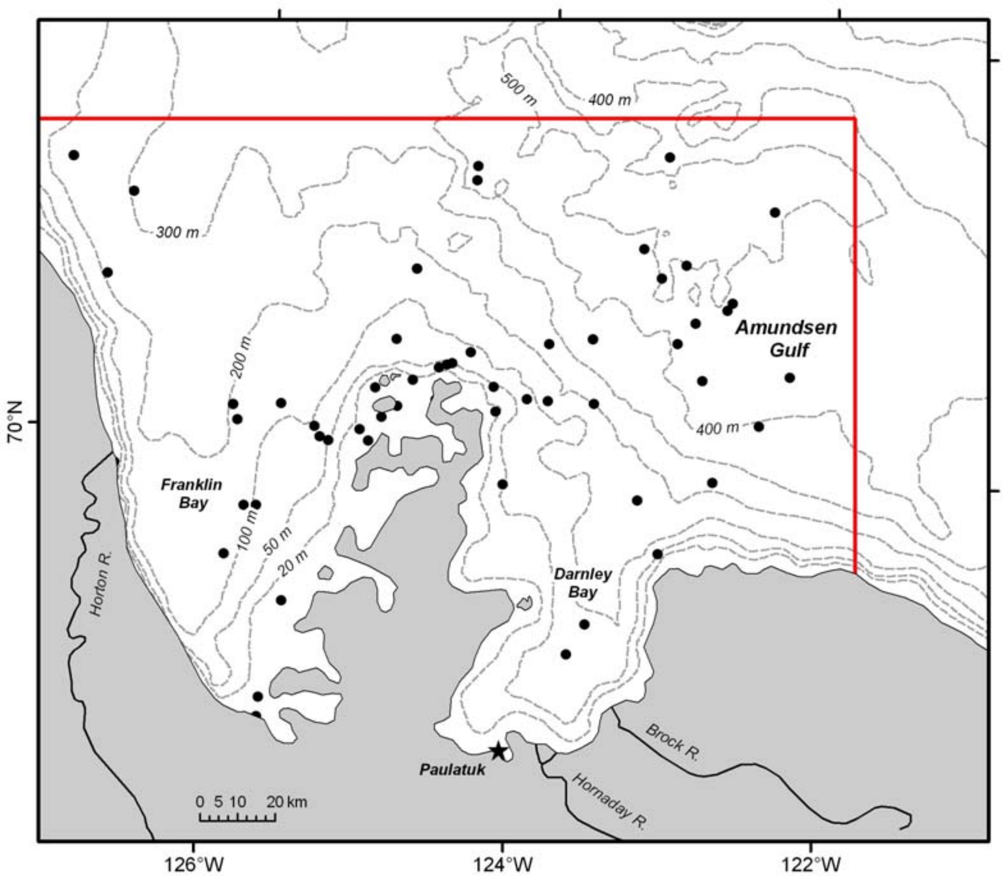


*Figure 32. Locations within the red boundaries where Arctic Cod have been sampled.*

## MARINE BIRDS

A wide variety of birds in the Canadian Arctic depend on marine habitat for breeding, feeding, and migration (Mallory and Fontaine 2004); they are widespread and can be found in substantial numbers in coastal, nearshore and offshore waters (Johnson and Herter 1989). In particular, significant numbers of birds migrate and stage along the open-water lead systems during spring (Alexander et al. 1997, Latour et al. 2008). The recurrent leads in the Canadian Beaufort Sea serve as an important migration corridor and staging area for nationally significant 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). The area immediately north of Cape Parry has been identified by the Canadian Wildlife Service (Environment Canada) as a key marine habitat (Mallory and Fontaine 2004; Figure 33).

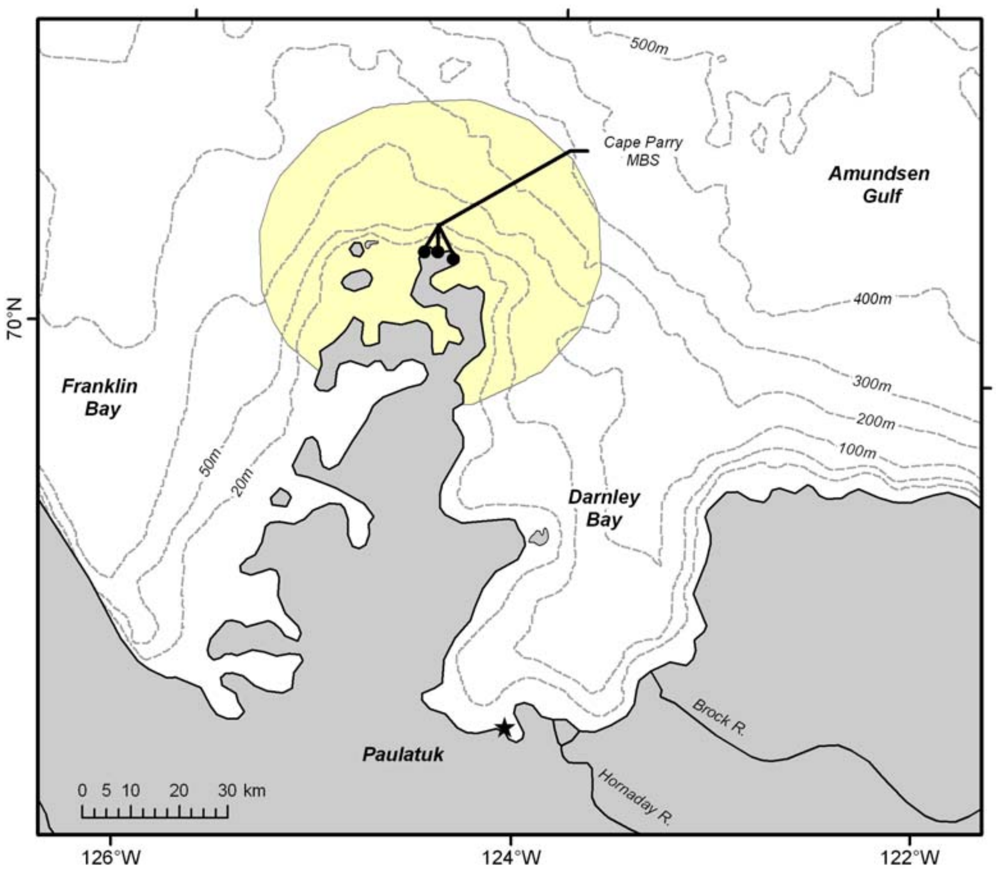


*Figure 33. Key Marine Habitat for Migratory Birds indicated in yellow and the Cape Parry Migratory Bird Sanctuary indicated in black as identified by the Canadian Wildlife Service, Environment Canada.*

Marine habitat north of Cape Parry is not only used as an important staging and migration corridor but also as a feeding area by a number of species that also utilize the terrestrial portion of Cape Parry as nesting habitat. There is a unique colony of Thick-billed Murres (*Uria lomvia arra*) nesting on the coastal cliffs of the Peninsula at Cape Parry (Johnson and Ward 1985); the only known breeding colony of this subspecies in Canada (Mallory and Fontaine 2004). Consequently, the area has been identified as key terrestrial habitat and was designated as a Migratory Bird Sanctuary (MBS) in 1961. Cape Parry is also a unique nesting site for Black Guillemots (*Cepphus grylle*); this is only one of two known colonies in the western Arctic (Johnson and Ward 1985, Latour et al. 2008). To a lesser extent, Cape Parry is also an important area for Common Murre (Johnson and Ward 1985). The Cape Parry MBS encompasses approximately 232 hectares and comprises three separate nesting sites on the Peninsula: 1) Police (West) Point; 2) Devon (Central) Point; and 3) East Point (CWS 1992; Figure 33). A complete list of species observed within the MBS can be found in CWS (1992).

Pelagic seabirds often require cliff habitat for nesting to avoid terrestrial predation. This type of habitat exists at only two locations in the southeastern Beaufort Sea: Cape Parry and Nelson

Head (Dickson and Gilchrist 2002). Dickson and Gilchrist (2002) observed that cliff-nesting seabirds only occupy the cliffs at Cape Parry suggesting that prey availability may be a factor in seabird nesting site preference (Dickson and Gilchrist 2002). Adult seabirds often prey on invertebrates at sea (Bradstreet 1982), but their chicks require fish to speed their growth rates during the short breeding season (Dickson and Gilchrist 2002). Thick-billed Murres are known to feed typically within a 30 km radius of the nesting sites (Mallory and Fontaine 2004) on small fishes, squid and large zooplankton (Gaston and Bradstreet 1993, Gaston and Hipfner 2000), and they can forage underwater to depths of 200 m (Croll et al. 1992, Falk et al. 2000). In the eastern Arctic, Gaston and Nettleship (1981) report Arctic Cod as the primary fish prey for seabird chicks however, changes in oceanographic and sea ice conditions often trigger shifts in the distribution of fish populations which are also reflected in changes in the dominant prey items of seabird diet (Gaston et al. 2003). The diets of Thick-billed Murres at Cape Parry could differ from the diets documented in the eastern Arctic since spatial variation is known to occur in murre diets (i.e., intercolony differences; Gaston and Bradstreet 1993).

## INFORMATION AND KNOWLEDGE GAPS

Much of the current understanding and knowledge for areas within the Beaufort Sea LOMA have strong geographical and seasonal bias, therefore literature and knowledge from the Beaufort Shelf was used to draw inference where information was limited for Darnley Bay. In addition, most research in the Canadian western Arctic has been typically conducted during the open-water season (summer) limiting our understanding during the fall to winter seasons. Researchers from the CCGS *Nahidik* did conduct work within Darnley Bay in the summer of 2008 and some of the preliminary results from this survey are presented in this report. In addition, one station was sampled in spring (April – May 2008) during the CircumPolar Flaw Lead (CFL) program which also revealed some interesting results for the study area (Mundy et al. 2009). The majority of research and monitoring for this area are related to Arctic Char and Beluga stocks and management of the Cape Parry Migratory Bird Sanctuary. There has been some interest from the oil and gas industry to use Wise Bay as a staging and/or overwintering site for equipment, however only a handful of internal reports have been produced to date and they were not accessed for this review.

Further study and analysis is needed to develop baseline knowledge for the following environmental components:

- 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;
- 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 MBS;
- 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.

## ECOLOGICAL MERITS AND SIGNIFICANCE OF THE AOI

Our current limited understanding of the structure and function the Darnley Bay ecosystem significantly limits our ability to conclusively identify areas for marine protection and develop associated conservation objective(s). Additionally, the Darnley Bay region exhibits high inter-annual and temporal variability and is under considerable change due to a warming Arctic climate, which can affect the relative importance of key habitat features at any point in time. Regardless, based on compiled ecological information for the Darnley Bay – Amundsen Gulf area, the following key ecosystem components were identified:

- 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 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.

Several other features were also identified as possible key ecosystem components though conclusive scientific data are not currently available to confirm their importance:

- Beluga that appear to exhibit a distinct foraging strategy and may show fidelity to the area;
- Arctic Cod, an Ecologically Significant Species (ESS), 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.

Within the Darnley Bay – Amundsen Gulf region, four areas appear to provide critical and/or important habitat for a number of species. These areas are presented in the following order of priority (Figure 34-36).

- 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.

Beluga, Arctic Cod, Bearded Seals, Ivory Gulls and Polar Bears also appear to play an important role in the Darnley Bay region and may benefit from protection of one or more of the identified priority areas.

Creating an MPA can enhance biological productivity and attract a variety of species to an area. However, it does not address stressors exerted on migratory population(s) outside of the MPA. In those cases, species management through other jurisdictional initiatives is needed in combination with habitat management within the MPA.

Depending on the location ultimately chosen, an 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.

## MEETING OBJECTIVES OF MPAS UNDER THE *OCEANS ACT*

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 fulfil the mandate of the Minister.

Designation of any one of the four identified priority areas would to a greater or lesser extent serve the combined purposes as described in Section 35 (Table 3).

*Table 3. Purpose(s) for which each of the four identified areas meet rationale for MPA designation under the Oceans Act.*

| 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) | ✓ | ✓ | ✓ | ✓ |

## DETAILED DESCRIPTIONS OF THE FOUR PRIORITY AREAS

### Darnley Bay Nearshore Migratory and Feeding Corridor

Arctic Char are an important resource and should be the primary focus of an MPA in Darnley Bay because the nearshore environment is critical for feeding and coastal migration of this species. Any associated environmental degradation in the area would likely have serious fitness consequences to Arctic Char populations in Darnley Bay. Arctic Char is an ESS in the Beaufort Sea LOMA as it is a major source of export/import of nutrients to/from the marine system. Protection of this habitat feature would serve to conserve and protect a number of other non-commercial fishery resources.

Arctic Char are dependent on the warm, freshened marine waters near the Hornaday and Brock rivers and the availability of prey in the river estuaries. The preferred feeding habitat is typically within the 5-10 m water depth in the nearshore coastal environment. There are several meteorological and oceanographic conditions that can influence water mass movements within Darnley Bay and, consequently, the semi-passive movements of char and their prey (e.g., Capelin). As a result, Arctic Char can also be found in the freshened portion of the water column further from shore.

The nearshore environment within Darnley Bay is maintained by the freshwater inputs from the Hornaday and Brock rivers (Figure 34). These brackish waters are critical for the physiology of Arctic Char because although this species can tolerate high salinities, they must undergo a gradual salinity change in order to acclimatize their body to marine waters. In addition, there exists unique overwintering habitat for Arctic Char within the Hornaday River delta. This habitat is potentially critical to the survival of an unknown portion of the overwintering population.

The Nearshore Migration and Feeding Corridor for Arctic Char in Darnley Bay should be given highest priority for protection. MPA boundaries for the corridor should be defined by the low-water mark to a water depth of 20 m, from the area indicated just north of Bennett Point to the area just east of Pearce Point, and include the brackish waters at the mouths of the Hornaday and Brock rivers (Figure 34). The defined area covers approximately 940 $km^2$ and is based on tagging data and habitat similarities. Designation for marine protection of this habitat could be used in combination with the existing management techniques to accomplish a variety of fisheries management objectives (e.g., Paulatuk Community Conservation Plan, the Beaufort

Sea Beluga Management Plan (BSSMP), the Paulatuk Community Arctic Char Fishery Management Plan).

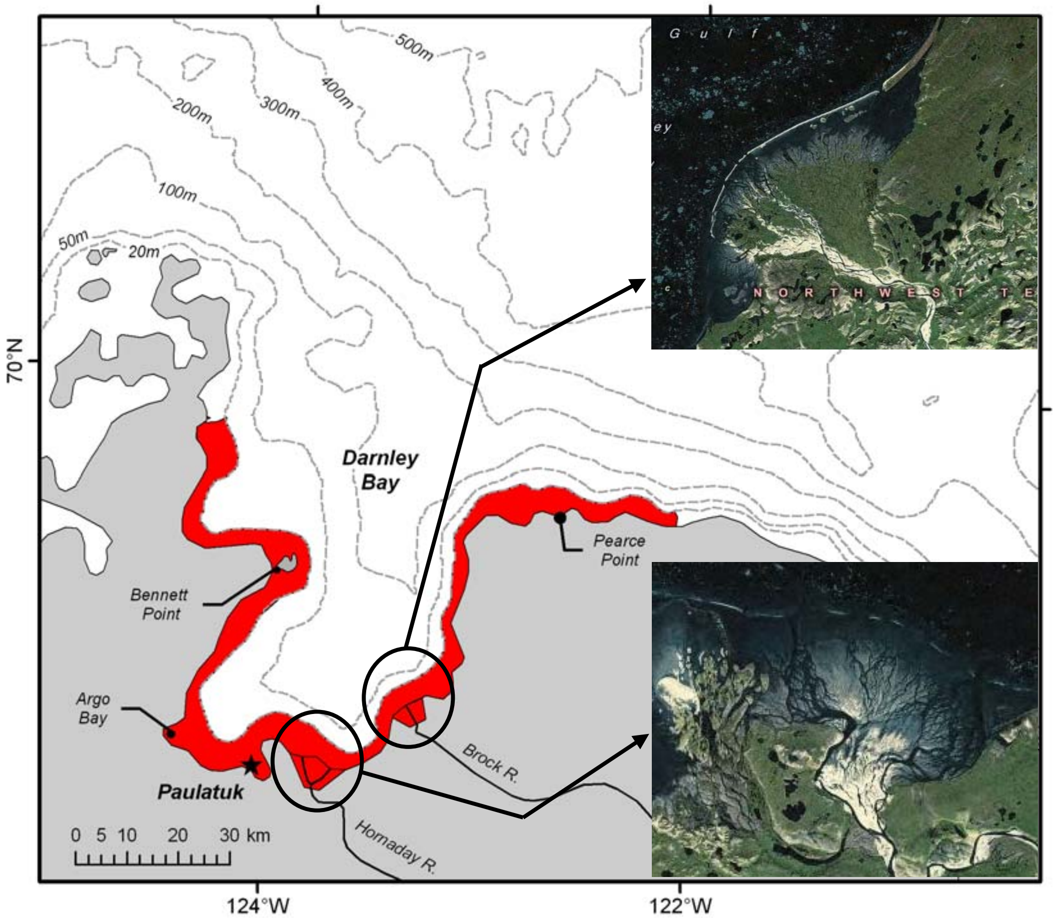


*Figure 34. Darnley Bay Nearshore Migration and Feeding Corridor is the highest priority area recommended for the protection within Darnley Bay. It would provide Arctic Char with important feeding and migratory routes adjacent to freshwater breeding habitats. Inset maps show detailed estuary images for the Brock (top) and Hornaday (bottom) rivers.*

## Cape Parry Offshore Marine Feeding Habitat

The marine habitat adjacent to Cape Parry is an area of high productivity. The marine currents, tides and the variable bathymetry result in upwellings that produce a rich marine environment. These waters provide important habitat for a number of species. During late winter and spring the polynya/sea-ice edge is used by marine mammals as a structural platform for hunting/feeding (e.g., Polar Bears, Ringed and Bearded Seals), or as a feature where preferred prey typically aggregate and provide important feeding areas for other key species (e.g., Beluga, Bowhead). The polynya/sea-ice edge is also an important staging area used by sea ducks. In late spring to early summer, during the open-water season, there also appears to be an abundance of key prey species for higher trophic level foraging (e.g., seabirds, Beluga). This offshore marine feeding habitat supports a unique seabird nesting area for Thick-billed Murres and Black Guillemots at the Cape Parry Migratory Bird Sanctuary (MBS). In late summer, King Eider and Common Eider use the marine waters as a staging and moulting area.

The polynya and sea-ice habitat off Cape Parry should be given second highest priority for protection. Limited scientific data are currently available for this region on which to base the exact boundaries. In the eastern Canadian Arctic, seabirds travel a median distance of 30 km from their nests to feed. Seabirds at Cape Parry may travel similar distances between their colonies and feeding areas (Mallory and Fontaine 2004). Assuming the protected area should be sufficiently large enough to accommodate the oceanographic and ecological processes that produce the rich marine environment there, as well as the species that depend on it, the recommended area should be at least 30 km in radius, centred on Cape Parry (Figure 35). The defined area covers approximately 3,000 $km^2$.

The conservation and protection of the habitat features within this defined area would serve to protect a number of non-commercial fishery resources that frequent the area and would assist other management plans within the area (e.g., Beaufort Sea Beluga Management Plan, Paulatuk Community Conservation Plan). In addition, a number of species that are considered Endangered or Special Concern also potentially utilize the habitat (COSEWIC 2009) including Bowhead, Polar Bear (Special Concern) and the Ivory Gull (Endangered). Conservation and protection regulations may provide additional protection to these species, particularly in circumstances where local activities may affect the quality of habitat.

Polynyas and flaw leads are defined as areas of reduced sea ice concentration and/or thickness that are important to biological and physical oceanography (Galley et al. 2008). These areas are known to generally exhibit enhanced primary production and higher upper trophic level populations. Polynya and flaw lead dynamics can ultimately alter both productivity and food web structure, hence biologically preconditioning the marine ecosystem in spring (Barber et al. 2010). Presence of marine mammals and seabirds at polynyas and flaw leads has historically been indicative of increased biological productivity, particularly if their presence persists into the summer months (Stirling 1997). The Thick-billed Murre colony is unique to the Beaufort Sea LOMA and although suitable nesting habitat exists elsewhere (Nelson Head, NT), the only colony within the LOMA is present at Cape Parry. This suggests that in late-spring and summer, when the success of Murre survival relies heavily on the success of adult foraging, the marine environment provides consistent and productive feeding habitat to the bird colonies. This productivity may be due to early spring preconditioning. Mallory and Fontaine (2004) report that Thick-billed Murres can forage as far as 200 km from the colony, however, a substantial amount of foraging occurs within 30 km. To date, no research has been conducted at the Cape Parry MBS with respect to foraging radius or dietary studies (B. Bartzen, pers.com.). Therefore, information for the foraging radius is based on research conducted at a number of other Thick-billed Murre colonies in the Canadian Arctic (Bradstreet and Brown 1985, Tuck and Squires 1955, Johnson et al. 1976, Gaston et al. 1985, Falk et al. 2001). Dragoo et al. (1989) found that a decline in the abundance of seabirds was matched by generally poor productivity in the marine environment. This suggests that differences in seabird population/distribution trends and prey species can be used as a proxy and provide clues to changes in ecosystem structure and function (Springer et al. 1996).

Protection of the integrity of sea-ice habitat in spring at Cape Parry is important to the productivity associated with the area in summer. This could be measured by the presence and success of seabird nesting colonies in the area. Evidence of the productivity of the region is also based on the occurrence of a number of species in the area year-round. Ringed Seals, Polar Bears, Beluga and Bowhead are all present to some extent in this area. Although aggregations themselves are not unique, presence of these marine mammals suggests there may be enhanced productivity and a number of food web interactions. Frederiksen et al. (2006) suggest that understanding the relative importance of top-down and bottom-up effects are critical for predicting impacts on top predators. It is currently unknown whether ecosystem structure and function (i.e., presence of species) is driven by food abundance, therefore the recommended area for protection is based on the general range of foraging for Thick-billed Murres in summer.

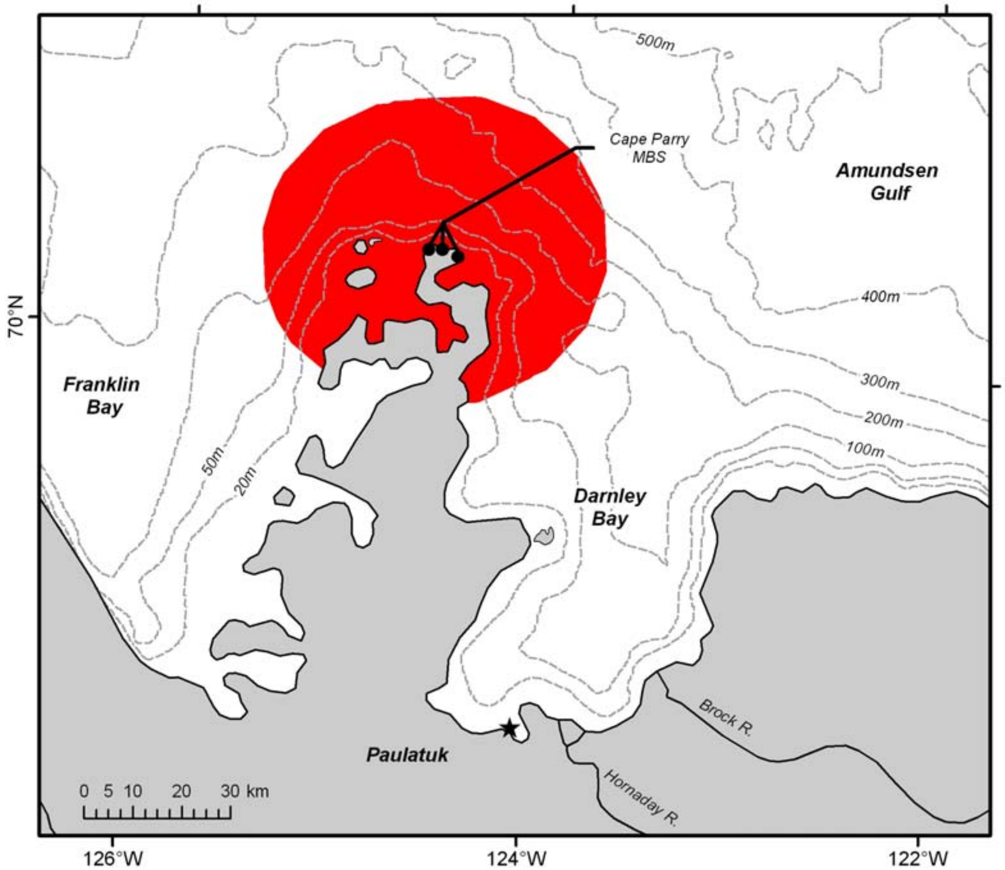


*Figure 35. Cape Parry Offshore Marine Feeding Habitat is the second highest priority area recommended for protection. Maintaining ecosystem productivity and marine feeding in these offshore waters is a conservation priority in order to maintain the existence of the unique seabird colonies nesting at the Cape Parry Migratory Bird Sanctuary (MBS). This rich marine environment also supports other higher-trophic species (e.g., Beluga).*

**Darnley Bay Offshore Ice-edge Habitat**

The Amundsen Gulf polynya and associated flaw lead system is a highly productive area offshore of Darnley and Franklin bays during late winter to spring. It drives productivity in the region and includes both fast-ice edges at the mouth of both Franklin and Darnley bays. The receding (melting) fast-ice edge habitat has long been recognized as a site of potentially enhanced biological productivity (Smith and Nelson 1986) and upwelling resulting from favourable winds along the sea-ice edge can also cause aggregations of prey and their predators (e.g., Beluga, Bowhead, Arctic Cod). In addition to the ice-edge, locations where isobaths diverge, such as along a steep slope, both wind and bathymetry can also play a role in producing variable and inconsistent upwellings along the continental coast near Pearce Point (W. Williams, pers. comm.). These areas are not unique to the Beaufort Sea LOMA but are important since they have been shown to bring nutrient-rich waters to the surface and allow for additional primary production in the region (Williams and Carmack 2008). The habitat is an important seasonal feature in Darnley Bay-Amundsen Gulf in spring, however, since it is a seasonal feature the timing and distribution of productivity can be highly variable.

A number of non-commercial species would be attracted and utilize the productivity that may be associated to the feature when upwelling conditions are favourable (e.g., prolonged and persistent easterly winds). Similar to the Offshore habitat at Cape Parry, Bowhead and Polar Bears (Special Concern) would opportunistically frequent the area for foraging and hunting, while the possibility that the Ivory Gull (Endangered) may be present in the area as well during this season. The boundaries for this area were determined based on the approximate location of the fast-ice edge (CIS 2002; Figure 36) and observations made during Bowhead aerial surveys conducted in the region. The boundaries for this area are dynamic and difficult to define since there is a high degree of inter-annual and seasonal variability. The defined area covers roughly 5,500 km$^2$.

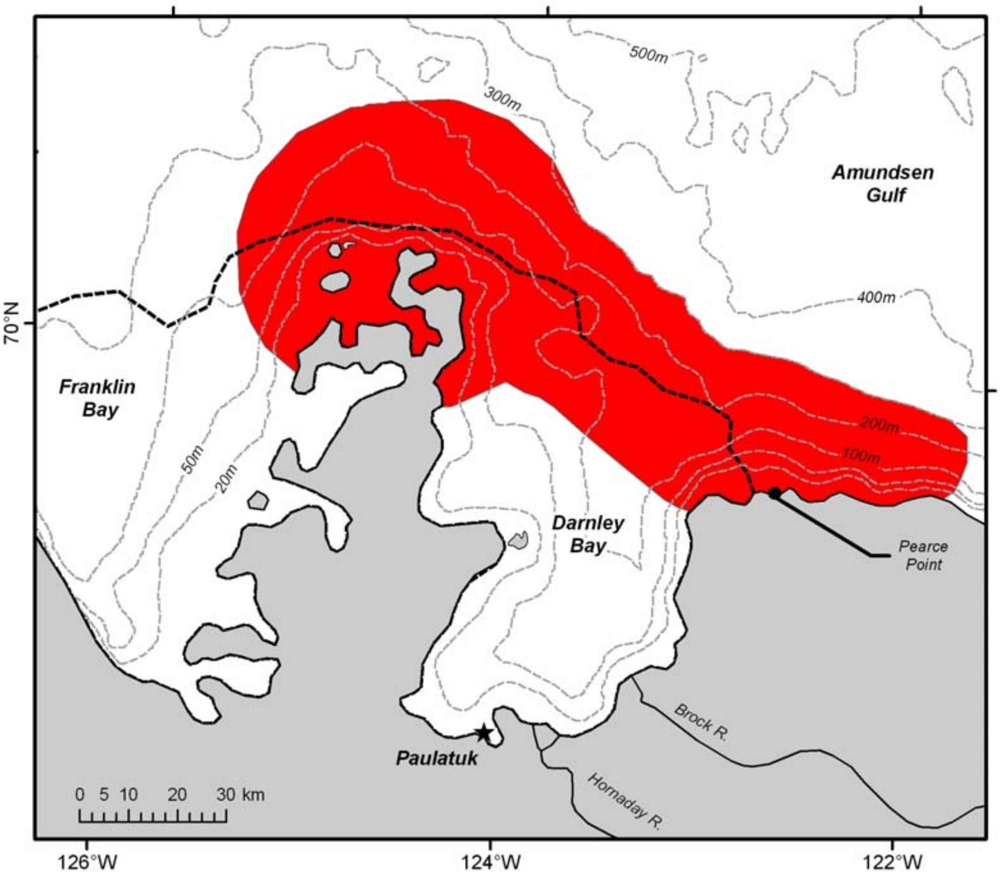


*Figure 36. The Darnley Bay Offshore Ice-edge Habitat is recommended for protection. Maintaining ecosystem productivity and marine feeding in these offshore waters is a conservation priority in order to maintain foraging areas for a number of key species. Dashed line shows approximate location of the fast-ice edge (CIS 2002).*

## Kelp Beds

Traditional knowledge indicates there are kelp beds near Argo Bay and in Wise Bay (Figure 15) and suggests there may be others that exist along the coastline of Darnley Bay. Kelp beds within the Beaufort Sea LOMA are considered rare and unique. The closest comparison is in

Alaska at Stefansson Sound (Boulder Patch) and areas within the Canadian Eastern Arctic (e.g., Resolute, Igloolik). Kelp beds are known to fulfill many diverse habitat functions in other coastal oceans, providing three-dimensional space, protection and food for potentially unique and/or diverse communities. They may also serve as important spawning habitat or nursery areas for juvenile life stages for some species of fishes. Identification of the exact location and species of kelp in Darnley Bay is necessary before they could be fully considered a key component of an MPA under the *Oceans Act*.

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