Kiggavik Project

Final Environmental Impact Statement

Tier 3 Technical Appendix 7A
Marine Environment Baseline

September 2014

History of Revisions

Revision Number	Date	Details of Revisions
01	December 2011	Initial release Draft Environmental Impact Statement (DEIS)
03	September 2014	FINAL Environmental Impact Statement

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Abbreviations

ASTIS ....Arctic Science and Technology Information System
CASES...Canadian Arctic Shelf Exchange Study
COSEWIC....................................... Committee on the Status of Endangered Wildlife in Canada
CWS .... Canadian Wildlife Service
DFO ....Fisheries and Oceans Canada
ELT ....Emergency Locator Transmitter
EPIRB ....Emergency Position Indicating Radio Beacon
HTO .... Hunters and Trappers Organization
GPS ....Geographical Positioning System
IBA ....Important Bird Area
IUCN ....International Union on the Conservation of Nature
IQ .... Inuit Qaujimajatuqangit
LSA ....Local Study Area
MBS ....Migratory Bird Sanctuary
MMO ....Marine Mammal Observer
NWMB .... Nunavut Wildlife Management Board
NRI.. Nunavut Research
RSA .... Regional Study Area
RWO .... Regional Wildlife Organizations
SARA .... Species at Risk Act

1 Introduction

1.1 Overview

AREVA Resources Canada Inc. (AREVA) is proposing a uranium mining and milling operation in the Kivalliq region of Nunavut, approximately 80 km west of the community of Baker Lake. The Project will require marine transportation of supplies to the mine and mill facilities during the open-water season.

Proposed marine transportation routes include:

- Marine shipment of fuel and dry cargo via ocean going vessels through Hudson Strait to Chesterfield Inlet. The cargo would then be lightered into barges or smaller self-propelled vessels in Chesterfield Inlet and delivered to the final destination in Baker Lake.
- Marine shipment via ocean going tug/barges from southern ports direct to Baker Lake.
- Marine shipment via ocean-going vessels through Hudson Strait and Hudson Bay to Churchill. The cargo would be transhipped from Churchill to Baker Lake via tug and barge. A rail link connecting to major southern railways is also available for shipping fuel and dry cargo to Churchill.

Shipping activity has the potential to disturb marine mammals, primarily through underwater sound production. Sound produced by vessels propagates horizontally and under certain conditions, can be detected by marine mammals at considerable distances from the area of operation (Richardson and Malme 1995). Marine mammals, birds, and fish are important cultural and subsistence resources to Nunavummiut and will potentially be affected by Project activities. The focus of this report is to develop an understanding of the baseline ecology of the marine environment and the presence and seasonal distribution of marine species in the Chesterfield Inlet, western Hudson Bay and Hudson Strait regions. Information presented in this baseline report will be used to support the environmental assessment for the Project.

1.2 Purpose

This report describes baseline conditions of the marine environment in the Project area to support the environmental assessment process. Most of the available information on habitat use by marine mammals, birds, and fish in Hudson Bay is not extensive or recent. The objectives of the Marine Environment Baseline studies were:

Objective 1: To collect available literature, Inuit Qaujimajatuqangit (IQ) and other expert information on marine mammal, bird, and fish habitat use and distribution near Chesterfield Inlet and in Hudson Bay and Hudson Strait;

Objective 2: To conduct focused collection of field data on seasonal marine mammal distribution, habitat use and relative abundance near Chesterfield Inlet in 2008; and

Objective 3: To collect field data on seasonal marine mammal distribution, habitat use and relative abundance along the proposed Hudson Bay vessel routes in 2009 (coastal and offshore regions).

1.3 Scope

This report describes the Project setting and study areas, methodology used to collect existing information and field data, results of the literature and field programs, and discussion and conclusions on marine mammal use of Chesterfield Inlet and the proposed vessel transport routes.

2 Setting

The Kiggavik Project is located in the Kivalliq Region of Nunavut. The closest settlement to the Project site is 80 km east at Baker Lake. Chesterfield Inlet is the next community 190 km east of Baker Lake. Marine shipping involves transporting supplies to Baker Lake along the west coast of Hudson Bay, from Churchill through Chesterfield Inlet, and from Churchill and Chesterfield Inlet through Hudson Strait to southern ports. Shipping will only occur during the open water season.

The Project is located in the northwest part of the Hudson Bay marine ecosystem. This ecosystem extends over a very large geographical area including James Bay and Hudson Bay. It is bounded in the east by the coast of Québec, in the south by Ontario and Manitoba, and in the west by Nunavut.

The ecosystem receives Arctic marine water input from Foxe Basin and freshwater runoff from a catchment basin fed by several large rivers, including the Churchill and Nelson (Stewart and Lockhart 2005a). The extreme southern penetration of Arctic marine water is a unique characteristic of Hudson Bay and contributes to the unique ecosystem. For example, the presence of Arctic water enables polar bears to live and breed at relatively southern latitudes. Because of its large extent, the ecosystem offers a broad range of habitats that are used year-round by a variety of arctic and sub-arctic wildlife, and seasonally by many migratory birds, mammals, and fish.

3 Study Areas

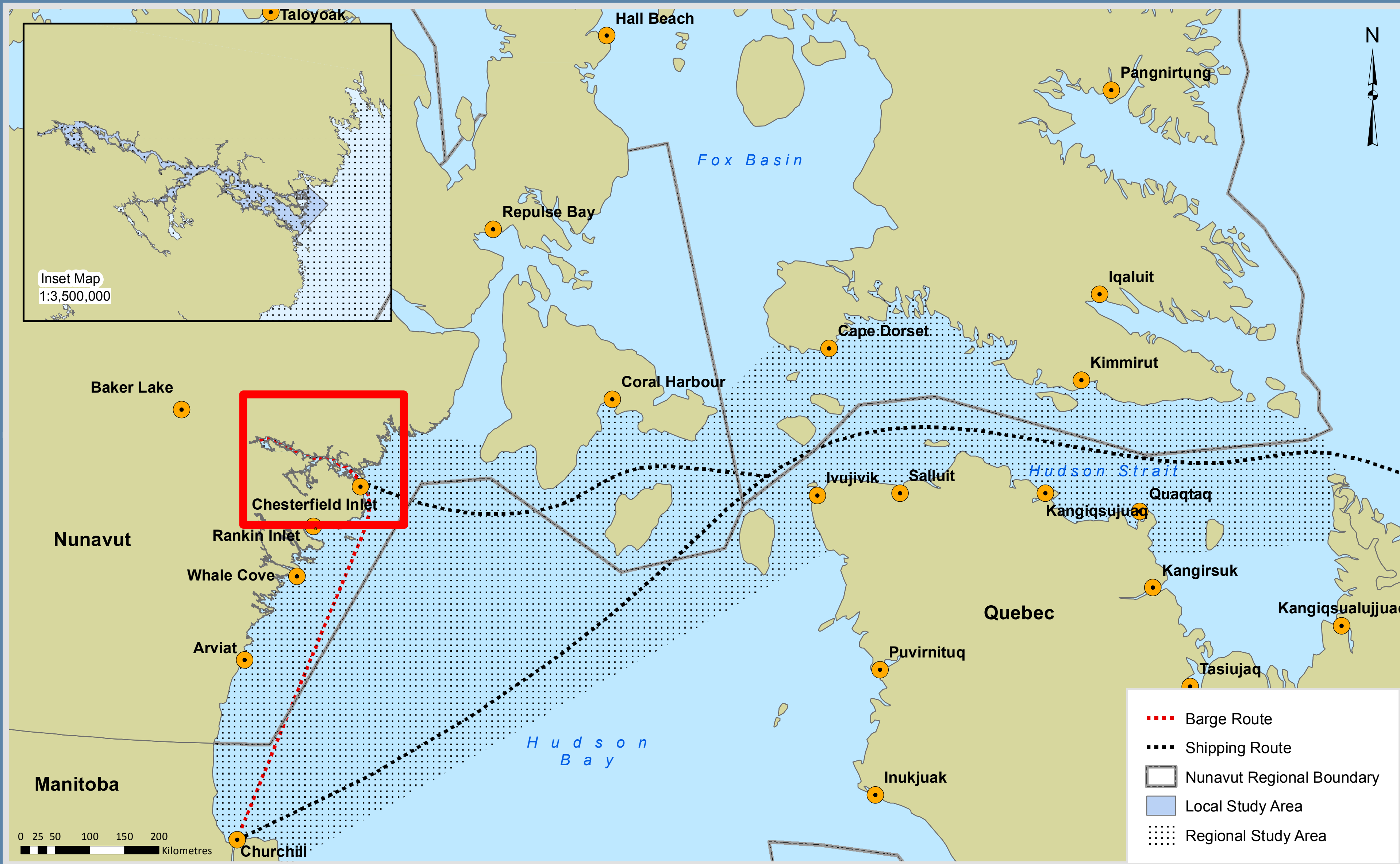
The study area for this project was divided into a local study area (LSA) and a regional study area (RSA) to characterize the marine environment of Chesterfield Inlet and along the planned vessel routes respectively. Two field programs (2008, 2009) were conducted in these study areas to supplement existing data on marine mammals. Baseline information for other aspects of the marine environment was collected from available literature.

3.1 Local Study Area

The LSA includes marine waters of Chesterfield Inlet and the adjacent coastal and offshore regions at the mouth of Chesterfield Inlet where measureable effects from project specific marine vessel traffic are most likely to occur. This area includes portions of the shipping route where marine vessels will be transiting to and from the main shipping routes in Hudson Bay (see Figure 3.1-1).

3.2 Regional Study Area

The RSA includes the LSA and extends beyond to encompass the shipping route in Hudson's Bay between Churchill and Chesterfield Inlet and the shipping route through Hudson Strait to the extent of Nunavut Territorial waters (Figure 3.1-1). The RSA encompasses the zone where project related vessels are reasonably likely to have a measureable effect and have the potential to act cumulatively with other projects.



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Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, Areva Resources Canada Inc.*

FIGURE 3.1-1
MARINE ENVIRONMENTAL STUDY AREAS

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4 Methods

Because the majority of the proposed project related marine transportation is expected to occur between Churchill, Chesterfield Inlet, and Baker Lake during the open water season only, the marine environment literature review and field surveys are primarily focused on the Chesterfield Inlet and Western Hudson Bay regions.

4.1 Literature Review

Standard literature search techniques were used to collect information on the marine environment in the LSA and RSA. The literature databases that were searched included those of:

- Federal Government agencies (e.g., Fisheries and Oceans Canada, Canadian Wildlife Service, Environment Canada);
- Government of Nunavut agencies (e.g., Department of Environment, Wildlife Research Group, Parks);
- Territorial research organizations and institutes (e.g., Nunavut Research Institute (NRI), Prince of Wales Northern Heritage Centre);
- Nunavut Wildlife Management Board (NWMB), Regional Wildlife Organizations (RWOs) and local Hunter and Trapper Organizations (HTOs);
- Universities and Colleges (e.g., ArcticNet, Canadian Arctic Shelf Exchange Study (CASES), Nunavut Arctic College, the Arctic Science and Technology Information System (ASTIS) database, International Polar Year and Arctic Institute of North America.

4.2 Marine Mammal Field Surveys

4.2.1 Aerial Surveys

Information gathered on presence/absence, abundance and migration timing of marine mammals from the literature, expert knowledge and local input was used in the design of the 2008 and 2009 open-water field programs.

4.2.1.1 Aerial Survey Design – 2008

The 2008 marine mammal aerial survey was designed and optimized to determine encounter rates and spatial variability of marine mammal habitat use in and near Chesterfield Inlet. The survey program covered an area of 1,628 km^2 in Chesterfield Inlet and adjacent coastal and offshore regions (Figure 4.2-1). Coastal regions were considered to be 5 km or closer to shore. Areas greater than 5 km from shore were considered offshore regions. The objective of the aerial survey was to describe marine mammal use of Chesterfield Inlet and adjacent areas during the open-water period.

A parallel transect strip survey design [Distance 5.0™ (Thomas *et al.* 2006)] was chosen to provide statistically meaningful data on the abundance and distribution of marine mammals within the study area. The coverage probability of the study area was designed to represent 20% of the total area, assuming a 1-km strip width (2-km strip width in total to account for both sides of the aircraft).

Fourteen evenly spaced (10 km) transects were delineated, orienting northwest to southeast and perpendicular to the shoreline (Figure 4.2-1). The location of the starting transect was randomly generated using Distance 5.0™ software. Transects ranged from 31 to 92 km in length (generated by the software) depending on the distance from shore required to cover the entire study area. The total length of all 14 planned transects combined was 737 km over an area of 1,629 km^2.

The survey was designed for replicate coverage of all 14 transects five times, over a five- to seven-day period (737 km of planned daily survey effort). Open-water surveys were planned to coincide with likely marine mammal presence in early to mid-September and to avoid limitations associated with weather delays in late-September and October.

Surveys were flown only when Beaufort Sea states were 0 (mirror smooth and glassy): 1 (small wavelets without crests); 2 (smooth wavelets with crests that do not break); or 3 (gentle breeze, large wavelets with crests that are beginning to break). In the event of inclement weather or sea states of greater than 3, the survey of off-shore transects was abandoned in favour of improved visibility along the shore.

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Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, Areva Resources Canada Inc.*

FIGURE 4.2-1
MARINE MAMMAL SURVEY AREA
AND PLANNED TRANSECTS
FOR THE 2008 AERIAL SURVEYS
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4.2.1.2 Aerial Survey Design – 2009

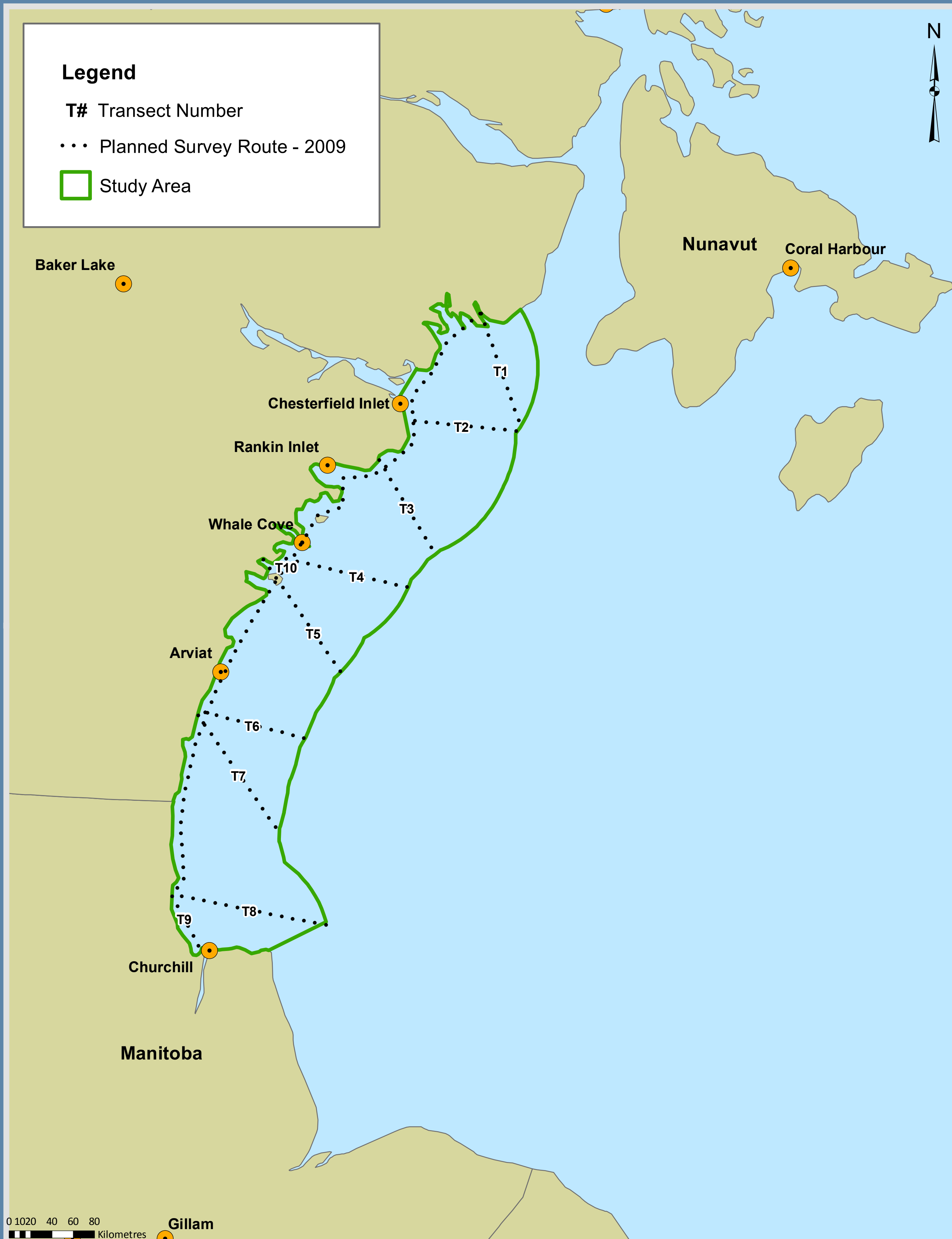
The main objective of the 2009 aerial survey program was to provide seasonal documentation of the distribution of marine mammals in the study area, which includes the shipping corridor between Churchill and Chesterfield Inlet. Portions of the regional study area were surveyed in 2009 to complement the 2008 survey and further describe large scale marine mammal use of Project shipping routes. The surveys covered 76,000 km^2 of the proposed vessel routes between Churchill and Chesterfield Inlet (Figure 4.2-2). Transects extended up to 100 km offshore to capture the extent of potential tug/barge routing.

A zigzag survey design was chosen to provide data on the offshore distribution of marine mammals within the study area. A separate design, which involved surveying a single transect adjacent and parallel to the coastline, was used to gather data on the coastal distribution of marine mammals. Percent coverage of the study area was designed to represent 6% of the total area, assuming a one-km strip width (two-km width in total to account for both sides of the aircraft).

Nine transects oriented diagonally across the study area were delineated (Figure 4.2-2). The location of the starting transect was randomly generated using Distance 5.0™ software. Planned transects ranged from 60 to 100 km in length. The total length of all transects, not including the coastal survey, was 1,600 km over an area of 76,000 km^2. The study was designed to replicate the survey coverage five times over a period of five days.

Surveys were timed to:

- Survey the study area immediately after ice breakup at the start of the open-water period (a period during which little is known about beluga presence/absence, abundance or distribution);
- Include periods of likely beluga whale presence in the summer and early fall to understand abundance and distribution within the study area; and
- Avoid limitations associated with inclement weather and high sea states in later September and October (as described in Section 4.2.1.1 above).



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Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, Areva Resources Canada Inc.*

FIGURE 4.2-2
MARINE MAMMAL STUDY AREA
AND PLANNED TRANSECTS
FOR THE 2009 AERIAL SURVEYS
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4.2.1.3 Equipment

A DeHavilland Twin Otter, specially outfitted with bubble windows, was used to conduct the surveys (Photo 4.2-1). Global positioning system (GPS) data were acquired via a Garmin 76Cx GPSMAP® handheld GPS receiver, placed on the dash of the aircraft. GPS track data were recorded every five seconds throughout the survey. GPS track points provided data that included input time, latitude, longitude and altitude with accuracy to within 3 m.

Photo 4.2-1 Twin Otter Aircraft Chartered for the Aerial Surveys

Each of the four observers (two primary and two secondary) had a digital wristwatch synchronized with the GPS unit, an Olympus© WS-331M digital voice recorder to record sightings and environmental data, and a Sunnto© inclinometer to record the angle of the sighting from the aircraft (thus allowing a calculation of lateral distance from the aircraft track-line).

Air speed was maintained at 185 km/hr while on transect. Altitude was maintained at 305 m (dependent on weather and visibility). Transect start and end points were programmed into the aircraft's navigation system prior to the start of the survey and flight position was determined by the pilot and co-pilot using the aircraft's GPS navigation system.

Onboard safety equipment included a portable Emergency Position Indicating Radio Beacon (EPIRB) attached to an 8-person automatically inflating life raft, an Emergency Locator Transmitter (ELT) installed in the aircraft, a 21-person survival kit and Mustang® immersion suits for each survey crew member, each equipped with a personal EPIRB device.

4.2.1.4 Survey Crew

The survey crew was comprised of five individuals: two primary observers, two secondary observers (local assistants) and a survey navigator (crew lead). The two most experienced marine mammal observers (MMOs) on the aircraft typically occupied the primary observer positions (Photo 4.2-2). Primary observers sat in the forward right and left seats, and the environmental and sightings data they collected were used for analyses. Secondary observers sat in the rear right and left seats and independently recorded the same data as the primary observers. Their data were to be used as a back-up should the primary observer data be lost for any reason. The secondary data were also compared to those collected by the primary observers to identify any whales missed by the primary observers. Observers regularly took breaks (in between transects) to minimize fatigue and optimize visual survey quality.

A list of all the observers involved in the 2008 and 2009 aerial surveys is provided in Table 4.2-1.

Photo 4.2-2 Primary Observer (Owen McHugh) and Secondary Observer (Gary Ippiak) Scanning for Marine Mammals. AREVA representative Barry McCallum in third rear position.

Table 4.2-1 List of Aerial Survey Crew Members in 2008 and 2009

Year	Crew Lead	Primary Observers	Secondary Observers*
2008	Todd Goodsell	Janine Beckett Mark Fraker	Andre Tautu Ron Alikashuk Don Mimialik
2009	Ben Wheeler	Marina Winterbottom Owen McHugh	Gary Ippiak Don Mimialik
NOTE: * Only two secondary observers were on board at a time			

4.2.1.5 Data Collection – 2008

Primary observers concentrated the survey effort within 1 km of the aircraft (between approximately 20 and 70 degrees from the horizontal). Upon observation of a marine mammal, the species, the number of animals, and the behaviour of animal(s) were recorded with personal voice recorders. When a large aggregation of animals was spotted, or identification was not initially possible, the aircraft temporarily left the transect line in order to collect more information. If mammals were detected beyond the 1 km survey distance, primary observers measured and recorded the angle of inclination to each sighted animal (when the initial sighting location was perpendicular to the aircraft).

Environmental conditions were recorded (e.g. weather, sea state, visibility, and glare). Weather categories were described as clear, partly cloudy, overcast, fog, mist, light rain, moderate rain, heavy rain or snow. Sea state was estimated using a modified Beaufort Wind Force Chart. Observers estimated Beaufort wind force using this chart and correlated the wind speed to a corresponding sea state using a table summarizing the Beaufort Wind Force Scale and the corresponding Sea State Scale.

4.2.1.6 Data Collection – 2009

At the start of each flight, each observer was issued an inclinometer, wristwatch (synchronized with GPS), digital voice recorder and coding 'cheat sheets' (Appendix A).

While surveying, the observers were responsible for recording the following information:

1. **Environmental Conditions:** Recorded every two minutes and at the end of each transect:
   a. **Weather:** General comments on ambient conditions (e.g., cloud cover, presence of precipitation, fog, etc., as listed in Section 4.2.1.5 above);
   b. **Ice type and percent cover:** Ice presence/absence. Percentage of ice cover in field of view;
   c. **Beaufort Wind Force:** Beaufort scale number (as described in Section 4.2.1.5 above);
   d. **Glare:** Effect of glare on field of view (none, moderate or severe); and
   e. **Sightability:** How easily a whale be sighted based on the interaction of factors listed above (excellent, good, moderately impaired, severely impaired or impossible).

Recording animal sightings was always the priority task; if sightings were frequent, observers were instructed to suspend recording of environmental conditions until fewer animals were seen.

2. **Sightings:** Information on a sighting was recorded the instant a marine mammal was spotted, but the time of the sighting was recorded when the animal was perpendicular to the aircraft. Critical information recorded was time, species, number of animals and inclinometer angles. When possible, additional details were also recorded:
   a. **Time:** Local time, based on the 24 hour clock, when a sighting was observed. Time of observations was linked with GPS data;
   b. **Species:** Common name of species observed;
   c. **Number:** Number of individuals in a group. Individuals were recorded as in a group if they were within 5–10 body lengths of each. If animals were farther apart, they were coded as separate sightings with a unique inclinometer angle;
   d. **Inclinometer angle:** Depression angle from the horizon to the centre of the group, taken when the marine mammal was perpendicular to the aircraft. One inclinometer reading was taken from the centre of a group (i.e., ranges of inclinometer readings were not recorded);
   e. **Sighting Category (On/Off Transect):** Sightings recorded along transects that were within the strip width markers on the aircraft windows were recorded as “ON” transect. If an animal was observed outside of these markers, it was considered as “OFF” transect.

Where possible, the following information was also collected for each sighting:

   a. **Activity:** A collection of behaviours that indicated a given animal was working toward an overall goal; (e.g., feeding, resting, migrating, socializing);
   b. **Behaviour:** Movements or biological processes in which an animal was engaged (e.g., blow, breach, dive, haul out);
   c. **Heading (if travelling):** Direction of travel in relation to the aircraft;
   d. **Speed (if travelling):** Relative speed of an animal’s travel; and
   e. **Age:** Apparent age class of the animal.

The MMOs also noted anecdotal observations, such as the presence of an ice edge, an oceanographic feature, a geographic feature and flocks of birds. The typical layout and equipment of an observing station is shown in Photo 4.2-3.

Photo 4.2-3 Typical Layout of an Observing Station: GPS Digital Synchronized Wristwatch, Coding "Cheat Sheet" and Delineation of Transect Boundaries

4.2.2 Vessel Reconnaissance Tour 2009

At community meetings on May 29, 2008 and July 16, 2009, the residents of Chesterfield Inlet proposed a vessel tour in Chesterfield Inlet to impart local knowledge of important hunting and fishing grounds in the area.

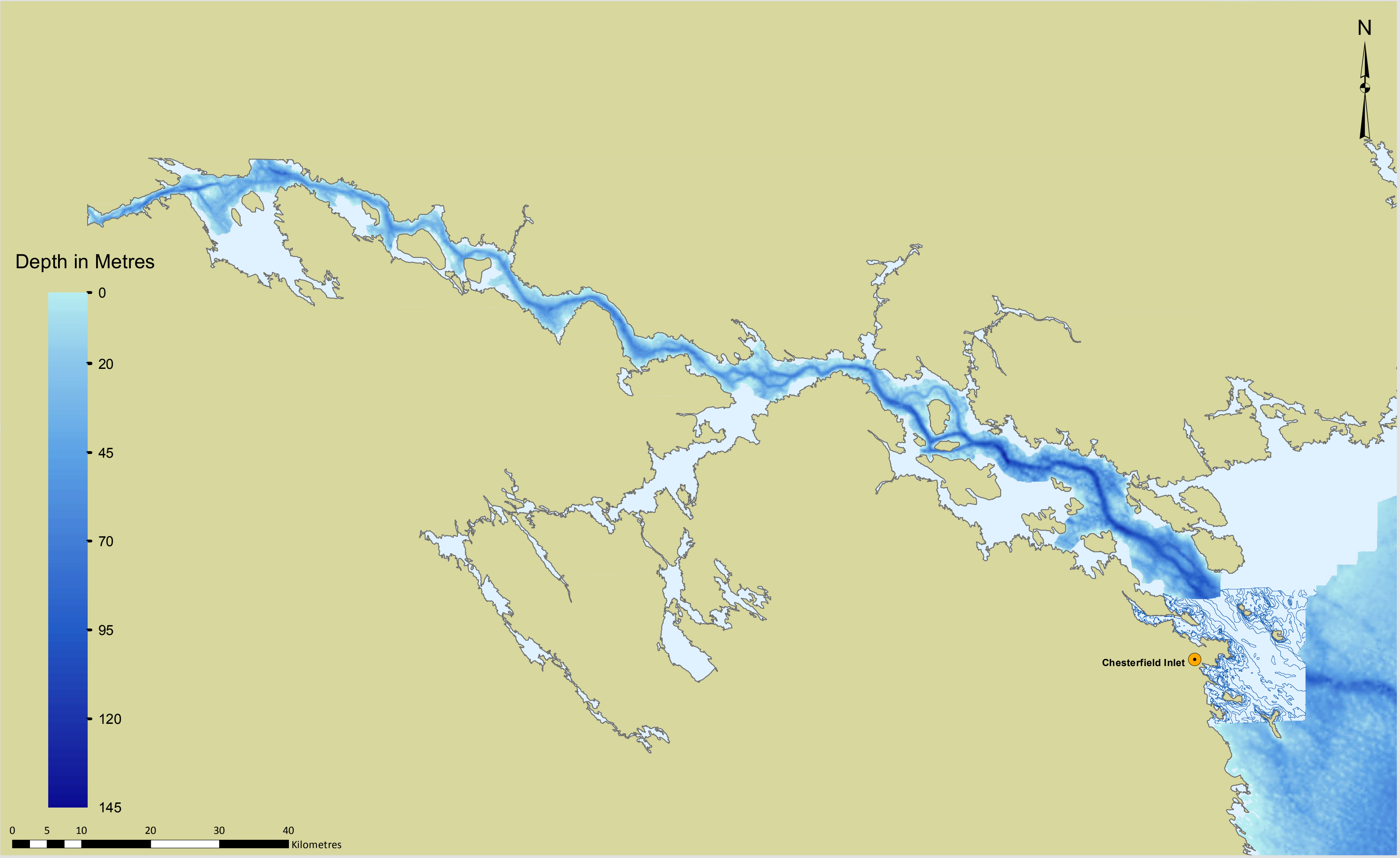
A boat was chartered from Leo and Don Mimialik on August 29, 2009. The survey route followed the north coast of Chesterfield Inlet for 40 to 50 km and then followed the south coast on return. Along the way, fishing cabins and popular hunting spots were highlighted. Opportunistic marine mammal sightings were recorded using a Garmin GPS. Leo and Don participated in an informal discussion regarding time and location of marine mammal hunting (e.g., beluga whale, seal, polar bear and walrus).

5 Physical and Biological Oceanography

5.1 Literature Review

Chesterfield Narrows drains Baker Lake and empties into Chesterfield Inlet. A 200 km, salt-water tidal corridor, Chesterfield Inlet joins Hudson Bay with Baker Lake. Bathymetric charts are available for the Chesterfield Inlet area from the Canadian Hydrographic Service (station 5140). High resolution Bathymetric data (derived from multibeam sonar surveys) for Chesterfield Inlet was procured from TCarta Global Geospatial Data (Figure 5.1-1). Chesterfield Inlet experiences large semi-diurnal tides, which ranged in 2007 from 1.0 – 4.0 m (Government of Canada 2010). Northern coastal areas and estuaries in the vicinity of Chesterfield Inlet are characterized by clear waters and deep photic zones[1] that permit extensive growth of macroalgae (Schneider-Vieira *et al.* 1993).

[1] The part of the near-surface body of an ocean or lake that receives enough sunlight for photosynthesis to be possible.



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File: 1038926.04-020
Data Sources: *Natural Resources Canada, Geobase®, National Topographic Database, Areva Resources Canada Inc.*

FIGURE 5.1-1
BATHYMETRY OF CHESTERFIELD INLET

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5.1.1 Ice Cover

Experiencing a full cryogenic cycle, ice generally starts to form in Hudson Bay in late October and the bay usually becomes ice-free in early August. Studying the dates of ice freeze-up and breakup in Hudson Bay between 1971 and 2003, Gagnon and Gough (2005) report statistically significant trends toward earlier ice breakup in western and southern Hudson Bay and James Bay (magnitude range: -0.49 to -1.25 days per year) and later freeze-up in the northern and northeastern regions of Hudson Bay (magnitude range: 0.33 to 0.55 days per year).

The closest survey stations to Chesterfield Inlet, 62.0° N, 92.0° W and 63.0° N, 89.0° W, experience mean ice freeze-up on November 14 and November 13, respectively (Gagnon and Gough 2005) (Table 5.1-1). The closest station to Chesterfield Inlet where ice breakup was recorded, at 61.0° N, 89.0° W, experienced mean breakup on July 9. Two stations located further south in western Hudson Bay at 59.0° N, 92.0° W and 60.0° N, 92.0° W, were found to experience mean ice freeze-up later, on November 23 and November 21, and mean breakup later, on July 15 and July 10, respectively. Ice breakup in northwestern Hudson Bay is marginally earlier than that experienced further south in western Hudson Bay due to ice removal by strong prevailing northwesterly winds and ocean currents (Saucier *et al.* 2004; Gagnon and Gough 2005).

Table 5.1-1 Ice Freeze-up and Break-up Dates of Sea Ice for Stations Sampled in Western Hudson Bay between 1971 and 2003

Location	Station Number	Freeze-up (Julian days)		Break-up (Julian days)	
		Mean	S.D.	Mean	S.D.
59.0° N, 92.0° W	15	328 (Nov 23)	8.8	197 (Jul 15)	14.6
60.0° N, 92.0° W	20	326 (Nov 21)	8.6	192 (Jul 10)	17.2
61.0° N, 89.0° W	26	326 (Nov 21)	8.5	191 (Jul 9)	12.6
62.0° N, 92.0° W	30	319 (Nov 14)	9.5	–	–
63.0° N, 89.0° W	34	318 (Nov 13)	8.7	–	–
SOURCE: Gagnon and Gough (2005)					

Within the Hudson Bay, Hudson Strait and Foxe Basin region, Saucier *et al.* (2004) report that the maximum sea ice growth rates are found in a relatively large and persistent polynya[2] in northwestern Hudson Bay and in western Foxe Basin. Maximums of sea-ice cover and thickness however are found in eastern Foxe Basin and southern Hudson Bay, where sea-ice advection and ridging serves to accumulate the ice.

Climate change is predicted to decrease overall ice cover in the Arctic (Johannessen *et al.* 2004; Serreze *et al.* 2007) and has the potential to affect the ice regime within the Hudson Bay. Effects of climate change have the potential to cause increased ice melt earlier in the year, less winter ice cover, and a change in frequency of icebergs traveling through the Bay.

5.1.2 Sea Currents and Circulation

In western Hudson Bay, in accordance with the cyclonic circulation pattern of the bay, monthly mean currents are set generally to the south and east (Prinsenberg 1987; Saucier *et al.* 2004). Barotropic, semidiurnal tidal currents, up to 28 cm s-1 in amplitude, represent the majority of observable currents in the area. The presence of sea ice in western Hudson Bay, typically between November and July, causes a decrease in the heights and amplitudes of tidal currents, and an advance in their arrival when compared to open water (ice-free) conditions. Storm-driven, clockwise flowing, inertial currents may be as strong as tidal currents but are typically absent during the ice covered season. Daily averaged currents, with amplitudes of up to 25 cm s-1, are typically dominated by 5- to 6-day periodic motions driven by passing weather systems (Prinsenberg 1987).

For a location 190 km northeast of Churchill, at 60.00° N, 91.95° W, Prinsenberg (1987) reports monthly mean currents, consisting of wind-driven and density-driven currents, set predominantly to the south with speeds of up to 4 cm s-1. Seasonal variations in the amplitudes of mean currents occur in association with sea ice coverage.

Effects of climate change may have a profound impact on the regions currents by altering fresh water flux between the Arctic and Atlantic Oceans. An increase in low salinity water entering the Atlantic may reduce the formation of North Atlantic Deep Water—a process that is critically linked to global oceanic circulation (Rahmstorf 1999; Vellinga and Wood 2002). This has the potential to affect the currents and weather patterns of the entire Canadian Arctic, including the Hudson Bay. These warm temperatures may result in increased ice melt and subsequent elevation in water levels (Munk 2003).

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[2] An area of open water surrounded by sea ice.

5.1.3 Marine Phytoplankton and Ice Algae

Phytoplankton are photosynthesizing microscopic organisms, typically abundant in well-lit surface waters (termed the 'euphotic zone'), which form the basis for the vast majority of marine food webs (food webs reliant on chemosynthesis are a notable exception). Phytoplankton are grazed on by zooplankton and benthic invertebrates, which in turn are consumed by fish and larger predators. Accounting for approximately half of all photosynthetic fixation of carbon on Earth, the primary productivity of phytoplankton provides valuable ecosystem functions including the maintenance of marine and atmospheric oxygen balances and the sequestration of carbon (Morel and Price 2003). The biomass and taxonomic composition of phytoplankton can be affected by environmental changes and have been widely used to examine effects of nutrient loading and metal pollution on ecosystems.

In the Arctic Ocean, phytoplankton primary productivity is limited by the long ice-covered season which reduces or, where thick enough, eliminates light availability for photosynthesis. Phytoplankton blooms, characterised by rapid increases in biomass and high cell concentrations, generally occur when the upper water column is nutrient rich and relatively stable. Such conditions may occur in exposed areas in late April and May when light increases and low-salinity meltwater serves to stabilise the upper water column (Legendre *et al.* 1982). Between mid and late summer in Hudson Bay, occasional increases in stratification strength of the upper water column limits the flow of nutrients into the euphotic zone and causes a reduction in phytoplankton primary productivity (Ferland *et al.* 2011).

Despite a relatively low primary productivity when compared with that of more temperate waters, the Hudson Bay-James Bay system has a diverse microalgal community, comprising of over 495 taxa (Roff and Legendre 1986). Such high diversity, which is the reversal of a general trend, is well known but poorly understood. Assemblages of phytoplankton found in Hudson Bay, comprising primarily of marine diatoms and dinoflagellates, are reported to not differ significantly in species composition from those identified in Arctic and North Atlantic waters. The phytoplankton assemblages reported are a mixture of arctic, boreal and temperate forms (Roff and Legendre 1986). From marine water sampled from the plume at the mouth of Chesterfield Inlet the most common species of dinoflagellates were *Massartia rotundata*, *Peridinium pallidum* and *Peridinium pellucidum* (Anderson 1979; Anderson *et al.* 1981).

As part of the "CALANUS" expeditions of northern Hudson Bay and Hudson Strait, Harvey *et al.* (1997) found the most commonly occurring phytoplankters (100% occurrence) to include one very abundant unidentified flagellate, one prasinophyte *Pyramimonas* sp. and two cryptophytes. Centric and pennate diatoms, and dinoflagellates were the most abundant groups reported throughout the transect sample stations, although abundances of dinoflagellates was reported to increase near the mouth of James Bay. With the exception of dinoflagellates and small flagellates, the abundances of most phytoplankters were found to be inversely correlated to temperature, silicates and the strength of stratification within the euphotic zone (Harvey *et al.* 1997).

During the springtime, the bottom 1 to 5 cm of sea ice is typically colonized by dense populations of ice algae and free-floating phytoplankton are often present in high concentrations at the ice-water interface (Legendre *et al.* 1992). Ice algal biomass below first-year sea ice can be predicted for much of the Arctic by use of information on cumulative surface light and snow depth (Welch *et al.* 1991). Welch *et al.* (1991) measured ice algal chlorophyll *a* (Chl), production between March and May near Chesterfield Inlet, Nunavut, as an estimator of phytoplankton biomass. Ice algae biomass was found to be negatively associated with snow depth at any given date or location and reached a maximum of approximately 170 mg Chl m^{-2} in thin ice over deep water.

5.1.4 Marine Zooplankton

Zooplankton are heterotrophic organisms ranging in size from microscopic, single-celled, protozoa to large, multicellular, metazoans. Although predominantly transported by drifting in ambient currents, most zooplankton have a source of locomotion in order to escape predation. Zooplankton may feed on phytoplankton, bacterioplankton, detritus or cannibalistically on other zooplankton. Typically, zooplankton are found in the surface waters where there is an abundance of phytoplankton and other zooplankton. Falling detritus however (termed 'marine snow') provides a food source for detritivorous zooplankton enabling abundances at greater depths. Due to their consumption of phytoplankton and other sources of primary production, zooplankton serve an ecologically important role in marine food webs as a conduit, packaging organic material for consumption by higher trophic levels. The vertical migrations of some zooplankton and zooplankton consumers in the water column also serve to restore sinking algal organic material back into the euphotic zone (Legendre *et al.* 1992).

There is a lack of information in the literature surrounding zooplankton dynamics in Hudson Bay. What literature there is primarily consists of information relating to eastern Hudson Bay and James Bay, brief taxonomic studies of occurrence and simple listings of specific groups of organisms *(Harvey et al.* 2001). Sampling a transect for zooplankton in Hudson Bay and Hudson Strait, Harvey *et al.* (2001) reported that the most commonly occurring (100% occurrence) zooplankters were the copepods *Calanus glacialis* and *Pseudocalanus* spp., the amphipod *Themisto libellula*, the chaetognath *Sagitta elegans*, and species from the phylum Cnidaria. *C. glacialis* and *Pseudocalanus* spp. were the most abundant species with reported densities of up to 26,769 individuals m^{-2} and 37,427 individuals m^{-2}, and mean densities of to 4,360 individuals m^{-2} and 12,477 individuals m^{-2}, respectively. Other commonly occurring taxa reported in Hudson Bay and Hudson Strait include other copepod species, molluscs, annelids, crustaceans, euphausiids, decapods and tunicates. Harvey *et al.* (2001) reported that zooplankton abundance was four times as high at sampling stations in the middle of Hudson Strait than at stations on the western side of Hudson Strait and in Hudson Bay. High abundances were associated with local hydrodynamic features which resulted in cooler and higher salinity mixed surface waters. Lower abundances of zooplankton were associated with warmer, lower salinity stratified surface waters.

Several amphipod and copepod species are known to graze on phytoplankton populations, including those of the diatom generas *Nitzschia* spp. and *Navicula* spp., present under sea ice and at ice edges in the Canadian High Arctic (Legendre *et al.* 1992). Siferd *et al.* (1997) investigated the seasonal distribution of sympagic[3] amphipods near Chesterfield Inlet and recorded several common species of amphipods including *Ischyrocerus anguipes, Pontogeneia inermis*, *Apherusa megalops* and *Weyprechtia pinguis.*

[3] An environment where water exists mostly as a solid.

6 Marine Fish and Invertebrates

6.1 Literature Review

6.1.1 Marine Invertebrates

Limited research is available on the occurrence and abundance of marine invertebrates in Hudson Bay and much about their ecology, abundance and distribution is still unknown (Stewart and Lockhart 2005b). Present data indicates that at least 689 species of metazoan invertebrates and 25 species of urochordates occur in waters of the Hudson Bay marine ecosystem (Stewart and Lockhart 2005b). Few invertebrates inhabit the intertidal zone on a permanent basis, likely due to the scouring action of the winter ice (Stewart and Lockhart 2005b). The pelagic zone is characterized by comb jellies, arrow worms, copepods and amphipods, euphausids, and pelagic sea butterflies (Stewart and Lockhart 2005b).

The summary below includes major invertebrate groups that provide significant value either through their trophic importance in the food chain or as a harvested species by some local groups. While some small scale subsistence fishing occurs in Nunavut, there are currently no large-scale commercial fisheries in Hudson Bay due to the relatively low species abundance, long time to reach maturity, and high cost to harvest these organisms (Stewart and Lockhart 2005b).

6.1.1.1 Squid

The boreal armhook squid (*Gonatus fabricii*) is the most abundant squid found in marine waters of the Arctic and sub-Arctic of the North Atlantic (Bjorke 2001) and is found within Hudson Bay (Stewart and Lockhart 2005b). *G. fabricii* is short lived and fast growing (Frandsen and Wieland 2004). Bjorke (2001) suggests that the life span of *G. fabricii* does not likely exceed two years of age but Frandsen and Wieland (2004) report spawning occurring up to three years of age. The largest recorded specimen of *Gonatus fabricii* was 385 mm mantle length (Bjorke 2001). They are considered ecologically important due to their presence in the diets of fish, birds and mammals (Gaston *et al.* 1985; Gardiner and Dick 2010).

6.1.1.2 Bivalves

Several species of harvested bivalves are found within Hudson Bay including clams (*Mya truncata*), Icelandic scallops (*Chlamys islandica*), and blue mussels (*Mytilus edulis*) (Stewart and Lockhart 2005b).

Mya truncata are found buried in sandy or muddy benthic substrates (Aitken and Fournier 1993). They are most common in waters <50 m in depth (Aitken and Fournier 1993). Icelandic scallop are most common at depths of 20 to 60 m (Pedersen 1994). They are generally found on substrates consisting of shells, gravel, stones, rocks, and occasionally mud and are often in areas associated with strong tidal currents (Pedersen 1994). *Mytilus edulis* occur in both the intertidal and subtidal zones. They are sessile organisms, requiring hard substrate (e.g., bedrock, boulder, cobble, docks, and pilings) for attachment although they can also inhabit areas of sand or mud if there are hard objects (e.g., stones or other shells) within it to attach to (Newell 1989).

Bivalves are important prey for many fish, bird and mammal species in the Hudson Bay area (Stewart and Lockhart 2005b). *Mya truncata* are important prey of walrus and bearded seals (Mansfield 1958; Smith 1981) and it is estimated that a single walrus consumes 4,500 to 6,500 *M. truncata* per day (Welch and Martin-Bergmann 1990). *Mytilus edulis* are also an important prey species for various fish and seabird species (Stewart and Lockhart 2005b). Subsistence harvesting of *Mya truncata, Chlamys islandica* and *Mytilus edulis* occurs in the Belcher Islands (Stewart and Lockhart 2005b). An Icelandic scallop bed exists at the mouth of Chesterfield Inlet (Mercier *et al.* 1994).

6.1.1.3 Green Sea Urchin

The Green sea urchin (*Strongylocentrotus droebachiensis*) has a circumpolar distribution and is found along the coasts of Baffin Island, Foxe Basin, Hudson Strait and Foxe Channel (Atkinson and Wacasey 1989) as well as in Hudson Bay and James Bay (Stewart and Lockhart 2005b).

Strongylocentrotus droebachiensis commonly inhabit the low intertidal zone (Stewart and Lockhart 2005b) and prefer rocky benthic substrates (Himmelman 1986). Aggregations of green urchins are generally correlated with high abundances of macroalgae, their primary food (Himmelman 1986). *Strongylocentrotus droebachiensis* is perhaps the most common and abundant echinoderm in the James Bay and southeastern Hudson Bay (Clark 1922; Giroux 1989; Morin *et al.* 1991). *Strongylocentrotus droebachiensis* are commercially harvested in Eastern Canada and the Belcher Islands (Stewart and Lockhart 2005b).

6.1.2 Marine Fish

Shorelines around Chesterfield Inlet are typically composed of flat bedrock which transitions to subtidal cobble, gravel and sand. Intertidal habitat consists of sand and/or mudflat with a gently sloping grade dominated by moderately dense rockweed cover. The mid to low intertidal zones have low diversity of red seaweeds.

At least 49 species of fish occur in the marine ecosystem of Hudson Bay; 22 marine, nine mostly marine with occasional use of brackish water, one estuarine, nine anadromous, and eight mostly freshwater with occasional use of brackish water (Stewart and Lockhart 2005b). Very little is known throughout most of the Arctic regarding fish species occurrence and distribution. The absence of commercially exploitable resources in Hudson Bay as well as physical limitations (such as a short ice-free season) has likely restricted research efforts on fish populations in the region (Stewart and Lockhart 2005b). IQ has been limited mostly to observations from shallow nearshore waters and stomach contents of harvested fish (Stewart and Lockhart 2005b). Offshore marine fish resources are virtually unknown (Stewart and Lockhart 2005b). Despite a paucity of direct research on fish species occurrence and distribution, some of this information is available indirectly from studies of seabird diets (Gaston *et al.* 2003). Although commercial fisheries are limited, subsistence harvest for a variety of species, such as Arctic char, can be substantial (Table 6.1-1).

Table 6.1-1 Estimated mean annual subsistence harvests of fishes by communities in RAA[1]

Community	Period	Cod	Sculpin	Arctic char
Arviat	1983 – 85	53	2	2643
Whale Cove	1982, 1984 – 5	–	–	3327
Rankin Inlet	1982 – 85	12	13	7361
Chesterfield Inlet	1983 – 85	–	–	237

NOTE:
[1] Table modified from (Stewart and Lockhart 2005a)

Several fish species of Baker Lake and Chesterfield Inlet play important roles in the ecological, economic and cultural health of the local communities. Arctic cod (*Boreogadus saida*), Arctic sculpin (*Myoxocephalus scorpioides*), Arctic char (*Salvelinus alpines*), fourhorn sculpin (*Triglopsis quadricornis*), banded gunnel (*Pholis fasciata*), and whitefish (*Coregonus nasus*) use sand and boulder benthic habitat around the mouth of Chesterfield Inlet.

No fish are listed under the Canadian *Species at Risk Act* (SARA) or designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as species of concern in Chesterfield Inlet and surrounding area. Arctic char, fourhorn sculpin and whitefish are listed under IUCN red list as a species of least concern (Table 6.1-2).

Table 6.1-2 Fish species status in the RSA[1]

Common Name	Scientific Name	Likely Found	Habitat Type	Conservation Status
Arctic cod	*Boreogadus saida*	Mouth of Chesterfield Inlet; Hudson Bay Coast	Demersal; anadromous; brackish; marine; 0 – 1,383 m	Not listed
Arctic sculpin	*Myoxocephalus scorpioides*	Mouth of Chesterfield Inlet; Hudson Bay Coast	Demersal; brackish; marine; 0 – 275 m; rocky bottoms among algae	Not listed
Arctic char	*Salvelinus alpinus*	Chersterfield Inlet; Hudson Bay	Benthopelagic; anadromous; brackish; marine; 30 – 70 m	IUCN Red List (Least Concern)
Fourhorn sculpin: marine form	*Triglopsis quadricornis* or *Myoxocephalus quadricornis*	Hudson Bay	Marine; 0 – 100 m	IUCN Red List (Least Concern)
Banded gunnel	*Pholis fasciata*	Mouth of Chesterfield Inlet,Hudson Bay	Demersal; marine; 0 – 94 m	Not listed
Broad whitefish	*Coregonus nasus*	Chersterfield Inlet; Hudson Bay	Demersal; anadromous ; brackish; marine	IUCN Red List (Least Concern)

NOTE:
[1] Table adapted from FishBase (2011, internet site)

Arctic char are the most abundant and dominant salmonid species throughout the Arctic; however they are not found much further south than 60°N due to competition from other species (Mercier *et al.* 1994). They can be both anadromous and landlocked. The anadromous char migrate out to Hudson Bay for summer feeding during ice break-up from mid-June to early July, and migrate back upstream from mid-August to mid-September to spend the winter in fresh water (Stewart and Lockhart 2005b). They spawn in late August to early October, preferring gravel substrate with sufficiently deep water to prevent the eggs from freezing and sufficient current to keep them clean (Stewart and Lockhart 2005b). After spawning, they will overwinter in the lake and migrate to the ocean to feed the following spring. While they are in the Bay during the summer they are known to feed on other marine fish including capelin (*Mallotus villosus*), sand lance (*Ammodytes americanus*), Arctic cod (*Boreogadus saida*) and Greenland cod (*Gadus ogac*) (Johnson 1989). In the Kivalliq region, they are harvested from the Thlewiaza River north to Daly Bay and into Chesterfield Inlet (Stewart and Lockhart 2005b).

Broad whitefish (*Coregonus nasus*) belongs to the second main group of anadromous fish in the Arctic, the coregonids (Stephenson and Hartwig 2010). They are known to occur in the Chesterfield Inlet area (FishBase 2011). Migration to spawning grounds in freshwater typically occurs in late July to early August (FishBase 2011).

Arctic cod are a small, pelagic cod species that play a key role in the Hudson Bay marine ecosystem. They are typically associated with ice cracks and edges and occur further inshore in late summer. They are widely distributed throughout the Bay where they support the diet of many other fishes, seals whales and marine birds (Stewart and Lockhart 2005b). They are occasionally taken for subsistence.

The banded gunnel is typically found inshore from the intertidal to 28 m at or near the bottom over rocky substrate. It is a prey item of Arctic cod, sculpins and seabirds (Stewart and Lockhart 2005b). The Arctic sculpin and fourhorn sculpin are eaten by larger fish and seabirds. Arctic sculpin is generally found over smooth or weedy bottoms from the intertidal to 110 m, while the fourhorn sculpin rarely occurs below 20 m and can be commonly found in tide pools and eelgrass beds (Stewart and Lockhart 2005b).

7 Marine Birds

7.1 Literature REview

The most common species of waterbirds observed in Baker Lake and Chesterfield Inlet area are Canada goose, long-tailed duck, and common loon (Höhn 1969). Red-throated, arctic and yellow-billed loons have also been observed in the area as well as tundra swan (Höhn 1969). The Kivalliq region of Nunavut represents an important migratory, staging, moulting, and nesting area for white-fronted, snow, and Canada geese, sandhill crane, tundra swan, dunlin, golden-plover species, Baird's sandpiper, numerous gull species and arctic tern (Canadian Circumpolar Institute 1992).

The Important Bird Area (IBA) Program is an initiative between Bird Studies Canada, Nature Canada and BirdLife International for the international conservation of discrete sites that support threatened birds, large groups of birds, and birds restricted by range or by habitat. While a variety of migratory and non-migratory bird species may be found with the project area, no IBAs are identified within the LSA and eight sites with coastal and marine habitat components have been identified in or adjacent to the RSA (Bird Studies Canada (BSC) 2011 Internet site). Key marine habitat areas have been identified by the Canadian Wildlife Service (CWS) as areas that are essential to the welfare of various migratory bird species in Canada. The CWS established 16 bird sanctuaries in Canada to control and manage areas of importance for the protection of migratory birds, their nests and eggs. There are two migratory bird sanctuaries (MBS) with coastal habitat that fall within or are adjacent to the RSA. First, Harry Gibbons MBS situated in northern Hudson Bay on Southampton Island supports 10% of the world's Snow Goose population (IBI, internet site). Second, McConnell River MBS (Environment Canada 2011, internet site) is a large , primarily coastal marsh habitat for between 3-5% of the Arctic's breeding population of Snow Goose and Ross's Goose (IBI program, internet site). There three key marine bird habitat sites identified within or adjacent to the RSA (Mallory and Fontaine 2004).

Within the southern RSA at the Port of Churchill, Ross's gull is known to breed and use coastal habitat within this area. The species is nationally designated as Threatened by COSEWIC and listed in Schedule 1 of SARA. Ross's gull are more commonly seen in the Churchill area than anywhere else in Canada and represents only one of four breeding areas in the country (COSEWIC 2007). The last observation of Ross's Gull in the Churchill area was 4 individuals in 2005 (COSEWIC 2007). Nesting records were located inland but within 1 km from the Hudson Bay coastline, and individuals were also observed using coastline habitat in early August following the breeding season between early June and late July (Chartier and Cooke 1980).

The King Eider is given special designation by the Government of Nunavut. The King eider has not been assessed by COSEWIC but is ranked as Sensitive in Nunavut due to national declines, which are at least partially attributed to international subsistence harvest. An estimated 20,000 are taken per year in Alaska and western Canadian Arctic but no estimates are available for eastern Arctic (Sea Duck Joint Venture 2003, internet site). King eider populations breeding in coastal areas of Hudson Bay are locally harvested at subsistence rates and commercially harvested (estimated at 20,000 individuals) during their wintering period in Greenland (Sea Duck Joint Venture 2003, internet site).

8 Marine Mammals

8.1 Literature Review

Based on available information, nine marine mammal species inhabit northwestern Hudson Bay (Table 8.1-1). Of these species, three are considered common (beluga whale, ringed seal and polar bear) and six are considered rare or uncommon (bowhead whale, narwhal, bearded and harp seals, walrus and killer whale). A brief overview of conservation status, distribution and abundance of these nine marine mammal species within the study areas are provided in the following sections.

Table 8.1-1 Conservation Status of Marine Mammals Present in Western Hudson Bay and Chesterfield Inlet

Species	Scientific Name	*Species at Risk Act* (SARA) Schedule	Committee on Status of Endangered Species in Canada (COSEWIC) Status	Occurrence[4] in Western Hudson Bay
Beluga whale (Western Hudson Bay population)	*Delphinapterus leucas*	Not Listed	Special Concern	Common
Ringed seal	*Phoca hispida*	Not Listed	Not at risk	Common
Polar Bear	*Ursus maritimus*	Not Listed	Special Concern	Common
Bowhead Whale	*Balaena mysticetus*	Not Listed	Special Concern	Uncommon
Bearded Seal	*Erignathus barbatus*	Not Listed	Data Deficient	Uncommon
Harp Seal	*Phoca groenlandica*	Not Listed	Not Listed	Uncommon
Walrus	*Odobenus rosmarus*	Not Listed	Special Concern	Uncommon
Narwhal	*Monodon monoceros*	Not Listed	Special Concern	Rare
Killer Whale	*Orcinus orca*	Not Listed	Special Concern	Rare

8.1.1 Beluga Whale

The most recent population estimate for the western Hudson Bay population of beluga whales is 57,300 animals (95% C.L.: 37,700 – 87,100) (Richard 2005a). Site specific information of habitat use by beluga whales in Chesterfield Inlet (and western Hudson Bay) is limited.

4 As determined from IQ and available literature.

After spring ice breakup in mid- to late June, western Hudson Bay belugas concentrate in the Churchill, Nelson and Seal River estuaries and increase in abundance until late July (Richard *et al.* 1990). Migration northward along the coast of Hudson Bay is believed to begin in late August or early September (COSEWIC 2004a). Satellite tag data shows the population moving towards wintering habitat in Hudson Strait; however, the routes taken between summering and wintering habitats are not well known. Belugas have been observed travelling north within the eastern portion of Chesterfield Inlet during the fall migration. Although few records of belugas in the western portion of Chesterfield Inlet exist, the Baker Lake Hunters and Trappers Organization recorded the migration of five animals through Chesterfield Inlet into Baker Lake (Hunters and Trappers Association of Nunavut 1992).

Beluga whales are economically important to the Inuit of Nunavut and are hunted by 20 out of 28 communities (Priest and Usher 2004). Over the five-year period from 1996 to 2001, the total annual mean number of belugas taken through hunting was 1,339 for all of Nunavut, while annual rates of belugas harvested from the community of Chesterfield Inlet ranged from three (2001) to 31 (1996) (Priest and Usher 2004). Based on Inuit knowledge belugas are easier to hunt than other marine mammals because they are naive of humans and are often approached without fleeing (Richard 2001).

8.1.2 Bowhead Whale

Bowhead whales have a nearly circumpolar distribution in the northern hemisphere and are widespread in Nunavut. Based on their summer distribution, there are two stocks in the eastern Canadian Arctic: one that summers in northern Hudson Bay (around Repulse Bay and Frozen Strait) and Foxe Basin; and the other in Baffin Bay, Davis Strait and the waters of the Canadian High Arctic (Cosens *et al.* 2004; Wheeler and Gilbert 2007). Inuit from Repulse Bay report that they are concentrated at the floe edge in June, disperse after ice breakup and then gather inshore in August (NWMB 2000). A few sightings of bowhead whales were recorded in the 1980s at Arviat and in the Churchill River estuary but they are not common in southern Hudson Bay (Watts 1988 in Stewart and Lockhart 2005b).

The bowhead whale population is believed to have been increasing for decades and is likely still increasing in the absence of commercial whaling. This increase is supported by evidence from both IQ and science, with a current total abundance estimated at around 1,525 (95% CI: 333 – 6,990) for the Foxe Basin-Hudson Bay stock and 6,344 (95% CI: 3,119 – 12,906) for a single Eastern Canada-West Greenland population (COSEWIC 2009). During the most recent surveys of bowheads in north western Hudson Bay and Foxe Basin, approximately 270 whales were found, mainly north of Southampton Island in Foxe Basin, Fury and Hecla Strait (Cosens *et al.* 2004). It is assumed that bowheads over-winter in northern Hudson Bay, Hudson Strait and in central Davis Strait, southern Baffin Bay and west near Greenland (Dueck *et al.* 2006; Koski *et al.* 2006; Wheeler and Gilbert 2007).

8.1.3 Polar Bear

The range of the Western Hudson Bay and Foxe Basin sub-populations of polar bears overlaps spatially but not temporally with the proposed shipping route through Chesterfield Inlet and Hudson Bay.

During the open-water season, polar bears spend several months along the western coastline of Hudson Bay from Southampton Island to Churchill (COSEWIC 2008). The Western Hudson Bay sub-population tends to congregate on coastal capes and headlands between Cape Churchill and Arviat (Stirling *et al.* 1999). The Foxe Basin sub-population concentrates on the west and northeast coasts of Southampton Island and along the coast of Wager Bay (north of Chesterfield Inlet) during the ice-free season when shipping activities are expected.

IQ data suggests that polar bear numbers are increasing in the Chesterfield Inlet area; however, the most recent estimate of the Western Hudson Bay sub-population indicates that overall abundance has declined from approximately 1,294 in 1987 to 935 in 2004 (COSEWIC 2008).

8.1.4 Narwhal

Two populations of narwhals have been recognized for the purpose of hunt management in Canada (Stewart and Lockhart 2005b). The tentative separation into Baffin Bay and Hudson Bay populations is based largely on summering distribution. Narwhals that summer in northwest Hudson Bay are believed to over-winter in eastern Hudson Strait (Richard 1991) and range over an area of roughly 250,000 km² (COSEWIC 2004b). The most recent population estimate, based on data from photographic aerial surveys in the Repulse Bay area between Roes Welcome Sound and Lyon Inlet, estimated the narwhal population at 1,780 animals (90% CI = 1212 – 2492) in 2000 (Stewart and Lockhart 2005b).

The seasonal movement patterns of the Hudson Bay narwhals are not well known. In the spring, they likely migrate westward from wintering grounds in eastern Hudson Strait (Richard 1991), traveling offshore through Hudson Strait and Foxe Channel until they reach the floe edge east of Repulse Bay in late June (Stewart and Lockhart 2005b). During the summer months, narwhals inhabit Hudson Bay, preferring coastal areas that offer deep water and shelter from the wind (COSEWIC 2004b). They tend to concentrate in the waters surrounding Southampton Island, with the largest aggregations found in Repulse Bay, Frozen Strait, western Foxe Channel and Lyon Inlet (Richard 1991). Whales from this population also spend the summer in Wager Bay and Duke of York Bay, although typically in smaller numbers (Stewart and Lockhart 2005b). Narwhal generally remain at their summering grounds until late August or early September, at which point they travel south eastward out of the area through Frozen Strait, following the east coast of Southampton Island.

In Hudson Bay, they are rarely seen west of Southampton Island or along the west coast of Hudson Bay, unless they are avoiding predation by killer whales (COSEWIC 2004b). Based on available data, narwhals are not expected to be common in or around Chesterfield Inlet. One narwhal was caught by a hunter between 1997 and 1998 in Whale Cove (south of Chesterfield Inlet) (DFO 1998) and three carcasses have been found along the Ontario coast of Hudson Bay (COSEWIC 2004b).

8.1.5 Killer Whale

Killer whales are known to inhabit arctic waters; however, there are no population estimates for killer whales in Nunavut. Their presence in Hudson Bay has been increasing since the mid-1900s, before which they were not reported in the area (Reeves and Mitchell 1988). They are seen infrequently and in small numbers in northern Hudson Bay, and south along the Kivalliq coast to Churchill. The community of Chesterfield Inlet reported seeing a pod of seven killer whales in August 2008, while the community of Arviat observed a group of approximately 30 killer whales at Sentry Island a few years ago. Inuit of Nunavut presently do not harvest killer whales.

8.1.6 Atlantic Walrus

Some of the most southerly populations of Atlantic walrus are now found in southeast Hudson Bay and James Bay, though walruses are more common and abundant in northwest Hudson Bay, Hudson Strait and Foxe Basin (Mansfield and St. Aubin 1991). Four distinct stocks of Atlantic walrus have been identified in Canadian waters (Outridge *et al.* 2003). Two of these, the South and East Hudson Bay Stock and the Hudson Bay-Davis Strait Stock, are known to occur in the regional study area (Stewart and Lockhart 2005b). The Northern Hudson Bay-Davis Strait population is distributed over an area of roughly 385,000 km^2 from Arviat, north and east through Hudson Strait, to Clyde River on the east coast of Baffin Island (Stewart 2002). The Hudson Bay-Davis Strait Stock may consist of separate sub-stocks that inhabit northern Hudson Bay, Hudson Strait, and Davis Strait. Inuit have observed differences in body size and tusk length that are consistent with these separations, suggesting that Chesterfield Inlet and Repulse Bay may not share the same walrus populations (Stewart and Lockhart 2005b).

In western Hudson Bay, walruses occur south to Churchill yet become increasingly numerous moving north along the coast. They often occur in areas of shallow, open water, which support an abundant clam community for foraging. During the summer they prefer to haul out on low, rocky shores with steep subtidal zones. Walruses are generally absent near Chesterfield Inlet in summer, but do over-winter in the Chesterfield Inlet-Roes Welcome Sound area and are found on the other side of the inlet in the spring (Stewart and Lockhart 2005b). They occur in Wager Bay when ice is minimal and Inuit indicate that they prefer areas with strong current. Walruses are common in the Repulse Bay area, but are seen less often when ice concentration remains high during the summer.

Walruses traditionally provide important staples in the subsistence economy of the eastern Canadian Arctic (COSEWIC 2006). Many (18 out of 28) communities in Nunavut hunt walrus (Priest and Usher 2004). Over a five-year period, from 1996 to 2001, the total number of walruses harvested near Chesterfield Inlet ranged between one and four animals annually (Priest and Usher 2004). During a series of interviews to collect IQ, residents of Chesterfield Inlet indicated they typically hunt walrus north of Chesterfield Inlet near Depot Island and Daley Bay (AREVA 2009).

8.1.7 Ringed Seal

The ringed seal is the most common and abundant species of seal in Hudson Bay, where it is resident year-round. Estimates of ringed seal populations are based mainly on aerial surveys conducted during the peak haulout and moulting period from late May to early July. Smith (1975) conducted an aerial survey of Hudson Bay between Churchill and Chesterfield Inlet, and estimated that there were 455,000 ringed seals in Hudson Bay—including Roes Welcome Sound. More recently, aerial systematic strip transect surveys extending from the Nelson River estuary to Rankin Inlet estimated 38,340 (SE = 3640) ringed seals in 1994 and 140,880 (SE = 8100) ringed seals in 1995 (Lunn *et al.* 1997). These estimates are likely conservative because they are based on the number of seals hauled out on the ice and were not corrected for seals that were submerged. The total population of the area may be twice as large (Stirling and Øritsland 1995).

In spring, the highest densities of breeding adults occur on stable, landfast ice in areas with good snow cover, whereas non-breeders tend to be found at the floe edge or in the moving pack ice (Stewart and Lockhart 2005b). Their ability to maintain breathing holes in ice enables them to occupy areas of Nunavut that are inaccessible to other marine mammals during the colder seasons.

8.1.8 Bearded Seal

Bearded seals are found along almost all coastal areas of Nunavut year-round (Gilchrist and Robertson 2000). They have a wide, yet patchy, distribution and a relatively low density; they are considerably less abundant than ringed seals (Stewart and Lockhart 2005b).

Aerial systematic strip transect surveys were conducted north from the Nelson River estuary to Rankin Inlet to derive population estimates. In 1994, the bearded seal population was estimated at 12,290 (SE = 2,520) while in 1995, it was estimated at 1,980 (SE = 560) (Lunn *et al.* 1997).

Bearded seals prefer areas of moving pack ice and open water, and may move between coastal and offshore areas in response to changing ice conditions (Stewart and Lockhart 2005b). Aggregations of bearded seals are most likely to occur during the winter months prior to ice breakup and during early summer when the availability of ice pans for haulout is limited. During the open-water period, they will enter estuaries and haulout on land, sometimes in the company of harbour seals (Stewart and Lockhart 2005b). The Arctic Marine Proceedings held in 1994 suggest that bearded seals are likely to be present throughout coastal areas in Hudson Bay and Chesterfield Inlet (Freshwater Institute 1994).

8.1.9 Harp Seal

The most recent aerial survey of the northwest Atlantic harp seal population was conducted in 2004 by DFO, and resulted in an estimate of 5.82 million individuals; however, there are no estimates for the population within Nunavut (DFO 2005). The northwest Atlantic harp seal population is concentrated (upwards of 20,000 individuals) in Lancaster, Eclipse and Jones Sounds, and at the head of Cumberland Sound and Frobisher Bay (Freshwater Institute 1994). A small number of harp seals seasonally migrate into Hudson Bay, occurring south to Arviat in the west and the Belcher Islands in the east (Richard 2001). Harp seals are less common in Hudson Bay than ringed or bearded seals (DFO 2005).

Local residents of Nunavut hunt harp seals for food and fur (Richard 2001). About half the communities (18 out of 28) in Nunavut hunt harp seal (Priest and Usher 2004). Over a five year period (1996 – 2001), a total of 24 harp seals were harvested from Chesterfield Inlet (Priest and Usher 2004), confirming the presence of this species in the region.

8.2 Aerial Survey Results – 2008

8.2.1 Overview

Aerial surveys were conducted over five days in 2008. The raw survey data can be found in Appendix B, and daily and overall effort, environmental conditions and sightings are summarized here.

The five surveys comprised a total of 3,868 km of linear survey over 17.51 hours Survey effort over offshore transects was impeded by poor conditions (sea state >4) during a portion of three survey dates (September 12, 13, and 15). Poor conditions (precipitation, low ceiling, high winds) grounded the aircraft on September 14. Sea state is a key factor that affects the ability to detect marine mammals during aerial surveys (Buckland *et al.* 2001). Sea state conditions were generally better near the shoreline and within Chesterfield Inlet over all days, compared to surveys conducted in offshore areas. Survey design was adapted due to frequently high sea state offshore, as well as to incorporate feedback on beluga whale habitat from local wildlife advisors. As a result, survey effort was greatest within Chesterfield Inlet (42% of total survey effort), followed by survey of offshore transects (34% of total survey effort) and survey of the shoreline between Rankin Inlet and Chesterfield Inlet (23% of total survey effort).

8.2.2 Daily Reports

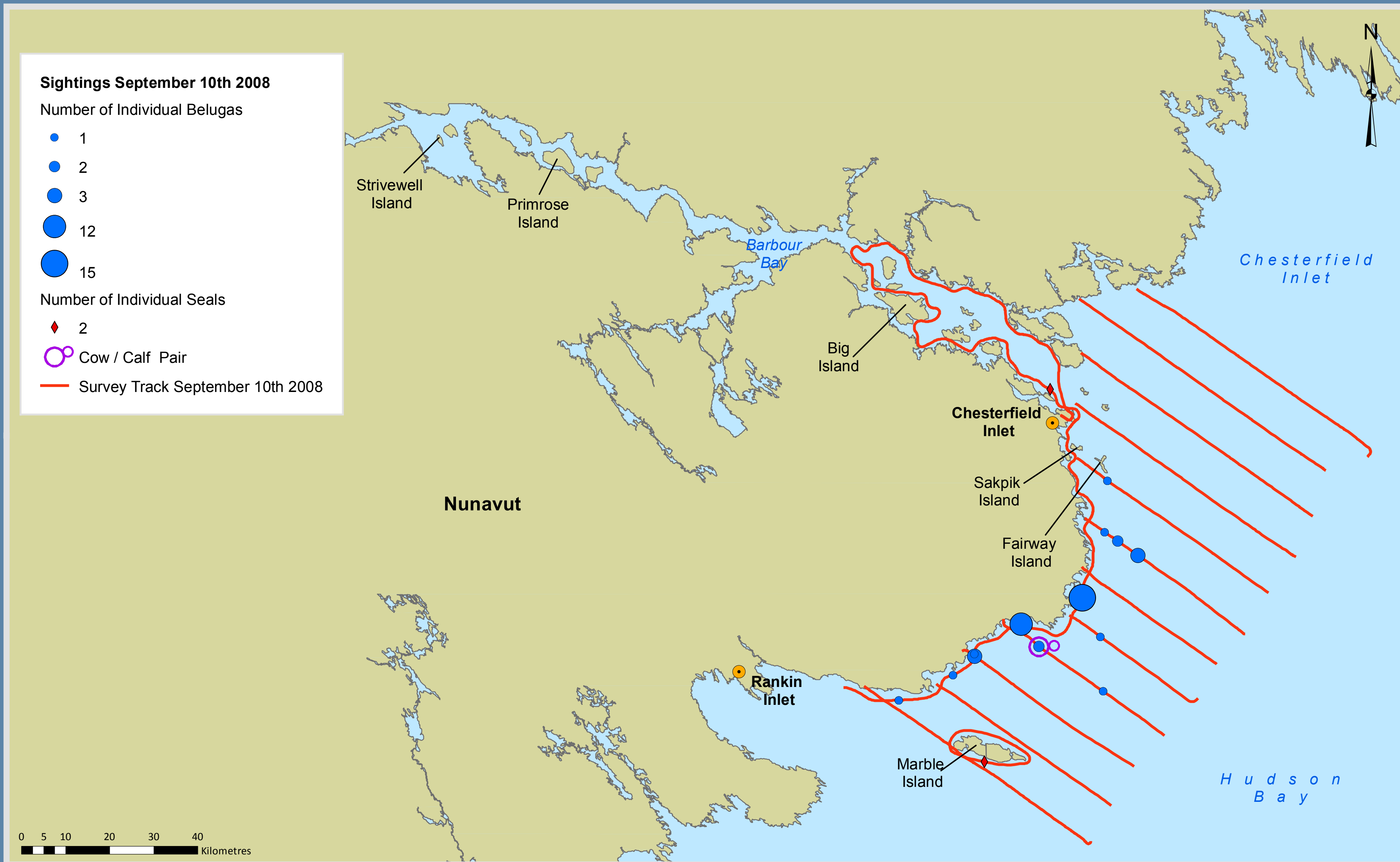
September 10, 2008

To maximize survey effort and airplane availability, the shoreline between Rankin Inlet and Chesterfield Inlet was surveyed en route to the community of Chesterfield Inlet for refuelling and to pick up secondary observers. Approximately half of Chesterfield Inlet was surveyed. Favourable conditions offshore allowed completion of offshore Transects 1 through 12 for a total effort of 805 km. The shoreline of Marble Island, located between offshore Transects 11 and 12, was surveyed after an undocumented report of killer whales in the area the week prior.

Weather varied between overcast with mixed cloud and sun throughout the day. Observation conditions ranged from good to excellent, with a sea state of less than 3, relatively calm winds and marginal glare throughout the day.

A total of 44 beluga whales were observed amongst 13 separate sightings. Photo 8.2-1 shows five adult belugas within a group of 15 animals sighted along the shoreline between Rankin Inlet and Chesterfield Inlet. Observed whales were swimming in one of two directions (north or east). This included one cow/calf pair sighted offshore (approximately 30 km) on Transect 9 (Figure 8.2-1). Two seals were observed over two independent sightings, one in the nearshore area of Marble Island and the second nearshore of Chesterfield Inlet.

Photo 8.2-1 Beluga Whales Sighted Near Shore between Rankin Inlet and Chesterfield Inlet on September 10, 2008



Projection: NAD 1983 UTM Zone 15N
Creator: SS
Date: 12/01/2009 Scale: 1:1,250,000
File: 1038926.04-019
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, Areva Resources Canada Inc.*

FIGURE 8.2-1
SURVEY EFFORT SEPTEMBER 10 2008
MARINE MAMMAL SURVEYS

KIGGAVIK PROJECT - EIS

Stantec
AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

September 11, 2008

Similar to the surveys conducted on September 10, a coastal survey was first conducted between Rankin Inlet and Chesterfield Inlet. Poor visibility and unfavourable sea state conditions precluded earlier surveys of Transects 1 to 14. Consequently, Chesterfield Inlet itself was surveyed. The survey of Chesterfield Inlet included a westward leg along the southern shore, and an eastward leg along the northern shore (Figure 8.2-2). After Chesterfield Inlet was surveyed, offshore Transects 1 through 8 were surveyed for a total survey effort of 977 km.

Weather varied throughout the day and between regions (offshore and inlet) from clear skies to rain. Visibility was generally good, with recorded sea states of between 1 and 3.

A total of 12 belugas were observed over 11 separate sightings and 55 seals were observed during three sightings (Table 6.2-3). This included a group of 24 seals that was observed approximately 2 km from the south shore of Chesterfield Inlet, east of Big Island. Observed behaviours of beluga whales included swimming, diving and milling. Photo 8.2-2 shows three whales swimming north, approximately 20 km offshore along Transect 1.