Indian and Northern Affairs Canada

Beaufort Sea Petroleum and Environmental Management Tool

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Executive Summary

This report accompanies a GIS-based petroleum and environmental management tool (PEMT) and database that are intended to support development of strategic options of oil and gas leasing options for portions of the Beaufort Sea and the Mackenzie Delta within the Inuvialuit Settlement Region (ISR). These products were produced for the Department of Indian and Northern Affairs Canada (INAC) - Northern Oil and Gas Branch (NOGB) to aid the NOGB in meeting their commitments associated with management of oil and gas resources on federal land and the provision of hydrocarbon development opportunities in the North, while ensuring environmental protection. The PEMT will assist managers and decision-makers in choosing appropriate processes and actions to responsibly manage offshore areas petroleum industry activities. The study area and analytical resolution were defined using the oil and gas leasing grid within the Beaufort Sea.

The study area has been the scene of oil and gas exploration activity since 1957. Oil was first discovered at Atkinson Point in 1969 and major gas fields in the early 1970's. Such finds spurred the proposal of the Mackenzie Valley Pipeline in 1974 and the addition of exploration and investment offshore. Exploration and drilling continued both onshore and offshore until the mid 1970's with the release of the Berger Report, which recommended a 10-year moratorium on the construction of the pipeline. After the release of the Berger Report, the pace of onshore activity declined but offshore exploration escalated in the 1980's. Offshore exploration was facilitated with innovative operating techniques and new offshore platforms that extended the ability to operate in the short open-water season and ice. With the minor exception of the small onshore gas field at Ikhil, no oil or gas has been commercially produced in the area.

The preparation of the GIS-based PEMT for the study area required the completion of a series of inter-related steps. The steps included:

1. Identification and review of potential and final valued ecosystem components (VEC) and valued socio-economic components (VSEC);
2. The review of past, present and potential oil and gas development activities in the region, and the residual effects of these activities (Appendix C);
3. The preparation of sensitivity layers for the VECs and VSECs;
4. The preparation of a geo-economic layer; and
5. The development of grid based sensitivity maps.

A key aspect of the PEMT development was the selection of Valued Ecosystem Components (VECs) and Valued Socio-Economic Components (VSECs). Following a review of selected literature, Community Conservation Plans, the VECs chosen for this project include polar bear, beluga and bowhead whale, ringed seal, Peary caribou, and migratory birds, both onshore and offshore. When choosing the particular VECs, the project team identified species at risk or species that had high ecological, social, cultural or economic value. All the VECs selected also play an important social, cultural and economic role for the four Inuvialuit Settlement Region (ISR) communities within the study area, i.e., Aklavik, Inuvik, Tuktoyaktuk, and Sachs Harbour.

The hunting of polar bears, beluga and bowhead whales, ringed seals, Peary caribou and migratory birds were identified as the crucial socio-economic and cultural component. To sustainably manage their resources, the Inuvialuit communities, designated special areas and recommended land use practices in their community conservation plans (CCP's), depending on the significance and sensitivity of cultural or renewable resources. The VSEC of hunting was selected to be included in the decision support tool because the activity of hunting and the species hunted are susceptible to changes in association with oil and gas activities. The Inuvialuit CCP's were used as the basis of the VSEC sensitivity scores.

The geo-economic layer components of the decision-support tool were based on an INAC-developed scorecard rating system for each grid cell in the study area. Each grid cell was scored based on geological factors, economic factors, and uncertainty.

Sensitivity maps were developed for each VEC and VSEC for two distinct seasons: open water (May-October), and ice-covered (November-April). The sensitivity layers are a composite of relevant ecosystem (habitat use and availability) and socio-economic information. In their compiled state, they form a sensitivity layer.

The sensitivity scores provide a relative appreciation of the biological (highlights the most vulnerable and sensitive areas, seasonal distribution, and provides information on the potential response to change resulting from hydrocarbon development), social or economic values within each area. As well, the PEMT provides a grid based version of each sensitive area. This information can be used by INAC-NOGB as well as other users to manage activities within that grid by providing a better understanding of the sensitive areas within a region. The PEMT process that is to be undertaken by the Branch will involve the development of leasing management options.

This PEMT has been designed to eventually support the inclusion of more VEC's and VSEC's as the geographic information becomes available. The tool could also be used to evaluate potential cumulative effects resulting from oil and gas activity in the region at strategic level.

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Acronyms

ABBREVIATION	FULL TEXT
BBOE	Billions of Barrels of Oil Equivalent
CCP	Community Conservation Plan(s)
CEAA	Canadian Environmental Assessment Agency
COGOA	Canada Oil and Gas Operations Act
COSEWIC	Committee on the Status of Endangered Wildlife In Canada
CPRA	Canada Petroleum Resources Act
CWS	Canadian Wildlife Service
DST	Decision Support Tool
EIRB	Environmental Impact Review Board
EISC	Environmental Impact Screening Committee
ESRI	Environmental Systems Research Institute
FEARP	Federal Environmental Assessment and Review Process
GIS	Geographic Information system
GLL	Gartner Lee Limited
GNWT	Government of the Northwest Territories
IBA	Important Bird Area
IBP	International Biological Programme
IFA	Inuvialuit Final Agreement
INAC	Indian and Northern Affairs Canada
ISR	Inuvialuit Settlement Region
MGP	Mackenzie Gas Project
NEP	National Energy Program
NOGB	Northern Oil and Gas Branch
OGMD	Oil and Gas Management Directorate
SARA	Species At Risk Act
SEA	Strategic Environmental Assessment
UGI	Unique Grid Identifier
VEC	Valued Ecosystem Component
VSEC	Valued Socio-Economic Component
WMAC	Wildlife Management Advisory Council

Glossary of Terms

Active ice	Ice that forms open water leads that expand and contract due to the pressures of wind and pack ice movement (also see Flaw Leads)
Anadromous	Living in marine water, while breeding in fresh waters.
Annual ice	The ice that forms on the ocean surface annually in late fall and melts in late spring
Anthropogenic	Effects of processes derived by human activities or actions.
Base Layer	A base layer is the electronic representation of geographic information that applies to the entire study area i.e., maps of the coast line, river systems, etc.
Benthic	The bottom of a sea, lake or river.
Component Layer	A component layer is electronic geographic information that is specific to valued ecosystem components (VECs) or valued socio-economic components (VSECs) and necessary to developing a sensitivity layer.
Country Food	Food derived or gathered from non-domestic sources (i.e. wild game)
Critical Habitat Area	As defined by the Species at Risk Act, the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species.
Critical Habitat Area	As defined by the Species at Risk Act, the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species.
Decision-support tool	The geographic information system (GIS) that contains a series of sensitivity layers generated for each valued ecosystem component (VEC), valued socio-economic component (VSEC) and the geo-economic potential in the study area, which can be manipulated to generate a picture of potential change, should an area be opened to exploration and development.
Development Pressures	a generalized set of environmental or socio-economic impacts or disturbances
Estuary	(1) The lower course of a river where its current is met by the tides and fresh and salt water mix. (2) An arm of the sea that extends inland to meet the mouth of a river.
Flaw leads	Productive areas of an open area of water that separates the central Arctic ice pack from landfast ice.
Geo-economic Layer	The geo-economic layer developed was based on INAC-developed scorecard rating system for each unique grid cell in the Study Area that was scored based on geological, economic, and uncertainty factors.
Geographic Information System (GIS)	A GIS is a computer-based system for capturing, storing, analyzing and managing data and associated attributes, which are spatially referenced to the earth.
Grid	The grid is the predetermined set of coordinates used by the Department of Indian Affairs and Northern Development.
Grid Layer	The grid layer is the visual categorization of the sensitivity rating to the grid.
Ice lead	Any fracture or passageway through sea ice, which is navigable by surface vessels. If the passageway lies between drift ice and the shore, it is termed a *shore lead*. If it lies between drift ice and fast ice it is called a *flaw lead*
Land fast ice	The ice that forms between the shore and sina (ice edge)
Moult	The periodic shedding of the outer skin layer.
Multi-year pack ice	Large area of floating ice that perennially covers the ocean surface.

PEMT	Petroleum Environmental Management Tool
Polynya	Polynyas are persistent and recurrent regions of open water and/or thin ice that occur at locations where a more consolidated and thicker ice cover would be climatologically expected.
Primary Productivity	Primary productivity is the accumulation of biomass, primarily through photosynthesis, In ocean environments, algae supports most primary production.
Secondary Productivity	Secondary productivity is the accumulation of biomass by heterotophs; such as the shrimp-like crustaceans, small fish and zooplankton that make up ringed seal diets.
Sensitivity Layer	A sensitivity layer is a visual representation of the rating gradient developed (1 to 5, whereby 1 is the least sensitive and 5 is the most sensitive), featuring the susceptibility of a VEC or VSEC to change. It is developed from a composite of component layers.
Shore lead	An area of open water between pack ice and fast ice or between floating ice and the shore.
Subsistence Harvesting	Hunting for wildlife to provide essential food and clothing
Surrogacy	The ability for a VEC/VSEC to act on behalf of other components of the environment.
Valued ecosystem component (VEC)	Any part of the biophysical environment that is considered important. Importance may be determined on the basis of cultural values or scientific concerns.
Valued socio-economic component (VSEC)	Those aspects of the socio-economic environment considered to be of vital importance to a particular region or community, including components relating to the local economy, health, demographics, traditional way of life, cultural well-being, social life, archaeological resources, existing services and infrastructure, and community and local government organizations.
Zone of Influence	The area surrounding a feature or activity in which animal abundance, distribution or health is impacted.

1. Introduction and Background

In July 2006, the Department of Indian and Northern Affairs Canada (“INAC”) - Northern Oil and Gas Branch (“NOGB” or “Branch”), contracted Gartner Lee Limited (“GLL”) to develop a geographic information system (GIS) based decision-support tool (“DST”) that would facilitate the completion of a Strategic Environmental Assessment (“SEA”) for a discrete area of the Beaufort Sea.

The NOGB is responsible for the management of oil and gas resources in the Northwest Territories, Nunavut and the northern offshore. The Branch[1], through the *Canada Petroleum Resources Act* (CPRA) provides access to federal Crown lands, issues rights, sets and collects royalties, while the National Energy Board, regulates petroleum industry activities in the North under the CPRA and the *Canada Oil and Gas Operations Act* (COGOA).

In seeking the creation of a decision-support tool to facilitate a SEA, the NOGB is advancing their commitment to sustainable development associated with management of oil and gas resources in the North, while ensuring environmental protection. The decision-support tool and SEA would assist managers and decision-makers in choosing appropriate processes and actions to responsibly manage the opening of offshore areas in the Beaufort Sea.

The work included the following (Gartner Lee 2008):

- a summary of information relating to the biophysical, social and economic environment;
- a summary of information on past and present offshore oil and gas activities in the region (Appendix C);
- a web accessible and GIS-based decision support tool (and supporting database); and
- a report summarizing the above work.

The objectives for the DST were twofold:

The first objective was to define sensitivity layers for a series of Valued Ecosystem Components (VECs) and Socio-economic Components (VSECs) so that parts of the study area that have greater susceptibility to development are identified. A series of VECs and VSECs were chosen to represent a variety of ecological and social components that were of value.

The second objective was to amalgamate the sensitivity layers using a GIS tool so that the combined results of sensitivity to development among VECs and VSECs could be viewed holistically and support future decisions regarding areas available for lease, for oil and gas exploration and development. The sensitively layers would be applied to the Northern Oil and Gas Branch’s Leasing Grids (termed herein Grid Sensitivity), and the combination could simultaneously identify areas of high or low sensitivity among several VECs/VSECs, and corresponding high and low values of geo-economic potential.

Additionally, these objectives were meant to contribute to the ability of INAC to complete strategic level environmental assessment and support long-term planning. By developing an understanding of where multiple environmental and socio-economic sensitivities were, and where the greatest and least economic potential lies (and where uncertainties exist), INAC could use that information in planning and evaluating future leasing decisions.

In 2008, there was a continuation of the Decision Support Tool (DST) by AECOM (formerly GLL). The spatial extent of the study area was modified, as interest in applying the application to onshore areas has

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[1] *http://www.ainc-inac.gc.ca/oil/vision_e.html*

been strong. To this end, a revised study area was prepared by INAC, and the existing Sensitivity Layers were extended to the NOGB grid network that exists onshore. Information related to polar bears and offshore waterfowl was updated. In addition, two new layers were added: bowhead whale and onshore waterfowl layers (AECOM 2009). In the completion of this work, AECOM had the cooperation and input of INAC and the departments that are holders of the information. Where expert involvement and data was not readily available, AECOM proceeded with the development of the layers using its own judgement, and data and information from other reputable sources.

Sensitivity layers were organized according to the summer open water season (May to October) and the winter ice-covered season (November to April), which correspond with seasons for sea ice concentrations (Barber and Hanesiak 2004). Sensitivity layers were extended to include the NOGB onshore grid network. The onshore sensitivity layers include an evaluation of onshore polar bear denning habitat, and staging, feeding, nesting, brood-rearing and moulting habitats for offshore (seabirds), and onshore (shorebirds, ducks and geese) migratory bird species. In general, the update and addition of sensitivity layers followed the same principles as was developed and applied in the earlier versions of the DST:

- life cycle and occurrence in the study area;
- susceptibility to habitat change;
- sensitivity to development; and
- importance to Inuvialuit.

The Beaufort Sea DST is now in its third phase and has been renamed as the Petroleum and Environmental Management Tool (PEMT). However, the objectives remain the same. The Beaufort PEMT geographic extent was initially based on the area of prominent economic interest in the southern Beaufort Sea and the area adjacent to the coast. This development phase focuses on creating an ISR-focused PEMT by including northern areas of the ISR where reasonable oil and gas potential exists. The work continues to use the two season (summer or open water, and winter or ice-covered) approach in describing and evaluating environmental and socio-economic sensitivities, and extends into the new defined study area. A third season, a summer operating season, was added which corresponds to the period when oil and gas activity is most likely to occur. One new layer was added with the expanded study area, Peary caribou.

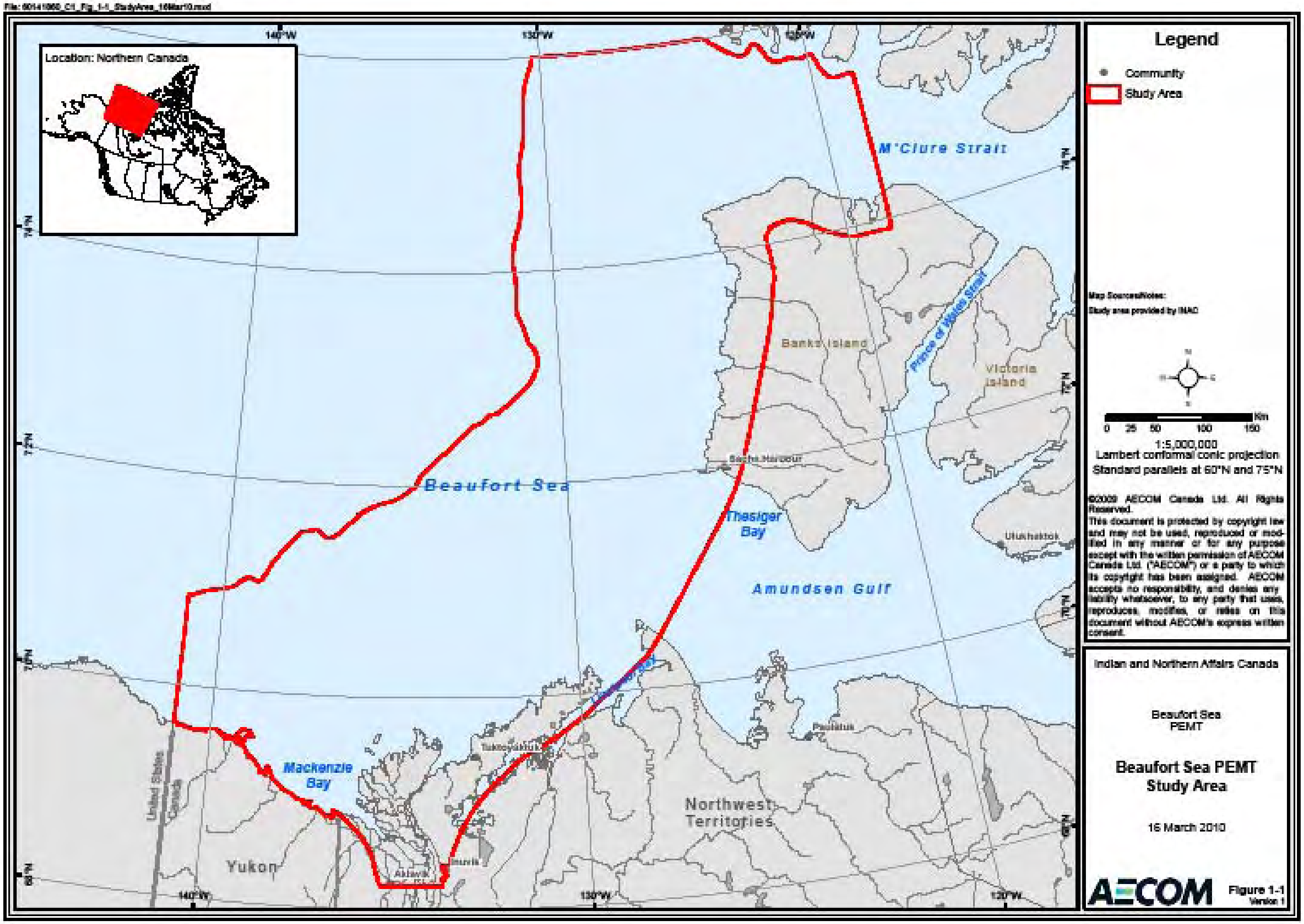
This phase integrates all current work and previous reports (Gartner Lee 2008, AECOM 2009) into a single comprehensive document. The report includes:

- relevant species life history information and description of sensitivity for the entire study area;
- literature citations and references to data used to develop sensitivity layers;
- an updated bibliography prepared as a separate file compliant with RefWorks v5.0

1.1 Study Area Description

The study area lies immediately north of Inuvik and Tuktoyaktuk in the Beaufort Sea, and borders the Canada-United States border to the west (141° W), approximately the mainland coast to the south, and the 128° W longitude to the east. The Beaufort PEMT geographic extent was initially based on the area of prominent economic interest in the southern Beaufort Sea and the area adjacent to the coast. A third phase focused on creating an ISR focused PEMT by including northern areas of the ISR where reasonable oil and gas potential exists. The new boundary follows the existing study area along the southern border and along the Canada/US border (141 degrees longitude) to a point where this line meets the 2,000 m water depth mark. The study area then follows the 2,000 m water depth line from the Canada-US border NE-ward to 75 degrees latitude N. The line follows 75 degrees latitude N to the northern coast of Banks Island, then follows the western shoreline of Banks Island to its south-western most tip. The line crosses Amundsen Gulf from Banks

Island to Cape Bathurst to join with the existing study area boundary (see Figure 1-1). The study area on the west coast of Banks Island also extends 25 km inland along whole length of the western coastline.


File: 60141060_C1_Fig_1-1_StudyArea_16Mar10.mxd
Location: Northern Canada
140°W
130°W
120°W
74°N
72°N
70°N
68°N
Beaufort Sea
M'Clure Strait
Banks Island
Prince of Wales Strait
Victoria Island
Sachs Harbour
Thesiger Bay
Ulukhaktok
Amundsen Gulf
Paulatuk
Tuktoyaktuk
Mackenzie Bay
Aklavik
Inuvik
Yukon
United States
Canada
Northwest Territories
Legend
Community
Study Area
Map Sources/Notes:
Study area provided by INAC
N
E
S
W
Km
0 25 50 100 150
1:5,000,000
Lambert conformal conic projection
Standard parallels at 60°N and 75°N
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Beaufort Sea PEMT
Beaufort Sea PEMT Study Area
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Figure 1-1
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Figure 1-1 Beaufort Sea PEMT study area

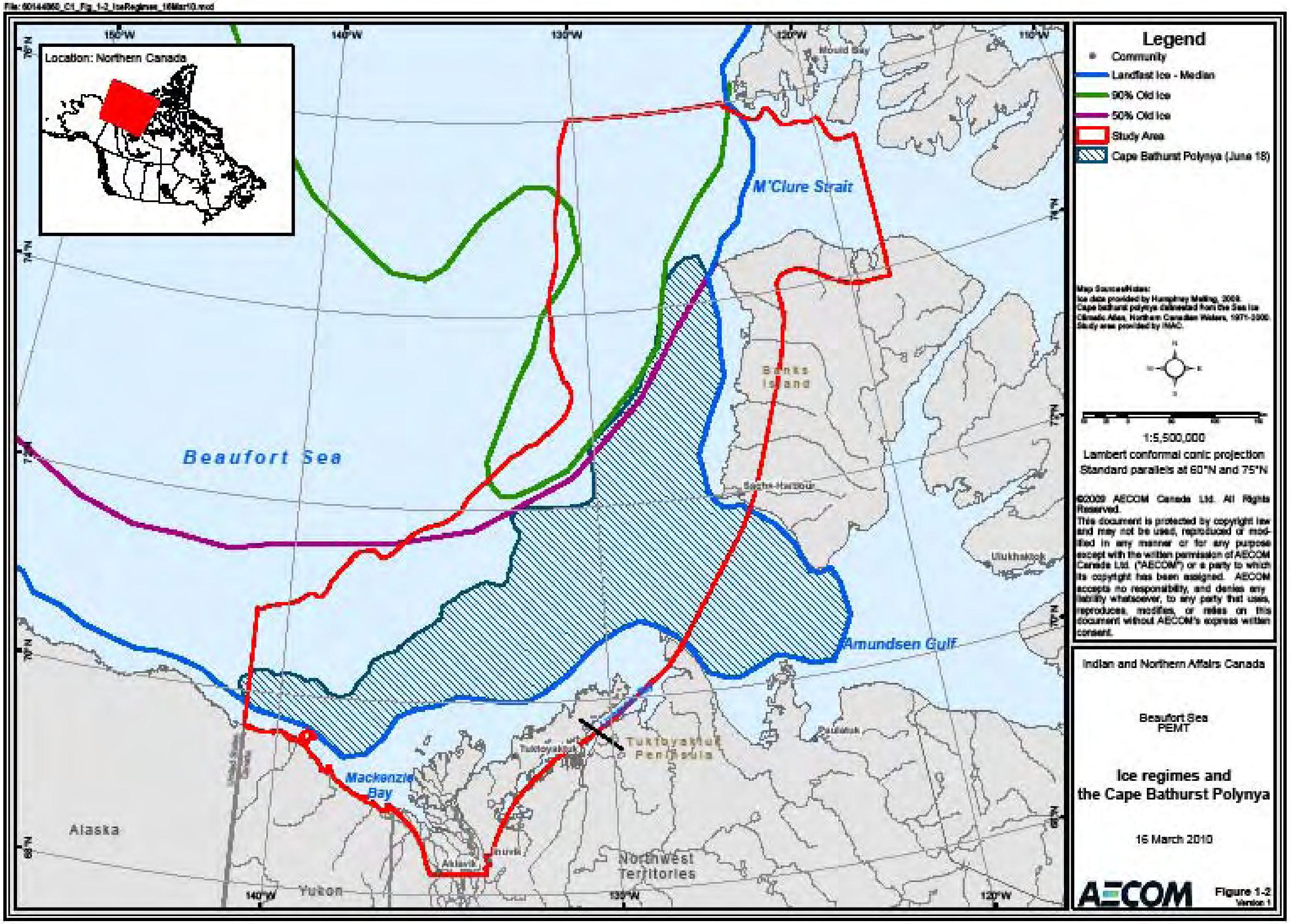
1.1.1 Environmental Setting

Seasonal ice cover characterizes the region and is categorized into three regimes: 1) offshore pack ice consisting of mobile annual ice and multi-year sea ice which occurs to the north of the study area, 2) landfast ice which forms annually within the coastal margins over the continental shelves, and 3) the Cape Bathurst Polynya complex which is a series of recurrent flaw leads (Barber and Hanesiak 2004). The landfast ice extends outward from the coast to the point at which water depth is approximately 20 m, after which rubble ice is formed. Beyond the rubble ice, on the seaward side is a flaw polynya, and beyond that there is drifting polar pack ice (DFO 2007). Figure 1-2 shows the extent of the principal ice domains (50% and 90% multiyear ice, and the landfast ice), as of June 10 and is based on 30-year ice climatology of the Canadian Ice Service for 1970-1999 (Canadian Ice Service 2002; H. Melling, pers. comm.).

Typically, in April, break-up of the nearshore ice begins. Freshwater from the Mackenzie River and sea-ice melt create circumstances not dissimilar to an estuary (Figure 1-3). The area becomes dominated by freshwater and allows freshwater biota to temporarily inhabit the nearshore waters. In the fall, autumn storms force an upwelling bringing off-shore waters to mix with the nearshore waters. Freeze-up starts in October and is generally complete by November.

The flaw lead systems on the seaward side of the landfast ice may be frozen during part of the winter, but all are among the first areas in which open water occurs in the spring. Passive microwave records indicate reductions in ice concentration in the area of the Cape Bathurst polynya flaw leads as early as December and definitely by April (Barber and Hanesiak 2004). Sustained reduction in concentrations occurs by mid-April in the areas of the Banks and Mackenzie Shelf flaw leads. Three nodes of sustained ice reduction appear by about mid-May just west of Banks Island, north of the Tuktoyatuk Peninsula, and in the eastern limit of Amundsen Gulf. These nodes interconnect in the subsequent weeks to produce a distinctive polynya complex with a limb along the shelf/slope break in the approximate locations of the flaw lead polynyas and with a limb into Amundsen Gulf. This ‘‘trinode’’ polynya complex then advances in size throughout the spring melt to a point where ice free water exist most of the way along the Alaskan coast by late August. The January open water area is approximately 52 km2; the July open water area is approximately 47,000 km2 (Barbour and Massom 2007).

These leads are predictable in their location, recurrent, among the most constant of areas in which open water may be found during winter and early spring, and are of enormous biological importance. There are high densities of seals and polar bears in the Cape Bathurst polynya system throughout the winter because of the unstable ice conditions, but these flaw leads also become the main arteries for migrating marine mammals (bowhead and beluga whales) and staging areas for hundreds of thousands of migratory waterfowl and seabirds (Stirling 1980).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140°W
130°W
120°W
110°W
76°N
74°N
72°N
70°N
68°N
Mould Bay
M'Clure Strait
Banks Island
Sachs Harbour
Ulukhaktok
Amundsen Gulf
Beaufort Sea
Tuktoyaktuk
Tuktoyaktuk Peninsula
Paulatuk
Mackenzie Bay
Aklavik
Inuvik
Alaska
Yukon
Northwest Territories
United States
Canada
Legend
Community
Landfast Ice - Median
90% Old Ice
50% Old Ice
Study Area
Cape Bathurst Polynya (June 18)
Map Sources/Notes:
Ice data provided by Humphrey Melling, 2009.
Cape bathurst polynya delineated from the Sea Ice Climatic Atlas, Northern Canadian Waters, 1971-2000.
Study area provided by INAC.
N
E
S
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Lambert conformal conic projection
Standard parallels at 60°N and 75°N
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Ice regimes and the Cape Bathurst Polynya
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Figure 1-2
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Figure 1-2 Ice regimes and the Cape Bathurst polynya

Figure 1-3 Winter and summer sea ice dynamics and the influence of the Mackenzie River

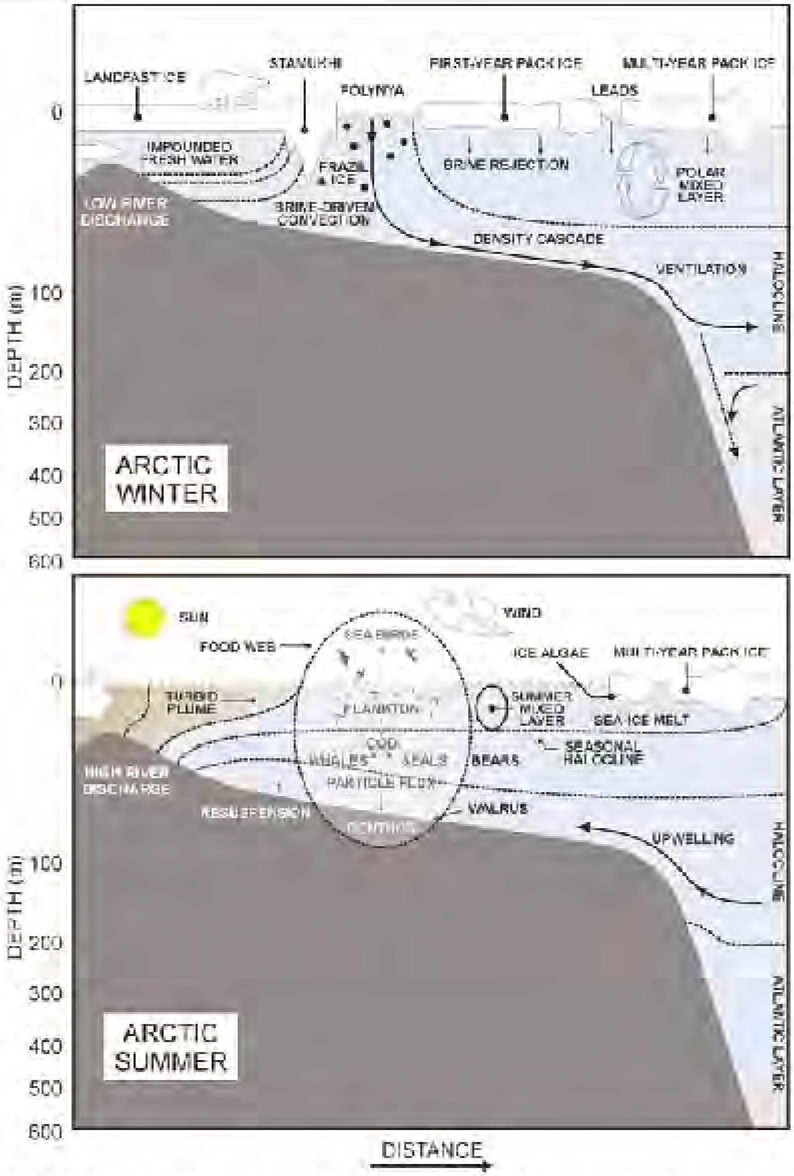

Figure 7. Beaufort Sea winter and summer sea ice dynamics and the influence of Mackenzie River discharge (courtesy of Dr. E.C. Carmack and Dr. R.W. Williams – DFO).

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Winter and summer sea ice dynamics and influence of the Mackenzie River

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Figure 1-3
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Map Document: 60131660_C1_Fig_1-3_SeaIceDynamics_16Mar10.mxd

The trophic relationships in the Beaufort are driven by light and nutrients absorbed by phytoplankton (primary producer). Phytoplankton growth is driven by light and nutrient availability in the Beaufort Sea. Zooplankton creates the link between phytoplankton and larger organisms (Figure 1-4). Fish species closely occupy the same points in the water column as zooplankton. Of primary importance are arctic cod (*Boreogadus saida*). Arctic cod are consumed by beluga whales (*Delphinapterus leucas*) and seals (*Phoca* sp.). At the top of the trophic scale, seals are consumed by polar bears (*Ursus maritimus*) (DFO 2007).

1.1.2 Background of Oil and Gas Development in the Beaufort Sea

The Beaufort Sea-Mackenzie Delta has been the scene of extensive oil and gas exploration activity including both onshore and offshore drilling activities. Oil and gas activity north of 60° extends back to the discovery of the fields in Norman Wells in 1919 (Morrell *et al.* 1995). Exploration activity in the area began onshore in 1957 with the first reconnaissance-level ground and air studies taking place in the Mackenzie Delta region by major industry corporations such as Dome, Chevron, Gulf, Esso and others (GNWT 2006). The discovery of oil at Atkinson Point in 1969 and discover of major gas fields at Taglu (1971), Parsons Lake (1972) and Niglintgak (1973) resulted in the proposal of the Mackenzie Valley Pipeline in 1974 and the addition of exploration and investment offshore (Morrell 2003). Offshore exploration began in the Beaufort Sea region in the early 1970’s with the use of artificial islands in shallow water (up to 12 metres of water depth) (Timco and Johnston 2002). These islands were constructed by either dredging the local sea bottom or by trucking or barging gravel from shore. The first of the islands was constructed in 1972, followed by the completion of 23 more before 1984 (FEARP 1984).

Exploration and drilling continued, both onshore and offshore, until the mid 1970’s and the release of the report on the inquiry for the Mackenzie Valley pipeline by Justice Berger. This report recommended a 10-year moratorium on the construction of a pipeline up the Mackenzie Valley in order to settle land claims with aboriginal groups and address environmental concerns (GNWT 2006). This prompted the federal government to institute a freeze on the issuance of new exploration rights in the Mackenzie Valley until land claims were settled (Morrell *et al.* 1995). At the same time, the National Energy Program (NEP) was initiated in 1980 to continue to promote activity in the Beaufort Sea – Mackenzie Delta region.

Figure 1-4 Trophic relationships of species in the Beaufort Sea region

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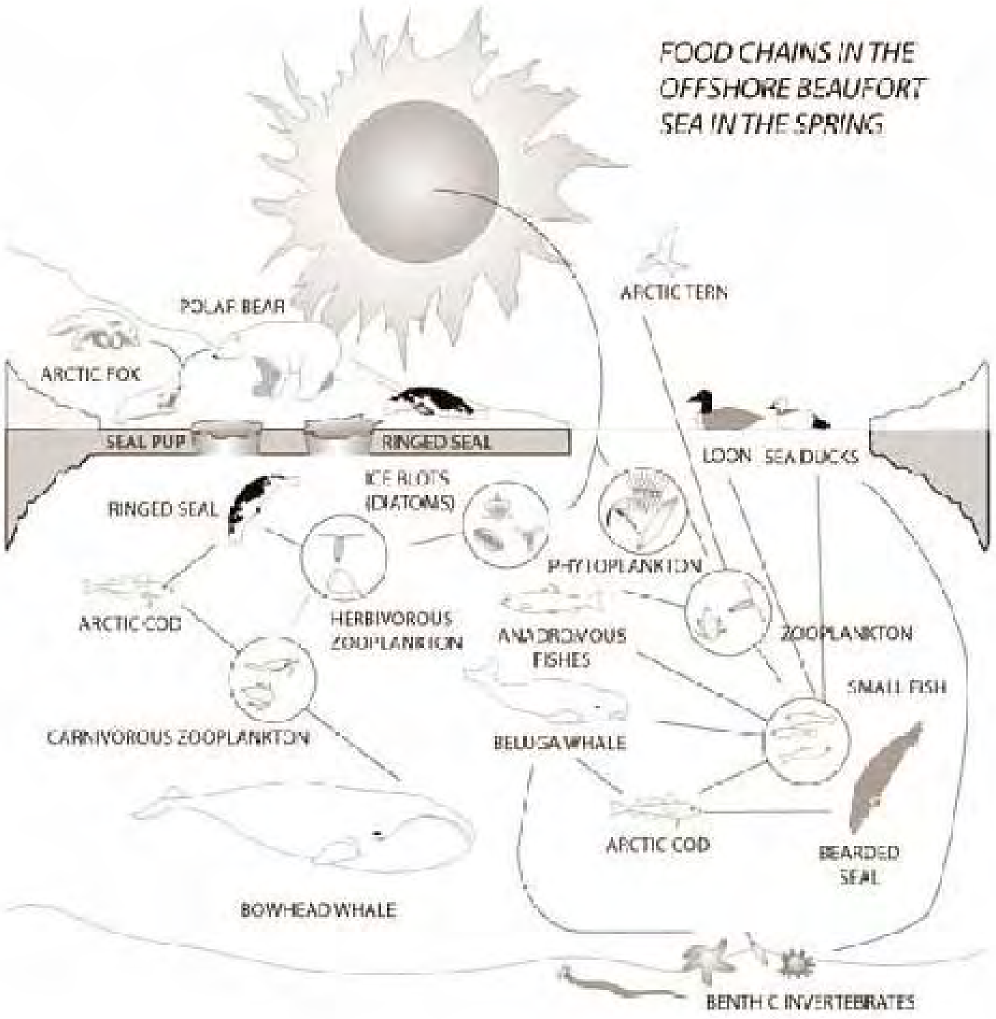

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Trophic relationships of species in the Beaufort Sea region

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Figure 1-4
Version 1

Offshore exploration escalated in the 1980's. Seismic exploration found numerous large structures and potential for "oil-prone source rocks". This precipitated additional offshore exploration with success at Kopanoar in 1976, and culminating with Amauligak, which was considered among the largest discoveries, in 1983 (Morrell *et al.* 1995). The success of this exploration has led to the issuing of numerous exploration and significant discovery licences (Figure 1-5). Offshore exploration was facilitated with innovative operating techniques and new offshore platforms that extended the ability to operate in the short open-water season and ice. Offshore petroleum discoveries continued each year until 1989 (Table 1-1). A total of 83 offshore wells had been drilled in the Beaufort-Mackenzie Basin (62 exploratory and 21 delineation). With the settlement of land claims in the Beaufort-Delta, rights issuance was again initiated in 1989 but it was not until 1999-2000 that companies took up extensive petroleum exploration rights both onshore in the Mackenzie Delta and in the Beaufort Sea (INAC 2001).

Table 1-1 Offshore Oil Discoveries in the Beaufort-Mackenzie Region from 1976-1989 (mmbls)

500-100 mmbls	100-25 mmbls	25-10 mmbls	<10 mmbls
Amauligak (1983)	Tarsiut (1978)	Nektoralik (1976)	Nerlerk (1977)
Adlartok (1985)	KoaKoak (1979)	W. Atkinson (1982)	Itiyok (1982)
Kopanoar (1976)	Issungnak (1980)	Amauligak (1988)	Arnak (1986)
	Havik (1983)	Nipterk (1989)	
	Pitsiulak (1983)		
	Nipterk (1984)		
	Kingark (1987)		

Note: mmbls = million barrels (Morrell et al. *1995)*

With the minor exception of the small onshore gas field at Ikhil, no oil or gas had been commercially produced, despite all of the exploration and monetary investment in the 1970s and 80s. Ikhil was put on-stream in the Mackenzie Delta in 1999 and currently supplies the town of Inuvik with energy for power generation and domestic use (Morrell 2003). In 2004, the Delta gas fields discovered at Taglu, Parsons Lake, and Niglintgak were proposed for development (Mackenzie Gas Project 2004). Offshore exploration was again revived with the 2005 drill program by Devon Canada. The drilling of the Paktoa well site was the first to be drilled offshore in the Beaufort Sea in sixteen years (Indian and Northern Affairs Canada 2005). At the end of 2005, although six gas fields were in production in the Northwest Territories, only one gas field was producing in the Mackenzie Delta (Ikhil) and none from the offshore Beaufort Sea (INAC 2006c).

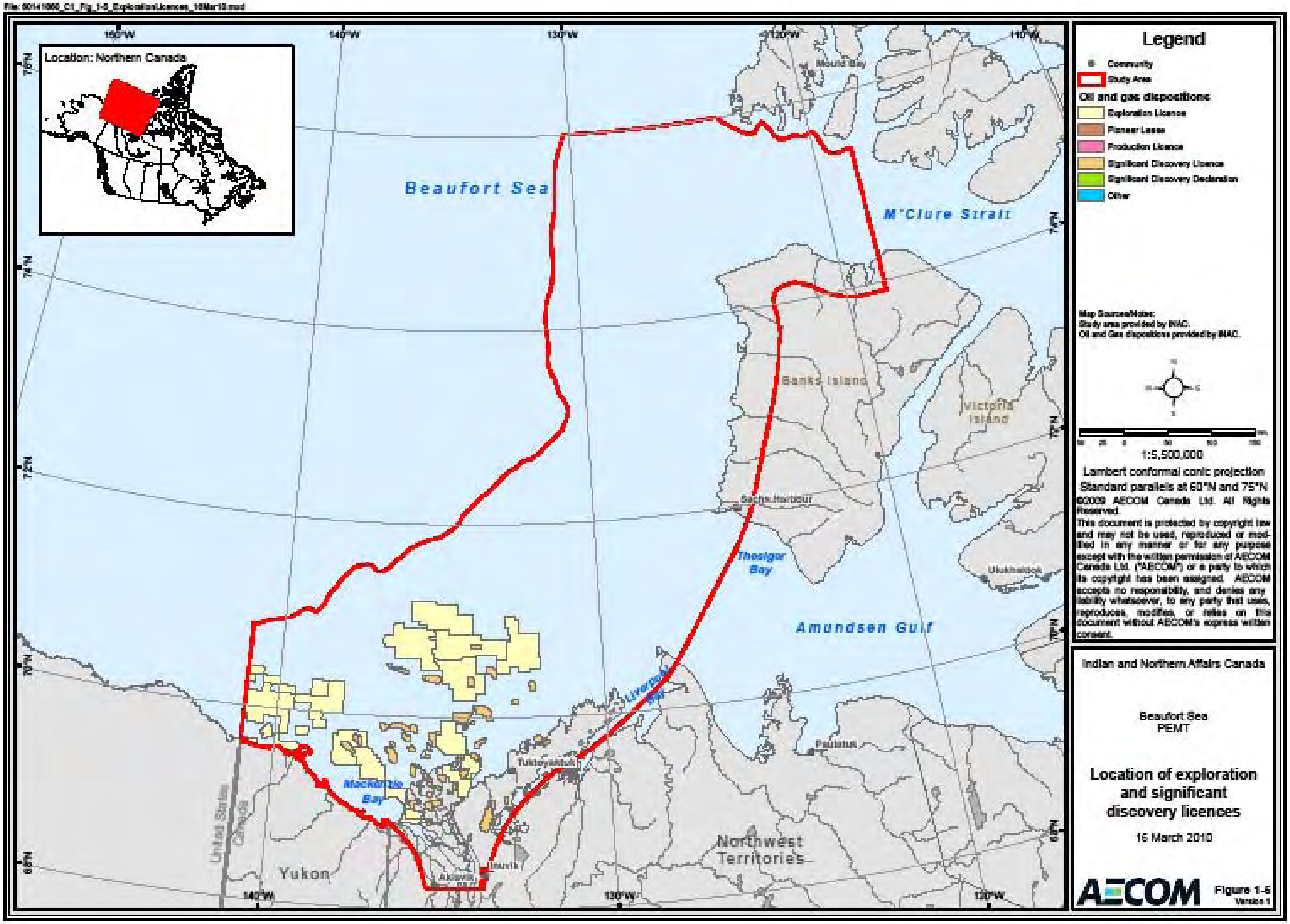

Figure 1-5 Location of exploration and significant discovery licences

2. Approach and Methods

A compilation and synthesis of environmental and cultural information in the form of an updated report and series of sensitivity and geo-economic maps was prepared for NOGB that included the expanded study area. Updated species sensitivity models to oil and gas activities were scientifically derived, and the sensitivity modeling techniques used were fully aligned and reported. The sensitivity modeling techniques used to date were also reviewed.

This section provides an overview of the methods to defining sensitivity layers for the selected VECs and VSECs, the development of the Geo-Economic layer, and how that information was used in building the PEMT.

2.1 VEC/VSEC Layer Development

2.1.1 Selection of Valued Ecosystem and Socio-Economic Components

A key aspect of the PEMT development was the selection of VECs and VSECs. It was critical that the VECs and VSECs be scientifically defensible and broadly accepted. In addition, consideration was given to whether or not a VEC or VSEC could be representative of components other than themselves (i.e., were they capable of acting as a surrogate for other components).

Identifying the candidate VECs and VSECs for this exercise was completed in the following manner:

- the development of a preliminary list of VEC/VSEC was based on candidate species of mammals, migratory birds and fish identified as species at risk and those components with a high ecological, social, cultural or economic value. a review of selected literature, including previously completed environmental assessments, research reports related to the Beaufort Sea Region, and the Community Conservation Plans (CCP) for the Inuvialuit Settlement Region;
- determination of which potential VECs and VSECs were associated with the study area for at least a portion of their annual life cycle;
- confirmation of the availability of information for the potential VECs and VSECs;
- determination of a potential relationship between the VECs and VSECs;
- determination of whether the VECs/VSECs displayed sensitivity to change; and
- importance to Inuvialuit.

A further step included consideration of VEC/VSEC responses to possible environmental effects related to oil and gas projects and discussions with regulators familiar with the Beaufort Sea region.

2.1.1.1 Selected Valued Ecosystem Components

A large list of candidate VECs was considered; and is summarized in Appendix A. One of the main factors in the final selection of VECs was the availability of spatially referenced information that could be used in a GIS approach to mapping the sensitive areas associated with VECs. It is intended that additional VECs/VSECs will be mapped in future, as additional spatial datasets become available. The mapping of a subset of the candidate VECs/VSECs and the subsequent review of the sensitivity layers will allow for modification to the mapping and processes in future (if necessary) as additional VECs/VSECs are mapped.[2] Data sources for the PEMT were publicly available regional and local

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[2] *It is NOGB's intention to further develop the list of VEC's and VSEC's as spatial information becomes available. The department of Fisheries and Oceans recently provided information on Ecologically and Biologically Significant Areas in the Beaufort Sea, which will be a priority for future integration into the tool.*

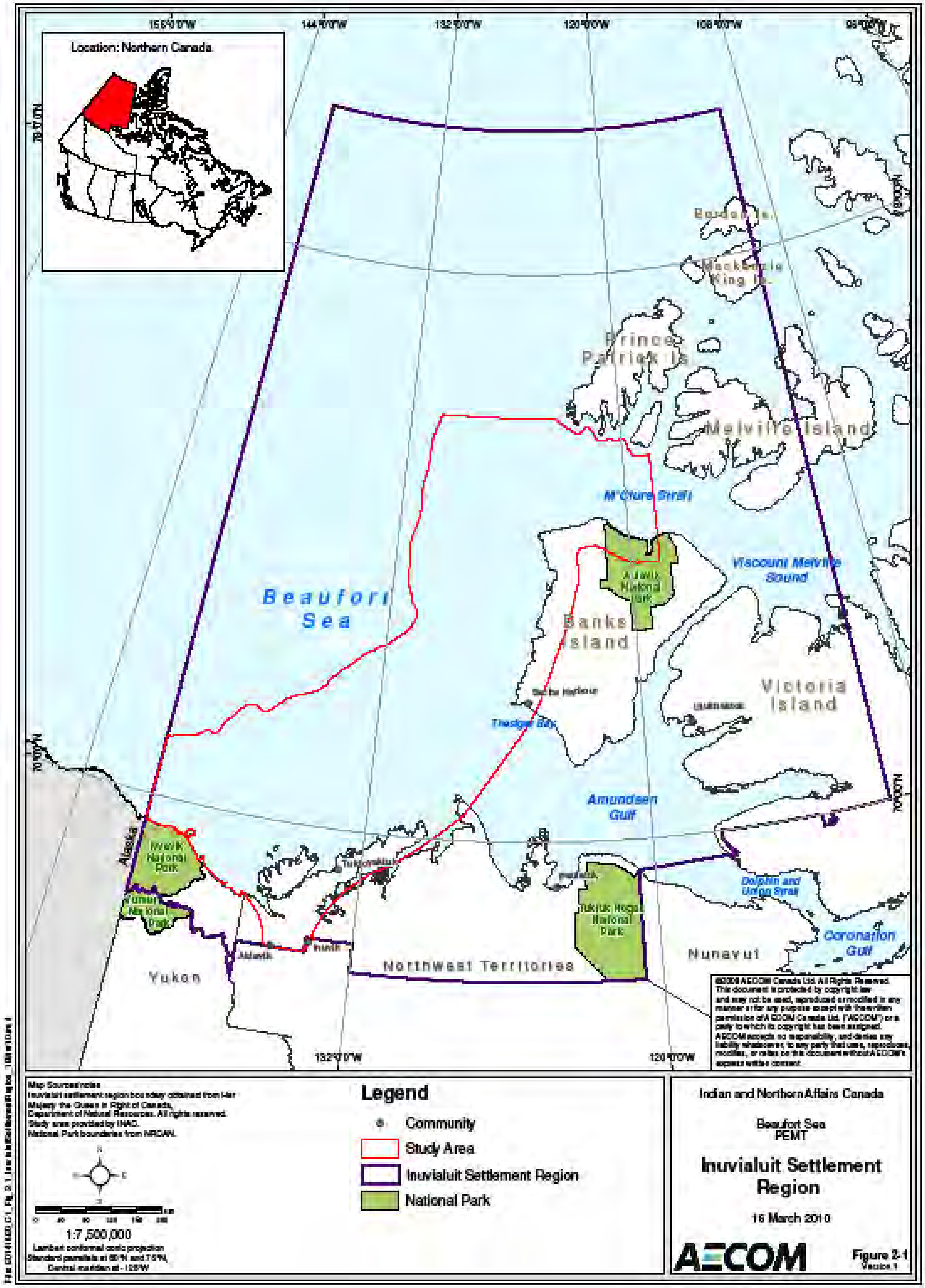
environmental and ecological data and maps provided by the communities, municipal, territorial and federal government agencies, scientific reports and peer-reviewed journal publications. The VECs selected for this project include:

- polar bear (*Ursus maritimus*);
- ringed seal (*Phoca hispida*);
- beluga whale (*Delphinapterus leucas*);
- bowhead whale (*Balaena mysticetus*);
- Peary caribou (*Rangifer tarandus pearyi*); and
- migratory birds (onshore and offshore species).

2.1.1.2 Valued Socio-Economic Components

All the VECs selected play an important social, cultural and economic role for the Inuvialuit Settlement Region (ISR) communities. The ISR Community Conservation Plans identify important wildlife habitat and seasonal harvesting areas, population goals and conservation measures appropriate for each species of concern, and make recommendations for their management. After a review of the CCPs, and a consideration of petroleum industry activities likely to take place in the study area, hunting and trapping was selected as the final VSEC. In reviewing all of the plans for the ISR communities it was determined that communities of Paulatuk and Ulukhaktok (Figure 2-1) did not identify lands within the study area which were used for hunting and trapping, therefore, the review of CCP information focused on the communities of Aklavik, Inuvik, Tuktoyaktuk, and Sachs Harbour. Additional details on the hunting and trapping VSECs are provided in Section 9.

Figure 2-1 Inuvialuit Settlement Region



2.1.2 VEC/VSEC Sensitivity Layer Development

2.1.2.1 Sensitivity Ranking Methodology

The process of developing sensitivity rankings was a process that linked ecological factors and habitats associated with individual species, and the nature of potential impacts to VECs and VSECs. In the completion of this work, AECOM had the cooperation and input of INAC and the departments that are holders of the information. Where expert involvement and data were not readily available, AECOM proceeded with the development of the sensitivity layers using its own judgement in combination with data and information from other reputable sources.

Sensitivity layers were organized according to summer open water season (May to October) and winter ice-covered season (November to April), which correspond with seasons for sea ice concentrations (Barber and Hanesiak 2004), and a summer operating season (August 1-October 31), was added which corresponds to the period when oil and gas activity is most likely to occur..

Each VEC and VSEC is unique. The process of assigning a rating to a sensitivity layer was in part, a subjective and individual method. The rating system and the principles for that can be described using as decision process diagram. However, there were several guiding principles that were common to the process of sensitivity ranking for all VECs and VSECs. The principles that guided this process were:

- the life cycle and occurrence in the study area. Habitats that have specific values (e.g. nesting, moulting, denning, etc.) for the suite of VECs were mapped;
- the sensitivity to development, the ecological value of habitat that support the viability of the population of a VEC were positively reflected in the sensitivity rating for an individual VEC;
- the susceptibility to habitat change for VECs, the greater the ability of a given area to respond to development pressures (including accidents) with elasticity and less functional change were given a lower sensitivity rating, and conversely, those areas that had less capacity to absorb changes due to development pressures were given higher sensitivity ratings; and
- the importance to Inuvialuit; the cultural value of areas to indigenous people was positively related to the sensitivity rating of a VSEC; especially in regard to the ability of the area to support culturally significant activities, history, or education
- in rating layers, the precautionary principle was applied, in that in areas with lesser certainty of either the value of habitats or the implications of development were rated with higher sensitivity.

These principles are similar to those established through the development of similar sensitivity atlases. Examples include the *Sensitivity Atlas of Peatlands to Climate Change* (Tarnocia *et al.* 2000), *Sensitivity of Eolian Processes to Climate Change in Canada* (Wolfe and Nickling 1997), and *Environmental Atlas for Beaufort Sea Oil Spill Response* (Dickins *et al.* 1987). Sensitivity atlases for the Beaufort Sea produced by Environment Canada focused in detail on inshore areas, and overall sensitivity ranks were based on 20 sensitivity elements among 3 categories: human use sensitivity, biological sensitivity, and shore zone or marine oil residence (Dickens *et al.* 1987).

The sensitivity rating of individual layers was assigned to five categories: 1) Low, 2) Low-Moderate, 3) Moderate, 4) Moderate-High, and 5) High. The highest ratings were meant to document those habitats or areas that support a specific ecological function or process critical to the survival and reproduction of a species at a population level or those areas that have the highest vulnerability to development pressures (specific to the individual VEC). Conversely, the lowest sensitivity rankings included habitats that are little used and of relatively low value to the viability of populations, and in which the receiving environment may show limited functional change with the addition of development pressures. Low-Moderate, Moderate, and Moderate-High rankings reflect intermediate stages between areas that are critical to the viability of species' populations, and those areas that have very limited value to the viability of the population. Differing histories of population growth or decline, and differing sensitivities to development pressures, make standardizing the ratings for the five rating classes among each VEC/VSEC difficult to quantitatively defend. Classification to the Low or High sensitivity ratings was easier to define because those areas of very high or very low value were better defined with the existing literature (for example, for the migratory birds VEC, defined areas are known to support a significant portion of the world' s population during a time of specific ecological function). In most cases, the distinction between Low-Moderate through Moderate-High was based on professional judgement. The guiding principles and sensitivity rating system described above is shown in Figure 2-2.

Principles used in the creation of the sensitivity layers can be applied when re-evaluating sensitivity layers layers for existing VECs and VSECs as new data becomes available, or can be applied to develop sensitivity layers for additional VECs that are added to the PEMT. It is important to recognize that the roots of this method lie in practicality, and providing a relatively simple approach to combine several ecological and cultural values together, so that decision makers can have a support tool to help evaluate the implications of opening areas of the Beaufort to exploration and development.

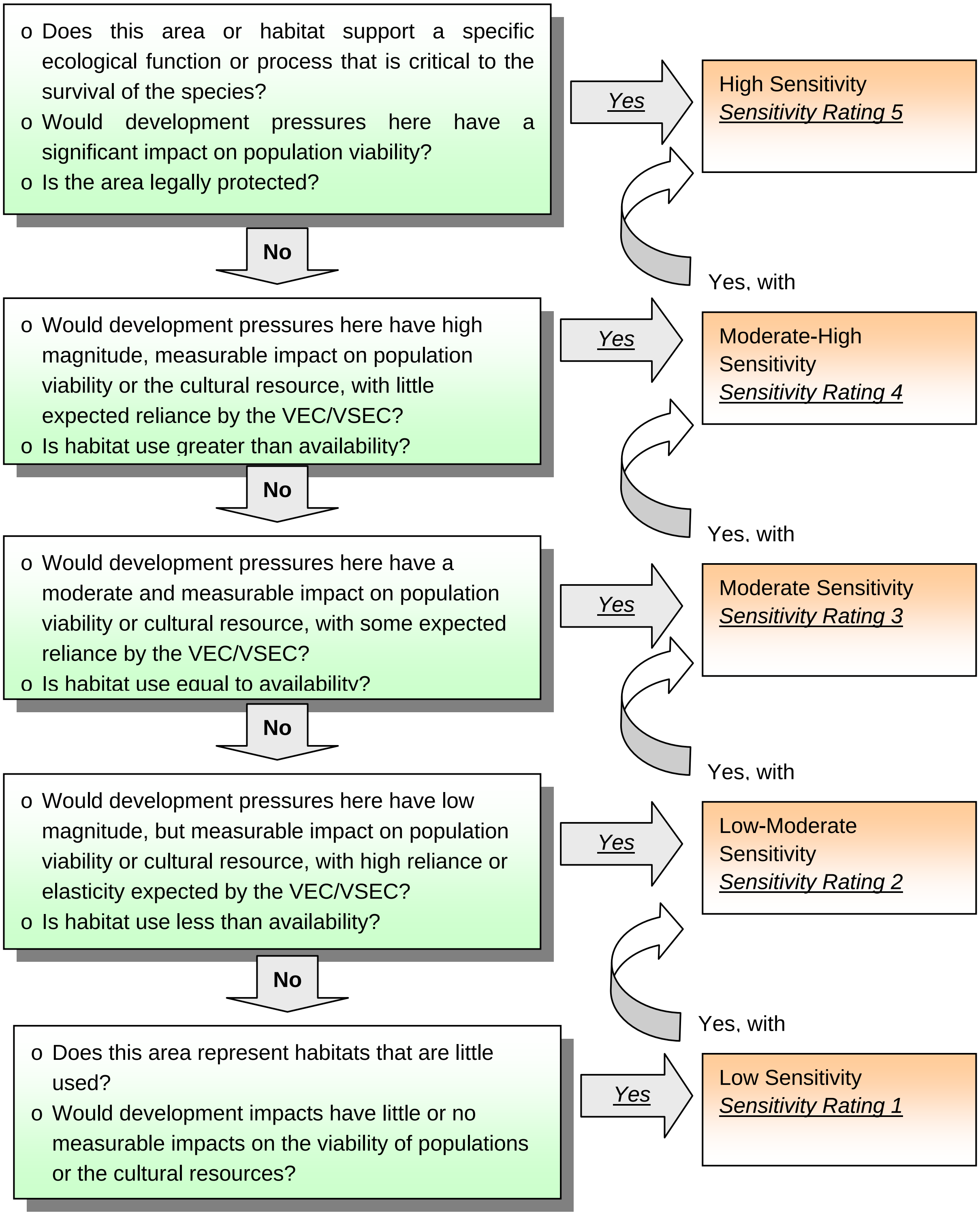
Seasonality

In ranking sensitivity for each VEC and VSEC, the seasonality of occurrence of potential development impacts was identified (e.g., winter, summer, summer operating season), and the value of the area or habitat that may only be used seasonally. VEC sensitivity was only ranked for the summer and winter season for beluga and bowhead whale. However, when VEC sensitivity changed during the true open water season (e.g. polar bear, ringed seal, migratory birds), those VEC species were ranked for a summer operating season (August 1 – October 31) to rank sensitivity at a time when oil and gas offshore activities are most likely to occur. Therefore, sensitivity for polar bear, ringed seal, and migratory birds was ranked for summer (open water), winter, and summer operating season.

As the overall objective of this work was to facilitate a PEMT for the potential issuance of oil and gas exploration permits (and ultimately production permits within the Study Area), the sensitivity rating was built to incorporate data from all seasons (i.e., it was seasonal). The main rationale for this approach is that development activities that may occur in one season often result in impacts that persist across other seasons (i.e., habitat loss that occurs in mid-winter may not have immediate impacts to the moulting areas of migratory birds, but those impacts will persist to result in habitat loss across all seasons, including during the moulting periods).

Figure 2-2 Creation of the sensitivity layer

Sensitivity Rating Decision Process (Top Down Process)



- Does this area or habitat support a specific ecological function or process that is critical to the survival of the species?
- Would development pressures here have a significant impact on population viability?
- Is the area legally protected?

High Sensitivity
Sensitivity Rating 5

- Would development pressures here have high magnitude, measurable impact on population viability or the cultural resource, with little expected reliance by the VEC/VSEC?
- Is habitat use greater than availability?

Moderate-High Sensitivity
Sensitivity Rating 4

- Would development pressures here have a moderate and measurable impact on population viability or cultural resource, with some expected reliance by the VEC/VSEC?
- Is habitat use equal to availability?

Moderate Sensitivity
Sensitivity Rating 3

- Would development pressures here have low magnitude, but measurable impact on population viability or cultural resource, with high reliance or elasticity expected by the VEC/VSEC?
- Is habitat use less than availability?

Low-Moderate Sensitivity
Sensitivity Rating 2

- Does this area represent habitats that are little used?
- Would development impacts have little or no measurable impacts on the viability of populations or the cultural resources?

Low Sensitivity
Sensitivity Rating 1

Confidence in Data Layers

The accuracy in which sensitivity layers are delineated in the model, the true value of habitats, and the true nature of how areas may respond to industrial disturbance is likely variable among VECs. Those underlying spatial data were treated more conservatively when it was suspected that limited confidence existed for the mapping of habitat values (such as the case with polar bears). It is hoped that use of this PEMT will ultimately spur primary researchers to better define and categorize the habitat values in the study areas, and the potential consequences of development.

2.2 Geo-Economic Layer Development

The geo-economic layer scoring in the decision-support tool was developed based on an INAC-developed scorecard rating system for each unique grid cell in the Study Area. A spreadsheet was created to hold the scores for all grid cells in the study area, based on a sample scorecard and rating system developed for individual UGI cells.

Essentially, each individual cell was scored based on the following three main categories:

- Geological Factors
- Economic Factors
- Uncertainty

The INAC-developed geo-economic layer scoring for the southern portion of the study area was quanitative and described below. The geo-economic layer scoring for the northern portion of the study area will be developed by INAC and will be more qualitative.

2.2.1 Geological Factors Score per UGI

The Beaufort-Mackenzie Basin is known for its proven and potential oil and gas resources. The discovered quantities of conventional oil and gas resources are estimated to be 277.3 x 10^6 m^3 recoverable crude oil and 332.4 x 10^9 m^3 recoverable natural gas. This assessment of resource potential was based on research completed by the Geological Survey of Canada, which identified 18 plays. The Basin itself has been organized into six distinct play groups. Geological scores were derived from the mean oil resource estimate for the following:

- Deep Water (outboard of the contemporary shelf edge);
- Basinal Facies (inboard of the contemporary shelf edge);
- West Beaufort Sea;
- Taglu Delta;
- Kugmallit Delta; and
- Rifted Margin.

These potential estimates were taken from Chen *et al.* (2006).

The allocation per grid was determined by dividing the mean potential estimate in Billions of Barrels of Oil Equivalent (BBOE), by the number of grids in the play group.

The mean oil score was multiplied by a gas/oil factor based on discovered resources in each play group, to determine a mean gas endowment per play group (Table 2-1). This factor was estimated from Dixon et al. (1994). No gas was assigned to the Deep Water play group.

Table 2-1 Beaufort and Mackenzie Basin Total Gas and Oil based on BBOE

Play Group	Total Gas + Oil (BBOE) Per Grid cell
Taglu Delta	33
West Beaufort Sea	25
Rifted Margin	11
Kugmallit Delta	36
Basinal Facies	29
Deep Water	31

Overlapping play areas (some grid cells have more than one play) had to be combined for each grid cell, so that percent coverage for each play in each grid cell could be calculated. The BBOE values inside each grid cell were added to get a total BBOE for that grid cell.

Totals per grid in BBOE (i.e., for oil and gas) were presented as the geo-potential map. There was a five-fold classification applied, with 5 indicating relatively high potential, and 1 indicating relatively low potential (Table 2-2). It should be noted that this is an indication of relative potential within the Beaufort-Mackenzie basin, as the entire basin has a high to very high potential for hydrocarbons.

Table 2-2 Geology Scores Classification

Score Range (BBOE)	Geology Score
0.03 – 7.02	1
7.021 - 18.07	2
18.071 - 29.15	3
29.151 - 47.44	4
47.441 - 80.00	5

2.2.2 Economic Factors Score per UGI

The economic score per grid was a simplistic indication of the cost of exploration and development. It was based on a number of objective factors such as distance from infrastructure (anticipated from the Mackenzie Gas Project), water depth, etc. Many other factors could be added to further refine the economics score. Table 2-3 shows a sample economics score card for a grid cell. Only a selected number of economic factors identified have been populated for the purpose of this exercise. Spatial calculations used in Economics worksheet include distance from planned infrastructure and geographic location.

Table 2-3 Economic Factors Score Card Example

Factors	Components	Score	Tick	Weight Factor	Points	Comment
Existing Commitments	Active Exploration License	5	No	1	0	
	Development Plan	10	No	1	0	
Distance From Planned Infrastructure	> 100 Km	1		3	0	
	>25 Km And < 100 Km	2		1	0	
	< 25 Km	3	Yes	1	3	
Target Pool Size	Pool Size BBOE Medium And Larger (=>4)	1		1	0	200 Bcf
	Pool Size BBOE Smaller Than Medium (<4)	1	Yes	1	1	Consider If Onshore
Potential Grouping	Discoveries Within 2 Grids (Number)	1	Yes	1	1	
Geographic Location	Slope	1		1	0	
[Proxy For Cost]	Deep Shelf	2		1	0	
	Shallow Shelf >10 M < 30 M	3		1	0	
	Shallow Shelf < 10 M	4		1	0	
	Nearshore <5 Km	5		1	0	
	Onshore	6	Yes	1	6	
Hydrocarbons	Heavy Oil	1	Yes	1	1	Consider If Onshore
	Non-Conventional Gas	1		1	0	Consider If Onshore
	Oil	1		1	0	
Or	Oil Or Gas/Associated Oil/Gas	2		1	0	
Or	Gas	3		1	0	
Or	Oil & Gas (Separate Reservoirs)	4	Yes	1	4	
Development Risks	Ice Shear	0	Yes	1	0	Not Relevant If Onshore
	Ice Scour	0	Yes	1	0	
	Other Development Risk	1		1	0	
		Total Points For Grid			**16**	

2.2.2.1 Distance from Planned Infrastructure

Different scores were required depending on the proximity to the Mackenzie Gas Project (MGP) infrastructure. The MGP layer (line) was buffered at 25 km and 100 km. Grid cells within 25 km of the MGP infrastructure were given a score of 3 for the distance from planned infrastructure portion of the economics score i.e., most favourable from an economic standpoint. Cells within 100 km were given a score of 2, and cells greater than 100 km were given a score of 1.

2.2.2.2 Geographic Location

The seabed contours of 200, 30, and 10 m depths were combined with a 5 km coastline buffer and all onshore areas. The area north of the 200 m-depth line (Slope) was given a score of 1 i.e., least favourable. The area between the 200 m and 30 m depth lines (Deep shelf) was given a score of 2. The area between the 30 m and 10 m depth lines (Shallow shelf) was given a score of 3. The area between the 10 m depth line and a 5 km distance from shore (Shallow shelf <10 m) was given a score of 4. The area between the coast and a 5 km distance offshore (Nearshore) was given a score of 5 and the onshore areas were given a score of 6.

The 1 to 5 scale depicts relative cost of development, with 5 representing a low cost and 1 representing a high cost (Table 2-4).

Table 2-4 Economic Scores Classification

Points Range	Economics Scores
2.0 – 4.0	1
4.1 – 7.0	2
7.1 – 11.0	3
11.1 – 15.0	4
15.1 – 25	5

2.2.2.3 Uncertainty/Standard Deviation

Associated with the geological score was an uncertainty score. This was an indication of the possibility of making a large discovery whose size alone would make it more economic to develop. The standard deviation of the probability curve for each play group (Table 2-5) was chosen as the proxy statistic for uncertainty. A high uncertainty score meant that there was a larger spread in the curve of potential estimates. Two play groups may have had the same mean potential, but one may have had a possibility of a much larger field. For a basin in the early stages of exploration and development, the allure is a key driver for exploration investment. The uncertainty score per grid was scaled from 1 to 5, with the high number indicating the largest standard deviation, and hence, the possibility of larger discoveries (Table 2-6).

Table 2-5 Summary of Standard Deviation Values

Play Group	Standard Deviation
Taglu Delta	58
West Beaufort Sea	120
Rifted Margin	112
Kugmallit Delta	135
Basinal Facies	142
Deep Water	285

Each play was assigned a standard deviation (SD) value. The maximum value in each grid cell was used.

Table 2-6 Uncertainty Score Classes

SD Value	Uncertainty Score
112	1
120	2
135	3
142	4
285	5

The individual scores for the geological, economic and uncertainty factors are then added together into a total score for each individual grid cell/UGI, called the Overall Development Likelihood Score (Table 2-7).

Table 2-7 Example of a Development Likelihood Score for a Grid Cell

Factor	Score
Geological Score	2
Uncertainty Score	4
Economics Score	2
Overall Development Likelihood Score	**8**

The final score for each grid was given a key and split into five main categories for analysis and mapping as follows (Table 2-8):

Table 2-8 Final Scores and Key

Score	Description
<6	Relatively low prospect for exploration and very low for development within 25 years
6	Relatively moderate prospect for exploration and low prospect for development within 25 years
7 - 8	Relatively good prospect for exploration and moderate prospect for development within 25 years
9 - 10	Relatively good prospect for exploration and development within 15 years
11 - 12	Active or imminent interest in exploration and development

2.3 Petroleum Environment Management Tool (PEMT)

The Beaufort PEMT is available on the INAC internet site (http://www.ainc-inac.gc.ca/nth/og/pemt/index-eng.asp).

As already mentioned, this work is intended to facilitate the commitment of INAC to complete a Strategic Environmental Assessment of potential development within the Beaufort Study Area. The PEMT's function is to allow users to overlay VSEC and VEC attributes on a grid thereby allowing comparison on maximum sensitivities, and with an overlay of geo-economic potential. In addition, the PEMT's function allows users to view sensitivity areas maps. The strength in this method is in understanding the relative values of leasing grids among a suite of VECs and VSECs, and for identifying those areas where leasing activities may be more or less favourable. For example, the tool allows for identification of those areas that have high sensitivities and low geo-economic potential, or areas with low sensitivities and high geo-economic potential.

2.3.1 Steps for Developing the Petroleum Environment Management Tool

The preparation of the GIS-based petroleum environment management tool required the completion of a series of inter-related steps. The steps included the following:

- Identification and review of potential and final valued ecosystem components (VEC) and valued socio-economic components (VSEC);
- the preparation of sensitivity layers for the VEC and VSEC;
- the preparation of the geo-economic layer; and
- the development of the grid based sensitivity maps.

2.3.2 Application of Grid Sensitivity

Sensitivity area layers are converted to Sensitivity grid layers using a spatial averaging calculation and both types of information is available on the PEMT. When applied to a particular Oil and Gas Leasing Grid, sensitivity ratings provide a relative appreciation of the biological values (highlights the most vulnerable and sensitive areas, seasonal distribution, and provides information on the potential response to change resulting from hydrocarbon development), social and economic values within a grid.

3. Polar Bear

3.1 Description

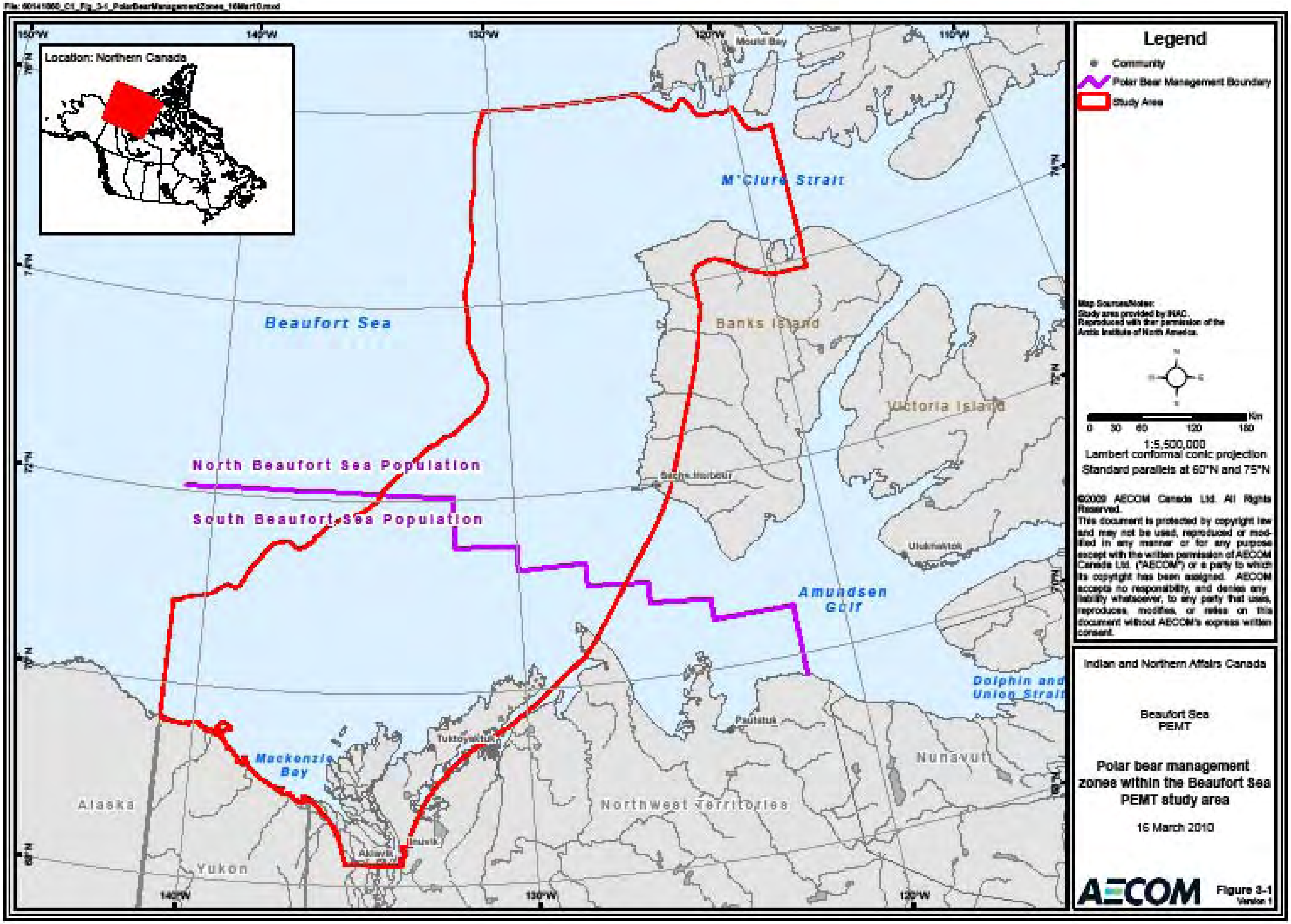
Polar bears are large ursids most comparable in size and shape to the brown bear, from which they evolved within the last 400,000 years (Thenius 1953; Kurtén 1964). Male polar bears can weigh up to 800 kg and reach 2.8 m in length from nose to tail (DeMaster and Stirling 1981) while females are smaller, usually not exceeding 400 kg and 2.5 m in length (Amstrup 2003). Polar bears are the top carnivore within the Arctic ecosystem and are found throughout the north circumpolar region (Figure 3.5). Polar bears evolved to take advantage of killing seals from a sea-ice platform, particularly ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*). Many of the physical traits of polar bears can be viewed as adaptations to hunting arctic seals. The grinding surfaces of the cheek teeth of polar bears are more serrated than brown bears, which is an adaptation to a more carnivorous diet. The forepaws of the polar bear are enlarged making them useful for paddling in water, and digging through or climbing on snow and ice, and the pads of the paws are entirely furred, which may function to help insulate the feet or improve traction on ice and snow. Translucent hair makes the pelage appear white, yellow or off-white, which provides camouflage while hunting.

Canada supports a majority of the world's polar bear population. Among the 14 recognized populations in Canada, the South Beaufort Sea and North Beaufort Sea populations occur within the study area (Figure 3-1). The North Beaufort Sea population is associated with the west coast of Banks Island, and the South Beaufort Sea population is associated with the mainland coast (COSEWIC 2008). The estimated number of bears within those populations totals approximately 2500 individuals and the current populations are believed to be stable or slightly increasing (COSEWIC 2008).

3.2 Rationale for Selection

Polar bears are a high profile species for several reasons – they are a potential indicator species for measures of climate change, they provide social and economic benefits, and they are identified as a potential A*t-Risk Species* (i.e., the area listed as Special Concern by COSEWIC). Canada supports a majority of the world's polar bear population and under the *International Agreement on the Conservation of Polar Bears* the conservation of species is mandated. Additionally, the polar bear has previously been identified as an important component of the Nearshore Marine Valued Component in the recent Beaufort Delta Cumulative Effects Project (Dillon Consulting Limited and Salmo Consulting Limited 2005), the Marine Mammal Valued Component of the Northwest Territories Cumulative Impacts Monitoring Program, and within the Community Conservation Plans within the study area. Polar bears also provide direct economic support to the communities that provide consumptive (hunting) and non-consumptive (tourism and wildlife viewing) use of the bears. Thus, concerns about the status of the species exist at both regional and national levels.

Figure 3-1 Polar bear management zones within the Beaufort Sea PEMT study area

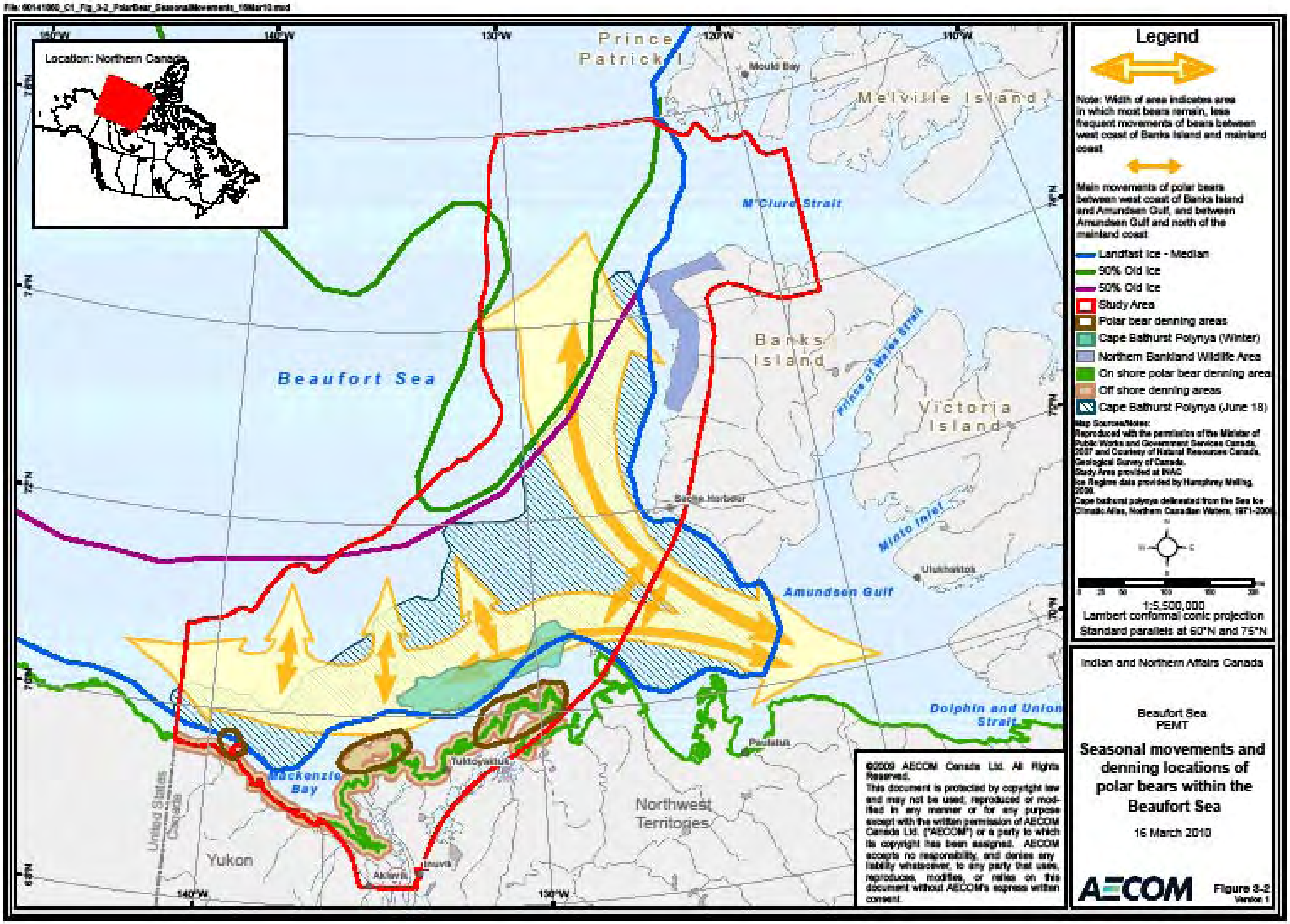


Additionally, polar bear habitat in the Northwest Territories lies within the Inuvialuit Settlement Region. Both the Government of the Northwest Territories (GNWT) and the Inuvialuit Final Agreement (IFA) requires a review process for exploration, development, and research activities, which includes a consideration of impact on polar bear populations and other wildlife.

3.3 Key Habitat

Distribution in the Beaufort Sea (and elsewhere) is influenced primarily by the type and distribution of sea ice, as well as the density and distribution of their primary food source – ringed seals (Stirling and Øritsland 1995). The eastern Beaufort Sea provides key areas of floe edge and moving ice habitats, between Banks Island and the Bathurst Peninsula moving westward towards the north coast of Canada and Alaska (Smith and Rigby 1981). Adult male polar bears tend to prefer floe edge habitat where seals and their pups are easy to prey upon, while females prefer stable ice, where there are fewer bears to compete for food with and less chance of their cubs being attacked by male polar bears.

Polar bear distribution in the Beaufort Sea varies with season. Northerly and southerly movements of bears (Figure 3-2) appear to be dependent on seasonal melting and refreezing of ice near shore and the distribution of suitable ice for hunting seals (Stirling and Øritsland 1995). Polar bear distribution in the Beaufort Sea can be summarized as follows:



Note: Width of area indicates area in which most bears remain, less frequent movements of bears between west coast of Banks Island and mainland coast.

Main movements of polar bears between west coast of Banks Island and Amundsen Gulf, and between Amundsen Gulf and north of the mainland coast.

Map Sources/Notes:
Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2007 and Courtesy of Natural Resources Canada, Geological Survey of Canada.
Study Area provided at INAC
Ice Regime data provided by Humphrey Melling, 2009.
Cape bathurst polynya delineated from the Sea Ice Climatic Atlas, Northern Canadian Waters, 1971-2000.

Figure 3-2 Seasonal movements and denning locations of polar bears within the Beaufort Sea

Winter: Density of polar bears was correlated with density of ringed seals (Stirling and Øritsland 1995). Density of ringed seals vary in response to overall productivity of the ecosystem (Stirling and Lunn 1998). Regions covered with multiyear ice are considerably less productive than areas that fluctuate seasonally between annual ice and open water (Kingsley *et al.* 1985). Annual primary productivity in areas with 1-year ice is 27 times that of areas with multiyear ice (Arrigo *et al*. 1997), and areas of annual ice also have 4-8 times greater primary productivity than areas of open water at the same latitudes (Ferguson *et al*. 2000) and results in greater seal density (Stirling and Øritsland 1995).

In winter (i.e. ice-covered season from approximately November through April), most bears are actively hunting seals on areas of annual ice (ice that forms and melts annually). Areas of annual ice within the Beaufort Sea that are most utilized for hunting include areas of inter-island channels, and areas where 'active ice' occurs, such as polynyas and landfast shore leads (Figure 3-3). Pregnant female bears may retire to maternity dens in late October to early November (Amstrup and Gardner 1994). These dens are found in snowdrifts on multiyear pack ice, but primarily on small islands near the western and northern shores of Banks Island, from Storkerson River to the north shore of Banks Island, and to a lesser extent on islands and coastal areas from Tuktoyaktuk east to Alaska (Figure 3-4). Herschel Island appears to be the most important maternal denning area on the mainland coast (Stirling and Andriashek 1992, WMAC 2000c,d). Cubs are usually born in late November to January, and are nursed within the den (Messier *et al.* 1994). During periods of particularly cold or inclement weather, solitary males and females with cubs, may also shelter in dens on multiyear pack ice, within several hundred kilometres of the southern extent of pack ice (Messier *et al.* 1992, Stirling 2002). Females with cubs often leave the dens in March or April to actively hunt seals (Amstrup and Gardner 1994, Messier *et al.* 1994).

Summer: As the sea ice breaks up in the spring and early summer, polar bears follow the receding ice edge where seals occur. Only areas > 20% ice cover are considered as available habitat as polar bears seldom used thinly distributed pack ice (Ferguson *et al.* 1998). During spring and summer, polar bears use landfast ice more intensively. Recent observations indicate that during most of the year, these preferred hunting habitats are sea-ice areas where the ice cover is ≥50%. (Stirling *et al*. 1999; Durner *et al*. 2004, 2006, 2007). Where the ice melts completely during the summer months, bears are forced onto the land or further north in the Beaufort Sea to the multi-year pack ice (Latour 1981, Ferguson *et al.* 2000a). For those areas and seasons with < 20% ice cover, available land within 5 km of the coastline was used as a measure of available habitat as most inland polar bear capture locations were within 5 km of the coast (Ferguson *et al*. 1997).

Breeding occurs over relatively short periods during April and May, and adult females are concentrated in the best feeding habitat along the leads that parallel the coast. Males are drawn to these areas by the females' presence (Stirling *et al.* 1993). Most mating takes place on open sea ice. Whereas only pregnant female polar bears enter dens for the entire winter, any bear may enter shelters for shorter periods to avoid storms, extreme cold or heat, or periods of poor hunting. In spring, bears retreat off-ice to denning locations on the North Slope of the Beaufort Sea and Banks Island, to den during the ice-free periods when prey is unavailable, or retreat northward to multi-year pack ice (Messier *et al.* 1994, Ferguson *et al.* 2000b, Schliebe *et al.* 2008).

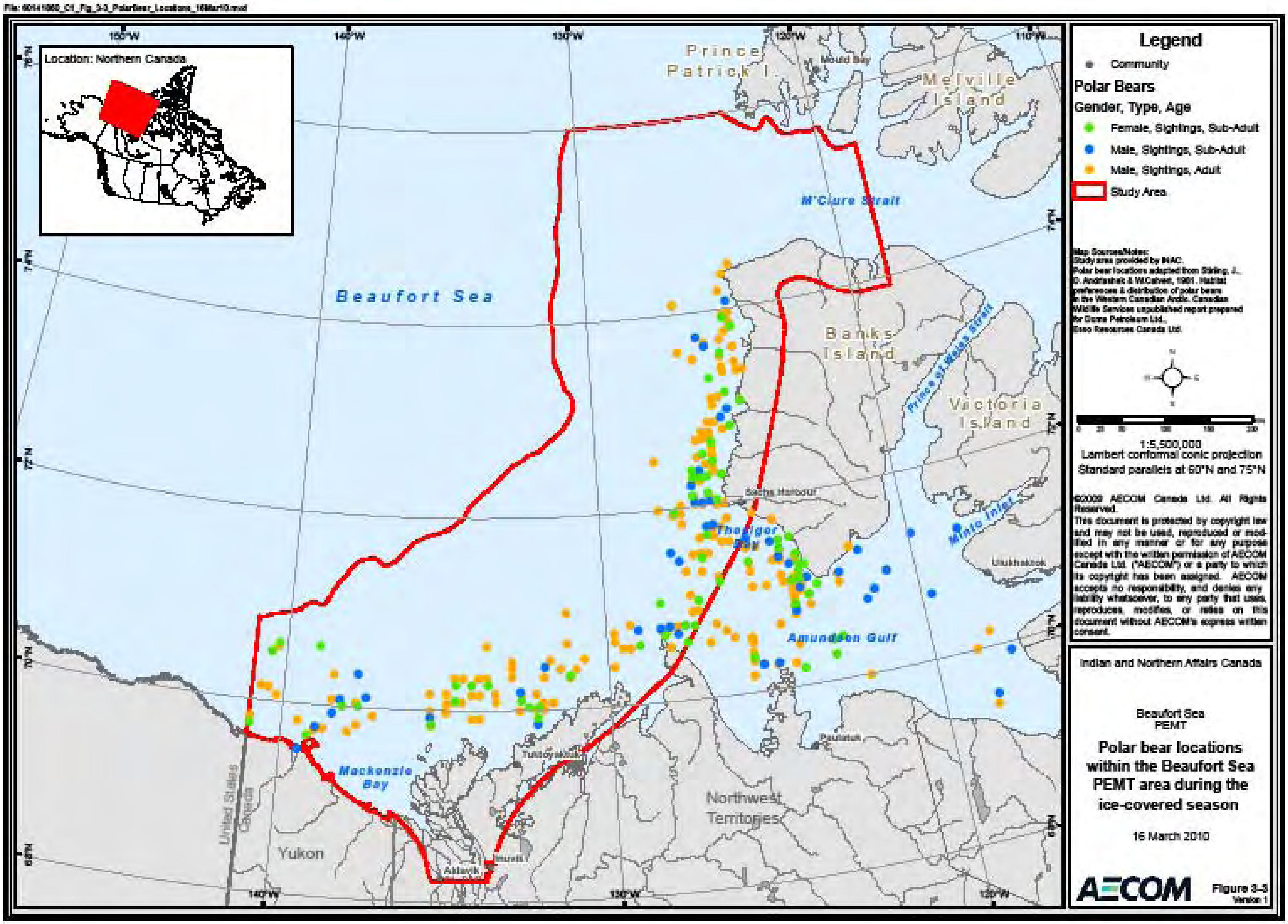


Figure 3-3 Polar bear locations within the Beaufort PEMT during the ice-covered season

3.4 Climate Change

Global circulation models predict substantial decreases in both thickness and coverage of arctic sea ice due to increased atmospheric CO_2. Present climate models are insufficient to predict regional ice dynamics. Changes that are likely to occur, but are difficult to model, include reduced total sea ice area, reduced sea ice duration, thinner ice, smaller floe sizes, more open water, altered snow cover, and increased rates of ice drift. However, we can speculate on the potential impacts of observed trends in Arctic climate on wildlife. Most of the characteristic mammals in the arctic marine ecosystem are specifically adapted to the sea ice environment. Changes to its distribution, characteristics, and timing will fundamentally alter the marine arctic ecosystem. The presence of sea ice is critical to polar bears because it provides the platform from which they hunt seals (Stirling and Archibald, 1977; Smith, 1980), seek mates and breed (Ramsay and Stirling 1986, Stirling *et al.* 1993), provides access to terrestrial maternity denning areas or as maternity denning habitat (Stirling and Andriashek 1992), and is used to make long-distance movements.

Polar bears show a marked preference for sea ice but quickly abandon the ice for land once the sea ice concentration falls below 50% (Mauritzen *et al.* 2003, Stirling *et al.* 1999). Changes in the extent and concentration of sea ice may alter the seasonal distributions, geographic ranges, patterns of migration, nutritional status, reproductive success, and the abundance and structure of some species.

Reduced sea ice duration (earlier break-up and later freeze-up) shortens the amount of time that bears are able to feed on seals and prolongs the fasting period (Derocher *et al.* 2004, Stirling *et al.* 2008). Declining body mass, reproductive rates and subadult survival are the potential effects of earlier spring break-up (Stirling and Derocher 1993, Derocher *et al.* 2004).

Female polar bears show fidelity to specific den areas, with the majority of maternity dens occurring on land in coastal areas adjacent to areas with high seal density in spring (Harington 1968; Ramsay 1990, Stirling and Andriashek 1992, Ferguson *et al.* 2000). If the extent of the polar pack is reduced and freeze-up is delayed, it may become difficult for pregnant females to reach coastal areas for denning. Under these conditions, more females may choose to den on the multiyear ice, as many already do in the Beaufort Sea population (Stirling and Andriashek 1992), or they may come ashore at break-up in the summer and attempt to fast until entering a maternity den in autumn, similar to pregnant females in Hudson Bay (Ramsay and Stirling, 1988).

Figure 3-4

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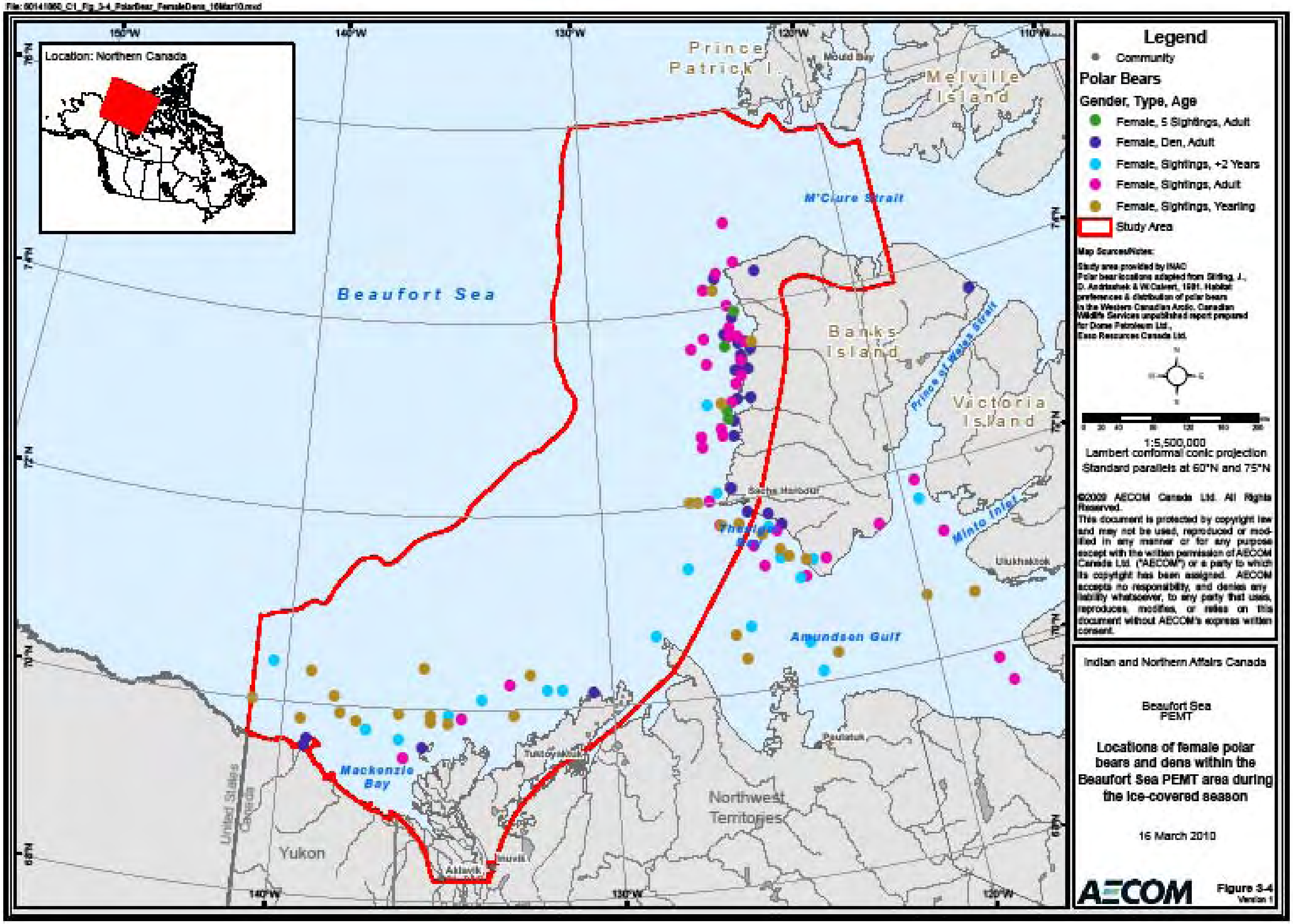


Map Sources/Notes:
Study area provided by INAC
Polar bear locations adapted from Stirling, I., D. Andriashek & W. Calvert, 1981. Habitat preferences & distribution of polar bears in the Western Canadian Arctic. Canadian Wildlife Services unpublished report prepared for Dome Petroleum Ltd., Esso Resources Canada Ltd.

Indian and Northern Affairs Canada

Beaufort Sea PEMT

Locations of female polar bears and dens within the Beaufort Sea PEMT area during the ice-covered season

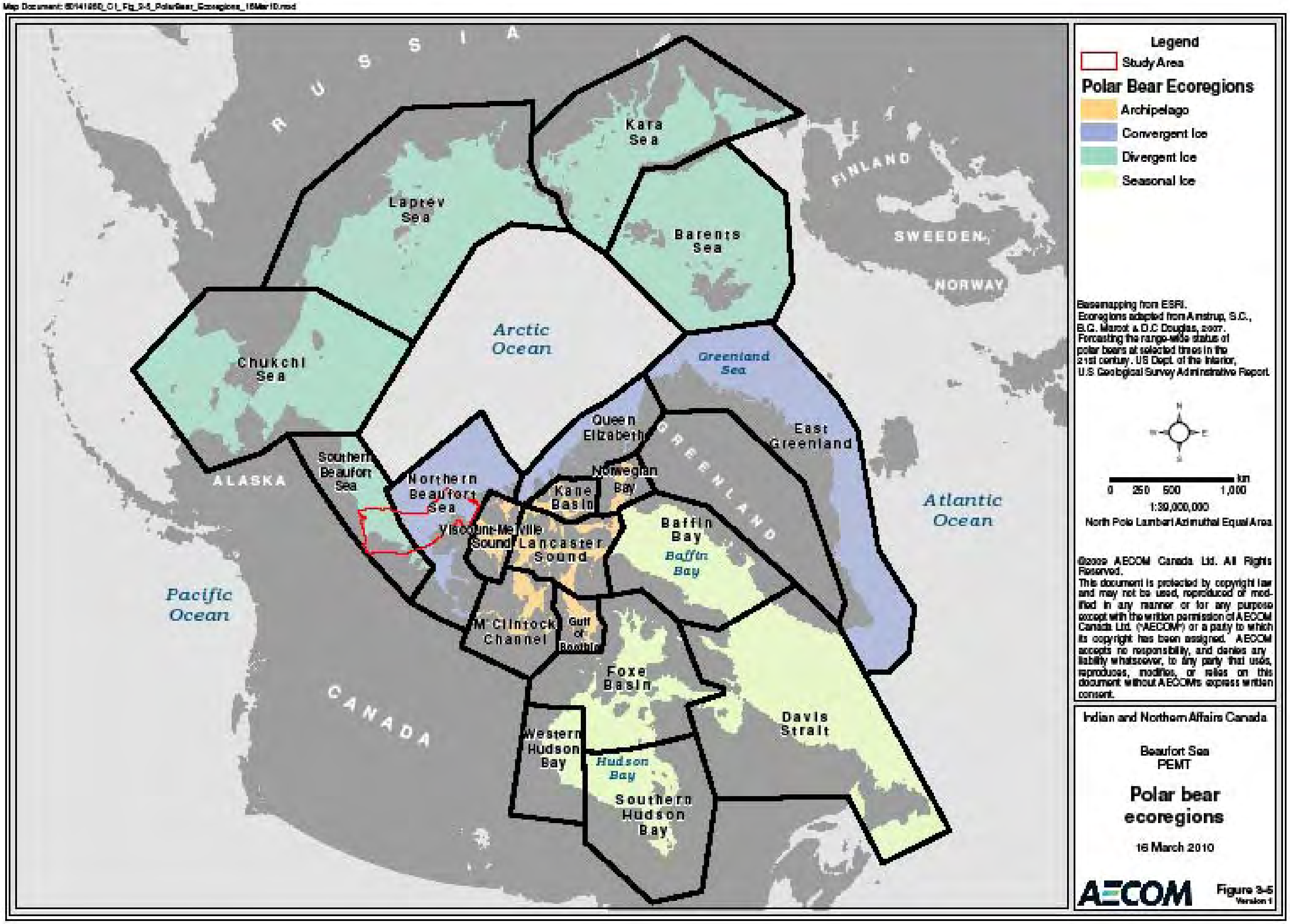
16 March 2010

Locations of female polar bears and dens within the Beaufort PEMT during the ice-covered season

3.5 Sustainability

Polar bears are closely tied to the presence of sea ice from which they hunt, mate, and carry on other life functions. The viability of polar bears is closely linked to availability of food sources at key times of the year, and suitable denning habitats. Both of these factors are associated with the pattern and timing of ice features in the Beaufort Sea. Polar bear ecoregions were defined based on spatial and temporal patterns of ice formation and ablation, and how bears respond to these patterns. Southern Beaufort polar bears are in the Polar Basin Divergent Ecoregion where ice is formed and then transported by wind or ocean currents away from near-shore areas. Northern Beaufort polar bears are in the Polar Basin Convergent Ecoregion where sea ice formed elsewhere tends to collect against the shore (Figure 3-5; Amstrup *et al.* 2007). The greatest overall threat to polar bears may be large-scale ecological change resulting from climatic warming (Stirling and Derocher 1993), which may change characteristics of sea ice. Continuing declines in ice coverage will restrict their productivity and could ultimately threaten their survival. It is suspected that with a dramatic retreat of the pack ice, record amounts and duration of open water, and longer ice-free seasons that have predominated in this region in recent years, the amount of sea ice available as a substrate is reduced and bears spend less time in early summer and autumn travelling and foraging. With the progressive earlier breakup of sea ice and the shortened foraging season, bears are forced to come onshore earlier and this may result in nutritional stress that leads to intraspecific killing and consumption of polar bears in the southern Beaufort Sea (Amstrup *et al.* 2006, Stirling *et al.* 2008). Hence, climatic warming, longer ice-free periods and associated declines in Arctic sea ice lowers polar bear survival, and breeding and cub-of-the year survival declines (Monnett and Gleason 2006, Hunter *et al.* 2007, Regehr 2007, Rode *et al.* 2007). In projections based upon mean ice predictions, decreases in ice habitat will result in declines in polar bear populations sooner in the more southern Polar Basin Divergent Ecoregion than the northern Convergent Ecoregion.

Figure 3-5 Polar bear



ecoregions

Evidence of climatic conditions that impact ringed seal populations (the polar bear's primary food source) is strong. In particular, potential changes in populations due to the availability of prey have been evidenced when heavy ice cover in the Beaufort Sea resulted in declines in seal populations in the mid-1970s and 1980s, and subsequent declines in the natality and survival of sub-adult bears (Stirling 2002). In recent years, there has been a greater abundance of open water (circa 1989) due to changes in mean air temperature and shifts in wind patterns (Macdonald *et al.* 1999), which has resulted in increased seal production, and combined with regulated hunting, stable bear populations. However, climatic warming and early rain (rather than snows) may expose ringed seal birth lairs, resulting in predation on seal pups at substantially higher predation rates (Stirling and Smith 2004), ultimately reducing the prey base for bears.

The low reproductive potential of bears means that the survival of juveniles and adult females is especially important to the viability of these populations. Therefore, maternal denning sites are a key element of bear ecology, potentially reducing the vulnerability of the cubs and nursing females to hunters and intraspecific predation. Historically, female polar bears were often hunted in maternal dens on Banks Island and the mainland, prior to protection of such dens approximately 30 years ago. The historic hunting of such bears may have contributed to the higher proportion of maternal denning sites currently found on multi-year pack ice off shore (Stirling 2002).

The polar bear population in the southern Beaufort Sea is unique among polar bear populations because approximately 50% of its maternal dens occur annually on the pack ice (Amstrup and Gardner, 1994). During winter, industrial activities in the northern Beaufort, such as seismic surveys and construction of ice roads and drill pads, are at their highest level. These activities coincide with the time when denning polar bears are giving birth or nursing young. Female polar bears appear to be particularly sensitive to disturbance during the autumn and may abandon dens more readily than later in the winter (Amstrup 1993, Lunn *et al.* 2004). Knowledge of the distribution of denning habitat and avoidance during the denning period may reduce potential conflicts (Durner *et al.* 2006).

In addition to habitat conditions, the harvesting of bears by Inuvialuit and sport hunters influences the sustainability of populations. Currently, most polar bears are harvested through a managed quota system. Sport hunters, accompanied by Inuit, take most bears, although subsistence hunting also occurs. The total harvest is governed by a quota system that allocates bears to each community in the Study Area, but the demographic parameters of the populations make polar bear populations very sensitive to over harvest. Prior to the establishment of quotas, populations were in decline (Stirling 2002), but have recovered since the imposition of quotas and are currently considered stable (COSEWIC 2002).

3.5.1 Susceptibility to Development

3.5.1.1 Linkages to Development

In recent history (i.e., in the past 50 years), industrial activity in the Arctic has been increasing, although the level of industrial activity and the number of ongoing projects are still very low in the Beaufort Sea. Much of the activity has been associated with petroleum exploration, mineral exploration, and marine shipping traffic. Given the relatively low amount of industrial activity in the Arctic, there is little empirical evidence to strongly associate project-specific impacts, or impacts from multiple industrial projects, to population parameters for polar bears. However, there are likely two means whereby the viability of polar bear populations can be linked to project-specific impacts:

- industrial activities may reduce the quality and amount of suitable habitat available to polar bears, especially for feeding and denning, and

- industrial activities may increase the risk of mortality to individual bears in proximity to developments.

3.5.1.2 Habitat Susceptibility

The potential disturbance of denning and feeding areas could seriously affect the individual populations of polar bears (COSEWIC 2002). Industrial activity may produce residual effects (as summarized in Section 3.2) that either result in a complete loss of habitat, as is common with the ‘footprint’ of industrial developments, or effective habitat loss, whereby polar bears avoid habitat in proximity to development. Depending upon the seasonality of occurrence of bears, and the timing of impacts, the habitat loss or avoidance that results from a specific project may be limited to specific seasons.

In the context of petroleum development and exploration, the maximum extent of predicted disturbance may extend up to 50 km from a point source impact (e.g., ice road construction and operations (Devon Canada Corporation 2004). Other oil and gas related projects would likely have more localized habitat impacts; flaring, drilling, and ice pad construction, may result in avoidance within approximately 1 km of a specific site. These localized disturbances may also result in avoidance of the site by two to seven seals (Devon Canada Corporation 2004), thus reducing foraging value for polar bears. Seismic activities that occur in open water are unlikely to directly affect polar bears in any measurable amount. The extent to which habitat losses from petroleum exploration and development may affect polar bear populations are uncertain, and will vary the amount, season, and duration of activities. In general though, it is unlikely that habitat loss from petroleum activity alone will directly influence populations, as mortality rate, and climate-induced habitat changes will most directly contribute to overall population trends.

The presence of oil or other contaminants resulting from accidents and malfunctions associated with petroleum exploration and fuel transfer also have the potential to reduce habitat availability. Contact with spilled oil may directly affect the health of individual bears, and/or reduce the availability of ringed seals. The population impacts that may result from such accidents would depend largely on the season, amount and type of contaminants released, climatic factors and the responses initiated. While the likelihood of serious accidents increases with increased exploration and development, no condensate or oil spills have occurred during the 85 offshore drilling programs that have been completed in the Beaufort Sea since 1990 (Devon Canada Corporation 2004). One shallow gas blowout occurred in the Beaufort Sea in 1989 (reported in Devon Canada Corporation 2004). The chance of large oil spills or blowouts occurring on any given wellsite is very small (1 in 12,000; Devon Canada Corporation 2004) and is further reduced by modern technology and operational standards in use today.

3.5.1.3 Mortality Risk

Human-wildlife conflicts have occurred with regularity in areas where humans and bears coexist, including in northern areas, such as Churchill, Manitoba. For species such as polar bears, the loss of adult females in such conflicts poses a particular risk to the population. This is because polar bears have low reproductive rates, exist at low densities, and reproduce relatively late in life. Thus, each individual adult female is important to the entire population’s viability, as there are relatively few reproducing females, and the loss of individual bears substantially reduces the reproductive potential of the entire population. High mortality rates of adult females would result in a relatively rapid population decline.

Risk of mortality to bears is greatest where bears may interact with project facilities (on ice in particular) and bears could be killed to maintain the safety of humans. Polar bears, because of their highly investigative behaviour, may be attracted to project facilities (Stirling 1988), which could result in defensive kills if not properly monitored and mitigated. Mortality risk also extends to near shore developments that are in close proximity to denning locations (especially during freeze up) where bears initiate offshore hunting on areas of active and annual ice. In general, the frequency with which polar bears come into contact with people and structures is undoubtedly a function of the amount of activity in their habitats, and mortality risk increases in relation to human activity even when the best mitigation measures are put in place.

In the Beaufort Sea study area, the mortality risk that is directly associated with oil and gas projects has not been quantified. However, strict bear monitoring, waste management deterrence measures, and encounter protocols have reduced the mortality risks to bears (Devon Canada Corporation 2004).

3.5.1.4 Seasonality of Development Impacts

In general, those activities that occur outside the seasons where polar bears are present (i.e., in open water periods throughout much of the study area) are unlikely to result in direct impacts to polar bears. That is, polar bears in denning locations not within a Zone of Influence of project impacts situated over open water will almost certainly not be affected. This may include activities such as shipping, seismic exploration, and island or platform drilling. However, contaminant spills (particularly hydrocarbon spills) remain a potential risk that could have direct consequences to seal populations in the Beaufort Sea, and subsequently, to polar bear populations. This risk can be managed appropriately through prevention measures, and it can be considered to have a relatively low probability of occurrence. On-ice activities such as ice-platform based drilling, ice road construction, and flaring have the greatest potential for direct impacts to bears, either through habitat loss or increased mortality risk.

3.5.1.5 Population vs. Individual Level Impacts

Impacts from individual projects would likely be most measurable at the individual or family group level (such as an adult female with cubs may avoid habitats near an operating drill site). However, all such impacts ultimately have population-level consequences. The intent to which they are apparent at the population level (such as reduced ranges, or lower population numbers or overall density) will depend on the magnitude to which impacts to the individual occur. In particular, bears killed in human-wildlife conflicts certainly result in an individual level impact (individual mortality), but the reproductive potential for the entire population is also impacted with the loss of individuals.

Additionally, because both the North and South Beaufort Populations’ range boundaries extend beyond the Study Area boundaries, impacts to the population that occur outside the study area may act in a cumulative fashion with impacts within the study area to influence the populations.

3.6 Mitigation

There are a wide variety of potential project types that vary in spatial extent, duration, and intensity, with a corresponding range in magnitude of impacts that may occur in the project area.

- Maternal denning areas are key areas that are important to the viability of the species, and therefore, impacts here should be avoided. Should development be initiated in areas where maternal dens are present, timing should coincide with the spring period when female bears are foraging away from maternal dens (from April to late spring). Females may occupy such dens during the open water season and during the birthing period (late October through to March or April).
- Areas of spring feeding are also especially important to both male and female bears, and as such, on-ice activity near areas of active ice and annual ice should be limited to levels to which the population level impacts are not apparent. In particular, mitigation planning to reduce mortality risk is especially important where defence kills are a possibility.

- On ice activities (such as exploration drilling) in areas lesser used for foraging and denning are less likely to result in population level impacts, but mitigation planning with respect to defence kills remains important.
- Open water activities are generally unlikely to produce residual effects beyond the open water season, especially if accidents and hazards are controlled.
- In the eastern Beaufort Sea, most of the offshore drilling activity has been in shallower areas (<50 m) and there is overlap between the most important polar bear feeding habitat and offshore drilling activities (Stirling 1988). Large scale spills or blowouts during the fall or winter could affect prime breeding (see above) and foraging habitat. Oil, entrapped in ice, would eventually reach the floe edge and moving-ice habitats.

3.7 Sensitivity Layers

Polar bears are present in the study area year round, although different areas are used for different purposes among seasons. Particular seasonal uses such as spring foraging and maternal denning have greater implications to the viability of the species than most other uses (such as foraging in non-critical times).

The rating system below was based on the period that polar bears are present and use the areas for either foraging or denning. The sensitivity layers established for polar bears reflect the environmental sensitivity of an area should development (primarily petroleum exploration and production, but also marine transportation and other human impacts) occur within the area. This sensitivity is expressed as a rating for each polygon from 1 through 5. Ratings of 1 represented the least utility and values to which development impacts would be least apparent in the population, while areas ranked 5 are the most used and/or critically important to the survival of the species and could be most affected by development. Areas of higher sensitivity were typically those that support potential denning and successful reproduction, as well as feeding areas necessary to support year-over-year survival. Potential residual effects from development would be most detrimental to the population viability in areas of annual ice that supports foraging activities, and areas that support denning. Thus, higher risk categories are associated with these features.

When assessing a grid cell for sensitivity to development during a specific time period, all time periods should be considered. Habitats that support key life stages are important to identify, regardless of the season in which it is most used, because habitat loss that occurs in one season may have impacts that extend beyond that season of impact. As an example, denning habitats are important to conserve in periods when bears are not actively denning, as they will return during the denning season, and as such, these habitats are key elements that support the species survival.

3.7.1 Sensitivity Layer Ranking

When assessing an area for sensitivity to development during a specific season, all seasons should be considered. Habitats that support key life stages are important to identify, regardless of the season in which it is most used, because habitat loss that occurs in one season may have impacts that extend beyond that season of impact. As an example, denning habitats are important to conserve in periods when bears are not actively denning, as they will return during the denning season, and as such, these habitats are key elements that support the species survival.

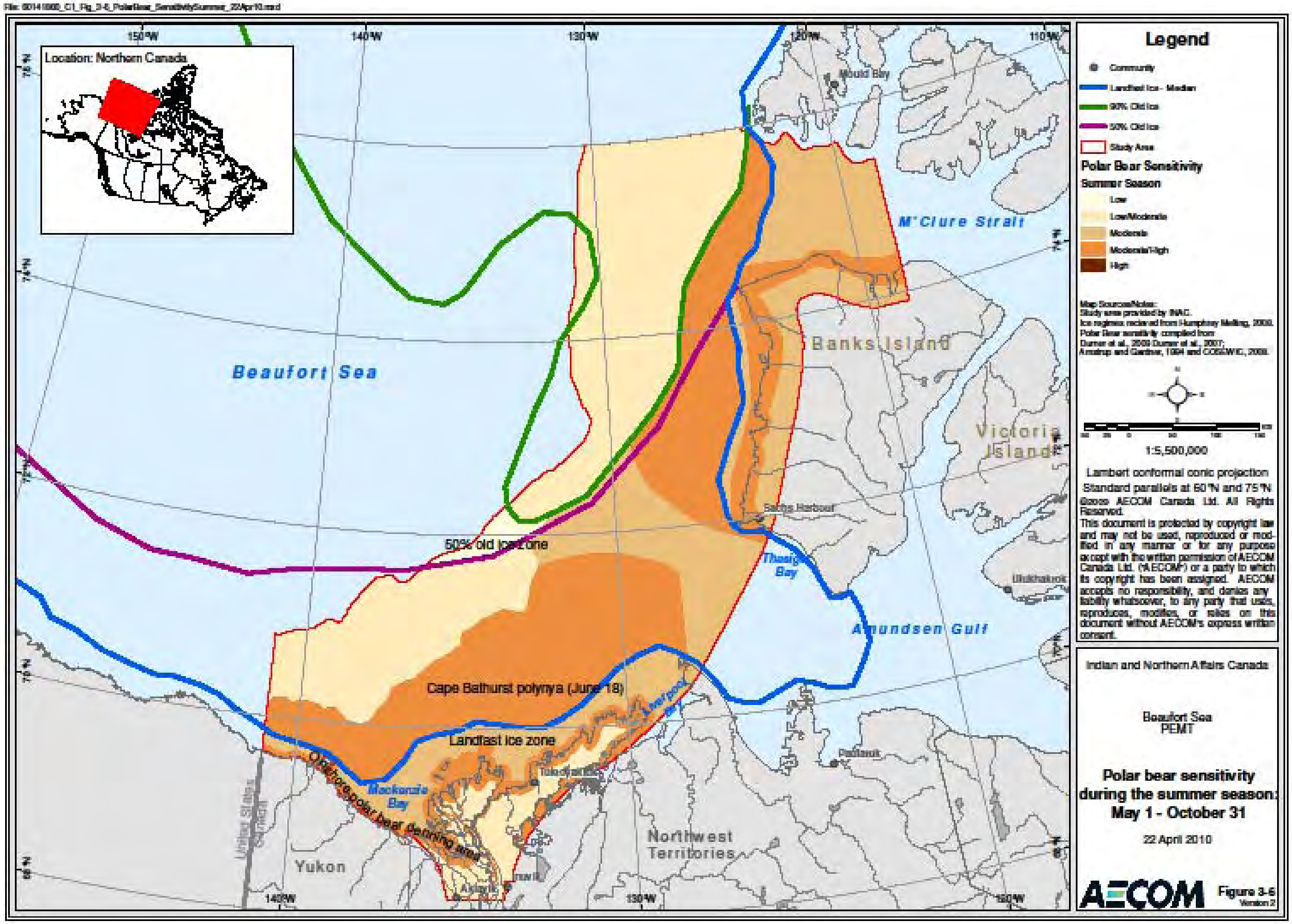
Summer Season May 1- Oct 31 Sensitivity (Figure 3-6)

As the sea ice breaks up in the spring and early summer, polar bears follow the receding ice edge where seals occur. Only areas > 20% ice cover are considered as available habitat as polar bears seldom used thinly distributed pack ice (Ferguson *et al.* 1998). During spring and summer, polar bears use landfast ice more intensively. Recent observations indicate that during most of the year, these preferred hunting habitats are sea-ice areas where the ice cover is ≥50% (Stirling *et al*. 1999; Durner et al. 2004, 2006, 2007). Where the ice melts completely during the summer months, bears are forced onto the land or further north in the Beaufort Sea to the multi-year pack ice (Latour 1981, Ferguson *et al.* 2000a). For those areas and seasons with < 20% ice cover, available land within 5 km of the coastline was used as a measure of available habitat as most inland polar bear capture locations were within 5 km of the coast (Ferguson *et al*. 1997).

- **Low Sensitivity (1):** open water areas that would have limited use in the summer season.
- **Low/Moderate Sensitivity (2):** A) Areas on the mainland > 5 km from the coastline where polar bears occurrence is unlikely during the winter season. (B) These areas represent parts of first year and multi-year pack ice that have limited use as foraging during the spring and summer season,
- **Moderate Sensitivity (3):** (A) Areas on Banks Island > 5 km from the coastline where polar bears occurrence is likely during the spring and summer season. (B)These areas represent foraging areas in non-critical time periods (open water season) and also include the summer limit of landfast ice to flow edge/moving ice area.
- **Moderate/High Sensitivity (4):** (A) Areas along the coastline and within 5 km of the coastline where polar bear occurrence is likely if they are forced onto land due to ice melt; (B) Foraging areas in critical time periods of spring (May seal pupping period) and early fall (area of moving ice/flow edges, polynyas); (C) extensively used nearshore denning and movement areas during open water times of limited prey availability.
- **High Sensitivity (5):** None for the summer season.

The sensitivity layer (Figure 3-6) that was developed was based on underlying spatial layers that are imprecise (spatial variability) and are subject to variability among years (temporal variability). Given this variability, it is recommended that conservative interpretations of potential impacts for projects among seasons be more rather than less conservative.

Figure 3-6 Polar bear sensitivity during the summer season: May 1 to October 31



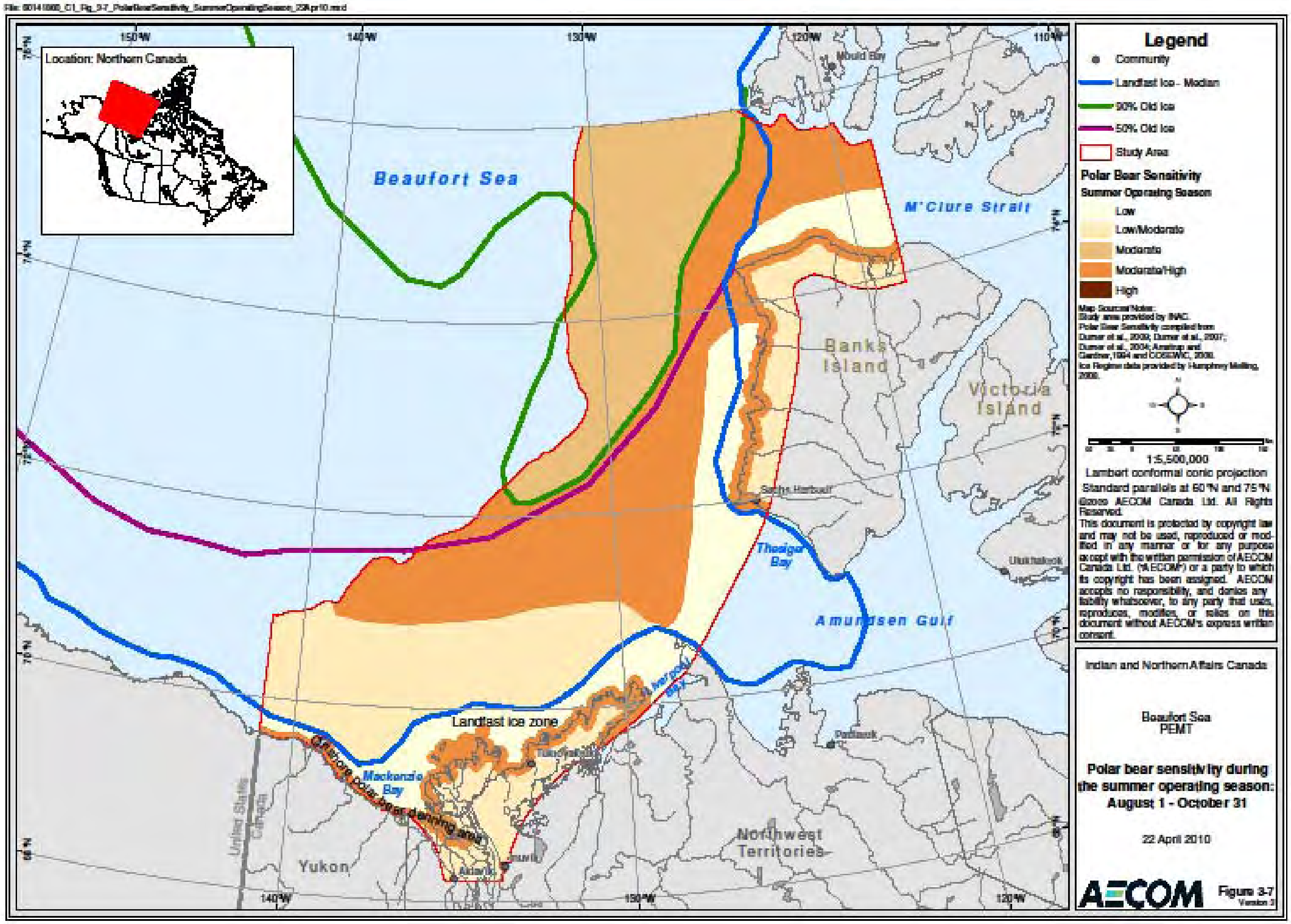
Summer Operating Season August 1 to October 31 Sensitivity (Figure 3-7)

The Summer Operating Season (August 1 to October 31) was developed with the assumption that polar bears are present within the PEMT Area where the ice cover is ≥ 50% (Dunner et al. 2009), > 20% or on land within 5 km of the coast (Ferguson *et al.* 1998). Where the ice melts completely during the summer months, bears are forced onto the land or further north in the Beaufort Sea to the multi-year pack ice (Latour 1981, Ferguson *et al.* 2000a). For those areas and seasons with < 20% ice cover, available land within 5 km of the coastline was used as a measure of available habitat as most inland polar bear capture locations were within 5 km of the coast (Ferguson *et al*. 1997).

When assessing an area for sensitivity to development during a specific season, all seasons should be considered. Habitats that support key life stages are important to identify, regardless of the season in which it is most used, because habitat loss that occurs in one season may have impacts that extend beyond that season of impact. As an example, denning habitats are important to conserve in periods when bears are not actively denning, as they will return during the denning season, and as such, these habitats are key elements that support the species survival. In August and September, polar bears will most likely be located in areas with ice > 20% or on land within 5 km of the coastline. Therefore, these areas are considered moderate to good habitat for polar bears and were given a moderate to a moderate high sensitivity. During August and September, polar bears will unlikely occur in open water and these areas were given a low to low/moderate sensitivity.

- **Low sensitivity (1):** Areas where polar bear activity is low during the summer operating season due to open water.
- **Low/Moderate Sensitivity (2):** (A) Open water areas where polar bear occurrence potential is low to moderate during the summer operating season, (B) Areas on land > 5 km from the coastline where polar bears occurrence is unlikely if they are forced onto land due to ice melt.
- **Moderate Sensitivity (3):** (A) Areas on multi-year pack ice and in areas where ice is > 90% where polar bear occurrence is likely.
- **Moderate/High Sensitivity (4):** (A) Areas considered good quality habitat for polar bears during the summer operating season and areas which will have a high occurrence of polar bears during the summer operating season;. (B) Areas within 5 km of the coastline where polar bear occurrence is likely if they are forced onto land due to ice melt
- **High Sensitivity (5):** None for summer operating season.

Figure 3-7 Polar bear sensitivity during the summer operating season: August 1 to October 31



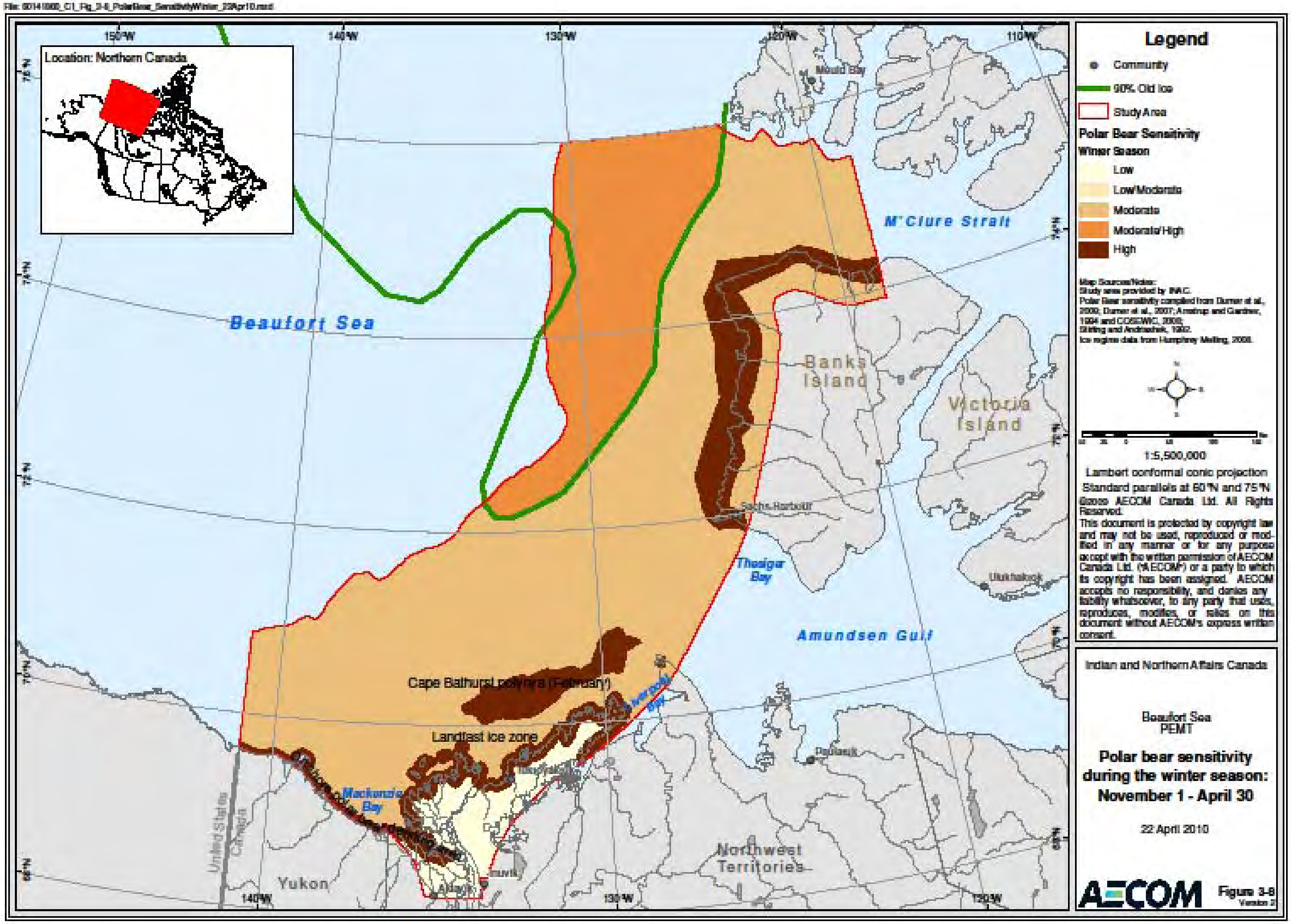
Winter Season November 1 to March 31 Sensitivity (Figure 3-8)

The location of leads strongly influences the distribution of seals and polar bear hunting activity during winter. In the winter polar bears move south toward the shoreline of the mainland coast or Amundsen Gulf (Stirling 2002). The most important floe-edge and moving–ice habitats are distributed in a band through the Bathurst polynya. This intermediate zone of fractured, unconsolidated annual ice lies in shallow waters between the landfast ice along the coast and the multi-year pack ice further offshore (Stirling 1990). In general, the polynya is visible as a distinct lead as early as March (Dickens *et al.* 1987). The maximum observed areal extent of the polynya during the period from April to June was used to establish a conservative set of boundaries for this zone for the winter/spring period (Dickens *et al.* 1987, Canadian Ice Service 2002).

Sensitivity areas in the winter are similar to the summer but also include the onshore and offshore maternity denning area. Maternal denning sites are a key element of bear ecology, potentially reducing the vulnerability of the cubs and nursing females to hunters and intraspecific predation. In early November, pregnant females dig maternity dens on land near the coast or offshore in the multi-year pack ice. Maternal dens located over broad regions of the Canadian Arctic were within 8 km of the coast (Harington 1968, Messier *et al.* 1994). Historically, female polar bears were often hunted in maternal dens on Banks Island and the mainland, and the hunting of such bears may have contributed to the higher proportion of maternal denning sites currently found on multi-year pack ice off shore (Stirling 2002). However, declining ice extent and degrading ice character have been associated with a shift towards more land-based denning as availability and quality of pack ice denning habitat decreases (Fischbach *et al.* 2007). Further declines in sea ice availability and an increase in polar bears denning in coastal areas are predicted. If the summer ice retreats far enough from shore and for a long enough time, it could prevent pregnant females that are foraging offshore from reaching the coast and bears will be forced to den in deteriorating pack-ice habitats (Fischbach *et al.* 2007). Should development be initiated in areas where maternal dens are present, timing should coincide with the spring period when female bears are foraging away from maternal dens (from April to late spring). Females may occupy such dens during the open water season and during the birthing period (late October through to March or April).

- **Low Sensitivity (1):** Areas on the mainland land > 5 km from the coastline where polar bears occurrence is unlikely. Areas that have very limited use year round, and have little value for reproduction (denning) or survival (limited use for foraging).
- **Low/Moderate Sensitivity (2):** None for the winter season.
- **Moderate Sensitivity (3):** (A) Areas on Banks Island > 5 km from the coastline where polar bears occurrence is likely during the winter season. (B) Foraging areas in non-critical time periods (November through early March) and is the transition ice zone of predominantly first year ice that extends from the northern boundary of the Bathurst Polynya and the southern boundary of the multi-year ice (Dickins *et al.* 1987). Forage value of these areas is associated with the mid and early winter periods.
- **Moderate/High Sensitivity (4):** (A) These areas (moving ice/flow edges, polynyas) represent foraging areas in critical time periods in winter (mid March and April), (B) Foraging areas on 90% old ice during the winter season.
- **High Sensitivity (5):** Critical Habitat Areas are legally defined areas under the Species at Risk Act that represent habitats critically important to the survival of the species. With reductions in stable old ice, increases in unconsolidated ice, and lengthening of the melt season, the proportion of polar bears denning in coastal areas will continue to increase, until such time as the autumn ice retreats far enough from shore that it precludes offshore pregnant females from reaching the coast in advance of denning.

Figure 3-8 Polar bear sensitivity during the winter season: November 1 to April 30



3.8 Recommendations and Data Certainty

Ecological attributes that polar bears are dependent on have been well researched, and it is known that conservation of areas used for denning, and spring, fall, and winter feeding, in addition to regulated hunting, are necessary for population viability. However, uncertainties do exist on several fronts, as the bounds of where such feeding or denning areas occur is not exact, nor do habitat selection models exist that demonstrate the relative value of such offshore habitats for polar bears. Furthermore, the impacts associated with development are not well documented in the Beaufort Sea (as little development beyond exploration projects has taken place), so the reliance and susceptibility of polar bears to respond to developments is uncertain. More pressing uncertainties relate to climate change, including how the locations of areas mapped herein may change with a warming climate, and if the susceptibility of polar bears to development will subsequently change. Hence, the recommendations for updating the polar bear sensitivity rating include research to document the habitat selection of bears within the Beaufort and identification of habitat values among scenarios for climate change.

3.9 Summary

Polar bears were considered a VEC because of their high public profile, economic importance, and importance within the food chain as the top predator in the Beaufort Sea. Polar bears have several seasonal-driven habitat uses, and the sensitivity ranking often reflected attributes such as important denning areas or spring or fall feeding areas. The ecology of polar bears, including factors that may limit population growth, susceptibility to development impacts and climate change, meant that sensitivity ranking was relatively conservative for this VEC. There are some uncertainties associated with the currently mapped areas for habitat use and their value, and it is anticipated that as new data becomes available, the sensitivity layer can be updated to refine habitat values and potential risks from development.

The sensitivity layer can be interpreted to mean that areas with the greatest inherent biological value should be subject to greater caution for activity, and implies that greater risk exists to polar bears from habitat loss and mortality risk in such areas. A higher sensitivity rating was most often associated with denning areas and foraging in critical time periods. Due to seasonal changes in polar bear distribution and habitat uses, it is recommended that a long-term view of the potential activities be considered when evaluating individual grids. Although oil and gas exploration activities may be limited to seasons when bears are not present (such as open water seismic), the potential petroleum production infrastructure associated with such exploration – which is the ultimate goal of exploration activities – may ultimately persist year round, and could impact polar bear populations beyond the season(s) of exploration. Specific recommendations regarding project seasonality and other mitigation measures should be a component of project-specific planning and/or impact assessment. Ongoing efforts to identify and map areas where polar bears are most likely to den and forage should also improve the ability of regulators and industry to reduce disturbance of denned bears (effective habitat loss) and reduce the likelihood of conflict-related bear kills (mortality risk).

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4. Ringed Seals

4.1 Description

The ringed seal (*Phoca hispida*) is a relatively small marine mammal that serves as a critical ecological link in the food chain within the Canadian Arctic marine environment. Populations of ringed seals are strongly linked to polar bear population numbers (Stirling 2002).

This seal is found throughout the circumpolar regions of the Northern Hemisphere, and the population of ringed seals in the Western Arctic is approximately 650 thousand seals (GNWT 2007a). In the southern Beaufort Sea, the estimates of population size are dated, but range from 41,200 in 1982 (open water surveys; Harwood and Stirling 1992), to a low of 2,900 in 1997 (spring surveys; Stirling *et al.* 1982). Estimates from open water surveys in 1986 were 14,300 (Harwood and Stirling 1992). The populations of seals observed are highly variable, and are influenced by ice conditions and prey availability (Stirling 2002). Sharp population declines in observed populations are closely associated with ice cover, which reduces primary and secondary productivity (Stirling 2002).

In the Beaufort Sea, predators of ringed seals are primarily polar bears, arctic foxes, wolves, and wolverine; Arctic foxes in particular, eat a high proportion of the pups in ringed seal dens. Ringed seals are however, the main prey of polar bears. Polar bears catch and consume about one seal every six and a half days (GNWT 2007b), or about an average of 43 seals per year (Stirling and Øritsland 1995). Given the current populations of ringed seals in the Beaufort Sea, there are likely not enough seals to support much more growth in polar bear populations, the latter of which have grown over the past 20 years.

4.2 Rationale for Selection

The ringed seal was selected primarily for two reasons – its important role within the food chain, and its economic importance as a hunted and cultural resource. Within the food chain, seals are a key prey item in the Beaufort Sea for large and medium- sized predators; in particular, polar bears, fox, and wolverine. There are strong associations in particular between the population of polar bears and ringed seals (Stirling 2002). Cultural and economic value of seals is also clearly evident, as seals have been a reliable source of heating oil, meat and skins for coastal Inuit. Sealing continues to be important for its nutritional and cultural values to northerners.

4.3 Key Habitat

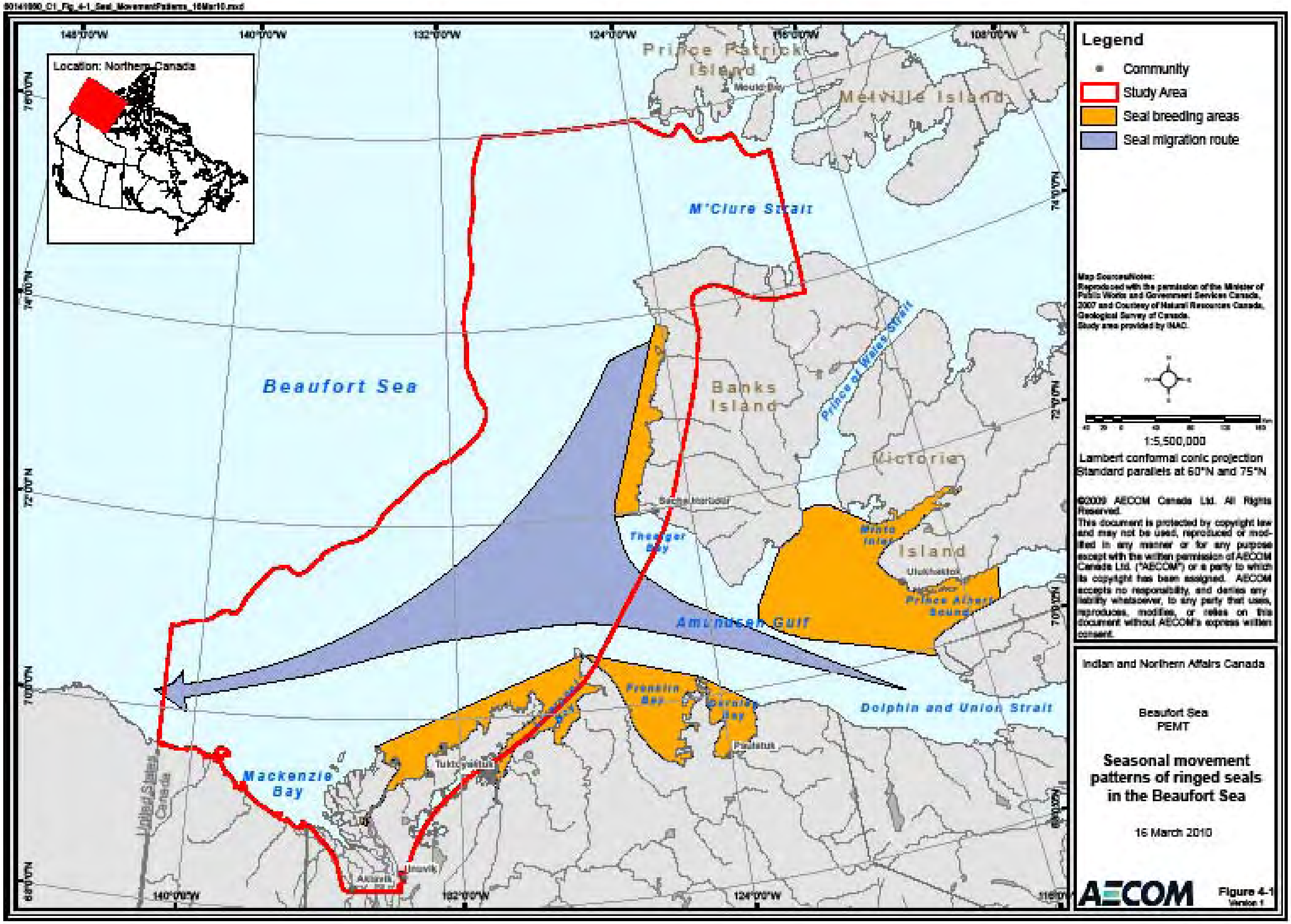
Preferred ringed seal habitat consists of flaw leads, pressure ridges and polynyas in the land-fast ice of the Arctic Ocean. Offshore pack ice is used irregularly. Very deep water areas appear less used than shallower depths (i.e., less than 100 m), but ringed seals are found throughout the Beaufort Sea (Stirling *et al.* 1982, Kingsley *et al.* 1985).

Density of ringed seals vary in response to overall productivity of the ecosystem (Stirling and Lunn 1998). Regions covered with multiyear ice are considerably less productive than areas that fluctuate seasonally between annual ice and open water (Bradstreet and Cross 1982). Relatively low densities of ringed seals have been reported in areas largely covered by thick multiyear ice (Kingsley *et al*. 1985). Annual primary productivity in areas with 1-year ice is 27 times that of areas with multiyear ice (Arrigo *et al*. 1997), and areas of annual ice also have 4-8 times greater primary productivity than areas of open water at the same latitudes (Ferguson *et al*. 2000) and results in greater seal density (Finley *et al.* 1983, Stirling and Øritsland 1995).

Ringed seals have a varied diet composed primarily of larger shrimp-like crustaceans, small fish and zooplankton. These food sources occur in open ocean areas, and in greater concentrations in areas where upwelling of currents or nutrient inputs occur. In late summer, prior to freeze up, the importance of foraging is heightened, as seals build up fat reserves for the winter.

Seasonally, there are some evident patterns that are associated with breeding, birthing, and summer feeding activities, although ringed seals are present in the study area on a year-round basis (Figure 4-1). During much of the winter, and until break up in June, adult seals maintain established territories around breeding areas and are generally solitary. Adult ringed seals maintain lairs and breathing holes beneath the snow throughout the winter (Smith and Stirling 1975), and females give birth in mid-March to mid-April in birthing lairs. Prior to ice break-up in late June, ringed seals are distributed throughout the southern Beaufort Sea and can be easily observed hauling out on the ice to moult. Seals appear to prefer areas where water is 75 to 100 m deep for haul out locations (Stirling *et al.* 1982). During the open water periods, seals forage and build up fat reserves for the coming winter. Seals may aggregate in groups of up to 21 members in areas where greater food abundance is located during late summer (L. Harwood, pers. comm. 2007; Harwood and Stirling 1992). The location of aggregations within the Beaufort Sea varies between years, but such areas appear to be most common north of the Tuktoyaktuk Peninsula (Harwood and Stirling 1992), and are very similar to the areas where bowhead whales concentrate and forage (L. Harwood, pers. comm. 2007). Seal density within the aggregations can be 6 to 13 times higher than regional mean densities (Harwood and Stirling 1992). As freeze up commences in late autumn, adult seals move into coastal areas of stable, landfast ice and establish breeding territories. Although still solitary, seal concentrations may be higher along complex shorelines (such as those with fjords and islands), as compared to more simple coastal areas (Smith 1987). Also at this time, there is a general westward movement of adolescent and young of the year seal pups through the study area from the Amundsen Gulf to the Chukchi Sea. This migration and segregation of age classes is thought to be in response to ice availability, food availability and population pressures (GNWT 2007a).

Figure 4-1 Seasonal movement patterns of ringed seals in the Beaufort Sea



4.4 Climate Change

Seals, especially ringed seals which are the main food source for polar bears, depend on the sea ice to provide a platform for resting, foraging, birthing and nursing pups, and moulting. Changes in the extent and concentration of sea ice may alter the seasonal distributions, geographic ranges, patterns of migration, nutritional status, reproductive success, and abundance of ringed seals. Ringed seals rely on both the duration of the ice cover and the total precipitation to create sufficient snow depth for the building of subnivean birthing lairs. If snow decreases in depth and melts earlier, pups may be exposed at an earlier age to freeze-thaw cycles and predators such as the polar bear (Stirling and Smith 2004, Ferguson *et al.* 2005).

The arctic cod is a pivotal species in the arctic food web, as a prey item to belugas, ringed seals, bearded seals, and other species (Bradstreet *et al.* 1982). The productivity of the arctic cod is dependent upon algal blooms that occurs at the ice-edge every spring. Reduction in the extent of the ice edge, and its associated community, may have harmful consequences for marine mammals that have evolved with these unique systems (Tynan and DeMaster 1997).

Another consequence of increased atmospheric CO_2 would be increased precipitation and continental runoff. Increase discharge from the Mackenzie River would increase the regional ice extent in the Beaufort Sea, and dramatic declines in polar bear and ringed seals population in 1974-75 and 1984-85 were associated with the heavy ice conditions during those years (Stirling *et al.* 1977, Harwood and Stirling 1992, Stirling and Parkinson 2006).

4.5 Sustainability

The viability of ringed seals is most closely associated with ice cover that provides suitable denning habitat and the productivity of and the rate of predation on pups by polar bear and foxes. Ice cover is impacted primarily by climatic conditions (wind, ambient air temperature, and solar radiation). Currently, ringed seals are not threatened in the Beaufort Sea, but they have undergone substantial fluctuation in abundance due to long-term changes in ice characteristics. Heavy ice years in the 1970’s and 1980’s were closely linked with a decline in food availability and the decline of populations (Stirling *et al.* 1982, Ferguson *et al.* 2000, Stirling 2002). During periods of heavy ice cover (such as 1974), decreased primary and secondary productivity alters prey availability for ringed seals, such that body condition declines and the ovulation rate can be reduced to <50% (Stirling *et al.* 1977, Stirling 2002). The opposite has been found to be true when there is early melting of landfast ice and later freeze up i.e., better body condition and a higher ovulation rate (Harwood and Smith 2001).

Hunting and predation rates also have the potential to limit populations. Here too, climatic conditions may influence susceptibility to predation, as early spring rains can expose birth lairs, resulting in high levels of predation on pups (Stirling and Smith 2004). Independent from climatic factors, human hunters may also take a significant proportion of animals, primarily for their pelts, oils, and as food for domestic dogs.

4.6 Susceptibility to Development

Linkages to Development

Given that ice characteristics are the greatest influence on population viability, potential impacts from industry that most influences ice cover in the study area would have the greatest affect on impacts to populations. However, widespread changes in ice cover (such as thickness and timing of freeze up and break up) are unlikely to be affected by most oil and gas projects. There are potential project impacts though, that may be apparent in a more localized nature. The extent to which such localized impacts influence population dynamics will depend on the number and extent of projects. Most project activities have potential impacts that can be grouped into three categories: Ice-Based Activities, Open-Water Activities, and Hydrocarbon Releases.

Ice-Based Activities

On-ice activities have several potential effects. Activities that are in close proximity to denning seals have the greatest potential to disturb birthing or rearing. Studies have shown displacement of ringed seals from areas close to artificial islands in the central Beaufort Sea and abandonment of breathing holes close to seismic survey lines (Frost and Lowry 1988; Kelly *et al.* 1988). Monitoring studies for the Alaskan Northstar and Liberty projects suggest minor effects on ringed seals from ice road construction and seismic exploration (Harris *et al*. 2001), as den locations are relatively ubiquitous throughout the study area. Ice-pad and ice-road construction also have the potential for disturbance due to noise and other human activity (Zwanenburg *et al*. 2006). Impact predictions associated with the Voisey's Bay Nickel Mine (CEAA 2007) also suggested that seals may suffer temporary hearing loss near vessels traveling through ice, and that they display avoidance behaviour at 500 to 700 m from such shipping activities. Devon Canada Corporation (2004) identified potential habitat alienation due to platform structures, ice pads and ice roads. It should be noted though, that there is no strong evidence to suggest that changes in densities of seals will result from oil and gas activities. In particular, Moulton *et al.* (2003) found no changes in seal densities in relation to an ice bound drilling operation in Alaska.

Open Water Activities

In open water, the presence of shipping activities, offshore facilities (such as drilling rigs), and open water exploration activities (primarily seismic exploration) can be expected to result in relatively short-term displacement of seals (Zwanenburg *et al.* 2006). The presence of open water production wells in areas where concentrated foraging takes place may reduce habitat use in such areas, potentially reducing overall body condition, ultimately resulting in decreased production of pups over a relatively short term. Seals are generally well known to habituate to development, human activities, and infrastructure (the abundance of harbour seals in most coastal city harbours are a good example of such habituation), and as such, long term impacts on seals exposed to open water activities is likely minimal.

Hydrocarbon Releases

As discussed in Section 3 (polar bears), contaminant spills (particularly hydrocarbon spills) remain a potential risk that could have direct consequences to seal populations in the Beaufort Sea. Open water hydrocarbon spills are one of the largest longer-term threats to populations, as a large spill would be expected to disrupt the food availability for seals, potentially decimating the population. It seems likely that an oil spill would affect ringed seals in the same way that the Exxon Valdez spill affected Harbour seals (*Phoca vitulina*) in Alaska (Frost *et al.* 1994). Seal habitat may be affected by contaminant spills, as contaminant presence may reduce the prey base for seals. A large-scale oil spill may also directly impact the health of individual seals. The risk of large-scale spills, however, is very low (Devon Canada Corporation 2004).

Seasonality of Development Impacts

There are three relatively distinct time periods in which development activities may impact aspects of seal ecology. Those include the open water, birthing, and winter periods. Seals are present throughout the study area on a year round basis. Open water impacts to seals would likely be limited to activities such as platform-based drilling, open water seismic, and marine transportation activities. Activities that may affect the winter and birthing ecology of seals would include all ice-bound exploration and drilling, ice road related operations and construction, and low-level aircraft flights.

Population vs. Individual Impacts

Projects may result in several key distinct residual effects to ringed seals, such as habitat avoidance, and contaminant exposure risk. These impacts are generally apparent at an individual level, such as localized and/or temporary avoidance of infrastructure. Overall, threats to the viability of populations are most closely associated with ice features that support successful denning and reproduction, and the productivity of waters in the Beaufort Sea for foraging. In most cases, the impact of project-related residual effects is limited to relatively short term time periods and small areas, which will not affect such parameters as ice features and marine productivity. However, there is the potential for population-level impacts to occur in the following two ways: cumulative effects due to multiple projects, and through large hydrocarbon spills or accidents.

Multiple projects, especially those that may occur in areas of concentrated late summer feeding, may have the potential to reduce habitat suitability on a broad scale, if there are enough projects acting in concert to do so. Similarly, a large hydrocarbon release also has the potential to reduce marine productivity, which would in turn result in lower populations and likely a reduced range that will reflect the location of greatest contaminant concentrations.

4.7 Mitigation

Although the preferred ringed seal habitat consists of flaw leads, pressure ridges and polynyas in the land-fast ice of the Arctic Ocean, ringed seal can be found throughout the Beaufort Sea. Therefore mitigation can be difficult and largely consists of timing restrictions during certain periods when seal are more vulnerable to disturbance by industry activities. Den locations are relatively ubiquitous throughout the study area, so timing restrictions are the best way to mitigate for this species. There are several strategies that can be applied to project-specific mitigation planning:

- Activities that are in close proximity to denning seals have the greatest potential to disturb birthing or rearing. Timing restrictions for development should be established during mid March to mid May when ringed seals are giving birth and raising young.
- Specific areas for foraging include the Mackenzie and Kugmallik Canyons, and areas near the mouth of the Mackenzie River. These key areas are important to the viability of the species, and therefore impacts here should be mitigated and/or avoided where possible.
- Timing restrictions during summer foraging periods should be established for noise generating activities.
- An oil spill response plan should be developed for area where seals are known to congregate and where known food sources occur within the upwelling of ocean currents.

4.8 Sensitivity Layers

In developing a sensitivity layer for ringed seals, the sensitivity rating was dependent on the physical attributes that are crucial to the growth and viability of the population. In particular, areas for denning and pupping, areas of feeding (for both young seal pups and adults), and movement or migratory corridors were considered of importance. Typically these areas were related to distances from shore and seasonal ice patterns. The abundance and distribution of seals may vary in response to ice conditions, and the spatial representation of these areas may thus change over time. Additionally, oceanographic features that support greater congregations of seals were identified and included the Mackenzie and Kugmallik Canyons, and areas near the mouth of the Mackenzie River. These same features provide similar habitat values as those selected by Bowhead whales. These areas are considered of greater value due to the upwelling of ocean currents and the influx of nutrients create areas of greater forage concentrations (crustaceans and zooplankton; L. Harwood, pers. comm, 2007).

Similar to those factors developed for polar bears, the sensitivity layer reflects a combination of habitats necessary for the viability of the population and the sensitivity to the sustainability of those areas given the potential impacts for development.

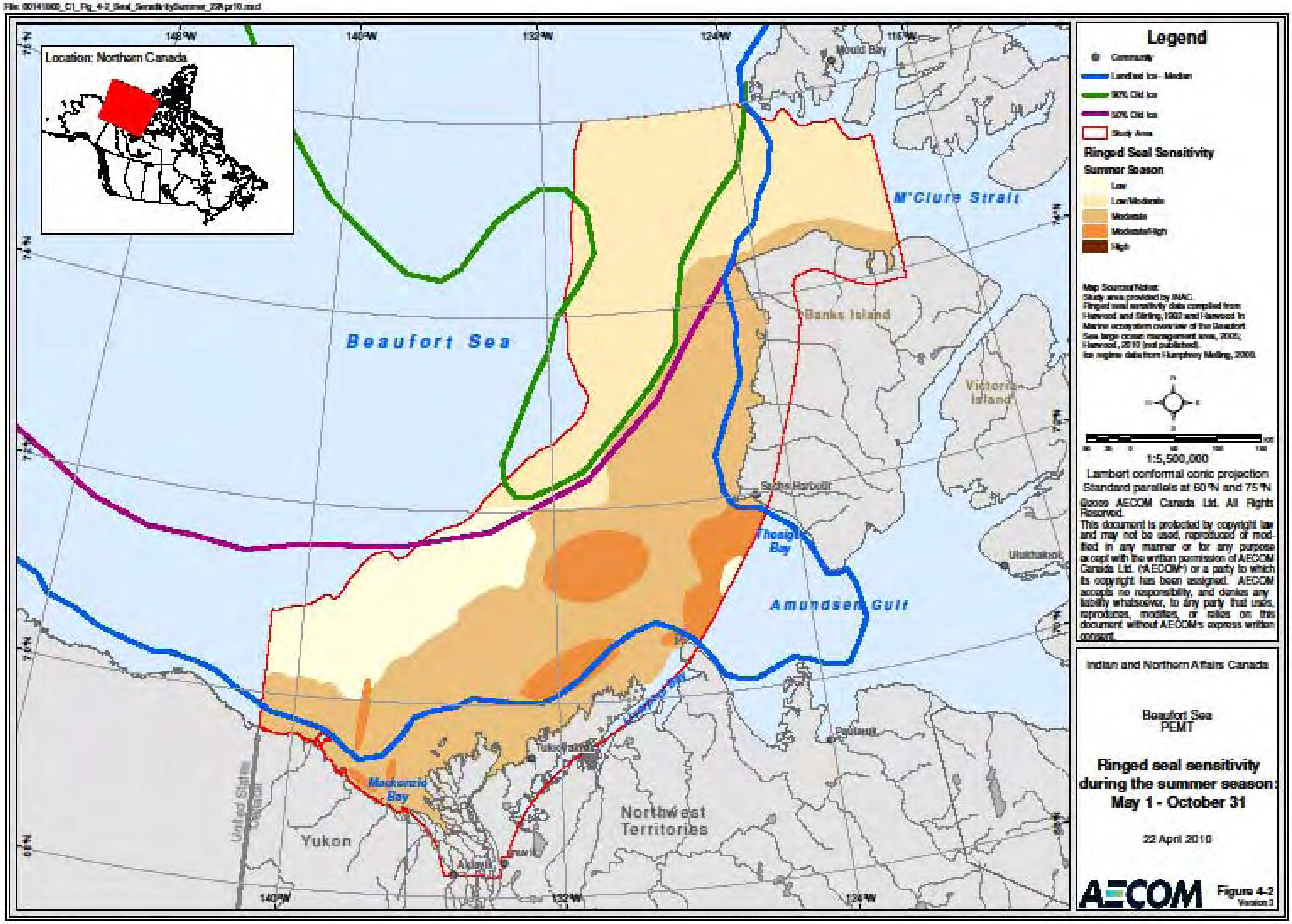
4.8.1 Sensitivity Layer Ranking

Summer Season May 1 to October 31 Sensitivity (Figure 4-2).

During much of the winter, and until break up in June, adult seals maintain established territories around breeding areas and are generally solitary. Prior to ice break-up in late June, ringed seals are distributed throughout the southern Beaufort Sea and can be easily observed hauling out on the ice to moult. Seals appear to prefer areas where water is 75 to 100 m deep for haul out locations (Stirling *et al.* 1982). During the open water periods, seals forage and build up fat reserves for the coming winter. In early summer, the highest density of ringed seals are found in nearshore fast and pack ice. During summer, ringed seals are found dispersed throughout open-water areas, although in some regions they move into coastal areas (Smith, 1987; Harwood and Stirling, 1992).

- **Low Sensitivity (1):** This rating reflects open water areas that have very limited use or selection during the spring and summer. Such areas do not contribute substantially to the viability of the species and these areas have little value for reproduction (denning) or survival (limited use for foraging).
- **Low/Moderate Sensitivity (2):** This rating reflects all areas of the Beaufort Sea, with the exception of multi-year pack ice, and areas classified as moderate or greater sensitivity. These areas have low density, uniform use for foraging, and have moderate, but low density use as denning areas.
- **Moderate Sensitivity (3):** Open water areas where seal occurrence is likely.
- **Moderate/High Sensitivity (4):** (A) Known aggregation areas between Banks Island and the mainland. (B) Foraging areas that may result in aggregates of seals during late summer feeding periods. They are associated with oceanographic features and include the Mackenzie Canyon, Kugmallit Canyon, and areas of the coastal shelf (these areas are also typical areas of summer bowhead whale aggregation).
- **High Sensitivity (5):** None for the summer season.

Figure 4-2 Ringed seal sensitivity during the summer season: May 1 to October 31

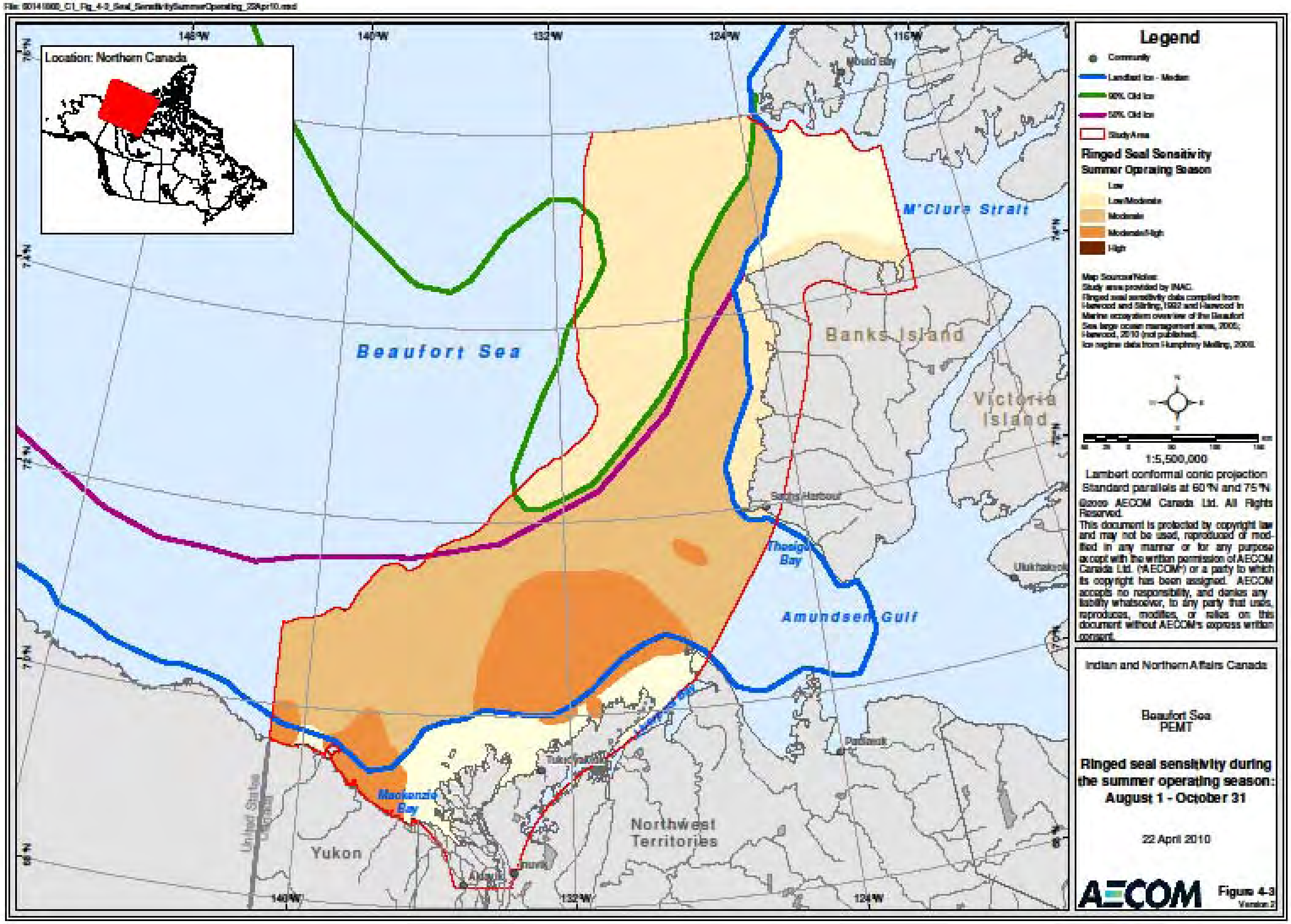


Summer Operating Season August 1 to October 31 Sensitivity (Figure 4-3)

During the open water periods, ringed seals forage and build up fat reserves for the coming winter. In August and September, ringed seals often aggregate in open-water areas where primary productivity is thought to be high (Harwood and Stirling, 1992). These aggregation areas are generally located north of the Yukon, north of Cape Dalhousie and north of the Tuktoyaktuk Peninsula (Harwood and Stirling 1992). Seals may aggregate in groups of up to 21 members in areas where greater food abundance is located during late summer (L. Harwood, pers. comm. 2007; Harwood and Stirling 1992). Aggregation areas are very similar to the areas where bowhead whales concentrate and forage (L. Harwood, pers. comm. 2007).

- **Low sensitivity (1):** (A) The M’Clure Straight which will be mostly covered in 90% old ice, ringed seal occurence is unlikely in this area (B) Areas in the landfast ice zone near the mainland. These areas are rated as low due to the decreased likelihood of ringed seals in this area during the summer operating season.
- **Low/Moderate Sensitivity (2):** (A) Ringed seal occurence is unlikely in this area since the area will mostly be covered in 90% old ice. (B) Areas in the landfast ice zone near Banks Island. These areas are rated as low due to the decreased likelihood of ringed seals in this area during the summer operating season.
- **Moderate Sensitivity (3):** Open water areas and waters under 50% old ice where ringed seal occurrence is expected.
- **Moderate/High Sensitivity (4):** Known and documented ringed seal aggregation areas in August and September (Harwood and Stirling 1992, L. Harwood pers. comm. 2009, 2010). These areas are suspected to be very high in prey and likely important for winter preparation.
- **High Sensitivity (5):** None for the summer operating season.

Figure 4-3 Ringed seal sensitivity during the summer operating season: August 1 to October 31



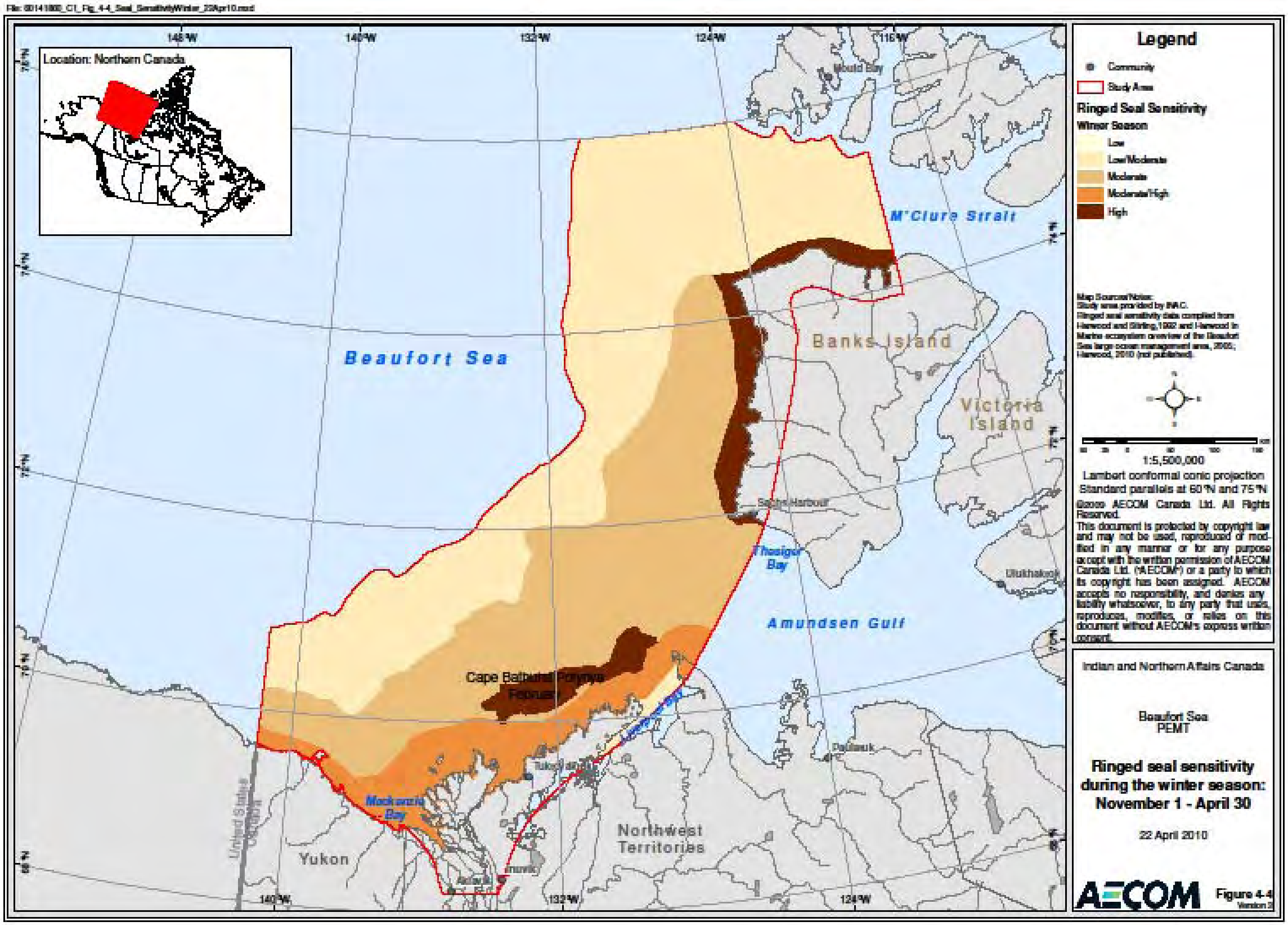
Winter Season November 1 to April 30 Sensitivity (Figure 4-4).

In winter and spring, the highest densities of ringed seals are found on stable, shorefast ice. Few, if any, seals inhabit ice-covered waters shallower than 3 m due to water freezing to the bottom and/or poor prey availability caused by the limited amount of ice-free water.

- **Low Sensitivity (1):** None for the winter season
- **Low/Moderate Sensitivity (2):** (A) These areas have low density, uniform use for foraging, and have moderate, but low density use as denning areas. (B) The area within Liverpool Bay which is considered low to moderate habitat value during the winter season.
- **Moderate Sensitivity (3):** These areas represent foraging areas that may result in aggregates of seals. They are associated with stable, shorefast ice, and the Cape Bathurst polynya in late March and early April
- **Moderate/High Sensitivity (4):** Areas in the landfast ice zone near the mainland. These areas are rated as moderate high due to the potential for high occurrence of ringed seal in that area during the winter. This area is also a good foraging area for ringed seals during the winter season.
- **High Sensitivity (5):** These areas represent extensively used near shore denning areas, and the Cape Bathurst polynya where primary productivity is high.

A note of importance is that the potential impact of short-term, localized disturbance, and potential hydrocarbon spills to ringed seals was considered greater in the areas of late summer foraging, rather than on multi-year pack ice, and thus, higher sensitivity ratings were applied to those key foraging areas. Similar to the sensitivity layer developed for polar bears, the underlying spatial layers are imprecise and subject to spatial variability among years. Thus, it is recommended that conservative interpretations of potential impacts for projects among seasons be more rather than less conservative.

Figure 4-4 Ringed seal sensitivity during the winter season: November 1 to April 30



4.9 Summary

Ringed seals were considered a VEC because of their important economic role, as well as their role in the food chain in supporting several predators, in particular, polar bears. Ringed seals are unique in that they are habitat generalists, and are ubiquitous throughout the area, with some spatial ties to feeding areas such as in under sea canyons and upwellings. Ringed seals have relatively low susceptibility to impacts of development impacts, such as short term, localized displacement, but much greater vulnerability to natural occurrences in ice characteristics. The sensitivity categories developed herein reflect relatively limited potential for significant residual impacts due to development, but do identify increased risk associated with key foraging areas.

5. Beluga Whale

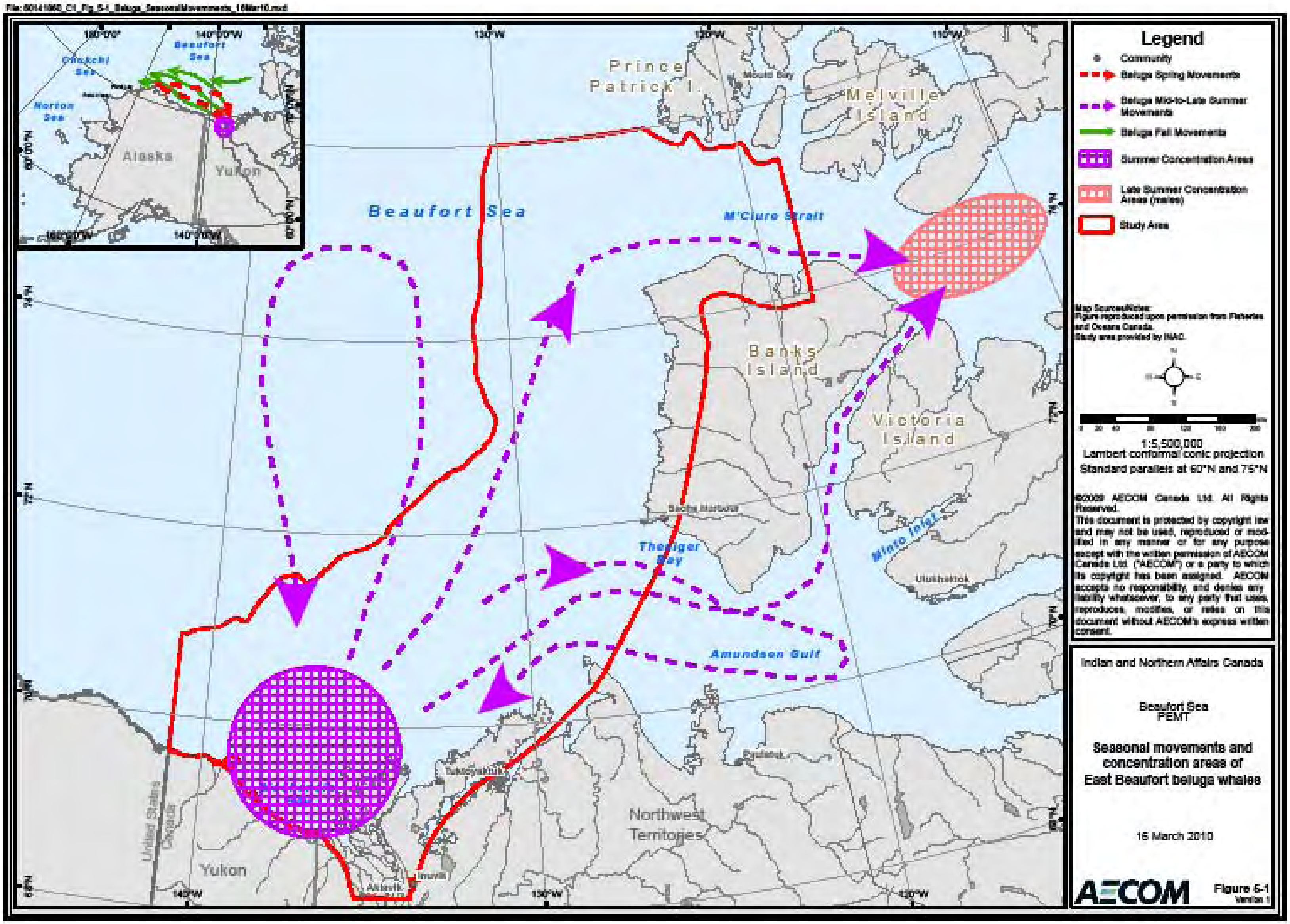
5.1 Description

The beluga whale (*Delphinapterus leucas)* belongs to the family Monodontidae, which includes the narwhal (*Monodon monoceros)* (COSEWIC 2004). These two species lack dorsal fins, a common characteristic thought to be an adaptation to life in ice-filled Arctic waters. Adult belugas can be distinguished by their pure white coloring, while juveniles are slightly grey in appearance. Belugas are long-lived with life spans that can exceed 63 years (COSEWIC 2004). Many harvested whales have been estimated to be over 40 years old (Harwood and Smith 2002). Females mature sexually between four to seven years and males reaching sexual maturity between six to seven years (COSEWIC 2004). Mating occurs during late winter to early spring with the peak of mating occurring before mid April. Gestation is estimated at 12 to 14 months with peak calving occurring during the late spring in offshore areas. Diet varies according to seasonal availability and consists of fish such as capelin, Arctic cod and herring, and invertebrates such as shrimp, squid and marine worms. Arctic cod are the most important summer food for Beluga whales (Loseto *et al*. 2009).

The Eastern Beaufort Sea beluga population winters in the Bering Strait and migrates eastward through the Alaskan Beaufort Sea during April and May, arriving off the west coast of Banks Island in late May and early June (Figure 5-1; Moore *et al.* 1993). Offshore leads are important during this portion of their spring migration (Barber *et al.* 2001, Richard *et al.* 2001, Harwood and Smith 2002). Depending on ice conditions, they may first appear near Herschel Island in late April or early May, and come to the shallow waters of the Mackenzie Delta in June to early July. They then move in a southwestward direction along the landfast ice edge off the Tuktoyaktuk Peninsula and into Kugmallit Bay, East and West Mackenzie Bays, Shallow Bay and the Kendall Island area where they aggregate for much of July (Harwood and Smith 2002). These areas are presumed to be of considerable importance to beluga because they return to these areas each summer despite significant hunting pressures (North/South Consultants Inc. 2003). The reasons why belugas come into estuaries were not well understood until recently. Earlier theories included a thermal advantage for calves and food availability. More recently, it has been shown that occupation of these warm, less saline waters is related to their annual moult and is connected with significant hormonal changes correlated with new skin growth (Harwood and Smith 2002). Mother-calf pairs are believed to spend longer periods in shallow water than other age or gender classes.

Belugas also aggregate offshore in the Beaufort Sea, Amundsen Gulf and Viscount Melville Sound where it is presumed they engage in feeding activities prior to the fall migration (Harwood and Smith 2002; Barber *et al*. 2001, Richard *et al.* 2001, DFO 2000). Belugas from the Mackenzie Estuary use deep offshore areas on their way to M’Clure Strait rather than using the shallower waters near Banks Island (Barber *et al.* 2001). In late August, the return migration consists of a variety of routes, varying from 100 to 400 km offshore of northern Alaska (Harwood and Smith 2002). During their migration to the wintering areas in the autumn, belugas feed heavily on schools of Arctic cod building up an accumulation of a thick layer of blubber, which acts both as insulation and a large reserve of energy in preparation for winter.

Figure 5-1 Seasonal movements and concentration areas of East Beaufort Sea beluga whales



5.2 Rationale for Selection

The beluga whale was selected because the species was previously cited as a VEC for the Beaufort region (GNWT 2005) and because information was available for this work, such as Beluga Management Zones identified in the Community Conservation Plans (Figure 5-2). Additionally, beluga whales are an important link in the arctic food web as both a predator and as prey. Belugas are known to feed on many species of fish species in the Beaufort Sea and Amundsen Gulf, including Arctic cod (*Boreogadus saida*), cisco (*Coregonus artedii*) and halibut (*Reinhardtius hippoglossoides*) (COSEWIC 2004). Benthic invertebrates are also frequently found in the stomachs of belugas (COSEWIC 2004).

5.3 Key Habitats

Arctic cod appear to play an important role in beluga whale habitat preference (Loseto *et. al*. 2009). Loseto *et al*. (2009) found that Arctic cod are the most important summer food for beluga whales residing in the Beaufort Sea. Arctic cod were located in two locations: Near shore waters and offshore waters. Based on their research findings, they suggested that larger whales fed on cod offshore and smaller whales fed on cod near shore. Loseto *et al*. (2009) proposed that arctic cod distribution into near and offshore habitats may potentially be essential to the Beaufort Sea beluga whale population by aiding in the sustainability of beluga energy requirements.

Beluga habitat preference associated with prey may affect beluga mercury levels (Loseto *et al*. 2008). For example, mercury concentration in beluga whales inhabiting the Estuarine Shelf (shallow open water) were significantly lower than whales in the Amundsen Gulf (sea ice edge) and the Epibenthic (closed sea ice) (Loseto *et al*. 2008). These findings were consistent with the mercury levels of potential prey of beluga whale since Estuarine Shelf fish had that lowest mercury levels (Loseto *et al*. 2008). Interestingly, Arctic cod mercury levels were higher in the Amundsen Gulf in comparison to the Estuarine Self (Loseto *et al*. 2008).

5.3.1 Beaufort Sea

- The Beaufort Sea provides important spring and fall migration corridor habitat, including marine waters up to and including 400 km north of the Northwest Territories, Yukon and Alaskan coasts.
- The Beaufort Sea, between the Bering Strait and Banks Island, provides important spring migration habitat, where belugas follow leads in the ice to reach the shallow waters, bays and river estuaries. During August, belugas are widely distributed in the area and feeding is probably their most important activity. During the fall migration in mid-August, belugas leave the shallow waters, bays and river estuaries and return to the Bering Strait for the winter. Few whales remain in the area past early September.
- The shallow waters, bays and river estuaries of the Beaufort Sea described above are recognized as special designated lands in the Aklavik, Inuvik and Tuktoyaktuk Community Conservation Plans as 712C – Beluga Management Zone 2 (WMAC 2000 a,b,c). Zone 2 extends from Kay Point on the Yukon coast to Baillie Islands (Cape Bathurst) in the east, and includes waters shallower than 20 m. Category C comprise lands and waters where cultural or renewable resources are of particular significance and sensitivity during specific times of the year.

5.3.2 Mackenzie Delta

The landfast ice edge off the Mackenzie Delta provides important spring migration habitat as belugas move into Kugmallit Bay, East and West Mackenzie Bays, Shallow Bay and the Kendall Island area.

5.3.2.1 Kugmallit Bay, East and West Mackenzie Bays, Shallow Bay, Kendall Island Area

- Kugmallit Bay, east and west Mackenzie Bays, Shallow Bay and the Kendall Island area provides important summer habitat. This area, which encompasses approximately 1800 km2 , comprise the only known traditional summer concentration areas for the Beaufort Sea beluga stock from late June to early August. Belugas use these areas for moulting, calving and feeding. Feeding is not always observed and empty stomachs in belugas landed in the subsistence hunt are common. Belugas in these traditional summer concentration areas are harvested by Inuvialuit from Aklavik, Inuvik and Tuktoyaktuk.
- These areas are recognized as special designated lands in the Aklavik, Inuvik and Tuktoyaktuk Community Conservation Plan as 711E, 714E and 716E – Beluga Management Zone 1A (WMAC 2000a, b, c). Category E comprise lands and water where cultural or renewable resources are of extreme significance and sensitivity. The CCPs recommend the highest degree of protection of category E lands and there shall be no development in these areas (WMAC 2000a,b,c).

5.3.2.2 Viscount Melville Sound

In mid to late summer, male beluga’s migrate from the MacKenzie estuary via M’Clure or Prince of Whales Straight to Viscount Melville Sound, which is considered a late summer concentration area for male belugas whales (Harwood 2002). Although this male concentration area is outside of the study area, sections of the study area are used for migration to Viscount Melville Sound.

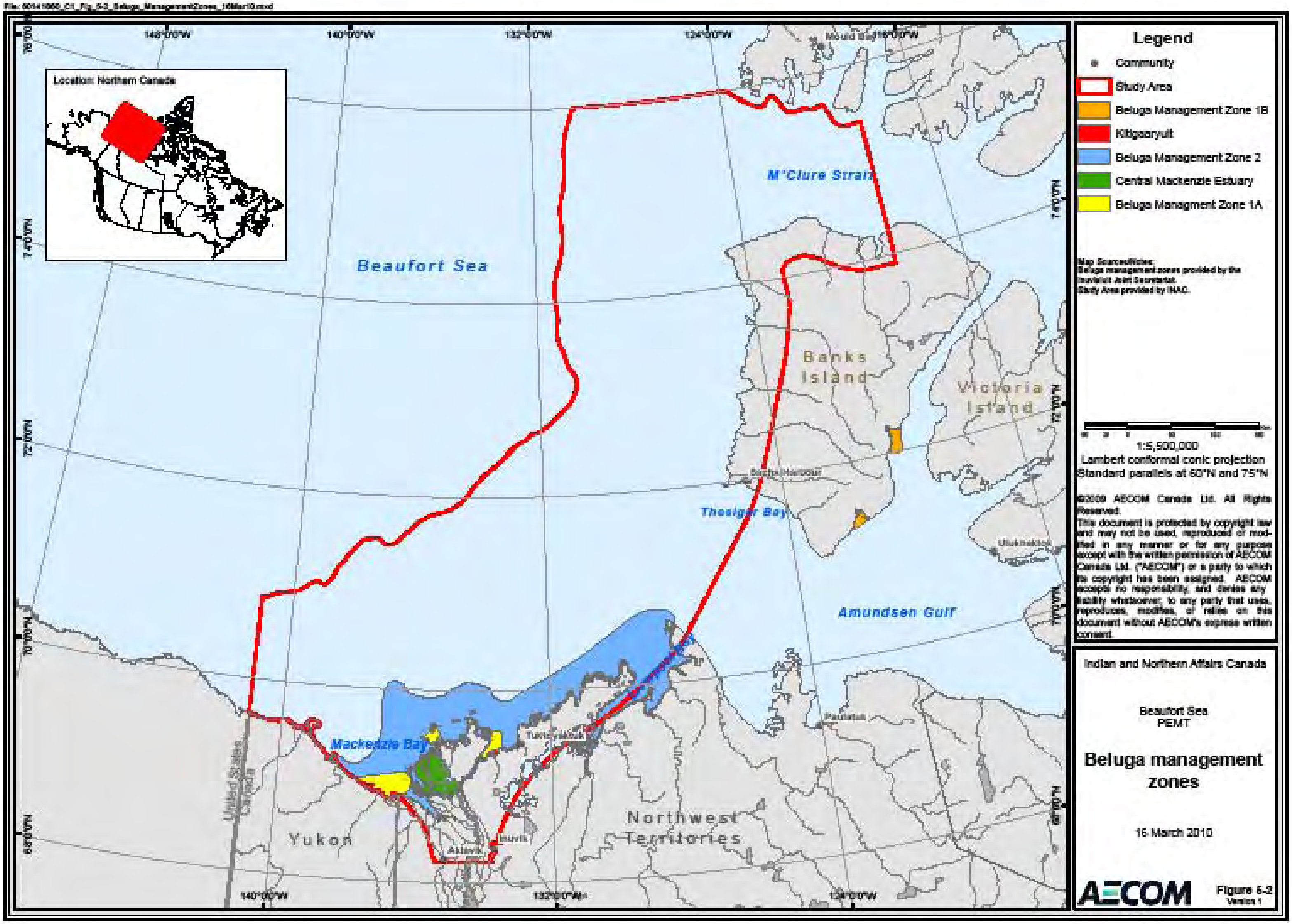


Figure 5-2 Beluga management zones

5.4 Climate Change

Global circulation models predict substantial decreases in both thickness and coverage of arctic sea ice due to increased atmospheric CO_2. For cetaceans, the potential detrimental effects of decrease ice extent is more indirect than the loss of ice habitat (Tynan and DeMaster 1997). In the case of the beluga whale, this indirect effect is the potential loss of its predominant prey, the arctic cod (*Boreogadus saida*) which is intimately associated with ice-edge habitats (Bradstreet 1982). The arctic cod is dependent on the secondary production in these habitats with the latter being sustained by ice algae. Ice algae form a thin, dense layer on the underside of ice at the ice-sea water interface and is well recognized as very important in the food web of marine mammals in the high Arctic (Bradstreet 1982, Tynan and DeMaster 1997).

Retreating ice extent would have an impact on the annual spring and fall migration of the belugas which timed these movements on the opening of ice leads in spring and advancing ice in fall. In summer the pack ice in the Northwest Passage has been the physical barrier separating the western and eastern stocks of belugas. If opening this passage for 100 days in summer comes to pass as predicted, then there is the potential of the mixing of these two stocks leading to reduce genetic diversity across the Arctic (Tynan and DeMaster 1997).

Retreading ice or a lack of ice cover in the Beaufort Sea due to future climate change will likely have an effect on beluga whale diet and potentially habitat preferences. Arctic cod are an ice-linked fish and are the dominant dietary preference of beluga whales (Loseto *et al*. 2009). In addition, Arctic cod appear to play a role in beluga whale habitat preference (Loseto *et al*. 2009). In the event of retreading ice, Beluga whales may be forced to alter their diets and/or their habitats. Recent research; however, has suggested that extreme regime shifts or ecosystems changes appear to have no affect on beluga whales in the Beaufort and Bering Seas (Luque and Ferguson 2009). Luque and Ferguson (2009) propose that beluga whales may be able to alter their diets without effecting their survival or growth. These findings suggest that beluga whales may be tolerant of ecosystem changes.

Anthropogenic activities in the mid 20th century have significantly increased mercury levels in beluga whales (Outridge et al. 2009). Recent research in the mercury levels in ringed seals has shown that mercury levels are correlated with ice free seasons (Gaden *et al*. 2009). Mercury levels in belugas may also be increasing with decreasing sea ice. Increased mercury levels are a concern since increasing levels of mercury in belugas could affect human beluga harvest.

5.5 Sustainability

The Eastern Beaufort Sea population is *Not at Risk* (SARA 2009). Population surveys in 1992 estimated the population at 19,629 (95% C.L. = 15,131 to 24,125) (Harwood *et al.* 1996) and in 2002 the estimate placed the population at 39,258 individuals when corrected for sightability (COSEWIC 2004).

Conserving habitat is fundamental to the viability of the Eastern Beaufort Sea beluga whale population. Belugas occur most often in the Mackenzie Estuary and within a deep trench in M'Clure Strait and Viscount Melville Sound during the summer. In the fall, the whales occur in the Mackenzie Estuary and Amundsen Gulf and north along the Yukon Coast (Barber *et al.* 2001). Presently, approximately 1716 km^2 of shallow waters, including Mackenzie Bay at 1160 km^2, the Kendall Island area at 193 km^2, and Kugmallit Bay at 363 km^2 has been identified as important beluga habitat. These areas are being considered for Protected Area status with the protection of the eastern Beaufort Sea beluga stock one of its primary objectives (North/South Consultants Inc. 2003; Fast *et al.* 1998). These same areas have already been recognized as special designated lands in the Aklavik, Inuvik and Tuktoyaktuk Community

Conservation Plans and have been identified as 711E – Beluga Management Zone 1A or as 712C – Beluga Management Zone 2.

The Beaufort Sea Beluga Management Plan has been established for the Eastern Beaufort Sea population (FJMC 2001). Under this plan, there are various management zones and areas in the Beaufort Sea (FJMC 2001). These areas are protected and should be avoided (FJMC 2001). This population is also protected under the *Marine Mammal Regulation* of the *Fisheries Act* (DFO 2009c). DFO passed beluga protection regulations in 1949 which protect beluga habitat and provide management (Richard and Pike 1993).

Offshore areas in the Beaufort Sea, both within and beyond the Study Area, have also been identified as important, since belugas congregate in these areas and engage in feeding activities from the sea floor before they migrate back to their wintering areas (Harwood and Smith 2002; DFO 2000). The migration routes followed by belugas vary and extend up to 400 km from the shoreline (Barber *et al.* 2001, Richards *et al.*. 2001), and these areas will also need to be protected and kept unobstructed if the belugas are expected to continue to use these routes (Harwood and Smith 2002).

5.6 Susceptibility to Development

The level of industry activity and the number of ongoing projects that may impact beluga populations in the Beaufort Sea is very low. Given the relatively low occurrence of industrial activity in the Arctic, there is little empirical evidence to strongly associate project-specific impacts, or impacts from multiple industrial projects, to population parameters for beluga whales. However, there are two likely means that viability of beluga whale populations can be linked with project specific impacts:

- industrial activities may reduce the quality and amount of suitable habitat available to beluga whales, especially for feeding, moulting, mating and calving, and
- industrial activities may increase the risk of mortality to individual beluga whales in proximity to developments.

Belugas are vulnerable to anthropogenic threats, such as industry activities because of their strong tendency to return to specific sites of summer aggregation to moult, feed, calve, socialize, rest and avoid predators (COSEWIC 2004; Pippard 1983). They continue to return to traditional areas of aggregation, even in the face of disturbance and harvesting pressures.

Habitat Susceptibility

Residual effects from industrial activity (as summarized in Section 3.2) may result in either complete loss of habitat, as is common with the ‘footprint’ of industrial developments, or effective habitat loss, whereby beluga whales avoid habitat in proximity to development. Depending upon the seasonality of occurrence of beluga whales, and the timing of impacts, the habitat loss or avoidance that results from a specific project may be limited to specific seasons.

Development activities to which beluga may be susceptible include:

- industrial pollution and miscellaneous spills;
- noise due to seismic activities and vessel movement; and
- island building or temporary drilling platforms.

Industrial pollution and miscellaneous spills that are discharged have the potential to result in either complete or effective habitat loss. Beluga whale habitats most susceptible to these releases are the shallow waters and river estuaries. The effects have been studied in the St. Lawrence beluga population where their critical shallow water and river estuaries habitat has been reduced as a result of extensive damming along the Manicouagan and Outardes rivers (Pippard 1983). Their habitat has also been reduced as a result of municipal, agricultural and industrial pollution discharged in the St. Lawrence and Saguenay rivers and their tributaries (Pippard 1983). Explanations for belugas abandoning these areas include:

- altering the heat budget making the water temperatures too low or unreliable for calving, and
- affecting fish and invertebrate reproduction, thereby reducing the number of prey species.

The population impacts that may result from an oil spill would depend largely on the season, amount and type of contaminants released, climatic factors and response initiated. An oil spill within the shallow waters and river estuaries identified as critical beluga habitat would be the most sensitive and could produce major site-specific impacts. An oil spill further offshore within the feeding, movement and migratory areas and corridors may produce fewer impacts because the beluga can navigate around the spill in these greater water depths. Contact with spilled oil may directly affect the health of individual whales, and/or reduce the availability of food, such as fish and invertebrates. In addition, exposure to aromatic hydrocarbons and polycyclic aromatic hydrocarbons (typical remaining pollutant after an oil spill) induces Cytochrome P450 1A1 which could be responsible for neoplastic lesions (tumors and cancer) in beluga whale (Wilson *et al*. 2005).

Noise from marine vessels movements or seismic activities may potentially negatively affect belugas by displacing belugas from the area and interfering with communication. Beugas should be able to detect some vessels up to 25 to 30 km away (Cosens and Duek 1993). The maximum extent of avoidance was predicted to be 50 km in a recent regulatory impact assessment (Devon Canada Corporation 2004). Marine vessels may have the greatest impact (in terms of habitat avoidance) in open water periods when aggregated belugas are feeding in shallow offshore waters. At its most extreme, noise can potentially also affect beluga whales by interfering with mating behaviours, communication and even cause damage to ears or other organs (Erbe and Farmer 1999). For example, Lesage *et al*. (1999) found that beluga whale communication was affected by changing call rates, repeated calling, increased call periods, and an increase in frequency range. They noticed that the effects were prolonged when exposed to a slow moving ferry than the small rapid moving water boat. Calls either increased or decreased and appeared to decrease when the boats were closer. Another study demonstrated that behavioural changes occurred in belugas exposed to 180–196 dB (Schlundt *et al*. 2000). Additionally, Romano *et al*. (2004) found that increasing high level sounds from seismic water guns and single pure tones has been shown to increase neural-immune levels which may indicate stress. Further, Finneran *et al.* (2002) found that after two minutes of exposure to seismic water guns, beluga whales exhibited masked hearing thresholds of 6 and 7 Db and 0.4 and 30 kHz.

Island building or the installation of temporary drill platforms in shallow waters identified as critical beluga habitat could potentially affect belugas and their habitat by competing with the belugas for space during the summer when they are congregating the shallow waters or by disrupting the habitat during the winter and rendering it unusable.

Seasonality of Development Impacts

Beluga whales that migrate into the Beaufort Sea during open water periods over-winter in waters outside of the study area. Therefore, industrial activities such as ice-platform based drilling, ice road construction, and flaring that occur outside the seasons when beluga whales are present (i.e., in frozen water periods throughout much of the study area) are unlikely to result in direct impacts to beluga whales. Open water industrial activities such as seismic, shipping and other marine vessel transport have the greatest potential for direct impacts to beluga whales. Potential accidents from these activities, such as contaminant spills (particularly hydrocarbon spills), have potential for direct impacts. These industrial activities and potential accidents also have a great potential for indirect impacts to belugas via food sources such as fish and invertebrates. If risk has been managed appropriately through prevention measures, and use of these measures is continued, the probability of occurrence of impacts remains low.

Population vs. Individual Level Impacts

Impacts from individual projects would likely be most measurable at the individual or family group level (such as a beluga cow with a calf). However, all such impacts ultimately have population-level consequences. The extent to which they are apparent at the population level (such as lower population numbers) will depend upon the magnitude to which impacts to the individual occur.

Additionally, because the Eastern Beaufort Sea beluga whales utilize waters beyond the Study Area boundaries (e.g., Amundsen Gulf and Viscount Melville Sound), impacts to the population that occur outside the study area may act in a cumulative fashion with impacts within the study area to influence the populations.

5.7 Mitigation

There is a variety of potential project types that vary in spatial extent, duration, and intensity (e.g., ice-platform based drilling, ice road construction, seismic, shipping and other marine vessel transport), with a corresponding range in magnitude of impacts that may occur in the project area. Based on the summary of project-specific residual effects, the seasonality of beluga whale movements, and the criteria used to define the grid rating, there are several strategies that can be applied to project-specific mitigation planning:

- An oil spill response plan should be developed for areas within the shallow waters and river estuaries identified as critical beluga habitat.
- In open water periods when aggregated belugas are feeding in shallow offshore waters, marine vessel movement activities within these areas should be limited to levels to which the population-level impacts are not apparent. When possible, vessels should keep a distance of 30 km from important beluga habitat (Kendall Island area, Kugmallit Bay, Mackenzie Bay and Estuary).
- Specific sites of summer aggregation to moult, feed, calve, socialize, rest and avoid predators are key areas that are important to the viability of the species, and therefore, impacts here should be mitigated and/or avoided where possible. These areas include the Kendall Island area, Kugmallit Bay, Mackenzie Bay and Estuary and within a deep trench in M’Clure Strait and Viscount Melville Sound. Should development be initiated in such areas, timing should attempt to coincide with periods when belugas are not present (from September to April).
- In areas of beluga spring and fall migration, marine vessel movement activities within these areas should be limited to levels to which the population-level impacts are not apparent.
- On-ice activities are generally unlikely to produce residual effects beyond the frozen water season, and may be a preferable option to open water activities, especially if accidents and hazards are controlled.

5.8 Sensitivity Layers

Beluga whales are present in the study area during open water periods and different areas are used for different purposes. Belugas select particular classes of sea ice concentration and water depth, presumably because both relate to factors such as prey distribution, predation, weather, moulting, and the rearing of young (Barber *et al.* 2001). The sensitivity layers established for beluga whales reflect the sensitivity of environmental components (important to beluga whales) to development. Areas of higher sensitivity were typically those that support moulting, successful reproduction and feeding areas, as well as movement and migratory corridors necessary for year-over-year survival.

The rating system below was based on the period that beluga whales are present and use the areas for moulting, feeding and calving, as well as for movement and migration. Potential residual effects from development would be most detrimental to the viability of the population in shallow water and river estuaries that support these activities. Thus, higher risk categories are associated with these important habitats.

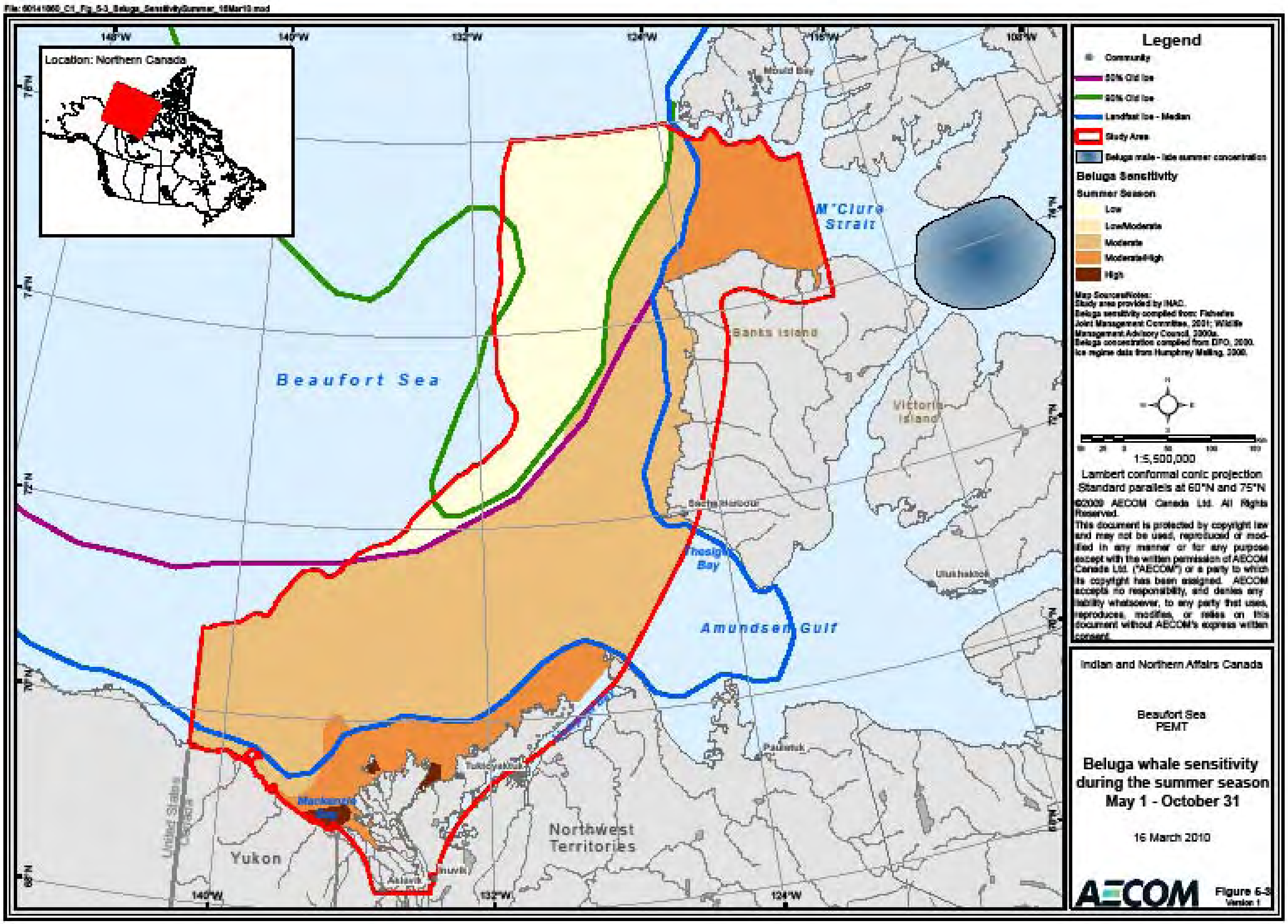
As with other VECs, when assessing a grid cell for sensitivity to development, all time periods should be considered. Habitats that support key life stages are important to identify regardless of the season at which it is most used, because habitat loss that occurs in one season may have impacts that extend beyond that season of impact. As an example, moulting habitats are important to conserve in periods when beluga whales are not actively moulting, as they will return during the moulting season, and such habitats are key elements that support the species survival.

Summer Season: May 1 to October 31 Sensitivity (Figure 5-3)

The spring/summer/fall sensitivity layer was developed with the assumption that beluga whales are likely not present in the proposed PEMT Area. The Eastern Beaufort Sea beluga population winters in the Bering Strait and migrates eastward through the Beaufort Sea during April and May, arriving off the west coast of Banks Island in late May and early June (Moore *et al.* 1993). Depending on ice conditions, beluga whales may first appear near Herschel Island in late April or early May, and come to the shallow waters of the Mackenzie Delta in June to early July. They then move in a southwestward direction along the landfast ice edge off the Tuktoyaktuk Peninsula and into Kugmallit Bay, East and West Mackenzie Bays, Shallow Bay and the Kendall Island area where they aggregate for much of July (Harwood and Smith 2002). These areas are presumed to be of considerable importance to beluga because they return to these areas each summer despite significant hunting pressures (North/South Consultants Inc. 2003).

- **Low sensitivity 1:** Most waters under 50% and 90% old ice. Beluga whales won’t likely go far into these areas due to the high ice cover. This sensitivity layer would have limited use year round.
- **Moderate Sensitivity (3):** (A) Spring migration route, located south of the 50% old ice (April to June). Belugas migrate eastward through the Beaufort Sea during April and May, arriving off the west coast of Banks Island in late May and early June (B) Mid to late summer male migration route, located west of Banks Island (August). Belugas migrate from the MacKenzie estuary to Viscount Melville Sound, which is considered a late summer concentration area for male belugas whales. (C) Fall migration route, located south of the 50% old ice (August to September). Belugas migrate west from Melville sound and the MacKenzie area towards their overwintering location in the Bering Strait.
- **Moderate/High Sensitivity (4):** (A) Important summer habitat and aggregation areas between Mackenzie Bay and the Amundesn Gulf and south of the Landfast Ice Median (June to August). (B) Mid to late summer male migration route, located north of Banks Island in the M’Clure Strait to Viscount Melville Sound, which is considered a late summer concentration area for male belugas whales.
- **High Sensitivity (5):** (A) Key moulting, feeding and calving areas which include the shallow waters and river estuaries within Kugmallit Bay, East and West Mackenzie Bays, Shallow Bay and around Kendall Island (June to August). Belugas in these traditional summer concentration areas are harvested by Inuvialuit from Aklavik, Inuvik and Tuktoyaktuk.

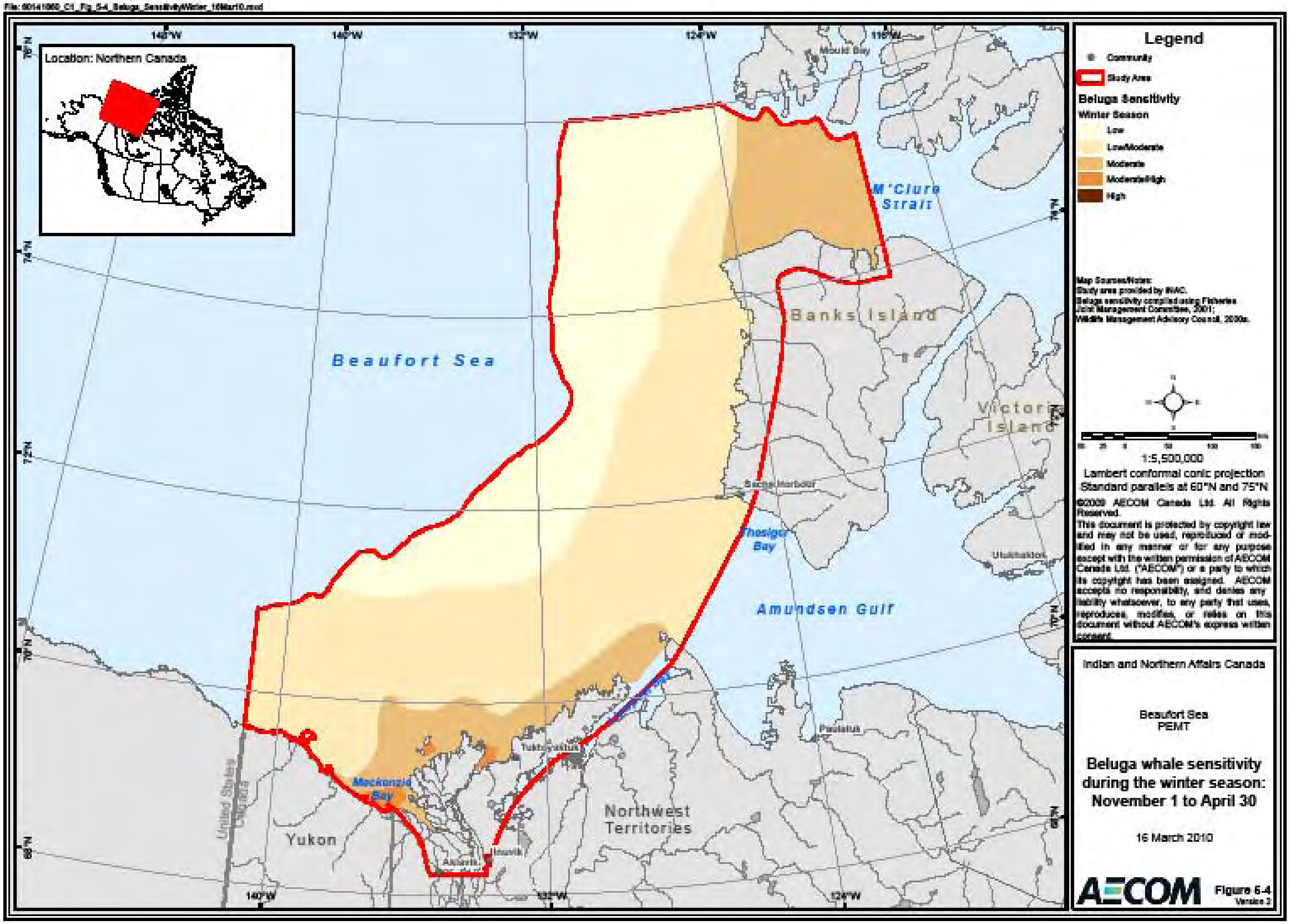
Figure 5-3 Beluga whale sensitivity layer during the summer season: May 1 to October 31



Winter Season: November 1 to April 30 Sensitivity (*Figure 5-4*)

The Eastern Beaufort Sea beluga population winters in the Bering Strait and migrates eastward through the Beaufort Sea during April and May, arriving off the west coast of Banks Island in late May and early June (Moore *et al.* 1993). Habitats that support key life stages and migration routes in the spring/summer/fall are important to identify regardless of the season at which it is most used, because habitat loss that occurs in one season may have impacts that extend beyond that season of impact

- **Low sensitivity 1:** Waters under the 50% and 90% old ice. This sensitivity layer would have limited use year round.
- **Low/Moderate Sensitivity (2):** Generally, the area south of the 50% old ice. Beluga whales are not present in the study area during the winter; however, this area is an important spring, mid to late summer and fall migration route for beluga whales.
- **Moderate Sensitivity (3):** (A) Generally, the area between Mackenzie Bay and the Amundesn Gulf and south of the Landfast Ice Median. Beluga whales are not present in the study area during the winter; however, this area is known for important beluga summer concentration. (B) The known mid to late summer male migration route through the M’Clure Strait to Viscount Melville Sound, which is considered a late summer concentration area for male belugas whales.
- **Moderate/High Sensitivity (4):** Shallow waters and river estuaries within Kugmallit Bay, East and West Mackenzie Bays, Shallow Bay and around Kendall Island. Beluga whales are not present in the study area during the winter; however, these locations are important summer moulting, feeding and calving areas. These locations are also important summer harvesting for Inuvialuit.


File: 60141060_C1_Fig_6-4_Beluga_SensitivityWinter_16Mar10.mxd
Location: Northern Canada
148°W
140°W
132°W
124°W
116°W
76°N
74°N
72°N
70°N
68°N
Mould Bay
M'Clure Strait
Banks Island
Beaufort Sea
Victoria Island
Sachs Harbour
Thesiger Bay
Amundsen Gulf
Ulukhaktok
Paulatuk
Tuktoyaktuk
Mackenzie Bay
Inuvik
Aklavik
United States
Canada
Yukon
Northwest Territories
Legend
Community
Study Area
Beluga Sensitivity
Winter Season
Low
Low/Moderate
Moderate
Moderate/High
High
Map Sources/Notes:
Study area provided by INAC.
Beluga sensitivity compiled using Fisheries Joint Management Committee, 2001;
Wildlife Management Advisory Council, 2000a.
1:5,500,000
Lambert conformal conic projection
Standard parallels at 60°N and 75°N
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Indian and Northern Affairs Canada
Beaufort Sea
PEMT
Beluga whale sensitivity during the winter season: November 1 to April 30
16 March 2010
AECOM
Figure 6-4
Version 2

Figure 5-4 Beluga whale sensitivity during the winter season: November1 to April 30

5.9 Summary

Beluga whales were considered a VEC because of their important link in the food web of Arctic waters, and because they have been previously selected as a VEC in the Beaufort region. Additionally, the Inuvialuit have long relied on them for subsistence.

Beluga whales are present in the study area during open water periods. In June to early July, belugas are found along the coastlines and in relatively shallow waters of the Mackenzie Delta including Kugmallit Bay, East and West Mackenzie Bays, Shallow Bay and the Kendall Island area. These areas are important as moulting, calving and feeding areas. Beginning in mid-August, belugas move away from the estuarine areas to feed in the deeper waters, and move west towards their winter areas in the Bering Strait and Chukchi Sea in mid-to-late September. Waters near the coastline and extending up to 400 km offshore are important as feeding areas and as spring and fall migration corridors.

Beluga whale habitats most sensitive to industrial activities in the Study Area are the shallow waters and river estuaries. Potential impacts from industrial pollution, miscellaneous spills, and noise are important to mitigate in these areas where possible. Beluga whales that migrate into the Beaufort Sea during open water periods over-winter in waters outside of the study area. Therefore, industrial activities that occur outside the seasons when beluga whales are present (i.e., in frozen water periods throughout much of the study area) are unlikely to result in direct impacts to beluga whales.

Numerous fish species present in the Beaufort Sea share and utilize many of the same shallow water and deep water beluga habitats. The sensitivity layers established for beluga whales reflect the environmental sensitivity of an area should development occur and could encompass the various fish species that occupy the same habitat.

6. Bowhead Whale

6.1 Description

The bowhead whale, *Balaena mysticetus*, is a baleen whale belonging to the family Balaenidae (COSEWIC 2005). An arched upper jaw, baleen plates and the absence a dorsal fin are all characteristics of whales in this family (Gaskin 1984). Bowhead whales are large, stocky whales, predominately black with a few whitish regions near the jaw, belly and tail stocks and flukes (SARA 2009). Bowheads become sexual mature at 25 years of age and may live longer than 100 years (COSEWIC 2005). Sexual activity occurs throughout the year; however, the majority of mating occurs in late winter or early spring with calves being born 12 - 16 months later in April to early June during the spring migration (Koski *et al.* 1993). Most births occur in May (Nerini 1984). Calving season is estimated to occur between March and August (Nerini 1984). Females give birth approximately every 3 to 6 years (Nerini 1984) to a single calf (COSEWIC 2005). Bowhead whales appear to spend the majority of their time between 0 and 16 m below the surface; though, bowhead whales have been observed at depths of up to 353 m (Krutzikowsky and Mate 2000).

Whales migrating from the Bering Sea to the Beaufort Sea are known as the Bering-Chukchi-Beaufort stock and are considered part of the western Arctic population in Canada (COSEWIC 2005). The fall migration appears to occur between late August (Blackwell et al 2007) and late November (Moore *et al.* 2009). The majority of fall migrating bowhead whales appear to travel most often between 20 m and 30 m offshore; however, whales were also observed migrating between 10 m and 20 m offshore and between 30 m and 40 m offshore (Blackwell *et al.* 2007). From November through April this population winters in the open water and broken pack ice in the western and central portions of the Bering Sea well to the west of the study area (COSEWIC 2005). The spring migration appears to occur between late March and mid-May (Moore *et al.* 2009). From April to June the majority of this population migrate towards summer areas in the eastern Beaufort Sea, following ice leads and open water areas that develop as a result of spring ice break up from the Bering Sea, to the Chuckchi Sea through areas of the northern Beaufort Sea to the western coast of Banks Islands (Figure 6-1) (COSEWIC 2005). Some whales from this population have been observed along the western and Alaskan Beaufort Sea, eastern Chuckchi and the Chukotka Peninsula (Braham *et al.* 1980, Carroll *et al.* 1987, Bogoslovskaya *et al.* 1982, Moore *et al.* 1989) suggesting that although the majority of this population summer in the eastern Beaufort Sea some individuals do not. Mother-calf pairs are the last to migrate in the season due to the birth of young at this time (COSEWIC 2005).

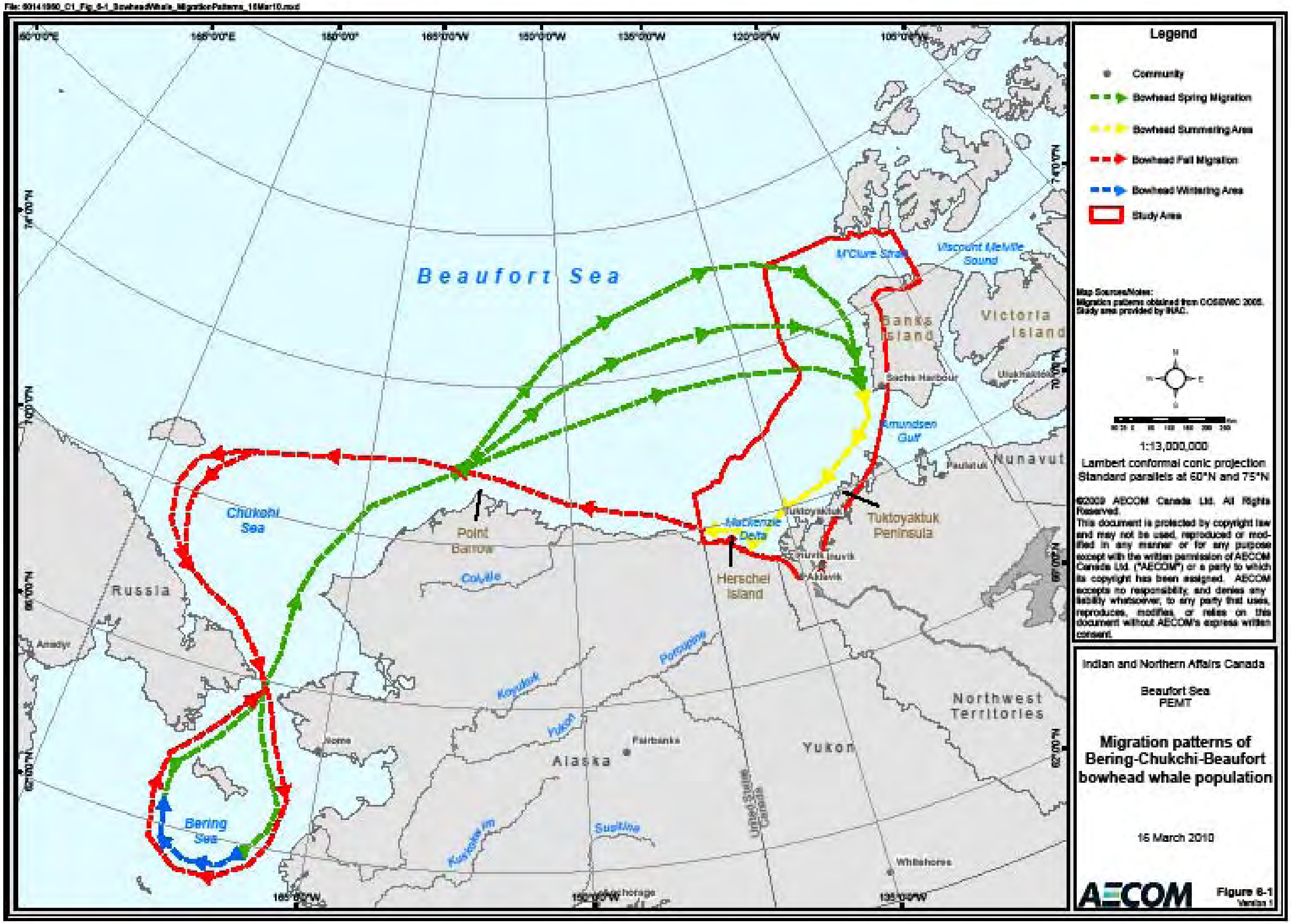


Figure 6-1 Migration patterns of Bering-Chukchi-Beaufort bowhead whale population

During June to September, bowhead whale summer distribution is primarily in the eastern Beaufort Sea where they form large loose aggregations offshore (Figure 6-2) from approximately mid-August to late September (Hardwood and Smith 2002; Harwood *et al.* 2008). The aggregations form in traditional areas where oceanographic conditions favour the concentration of crustaceous zooplankton, their main prey item (Thomson *et al.* 1986). Habitat requirements of bowhead whales in summer grounds largely depend on the distribution of main prey resources which can vary from year to year depending on temperature, salinity, light intensity and nutrient availability (Mackas *et al.* 1985).

Bowhead diet typically consists of crustacean zooplankton, such as copepods and euphausiids, and epibenthic organisms such as mysids and gammarid amphipods (Schell *et al.* 1987, Lowry 1993). Bowhead whales appear to consume the majority of their annual food intake in the Bering-Chuckchi system and they consume a lesser amount in the Beaufort Sea (Lee *et al.* 2005). Compared to the Bering Sea, annual productivity and zooplankton biomass is lower in the Beaufort Sea (Griffiths and Buchanan 1982). Nonetheless, the Beaufort Sea is an important feeding area for bowhead whales in the summer (Budge *et al.* 2008). In the Beaufort Sea, bowhead whales feed on different prey and they appear to feed mainly on copepods (Budge *et al.* 2008). Subadults appear to feed more in the Beaufort Sea than adults (Lee *et al.* 2005). Feeding is the predominant activity of bowhead whales in the Beaufort Sea.

Killer whale distribution overlaps with that of the bowhead whale in the Bering Sea (George *et al.* 1994), and killer whales have been observed in the Beaufort Sea (Lowry *et al.* 1987). The killer whale is a predator of the bowhead whale, and has been suggested as the main mortality source in the Baffin Bay-Davis Strait populations (Finley 1990).

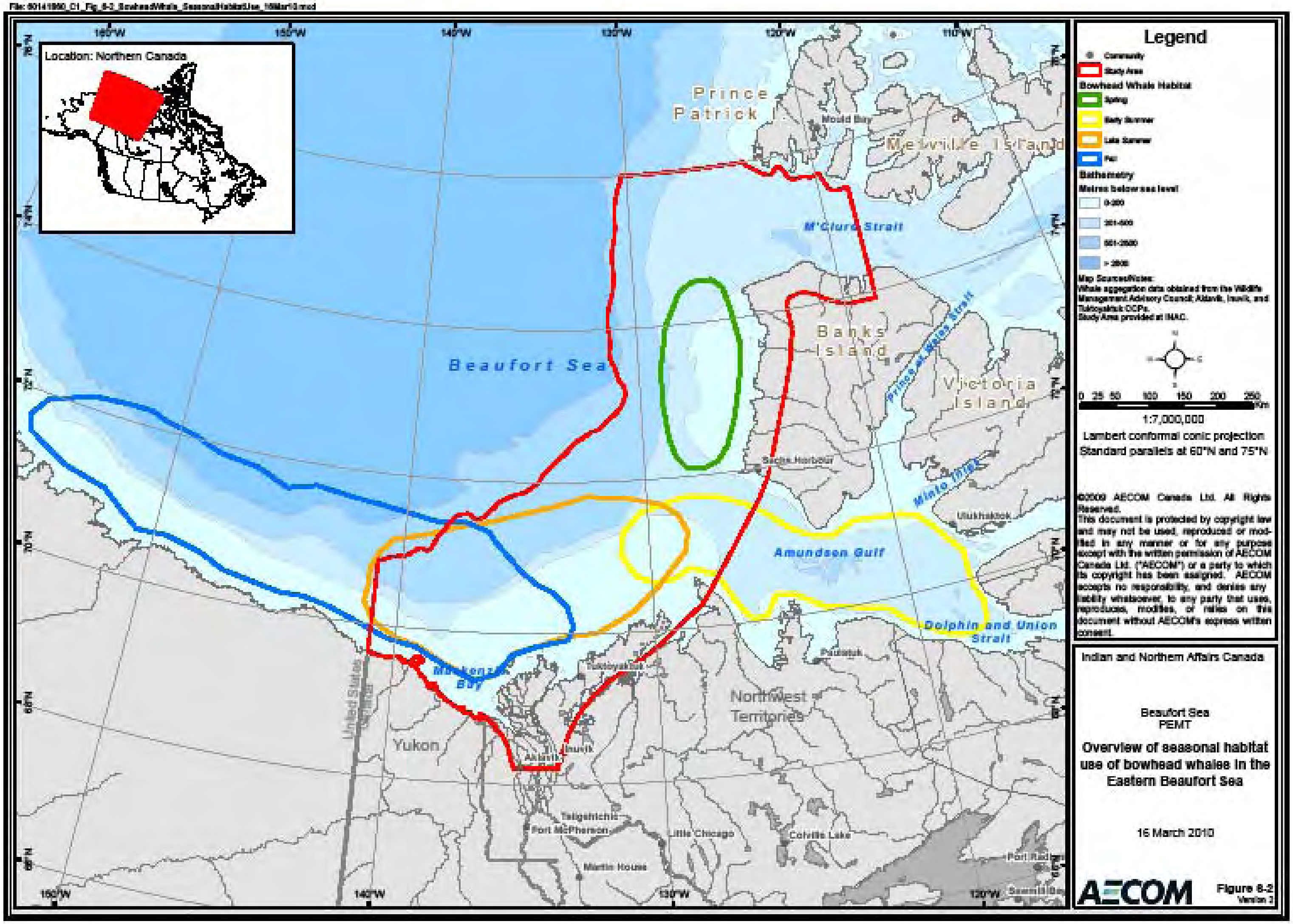
6.2 Rationale for Selection

The bowhead whale was largely selected as it is of cultural importance to Inuit hunters. Archaeological records indicate that bowhead whales have been hunted in the Canadian Arctic since 1100 A.D. (Freeman *et al.* 1998). Historically, the bowhead whale was a very important resource to the Inuit, aiding in survival by providing a year's worth of food, oil and building material for an entire camp from a single whale (NWMB 2000). In the NWT, the Inuvialuit Settlement Region is currently allowed to harvest one bowhead whale annually. Current hunting of bowhead whales by Inuit is more of a cultural and traditional importance rather than a food source. The bowhead whale hunt is viewed as a vital element to Inuit culture and the passage of traditional knowledge (NWMB 2000).

Other reasons for its selection include the importance of the Beaufort Sea to the bowhead whales life history. Federally, the Bering-Chukchi-Beaufort bowhead whale population is listed as *Special Concern* (Schedule 1 in Canada, SARA 2009) and *lower risk/conservation-dependent* by the World Conservation Union (IUCN). Due to commercial hunting pressures in the past, the bowhead whale was almost hunted to extinction (COSEWIC 2005). The Bering-Chukchi-Beaufort population has recovered from these detrimental levels but continued monitoring of the species is needed.

Additionally, bowhead whales are an important component to the ecological functions in the Arctic seas both as predator and prey. Bowhead whale appear to be closely tied to the distribution of their prey (Würsig *et al.* 1989, Treacy *et al.* 2006) and could be a good indicator of ecological changes in the Beaufort Sea dynamics.

Figure 6-2


File: 60141990_C1_Fig_6-2_BowheadWhale_SeasonalHabitatUse_16Mar10.mxd
Location: Northern Canada
160°W
150°W
140°W
130°W
120°W
110°W
76°N
74°N
72°N
70°N
68°N
66°N
Prince Patrick I.
Mould Bay
Melville Island
M'Clure Strait
Banks Island
Prince of Wales Strait
Victoria Island
Beaufort Sea
Sachs Harbour
Minto Inlet
Ulukhaktok
Amundsen Gulf
Dolphin and Union Strait
Paulatuk
Mackenzie Bay
Tuktoyaktuk
Northwest Territories
Yukon
United States
Aklavik
Inuvik
Tsiigehtchic
Fort McPherson
Little Chicago
Colville Lake
Martin House
Fort Good Hope
Legend
Community
Study Area
Bowhead Whale Habitat
Spring
Early Summer
Late Summer
Fall
Bathymetry
Metres below sea level
0-200
201-500
501-2500
> 2500
Map Sources/Notes:
Whale aggregation data obtained from the Wildlife Management Advisory Council; Aklavik, Inuvik, and Tuktoyaktuk CCPs.
Study Area provided at INAC.
N
0 25 50 100 150 200 250 Km
1:7,000,000
Lambert conformal conic projection
Standard parallels at 60°N and 75°N
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Indian and Northern Affairs Canada
Beaufort Sea PEMT
Overview of seasonal habitat use of bowhead whales in the Eastern Beaufort Sea
16 March 2010
AECOM
Figure 6-2
Version 2

Overview of seasonal habitat use of bowhead whales in the Eastern Beaufort Sea

6.3 Key Habitats

The Beaufort Sea appears to be a very important component to the habitat requirements of the bowhead whale as it may not only provide an abundance of food resources but also protection from predation. Key habitat areas include the Tuktoyaktuk Peninsula, the Amundsen Gulf, and the south and west coastal areas of Banks Island (COSEWIC 2005). In general, whales can be found in deep (>200m) or shallow (<50m) waters depending on the summer month and the availability of food (Griffiths and Buchanan 1982, Richardson *et al.* 1985, Mate *et al.* 2000, Koski and Miller 2009). The older, mature bowheads (including cows and calves) tend to be found in the further offshore feeding areas (e.g., off the Tuktoyaktuk Peninsula), whereas the subadults tend to occur in feeding areas closer to shore (e.g., off the Yukon coast) (L. Harwood, pers. comm.) (Koski and Miller 2009). Mothers and calves tend to avoid depths <20 m; noticeably more mothers and calves were found and at depths between 40 and 200m (Koski and Miller 2009).

Banks Island Coast and Amundsen Gulf

- Banks Island Coast and Amundsen Gulf are the first summer areas bowhead reach after migrating through offshore routes of the Beaufort Sea (Fraker and Bockstoce 1980, COSEWIC 2005). Bowheads can reach the coastal waters of Bank Island and Amundsen Gulf as early as May (Branham *et al.* 1980). Although bowhead are more frequently seen in May near the Banks Island coast (Hazard and Cubbage 1982).
- Bowheads are often seen in the Amundsen Gulf along King’s Bay in late July and early August (Hazard and Cubbage 1982). The western half of Amundsen Gulf are important summer grounds during July, where bowhead take advantage of early ice break up in these areas and forage in deep waters (>200 m) (COSEWIC 2005).

Tuktoyaktuk Peninsula

- Areas north of the Tuktoyaktuk Peninsula are important summer areas in late August and September (Hardwood and Borstad 1985, Richardson et al. 1987, Dickens et al. 1987) where whales have been observed feeding off the shore of the Peninsula (Würsig et al. 1989).
- The Kugmallit Canyon and Tuktoyaktuk Peninsula inner and outer shelves are considered sensitive habitat areas for bowhead whale in the southeastern Beaufort Sea (Figure 6-2).

Mackenzie River Plume

The influence of freshwater into the Beaufort Sea creates nutrient rich environmental conditions ideal for foraging bowhead whales. Areas off King Point, Shingle Point, Mackenzie Bay and Herschel Island have all been identified as important bowhead whale habitat (WMAC 2000a, WMAC 2000b, WMAC 2000c, Dickens *et al.* 1987).

- Bowheads use areas around the Mackenzie Delta in late summer (Figure 6-2). Distribution in the Mackenzie Delta can vary from year to year where in some years whales stick to shallow ice-free waters and in other years they are found offshore either in or near ice (Richardson et al. 1987).
- In late August and September bowhead congregate around the Mackenzie River plume, where turbid, brackish water from active surface circulation and upwellings likely create nutrient rich environments for invertebrate prey species (Hardwood and Borstad 1985, Würsig et al. 1989).
- Between August and October bowhead have been seen near Herschel Bay as they slowly make their fall migration back to the Bering Sea (Hardwood and Borstad 1985, Richardson et al. 1987).
- Herschel Island, Komakuk area, Mackenzie Canyon and the shelf break north of Herschel Island are all ranked sensitive for bowhead whale (Figure 6-2).

6.4 Climate Change

Global circulation models predict substantial decreases in both thickness and coverage of arctic sea ice due to increased atmospheric CO_2. Present climate models are insufficient to predict regional ice dynamics, winds, mesoscale features, and mechanisms of nutrient resupply, which must be known to predict productivity and trophic response (Tynan and DeMaster 1997). However, we can speculate on the potential impacts of observed trends in Arctic climate on wildlife. Changes in the extent and concentration of sea ice may alter the seasonal distributions, geographic ranges, patterns of migration, nutritional status, reproductive success, and the abundance and structure of some species. For bowhead whale, like most cetaceans, decreases in ice extent will be more of an indirect effect than actual loss of habitat (Tynan and DeMaster 1997). One of these indirect effects include the potential change in abundance and distribution of marine invertebrates the bowhead whales food source.

Ice algae are an important component in the Arctic environment being the primary source in the food chain (Alexander 1995). Formed at the ice-seawater boundary, this ice algae forms on the underside of the ice and becomes part of the water column during spring melt. The presence of this new food source in the water column in spring creates a bloom of phytoplankton, where copedpods (the primary prey of bowhead whales) thrive (Drolet *et al.* 1991, Tynan and DeMaster 1997). Therefore, ice edge habitat is a very important component to bowhead whales. Change in the timing or loss of this spring food source could result in a shift of behaviour, migration patterns, distribution and survival of bowhead whales (COSEWIC 2005).

The prediction of reduced or no ice cover in the arctic (Stroeve et al. 2007) will likely have both positive and negative effects on bowhead whales. Some speculations include; increased predation by killer whales, geographic range expansion, change in food locations, exploration and further travel in search of new feeding grounds, increased food supply, potential changes in over wintering habitat, and decreased purpose of traditional migration routes and calving areas due to potential increased predation and decreased food supply in these areas (Dueck and Ferguson 2009).

6.5 Sustainability

The bowhead whale the Bering-Chukchi-Beaufort population had almost been hunted to extinction in the mid the mid-19th century due to commercial whaling pressures. This population is not yet secure and currently is at about 50% of its historical population size and has increase 3.4% from 1978-2001 (George *et al.* 2004, COSEWIC 2005). The most recent documented population estimate is 10,740 (George *et al.* 2004). More subadults have been estimated in the population than adults (Koski and Miller 2009) Regulation of commercial whaling is an important component in the sustainability of bowhead whales. Due to the late age of sexual maturity and low fecundity of this species, removal of individuals in the population can have significant effects on the population (COSEWIC 2005).

Historical sightings of bowhead whale in the Beaufort Sea indicate the importance of this area for spring, summer and fall migration periods. Predation, offshore human activity and climatic pressures that influence ice conditions all have the potential to affect the survival and distribution of the bowhead whale in the Beaufort Sea (COSEWIC 2005). Conservation of high use feeding areas within the Beaufort Sea is an important component in sustaining viable populations of this species as the distribution of bowhead whale appears to be closely linked to vertical and horizontal distribution of prey (Würsig *et al.* 1989).

6.6 Susceptibility to Development

Potential implications of industrial development on bowhead whales in the Beaufort Sea include:

- industrial activities may reduce the quality and amount of suitable habitat available to bowhead whales, especially for feeding
- industrial activities may increase the risk of mortality to individual bowhead whales in proximity to developments
- industrial activities may cause disruption of migration patterns and behaviour making whales more susceptible to other environmental pressures such as predation and climatic change
- certain industrial activities (e.g. moving vessels, low flying aircraft, airguns) have the potential to have a short term and negative effect on bowhead whale behaviour and natural activities.

Habitat Susceptibility

Due to the occurrence of bowhead whale in the Beaufort Sea from spring to fall, they are susceptible to habitat impacts from industrial activities throughout most of the year in the Beaufort Sea. Residual effects from industrial activity may result in either complete loss of habitat, as is common with the ‘footprint’ of industrial developments, or effective habitat loss, whereby bowhead whales avoid habitat in proximity to development.

Development activities to which bowhead whales may be susceptible include:

- industrial pollution and miscellaneous spills
- noise due to seismic activities and vessel movement
- injuries due to marine vessel collisions
- island building or temporary drilling platforms
- low flying aircraft
- air guns

Pollution

Industrial pollution and miscellaneous spills that are discharged have the potential to result in either complete or effective habitat loss. Bowhead whale habitats which are most susceptible to these releases are the shallow waters in the Mackenzie Delta and Amundsen Gulf. The population impacts that may result from an oil spill would depend largely on the season, amount and type of contaminants released, climatic factors and response initiated. An oil spill within the shallow waters and river estuaries identified as important bowhead whale habitat would be the most sensitive and could produce major site-specific impacts. Areas around the Mackenzie River plume would be vulnerable due to the large number of whales that congregate in the area in late summer. An oil spill further offshore within the feeding, movement and migratory areas and corridors may produce fewer impacts because they can navigate around the spill in these greater water depths. Contact with spilled oil may directly affect the availability of invertebrate food and therefore the health and migratory behaviour of whales.

Rosa *et al.* (2009) have recently completed a heavy metal and histology study on bowhead whales from the Bering-Chukchi-Beaufort sea population which will be used as baseline data for upcoming industrial activities and future climate change. Bowhead whale kidneys and livers in the Beaufort Sea were found to have normal or below average levels of mercury, copper, zinc, and silver. Cadmium levels, however, were high and were associated with bowhead whale lung fibromuscular hyperplasia and renal fibrosis.

Noise

Man-made noise pollution in the Beaufort Sea may have detrimental effects on this species. Bowhead whale are sensitive to human noise created by drilling, marine construction, seismic exploration, and ships causing changes in normal behavioural patterns and in some cases avoidance of areas with activity (Richardson *et al.* 1985, 1986, Ljungblad *et al.* 1988, Davies 1997, Blackwell *et al.* 2008). Bowhead whales appear to be sensitive to noise including natural noises. For example Blackwell *et al.* (2007) found that bowhead whale calls were significantly reduced with higher background noise such as wind. In addition, natural bowhead whale behaviour such as breathing, surfacing and diving has been shown to be quite variable (Dorsey *et al*. 1989).

Some studies have found that bowhead whales have strong negative short term reactions to approaching vessels, low flying aircraft, and air guns. For example, fixed-wing aircraft has a negative short term effect on bowhead whales at altitudes ≤ 305 m asl (Richardson *et. al* 1985). Most of the observed reactions were hasty dives and tail slaps. Idling or moving vessels can have a strong negative short term effects on bowhead whales at distances up to 4 km (Richardson *et al.* 1985) and 7.2 km (Ljungblad *et al.* 1988). Subtle responses have been observed at 8.2 km (Ljungblad *et al.* 1988). Vessels producing noise appear to temporarily disrupt the behaviour of bowhead whales by causing them to quickly swim away in another direction or quickly dive (Fraker *et al.* 1985, Richardson *et al.* 1985). Observed reactions to approaching vessels producing airgun blasts include; reduced dive times and surfacing, shorter blows, longer blow periods, surface behavioural changes, partial avoidance and complete avoidance (Ljungblad *et al.* 1988). Bowheads have been observed swimming up to 3 km after disruption from vessels (Richardson *et al.* 1985). More recent research has shown that seismic activities (air gun sounds) caused a significant reduction in bowhead whale call detection rates and caused a significant change in bowhead whale positioning from shore (Blackwell *et al.* 2008). Similarly, Richardson *et al.* (1985) found that although bowhead whales did not avoid the air gun firing area; they did not call during air guns firing and echelon size was reduced. Richardson *et al.* (1986) found that seismic noise (vessel and pulses) caused bowhead whales to have significantly less blows, shallow dives, prolonged blow periods and noticeably shorter time spend on the surface.

Some studies have found that bowhead whales have little or no short term reactions to certain industrial activities. For example, bowhead whales were minimally or not disturbed by fixed-wing aircraft circling at 457 m asl. (Richardson *et al.* 1985). In addition, Richardson *et al.* (1985) found that bowhead whales did not seem to react to aircraft noise while they were feeding, even at altitudes of 305 m asl. Likewise, Koski *et al.* (2009) found that bowhead whales tolerated relatively high seismic noises (~160dB) while feeding. Richardson *et al.* (1985) found that bowhead whales did not appear to avoid dredging noises and appeared to often tolerate extensive noise. Furthermore, drill ships appeared to have minimal effects on bowhead whale behaviour (Richardson *et al.* 1985). Bowhead whales have also been observed approaching drill ships and although behaviour was generally normal, some behavioural alterations were observed (Richardson *et al.* 1985). Slight reactions were apparent when drill ships transmitted brief sounds and these small alterations in behaviour may have been an indication of internal stress. Similarly, Richardson *et al.* (1990) found that some bowhead whales could tolerate substantial noises from drill ships and dredges and displayed normal behaviour. Some studies have demonstrated that bowhead whales do not appear to avoid seismic vessels (Fraker *et al.* 1985, Richardson *et al.* 1985) and vessels producing no noise do not appear to have an effect (Richardson *et al.* 1985).

One speculation as to why bowhead whales respond differently to certain industrial activities could be noise habituation. Bowhead whales may react strongly to new or brief noises, but may become habituated to sustained or accustomed noise overtime with no negative outcome. Although no studies have been found to support whale habituation to noises, the available literature on the reactions of bowhead whales to noise suggests that noise habituation may be occurring.

Long-term effects of noise pollution on bowhead whales in the Beaufort Sea are unknown; although it is considered a high threat to bowheads in the eastern arctic (Moshenko *et al.* 2003). One concern is the long term effects of industrial noise on bowhead whale communication and long range noise detection (Richardson *et al.* 1985). Amplifying low frequency background noises can decrease call range recognition and signal-to-noise ratios; however, the significance of communication interference is known

(Richardson *et al.* 1985). In addition, the significance of long range noise detection in bowhead whales is unknown (Ljungblad *et al.* 1988, Richardson et al. 1995).

Vessel Collisions

Marine vessels have the potential to collide with bowhead whales resulting in severe injuries. Collision with vessels can create large lacerations (George *et al.* 1994), which can affect the health of an individual whale directly and indirectly through alterations to feeding and other survival behaviour. George *et al.* (1994) found that vessel-inflicted injuries where low at approximately 1% in the Bering-Chukchi-Beaufort Sea stock. This could be correlated to the low rate of vessels in the area (George *et al.* 2004); however, similar to right whales, it may also be due low survival rates of those whales that have collided with vessels (Kraus 1990). Bowhead calves may have trouble avoiding boats traveling at high speeds (Richardson *et al.* 1985). For example one boat traveling at 41 km/h almost collided into a calf (Richardson *et al.* 1985).

Islands and Platforms

Island building or the installation of temporary drill platforms in shallow waters identified as important bowhead whale habitat could potentially affect belugas and their habitat by creating avoidance of these areas. In addition, presence of drilling rigs can create a significant temporary loss of available habitat (Schick and Urban 2000). During times of bowhead whale congregation this may result in competition for available space in shallow waters.

6.7 Mitigation

There are several strategies that can be applied to project-specific mitigation planning, based on the summary of project specific residual effects, the seasonality of bowhead whale movements, and the criteria used to define the grid rating. These considerations should not be interpreted as a prescription for actions imminently required; rather, they are strategies that may be valuable in project planning.

- High quality foraging areas are key areas that are important to the viability of the species, and therefore impacts here should be mitigated and/or avoided where possible. These areas include Mackenzie Bay and the Tuktoyaktuk Peninsula. Should development be initiated in such areas, timing should attempt to coincide with periods when bowheads are not present (from December to early March). Negative short term responses of bowhead whales to marine vessels have occurred at distances less than 10 km (Ljungblad et al. 1988). When possible, vessels should keep a distance of 10 km from important bowhead habitat.
- In areas of bowhead spring and fall migration, marine vessel movement activities within these areas should be limited to levels to which the population-level impacts are not apparent. When possible, vessels should keep a distance of 10 km from important bowhead migration routes (10 to 40 m offshore).
- Minimize low flying aircraft when bowhead whales are present (April to September). When possible, aircraft should fly high (> 457 m as) and should avoid flying over important bowhead habitat as much as possible.
- On-ice activities are generally unlikely to produce residual effects beyond the frozen water season, and may be a preferable option to open water activities, especially if accidents and hazards are controlled.

6.8 Sensitivity Layers

Areas of higher sensitivity are typically those that support quality feeding areas, as well as movement and migratory corridors necessary for year-over-year survival. As with other VECs, when assessing a grid cell for sensitivity to development, all time periods should be considered. Habitats that support key life stages are important to identify regardless of the season at which it is most used, because habitat loss that occurs in one season may have impacts that extend beyond that season of impact.

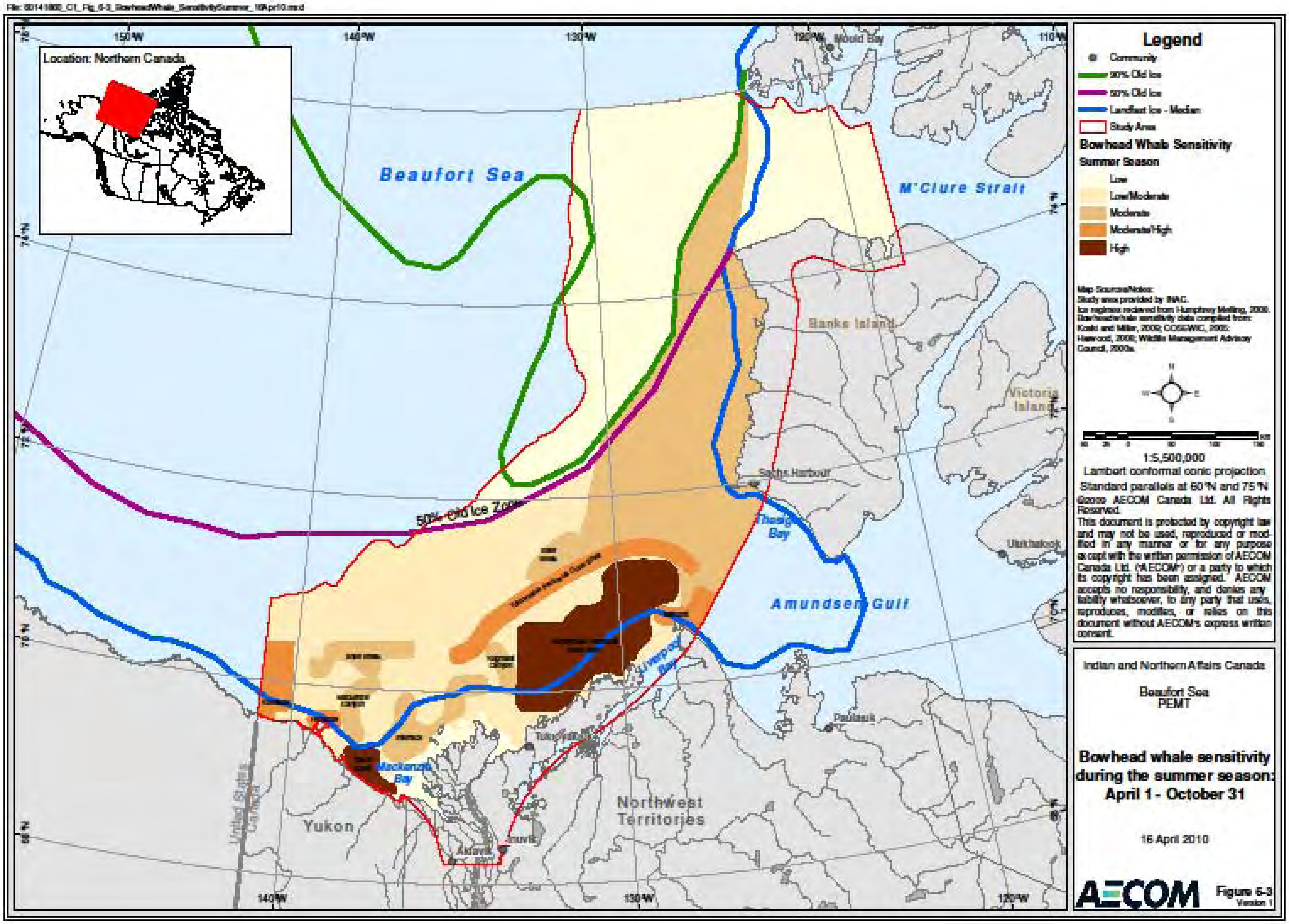
Summer Season: April 1 to October 31 Sensitivity (Figure 6-3)

The summer layer was developed with the assumption that bowhead whales are present within the PEMT Area. Bowhead whale summer distribution is primarily in the eastern Beaufort Sea where they form large loose aggregations offshore (Figure 6-3) from approximately mid August to late September. Data sets on bowhead distribution from 1980-1986 and from more recent surveys in 2007-2008 have been used to derive this sensitivity map. Observed bowhead densities have been calculated for 20 km x 20 km grid cells, and grid cells with $\geq$5 bowheads/100 km^2 have been designated as aggregation areas according to our present working definition (Harwood *et al.* 2008).

The number of times that bowheads aggregated in a given grid cell have been tallied over the available survey years, with the frequency of aggregations being used to designate a sensitivity of 3, 4 or 5. The rating system below was based on the period that bowhead whales are present and use the areas for feeding as well as for movement and migration. Potential residual effects from development would be most detrimental to the viability of the population in congregation areas and areas where upwelling provides quality foraging habitat for these activities. Thus, higher risk categories are associated with these important habitats.

- **Low sensitivity 1:** (A) All non-aggregation areas shallower than 2 m, as bowheads cannot access such depths given their body size. (B) Waters under the 50% and 90% old ice. Bowhead whales won't likely go far in these areas due to the high ice cover.
- **Low/Moderate Sensitivity (2):** all non-aggregation areas deeper than 2 m.
- **Moderate Sensitivity (3):** (A) Areas around the Mackenzie Delta in late summer. Distribution in the Mackenzie Delta can vary from year to year where in some years whales stick to shallow ice-free waters and in other years they are found offshore either in or near ice. In addition, the Shelf Break and the Kugmallit Canyon are sensitive for bowhead whales. (B) Spring migration route located west of Bank's Island. Bowhead whales migrate eastward through the Beaufort Sea during late March to mid-May.
- **Moderate/High Sensitivity (4): western half of Amundsen** (A) Western half of Amundsen Gulf are important summer grounds during July, and areas off Bathurst, Komakuk, Herschel and the Tuktoyaktuk Peninsula Outershelf. (B) Fall migration located near Komakuk. Bowhead whales migrate west through the Beaufort Sea to the Bering Sea from August to November.
- **High Sensitivity (5):** areas north of the Tuktoyaktuk Peninsula and the Yukon coast are important summer areas in late August and September.

Figure 6-3 Bowhead whale sensitivity layer during the summer season: April 1 to October 31

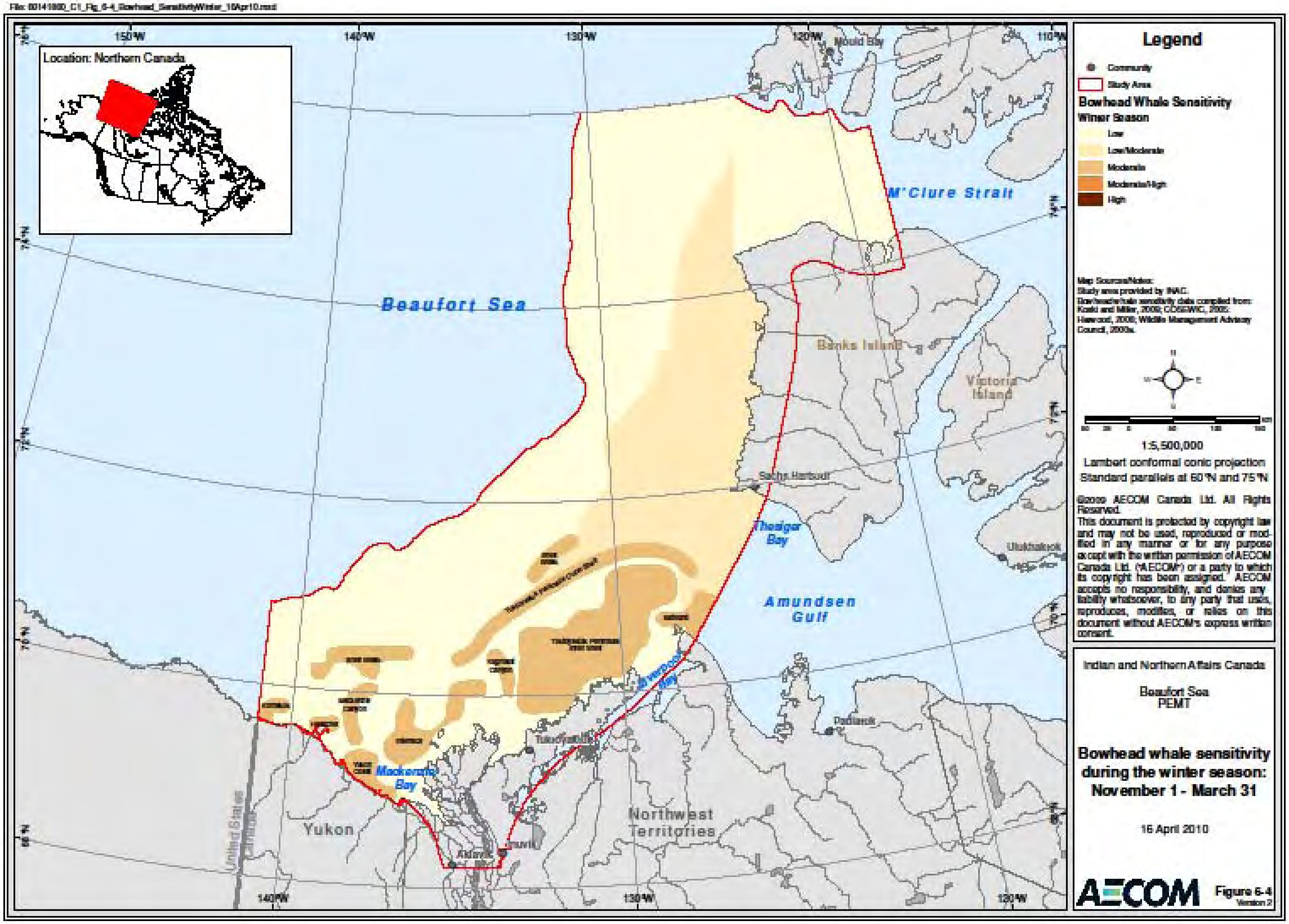


Winter Season: November 1 to March 31 Sensitivity (Figure 6-4)

The winter sensitivity was developed with the assumption that bowhead whale presence is unlikely in the PEMT Study Area. The fall migration appears to occur between late August (Blackwell *et al.* 2007) and late November (Moore *et al.* 2009). In addition, the spring migration appears to occur between late March and mid-May (Moore *et al.* 2009). Bowhead whale calls have been detected as early as March 25 (Moore *et al.* 2009). The Western Arctic stocks of bowhead (and beluga) whales spend the winter (late November to mid-March) in the Bering Sea, primarily at or near the ice edge. Bowhead whales begin migrating eastward from the Bering Sea into the Beaufort Sea in the spring, with peak migration occurring from the last week in April to the last week in May (Braham *et al.* 1980). From April to June the majority of this population migrate towards summer areas in the eastern Beaufort Sea, following ice leads and open water areas that develop as a result of spring ice break up. Due to persistent nearshore ice cover, bowhead whale spring migration is along the east-west shear zone in offshore waters well north of the study area (Figure 6-4).

- **Low sensitivity 1:** Bowhead whale are unlikely to be present in these areas during the winter months
- **Low/Moderate Sensitivity (2):** Generally the area west of Banks' Island. This area in an important spring migration route during late March to mid-May. Bowhead whales may occur in this area as early as March.
- **Moderate sensitivity 3:** Key summer foraging and fall migration areas and include King Point, Shingle Point, Mackenzie Bay, Herschel Island, the Tuktoyaktuk Peninsula, Kugmallit Canyon and Amundsen Gulf, Bathrust, Komakuk, Herschel, Shelf Break and the Tuktoyaktuk Peninsula Outershelf.

Figure 6-4 Bowhead whale sensitivity layer during the winter season: November 1 to March 31



6.9 Summary

The bowhead whale was largely selected as a VEC due to it is of cultural importance and traditional use to Inuit hunters. Federally the bowhead whales of Bering-Chukchi-Beaufort population area listed as *Special Concern* Schedule 1 in Canada (SARA 2009) and *lower risk/conservation-dependent* by the World Conservation Union (IUCN). Bowhead whales are an important component to the ecological functions in the arctic sea, and are closely tied to invertebrate prey distributions making them a potentially good indicator of ecological changes in the Beaufort Sea dynamics. Bowhead whales are present in the study area from spring to fall, which summer distribution primarily in the eastern Beaufort Sea. Key habitat areas include the west coastal areas of Banks Island, the Amundsen Gulf, the Tuktoyaktuk Peninsula, and the Mackenzie River Delta (COSEWIC 2005). Feeding is the predominant activity of bowhead whales in the Beaufort Sea.

The bowhead whales migration route in the Beaufort Sea follows leads in the ice where open water areas develop as a result of spring ice break up. Therefore, climatic changes such as reduced ice have the potential to effect migration patterns, food abundance and survival of bowhead whales in the Beaufort Sea.

Potential impacts from industrial activity include pollution, miscellaneous spills, man-made noise impacts, and marine vessel collisions. Industrial activities occur during the winter season (i.e. in frozen water periods throughout much of the study area) are unlikely to result in direct impacts to bowhead whales as they winter in the Bering Sea. Industrial development during spring, summer and fall have the potential to impact bowhead whales depending on the location of these activities in the Beaufort Sea.
The sensitivity layers established for bowhead whales reflect the environmental sensitivity of an area should development occur. There is a variety of potential project types that vary in spatial extent, duration, and intensity, with a corresponding range in magnitude of impacts that may occur in the project area. Given that such activities, over time, may occur anywhere within the several hundred leasing grids in the study area, it is impossible to recommend specific mitigations and/or limitations (i.e. whether certain grids should have seasonal restrictions on specific activities or not) for each grid. Such considerations should be a component of project-specific mitigation planning for individual projects and/or grids.

7. Migratory Birds

7.1 Description

The Beaufort Sea supports over 65 species of breeding and non-breeding migratory birds which rely on the area for breeding, feeding, moulting, and staging during spring and fall migrations (Alexander *et al*. 1997). Virtually, the entire western Canadian Arctic population of some species, including king (*Somateria spectabilis*) and common eiders (*Somateria mollissima*) and red-throated loons (*Gavia stellata*), migrate through the Beaufort Sea area (Alexander *et al*. 1988, 1997; Dickson *et al*. 2005). These marine habitats support considerable diversity and abundance of migratory birds and include coastline, open sea (inshore, near shore and offshore sites) and polynyas. Many migratory birds use the Beaufort Sea from spring to fall, with arrival and departures influenced by break up and freeze up of the sea ice. Starting in late May, hundreds of thousands of birds migrate across the Beaufort Sea, travelling north and east following a series of open leads and polynyas, to breeding grounds in Arctic Canada. Birds remain in the ice leads for two to four weeks until breeding areas are available for nesting (Alexander *et al*. 1997). From June to freeze-up, coastal lagoons, bays, barriers islands and tidal marshes along the Beaufort Sea coast are all important bird nesting, moulting and staging areas. Most nesting occurs from mid-June to mid-July, and brood rearing and moulting from mid-July to mid-August. Many species are flightless for two to three weeks during the moulting period.

7.2 Rationale for Selection

Concerns about the status of several species exist at regional and national levels. Available regional and continental data from waterfowl breeding population and habitat surveys suggest that 10 of 15 sea duck species have declined over the long term, including long-tailed duck (*Clangula hyemalis*), king, spectacled (*Somateria fischeri*), common and Stellar's eider (*Polysticta stelleri*), surf (*Melanitta perspicillata*), white-winged scoter (*Melanitta fusca*), and gray-bellied and black brant (*Branta bernicla nigricans*) (Sudyam *et al*. 2000; Bowman and Koneff 2002; Dickson and Gilchrist 2002; Haszard 2002). Of the 42-shorebird species that breed in Canada, 26 breed exclusively at or above treeline, and most of their habitat is in NWT and Nunavut. Out of the 26 NWT/Nunavut-nesting species that were analysed, 21 show persistent, negative trends regarding their respective populations (Environment Canada 2001).

Populations that are concentrated for any part of the year (e.g., staging, moulting, and foraging areas) are vulnerable to site-specific threats because a significant proportion of the population could be affected. As well, populations that occupy geographically restricted habitats (rare, threatened or endangered species) are vulnerable if their habitats are threatened. Adequate habitat is fundamental to the conservation of wildlife. Habitat provides the needs for species' survival and reproduction. Habitat loss and degradation are the leading causes of species endangerment. Sites were considered to be key terrestrial and marine migratory bird habitat if they met the following criteria:

- support at least 1% of the Canadian population (Mallory and Fontaine 2004; Latour *et al*. 2006) (Figures 7-3 to 7-8). This criterion has been used extensively in the selection of sites of international importance under the Convention on the Conservation of Wetlands of International Importance (aka Ramsar Convention), and meets the criteria established by the CWS Executive Committee,
- support populations that occupy geographically restricted habitats,
- sites that are of exceptional species diversity,
- have a conservation area status or designation (e.g., Canadian Important Bird Area (IBA) or International Biological Programme (IBP) sites). There are no regulatory controls in place for protecting IBA or IBP sites, but the designation serves to highlight the ecological importance of particular areas (Figure 7-1)

7.3 Description of Key Terrestrial (onshore) and Marine (offshore) Migratory Bird Habitat

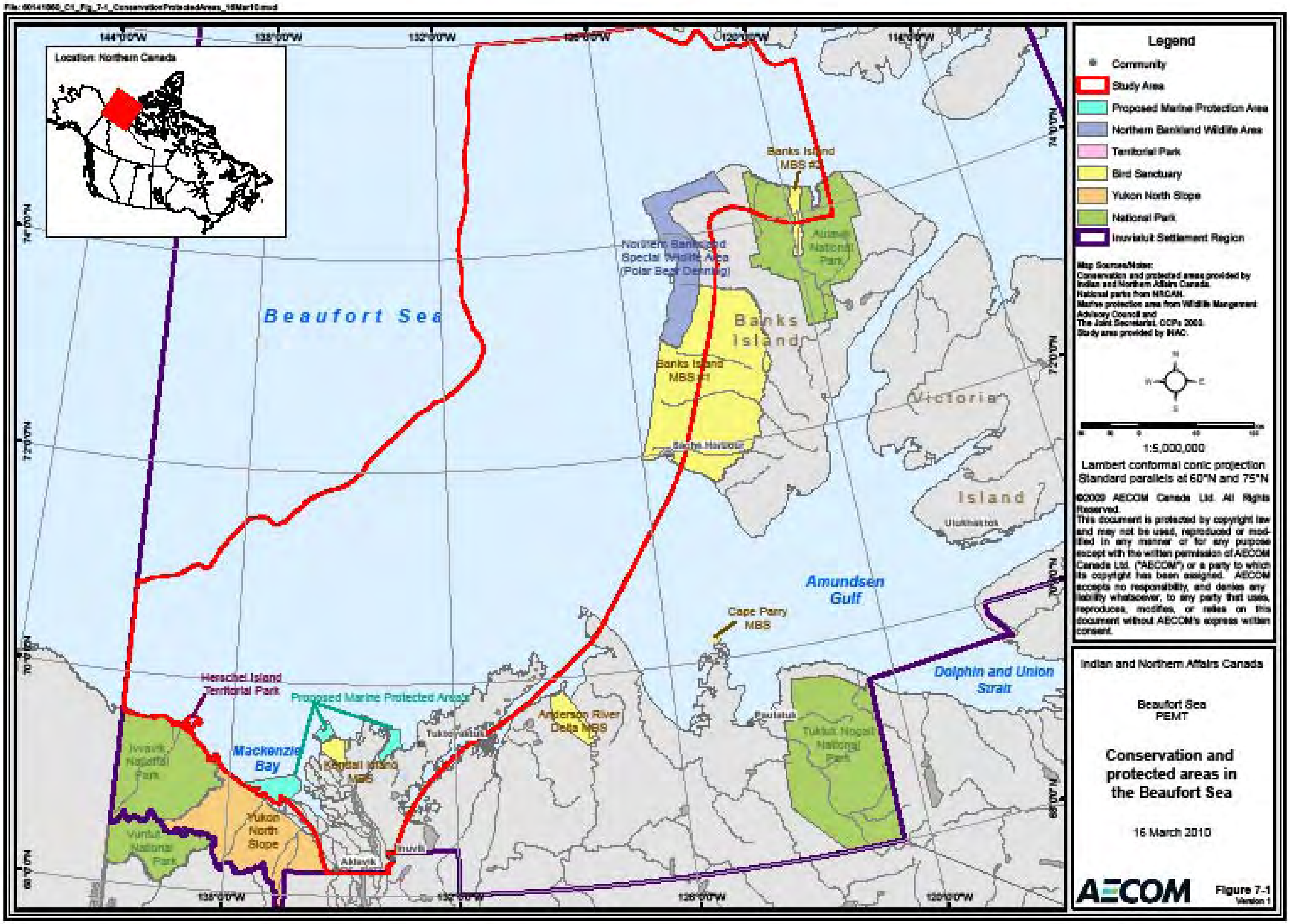
Species include many species of sea ducks that are focused more on the marine environment and offshore areas for foraging and terrestrial environments, such as coastal shorelines and islands, for nesting. Other species are more terrestrial focused such as geese, swans, dabbling ducks and shorebirds. These species use shorelines, inland wetlands and upland areas for breeding and sometime use coastal inlets and deltas for foraging and staging. Onshore and offshore habitats are important to both groups of species.

Marine Focused Species

Offshore habitat is important to sea ducks or diving ducks such as eiders, scoters, mergansers, scaups and long-tailed ducks. Arrival and departure of sea ducks and diving ducks into the Beaufort Sea area is largely influenced by the break up and freeze up of the sea ice. They are well adapted for life at sea and are designed to be efficient swimmers in order to catch there marine prey. They are commonly found on the open sea near coastal areas foraging in large groups. (Figure 7-2).

Stable environments with predictable food resources during the breeding season are an important component to the life history of sea ducks (Mehl 2004). Sea ducks have delayed maturity and typically begin breeding at two to three years of age. Delay of the nesting season due to seasonal weather conditions can result in failure of breeding for that year. Young of sea ducks are often raised in the open sea water where they are more exposed to predators (Mehl 2004). The vulnerability of the young during rearing period and the delayed reproductive maturity of adults makes sea ducks susceptible to population fluctuations and therefore sensitive to environmental change. Key breeding, foraging and staging habitats in the Beaufort Sea are important to the survival of these species.

Figure 7-1



Conservation and protected areas in the Beaufort Sea

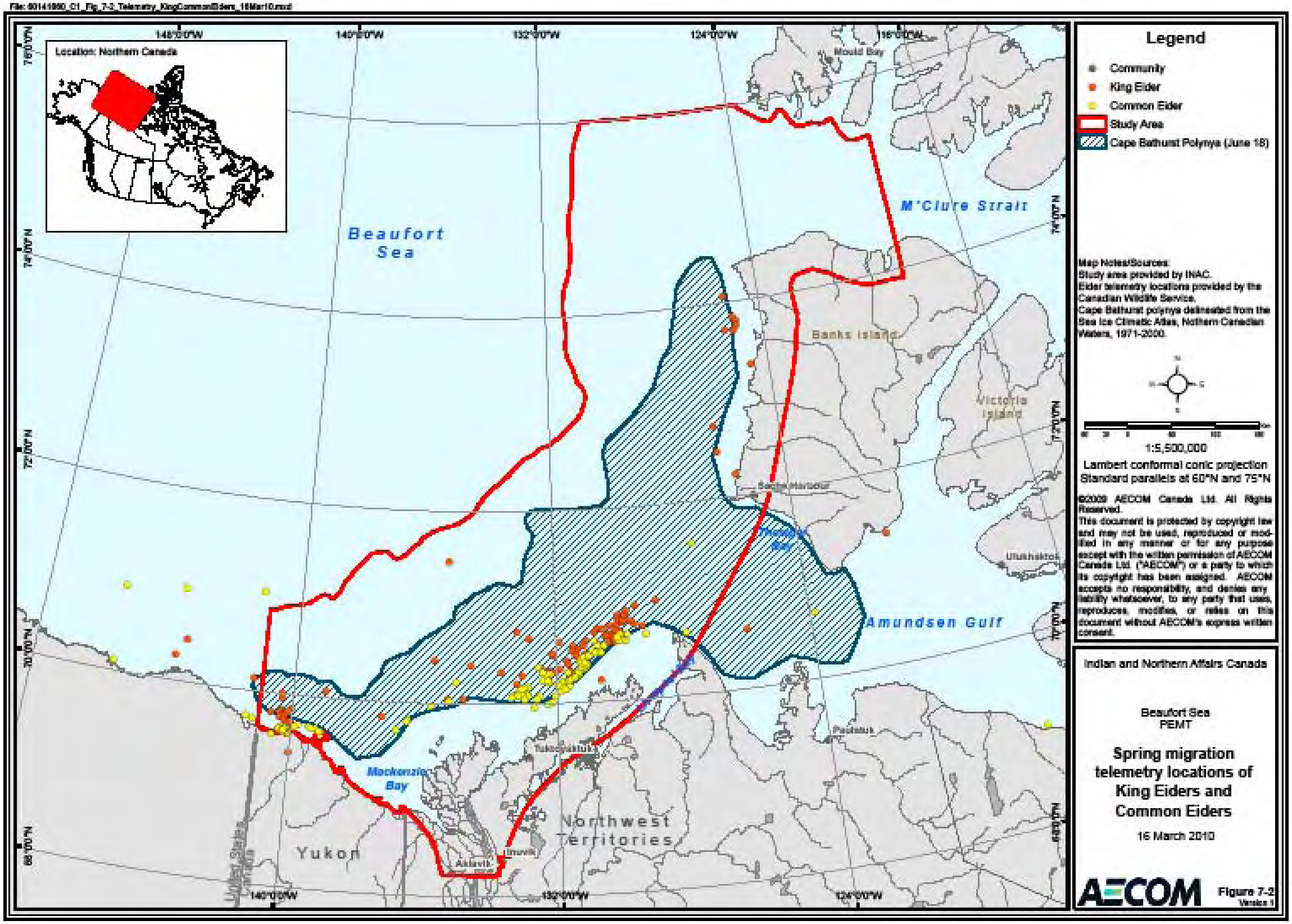


Figure 7-2 Spring migration telemetry locations of king eiders and common eiders

Terrestrial Focused Species

Species such as dabbling ducks, geese, swans and shorebirds spend a lot of their time inland or along coastal land masses during the breeding season using habitats such as ponds, salt marshes, grass-sedge wetlands, and tidal mudflats. Upland and grassy-sedge habitats adjacent to wetland areas are often used for nesting with wetlands, ponds, lagoons, inland channels and salt marshes used for foraging, brood rearing and moulting. Invertebrates, crustaceans, and aquatic vegetation, that make up the diets of most of the terrestrial focused waterfowl, can be found inland in aquatic habitats or in coastal areas. Drought conditions or climatic delay of melt has the potential to drastically affect the quality and availability of these habitats and their much needed food sources.

Description of Habitat Zones

Three broad “habitat zones” support considerable diversity and abundance of migratory birds in the Canadian Beaufort Sea and include the following: (1) coastline, (2) open sea (including inshore, near shore, and offshore components), and (3) polynyas. Coastline habitats include wetlands, salt marshes, mudflats, and estuaries and are important as nesting and brood-rearing areas. Inshore, near shore, and offshore open sea habitats are important as feeding, spring migration staging, and moulting areas. Polynyas and shore leads provide the open water required as feeding sites for migrating birds and they form important migration corridors and staging areas.
Within these “habitat zones”, 11 key onshore and offshore migratory bird habitat sites have been identified, based on certain criteria. Each site identified:

- supports at least 1% of the Canadian population of a migratory bird species during some part of its life cycle (nesting, moulting, staging)
- consists of a population that occupies geographically restricted habitat
- is a site of exceptional species diversity

These sites are recognized for their unique physical or ecological characteristics and as such, will have a conservation designation such as the following: International Biological Programme Site (IBP), Canadian Important Bird Area (IBA), Migratory Bird Sanctuary, National Park, Territorial Park, Canadian Wildlife Service (CWS) Key Migratory Bird Terrestrial or Marine Habitat site, special designated land in Community Conservation Plans (CCPs). Migratory Bird Sanctuaries, National and Territorial Parks give birds full protection, while IBP, IBA, CWS Key Habitat, and CCP designations do not.

As a signatory to the Convention on the Conservation of Wetlands of International Importance, Canada participated in the International Biological Program. Under the Convention, Canada has obligations to identify and adequately protect wetlands of international importance. There are no regulatory controls in place for protecting IBP sites but the designations serves to highlight the importance of these areas.

The Important Bird Areas (IBA) program has two complementary goals: 1) to identify those sites most critical for the protection of birds in North America; and 2) to take positive and coordinated action to promote the conservation of these sites. The criteria for what qualifies as an IBA fall into four basic categories:

- those protecting globally or nationally threatened species
- those protecting species with restricted ranges (such as many endemic species)
- those protecting species which breed only or primarily in a single biome
- those protecting congregations of species, such as nesting colonies of seabirds

The IBAs represent sites which include both terrestrial and non-terrestrial habitats that are critically important for bird species not just during the breeding and wintering seasons but also during migration.

They are intended to be large enough to support self-sustaining populations of those species for which they are important.

CWS catalogues, protects and manages Key Migratory Bird Terrestrial or Marine Habitat sites that are essential to the welfare of a large number of migratory birds. These sites serve as a statement of CWS interest in lands where special conservation measures may be required.

CCP land management categories A through E were developed to recognize priority land uses and activities, as well as areas of special ecological and cultural importance (see section 9).

7.3.1 Offshore Habitat for Migratory Birds

Description

Offshore habitat provides many important niches for staging and foraging migratory birds. Although, the majority of the offshore habitat is used for foraging and broad rearing of sea ducks; other species, such as geese and dabbling ducks will use offshore areas such as coastal inlets and deltas for staging during migratory seasons.

Key Marine (Offshore) Habitats

The Cape Bathurst Polynya is a recurrent crack and lead system, coinciding with the 30 m water depth contour that develops in the Beaufort Sea between the landfast ice and the Arctic pack ice (Figure 1-2)

The open water is continuous from Mackenzie Bay to Cape Bathurst, north around the west side of Banks Island, and east into Amundsen Gulf, and is the largest polynya in the western Arctic (Smith and Rigby 1981). Telemetry data shows high use of this area by king and common eiders (Figure 7-2). These results are most useful in that they indicate that a large percentage of both king and common eiders populations stop in the southeastern Beaufort Sea for a period of 2-4 weeks during spring migration in mid May to mid June, which means if there is an oil spill, Canada's entire breeding population of both species is at extreme risk. The telemetry data overlaid with the appropriate ice data also confirm that the common eider tends to concentrate along the shorefast ice edge during spring migration, whereas the king eider is more widely scattered along both the shorefast and offshore ice edges.

- This area is of critical importance, for it provides feeding sites, migration corridors and staging areas and supports up to 2%, 36% and 1% of the Canadian populations of king eiders, common eiders and long-tailed ducks (*Clangula hyemalis*), respectively (Searing *et al*. 1975, Alexander *et al*. 1997; Mallory and Fontaine 2004).
- It has been recognized as a Canadian Important Bird Area (NT039, IBA Canada 2004) and a Key Migratory Bird Marine Habitat site by the Canadian Wildlife Service (Site 19, Mallory and Fontaine 2004).

Banks Island Ice Lead is a recurrent ice lead which opens at the end of April and runs along the west coast of Banks Island south to Kellett Point and southeast to Nelson Head.

- Surveys conducted in 1993, found 39, 000 king eiders, 6% of the Canadian population, in these waters off the western coast of Banks Island (Alexander *et al*. 1997).
- King eiders are the first birds to arriving in these waters in early May, followed by Pacific common eiders in early to mid May (Kay *et al.* 2006).
- Mixed group of eiders will move from main staging areas off Nelson Head to the Cape Kellett areas (Kay *et al.* 2006).

- Over 24,000 long-tailed ducks were observed in 1974 in the shore lead west of Storkerson Bay (Searing *et al.* 1975) approximately 1% of the population.

Sachs Harbour – Banks Island

- Lesser snow geese will arrive in Sachs Harbour in mid to late May and use the harbour as spring staging areas before moving to their breeding grounds (Kay *et al*. 2006).
- Similarly black brant will use the harbour before moving to breeding sites, however, they are relatively late arrivals in early June (Kay *et al*. 2006).
- Pacific common eiders use open waters off Sachs Harbour until early October before migrating for the winter (Kay *et al*. 2006).

7.3.1.1 Mackenzie Delta

The Mackenzie River Delta includes Shallow Bay, Olivier, Ellice, Garry, Pelly and Kendall Islands, as well as part of Richards Island (Figure 7-3). In addition to the terrestrial habitat for migratory birds these islands in the outer Mackenzie delta also provide offshore habitat for migratory birds.

- The islands of the outer delta are important staging grounds from late August to late September for geese (>1% of the Canadian populations of lesser snow geese (*Chen caerulescens*), white-fronted geese (*Anser albifrons*) and dabbling ducks; 5% of the Canada goose population (*Branta canadensis*), 20% of the Pacific brant population and 10% of the tundra swan (*Cygnus columbianus*) population (Latour *et al*. 2006).

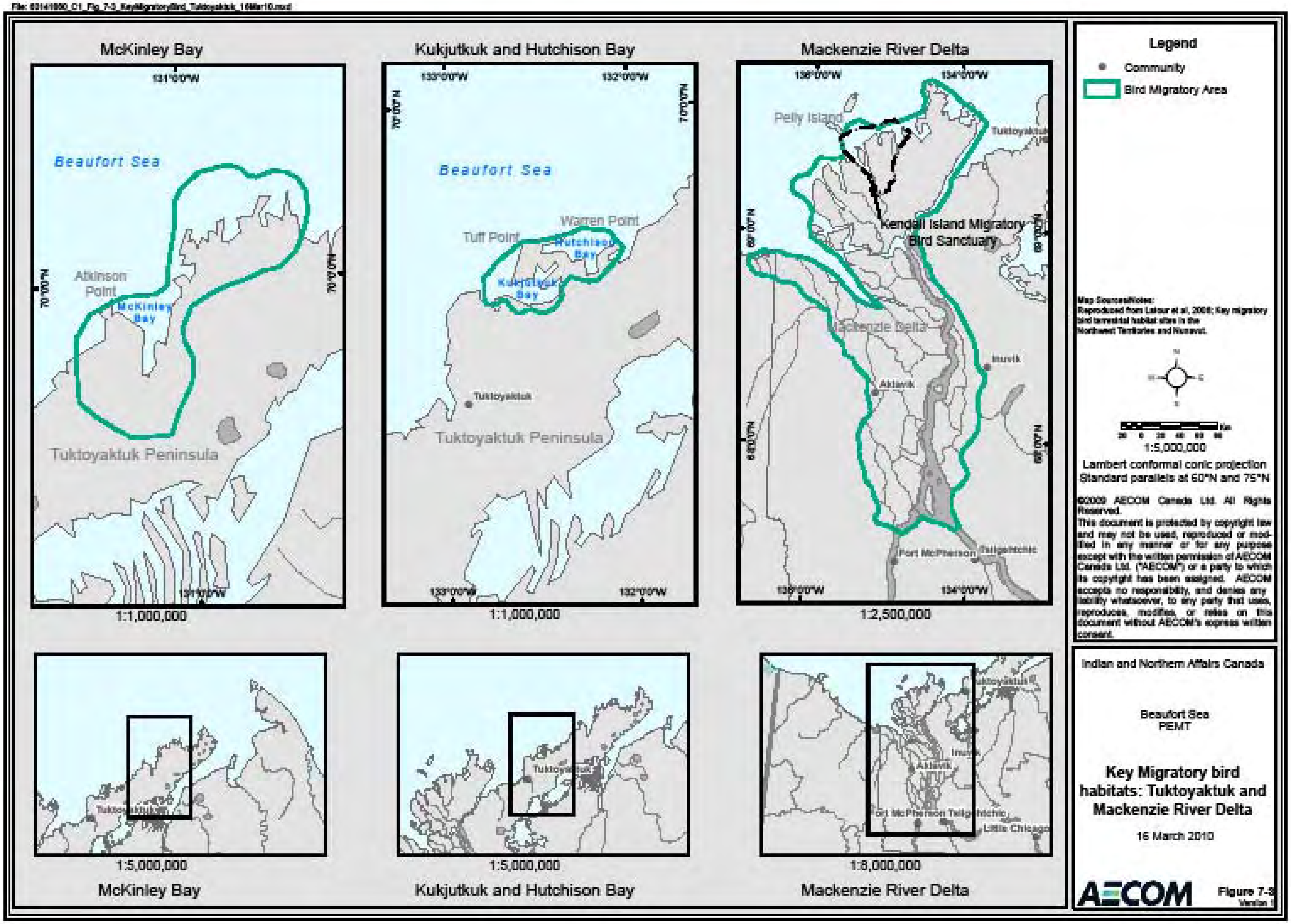


Figure 7-3 Key migratory bird habitats:

Tuktoyaktuk and Mackenzie River Delta

7.3.2 Onshore Habitat for Migratory Birds

Description

Onshore habitat is important for both marine focused species such as sea ducks and terrestrially focused species such as geese and swans (Figures 7-4 to 7-5). Whether a migratory bird spends most of its life history in the north at sea or on a small pond in upland habitat, land provides the foundation necessary for these nesting species. Several islands and coastal land masses provide nesting habitat for sea ducks, dabbling ducks, geese and swans.

7.3.2.1 Key Terrestrial (Onshore) Habitats

Yukon North Slope

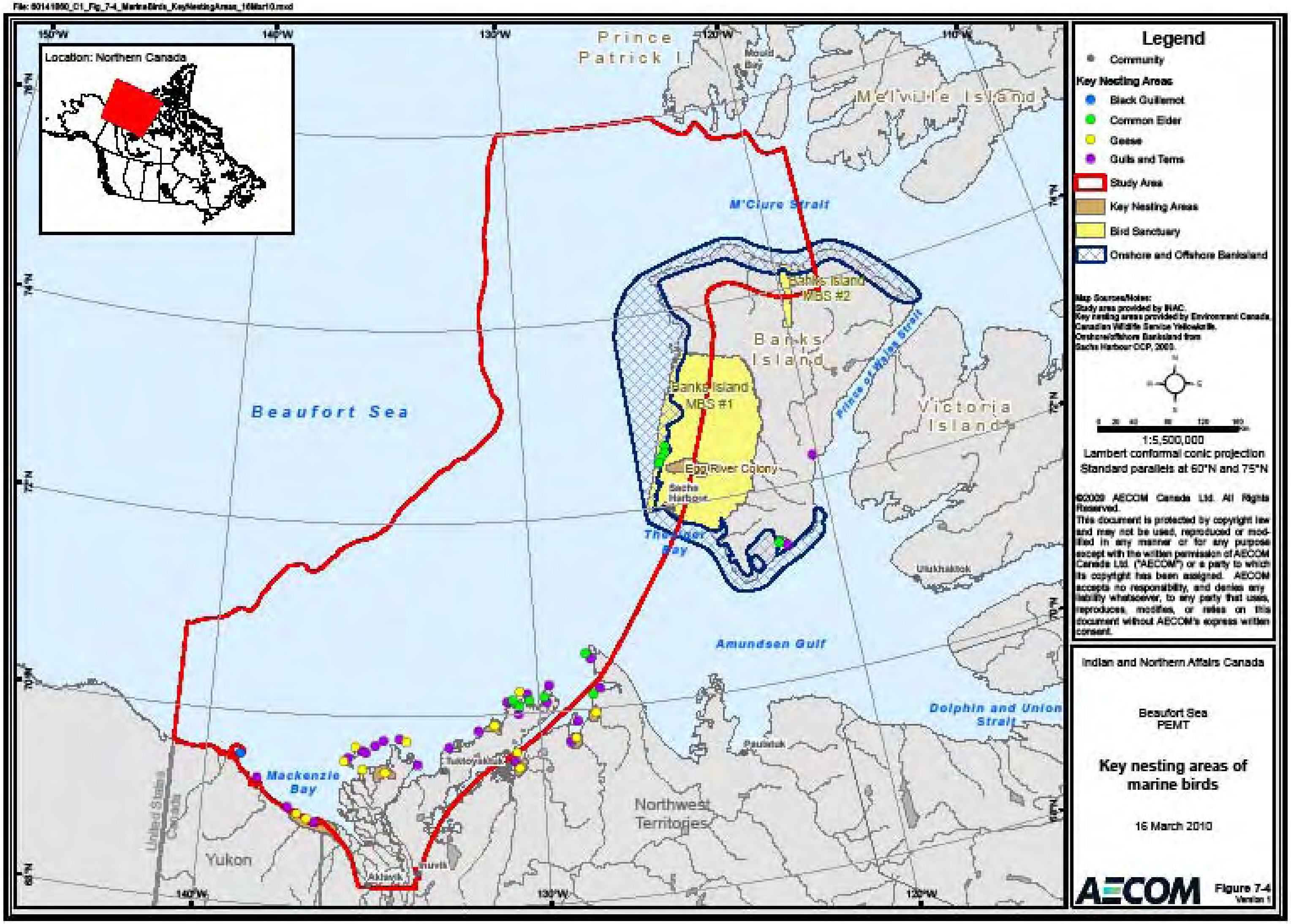
The area known as the Yukon North Slope (Figure 7-6) was designated under the IFA as a Special Management Area. All development proposals relating to the Yukon North Slope are screened to determine whether they could have a significant negative impact on the wildlife, habitat or ability of the aboriginals to harvest wildlife. Development proposals that may have a significant negative impact are subject to a public environmental impact assessment (EIA) and review process.

The Blow River Delta, located on the northeast Yukon Coast, extends about 35 km in length, starting in the west with Shingle Point and Escape Reef, through Whitefish Station, Shoalwater Bay, and finally, to Tent Island on the east (Figure 7-6). The inland eastern part of this site includes Moose Channel, which is the extreme northwestern arm of the massive Mackenzie River delta system to the east. The site extends inland from the coast up to 15 km to include areas of channels, ponds, and salt marshes. Storm tides can inundate a large part of the grass-sedge flats; hence, a wide band of land is considered to be influenced by the sea. Most of the coastline that is not delta habitat, consists of gravel and sand beaches.

- Escape Reef supports a substantial nesting colony of glaucous gulls (*Larus hyperboreas*) in the Beaufort Sea region (Alexander *et al*. 1988).
- The delta is especially important for the habitat it provides to shorebirds, supporting 4% of the global population of American golden plover (*Pluvialis dominica*), 12% of the global population of pectoral sandpiper (*Calidris melanotos*) (Alexander et al. 1988) and 6% of the Western Central Flyway population of snow geese (*Chen caerulescens caerulescens*) during the fall migration (Alexander *et al*. 1988)
- This site has been recognized as a Canadian Important Bird Area (YK008, IBA Canada 2004), and a special designated land (725D Aklavik and Inuvik Community Conservation Plans (CCPs), WMAC 2000a, b).

Babbage and Spring River Deltas (Figure 7-6) are located on the Beaufort Sea along the Yukon coast. The site encompasses about 15 km of coastline and extends out 12 km into the Beaufort Sea to include Kay Point and Phillips Bay. The site continues about 1 km inland, except at the Babbage River delta, where it continues up to 5 km inland. The dominant habitats include ponds, channels, grass-sedge wetlands, salt marshes, and tidal mudflats. Along the coast, gravel and sand beaches dominate, while further inland, Arctic tundra consists of dwarf shrubs, sedges, and herbs.

Figure 7-4 Key nesting areas of marine birds



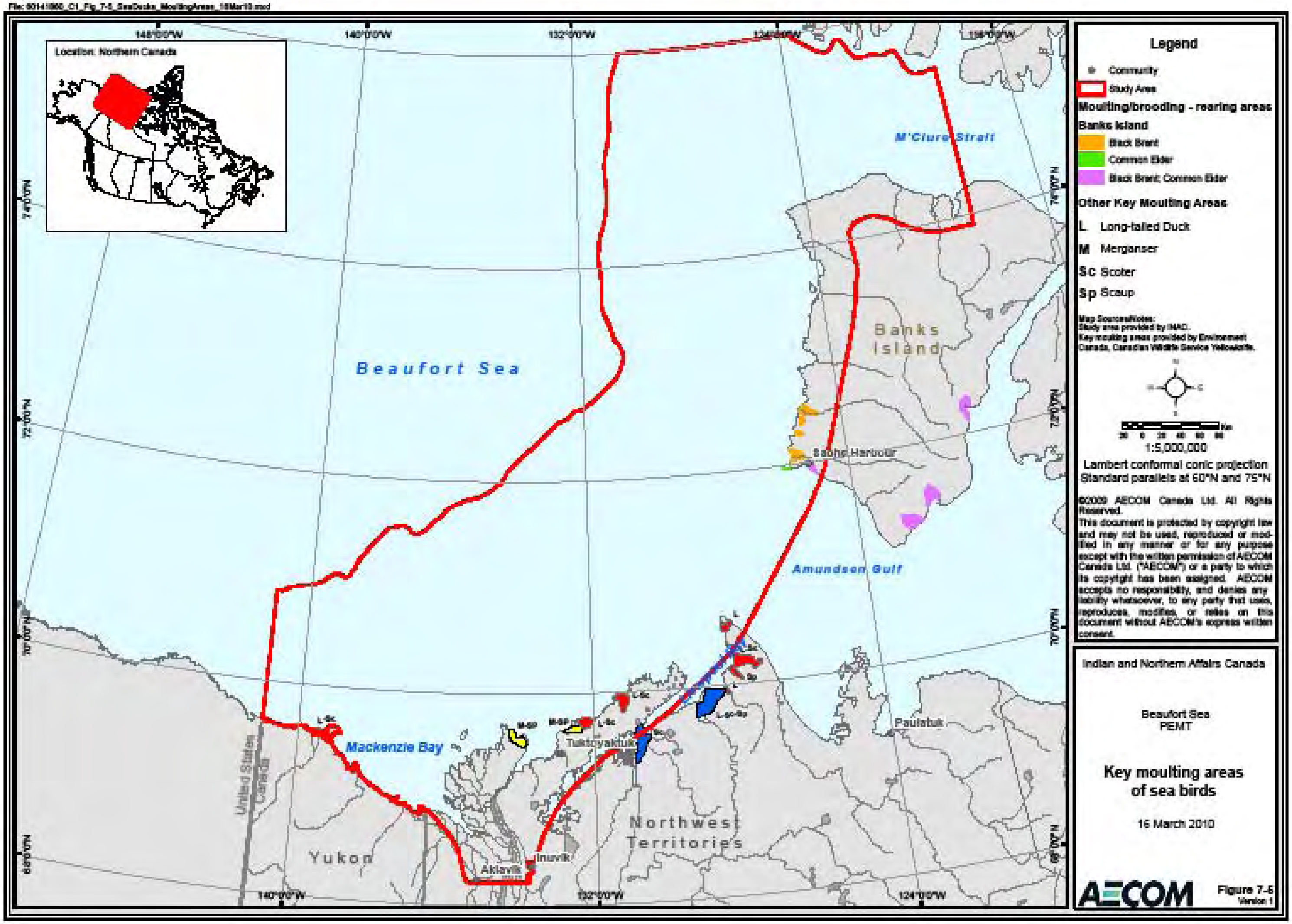
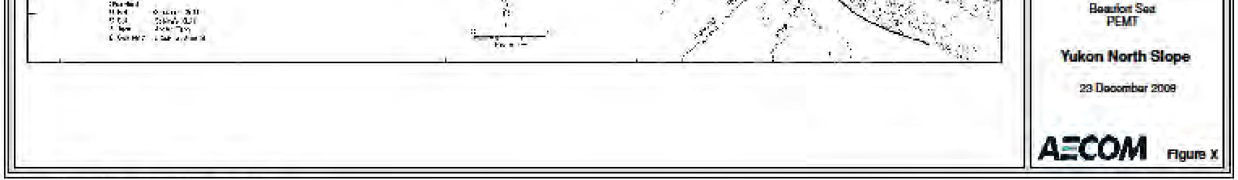


Figure 7-5 Key moulting areas of sea birds



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Map Document: 60141060_C1_Fig_X_YukonNorthSlope_23Dec09.mxd

Figure 7-6 Yukon North Slope

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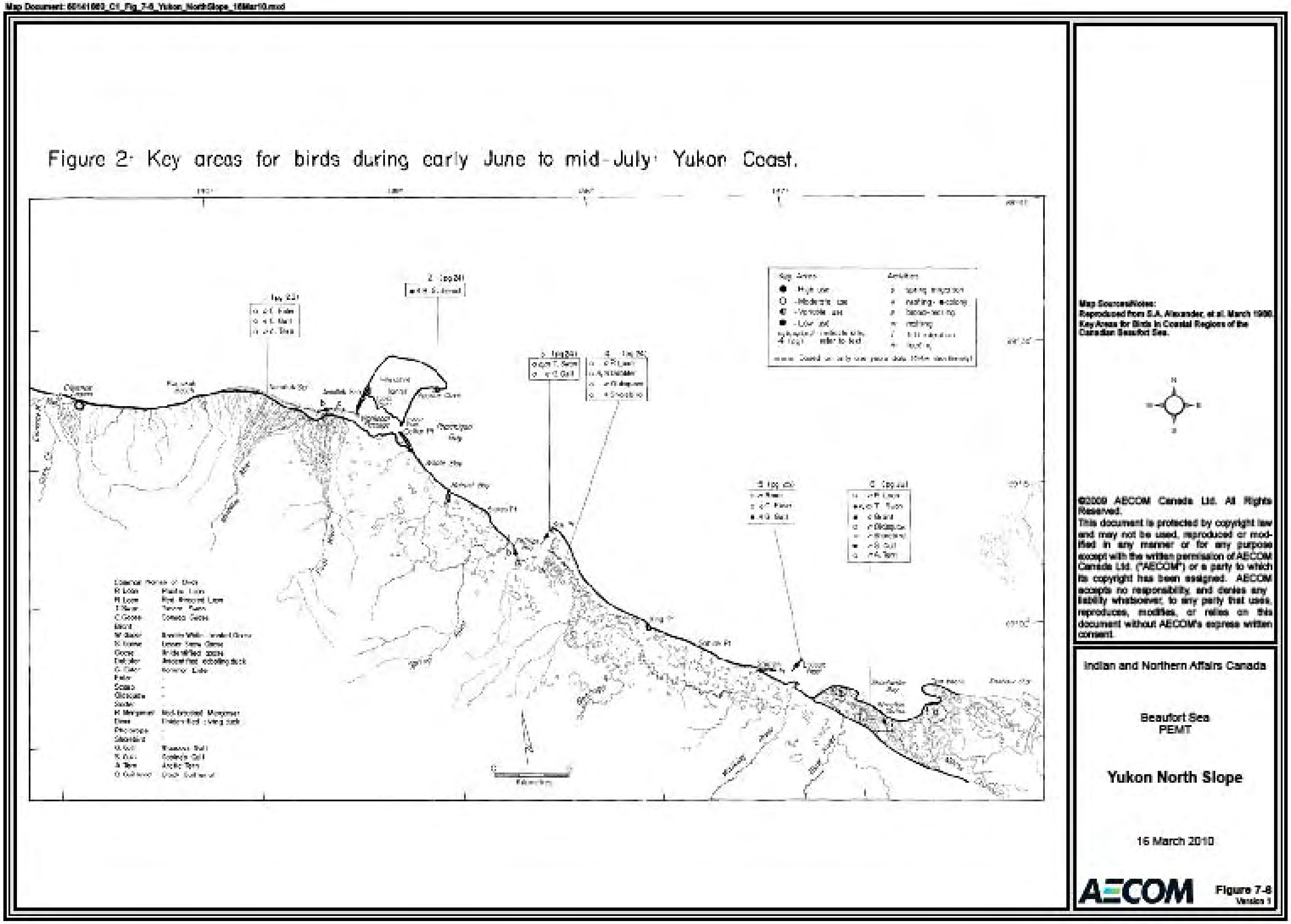


Map Sources/Notes:
Reproduced from S.A. Alexander, et al. March 1986. Key Areas for Birds in Coastal Regions of the Canadian Beaufort Sea.

- The area is important for brood-rearing and staging shorebirds from late July to early September. Breeding birds recorded in the area in late summer include Pacific loon (*Gavia pacifica*), northern pintail (*Anas acuta*), American wigeon (*Anas americana*), northern shoveler (*Anas clypeata*), green-winged teal (*Anas crecca*), long-tailed duck, red-breasted merganser (*Mergus serrator*), and shorebirds, such as semipalmated sandpiper (*Calidris pusilla*) and red-necked phalarope (*Phalaropus lobatus*) (Alexander *et al*. 1988).
- This site has been recognized as a Canadian Important Bird Area (YK007, IBA Canada 2004) and as special designated lands in the Aklavik, Inuvik and Tuktoyaktuk Community Conservation Plans (725D, 726D WMAC 2000a, b, c).

Yukon Coastal Plain. The Yukon coastal plain (Figure 7-6) extends from the Alaska-Yukon border to the Mackenzie Delta and varies in width from approximately 5 km near the Alaskan border, to 30 km at the Babbage River. Spits and lagoons, sand and shingle beaches, and areas of steep cliffs characterize the coastline. Vegetation consists of shrubby tundra vegetation: dwarf birch (*Betula glandulosa*), willow (*Salix* spp.), northern Labrador tea (*Ledum groenlandicum*), *Dryas* spp., and tussock-forming sedge (*Carex* spp.) in Arctic coastal habitats.

- Important staging grounds from late August to late September for 6% of the Canadian population of lesser snow geese (Alexander *et al*. 1988).
- Ivvavik National Park occurs within the site and is protected under the National Parks Act, and is recognized as special designated lands in the Aklavik and Inuvik Community Conservation Plans (727E, WMAC 2000a, b).

Nunaluk Spit, Workboat Passage and Herschel Island are remote areas on the Beaufort Sea along the Yukon coast (Figure 7-6). The site encompasses about 45 km of coastline extending from the base of Nunaluk Spit at the west end, to Calton Point at the east end. The site also includes the open waters of Workboat Passage, which lies between Herschel Island and the coast. The site extends inland approximately 1 km (and occasionally up to 4 or 5 km) to the higher coastal plain. The coast is composed of sandy spits and deltaic wetlands.

- Pauline Cove on Herschel Island is the only site in the Beaufort Sea region supporting a substantial nesting colony of black guillemot (*Cepphus grylle*) (Alexander *et al*. 1988).
- The area provides moulting habitat in August for 12% and 3% of the Canadian populations of long-tailed duck and white-winged scoter (*Melanitta fusca*), respectively, and significant numbers (52,000) of red-necked phalaropes (Alexander *et al*. 1988).
- This site has been recognized as a Canadian Important Bird Area (YK005, IBA Canada 2004) and as special designated lands in the Aklavik and Inuvik Community Conservation Plans (726D, 730E WMAC 2000a,b; Herschel Island is a Territorial Park and is protected under the Yukon Territorial Act).

Mackenzie Delta

The Mackenzie River Delta includes Shallow Bay, Olivier, Ellice, Garry, Niglintgak, Pelly and Kendall Islands, as well as part of Richards Island (Figure 7-3). The islands are generally marshy and covered in sedges, grasses (*Eriophorum* spp.), and horsetail (*Equisetum* spp.), with shrubs in higher areas. The lowlands of Richards Island are dotted with numerous lakes and ponds.

- It provides important nesting habitat for several bird species from May through August and supports up to 2%, 10%, and 1% of the Canadian populations of white-fronted goose (*Anser albifrons*), tundra swans (*Cygnus columbianus*), and dabbling ducks, respectively (Hines *et al*. 2006; Latour *et al*. 2006).

- It provides important nesting/brood-rearing habitat for several shorebird species from May through August, and supports up to 1% of the Canadian populations of American golden plover, Hudsonian godwit (*Limosa haemastica*), pectoral sandpiper, red-necked phalarope, stilt sandpiper (*Micropalama himantopus*) and whimbrel (*Numenius phaeopus*) (Gratto-Trevor, 1996; Environment Canada 2006).
- South of the Mackenzie Delta on the mainland of the Inuvialuit Settlement Region is important habitat for fall staging of diving ducks, geese, swans, and dabbling ducks.
- Kendall Island Migratory Bird Sanctuary (KIBS) is a site for one of the two major nesting colonies for snow geese in the southeastern Beaufort Sea (the other site is in the Anderson River Delta). It supports 1% and 4% of the Canadian populations of Hudsonian godwit and whimbrel, respectively (Environment Canada 2006). It is legislatively protected under the Migratory Birds Convention Act, 1994.
- Short-eared owls (*Asio flammeus*), a species listed under SARA (Special Concern, Schedule 3), have been recorded at various locations throughout the outer Delta, including KIBS.
- Ponds located on Niglintgak Island provide suitable nesting habitat for non-territorial red-necked phalarope. The high occupancy rates of these ponds appear to provide social stimulation which is thought to be an important selection factor in use of ponds for breeding (Walpole *et al*. 2008).
- The coastal tundra vegetation, channels and wetlands provides key moulting habitat for several species. Lesser snow geese, tundra swans, white-fronted geese, sandhill cranes (*Grus canadensis*), Pacific brant, glaucous gulls, Arctic terns (*Sterna paradisaea*), dabbling ducks, and shorebirds nest and moult in the area.
- This site has been recognized as an International Biological Programme Site (Sites 8 and 42, Beckel 1975), a Canadian Important Bird Area (NT016, IBA Canada 2004), as special designated lands (715C, 716CE, 717B Aklavik, Inuvik and Tuktoyaktuk CCPs, WMAC 2000a, b, c), and a Key Migratory Bird Terrestrial Habitat site by the Canadian Wildlife Service (NT Site 12, Latour *et al*. 2006).

Tuktoyaktuk Peninsula

The Kugaluk, Moose and Smoke River Deltas cover about 40 km of the Kugaluk River, the lower 10 km of both the Moose and Smoke Rivers and the upper reaches of Liverpool Bay (Figure 7-3). Two large islands in the bay, one of which is Campbell Island, are also included. The site is extremely flat and the vegetation is primarily sedge and grass, marsh and meadow. Shorelines are non-vegetated tidal sand flats.

- This is one of the most important breeding areas for Pacific brant, supporting 10% of the Canadian population (Latour *et al*. 2006; Hines *et al*. 2006).
- The sedge marshes and sandflats are important moulting areas for several species of waterfowl: 10%, 3% and 1% of the Canadian populations of Canada geese (short grass prairie population), white-fronted geese and tundra swans, respectively.
- This site has been recognized as an International Biological Programme Site (IBP Site 44, Beckel 1975), a Canadian Important Bird Area (NT037, IBA Canada 2004), a special designated land (703D Aklavik, Inuvik and Tuktoyaktuk CCP, WMAC 2000a, b, c) and a Key Migratory Bird Terrestrial Habitat site by the Canadian Wildlife Service (NT Site 9, Latour *et al*. 2006).

Lower Anderson River Delta (and Mason River) follows the lower 50 km of the Anderson River and includes most of Wood Bay and the lower 20 km of the Mason River (Figure 7-7). The land is low-lying, lakes and ponds are common in the surrounding area and the river breaks up into several channels at the delta. At the highest reaches of the site, the surrounding land is spruce forest. *Dryas* tundra is found a little farther down, and at the river delta, the vegetation is made up of grasses, sedges and willows. Many species of waterfowl use the area for breeding, moulting and staging.

- In the 1970s, the area provided nesting habitat from late May through August for 1%, 1% and 6% of the Canadian populations of lesser snow geese, tundra swans, and Pacific brant, respectively, but numbers of snow geese and brant have declined since then (Latour *et al*. 2006; Wiebe Robertson and Hines 2006).
- The Eskimo curlew (*Numenius borealis*) used to breed here. This shorebird is globally listed as critical and nationally listed as endangered (Schedule 1, SARA), but may now be extinct. The bird was last seen somewhere along the Anderson River in 1989 (Latour *et al*. 2006).
- About 2% of the Canadian population of Pacific brant moult in the inner delta area, and 6% of the Canadian population of long-tailed ducks, scaup (*Aythya* spp.) and scoters use Wood Bay and the Mason River delta for moulting (Alexander *et al*. 1988; Latour *et al*. 2006).
- Most of the site is within the Anderson River Delta Migratory Bird Sanctuary and is legislatively protected under the Migratory Birds Convention Act, 1994. This site has been recognized as an International Biological Programme Site (IBP Site 43, Beckel 1975), a Canadian Important Bird Area (NT038, IBA Canada 2004), a special designated land (707D Aklavik, Inuvik and Tuktoyaktuk CCP, WMAC 2000a, b, c) and a Key Migratory Bird Terrestrial Habitat site by the Canadian Wildlife Service (NT Site 8, Latour *et al*. 2006).

Harrowby Bay is a deep bay in the centre of the Bathurst Peninsula (Figure 7-7). The site contains the open sea of Harrowby Bay, Ikpisugyuk Bay, and the area around the Old Horton River bed. The north shores of Harrowby Bay are composed of low bluffs and sand and gravel beaches and spits. The south shore is marshy and leads to a series of terraces and finally to a plateau surrounding the muddy Ikpisugyuk Bay. The oxbow lakes of the Old Horton Channel are surrounded by lush sedge-grass vegetation.

- From mid-summer through to autumn, 2 to 4% of the Canadian populations of Canada goose and white-fronted goose spend about a month and a half moulting in the Old Horton Channel area. Thousands of long-tailed ducks, scoters, and scaup moult in the waters of Harrowby Bay.
- This site has been recognized as a special designated land (321D Tuktoyaktuk CCP, WMAC 2001c) and a Key Migratory Bird Terrestrial Habitat site by the Canadian Wildlife Service (NT Site 7, Latour *et al*. 2006).

McKinley Bay-Phillips Island. The sandy barrier islands, sheltered bays and lagoons of the McKinley Bay-Phillips Island area are characterized by numerous ponds and lakes, extensive wetlands dominated by grasses and sedges, and lowland tundra (Figure 7-3). The area is heavily used by moulting and pre-moulting diving ducks (primarily long-tailed ducks, surf and white-winged scoters), white-fronted geese, red-throated loons, and dabbling ducks.

- The area provides moulting habitat for 1% of the Canadian populations of long-tailed duck, surf and white-winged scoter, and white-fronted geese (Latour *et al*. 2006).
- This site has been recognized as a special designated land (308C Tuktoyaktuk CCP, WMAC 2000c) and a Key Migratory Bird Terrestrial Habitat site by the Canadian Wildlife Service (NT Site 10, Latour *et al*. 2006).

Kukjutkuk and Hutchison Bay. The sandy barrier islands, sand spits, sheltered bays and lagoons of Kukjutkuk and Hutchison Bays provide moulting habitat for diving ducks, loons, white-fronted geese, Pacific brant, and tundra swans (Figure 7-3). Inland areas are characterized by numerous ponds and lakes, wetlands and tundra polygons, and lowland tundra.

- The area provides moulting habitat for 1% of the Canadian populations of long-tailed duck, surf and white-winged scoter (Latour *et al*. 2006).

- This site has been recognized as a special designated land (308C Tuktoyaktuk CCP, WMAC 2000c) and as a Key Migratory Bird Terrestrial Habitat site by the Canadian Wildlife Service (Latour *et al*. 2006).

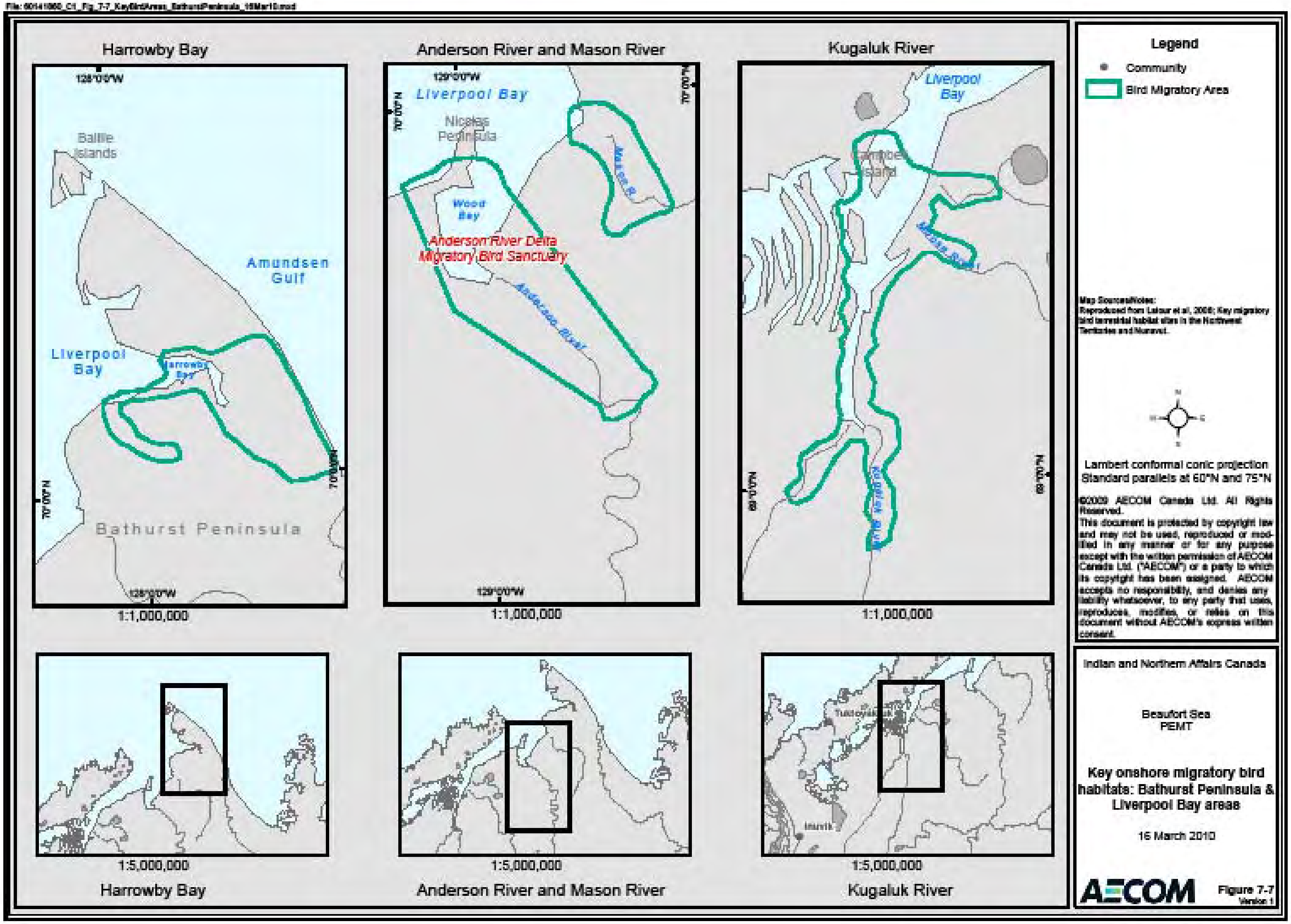


Figure 7-7 Key Onshore migratory bird habitats: Bathurst Peninsula & Liverpool Bay areas

Southwestern Banks Island (Figure 7-8)

Banks Island Migratory Bird Sanctuary No. 1. This Important Bird Area consists of rolling hills vegetated with grass- and sedge-dominanted tundra in low areas and mountain avens and other flowering plants on drier slopes (Latour *et al.* 2006). The area consists of several river drainages which create numerous shallow ponds inland and broaden into deltas towards the coast.

- Approximately 10% of the western Arctic population of king eiders have been observed in the area, where a large number of them nest (Dickson 1997, Latour *et al.* 2006).
- Approximately 20% of the Canadian population of Pacific brant moult in the Sanctuary (Latour *et al.* 2006). Moulting areas for black brant have been identified around the area of confluence of the Big River, the Lennie River and the Kellett River with the Beaufort Sea (Kay *et al.* 2006).
- Brant geese have been observed during the summer in this area since the mid 1800's (Manning *et al.* 1956).
- Long-tailed ducks occur throughout most of Banks Island, but are most abundant near the low western coast at sea in the shore lead west of Storkerson Bay and on lagoon and lakes inland (Manning *et al.* 1956, Searing *et al.* 1975, Latour *et al.* 2006).
- Nesting colonies of Pacific common eiders have been found along the coastal upland of the sanctuary along barrier beaches, sand spits; with nesting colonies observed on Sik-Sik, Rabbit, Moose and Terror islands off the mouth of Big River (Kay *et al.* 2006).
- Other nesting colonies of Pacific common eiders have been observed at Kellett Point, and at Princess Royal Islands, which is reported to support hundreds of nesting Pacific common eiders (Kay *et al.* 2006).

Egg and Big River

- This area is within a Key Migratory Bird Terrestrial Habitat site identified as by the Canadian Wildlife Service (NT Site 3, Latour *et al.* 2006).
- This area is designated as a Category E Land Use area in the Sachs Harbour CCP, and is stated as providing very important nesting and moulting area for geese and other birds from May to September (WMAC 2000d).
- About 95% of the Western Arctic Population of lesser snow geese and >10% of the Canadian population of lesser snow geese nest in the large valley's of Egg and Big Rivers (Kerbes *et al.* 1999, Samelius *et al.* 2008). Geese will begin nesting at the colony during the first week of June (Kay *et al.* 2006).
- Estimated population of nesting lesser snow geese at the Egg River colony varied from 264, 000 – 452 000, between 1995 – 1998 (Samelius *et al.* 2008).

Lennie, Storkerson, Bernard, Kellet and Satchik Rivers. Valleys adjacent to these river systems are documented as providing brood-rearing habitat for lesser snow geese (Samelius *et al.* 2008) and other migratory bird species (Cotter and Hines 2006, Latour *et al.* 2006).

- An estimated 441, 000 – 644 000 lesser snow geese were dispersed throughout the Banks Island Migratory Bird Sanctuary No. 1 during the brood-rearing season in 1996 – 1998, with the high densities occurring around the above river systems (Samelius *et al.* 2008).
- Approximately 60% of Pacific brant captured between 1992 – 1994 used lakes located 15 – 30 km north of the mouth of the Storkerson River for moulting habitat (Cotter and Hines 2006).
- King eiders have been reported nesting at higher densities near the lower Kellett River compared to other nest locations throughout Banks Island (Kay *et al.* 2006).

Northwestern Banks Island

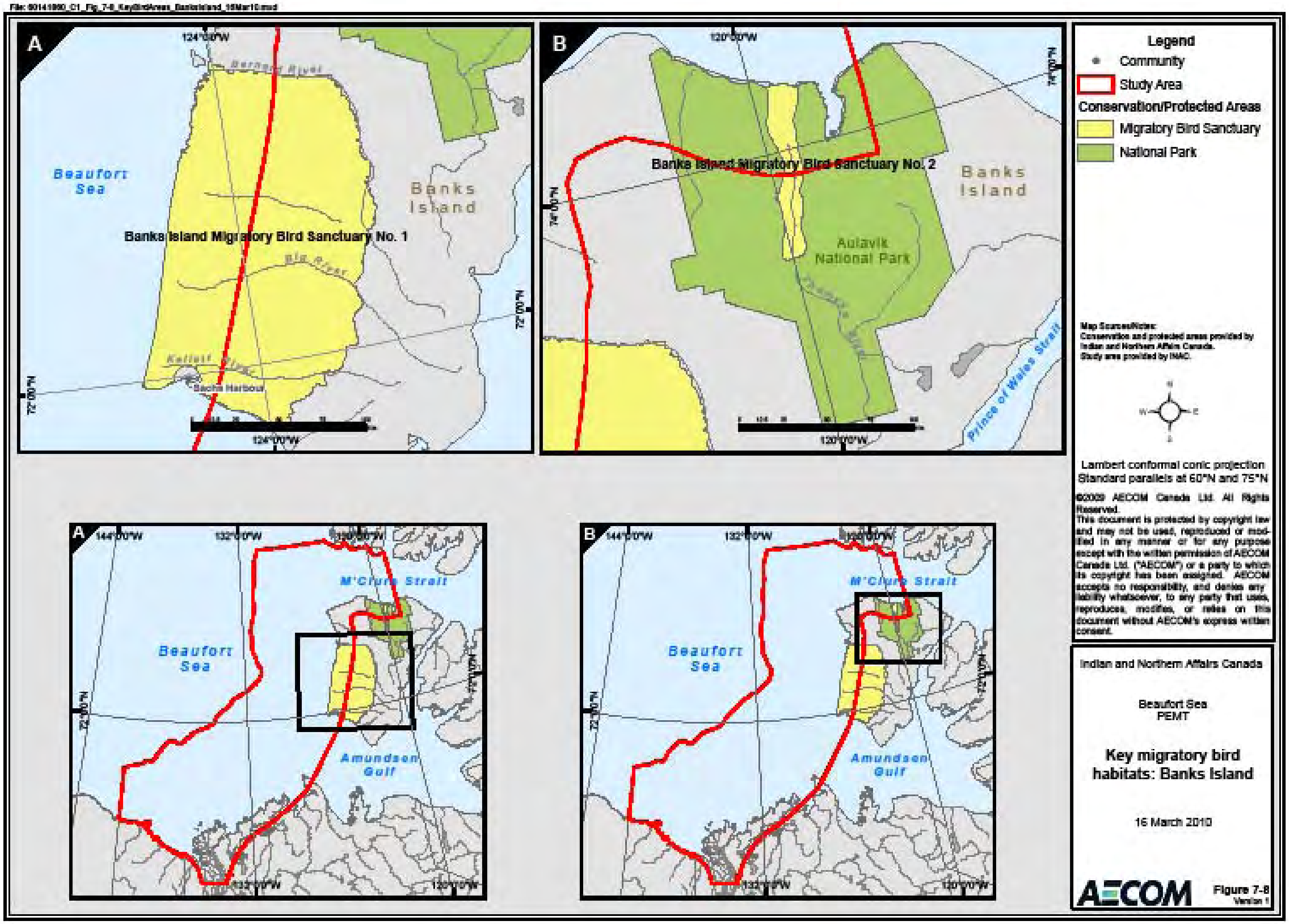
Banks Island Migratory Bird Sanctuary No. 2 – Thomsen River. The Thomsen River and Castel Bay is located on the north portion of Banks Island. Plains dominated by polar desert and arctic tundra communities change to rolling hills that are dissected by gullies and the flat-bottomed valley of the Thomsen river system (Latour *et al.* 2006). This site has been identified as a Key Migratory Bird Terrestrial Habitat site by the Canadian Wildlife Service (NT Site 2, Latour *et al.* 2006). This area is also designated as a Category D Land Use area in the Sachs Harbour CCP (WMAC 2000d).

- The area provides moulting habitat for lesser snow geese, and Pacific brant. In 1970, 5% and 12% of the Canadian populations of lesser snow geese and Pacific brant were observed in the area (CWS 1972, Beak Consultants Ltd. 1975).
- Foraging geese have also been observed in wet sedge meadow habitat along the Thomsen and Muskox River valleys (R.S. Ferguson and B. McLean, pers. comm., in Alexander *et al.* 1991).

Aulavik National Park. This park is located in the northern portion of Banks Island and contains a diversity of habitat from upland plateaus, unvegetated polar deserts, wetlands with frost polygon features, to the valley of the Thomson River and the cliffs along the coast and southeast of Mercy Bay (Henry and Mico 1997).

- This area includes Category A and E Land Use Areas in the Sachs Harbour CCP, and is stated as a moulting area for lesser snow goose from June to July (WMAC 2000d).
- Surveys conducted during the summer months of 1995 and 1996, found 43 species of birds in Aulavik National Park of which 75% where found using the park for breeding (Henry and Mico 1997).

Figure 7-8 Key



onshore migratory bird Habitats: Banks Island

7.4 Climate Change

Global circulation models predict substantial decreases in both thickness and coverage of arctic sea ice due to increased atmospheric CO_2. Present climate models are insufficient to predict regional ice dynamics, winds, mesoscale features, and mechanisms of nutrient resupply, which must be known to predict productivity and trophic response (Tynan and DeMaster 1997). However, we can speculate on the potential impacts of observed trends in Arctic climate on wildlife. Birds are potentially useful as indicators of broader ecological effects of climate change because they occupy a wide range of habitats. Climatic variables most often identified as influencing bird responses include a rise in air and sea surface temperatures, rising sea levels, drying of wetlands, and sea ice variability. In northern regions, warming may extend nesting periods, provide more food for young and decrease chick mortality. However, warming may reduce breeding and foraging habitats, sea level rise may damage important shoreline nesting areas, and increasing storms during nesting season could destroy essential nesting effort, eggs, and chicks (UNEP 2007). Warming temperatures can also lead to increase in “unusual mortality” of adult seabirds, such as those caused from storms and rock falls from eroding cliff faces were some species are nesting (Mallory *et al.* 2009).

Climate change also has the potential to indirectly impact seabirds and waterfowl by opening up more marine areas for tourism, ship transportation and other industrial activities in areas of breeding birds (Mallory *et al.* 2009). These activities have the potential to increase mortality of seabirds in areas which are relatively untouched at the current period. In addition, while these changes in climate create conditions that are more suitable for humans use and activity, they can decrease suitability of habitat for some birds. Suitable habitat for some birds, such as the red-necked phalarope, can be affected when premature drying and encroachment of shrub vegetation has the potential to decrease existing breeding habitat (Walpole *et al.* 2008).

The crack and lead system of the Cape Bathurst Polynya has the potential to be drastically affected by climate change. Increases in temperature or delay in seasonal climate shifts can greatly affect the size and availability of this critical bird habitat. Delay in the availability of this important habitat to seaducks could result in impacts to reproductive productivity to these species as they usually have a single nesting attempt and have the potential to skip a year of breeding due to weather impacts (Mehl 2004).

Climate change may lead to alterations in location, timing and length of migration routes. Spring migration of birds is generally considered more important than autumn migration because it determines their arrival timing at breeding grounds, which is crucial for mating and territory choice. Arthropod activity and abundance appears to be tied to date and weather in the Arctic, with temperature, wind and precipitation having strong influences (Tulp and Schekkerman 2008). Climatic change has the potential to alter the timing of food abundance for migratory birds. Warming trends could cause lower food abundance coinciding with the arrival of migratory birds, creating a necessary shift in the migratory schedule (Tulp and Schekkerman 2008). There is concern some long distance migrant bird species may not be able to alter their migratory behaviour sufficiently to match shifts in the availability of important food sources such as insects, flowers and berries (Climate Risk 2006). These timing shifts are a threat when they force birds’ life cycles out of synchrony with plants and insects on which their survival and reproduction depends upon.

7.5 Sustainability

The most effective way to conserve species diversity is to conserve the ecosystems and habitats that permit this diversity. In the event of population fluctuations, or even local extinctions, the ecosystem would still be able to support the recolonization and success of its plants and animals. In order to be protected, key migratory bird terrestrial and marine habitat must first be identified. Protection of these key areas will play an important role in maintaining the integrity of the terrestrial and marine ecosystem and in preserving marine birds and waterfowl.

Thousands of migrating birds stop temporarily in off-shore areas to feed, rest and court and are dependent on open-water leads and polynyas during the spring migration. Factors that might affect the suitability of staging areas include the annual recurrence of open water, availability of shallow water feeding areas, and water turbidity. Regardless of ice conditions, open water between Cape Dalhousie and the Baillie Islands is extremely important to eiders and long-tailed ducks. Water turbidity reduces visibility and hampers foraging.

Spring weather and timing of snowmelt are critical factors limiting the reproductive success of Arctic waterfowl. Reproductive success of all species is highest during earlier springs and lowest during the coolest springs (Newton 1977). Offshore open water leads and clear-water bays and lagoons which are sheltered from the Mackenzie River plume, are important for spring staging, nesting, brood-rearing, moulting, feeding and fall staging (Figures 7-2, 7-4, 7-5).

7.6 Susceptibility to Development

Bird species that frequent sea coasts and marine waters in the Beaufort Sea have the potential to be impacted by oil and gas activities. Degradation or destruction of habitat could have a significant impact on a particular population. The importance of a particular terrestrial or marine habitat depends on the size of the population that it supports during any part of the species’ life cycle. Activities such as dredging, shore-based staging areas and offshore platforms could alter valuable coastal bird habitat and may cause displacement. Flare stacks, staff quarters, gas conditioning facilities and other tall structures could increase bird mortality by direct strikes.

The impacts of a major oil spill will vary depending on the location, size, timing and clean-up of the spill. During certain life-cycle phases (e.g., nesting, brood-rearing, moulting), bird species are relatively sedentary and oil spills can have catastrophic site-specific effects. Sea ducks and sea birds are especially vulnerable to oil spills, because they tend to congregate in such large numbers that even a small spill can affect a large number of birds (Dickson and Gilchrist 2002). Polynyas and associated lead systems are important spring feeding and staging areas for migrating sea ducks and serve as major feeding areas for substantial numbers of seabirds during the summer months (Stirling 1980, 1997). Oil pollution in offshore areas in the southern Beaufort Sea during spring migration could be devastating to several populations. Nesting and moulting seabirds and waterfowl concentrate in nearshore sheltered bays from late July to mid-August. Since they are flightless during the moult, they are susceptible to disturbance and vulnerable to oil spills during this period.

Onshore areas in relatively protected waters of inlets and bays, such as Thrasher Bay, Shoalwater Bay, and Shallow Bay are vulnerable to spills as beached oil can persist for some time (Dickins *et al.* 1987). Therefore, although impacts to migratory bird areas are most vulnerable during the summer season, when birds are present in the Beaufort Sea area, high sensitive habitat areas and those areas sensitive to persistence of beached oil are vulnerable all year round. Typical dispersant use for oil spills maybe less effective in the areas of low salinity such as the Mackenzie River outflow (Dickson *et al.* 1987). Should a spill occur, certain response measures should be taken to divert oil away from areas where high sensitive bird habitats occur and clean up methods become more difficult, such as inlets southwest of Thumb Island in Liverpool Bay (Dickson *et al.* 1987).

Birds may be disturbed by aircraft overflights between shore-bases and offshore platforms. Negative effects of noise (e.g., flushing, displacement, or abandonment of key areas) are species dependent, as well as being dependent on the life history stage of the birds (nesting vs. staging) (Bunnell *et al.* 1981; Belanger and Bedard 1989). Birds that are colonial nesters are especially vulnerable, due to their clumped nature. Birds are also vulnerable during the sedentary moulting and brood-rearing periods, as well as during the fall. In 1997, the Wildlife Management Advisory Council in the NWT concluded that a flight altitude of 650 m was appropriate to minimize disturbance to birds under normal conditions, and that a minimum flight altitude of 1100 m should be adhered to in areas where birds were known to concentrate (sanctuaries, colonies, and moulting areas). The Inuvialuit Environmental Impact Screening Committee (EISC) has adopted these flight height criteria (Inuvialuit Joint Secretariat 2002). In addition, Environment Canada has recommended avoidance of concentrations of migratory birds by a distance of 1.5 km during the nesting, breeding and moulting seasons, and a distance of 3 km during the spring and fall staging periods (Belanger and Bedard 1989; Environment Canada 2006).

Drilling programs may involve summer drilling in the area as they have in the past. Unless adequate measures are taken, the discharge of drilling muds, cuttings, and other fluids and solids (e.g., grey water, sewage, reverse osmosis reject water, miscellaneous wash water) has the potential to affect birds. Exploration wells could be drilled during the winter within the landfast ice zone and the preferred method of disposal of drilling waste is under-ice (Environment Canada 2006). Most birds are not present in the study area during the ice-covered winter period. Because the drilling waste will be discharged under the ice, there will be no opportunity for overwintering birds such as ravens to interact with the waste.

Seismic lines associated with oil and gas development also have the potential to directly and indirectly effect available habitat to upland bird species in the Arctic. Plans to increase oil and gas exploration in the Canadian Arctic could have detrimental effects on breeding habitat for migratory birds. Due to the alteration of vegetation along seismic lines in upland tundra, the habitat for breeding birds becomes altered. Although birds have been documented using seismic lines, passerine abundance appears to be lower in these disturbed areas even 10 – 30 years after development (Ashenhurst and Hannon 2008).

7.7 Mitigation

During certain life-cycle phases (e.g., nesting, brood-rearing, moulting), bird species are particularly vulnerable to developmental impacts such as oil spills. There are several strategies that can be applied to project-specific mitigation planning:

- Seaducks and seabirds are especially vulnerable to oil spills. Important offshore areas such as Cape Bathurst Polynya and Mackenzie River Delta should have appropriate oil spill response plans developed for specific water conditions in these areas.
- Nesting and moulting seabirds and waterfowl concentrate in nearshore sheltered bays from late July to mid-August. Since they are flightless during the moult and relatively sedentary during nesting, they are susceptible to disturbance and vulnerable to oil spills during this period. Timing restrictions for development should be established for these nesting and moulting periods and specific response plans for shoreline oil spills should be developed for these areas and include measure to divert oil away from areas.
- Established Important Bird Areas, where possible, should be avoided for development. Depending on the specific IBA and its timing of use restrictions periods should also be established for working in and around these areas.

7.8 Sensitivity Layers

Populations that are concentrated for any part of the year (e.g. staging, moulting, and foraging areas) are vulnerable to site-specific threats because a significant proportion of the population could be affected. As well, populations that occupy geographically restricted habitats (rare, threatened or endangered species) are vulnerable if their habitats are threatened.

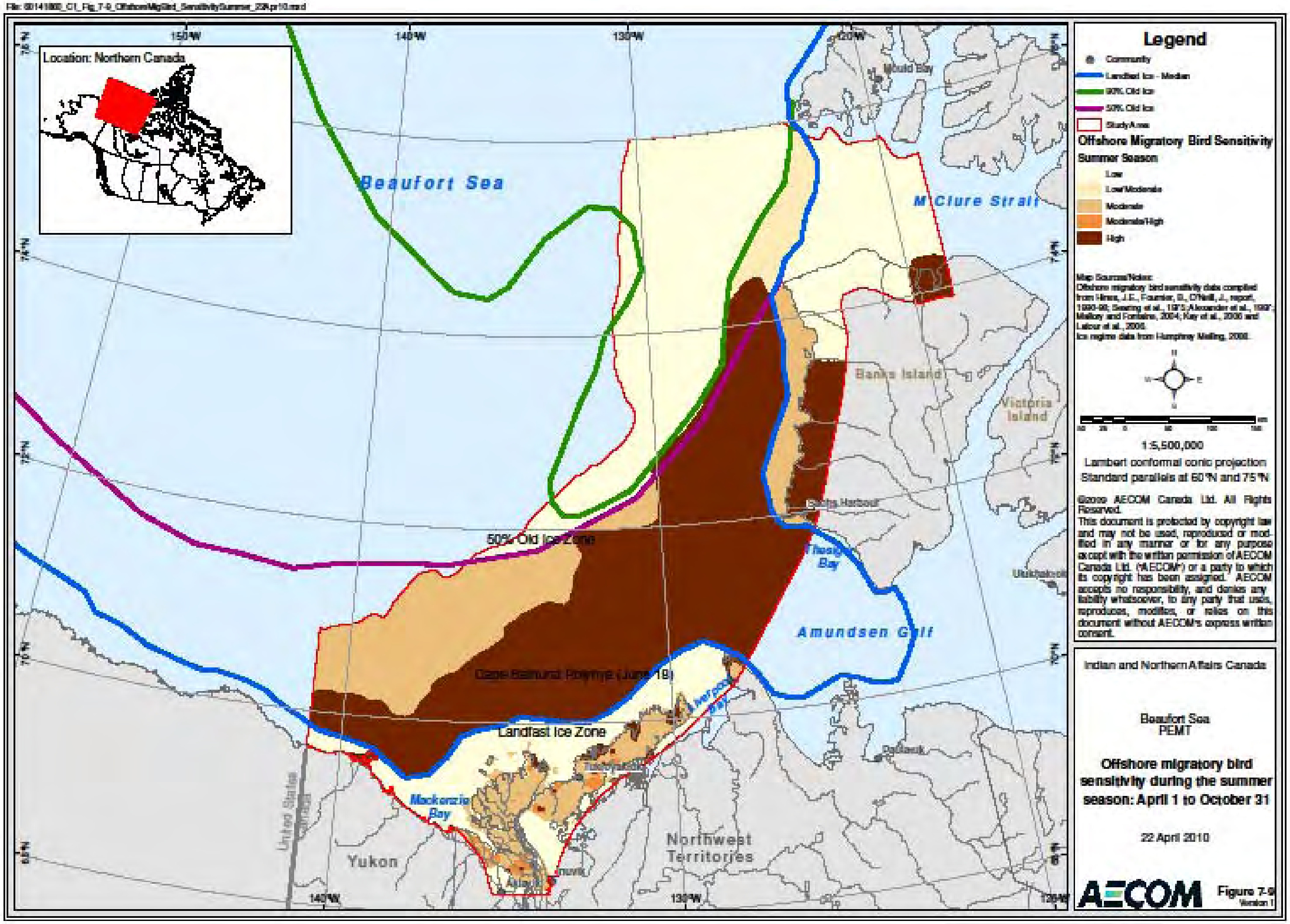
7.8.1 Offshore Sensitivity

Summer Season: April 1 to October 31 Offshore Sensitivity (Figure 7-9)

Many migratory birds use the Beaufort Sea from spring to fall, with arrival and departures influenced by break up and freeze up of the sea ice.

- **Low Sensitivity (1):** areas that have very limited use year round and include the area beyond the summer extent of pack ice (approximate summer extent of pack ice as defined in Stirling 2002).
- **Low/Moderate Sensitivity (2):** areas where populations are geographically widespread or widely dispersed throughout a variety of habitats. These populations are less vulnerable to site-specific threats, as only a small portion would be affected. Includes coastal and offshore areas to the limit of summer pack ice and upland and floodplain.
- **Moderate Sensitivity (3):** areas where populations are concentrated in a habitat site for any part of the year including staging areas, nesting colonies, moulting and feeding areas. Includes sites with moderate to high densities, but <1% of the Canadian population, and coastal and offshore areas to the limit of summer pack ice and upland and floodplain.
- **Moderate/High Sensitivity (4):** populations that occupy geographically restricted habitats and sites that support at least 1% of the Canadian population and/or have a conservation area status or designation. This includes key areas along the Yukon North Slope (Blow River delta, Nunaluk Spit, Workboat Passage, Herschel Island, Babbage and Spring River deltas), the Yukon Coastal Plain, the Mackenzie River Delta, areas along the Tuktoyaktuk Peninsula (Kugaluk, Moose, and Smoke Rivers; lower Anderson and Mason River deltas; Harrowby Bay, Kukjutkuk and Hutchinson Bay, McKinley Bay and Phillips Island), the Banks Island Ice lead and coastal waters off the Banks Island Migratory Bird Sanctuary No.1. Also includes sites of exceptional species diversity, and includes coastal and offshore areas to the limit of summer pack ice and upland and floodplain
- **High Sensitivity (5):** sites that support 50% of the Canadian population. This includes the Cape Bathurst polynya and includes critical habitat as defined by the Species At Risk Act (SARA)

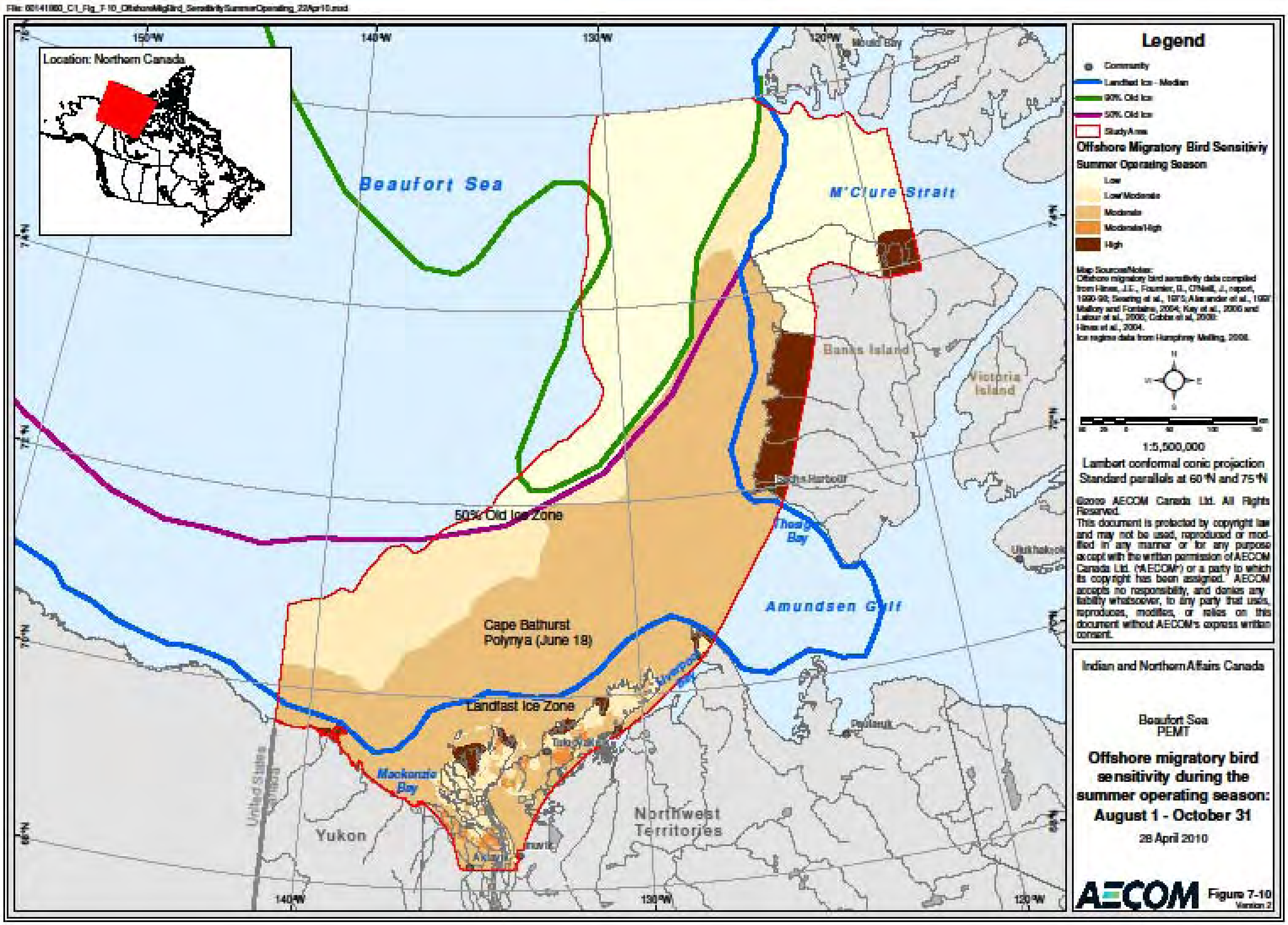
Figure 7-9 Offshore migratory bird sensitivity during the summer season: April 1 to October 31



Summer Operating Season: August 1 to October 31 Offshore Sensitivity (Figure 7-10)

- **Low Sensitivity (1):** areas that have very limited use year round and include the area beyond the summer extent of pack ice (approximate summer extent of pack ice as defined in Stirling 2002).
- **Low/Moderate Sensitivity (2):** areas where populations are geographically widespread or widely dispersed throughout a variety of habitats. These populations are less vulnerable to site-specific threats, as only a small portion would be affected. Includes coastal and offshore areas to the limit of summer pack ice and upland and floodplain.
- **Moderate Sensitivity (3):** areas where populations are concentrated in a habitat site for any part of the year including staging areas, nesting colonies, moulting and feeding areas. Includes sites with moderate to high densities, but <1% of the Canadian population, and coastal and offshore areas to the limit of summer pack ice and upland and floodplain.
- **Moderate/High Sensitivity (4):** sites of exceptional species diversity, and includes coastal and offshore areas to the limit of summer pack ice and upland and floodplain This includes key areas along the Yukon North Slope (Blow River delta, Nunaluk Spit, Workboat Passage, Herschel Island), the Mackenzie River Delta, areas along the Tuktoyaktuk Peninsula (Kugaluk, Moose, and Smoke Rivers; lower Anderson and Mason River deltas; Harrowby Bay, Kukjutkuk and Hutchinson Bay, McKinley Bay and Phillips Island).
- **High Sensitivity (5):** populations that occupy geographically restricted habitats and sites that support at least 1% of the Canadian population and/or have a conservation area status or designation, and. sites that support 50% of the Canadian population. This includes the Migratory Bird Sanctuaries, nesting and moulting areas, and the black guillemot nesting colony on Herschel Island.

Figure 7-10 Offshore migratory bird sensitivity during the summer operating season: August 1 to October 31

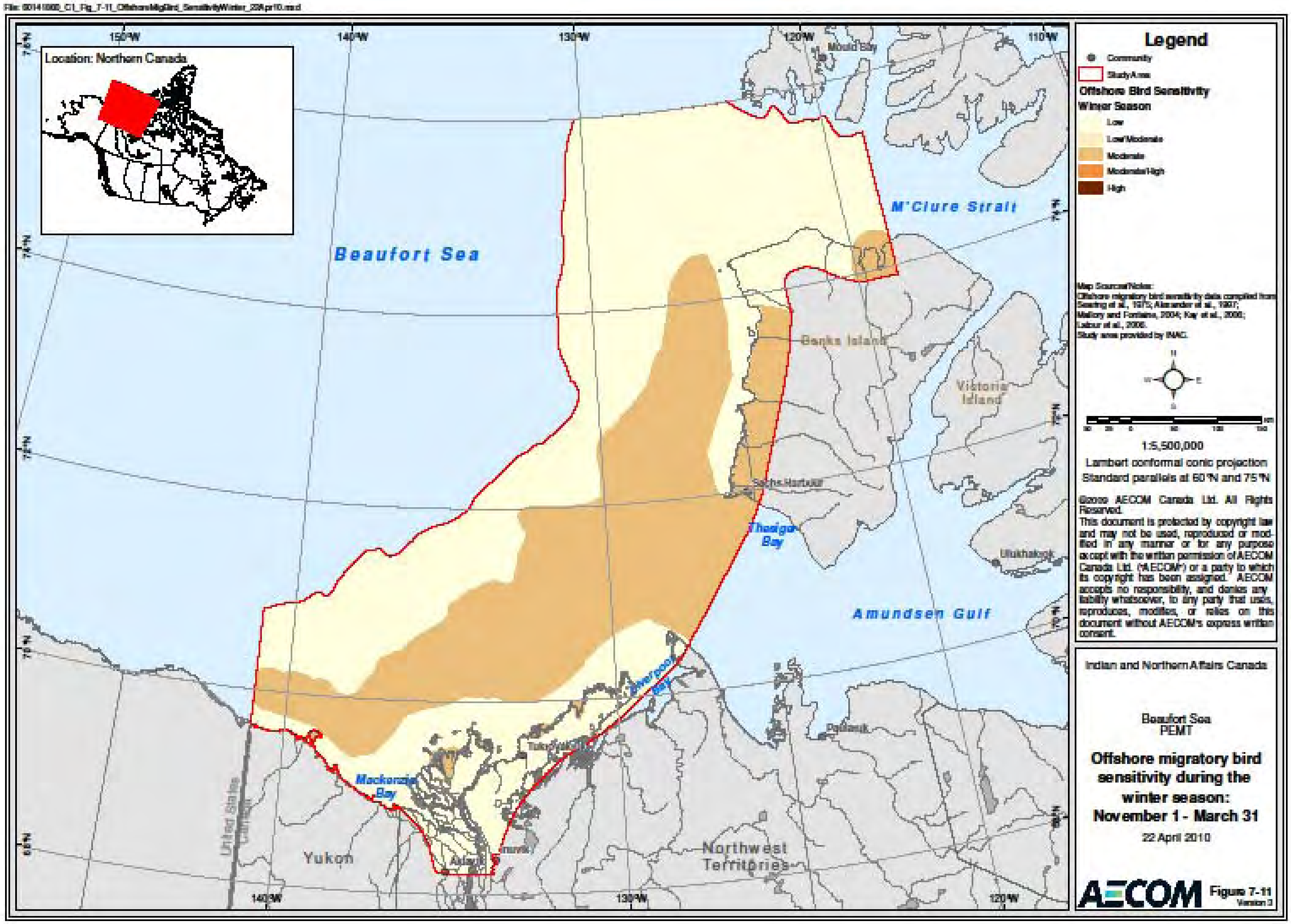


Winter Season: November 1 to March 31 Offshore Sensitivity (Figure 7-11)

Most birds are not present in the study area during the ice-covered winter period because long, cold winters and limited food availability limit populations. However, their absence during the winter does not diminish the significance of the identified key migratory bird terrestrial and marine habitat. These habitats provide the needs for a species' survival and reproduction and are fundamental to the conservation of many species.

- **Low Sensitivity (1):** offshore areas that are completely ice-covered.
- **Moderate Sensitivity (3):** Pauline Cove on Herschel Island is the only site in the Beaufort Sea region supporting a substantial nesting colony of black guillemot (*Cepphus grylle*) (Alexander *et al*. 1988). This habitat provides the needs for the species' survival and reproduction.

Figure 7-11 Offshore migratory bird sensitivity during the winter season: November 1 to March 31



Map Source/Notes:
Offshore migratory bird sensitivity data compiled from Searing et al., 1975; Alexander et al., 1997; Mallory and Fontaine, 2004; Kay et al., 2006; Latour et al., 2006.
Study area provided by INAC.

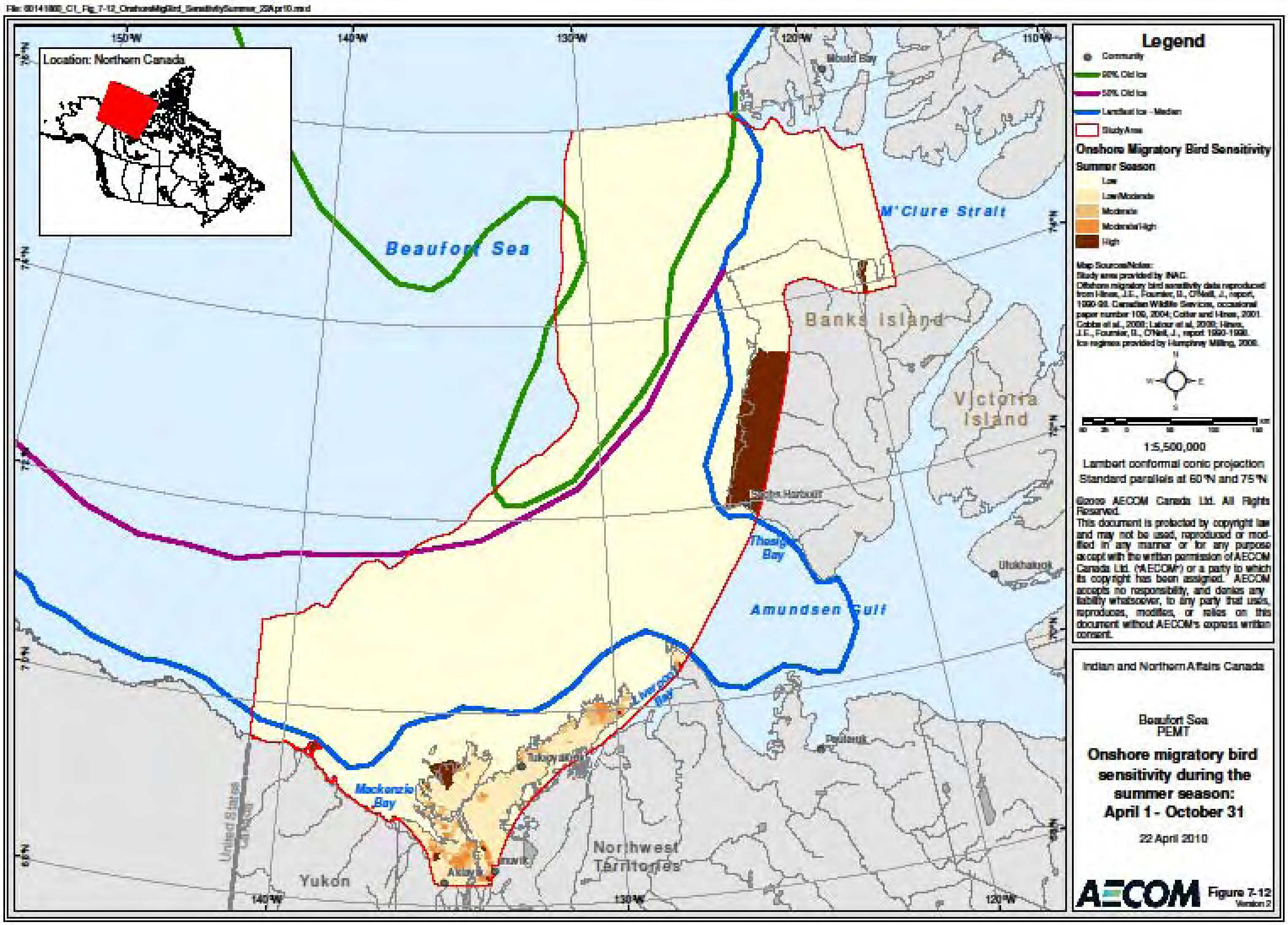
7.8.2 Onshore sensitivity

Open Water Season: April 1-October 31 Summer Onshore Sensitivity (Figure 7-12)

Many migratory birds use the Beaufort Sea from spring to fall, with arrival and departures influenced by break up and freeze up of the sea ice.

- **Low Sensitivity (1):** areas that have very limited use year round.
- **Low/Moderate Sensitivity (2):** areas where populations are geographically widespread or widely dispersed throughout a variety of habitats. These populations are less vulnerable to site-specific threats, as only a small portion would be affected. Includes coastal, upland and floodplain areas.
- **Moderate Sensitivity (3):** areas where populations are concentrated in a habitat site for any part of the year including staging areas, nesting colonies, moulting and feeding areas. Includes sites with moderate to high densities, but <1% of the Canadian population, and coastal, upland and floodplain areas.
- **Moderate/High Sensitivity (4):** geographically restricted habitats and sites that support at least 1% of the Canadian population and/or have a conservation area status or designation. This includes key areas along the Mackenzie River Delta, areas along the Tuktoyaktuk Peninsula (Kugaluk, Moose, and Smoke Rivers; lower Anderson and Mason River deltas; Harrowby Bay, Kukjutkuk and Hutchinson Bay, McKinley Bay and Phillips Island).
- **High Sensitivity (5):** areas where populations are concentrated in a habitat site for any part of the year including staging areas, nesting colonies, moulting and feeding areas. Includes sites with high densities such as southwestern Banks Island (Egg River Colony, Lennie, Storkerson, Bernard, Kellet and Satchik Rivers in Banks Island Migratory Bird Sanctuary No. 1), and northwestern Banks Island (Thomsen River Migratory Bird Sanctuary). Also includes sites of exceptional species diversity, and includes coastal, upland and floodplain areas.

Figure 7-12 Onshore migratory bird sensitivity during the summer season: April 1 - October 31

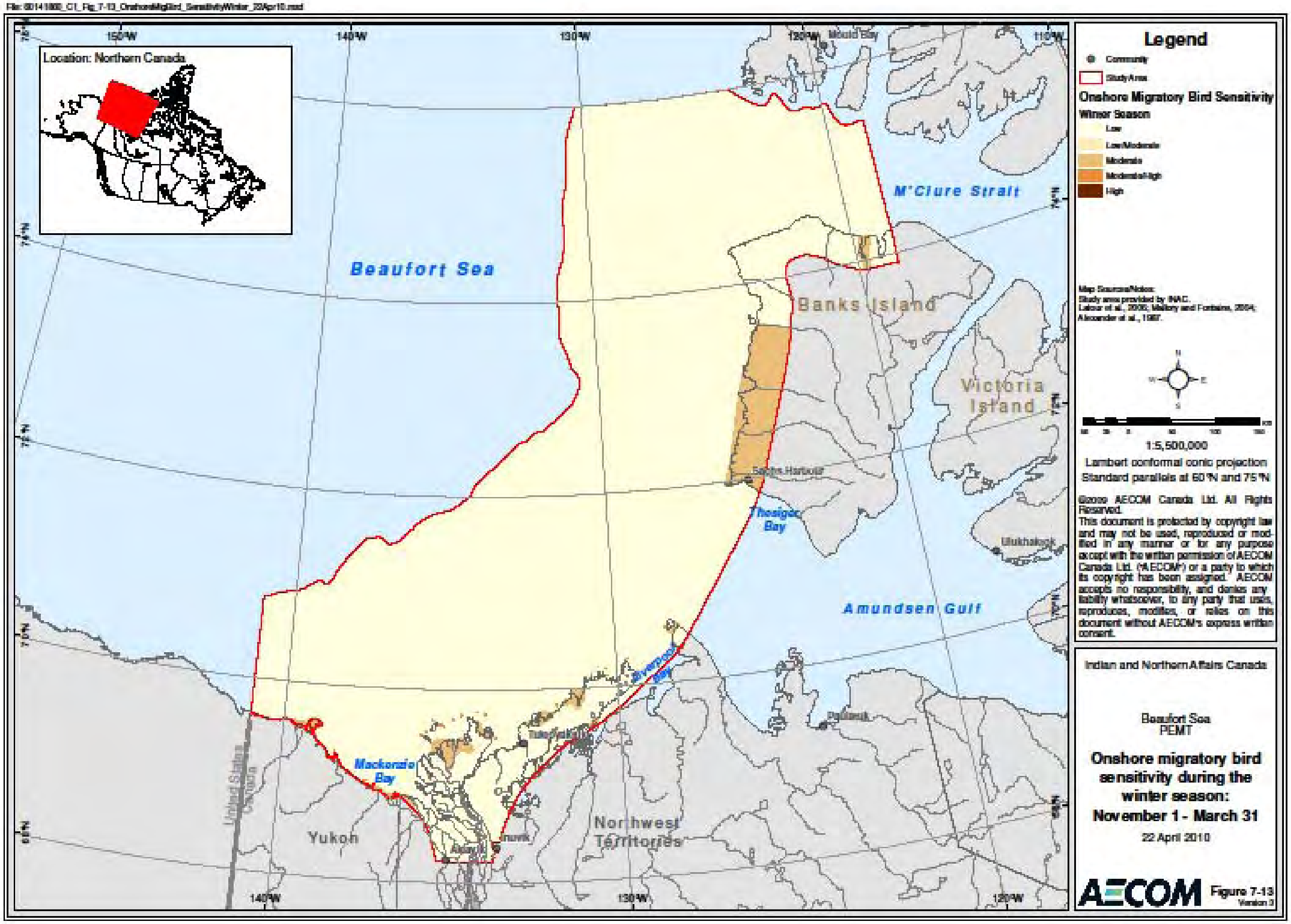


Ice-covered Season: November 1 – March 31 Winter Onshore Sensitivity (Figure 7-13)

Most birds are not present in the study area during the ice-covered winter period because long, cold winters and limited food availability limit populations. However, their absence during the winter does not diminish the significance of the identified key migratory bird terrestrial and marine habitat. These habitats provide the needs for a species' survival and reproduction and are fundamental to the conservation of many species.

- **Low Sensitivity (1):** coastal, upland and floodplain areas extending 1 km offshore and backshore to include the maximum extent of positive storm surges.
- **Moderate/High Sensitivity (4):** geographically restricted habitats and sites that support at least 1% of the Canadian population and/or have a conservation area status or designation. This includes key areas along the Yukon North Slope (Blow River delta, Nunaluk Spit, Workboat Passage, Herschel Island, Babbage and Spring River deltas), the Yukon Coastal Plain, the Mackenzie River Delta, areas along the Tuktoyaktuk Peninsula (Kugaluk, Moose, and Smoke Rivers; lower Anderson and Mason River deltas; Harrowby Bay, Kukjutkuk and Hutchinson Bay, McKinley Bay and Phillips Island) southwestern Banks Island (Egg River Colony, Lennie, Storkerson, Bernard, Kellet and Satchik Rivers in Banks Island Migratory bird Sanctuary No. 1), and northwestern Banks Island (Thomsen River Migratory Bird Sanctuary). Also includes sites of exceptional species diversity, and includes coastal, upland and floodplain areas. Also includes sites of exceptional species diversity, and includes coastal, upland and floodplain areas.

Figure 7-13 Onshore migratory bird sensitivity during the winter season: November 1 - March 31



7.9 Summary

The NWT coastal and marine zones support a considerable diversity and abundance of migratory birds which use coastline, open sea (inshore, nearshore and offshore sites) and polynyas during some part of their life cycle (nesting, moulting, staging). Species that use the offshore waters include the red-throated, Pacific and yellow-billed loons, common and king eiders, long-tailed ducks, Sabine's gulls and glaucous gulls. Bird species that depend on the nearshore waters include the red-throated loon, Pacific loon, brant, tundra swan, glaucous gull, Arctic tern, lesser snow geese, black guillemots, common and king eiders and thick-billed murres. Most birds are not present in the Project area during the winter ice-covered period; therefore, interactions are only likely to occur during the pre-operations mobilization period and at spring breakup, following winter drilling operations.

Key terrestrial and marine habitat for birds exists in both offshore and coastal areas. Polynya and lead habitats off Cape Bathurst, Banks Island and the Mackenzie Delta are critically important to sea ducks (king and common eiders and long-tailed ducks) during spring migration. Birds arrive on their nesting grounds in the Beaufort Sea in late May to early June. From late July to early August McKinley Bay–Phillips Island, the Kukjuktuk and Hutchison Bay area, and Workboat Passage at Herschel Island are key habitats for >100,000 moulting and pre-moulting ducks. Due to the fact that migratory birds concentrate to feed at ice edges and in open leads, and during breeding, nesting, moulting and migration periods, they are particularly vulnerable to oil. Oil spills could seriously reduce or even eliminate some of these birds in areas of concentration, and have a lasting impact on the entire population of migratory birds in the region. Concern over this potential threat has resulted in research that has vastly improved our knowledge of the location, size, breeding success, feeding habits, and migration patterns of many migratory bird species in the Beaufort Sea (Alexander *et al*. 1988; Gratto-Trevor 1996; Dickson 1997; Hines and Wiebe Robertson 2006).

Fourteen key terrestrial and marine migratory bird habitat sites have been identified. Each site selected supports at least 1% of the Canadian population of a migratory bird species during some part of its life cycle (nesting, moulting, staging), or a population that occupies geographically restricted habitat, or is a site of exceptional species diversity. These sites are recognized for their unique physical or ecological characteristics and as such, have a conservation designation (International Biological Programme Site, Canadian Important Bird Area, Migratory Bird Sanctuary, National Park, Territorial Park, Canadian Wildlife Service Key Migratory Bird Terrestrial or Marine Habitat site, special designated land in Community Conservation Plans). Migratory Bird Sanctuaries, National and Territorial Parks give birds full protection, while IBP, IBA, CWS Key Habitat, and CCP designations do not. Their identification is intended to raise awareness and draw attention to activities that may threaten an area.

Additionally, key migratory bird terrestrial and marine habitat extends beyond the study area boundary (e.g. portions of the west, north, and south coasts of Banks Island). Impacts to certain migratory bird populations (e.g., king eiders) outside the study area, may act in a cumulative fashion with impacts within the study area to influence the populations.

It is possible to make some general predictions regarding the effects of the petroleum industry on seabirds and other marine life in the Canadian Arctic. Despite the most conscientious efforts by the industry to minimize losses during its day-to-day operations, accidents do occur and there could be low levels of oil pollution in some areas from time to time. There could be extensive mortality in the event of a major spill in any of the areas where large numbers of migratory birds congregate. Accidents arising from equipment failure or human carelessness can be reduced by design, construction and maintenance, and by taking adequate precautionary measures. In the event of a significant accident, human resources and equipment must be made immediately available to contain and clean up the spill to the greatest extent possible. The presence of additional humans, along with ships, aircraft and other oil and gas project related activities in the region, could result in more extensive disturbance of marine life, including migratory birds. It is possible through diligent project design, construction and maintenance to minimize the impact of oil and gas exploration and development. For instance, it is possible to reduce the level of disturbance from aircraft and ships by identifying and avoiding sensitive areas at certain times of the year.

8. Peary Caribou

8.1 Description

8.1.1 General

Peary caribou (*Rangifer tarandus pearyi*) belong to the family *Cervidae* (COSEWIC 2004). These caribou are small and short and are also distinguished by their high cranium and pointed rostrum (COSEWIC 2004). The summer coat is slate brown which turns a cream white during the winter months (COSEWIC 2004). Average weights and lengths of female Peary include: 52 kg and 146 cm (Prince Patrick Island), 55.2 kg, 149.8 cm (Eglinton Island) and 56.3 kg, 149.4 cm (Melville and Byan Martin Islands) (Thomas and Everson 1982). Female sexual maturity is typically reached at 3 years of age (COSEWIC 2004); however some can reach maturity as early as one year (Thomas 1982). Infertility or delayed sexual maturity can occur during periods of nutritional deficiency or low fat reserves (Thomas 1982). Calves have are born in early June (Tener 1965) or late June (Madsen 2001). The diet of Peary caribou is dominated by sedges, willows (*Salix arctica*), legumes (*Astragalus* spp., *Oxytropis* spp.) and rose/saxifrage (*Dryas integrifolia*) (Larter and Nagy 2004).

8.1.2 Populations

Peary caribou occur throughout most of the northern islands in Northwest Territories and Nunavut (COSEWIC 2004). A minimum of four genetically different populations exist: (1) Queen Elizabeth Islands; (2) Banks Island and northwestern Victoria Island; (3) Prince of Wales Island and Somerset Island, and (4) Boothia Peninsula (COSEWIC 2004). Populations of Peary caribou which occur within or near the PEMT Area include: the Queen Elizabeth Islands population (Melville, Prince Patrick and Eglinton Islands) and the Banks Island population.

In the past, Peary caribou populations were noticeably in decline on Banks Island (Fraser *et al*. 1992, McLean *et al*. 1992, Nagy *et al*. 1996). More recently however, Banks Island populations appear to be stable or slowly increasing (J. Nagy, pers. comm. February 2, 2004 *In* COSEWIC 2004). In 2001, Peary caribou populations on Banks Island (1,587) have almost tripled from estimations in 1998 (558) (J. Nagy, pers. comm. February 2, 2004 *In* COSEWIC 2004). However, populations in the western Queen Elizabeth Islands appear to be in decline (Gunn and Dragon 2002, Miller and Gunn 2003). For example, caribou on Melville Island have decreased from an estimated 12,799 in 1961 (Tener 1963) to an estimated 787 in 1997 (Gunn and Dragon 2002). In addition, caribou on Prince Patrick Island have decreased from an estimated 5,001 in 1961 (Tener 1963) to an estimated 84 in 1997 (Gunn and Dragon 2002).

Human harvest, natural predation and poor winter conditions are all possible explanations for population declines (McLean and Fraser 1992). Many studies have found that severe snow and ice conditions are a major cause of population decline (Parker *et al*. 1975, Gunn and Dragon 2002, Miller and Gunn 2003). Harsh winters causing food inaccessibility can lead to malnutrition and has caused population declines in the past (Parker *et al*. 1975, Gunn and Dragon 2002, Miller and Gunn 2003). For example, severe winter conditions (snow and ice) caused a major decline in caribou numbers from 1994-1995 to 1996-1997 in the western Queen Elizabeth Islands (Miller and Gunn 2003). Similarly, Peary caribou populations on the western Queen Elizabeth and Prince of Whales Islands crashed after a severe winter (1973 to 1974) (Parker *et al*. 1975). Starvation due to forage inaccessibility was the main cause of the population decline. Miller *et al*. (1982) discovered that Peary caribou purposely seek out poorly vegetated areas with less snow and high winds above areas with abundant vegetation covered in ice. They also found that in the spring, caribou will move as a result of poor snow and ice conditions. Even though Peary caribou have made adaptations to escape starvation, population declines are still evident, especially the Queen Elizabeth Island population.

8.1.3 Migration

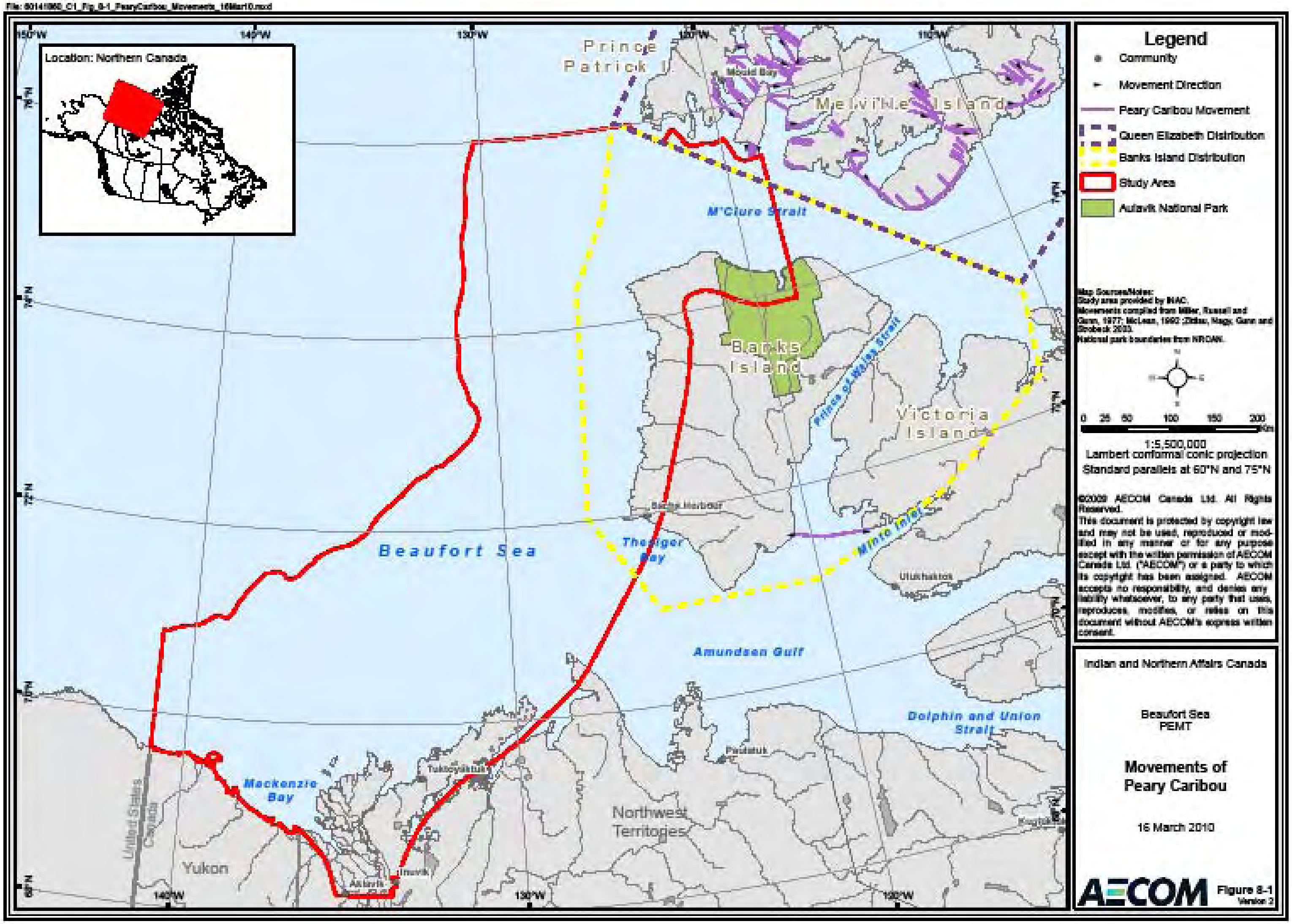
Peary caribou migrate long distances on islands and between islands in search of food (Miller and Gunn 1978, COSEWIC 2004), to reach key habitats (Urquhart 1973), and for regular seasonal movements (Miller *et al*. 1977a, 1982). Additionally, in one situation, Inuit harvesters considered that caribou movements may have been caused by seismic activities (Freeman 1975). Peary caribou are known to migrate annually and seasonally between the Queen Elizabeth Islands (Miller *et al*. 1977a). Although the majority of inter-island movements occur during ice cover, some caribou have been known to swim up to 2.5 km (Miller 1995). Peary caribou are known to migrate between Prince Patrick, Eglinton and Melville Islands (Miller *et al*. 1977a) (Figure 8-1). Inter-island travel for some of these caribou was estimated to be up to 450 km. Migration is also known to occur between Banks and north-western Victoria Island; however, this migration route is based on DNA evidence (Zittlau *et al*. 2003) and local knowledge (McLean 1992, see Zittlau *et al*. 2003) (Figure 8-1). Evidence has not been found to support inter-island movements between Banks Island and the western Queen Elizabeth Islands. Peary caribou are especially sensitive during the fall, winter, and early spring due to inter-island movements and migrations. In the spring Peary caribou start migrating to their calving grounds (Madsen 2001). On Banks Island, Kevan (1974) indicated that Peary caribou likely start migrating north as the snow melts.

8.2 Rationale for Selection

Peary caribou were mainly selected as a VEC due to their cultural and nutritional importance to Inuit communities (Tews *et al*. 2007). On Banks Island, Peary caribou are an important traditional food for individuals living in Sachs Harbour (Larter and Nagy 2000). Peary caribou are protected by Land Claim Agreements with the Inuvialuit (COSEWIC 2004). In addition, caribou are managed by Land Claim organizations and the Territorial governments.

Peary caribou were also selected as a VEC due to their listing territorially and federally. In the Northwest Territories, Peary caribou are listed as *At Risk* (NWT 2009a). The Banks Island and High Arctic populations of Peary Caribou are listed as *Endangered* under Schedule 2 of the *Species at Risk Act* (SARA 2009). The Low Arctic population is listed as *Threatened* under Schedule 2 (SARA 2009).

Figure 8-1



Movements of Peary Caribou

8.3 Key Habitats

Peary caribou prefer mesic tundra and polar desert habitat types consisting of lichens, grasses, sedges, and forbs (Parker and Ross 1976). In the winter, caribou prefer higher ground for easy foraging due to less snow cover (Parker and Ross 1976).

Peary caribou on Banks Island with and without calves noticeably prefer well drained lands on hills or slopes with undeveloped hummocks, which were mostly dominated by *Dryas integrifolia* and *Kobresia myosuroides* (Kevan 1974). Peary caribou with calves appear to moderately prefer wet areas with plant species such as *Eriophorum scheuchzeri* and *Carex aqatalis* and well drained lands on hills or slopes with hummocks (Kevan 1974). Vegetation in well developed hummocks included *Dryas integrifolia* and *Cassiope teragona*. Less preferred habitat types included: stony barrens and snow covered areas (Kevan 1974).

8.3.1 Banks Island

Key calving grounds are located in the north-east, south-east, and north-west sections of Banks Island (Larter and Nagy 2000a, Kevan 1974). High densities of Peary caribou with calves were observed in the north-east of Banks Island in June (Kevan 1974). Kevan (1974) indicated that identified areas in the northern end of Banks Island should be considered critical for caribou survival in the spring (Figure 8-2). The summer range for Peary caribou was identified in the northwest of Banks Island (Larter and Nagy 2000a). Peary caribou were also observed on the southeastern end of Banks Island in July 1998 and in the northwest end in July 1998 and 1999 (Larter and Nagy 2000b). The winter range has been acknowledged in the south-west section of Banks Island (Larter and Nagy 2000a).

8.3.2 Western Queen Elizabeth Islands

Limited data is available on key Peary caribou habitat on Prince Patrick, Eglinton, and Melville Islands (e.g. Miller *et al*. 1977a, Miller *et al*. 1977b, Larter and Nagy 2000b). Specific summering, wintering and calving grounds have not been identified on these islands. One exception might be the southern end of Dundas Peninsula on Melville Island which may serve as a summer range for Peary caribou (Larter and Nagy 2000b). Data collected by Miller *et al.* (1977a) in 1973 and 1974 suggest that large numbers of caribou migrate seasonally and interchangeably between these islands. One suggestion from reviewing this data is that a summer range for one group of caribou may serve as winter range for a different group of caribou and vice versa.

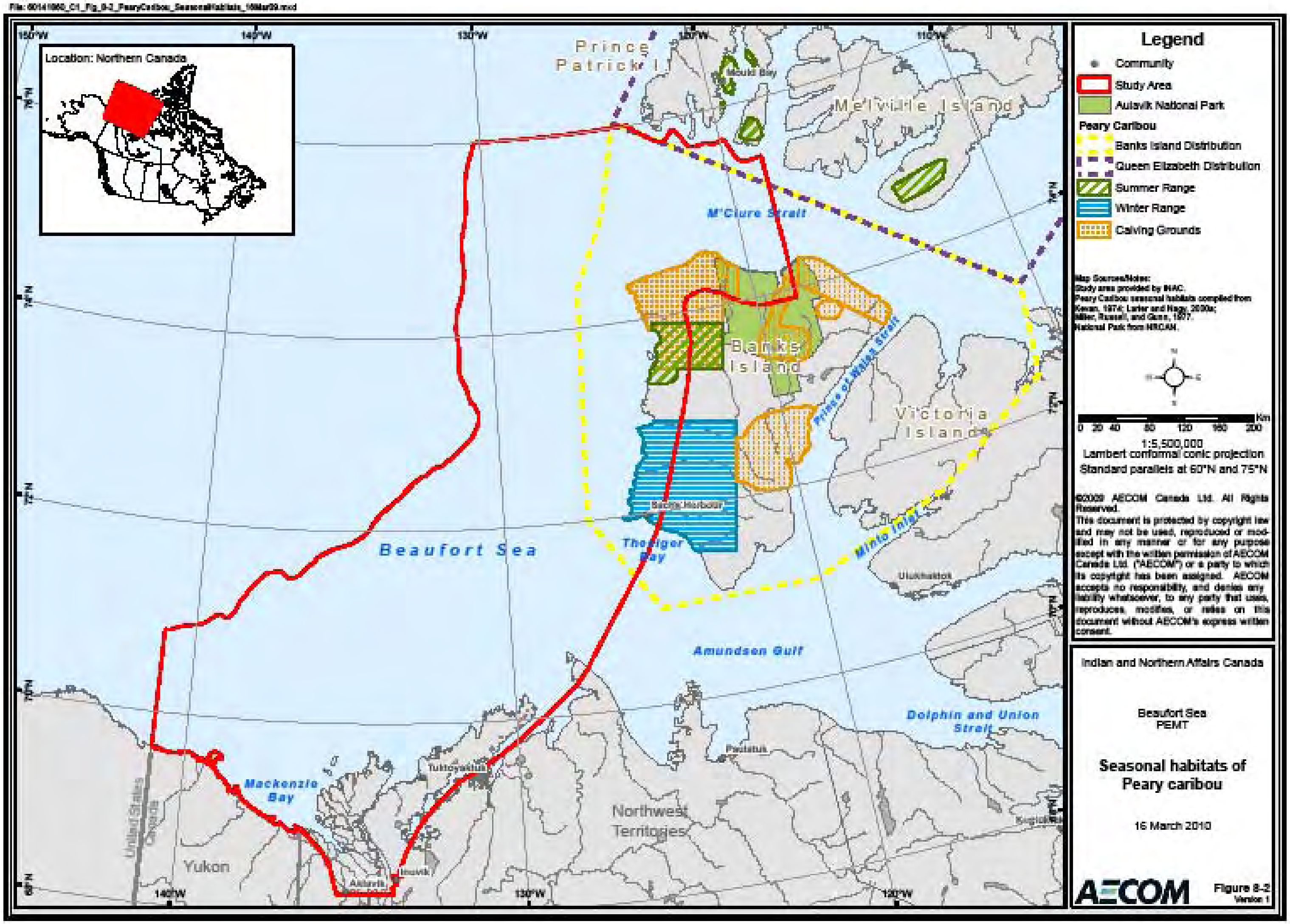


Figure 8-2 Seasonal habitats of Peary caribou

Eglinton Island

Caribou appeared to concentrate on the southern end of Eglinton Island in June and July 1974 (Miller *et al*. 1977a) (Figure 8-2). In total, 57 caribou were observed within separate groups on this section of the island. In 1973, approximately 87% of caribou overwintering on Eglinton Island migrated to either Melville or Prince Patrick Island in spring or early summer to (Miller *et al*. 1977a). Nonetheless, 50% of caribou overwintering on Prince Patrick Island migrated to either Melville or Eglinton Island in spring or early summer to (Miller *et al*. 1977a).

Melville Island

The summer concentration for Peary caribou on Melville Island in July 1998 and 1999 was identified in the southern end of Dundas Peninsula (Larter and Nagy 2000b). They indicated that the majority of caribou in western Melville Island were gathered at this location. In June and July 1974, Miller *et al*. (1977a) indentified small groups of Peary caribou throughout Mellville Island (Figure 8-2). Data obtained from a study conducted in 1973 found that 40% more caribou spent the summer on Melville Island than during the winter (Miller *et al*. 1977a).

Prince Patrick Island

During June and July 1974, caribou congregated on the central eastern end of Prince Patrick Island, specifically on land near Domes point (14 caribou), Manson Point (162 caribou), and Wilkie Point (33 caribou) (Miller *et al*. 1977a) (Figure 8-2). In 1973, approximately 50% of caribou overwintering on Prince Patrick Island migrated to either Melville or Eglinton Island in spring or early summer (Miller *et al*. 1977a). On the other hand, approximately 87% of caribou overwintering on Eglinton island, migrated to either Melville or Prince Patrick Island in spring or early summer to (Miller *et al*. 1977a). In April 1974, 1234 caribou were observed wintering on Prince Patrick Island and only 46% remained for the summer months (Miller *et al*. 1977b).

8.4 Climate Change

Noticeable changes in climate are predicted for the Canadian arctic. For example, models have predicted an increase in the average air temperature, an increase in precipitation, and a decrease in ice and snow cover (Kattsov and Kallen 2005). Increased temperatures are resulting in increased vegetation biomass, reduced vegetation nutrition, and an increase in insect populations (Gunn *et al*. 2009). In addition to warmer temperatures, increased sea levels are also anticipated (Church and White 2006) as well as reduced or no ice cover (Stroeve *et al*. 2007). Despite the predications in future climate change, a small number of studies exist on the effects of climate change on wildlife (Tews *et al*. 2007).

Historically, climate change has affected Peary caribou populations and those populations have adapted (Ferguson 1996). Whether negative or positive, future climate change should also have an effect on Peary caribou populations (Tews *et al*. 2007). Only one modeling study exists on the effects of climate change on Peary caribou (Tews *et al*. 2007). In this study, model parameters consisted of the following: (1) increase in disturbance events, (2) increase in forage inaccessibility, and (3) increase in biomass. Study results indicated that a significant reduction in winter population loss may occur during severe years if biomass increases to 50% and if disturbance events do not effect foraging. Similarly, Harding (2004) suggested that increased temperatures and reduced snow cover periods could have a positive effect on Peary caribou populations. Negative impacts to Peary caribou populations are anticipated if harsh winter conditions result in a reduction of foraging availability by greater than 30% over the next 100 years (Tews *et al*. 2007). In general, future predicted climate change could have positive or negative effects on Peary caribou (Table 8-1) (e.g. COSEWIC 2004, Harding 2004, Tews *et al*. 2007).

Some evidence of climate change in the Arctic is already occurring and the changes may eventually have an impact on Peary caribou populations. For example, shrubs in the Arctic have expanded 320 km^2 over the past 50 years (Sturm *et al*. 2001). Therefore, extreme snow and ice cover events may not be an issue if taller and stronger plant species started growing in Peary caribou foraging grounds. In addition, sea levels are slowing rising (Church and White 2006), which may eventually force caribou to retreat to higher grounds (COSEWIC 2004). Furthermore, evidence exists that the Arctic sea ice extent has declined (Stroeve *et al*. 2007), which may eventually interfere or potentially eliminate Peary caribou inter-island movements. Although the future effects of climate change on Peary caribou are unknown and highly variable, Peary caribou have adapted to climate change in the past (Ferguson 1996).

Table 8-1 Suggested Climate Change and Anticipated Positive and Negative Effects on Peary Caribou

Suggested Climate Change	Anticipated Positive Effects	Anticipated Negative Effects
Warmer Winters	Reduction in energy utilization	• More rain and freezing events which can be detrimental to caribou survival
Warmer Summers	Increased vegetation growth	• Barren ground caribou may migrate into Peary caribou habitat (competition)
Warmer Weather Overall	• Warmer soils and increased soil depth may allow more plant growth and allow other plant species such as shrubs to grow. Shrubs are much taller than lichens and would not be an inaccessible food supply during ice and snow cover.	• Introduction of historically foreign parasites and diseases. • Invasive species • Increase or introduction of disruptive/parasitic insect species (mosquitoes, black flies, ticks, ect).
Change in sea ice dynamics		• Interference with inter-island movements
Increased periods of open sea water		• Increased cloud cover may reduce plant growth. • Interference with inter-island movements
Higher Sea Levels		• Proposed higher sea levels would force caribou to move to higher ground

8.5 Sustainability

Peary caribou populations in the Queen Elizabeth Islands are in decline (Miller and Gunn 2003) as were Banks Island populations (Fraser *et al*. 1992, McLean *et al*. 1992). More recently, however, Banks Island populations appear to be stable or slowly increasing (J. Nagy, pers. comm. February 2, 2004 *In* COSEWIC 2004). Human harvest, natural predation and poor winter conditions are all possible explanations for population declines (McLean and Fraser 1992). Miller and Gunn (2003) concluded that the most likely explanation for die-offs in their study was poor winter conditions leading to reduced foraging which ultimately lead to malnutrition and starvation.

Peary caribou populations within or near the PEMT Area receive territorial (NWT 2009a) and federal protection (SARA 2009) due to their territorial and federal listed status (see Section 8.2). Peary caribou are also protected by Land Claim Agreements with the Inuvialuit (COSEWIC 2004). In addition, Peary caribou are protected on Banks Island in Aulavik National Park which occurs in key Peary caribou habitat. In 2010, Peary caribou and their habitat will also be protected under the new Species at Risk (NWT) Act (NWT 2009b).

Hunting has been proposed as possible cause of population decline on Banks Island (McLean and Fraser 1992). In addition, Gunn *et al*. (2006) have suggested that decreasing harvest limits may aid in Peary caribou recovery. In the past, the Banks Island Peary caribou population was assessed as Endangered by COSEWIC in 1991 (COSEWIC 2004). In May 2004, the Peary caribou was assessed separately from barren-ground caribou, and based on an updated status report, were designated Endangered because the population continues to decline (COSEWIC 2004). Extended consultations are under way by the federal government to legally list Peary caribou as Endangered under Schedule 1 of the *Species At Risk Act*. Peary caribou are currently managed by Land Claim organizations and the Northwest Territories government. Together, these groups work to conserve Peary caribou while allowing reasonable harvest. Only subsistence hunting by Inuvialuit is allowed. Since 1991, residents of Sachs Harbour have had a hunting quota of 36 caribou (only one male) (Madsen 2001). Continued hunting management should sustain Peary caribou populations where they are hunted (e.g., Banks Island) (COSEWIC 2004). In general, caribou populations should not be negatively affected by hunting as long as biologists and communities agree on conservation (COSEWIC 2004).

Peary caribou population growth may occur intermittently over many years if wolf populations are stable and if good weather reduces extreme snow and ice condition (Miller and Barry 2009). Although weather cannot be controlled, managing wolf populations may aid in sustaining Peary caribou populations. For example, in 2001, population growth on Banks Island occurred after Inuit hunters increased the wolf harvest in the 1990’s (J. Nagy, pers. comm. 2004 *In* Gunn *et al*. 2006).

The effects of climate change are currently uncertain and may have positive and/or negative effects on Peary caribou (see Section 8.4).

8.6 Susceptibility to Development

Few studies have been conducted on the effects of human activity on Peary caribou (Beaks Consulting 1975, Miller and Gunn 1979, Gunn and Miller 1980, Miller and Gunn 1981). For example, Peary caribou appear to be highly tolerant to seismic vehicles; however, snowmobile activity within 100 m has been known to disrupt caribou (Beaks Consulting 1975). Several studies have been conducted on the response of Peary caribou to helicopter harassment (Miller and Gunn 1979, Gunn and Miller 1980, Miller and Gunn 1981). Peary caribou cows and calves are the most affected by helicopter harassment; however, they are quick to return to normal activities (Miller and Gunn 1979, Gunn and Miller 1980). In addition, calf play and excitability significantly increased during helicopter activity (Miller and Gunn 1981). Larger groups and groups containing calves appear to be more affected than smaller groups (Miller and Gunn 1979). Although the effect of helicopter activity on caribou appears to be minimal and temporary, the energy utilization during harassment and the long term effects are unknown (Miller and Gunn 1979).

No studies have been conducted on the long term effects of human industrial activities on Peary caribou. Miller and Gunn (1979) have made several comments regarding the anticipated effects of human activity on Peary caribou. For example, human activities could have a negative effect on daily feeding, inter-island migrations and movement, gene flow, and island restocking. In addition, Parker *et al*. (1975) suggested that the effects of industrial activities occurring near malnourished caribou populations could be significant. Further Miller *et al*. (1977a) indicated that the effects of a pipeline in the Arctic would be difficult to determine due to the inter-island seasonal Peary caribou movements. Further research is needed to determine the long term effects of anthropogenic activities on Peary caribou populations.

Potential Residual Effects of Industrial Disturbance

Short or long term industrial disturbances may have residual impacts on Peary caribou populations. Industrial activities on land or in between the western Queen Elizabeth Islands would likely have a greater impact on caribou than activities in the Beaufort Sea or the McClure Strait. A major concern is that future shipping traffic and early/late season ice breaking has the potential to disrupt Peary caribou migration between Banks and Victoria Island.

Residual effects from industrial activity may result in either complete loss of habitat, as is common with the ‘footprint’ of industrial developments, or effective habitat loss, whereby Peary caribou avoid habitat in proximity to development. Industrial activities may also cause Peary caribou to alter migration routes to less preferred or longer routes. Further, industrial disturbances may increase result in additional energy losses. Potential residual implications of long term industrial development on Peary caribou within or near the PEMT Area include:

- Disruption or loss of critical calving grounds
- Disruption or loss of key summer and winter ranges
- Interference of movement and migration between critical habitat areas.
- Increased energy losses due to an increase in industrial disturbance

Peary caribou are most vulnerable at the end of winter (Miller *et al*. 1982), especially during severe winters (Miller and Gunn 2003). Increased energy losses due to an increase in industrial disturbance during these severe winters may be detrimental to the survival of a population. Therefore, additional mitigation and restrictions for industrial activities may be necessary near key habitat areas and migrations routes during late winter and early spring.

8.7 Mitigation

According to the reviewed literature, Peary caribou are most sensitive and vulnerable during inter-island winter migrations, during calving season and at key wintering and summering grounds. Activities which have the potential to negatively impact Peary caribou include:

- Any winter activities (e.g. shipping traffic and early/late season ice breaking) occurring between Banks Island and Victoria Island and near Prince Patrick Island and Eglinton Island.
- Low flying aircraft near key habitat areas (Figure 8-2).
- Open water activities occurring close to shore.
- On land activities (e.g. camps, access roads, pipelines, lease sites, air strips, aircraft fuelling stations, etc.) near key habitat areas and between migration routes.

There are strategies that can be applied to project-specific mitigation planning, based on the summary of project specific residual effects, key habitat, the seasonality of caribou movements, and the criteria used to define the grid rating. These considerations should not be interpreted as a prescription for actions imminently required; rather, they are strategies that may be valuable in project planning.

- Permits may be required from associated federal and territorial governments if industrial activities are proposed in caribou habitat.
- Avoid industrial harassment or disturbance to Peary caribou. Permit terms and conditions typically disallow industrial harassment
- Spill response plan and contingency plan
- Reduce or eliminate anthropogenic disturbance or activities near calving grounds from April to August
- Reduce or eliminate anthropogenic disturbance or activities near key summer and winter ranges.
- Avoid interfering or disrupting caribou movements and migration

- Additional mitigation and restrictions for industrial activities may be necessary near key habitat areas and migrations routes during late winter and early spring.

8.8 Sensitivity Layers

Areas of higher sensitivity are typically those that support quality feeding areas, as well as movement and migratory corridors necessary for year-over-year survival. As with other VECs, when assessing a grid cell for sensitivity to development, all time periods should be considered. Habitats that support key life stages are important to identify regardless of the season at which it is most used, because habitat loss that occurs in one season may have impacts that extend beyond that season of impact.

Summer season: May 1 to October 31 Sensitivity (Figure 8-3)

Key calving grounds are located in the northeast, southeast, and northwest sections of Banks Island (Larter and Nagy 2000a, Kevan 1974). Kevan (1974) indicated that identified areas in the northern end of Banks Island should be considered critical for caribou survival in the spring (Figure 8-2). Summer grounds for Peary caribou are located in the northwest (Larter and Nagy 2000a, Kevan 1974).

- **Low/Moderate Sensitivity (2):** The rest of Banks Island which is not identified as calving grounds, summer grounds, or wintering grounds is considered low/moderate sensitivity due to migration between these grounds during the spring and fall. These areas would be most sensitive during spring migration (April to June). And fall migration (August to October). Peary caribou can also be dispersed in low densities throughout the island.
- **Moderate Sensitivity (3):** Known key wintering grounds
- **Moderate/High Sensitivity (4):** Summer grounds for Peary caribou are located in the north-west of Banks Island.
- **High Sensitivity (5):** Calving grounds in the north-east, south-east, and north-west sections of Banks Island. These areas would be most sensitive from May until August.

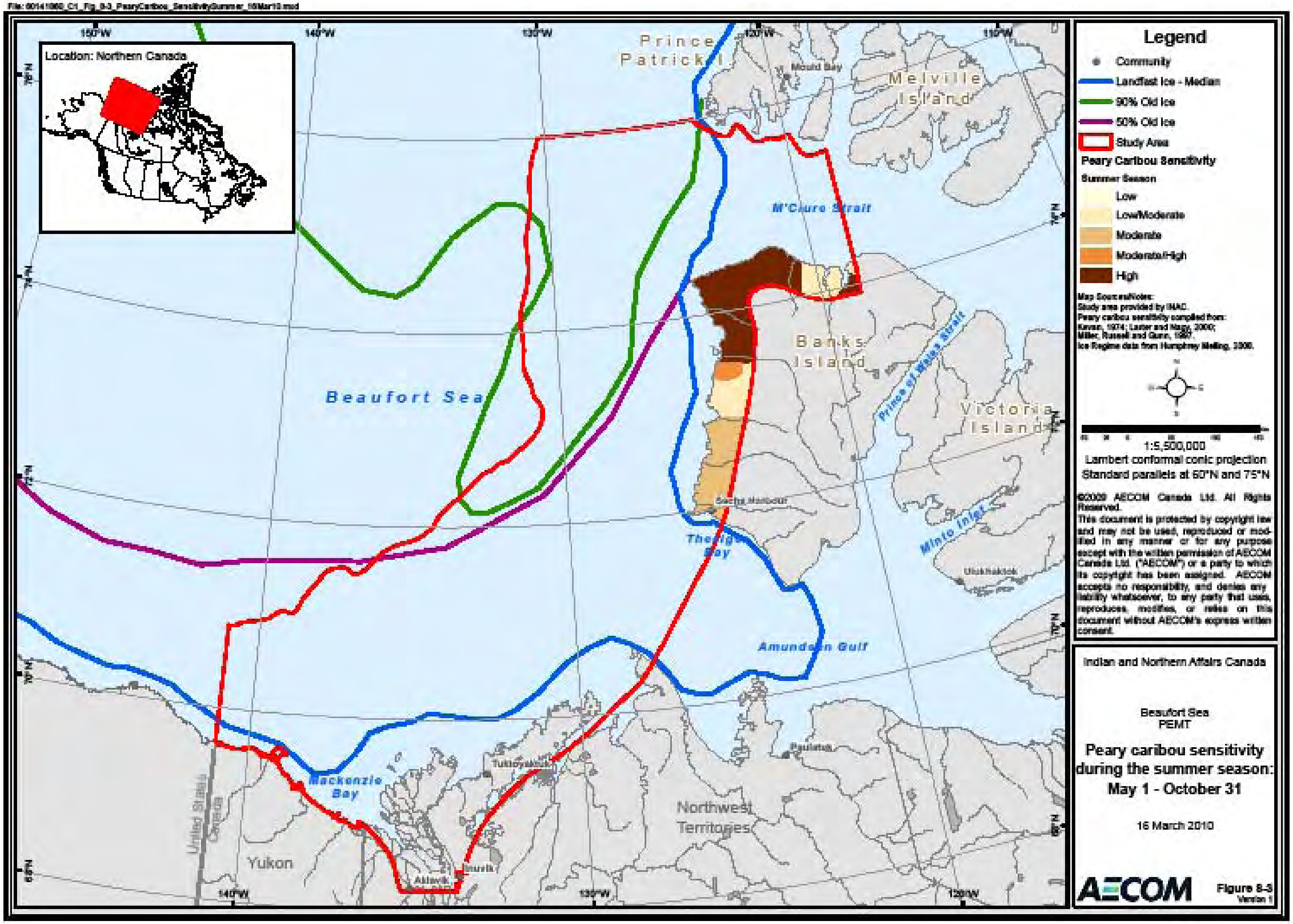


Figure 8-3 Peary caribou sensitivity during the summer season: May 1 to October 31

Winter season: November 1 to April 30 Sensitivity (Figure 8-4)

The winter range has been identified in the south-west section of Banks Island (Larter and Nagy 2000a). Peary caribou are most vulnerable at the end of winter (Miller et al. 1982), especially during severe winters (Miller and Gunn 2003). Increased energy losses due to an increase in industrial disturbance during these severe winters may be detrimental to the survival of a population. Thus, higher risk category is associated with important wintering habitat.

- **Low/Moderate Sensitivity (2):** Summer grounds located in the northwest of Banks Island. The rest of Banks Island which is not identified as calving grounds, summer grounds, or wintering grounds is considered low/moderate sensitivity due to migration between these grounds during the spring and fall. These areas would be most sensitive during spring migration (April to June). And fall migration (September to October). Peary caribou can also be dispersed in low densities throughout the island.
- **Moderate Sensitivity (3):** Calving grounds located in the northeast, southeast, and northwest sections of Banks Island.
- **Moderate/High Sensitivity (4):** Wintering grounds located in the southwest section of Banks Island (October to April)

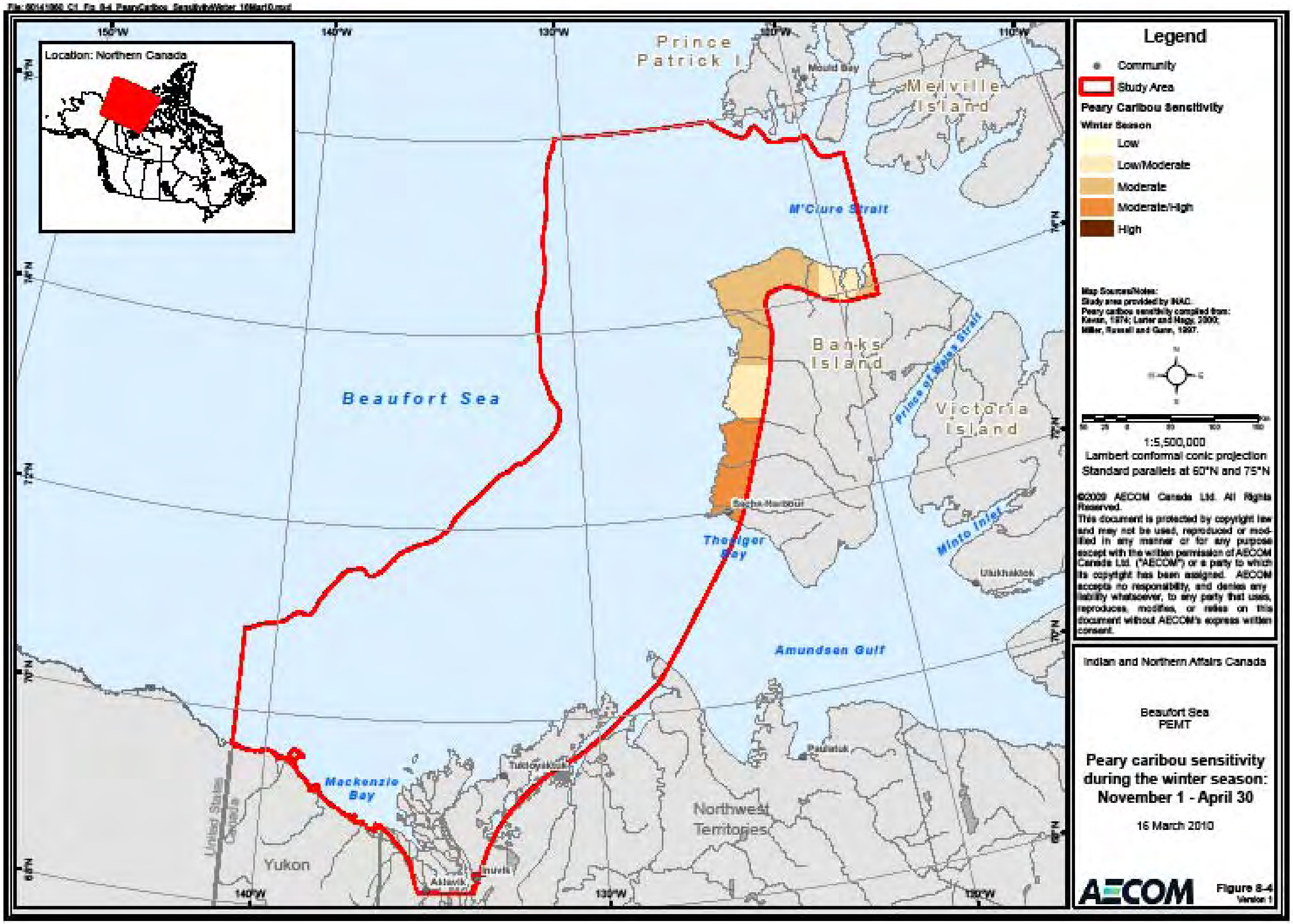


Figure 8-4 Peary caribou sensitivity during the winter Season: November 1 - April 30

8.9 Summary

The Peary Caribou was largely selected as a VEC due to their cultural and nutritional importance to Inuit communities. In the Northwest Territories, Peary caribou are listed as *At Risk* (NWT 2009a). Federally, the Banks Island and High Arctic populations of Peary Caribou are listed as *Endangered* under Schedule 2 of the *Species at Risk Act* and the Low Arctic population is listed as *Threatened* under Schedule 2 (SARA 2009). Within the study area Peary caribou are located on Banks Island throughout the year. Key calving grounds are located in the north-east, south-east, and north-west sections of Banks Island from May until August. Summer grounds for Peary caribou are located in the north-west of Banks Island. The winter range for Peary caribou is located in the south-west of Banks Island. In the study area, movement occurs between summer, winter and calving grounds in the spring and fall. Migration is also known to occur between Banks and north-western Victoria Island. Migration has not been documented between Banks Island and the western Queen Elizabeth Islands.

One modeling study exists on the effects of climate change on Peary caribou (Tews *et al*. 2007). Negative impacts to Peary caribou populations are anticipated if harsh winter conditions result in a reduction of foraging availability by greater than 30% over the next 100 years; however, increased temperatures and reduced snow cover periods could have a positive effect on Peary caribou populations.

Potential impacts from industrial activity include man-made noise impacts, low flying aircraft, anthropogenic development on Bank’s Island and shipping during ice cover in between islands of known movements. Industrial activities near on in active calving grounds, active wintering grounds, and active migration routes could potentially have a long term negative impact on the population.

The sensitivity layers established for Peary caribou reflect the environmental sensitivity of an area should development occur. There is a variety of potential project types that vary in spatial extent, duration, and intensity, with a corresponding range in magnitude of impacts that may occur in the project area. Within the PEMT study area on Banks Island, the most sensitive areas would include calving grounds from May to August and wintering grounds from October to April.

There are strategies that can be applied to project-specific mitigation planning, based on the summary of project- specific residual effects, key habitat, the seasonality of caribou movements, and the criteria used to define the grid rating. These considerations should not be interpreted strategies that may be valuable in project planning.

9. Traditional Hunting

9.1 Description

For the purpose of developing the petroleum and environment management tool, traditional hunting of polar bears, beluga whales, ringed seals, and migratory birds was selected as the VSEC. Polar bears, beluga whales, ringed seals, and migratory birds were examined from a socio-economic and cultural perspective because of the important role they play in subsistence economies and cultural sustainability. The information for this VSEC is based primarily on the Community Conservation Plans ("CCPs" or "Plans") for the Inuvialuit communities of Aklavik, Inuvik, Tuktoyaktuk and Sachs Harbour (WMAC 2000a, b, c, d), and a study on the Inuvialuit use of resources in the Beaufort Sea during the 1960s and 1990s (Usher 2002). The CCPs for Ulukhaktok, and Paulatuk were not considered in this research because the Plans do not overlap with the study area.

9.2 Rationale for Selection

The Inuvialuit of the Beaufort Sea coastal area have relied upon the area's wildlife for many years. Hunting (and trapping) continues to be of cultural, social and spiritual importance for Inuvialuit communities, as well as, economic importance. The CCPs were developed to help protect the environment in the Mackenzie Delta / Beaufort Sea coastal, onshore and offshore areas to ensure cultural survival of the Inuvialuit Community. One of the goals of the CCP is to identify and protect important wildlife habitat, seasonal harvesting areas and cultural sites (e.g., cabin sites) and make recommendations for the conservation and management of the resources on which priority lifestyles depend. Oil pollution represents a threat to the area wildlife that is the foundation of subsistence livelihood and part of gross income. Section 13 of the Inuvialuit Final Agreement (IFA) identifies a wildlife compensation and liability regime for damages resulting from development.

13. (1) The objectives of this section are:
   a) to prevent damage to wildlife and its habitat and to avoid disruption of Inuvialuit harvesting activities by reason of development; and
   b) if damage occurs, to restore wildlife and its habitat as far as is practicable to its original state and to compensate Inuvialuit hunters, trappers and fishermen for the loss of their subsistence or commercial harvesting opportunities.

13. (12) The Government agrees that every proposed development of consequence to the Inuvialuit Settlement Region that is within its jurisdiction and that could have a significant negative impact on wildlife habitat or on present or future wildlife harvesting will be authorized only after due scrutiny of and attention to all environmental concerns and subject to reasonable mitigative and remedial provisions being imposed.

9.3 Key Habitats

Several onshore and offshore areas in the Beaufort Sea are used as traditional hunting areas for arctic species. These areas are organized by species and their associated land marks below.

Polar Bear

Tuktoyaktuk Peninsula

- Offshore of the Tuktoyaktuk Peninsula from west of Pelly Island east to Franklin Bay is a key area for subsistence harvesting of polar bear during the winter (WMAC 2000c).

Banks Island

- Offshore and coastal habitats of Banks Island are important past and present traditional hunting areas for polar bears (Nov. – May) (WMAC 2000d).

Beluga Whales

Mackenzie Bay

- Mackenzie Bay is within the Beluga Management Zone 1A with three whaling camps used between June 15 to August 15 (WMAC 2000a). These camps are located at Shingle Point, Running River and Bird Camp.

Kendall Island

- This island is adjacent to the Beluga Management Zone 1A and supports a summer whaling camp for the Inuvik people (WMAC 2000a).

Kugmallit Bay

- The Bay is within the Beluga Management Zone 1A & 2 (WMAC 2000a).
- Four whaling camps of Tuktoyaktuk and Inuvik people occur around the bay including camps at West and East Whitefish station, Ikinaluk and on Hendrickson Island (WMAC 2000a, North/South Consultants Inc. 2003).

Ringed Seal

Tuktoyaktuk Peninsula

- Coastal areas off the Tuktoyaktuk Peninsula including Kugmallit Bay extending north to Atkinson Bay; Liverpool Bay/Wood Bay, extending through Fingers Area, into Husky Lakes provide habitat for fall seal harvesting (WMAC 2000c).
- Winter seal harvesting areas is provided on sea ice off the Tuktoyaktuk Peninsula from Baillie Island west to Pelly Island and north (WMAC 2000c).
- Spring harvesting of seals is provided in the eastern portion of Husky Lakes just inside the Finger Lakes area from April to June.

Banks Island

- Offshore and coastal habitats of Banks Island are important past and present traditional hunting areas for year round seal hunting (WMAC 2000d).
- Subsistence harvesting of ringed and bearded seals occurs from March to May and year round at Thesiger Bay.

Migratory Birds

Tuktoyaktuk Peninsula

- Land from Mackenzie Bay to Liverpool Bay including Pullen Island and Kugmallit Bay provides fall goose harvesting habitat (WMAC 2000c).
- Areas of the Beaufort Sea surrounding Garry Island, Pelly Island and Hooper Island, McKinley Bay, lands east of Kugmallit Bay and and Hutchison Bay provide summer goose harvesting areas (WMAC 2000c).
- Spring goose harvesting areas are present along Islands in the western portion of the Mackenzie River Estuary, from eastern Richards Island to Mason River Estuary including all of the Tuktoyaktuk Peninsula and the Husky Lakes area (WMAC 2000c).

- Fall goose hunting areas include all of the coastline from Yukon/Alaska border in the west, to the Mason River in the east, including sites on Anderson River and Crossley Lakes.

Mackenzie Bay.

- This area provides important past and present subsistence harvesting area for waterfowl (June to September).

Banks Island.

- Offshore and coastal habitats of Banks Island are important past and present traditional hunting areas for waterfowl (May – Sept.) (WMAC 2000d).
- Sachs River and the area near Kellet Point are areas where migrating waterfowl (particularly Black Brant and Eiders) have been harvested in the fall (Kay et al. 2006).
- The Community Working Group has identified the Kellet and Lennie River areas as important subsistence harvest area for geese.

Caribou

Tuktoyaktuk Peninsula.

- Land surrounding Husky Lakes, from Kugmallit Bay to Liverpool Bay provide spring, summer fall and winter caribou harvesting areas (WMAC 2000c).

Banks Island.

- Sachs, Kellett and Lennie Rivers and Siksik and Survey lakes - Important to past and present year round harvest for caribou (WMAC 2000d).
- Southern Banks Island (defined as Area 604C in the Sachs Harbour CCP) – this area of importance runs from Lennie River north including portions of the Big River along the coast to Haswell Point. This area provides subsistence harvesting for caribou from July – December (WMAC 2000d).

9.4 Climate Change

Despite changes in today’s world, the importance of wildlife to Inuit remains as true as it ever was as a food source, a cultural source, a knowledge source, a spiritual and inspirational source, and a livelihood source. Changes in the extent and concentration of sea ice may alter the seasonal distributions, geographic ranges, patterns of migration, nutritional status, reproductive success, and the abundance and population structure of some species. Because of the importance of belugas, migratory birds, and ringed seals as a principal food source or resource, there is concern regarding climate change and the resultant changes in sea ice and coastal habitat, which may eventually change animal movements, breeding and feeding behaviour, geographic ranges, and hunter access to the resource. Any reduction in abundance and distribution of these species would also lead to a change in dietary habits and cultural practices.

Climate change can have impact on the availability and use of species for traditional food. Historically, Arctic people are used to adapting to a changing environment; however, the current rate and extent of climate change may be outside of their historical experience (Riedlinger 1999*).* Climate changes observed in the 1990s were said to be without precedent and outside the range of variation that the Inuvialuit consider normal (Berkes and Jolly 2001).

Harvesting impacts from climate change included changes in access to resources, safety, predictability, and species availability (Berkes and Jolly 2001). Climate can be a determining factor on the access to harvesting areas. Faster snow melt and breakup of river ice due to warmer springs and deeper, softer snow fall can make it difficult to access some area and can shorten the length of time for harvesting (Berkes and Jolly 2001). These changes also make predicting safety of the environment difficult. Those hunting areas closer to shore, such as ice leads, may be less risky than areas farther offshore (Laidler *et al.* 2006). Ice movement in winter and spring in the 1990's was found to be less predictable with more movement, overall thinning and changes in the distribution of pressure ridges, and cracks and leads (Berkes and Jolly 2001).

All of these climatic changes in the environment impacts the availability of some species and can reduce access to traditional food (Ford *et al.* 2008). Some traditional harvesting areas maybe unavailable or shortened due to access difficulties or some may no longer provide key harvesting areas due to species response to a changed environment. In those areas where species are still available, hunting conditions (e.g., visibility of seals on summer ice), can be more difficult due to the changed environment (Berkes and Jolly 2001).

9.5 Sustainability

The total area used for hunting by the Inuvialuit has not changed much since the 1960s, but there has been a decline in the number of harvesters and a shift from full-time to part-time harvesting (Usher 2002). The mean annual harvest of country food has declined from the 1960s to the 1990s (Table 9-1). There are several reasons for the decline; principally, the abandonment of dogs (which were primarily fed marine species of seal and whitefish) for transportation; the increased use of snowmobiles and the shift from full-time to part-time harvesting. These changes in lifestyle have led to an overall shift from marine to terrestrial country food sources. While the total amount of country food produced has declined, the amount consumed by Inuvialuit has increased. Subsistence harvesting thus continues to persist as significant economic and cultural practices in the region (Usher 2002).

Table 9-1 Mean Annual Inuvialuit Harvest of Selected Species, 1960-65 and 1988-97

Species	1960-65	1988-97
Marine Mammals		
beluga	83	117
ringed seals	4900	1085
polar bear	68	56
Terrestrial Mammals		
caribou	1300	3114
muskox	0	327
moose	60	28
muskrat	98000	10019
arctic fox	5300	1384
Marine and anadromous fish (kg)	400000	92034
Freshwater fish (kg)	40000	17450

Source: Usher 2002.

Hunters typically show an affinity for particular harvesting areas (Bromley 1996; Byers and Dickson 2001). Much of the terrestrial wildlife harvesting occurs near the coast, due to the ease of transport and accessibility. To sustainably manage their resources, the Inuvialuit have designated special areas and recommended land use practices for their planning areas. In designating land management categories, the communities have prioritized land uses and activities, in addition to denoting areas of special ecological and cultural importance.

Polar Bears

Currently, polar bear sport hunts account for half of the total harvests in the Inuvialuit Settlement Area, mainly in Sachs Harbour, Holman (now Ulukhaktok), Paulatuk, and Tuktoyaktuk (Usher 2002). The polar bear harvest is managed via a quota system that allocates bears to each community in the study area. Prior to the establishment of quotas, populations were in decline (Stirling 2002), but have recovered since that time and are considered stable (COSEWIC 2002). Traditional uses of polar bears in the three communities include the occasional consumption of their meat and the use of their fur for clothing (WMAC 2000a, b, c, d).

Beluga Whales

The Inuvialuit have a long history of hunting beluga and rely on them for subsistence (Fast *et al.* 1998; Harwood and Smith 2002). Beluga whales remain a highly valued food source in the four communities under study (WMAC 2000a, b, c, d). Table 9-1 shows that the mean annual beluga harvest has increased from 83 in the 1960s to 117 (nearly 50% higher) in the 1990s. This harvest effort is supported by the Inuvialuit Joint Secretariat, which states that the difference in numbers is not significant and that the beluga harvest has not increased significantly over the years (Richard Binder, pers. comm., 2007). The current annual harvest varies between 100-130 animals.

Ringed Seals

Seals have been a reliable source of heating oil, meat and pelts for Inuvialuit hunters. The ringed seal is an important species in the subsistence harvest and economy of the three communities, particularly in Tuktoyaktuk, but it is shifting due to changes in technology. Seals were the primary source of dog feed in the 1960s and their harvest declined between the 1960s and the 1990s, due to the shift to snowmobiles from dog teams. A secondary factor in reduced harvests was the decline in pelt prices, due to European and American import bans (Usher 2002).

Seals continue to be harvested for consumption by humans and dogs. They are also harvested for their pelts, which are used in handicrafts and clothing (i.e., boots and mittens) (WMAC 2000a, b, c, d).

Caribou

Caribou are an important traditional food source for northern communities. When harvesting caribou for their own use, there are few limitations to aboriginal hunters. Allowable harvest for game is determined by the Wildlife Management Advisory Council (NWT) of the Inuvialuit Final Agreement to ensure long term resource conservation. Three herds within the Beaufort Sea study area provide harvesting sources for Inuvialuit use: the Cape Bathurst and the Bluenose West con the mainland and the Peary caribou herd on Banks Island (GNWT 2009). Both Cape Bathurst and Bluenose West herds have shown population declines (GNWT 2009) and are listed as *Sensitive* in the NWT (GNWT 2009). The Peary caribou herd is listed as *Endangered* by COSEWIC and *At Risk* in the NWT, and more recent surveys show the population on Banks Island appears to be stable or slowly increasing (J. Nagy, pers. comm. February 2, 2004 In COSEWIC 2004).

Migratory Birds

Many species of waterfowl in the Beaufort Sea are harvested for subsistence purposes including ducks, geese and tundra swan. Waterfowl have cultural, social and spiritual well-being importance (Usher 2002). The Inuvialuit are concerned about the regional management of waterfowl as some of their populations are declining, in particular king eider, common eider and black brant (WMAC 1999; 2000a, b, c, d).

Ducks: *King Eider and Common Eider* – The Inuvialuit traditionally consume the king eider and common eider in the spring and fall. King eiders comprise 96% of the total eider harvest with the majority of the harvest occurring in June (Fabijan *et al.* 1997; WMAC 1999; Byers and Dickson 2001).

Geese and Tundra Swan: *Canada Goose, Snow Goose, White-fronted Goose, Brant Swan and Tundra Swan* - Geese and tundra swans are important food sources and as a source of feathers for pillows and blankets. Over one-third of Inuvialuit harvesters hunt snow geese (Usher 2002). Lesser snow geese comprise approximately 70% of the goose and swan harvest, with the majority of the harvest occurring in the spring (Bromley 1996).

9.6 Susceptibility to Development

Hunting is susceptible to development in the following ways: loss of access to hunting areas, loss of the species being pursued, change in technology, and loss of hunting time to employment. Changes in technology and loss of time to employment have had an impact on the cultural role of hunting. Hunting, while still a family event is compressed in time to weekends or days off and renewing contact with the land, as well as the passing of knowledge and skills of a traditional lifestyle are affected. Accelerated oil and gas exploration may result in further declines in hunting activities (Byers and Dickson 2001).

The harvest of large marine mammals and migratory waterfowl is highly restricted in time and space (Usher and Wenzel 1987). Inuvialuit consistently harvest in the same areas for reasons of access and known congregation of animals. Many of these harvest areas are seasonally important for wildlife species (e.g., migration, nesting, denning). The coastal and offshore regions of the study area overlap much of the area where Inuvialuit hunters harvest polar bears. Oil and gas activities related to petroleum development might affect the movements of polar bears and make them less available for hunting, or interfere with their denning sites (Perham 2005). Polar bears are also susceptible to any changes in their food supply due to tainting, spills and disruption due to noise (Report of the Scientific Review Panel 2002). This may also cause polar bears to move from an area of disturbance and affect hunting.

Seals may be affected by changes to their food supply such as tainting. Seals do not avoid oiled areas. This has implications for birthing and nursing pups. As a result, an increase in pup mortality has been observed, in addition to eye and brain damage (Report of the Scientific Review Panel 2002). These changes could affect hunting and access to hunting areas, at least temporarily.

Whales do not avoid areas that have been oiled or otherwise contaminated. They do avoid areas where there are explosions by seismic airgun arrays by moving to the surface, hiding in acoustical shadows, move apart or simply avoid an area. (Report of the Scientific Review Panel 2002). These behavioural changes have been observed by Alaska natives.

Migratory birds are an integral part of the food chain. They consume vegetation, zooplankton, shellfish and fish. Changes in food supply and oiling has been shown to result in mortality, reduced reproduction, growth and distribution. Each of these activities interferes with hunting.

Harvesting activities have an economic role, providing food and cash income, and a cultural role, as a family event and renewing contact with the land and passing on the knowledge and skills of a traditional lifestyle. Accelerated oil and gas exploration may result in significant changes to employment and income patterns, which has the potential of replacing a predominantly subsistence economy with an increasingly dominant wage economy resulting in a decline in fishing and hunting activities (Byers and Dickson 2001).

9.7 Mitigation

Oil pollution represents a threat to the area wildlife that is the foundation of subsistence livelihood and part of gross income. Section 13 of the Inuvialuit Final Agreement (IFA) identifies a wildlife compensation and liability regime for damages resulting from development.

13. (1) The objectives of this section are:
  c) to prevent damage to wildlife and its habitat and to avoid disruption of Inuvialuit harvesting activities by reason of development; and
  d) if damage occurs, to restore wildlife and its habitat as far as is practicable to its original state and to compensate Inuvialuit hunters, trappers and fishermen for the loss of their subsistence or commercial harvesting opportunities.

Subject to Section 13(3), the Inuvialuit shall be compensated for actual wildlife harvest loss resulting from development in the Inuvialuit Settlement Region, and Section 13(4) shall benefit from environmental protection measures designed to reduce future harvest loss resulting from development in the Inuvialuit Settlement Region.

13. (12) The Government agrees that every proposed development of consequence to the Inuvialuit Settlement Region that is within its jurisdiction and that could have a significant negative impact on wildlife habitat or on present or future wildlife harvesting will be authorized only after due scrutiny of and attention to all environmental concerns and subject to reasonable mitigative and remedial provisions being imposed.

Mitigative measures include:

- Identifying valued wildlife species. Valued wildlife species are limited to those harvested species of the ISR that may be affected by an oil spill.
- Assessing wildlife species vulnerability and sensitivity to oil spills. Vulnerability refers to the likelihood of key habitat being impacted and sensitivity refers to response at a population level (short-term or long-term) based on reproductive capacity.
- The Inuvialuit Community, the Wildlife Management Advisory Council (WMAC (NWT), Fisheries Joint Management Committee (FJMC), Inuvialuit Game Council (IGC), Environmental Impact Screening Committee (EISC), Environmental Impact Review Board (EIRB) and Inuvialuit Land Administration (ILA) will rely on their procedures, the Inuvik Inuvialuit Community Conservation Plan and the provisions of the IFA to ensure the protection of the Inuvik community harvesting areas that are within the ISR
- All regulatory agencies support the priority land uses as outlined in the Community Conservation Plans
- To ensure the protection of the wildlife resource and harvest, HTCs should be consulted regarding any licenses, permits or operating procedures approved for activities within the zones.
- All shipping activities (including dredging) should be confined to designated routes and areas. Passage through or close to Zone 1 outside of designated routes should be avoided from break-up to 15 August as outlined in the Beluga Management Plan (FJMC 1998).
- Ensure that waterfowl and their habitat are protected from industrial activities and other projects in the area from May 1 to September 30
- ensure no air traffic related to non-renewable resource development is allowed within a 16 km (10 mi.) Radius of the centre of the bird sanctuary and below 914 m (3000 ft.) between May 1 and September 30.
- Industrial activities or other projects may be permitted if they do not adversely affect the conservation of the wildlife resource and the protection of wildlife habitat and harvesting, and they are conducted in a controlled and responsible manner.

- The Beluga Management Plan recommends that no oil and gas, seismic or production activities be allowed within Beluga Management Zone 1a from break-up to August 15.

9.8 Sensitivity Layers

Community Conservation Plans were developed to help protect the environment in the Mackenzie Delta area and onshore and offshore areas of the Beaufort Sea. Within the CCPs, important wildlife habitat and/or harvesting areas have been identified. These areas were assigned management categories according to ecological and cultural importance, need to conserve a renewable resource, and need to protect priority activities. Figure 9-1 includes all areas identified in the CCP's as important areas to Inuvialuit. As the Inuvialuit had already created a five-part classification system consistent with the classification system being used in developing the decision-support tool, their system of classification was adopted for the purposes of this project. Categories A to E were used to create a base rating system for sensitivity layers. Sensitivity ratings 1 to 5 correspond to Categories A to E, respectively. Definitions of the CCP's Category's are provided below:

Category A: represents lands and waters where there are no known significant and sensitive cultural or renewable resources.

Category B: represents lands and waters where there are cultural or renewable resources of some significance and sensitivity.

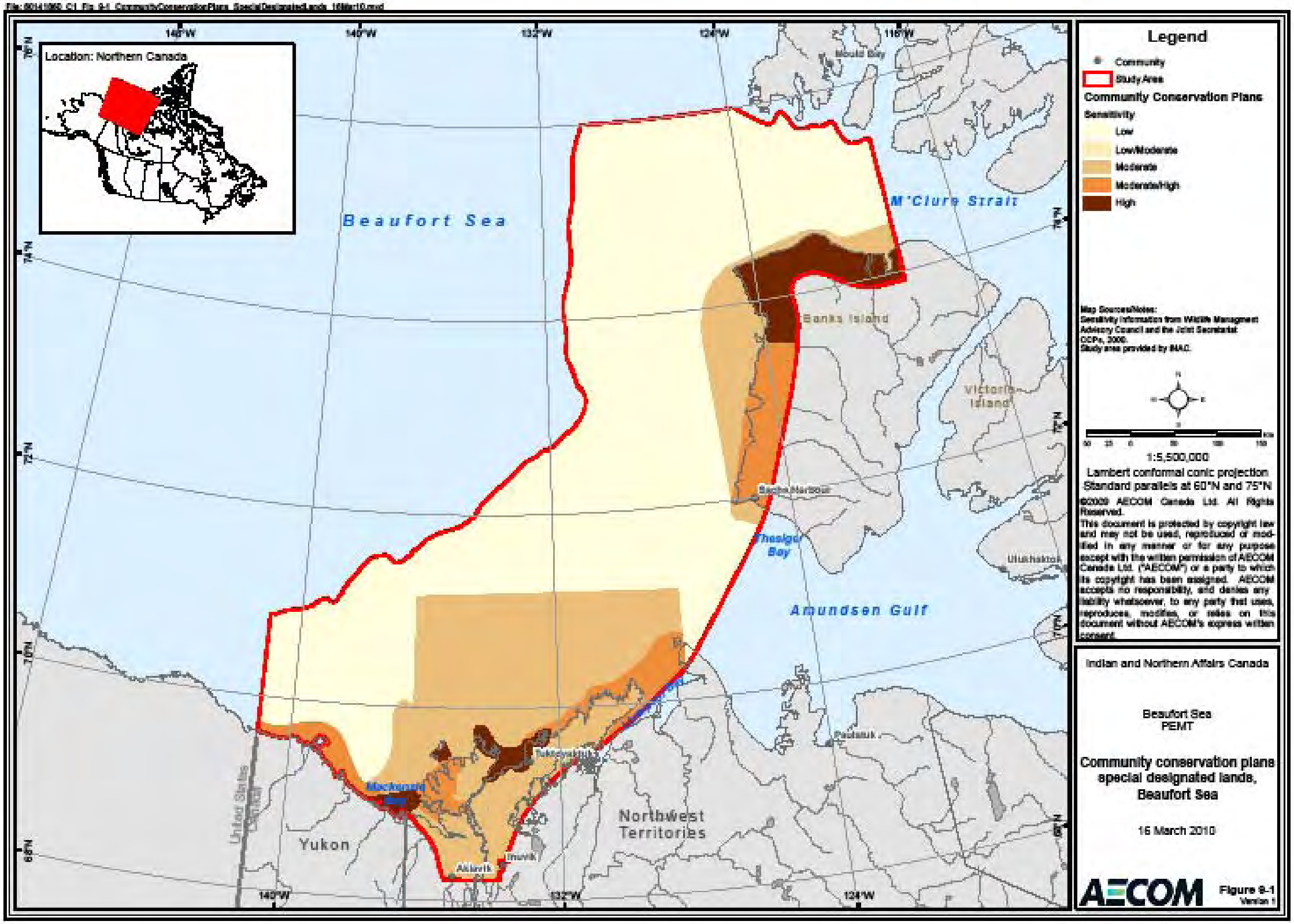
Category C: represents lands and waters where cultural or renewable resources are of particular significance and sensitivity during specific times of the year.

Category D: represents lands and waters where cultural or renewable resources are of particular significance and sensitivity throughout the year.

Category E: represents lands and waters where cultural or renewable resources are of extreme significance and sensitivity.

In addition, to the areas defined by Categories A to E in the CCP's, we identified areas during ice-covered and open water seasons that were identified for harvesting as well as important for the biology of harvest species. Areas of higher sensitivity are typically those that supported quality harvesting areas and were identified as biologically important to hunted species.

Figure 9-1



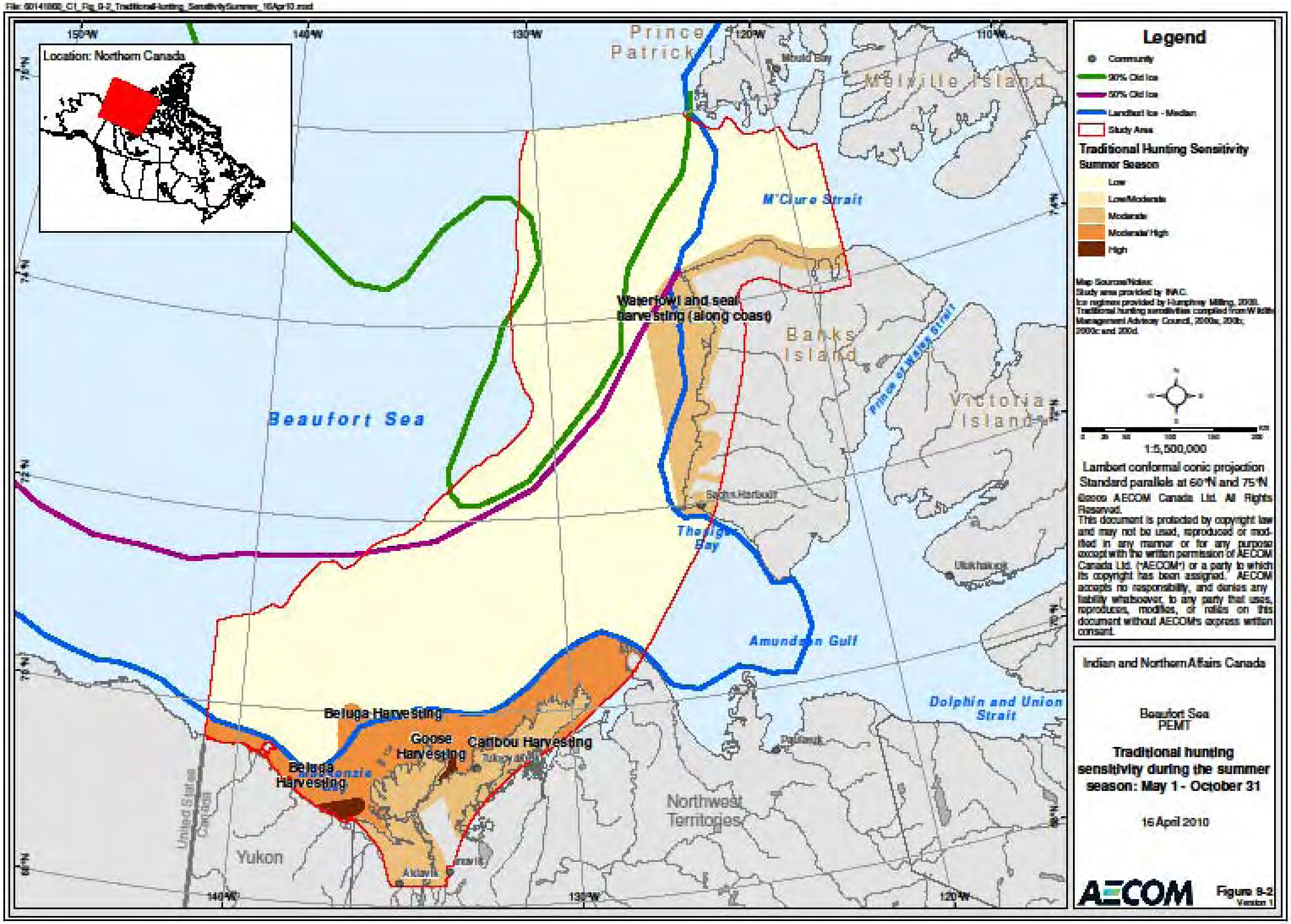
Community Conservation Plans special designated lands, Beaufort Sea

Summer Season May 1 to October 31 Sensitivity (Figure 9-2)

During the open-water season several harvesting areas are important to the Inuvialuit (WMAC 2000a, b, c, d). Several species are important sources for hunting from summer to fall including waterfowl, caribou, goose, beluga and seal.

- **Low Sensitivity (1):** Harvesting areas identified in the CCP's as Category A; Landfast ice 50% Old Ice and greater.
- **Low/Moderate Sensitivity (2):** Harvesting areas identified in the CCP's as Category B;
- **Moderate Sensitivity (3): Ha**rvesting areas identified in the CCP's as Category C including seal harvesting and waterfowl hunting areas offshore of Banks Island.
- **Moderate/High Sensitivity (4):** Harvesting areas identified in the CCP's as Category D; Beluga Management Zone 2 which provides biological support to beluga during open-water season.
- **High Sensitivity (5):** Harvesting areas identified in the CCP's as Category E including Beluga Management Zone 1A which encompasses the only known traditional summer concentration areas for the Beaufort Sea beluga stock.

Figure 9-2 Traditional hunting sensitivity during the summer season: May 1 to October 31



Map Sources/Notes:
Study area provided by INAC.
Ice regimes provided by Humphrey Milling, 2008.
Traditional hunting sensitivities compiled from Wildlife Management Advisory Council, 2000a, 2000b, 2000c and 2000d.

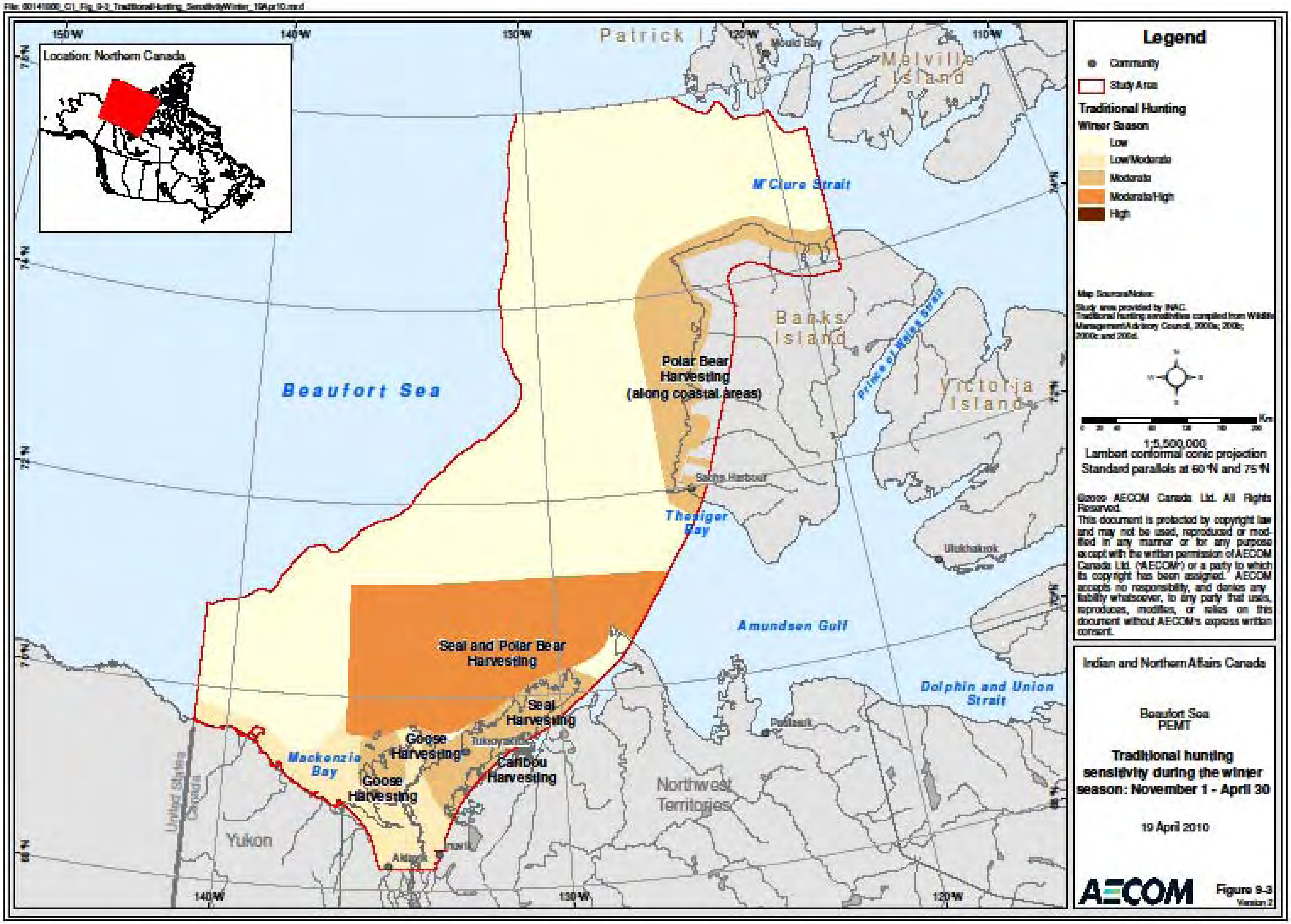
Lambert conformal conic projection
Standard parallels at 60°N and 75°N

Winter Season November 1 to April 30 Sensitivity (Figure 9-3)

During the ice-covered season several harvesting areas are important to the Inuvialuit (WMAC 2000a, b, c, d). Several species are important sources for hunting during winter and spring including caribou, goose, polar bear, beluga and seal.

- **Low Sensitivity (1):** Harvesting areas identified in the CCP's as Category A.
- **Low/Moderate Sensitivity (2):** Harvesting areas identified in the CCP's as Category B.
- **Moderate Sensitivity (3):** Harvesting areas identified in the CCP's as Category C; offshore areas along Tuktoyaktuk Peninsula and Mackenzie Bay,; caribou harvesting areas on mainland of Banks Island and Tuktoyaktuk Peninsula; goose harvesting areas on mainland Tuktoyaktuk Peninsula; and seal and polar bear harvesting area offshore of Tuktoyaktuk Peninsula and Mackenzie Bay.
- **Moderate/High Sensitivity (4):** Harvesting areas identified in the CCP's as Category D; Polar bear hunting areas offshore of Banks Island.
- **High Sensitivity (5):** Harvesting areas identified in the CCP's as Category E.

Figure 9-3 Traditional hunting sensitivity during the winter season: November 1 - April 30



9.9 Summary

The hunting of polar bears, beluga whales, ringed seals, and migratory birds were identified as crucial socio-economic and cultural components. This is true for the four Inuvialuit communities in the study area: Aklavik, Inuvik, Tuktoyaktuk, and Sachs Harbour. These species are still consumed for food and used for clothing. The four communities continue to sustain their populations for subsistence harvest purposes. Industrial development, such as oil and gas activity, must not adversely affect the ability of northern aboriginal peoples to harvest wildlife.

10. Oil Spill Sensitivity

An environmental sensitivity ranking system was developed to describe the relative sensitivity of onshore and offshore areas of the Beaufort Sea to the effects of oil spills (Dickins *et al.* 1987). Onshore boundaries extend 1 km offshore and backshore to include the maximum extent of positive storm surges and sensitivity values (low, moderate, high) apply for the period from May through October.

Shoreline sensitivity was based on biological sensitivity and factors that influence the persistence of oil such as wave exposure, coastal morphology, substrate and coastal stability (Figure 10-1). Oil will persist in areas of low wave exposure and low coastal relief (e.g., estuaries, embayments, deltas and inundated tundra) for a longer period than in areas of high wave exposure (e.g., barrier islands and spits).

Species sensitivity was based on three characteristics:

- known toxic effects of petroleum hydrocarbons on individual species or groups
- the probability of potential contact of the population with oil
- the potential for the population to recover from adverse effects of oil exposure (Dickins *et al.* 1987)

Birds were the most sensitive species. Rare and endangered birds were considered to be the most sensitive group since mortality of a relatively small number of individuals may lead to the extinction of the species. Those bird species that depend primarily on the marine environment for food and spend a considerable amount of time on the water (diving ducks, loons, shorebirds, gulls, brant) were considered the next most sensitive group. Bird species (dabbling ducks, geese and swans) that utilize the onshore habitats to a greater extent than marine areas are less sensitive to the effects of a marine oil spill.

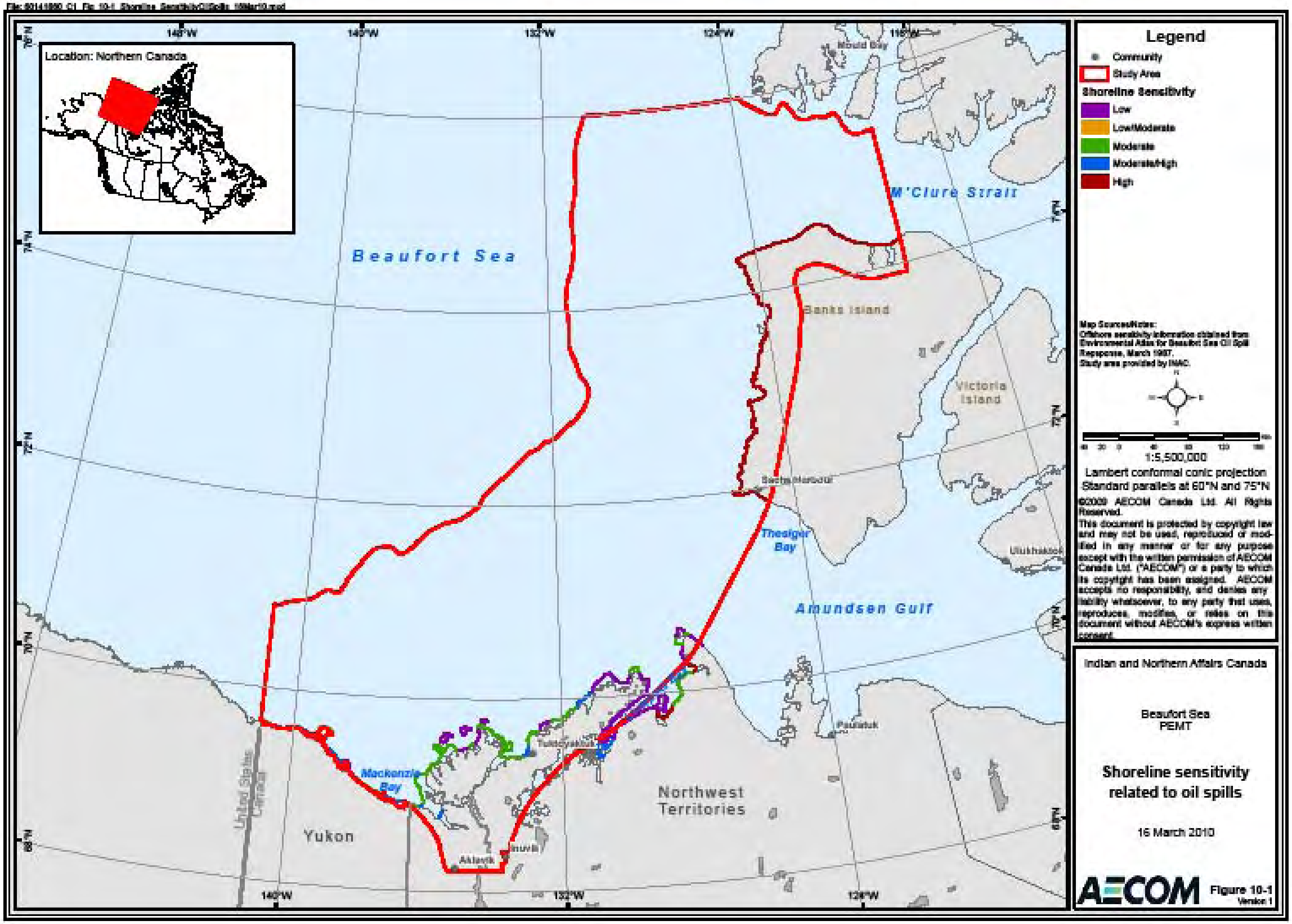
Polar bears (and seals) were judged to be the next most sensitive after birds due to the potential lethal effects of oil (Figures 10-2 and 10-3). Although there are no documented cases of death of polar bears from exposure to oil in the natural environment, mortality has resulted in field trials (Øritsland *et al.* 1981). Polar bears are vulnerable hunting and swimming for seals in the floe edge and active ice habitat areas where oil may be concentrated (Stirling 1990).

Bowhead whales were rated similarly to polar bears because of the status of the species (Special Concern) and the anticipated long recovery period required for this population. Beluga whales were less sensitive than bowheads because of the shorter anticipated period of recovery (Dickins *et al*. 1987). Areas and level of sensitivity by species are shown in Table 10-1. Shoreline sensitivity levels for northern and western areas of Banks Island was based on similar protocols from Dickens *et al.* (1987) but is more quantitative than qualitative.

Table 10-1 Areas of High and Moderate Shoreline Sensitivity of the Beaufort Sea to Effects of Oil Spills

Area	Sensitivity	Species
Workboat Passage	high	mid July – mid Aug: important moulting area for diving ducks
Avadlek Spit	moderate	mid – late Aug: important feeding area for shorebirds
Pauline cove	high	June – Sept: major breeding concentration of black guillemots
Phillips Bay	high	mid Aug – late Sept: important fall staging area for diving ducks and brant April - May: polar bear and seal are hunted on the landfast ice
Shingle point	high	June – late July: Escape Reef important breeding area for glaucous gulls
Shingle point	moderate	late Aug – early Sept: subadult bowhead concentrate to feed
Shoalwater Bay	high	June-Sept: important breeding, moulting and staging area for tundra swans, and staging area for geese (mid Aug-late Sept) late June-mid July: beluga concentration area
Shallow Bay	high	important beluga hunting area
Shallow Bay	moderate-high	June-Sept: important breeding, moulting and staging area for tundra swans, and staging area for geese (mid Aug-late Sept)
Olivier Islands	moderate	mid Aug-late Sept: important fall staging area for brant
Garry-Kendall Islands	moderate	June-late Aug: important goose nesting, brooding and staging area
Mallik Bay	moderate	June-mid Aug: important brooding, moulting and staging area for geese, tundra swans and diving ducks
North Point	moderate	Aug: important moulting and feeding area for diving ducks
Kittigazuit Bay	moderate	Aug-Sept: important goose staging area
Kugmallit Bay	moderate	mid July: beluga concentration area Sept: important goose staging area
Hutchison Bay	moderate	mid July-mid Sept: important moulting area for diving ducks
McKinley Bay	moderate-high	June-late Aug: important nesting, brooding, moulting and staging area for brant and diving ducks
Kugaluk, Moose and Smoke River deltas	high	June-mid Aug: important nesting, moulting and staging area for brant, tundra swans and diving ducks
Wood Bay	moderate-high	June-late Aug: important nesting, moulting and staging area for brant, tundra swans, dabbling and diving ducks
Cape Wolki	moderate	Important moulting area for brant and tundra swans (early Jul-late Aug) and moulting and staging area for diving ducks (early Jul-late Sept)
Harrowby Bay	high	mid Jul-mid Sept: important moulting and staging area for geese and diving ducks
Baillie Islands	moderate	mid Jul-early Aug: important moulting and feeding area for diving ducks
Banks Island (Western)	High	Polar Bear Denning (October 1 to March 31) Ringed Seal Pupping (March1 to April 30) Peary Caribou Calving (April 1 to June 30) Migratory Bird Sanctuary: Banks Island No. 1
Banks Island (Northern)	High	Polar Bear Denning (October 1 to March 31) Ringed Seal Pupping (March1 to April 30) Peary Caribou Calving (April 1 to June 30) Migratory Bird Sanctuary: Banks Island No. 2 Aulavik National Park

Figure 10-1 Shoreline



sensitivity related to oil spills

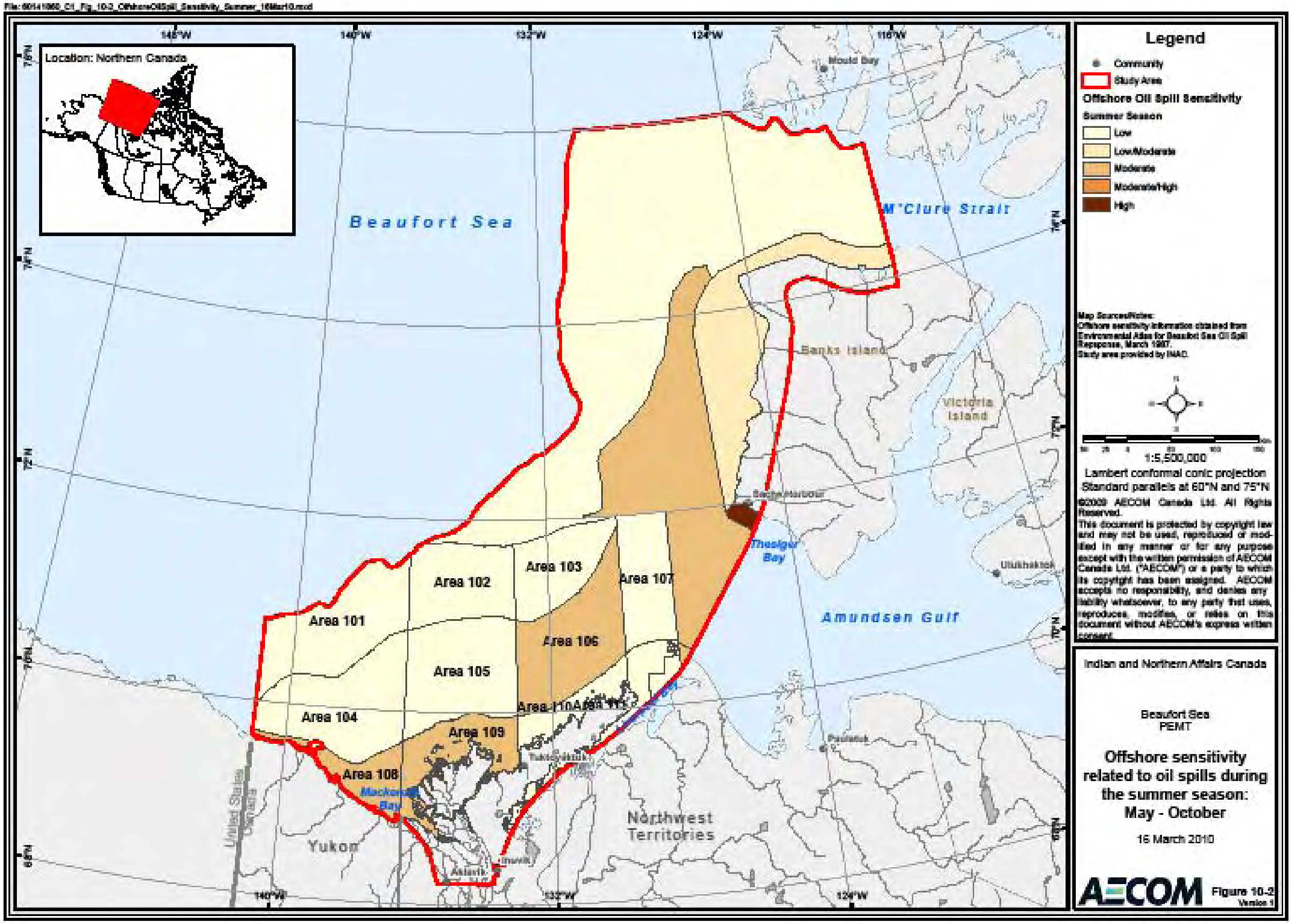
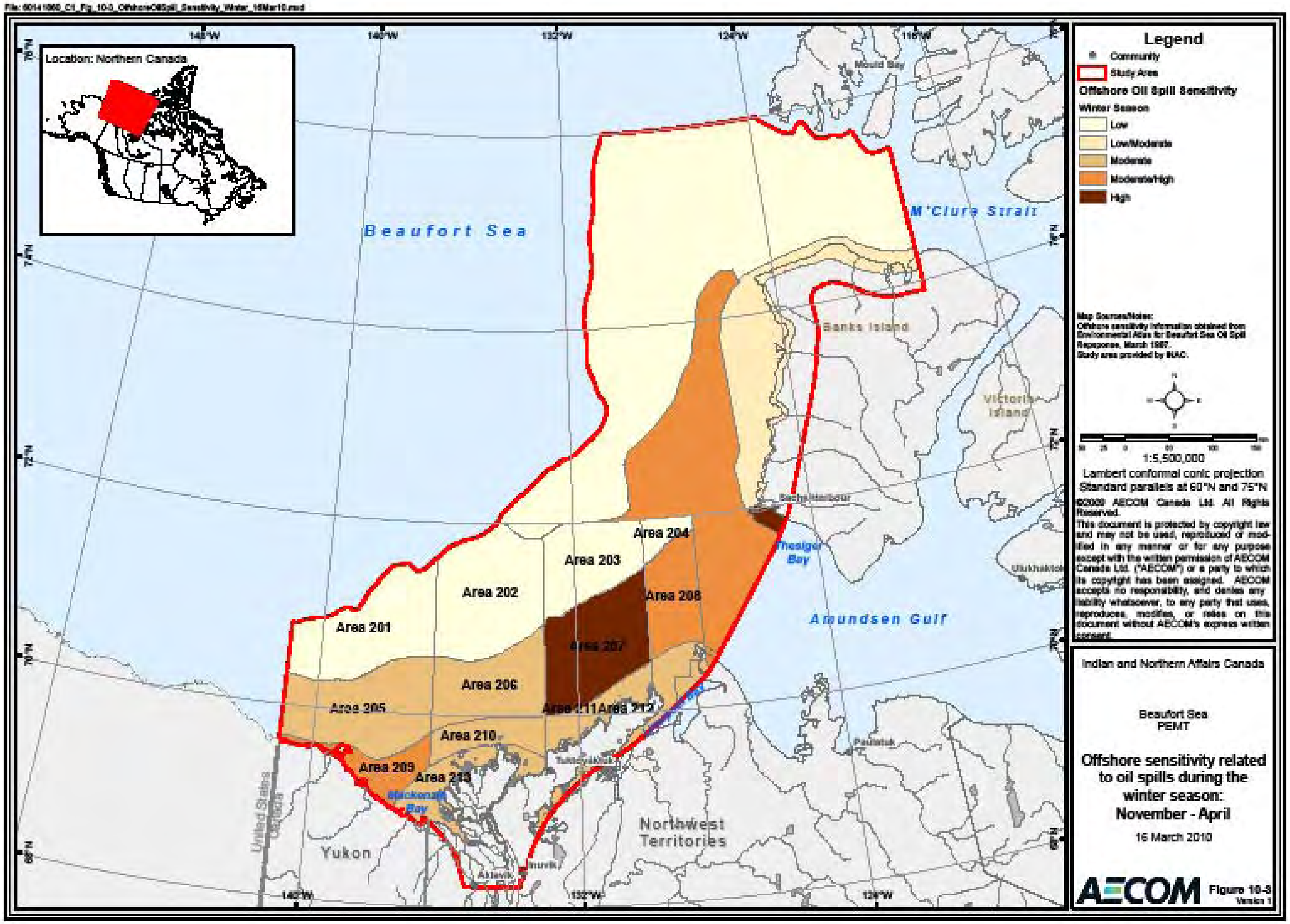


Figure 10-2 Offshore sensitivity related to oil spills during the summer season: May 1 to October 31

Figure 10-3 Offshore sensitivity related to oil spills during the winter season: November 1 to April 30



11. References

AECOM Canada Limited. 2009. Beaufort Sea decision support tool update. Report prepared for Indian and Northern Affairs Canada. 56 pp.

Alexander, S.A., T.W. Barry, D.L. Dickson, H.D. Prus and K.D. Smith, 1988: Key areas for birds in coastal regions of the Canadian Beaufort Sea. Canadian Wildlife Service, Edmonton.

Alexander, V. 1995. The influence of the structure and function of the marine food web on the dynamics of contaminants in Arctic Ocean ecosystems. The Science of the Total Environment 160/161:593-603.

Alexander, S.A., D.L. Dickson and S.E. Westover, 1997: Spring migration of eiders and other waterbirds in offshore areas of the western Arctic. Pp. 6-20 *in* D.L. Dickson (ed.) 1997. King and common eiders of the western Canadian Arctic. Canadian Wildlife Service, Occasional Paper 94:6-20. Edmonton.

Amstrup, S.C. 2003. Polar bear. pp. 587–610 in G.A. Feldhamer, B.C. Thompson, and J.A. Chapman (eds). Wild mammals of North America: biology, management, and conservation. 2nd Edition. John Hopkins University Press, Baltimore, MD.

Amstrup, S.C., and C. Gardner. 1994. Polar bear maternity denning in the Beaufort Sea. J. Wildl. Manage. 58: 1–10

Amstrup, S.C., B.G. Marcot and D.C. Douglas. 2007. Forecasting the range-wide status of polar bears at selected Times in the 21st century. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia, 126 pp.

Amstrup, S., I. Stirling, T.S. Smith, C. Perham and G.W. Thiemann. 2006. Recent observations of intraspecific predation and cannibalism among polar bears in the southern Beaufort Sea. Polar Biol. 29: 997-1002.

Arrigo, K.R., D.L. Worthen, M.P. Lizotte, P. Dixon, and G . Diekmann.1997. Primary production in Antarctic sea ice. Science 276:394-397.

Ashenhurst, A.R. and S.J. Hannon. 2008. Effects of seismic lines on the abundance of breeding birds in the Kendall Island Bird Sanctuary, Northwest Territories, Canada. Arctic 61: 190-198.

Barber, D.G. and J.M. Hanesiak. 2004. Meteorological forcing of sea ice concentrations in the southern Beaufort Sea over the period 1970 to 2000. Journal of Geophysical Research 109: C06014

Barber, D.G. and R.A. Massom (2007), Chapter 1: The role of sea ice in Arctic and Antarctic polynyas, In: Polynyas windows to the world, Smith, W.O. Jr. and D.G. Barber (eds.), Elsevier oceanographic series 74, Amsterdam.

Beaks Consultants. 1975. Seismic activities and muskoxen and caribou on Banks Ilsand, NWT. Unpublished report prepared for Panarctic Oils Ltd., Calgary, Alberta 15 pp.

Beckel, D., 1975. IBP ecological sites in subarctic Canada. Panel 10 summary report, International Biological Programme, University of Lethbridge.

Belanger, L. and J. Bedard, 1989. Responses of staging Greater Snow Geese to human disturbance. Journal of Wildlife Management 53:713-719.

Berkes, F. and D. Jolly. 2001. Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. Conservation Ecology **5**(2): 18. [online] URL: http://www.consecol.org/vol5/iss2/art18/

Blackwell, S.B., Nations, C.S.S., McDonald, T.L., Greene, Jr. C.R., Thode, A., and Macrander, A.M. 2008. Effects of sounds from seismic exploration on the calling behaviour of bowhead whales. Abstract *In* Noise and animal bioacoustics: Advances in measurement and noise and noise effects on human and non-human animals in the environment II. Schulte-Fortamp, B and Bowles, A.E., Cochairs.

Blackwell, S.B., Richardson, W.J., Greene, C.R. Jr., Streever, B. 2007. Bowhead whale (*Balaena mysticetus*) migration and calling behaviour in the Alaskan Beaufort Sea, autumn 2001-04: An acoustic localization study. Arctic 60(3): 255-270.

Bogoslovskaya, L.S., L.M. Votrogov, and I.I. Krupnik. 1982. The bowhead whale off Chukotka: migrations and aboriginal whaling. Report of the International Whaling Commission 32:391-399.

Bowman, T.D. and M. Koneff, 2002. Status and trends of North American sea duck populations: what we know and don’t know. North American sea duck conference and workshop, 6-10 November 2002, Victoria.

Bradstreet, M.S.W. 1982. Occurrence, habitat use, and behavior of seabirds, marine mammals, and Arctic cod at the Pond Inlet ice edge. Arctic 35: 28-40

Bradstreet, M.S.W., and W.E. Cross. 1982. Trophic relationships at High Arctic ice edges. Arctic **35**:1–12

Braham, H.W., M.A. Fraker, and B.D. Krogman. 1980. Spring migration of the western Arctic population of bowhead whales. Marine Fisheries Review 42(9-10):36-46.

Braham, H.W., Krogman, B.D., and Carroll, G.M. 1984. Bowhead and white whale migration, distribution, and abundance in the Bering, Chukchi, and Beaufort seas, 1975–78. NOAA Tech. Rep. NMFS SSRF-778.

Bromley, R.G., 1996. Characteristics and management implications of the spring waterfowl hunt in the western Canadian Arctic, Northwest Territories. Arctic 49:70-85.

Budge, S.M., Springer, A.M., Iverson, S.J., Sheffield, G., and Rosa, C. 2008. Blubber fatty acid composition of bowhead whales, *Balaena mysticetus*: Implications for diet assessment and ecosystem monitoring. Journal of Experimental Biology and Ecology 359: 40-46.

Bunnell, F.L., D. Dunbar, L. Koza and G. Ryder, 1981. Effects of disturbance on the productivity and numbers of white pelicans in British Columbia - observations and models. Colonial Waterbirds 4:2-11.

Byers, T. and D.L. Dickson, 2001. Spring migration and subsistence hunting of king and common eiders at Holman, Northwest Territories, 1996-98. Arctic 54:122-134.

Carroll, G.M., J.C. George, L. F. Lowry, and K.O. Coyle. 1987. Bowhead whale (Balaena mysticetus) feeding activities near Point Barrow, Alaska, during the 1985 spring migration. Arctic 40:105-110.

Cherry, S.G., A.E. Derocher, I. Stirling and E.S. Richardson. 2009. Fasting physiology of polar bears in relation to environmental change and breeding behaviour in the Beaufort Sea. Polar Biology 32: 383-391

Church, J.A., and White, N.J. 2006. A 20th century acceleration in global sea-level rise. Geophysical research letters, 33: L01602

Climate Risk. 2006. Bird species and climate change. The global status report.

Cornish, B.J. and D.L. Dickson, 1997. Common eiders nesting in the western Canadian Arctic. pp. 50 *in* Dickson, D.L. (ed.) 1997. King and common eiders of the western Canadian Arctic. Canadian Wildlife Service, Occasional Paper No 94. Edmonton.

Cosens, S.E., and Dueck., L.P. 1993. Ice breaker noise in Lancaster sound, N.W.W, Canada: Implications for mammal behaviour. Marine Mammal Science: 9(3) 285-300

COSEWIC, 2008. COSEWIC assessment and update status report on the polar bear *Ursus maritimus* in Canada. Committee On the Status of Endangered Wildlife In Canada. Ottawa. vi + 75 pp.

COSEWIC 2005. COSEWIC assessment and update status report on the bowhead whale *Balaena mysticetus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 51 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC 2004. COSEWIC assessment and update status report on the Peary caribou *Rangifer tarandus pearyi* and the barren-ground caribou *Rangifer tarandus groenlandicus* (Dolphin and Union population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 91 pp.

COSEWIC, 2002. COSEWIC assessment and update status report on the polar bear *Ursus maritimus* in Canada. Committee On the Status of Endangered Wildlife In Canada. Ottawa. vi + 29 pp.

Cotter, R.C. and J.E. Hines, 2001. Breeding biology of brant on Banks Island, Northwest Territories. Arctic 54:357-366.

Cotter, R.C. and J.E. Hines, 2006. Distribution of breeding and moulting brant on Banks Island, Northwest Territories, 1992-1994. pp. 18-26 *in* Hines, J.E. and M.O. Wiebe Robertson (eds.) 2006. Surveys of geese and swans in the Inuvialuit Settlement Region, Western Canadian Arctic, 1989-2001. Canadian Wildlife Service, Occasional Paper No. 112.

Cotter, R.C., D.L. Dickson and Cindy J. Cotter, 1997. Breeding biology of the king eider in the western Canadian Arctic. pp. 51-57 *in* Dickson, D.L. (ed.) 1997. King and common eiders of the western Canadian Arctic. Canadian Wildlife Service, Occasional Paper 94. Edmonton.

Davies, J.R. 1997. The impact of an offshore drilling platform on the fall migration path of bowhead whales: a GIS-based assessment. Master's thesis, Western Washington University, Bellingham, Wash.

DeMaster, D.P., and I. Stirling. 1981. *Ursus maritimus*. Polar bear. Mamm. Spec. 145: 1-7

Department of Fisheries and Oceans (DFO). 2009. Fisheries Act. Minister of Justice. 52 pp.

Derocher, A. 2009. Chair, IUCN/SSC Polar Bear Specialist Group Professor Department of Biological Sciences University of Alberta Edmonton

Dickens, D., L. Martin, I. Bjerkelund, S. Potter, D. Erickson, J. Harper, P. Norton, S. Johnson and P. Vonk. 1987. Environmental atlas for Beaufort Sea oil spill response. Prep. for Environment Canada Environmental Protection Service, Yellowknife, NWT and Whitehorse, Yukon. 182 pp + appendices

Dickson, D.L., (ed.), 1997. King and common eiders of the western Canadian Arctic. Canadian Wildlife Service, Occasional Paper 94. Edmonton.

Dickson, D.L. and H.G. Gilchrist, 2002. Status of marine birds of the southeastern Beaufort Sea. Arctic 55:46-58.

Dickson, D.L., T. Bowman, A.K. Hoover, G. Raven and M. Johnson, 2005. Tracking the movement of common eiders from nesting grounds near Bathurst Inlet, Nunavut to their moulting and wintering areas using satellite telemetry, 2003/2004 progress report. Unpublished Report, Canadian Wildlife Service. Edmonton.

Dillon Consulting Ltd and Salmo Consulting Ltd., 2005. Beaufort Delta Cumulative Effects Project, May 2005, Environmental Studies Research Funds Report No. 155, Calgary, 263 pp.

Dorsey, E.M., Richardson, W.J., and Würsig, B. 1989. Factors affecting surfacing, respiration, and dive behaviour of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea. Can. J. Zool. **67**: 1801–1815

Drolet, R., L. Fortier, D. Ponton, and M. Gilbert. 1991. Production of fish larvae and their prey in subarctic southeastern Hudson Bay. Marine Ecology Progress Series 77:105-118.

Durner, G.M., Douglas, D.C., Nielson, R.M., Amstup, S.C., McDonald, T.L., Stirling, I., Mauritzen, M., Born, E.W., Wiig, O., DeWeaver, E., Serreze, M.C., Belikov, S.E., Holland, M.M., Maslanik, J., Aars, J., Bailey, D.A., and Derocher, A.E. 2009. Predicting 21st-century polar bear habitat distribution from global climate models. Ecological Monographs, 79(1): 25-58.

Durner, G.M., Douglas, D.C., Nielson, R.M., Amstrup, S.C., and McDonald, T.L. 2007. Predicting the future distribution of polar bear habitat in the polar basin from resource selection functions applied to 21st century general circulation model projections of sea ice. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia, 61 pp.

Durner, G.M., S.C. Amstrup and K.J. Ambrosius. 2006. Polar bear maternal den habitat in the Arctic National Wildlife Refuge, Alaska. Arctic 59: 31-36

Durner, G.M., Amstrup, S.C., Neilson, R., and McDonald, T. 2004. The use of sea ice habitat by female polar bears in the Beaufort Sea. Prepared for U.S. Department of the Interior Mineral Management Service, Alaska OCS Region, Anchorage, Alaska, 49 pp.

Environment Canada, 2006. Written Submission to the Joint Review Panel Topic Specific Hearing Topic 7: Wildlife and Wildlife Habitat Migratory Birds including Kendall Island Bird Sanctuary. November 15-16, 2006. Mackenzie Valley Oil and Gas Project Environmental Assessment.

Environment Canada, 2001. Shorebird conservation strategy and action plan. Environment Canada Prairie and Northern Region. 17 pp.

Ferguson, M.A.D. 1996. Arctic tundra caribou and climate change: Questions of temporal and spatial scales. Geoscience Canada: 23: 245-252

Ferguson, S.H., Taylor, M.K., and Messier, F. 2000a. Influence of sea ice dynamics on habitat selection by polar bears. Ecology 81: 761-772

Ferguson, S.H., Taylor, M.K., Rosing-Asvid, A., Born, E.W., and Messier, F. 2000b. Relationships between denning of polar bears and conditions of sea ice. J. Mamm. 81: 1118–1127

Ferguson, S.H., Born, E.W., Taylor, M.K., and Messier, F. 1998. Fractals, sea-ice landscape, and spatial patterns of polar bears. Journal of Biogeography 25:1081–1092

Ferguson, S.H., Taylor, M.K. & Messier, F. 1997. Space-use of polar bears in and around Auyuittuq National Park, Northwest Territories, during the ice-free period. Can. J. Zool. 75, 1585-1594

Finley, K.J. 1990. Isabella Bay, Baffin Island: An important historical and present-day concentration area for the endangered bowhead whale (*Balaena mysticetus*) of the eastern Canadian Arctic. Arctic 43(2): 137-152.

Finley, K. J., G. W. Miller, R. A. Davis, and W. R. Koski. 1983. A distinctive large breeding population of ringed seals (*Phoca hispida*) inhabiting the Baffin Bay pack ice. Arctic 36:162–173

Finneran, J.J., Schlundt, C.E., Dear, R., Carder, D.A., and Ridgway, S.H. 2002. Temporary shift in masked hearing thresholds in odeontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America 111 (6): 2929 – 2940

Fischbach, A.S., S.C. Amstrup and D.C. Douglas. 2007. Landward and eastward shift of Alaskan polar bear denning associated with recent ice changes. Polar Biology 30: 1395-1405

Fisheries Joint Management Committee. 2001. Beaufort Sea Beluga Management Plan. Amended Third Printing. Inuvik, Northwest Territories.

Ford, J.D., Pearce, T., Gilliganhttp://www.bioone.org/doi/abs/10.1657/1523-0430(07-040)%5BFORD%5D2.0.CO%3B2 - aff2 J., Smit, B., and J. Oakes. 2008. Climate change and hazards associated with ice use in northern Canada. Arctic, Antarctic, and Alpine Research 40(4):647-659

Fraker, M.A. and J.R. Bockstoce. 1980. Summer distribution of bowhead whales in the eastern Beaufort Sea. Marine Fisheries Review 42(9-10): 57-64.

Fraker, M.A., Ljungblad, D.K., Richardson, W.J., and Van Schoik, D.R. 1985. Bowhead whale behaviour to seismic exploration, Alaskan Beaufort Sea, Autumn 1981. U.S. Minerals Management Service, Reston, VA, 40pp.

Fraser, P., A. Gunn, and B.D. McLean. 1992. Abundance and distribution of Peary caribou and muskox on Banks Island, NWT, June 1991. Dept. of Renewable Resources, Gov't. of the NWT, Inuvik. Manuscript Report 63. 18pp.

Freeman, M. M. R. 1975. Assessing movement in an Arctic caribou population. J. Environ. Manage. 3: 251-257. *In* Gunn, A., and Dragon, J. 2002. Peary caribou and muskox abundance and distribution on the western Queen Elizabeth Islands, Northwest Territories and Nunavut, June-July 1997. Northwest Territories Department of Resources, Wildlife and Economic Development, File Report 130. 93 p.

Freeman, M.M.R., L. Bogoslovskayas, R.A. Caulfield, I. Egede, I.I. Krupnik, and M.G. Stevenson. 1998. Inuit, Whaling, and Sustainability. AltaMira Press, A Division of Sage Publications, Inc, Walnut Creek, CA.

Gaden, A., Ferguson, S.H., Harwood, L., Melling, H., and Stern, G.A. 2009. Mercury trends in ringed seals (*Phoca hispida*) from the Western Canadian Arctic since 1973: Associations with length of ice-free season. Environmental Science and Technology 43(10): 3646-3651

Gartner Lee Limited. 2008. Development of a decision support tool for resource management in support of a strategic environmental assessment for the Canadian Beaufort Sea. Report prepared for the Department of Indian and Northern Affairs. 111 pp. + Appendices

George, J.C., L.M. Philo, K. Hazard, D. Withrow, G.M. Carroll, and R.S. Suydam. 1994. Frequency of killer whale (*Orcinus orca*) attacks and ship collisions based on scarring on bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Seas stock. Arctic 47(3):247-255.

George, J.C., Zeh, J., Suydam, R., and Clark, C. 2004. Abundance and population trend (1978-2001) of western Arctic bowhead whales surveyed near Barrow, Alaska. Marine Mammal Science 20:755-773.

Gratto-Trevor, C.L., 1996. Use of Landsat TM imagery in determining priority shorebird habitat in the Outer Mackenzie Delta, NWT. Arctic 49:11-22.

Griffiths, W. B. and R.A. Buchanan. 1982. Characteristics of bowhead feeding areas. P 347-455 In: W.J. Richardson (ed.), Behaviour, distribution responses and feeding of bowhead whales *Balaena* *mysticetus* in the Beaufort Sea, 1980-81. Unpubl. Rep. By LGL Ecological Research Associates, Inc., Bryan, TX, for U.S. Bureau of Land Management, Washington. 456 p.

Gunn, A., and Dragon, J. 2002. Peary caribou and muskox abundance and distribution on the western Queen Elizabeth Islands, Northwest Territories and Nunavut, June-July 1997. Northwest Territories Department of Resources, Wildlife and Economic Development, File Report 130. 93 p.

Gunn, A., Russell, D., White, R.G., and Kofinas, G. 2009. Facing a future of change: Wild migratory caribou and reindeer. Arctic 62(3): iii-vi.

Gunn, A. Miller, F.L., Barry, S.J., and Buchan, A. 2006. A near-total decline of caribou on Prince of Wales, Somerset and Russell Islands, Canadian Arctic. Arctic 59: 1-13

Gunn, A. and F.L. Miller. 1980. Responses of Peary caribou cow-calf pairs to helicopter harassment in the Canadian high Arctic. Pp. 497-507 *in* Reimers, E., E. Gaare and S. Skjenneberg, (eds.). 1980. Proc. 2nd International reindeer/caribou symposium, 17-21 Sept. 1979. Roros, Norway

Harding, L.E. 2004. The future of Peary caribou (*Rangifer tarandus pearyi*) in a changing climate. *In* Proceedings of the species at risk 2004 pathways to recovery conference. Hooper, T.D., (ed.). March 2-6, 2004, Victoria, B.C. Species at risk 2004 pathways to recovery conference organizing committee, Victoria, B.C.

Harwood, L.A, 2010. Department of Fisheries and Oceans Canada. Personal Communication.

Harwood, L.A, 2009. Department of Fisheries and Oceans Canada. Personal Communication.

Harwood 2005 *In* North/South Consultants Inc. 2005. Marine ecosystem overview of the Beaufort Sea large ocean management areas (LOMA). Prepared for Department of Fisheries and Oceans. Inuvialuit Cultural Resource Center, Inuvik, NT, 110pp.

Harwood, L.A. and T.G Smith, 2002. Whales of the Inuvialuit Settlement Region in Canada's Western Arctic: An Overview and Outlook. Arctic. Vol. 55, Supp. 1 (2002) pp.77-93.

Harwood, L.A. and I. Stirling, 1992. Distribution of ringed seals in the southeastern Beaufort Sea during late summer. Canadian Journal of Zoology 70:891-900.

Harwood, L. A., A. Joynt, and S. Moore. 2008. Bowhead whale feeding aggregations in the Canadian Beaufort Sea and their role in the mitigation of effects of seismic underwater noise. Working Paper presented at the Review of Scientific Information on the Impacts of Seismic Sound on Fish, Invertebrates, and Marine Mammals, Workshop II, March 26-28, 2008, Ottawa, Ontario.

Haszard, S.L. and R.G. Clark, 2002. Habitat requirements of white-winged and surf scoters in the Mackenzie delta region, Northwest Territories. North American sea duck conference and workshop, 6-10 November 2002, Victoria.

Hazard, K.W., and J.C. Cubbage. 1982. Bowhead whale distribution in the southeastern Beaufort Sea and Amundsen Gulf, summer 1979. Arctic 35: 519-523.

Hines, J.E., M.O. Wiebe Robertson, M.F. Kay and S.E. Westover, 2006. Aerial surveys of greater white-fronted geese, Canada geese and tundra swans on the mainland of the Inuvialuit Settlement Region, Western Canadian Arctic, 1989-1993. pp. 27-43 *in* Hines, J.E. and M.O. Wiebe Robertson (eds.) 2006. Surveys of geese and swans in the Inuvialuit Settlement Region, Western Canadian Arctic, 1989-2001.Canadian Wildlife Service, Occasional Paper No. 112.

Hunter, C.M., H. Caswell, M.C. Runge, E.V. Regehr, S.C. Amstrup and I. Stirling. 2007. Polar bears in the southern Beaufort Sea II: demography and population growth in relation to sea ice conditions. U.S. Dept. of the Interior, U.S. Geological Survey Administrative Report. 46 pp.

Important Bird Areas (IBA) Canada, 2004. Important bird areas of Canada. Bird Studies Canada, BirdLife International and Nature Canada. URL: www.ibacanada.com, last accessed April 10, 2007.

Ingram, J. 2009. Head, Mackenzie Delta Unit, Canadian Wildlife Service, Prairie & Northern Environment Canada, Inuvik, NWT.

Inuvialuit Regional Corporation. 1987. The Western Arctic Claim. The Inuvialuit Final Agreement as Amended January 15, 1987

Jayko, K., Reed, M., Bowles, A 1990. Simulation of interactions between migrating whales and potential oil spills. Environmental Pollution 63: 97-127.

Kay, D.G., Kuptana, D., Wolki Sr., G., and J.E. Hines. 2006, Inuvialuit ecological knowledge of King Eiders, Pacific Common Eiders, Black Brant, and some other birds near Holman and Sachs Harbour, Northwest Territories. *In* Hines, J.E. and M.O. Wiebe Robertson (eds.) 2006. Surveys of geese and swans in the Inuvialuit Settlement Region, Western Canadian Arctic, 1989-2001.Canadian Wildlife Service, Occasional Paper No. 112.

Kattsov, V.M., and Kallen, E. 2005. Future Climate Change. *In* Modeling and scenarios for the arctic. ACIA, 2005. Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK, 1042 pp.

Kevan, P.G. 1974. Peary caribou and muskoxen on Banks Island. Arctic 27: 256-264

Kingsley, M. C. S., I. Stirling, and W. Calvert. 1985. The distribution and abundance of seals in the Canadian High Arctic, 1980–1985. Canadian Journal of Fisheries and Aquatic Science 42:1189–1210

Koski, W.R., and Miller, G.W. 2009. Habitat use by different size classes of bowhead whales in the central Beaufort Sea during late summer and autumn. Arctic: 62(2): 137-150.

Koski, W.R., D.W. Funk, D.S. Ireland, C. Lyons, K. Christie, A.M. Macrander and S.B. Blackwell. 2009. An update on feeding by bowhead whales near an offshore seismic survey in the central Beaufort Sea. Intern. Whal. Comm. Working Pap. SC/61/BRG3. 15 p

Koski, W.R., R.A. Davis, G.W. Miller, and D.E. Withrow. 1993. Reproduction. Pages 239-274 *in* J.J. Burns, J.J. Montague and C. J. Cowles, eds. The bowhead whale. Special Publication No. 2. Society for Marine Mammalogy, Lawrence, KS.

Krutzikowsky, G.K., Mate, B.R. 2000. Dive and surfacing characteristics of bowhead whales (*Balaena mysticetus*) in the Beaufort and Chukchi seas. Canadian Journal of Zoology 78: 1182-1198.

Kurtén, B. 1964. The evolution of the polar bear, *Ursus maritimus* Phipps. Acta Zool. Fenn. 108:130

Larter, N.C., and J.A. Nagy. 2004. Seasonal changes in the composition of the diets of Peary caribou and muskoxen on Banks Island. Polar Research 23 (2): 131-140.

Larter, N.C., and J.A. Nagy, 2000a. Calf production and overwinter survival estimates for Peary caribou, *Rangifer tarandus pearyi*, on Banks Island, Northwest Territories. The Canadian Field-Naturalist, 114: 661-670.

Larter, N.C. and J. Nagy. 2000b. Overwinter changes in urea nitrogen:creatinine and cortisol:creatinine ratios in urine from Banks Island Peary caribou. Rangifer Spec. Issue No. 12: 125-132

Latour, P. 1981. Spatial relationships and behaviour of polar bears *(Ursus maritimus* Phipps) concentrated on land during the ice-free season of Hudson Bay. Can. J. Zoology 59:1763-177

Latour, P.B., J. Leger, J.E. Hines, M.L. Mallory, D.L. Mulders, H.G. Gilchrist, P.A. Smith and D.L. Dickson, 2006: Key migratory bird terrestrial habitat sites in the Northwest Territories and Nunavut. Canadian Wildlife Service, Occasional Paper. 121 pp.

Lee, H.S., Schell, D.M., McDonald, T.L., and Richardson, W.J. 2005. Regional and seasonal feeding by bowhead whales *Balaena mysticetus* as indicated by stable isotope ratios. Marine Ecology Progress Series 285: 271-287.

Lesage, V., and Barrette., C. 1999. The effect of vessel noise on the vocal behaviour of belugas in the St. Lawrence River estuary, Canada. Marine Mammal Science 15(1): 65-84.

Ljungblad, D.K., Wursig, B., Swartz, S.L., and Keene, J.M. 1988. Observations on the behavioural responses of bowhead whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. Arctic: 41(3): 183-194.

Loseto, L.L., Stern, G.A., Connelly, T.L., Deibel, D., Gemmill, B, Prokopowicz., Fortier, L.,and Ferguson, S.H. 2009. Summer diet of beluga whales inferred by fatty acid analysis of the eastern Beaufort Sea food web. Journal of Experimental Marine Biology and Ecology 374: 12-18.

Loseto, L.L., Stern, G.A., Deibel, D., Connelly, T.L., Prokopowicz, Lean, D.R.S., Fortier, L., and Ferguson, S.H. 2008. Linking mercury exposure to habitat and feeding behaviour in Beaufort Sea beluga whales. Journal of Marine Systems 74: 1012-1024

Lowry, L.F. 1993. Foods and feeding ecology. Pages 201-238 *in* J.J. Burns, J.J. Montague and C.J. Cowles, eds. The bowhead whale. Special Publication No. 2. Society for Marine Mammalogy, Lawrence, KS.

Lunn, N.J., I. Stirling, D. Andriashek and E. Richardson. 2004. Selection of maternity dens by female polar bears in western Hudson Bay, Canada and the effects of human disturbance. Polar Biol. 27: 350-356

Luque, S.P., and Ferguson, S.H. 2009. Ecosystem regime shifts have not affected growth and survivorship of eastern Beaufort Sea belugas. Oecologia 160: 367-378

Mackas, D.L., K.L. Deman and M.R. Abbott. 1985. Plankton patchiness: biology in the physical vernacular. Bulletin of Marine Science 37(2):652-674.

Madsen, K. 2001. Project caribou: An educator's Guide to wild caribou of North America. Peary caribou: An arctic endangered species. Conservation Education Coordinator, Yukon Department of Environment. Whitehorse, Yukon. 5pp. Available online: http://www.taiga.net/projectcaribou/pdf/casestudies/peary_study.PDF

Mallory, M.L. and A.J. Fontaine, 2004. Key marine habitat sites for migratory birds in Nunavut and the Northwest Territories. Canadian Wildlife Service, Occasional Paper No. 109.

Mate, B.R., G.K Krutzikowsky, and M.H. Winsor. 2000. Satellite-monitored movement of radio-tagged bowhead whales in the Beaufort and Chuckchi seas during the late-summer feeding season and fall migration. Can. J. Zool. 78: 1168-1181.

McLean, B.D. 1992. Abundance and distribution of caribou on Banks Island, NWT – July 1987. Dept. of Renewable Resources, Gov't. of the NWT, Inuvik. File Report 95. 28pp.

McLean, B.D. and P. Fraser. 1992. Abundance and distribution of Peary caribou and muskoxen on Banks Island, NWT – June 1989. Dept. of Renewable Resources, Gov't. of the NWT, Inuvik. File Report 106. 18pp.

McLean, B.D., P. Fraser, and A. Gunn. 1992. Aerial survey of Peary caribou on Banks Island, NWT, September 1990. Dept. of Renewable Resources, Gov't. of the NWT, Inuvik. Manuscript Report 62. 18pp.

Mehl, K. 2004. The curious lives of sea ducks. Ducks Unlimited. www.ducks.org/Conseration/WaterfowlBiology/2114/The CuriousLivesofSeaDucks.html

Melling, H. 2009. Department of Fisheries and Oceans Canada. Personal Communication.

Messier, F., M.K. Taylor, and M.A. Ramsay. 1994. Denning ecology of polar bears in the Canadian Arctic Archipelago. Journal of Mammalogy 75: 420-430

Messier, F., M.K. Taylor, and M.A. Ramsay. 1992. Seasonal activity patterns of female polar bears (*Ursus maritimus*) in the Canadian Arctic as revealed by satellite telemetry. Journal of Zoology, London 226:219– 229

Miller 1995. Inter-island water crossings by Peary caribou, south-central Queen Elizabeth Islands. Arctic 48:8-12.

Miller, F.L., and Barry, S.J. 2009. Long-term control of Peary caribou by unpredictable, exceptionally severe snow or ice conditions in a non-equilbrium grazing system. Arctic 62(2): 175-189.

Miller, F.L. and A. Gunn. 2003. Catastrophic die-off of Peary caribou on the western Queen Elizabeth Islands, Canadian high Arctic. Arctic 56: 381-390

Miller, F.L., E.J. Edmonds and A. Gunn*.* 1982. Foraging behaviour of Peary caribou in response to springtime snow and ice conditions. Can. Wildl. Serv. Occas. Pap. No. 48. 39 pp.

Miller, F.L., Gunn, A. 1981. Play by Peary caribou calves before, during, and after helicopter harassment. Canadian Journal of Zoology, 59: 823-827.

Miller, F.L. and A. Gunn. 1979. Responses of Peary caribou and muskoxen to helicopter harassment. Can. Wildl. Serv.Occas. Pap. No. 40. 88 pp.

Miller, F.L. and A. Gunn. 1978. Inter-island movements of Peary caribou south of Viscount Melville Sound, Northwest Territories. Can. Field-Nat. 92: 327-333

Miller, F.L., Russell, R.H., and Gunn, A. 1977. Interisland movements of Peary caribou (*Rangifer tarandus pearyi*) on western Queen Elizabeth Islands, Arctic Canada. Canadian Journal of Zoology. 55: 1029-1037

Monnett, C. and J.S. Gleason. 2006. Observations of mortality associated with extended open-water swimming by polar bears in the Alaskan Beaufort Sea. Polar Biology 29: 681-687

Moore, S.E., Stafford, K.M., and Munger, L.M. 2009. Acoustic and visual surveys for bowhead whales in the western Beaufort and far northeastern Chukchi seas. Deep Sea Research II: *Article in Press*

Moore, S.E., J.T. Clarke, and D.K. Ljunglbad. 1989. Bowhead whale (*Balaena mysticetus*) spatial and temporal distribution in the central Beaufort Sea during late summer and early fall 1979-86. Report of the International Whaling Commission 39:283-290.

Moshenko, R.W., S.E. Cosens and T.A. Thomas. 2003. Conservation Strategy for Bowhead Whales (*Balaena mysticetus*) in the Eastern Canadian Arctic. National Recovery Plan No. 24. Recovery of Nationally Endangered Wildlife (RENEW).Ottawa, Ontario. 51 pp.

Nagy, J.A., Larter, N.C. and P. Fraser. 1996. Population demography of Peary caribou and muskox on Banks Island, N.W.T., 1982-1992. Rangifer Special Issue No. 9: 213-222

Nerini, M.K. 1984. Life history of the bowhead whale, *Balaena mysticetus* (Mammalis: Cetacea). Journal of Zoology 204: 443-468.

Newton, I., 1977. Timing and success of breeding in tundra-nesting geese. Pp. 113-126 *in* B. Stonehouse and C. Perrins (eds.) Evolutionary Ecology. University Park Press, London, UK.

Northwest Territories Environment and Natural Resources (NWT) 2009a. Species at Risk in the NWT. Available Online: http://www.enr.gov.nt.ca/_live/pages/wpPages/Species_at_Risk.aspx

Northwest Territories Environment and Natural Resources (NWT) 2009b. Species at Risk (NWT) Act. Available Online:

http://www.enr.gov.nt.ca/_live/documents/documentManagerUpload/Species%20at%20Risk%20%28NWT%29%20Act.pdf

Northwest Territories Environment and Natural Resources (NWT) 2009c. Northwest Territories Summary of Hunting Regulations July 1, 2009 to June 30, 2010. Available Online: http://www.enr.gov.nt.ca/_live/pages/wpPages/home.aspx

Nunavut Wildlife Management Board (NWMB). 2000. Final report of the Inuit bowhead knowledge study. Nunavut, Canada

Outridge, P.M., Hobson, K.A., Savele, J. 2009. Long-term changes of mercury levels in ringed seal (*Phoca hispida*) from Amundsen Gulf, and beluga (*Delphinapterus leucas*) from the Beaufort Sea, western Canadian Arctic. Science of the Total Environment 407: 6044-6051

Parker, G. R., Ross, R. K. 1976. Summer habitat use by muskoxen (*Ovibos moschatus*) and Peary caribou (*Rangifer tarandus pearyi*) in the Canadian High Arctic, Polarforschung, 46, 1, 12-25

Parker, G.R., Thomas, D.C., Broughton, E., and Gray, D.R. 1975. Crashes of muskox and Peary caribou populations in 1973-74 on the Parry Islands, Arctic Canada. Canadian Wildlife Service, Environment Canada.

Regehr, E.V., C.M. Hunter, H. Caswell, S.C. Amstrup and I. Stirling. 2007. Polar bears in the southern Beaufort Sea I: survival and breeding in relation to sea ice conditions, 2001-2006. U.S. Dept. of the Interior, U.S. Geological Survey Administrative Report. 45 pp.

Richard, P.R., and Pike, D.G. 1993. Small whale co-management in the Eastern Canadian Arctic: a case history and analysis. Arctic 46(2): 138-143.

Richardson, W.J., Würsig, B., and Greene, C.R., Jr. 1990. Reactions of bowhead whales, *Balaena mysticetus*, to drilling and dredging noises in the Canadian Beaufort Sea. Mar. Environ. Res. 29: 135–160

Richardson, W.J., R.A. Davis, C.R. Evans, D.K. Ljungblad and P. Norton. 1987. Summer distribution of bowhead whales, *Balaena mysticetus*, relative to oil industry activities in the Canadian Beaufort Sea, 1980-84. Arctic 40: 93-104

Richardson, W.J., Fraker, M.A., Würsig, B., and Wells, R.S. 1985. Behavior of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: reactions to industrial activities. Biol. Conserv. 32: 195–230

Richardson, W.J., Würsig, B., and Greene, C.R., Jr. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. J. Acoust. Soc. Am. 79: 1117–1128

Richardson, W.J., Finley, K.J., Miller, G.W., Davis, R.A., and Koski, W.R. 1995. Feeding, social and migration behavior of bowhead whales, *Balaena mysticetus*, in Baffin Bay vs. the Beaufort Sea—regions with different amounts of human activity. Mar. Mamm. Sci. 11: 1–45

Rode, K.D., S.C. Amstrup and E.V. Regehr. 2007. Polar bears in the southern Beaufort Sea III: stature, mass and cub recruitment in relationship to time and sea ice extent between 1982 and 2006. U.S. Dept. of the Interior, U.S. Geological Survey Administrative Rport. 28 pp.

Romano, T.A., Keogh, M.J., Kelly, C., Feng., P., Berk, L., Schlundt, C.E., Carder, D.A., and Finneran, J.J. 2004. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences 61: 1124-1134

Schell, D.M., S.M. Saupe, and N. Haubenstock. 1987. Bowhead whale feeding: allocation of regional habitat importance based on stable isotope abundances. In W.J. Richardson (ed.), Importance of the eastern Alaskan Beaufort Sea to feeding bowhead whales 1985-86, p. 369-415. Rep. to U.S. Minerals Manage. Serv. by LGL Ecol. Res. Assoc. Inc., NTIS No. PB88-150271.

Schick, R.S. and D.L. Urban. 2000. Spatial components of bowhead whale (*Balaena mysticetus*) distribution in the Alaskan Beaufort Sea. Can. J. Fish. Aquat. Sci. 57: 2193-2200.

Schlundt, C.E., Finneran, J.J., Carder, D.A., Ridgway, S.H. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncates*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. Journal of the Acoustical Society of America 107 (6): 3496-3508

Smith, M. and B. Rigby, 1981. Distribution of polynyas in the Canadian Arctic. pp. 7-28 *in* I. Stirling and H. Cleator (eds.) Polynyas in the Canadian Arctic. Canadian Wildlife Service. Occasional Paper No. 45.

Smith, T.G. 1980. Polar bear predation of ringed and bearded seals in the land-fast sea ice habitat. Can. J. Zool. 58: 2201-2209

Smith, T.G., and I. Stirling. 1975. The breeding habitat of the ringed seal *(Phoca hispida).* The birth lair and associated structures. Canadian Journal of Zoology 53:1297-1305.

Smith, T.G., M.O. Hammill and G. Taugbol. 1991. A review of the developmental, behavioural and physiological adaptations of the ringed seal, *Phoca hispida*, to life in the Arctic winter. Arctic 44: 124-131

Species at Risk Public Registry (SARA), 2009: http://www.sararegistry.gc.ca Accessed October, 2009.

Stirling, I. 2002. Polar bears and seals in the eastern Beaufort Sea and Amundsen Gulf: a synthesis of population trends and ecological relationships over three decades. Arctic 55, Supp. 1: 59-76

Stirling, I. 1997. The importance of polynyas, ice edges, and leads to marine mammals and birds. J. Marine Systems 10: 9-21

Stirling, I. 1990. Polar bears and oil: ecologic perspectives. *In* Sea mammals and oil: confronting the risks. *Edited by* J.R. Geraci and D.J. St. Aubin. Academic Press, San Diego. pp. 223–234

Stirling, I., 1988. Polar Bears. University of Michigan Press, Ann Arbor, Michigan

Stirling, I. 1980. The biological importance of polynyas in the Canadian Arctic. Arctic 33: 303-315

Stirling, I., E. Richardson, G.W. Thiemann and A.E. Derocher. 2008. Unusual predation attempts of polar bears on ringed seals in the southern Beaufort Sea: possible significance of changing spring ice conditions. Arctic 61: 14-22

Stirling, I. and D. Andriashek, 1992. Terrestrial maternity denning of polar bears in the eastern Beaufort Sea area. Arctic 45:363-366.

Stirling, I., and A.E. Derocher, 1993. Possible impacts of climatic warming on polar bears. Arctic 46:240-245.

Stirling, I. and N.A. Øritsland, 1995. Relationships between estimates of ringed seal and polar bear populations in the Canadian Arctic. Canadian Journal of Fisheries and Aquatic Sciences 52:2594-2612.

Stirling, I., D. Andriashek and W. Calvert. 1993. Habitat preferences of polar bears in the western Canadian Arctic in late winter and spring. Polar Record 29: 13-24

Stirling, I. and T.G. Smith. 2004. Implications of warm temperatures and an unusual rain event on the survival of ringed seals on the coast of southeastern Baffin Island. Arctic 57:59-67.

Stroeve, J. Holland, M.M., Meier, W., Scambos, T., Serreze, M. 2007. Arctic sea ice decline: Faster than forecast. Geophysical Research Letters, 34: L09501.

Sturm, M., Racine, C., and Tape, K. 2001. Increasing shrub abundance in the Arctic. Nature 411, 546-547

Sudyam, R.S., D.L. Dickson, J.B. Fadely and L.T. Quakenbush, 2000. Population declines of king and common eiders of the Beaufort Sea. Condor 102:219-222.

Tarnocai, C., I.M. Kettles. and B. Lacelle. 2000. *Peatlands of Canada Map.* Geological Survey of Canada, Open File 3834. Scale 1: 6 500 000. Ottawa: Natural Resources Canada.

Tener, J.S. 1965. Muskoxen in Canada, a biological and taxonomic review. Canadian Wildlife Service Monograph no. 2, 166 pp.

Tener, J.S. 1963. Queen Elizabeth Islands game survey, 1961. Canadian Wildlife Service Occasional Papers No. 4. 50 pp. *In* COSEWIC 2004. COSEWIC assessment and update status report on the Peary caribou Rangifer tarandus pearyi and the barren-ground caribou Rangifer tarandus groenlandicus (Dolphin and Union population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 91 pp.

Tews, J., Ferguson, M.A.D., Fahrig, L. 2007. Potential net effects of climate change on high arctic Peary caribou: Lessons from a spatially explicit simulation model. Ecological Modeling: 207: 85-98

Thenius, E. 1953. Concerning the analysis of the teeth of polar bears. Mammal. Bull. 1:14-20

Thomas, D.C. 1982. The relationship between fertility and fat reserves of Peary caribou. Canadian Journal of Zoology, 60: 597-602.

Thomas, D.C., Everson, P. 1982. Geographic variation in caribou on the Canadian arctic islands. Canadian Journal of Zoology, 60: 2442-2454

Treacy, S.D., J.S. Gleason, and C.J. Cowles. 2006. Offshore distances of bowhead whales (*Balaena mysticetus*) observed during fall in the Beaufort Sea, 1982-2000: An alternative interpretation. Arctic 59(1): 83-90.

Tulp, I. and H. Schekkerman. 2008. Has prey availability for Arctic birds advanced with climate change? Hindcasting the abundance of tundra arthropods using weather and seasonal variations. Arctic 61: 48-60

Tynan, C.T. and D.P. DeMaster. 1997. Observations and predictions of Arctic climate change: potential effects on marine mammals. Arctic 50: 308-322

Urquhart, D.R. 1973. Oil exploration and Banks Island wildlife – a guideline for the preservation of caribou, muskox and Arctic fox on Banks Island, NWT. NWT Wildl. Serv. Report. 105 pp.

Walpole, B., E. Nol and V. Johnston. 2008. Pond characteristics and occupancy by red-necked phalaropes in the Mackenzie Delta, Northwest Territories, Canada. Arctic 61: 426-432

Wiebe Robertson, M.O. and J.E. Hines, 2006. Aerial surveys of lesser snow geese colonies at Anderson River Delta and Kendall Island, Northwest Territories, 1996-2001. pp. 58-61 57. *in*: Hines, J.E. and M.O. Wiebe Robertson (eds.) 2006. Surveys of geese and swans in the Inuvialuit Settlement Region, Western Canadian Arctic, 1989-2001. Canadian Wildlife Service, Occasional Paper No. 112.

Wiken, E., 1986. Terrestrial ecozones of Canada. Ecological Land Classification Series No. 19. Lands Directorate, Environment Canada. 26 pp.

Wildlife Management Advisory Council (WMAC), 1999. Status of waterfowl in the Inuvialuit Settlement Region. Canadian Wildlife Service, Yellowknife. 44 pp.

Wildlife Management Advisory Council (WMAC), 2000a. Aklavik Inuvialuit Community Conservation Plan. 166 pp.

Wildlife Management Advisory Council (WMAC), 2000b. Inuvik Inuvialuit Community Conservation Plan. 160 pp.

Wildlife Management Advisory Council (WMAC), 2000c. Tuktoyaktuk Inuvialuit Community Conservation Plan. 168 pp.

Wildlife Management Advisory Council (WMAC), 2000d. Sachs Harbour Inuvialuit Community Conservation Plan. 168 pp.

Wilson, J.Y., Cooke, S.R., Moore, M.J., Martineau, D., Mikaelian, I., Metner, D.A., Lockhart, W.L., and Stegeman, J.J. 2005. Systemic effects of arctic pollutants in beluga whales indicted by CYP1A1 expression. Environmental Health Perspectives 113(11): 1594-1599

Wolfe, S.A. and W.G. Nickling. 1997. Sensitivity of eolian processes to climate change in Canada. Geological Survey of Canada, Bulletin 421. Ottawa.

Wursig, B., E.M. Dorsey, W.J. Richardson and R.S. Wells. 1989. Feeding, aerial and play behaviour of the bowhead whale, *Balaena mysticetus*, summering in the Beaufort Sea. Aquatic Mammals 15: 27-37

Wursig, B., E.M. Dorsey, M.A. Fraker, R.S. Payne and W.J. Richardson. 1985. Behaviour of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: a description. Fishery Bulletin 83: 357-377

Zittlau, K., J. Nagy, A. Gunn, and C. Strobeck. 2003. Do subspecific divisions make good conservation units? Pp 36-50 in C. Strobeck (ed) Caribou Genetics and Relationships Workshop, March 8-9, 2003. Edmonton, Alberta, Department of Resources, Wildlife and Economic Development, Yellowknife, Northwest Territories.

Appendix A

Valued Ecosystem Components and Socio-Economic Components Selection Process

VEC's and VSEC's historically identified and used within the Mackenzie Delta and Beaufort Sea Region

Mammals

- Polar Bears
- Grizzly Bears
- Black Bears
- Reindeer
- Caribou
- Moose
- Muskrat
- Arctic Fox
- Wolf
- Marten
- Lynx
- Dall Sheep
- Ringed Seal
- Bowhead Whale
- Bearded Seal
- Narwhal

Birds

- Lesser Snow Goose
- Greater White Fronted Goose
- Common Eider
- King Eider
- Oldsquaw (long-tailed duck)
- Glaucous Gull
- Arctic Term
- Brant Goose
- Red Throated Loon
- Scoter
- White Winged Scoter
- Lesser Scaup
- Pacific Common Eider
- Jaeger
- Murre
- Common Raven

Fish

- Arctic Cisco
- Least Cisco
- Fourhorn Sculpin
- Arctic Char
- Arctic Cod
- Broad Whitefish
- Lake Whitefish
- Pacific Herring
- Inconnu
- Rainbow Smelt
- Blackline Prickleback
- Arctic Flounder
- Starry Flounder

Geographic Feature

- Polynya

Socio-Economic

- Economic Potential
- Hunting
- Trapping
- Fishing
- Transportation / Access

Appendix B

List of Contacts and Data Sources

List of Contacts and Data Sources

Government of Canada departments and agencies contacted to supply data and GIS layers included the following:

Department of Fisheries and Oceans
Humfrey Melling
Arctic Aquatic Research Division
Central & Arctic Region
Fisheries and Oceans Canada
501 University Crescent, Winnipeg, Manitoba R3T 2N6
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Institute of Ocean Sciences
Pierre Richard
State of the Ocean
Pacific Region
9860 West Saanich Road
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Sidney, British Columbia V8L 4B2

Fisheries and Oceans Canada
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National Energy Board
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444 7th Avenue SW
Calgary AB, T2P 0X8
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Indian and Northern Affairs Canada, Gatineau
Northern Oil and Gas Branch
Mythily Thadchanamoorthy
Les Terrasses de la Chaudière
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Non-government Contacts
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Cape Bathurst polynya information

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Faculty of Science
Dept. Of Biological Sciences
CW405 Biological Science Center
University of Alberta
Edmonton, AB T6G 2E9
Polar bear information

Appendix C

Review of Past, Present, and Potential Development Activities in the Region and the Residual Effects of these Activities

Summary of Residual Effects

Introduction

Numerous exploration projects have been completed in the Beaufort Sea-Mackenzie Delta region since oil and gas were first discovered over 40 years ago. An understanding of the residual effects (spatial and temporal) associated with these exploration projects will provide the opportunity to look at multiple activities in the study area in relation to important VEC habitat and assess whether special management action is needed. This will increase our ability to complete strategic level cumulative effects assessments, as well as improve leasing plans and resource management. In an effort to establish zones of influence for the environmental effects of offshore projects, several projects in the Beaufort Sea – Mackenzie Delta region were reviewed, as well as material from other regions where off-shore drilling has taken place. These include:

- Fisheries and Oceans Canada Implications of Ecosystem Dynamics for the Integrated Management of the Eastern Scotian Shelf (Zwaneburg *et al*. 2006),
- Institute of Ocean Sciences Review of Models in Support of Oil and Gas Exploration off the North Coast of British Columbia (Foreman *et al*. 2005),
- Devon Canada Corporation regarding the *Comprehensive Study Report Devon Beaufort Sea Exploration Drilling Program* (Devon Canada Corporation 2004),
- Department of Fisheries and Oceans (DFO) Review of Scientific Information on Impacts of Seismic Sounds on Fish, Invertebrate, Marine Turtles and Marine Mammals (DFO 2004),
- Northern Oil and Gas Directorate Economic and Strategic Significance of Petroleum Resources Potentially Affected by a Marine Protected Area in the Beaufort Sea (Morrell 2003),
- Stanislav Patin book regarding *Environmental Impact of the Offshore Oil and Gas Industry* (Patin 1999),
- Environmental Impact Review Board *Public Review of the Gulf Canada Resources Limited Kulluk Drilling Program 1990 – 1992* (EIRB 1993),
- Environmental Impact Review Board *Public Review of the Esso Chevron et al Isserk I-15 Drilling Program* (EIRB 1989),
- Federal Environmental Assessment Panel *Beaufort Sea Hydrocarbon Production and Transportation* proposal (FEARP 1984), and
- Dome Petroleum Ltd, Esso Resources Canada Ltd and Gulf Canada Resources Inc., *Hydrocarbon Development in The Beaufort Sea – Mackenzie Delta Region* (Dome *et al*. 1982).

Although numerous reports and sources were reviewed, information regarding development-related residual effects in the Beaufort Sea was limited. As a result, zones of influence for potential residual effects were largely based on estimates provided in the Devon Canada Corporation Comprehensive Study Report of the Beaufort Sea Exploration Drilling Program. As such, this summary of residual effects in the Beaufort Sea is intended as first step towards a larger and more comprehensive study.

For the purposes of this report, information regarding residual effects was identified, analyzed and categorized based on disturbance type. The Devon report included potential effects to several animals that were not listed as VECs by GLL, including Arctic fox, benthic invertebrates, humans, plankton, reefs and water quality. These were not included in this report since they were not identified as VECs by GLL. The information is summarized in Table C-1.

Table C-2. Potential Residual Effects, Sources and Categories Related to Oil and Gas Development

Potential Residual Effects Category	Potential Source of Residual Effects	Potential Residual Effect
Drilling Waste Products	Drilling Muds (Oil & Water-based) Produced Water Cuttings Toxins (heavy metals, barium, hydrocarbons, etc.)	Poisoning Tainting Smothering
Other Miscellaneous Releases	Food Waste Sewage Disposal Spills (oil, organochlorines, ethylene glycol)	Animal Attractant Poisoning
Seismic Activity	Seismic Waves / Energy Pulses	Pressure Differentials Sound Bursts Mortality (i.e., fish)
Localized Disturbances	Drill Platform (Staging, Mobilizing, Set Down, Storage) Drill Ships Ice Pad & Ice Road Construction Pipe-laying Support Facilities Construction	Localized Disturbance of on-ice and underwater habitat Animal avoidance
Noise	Drilling Flaring Construction (Ice Pad, Ice Road, Pipe-laying, Support Facilities) Marine Transport Air Transport (Landings, Takeoffs, Flyovers) Road Transport	Noise Disturbance Animal avoidance
Light	Fixed & Portable Lights Flaring	Animal Attractant Chemical Residues

Drilling Waste Products

Various types of drilling fluids (i.e., mud) can be used for offshore operations, including oil-based, synthetic based and water-based[3] fluids (Table C-1). It's predicted that oil-based drilling muds will have no residual effects beyond a 1.5 km radius from the discharge source that would affect fish and fish habitat, and the effects are expected to persist for less than three years (Devon Canada Corporation 2004). The Department of Fisheries and Oceans (DFO) found various re-suspended drilling mud up to 10 km from the discharge source (Zwanenburg *et al.* 2006). The effect of smothering from various drilling muds was found to be proportionate to the size of the release (DFO 2004).

Toxins from cuttings have been found up to 10 km from the discharge source in benthic invertebrate samples (Patin 1999). Heavy metals and barium distribution in bottom sediments was found to result in concentrations 100 to 1000 times higher than background levels characteristic in benthic invertebrate communities (Patin 1999). Tainting was observed up to 500 m from the discharge source and the potential residual effects to fish and fish habitat are predicted persist for less than one year (Devon Canada Corporation 2004; Zwanenburg *et al*. 2006).

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[3] To date, not all of these have been used in the Beaufort off-shore.

Produced water, which can include metals and hydrocarbons, are predicted to produce no residual effects beyond a 1.5 km radius that would affect fish and fish habitat and these effects are expected to persist for less than three years (Devon Canada Corporation 2004).

Other Miscellaneous Releases

Other miscellaneous releases that have been known to be associated with offshore oil and gas activities include food waste, sewage discharge, ethylene glycol, organochlorines and other typical household wastes (e.g., plastics, paper, glass) (Table C-1). Oil spills are discussed separately below. These compounds can potentially be consumed either directly or indirectly by polar bears or other species (Perham 2005). The release of sewage waste into the aquatic environment has been shown to stimulate algae growth (Devon Canada Corporation 2004; Patin 1999). It's predicted that they will not produce any residual effects beyond a 1 km radius from the discharge source and that these effects would persist less than one year (Devon Canada Corporation 2004). Flaring activities have been found to produce residual chemical effects, whereby ice surfaces around flaring sites tended to be polluted by atmospheric fallout of heavy oily residue (Patin 1999).

Oil Spills

Oil spills and other hydrocarbon releases can have similar potential effects as other miscellaneous releases discussed above (Table C-1). Oil Spills and other hydrocarbon releases can be lethal to species exposed through consumption of contaminated prey, grooming and inhalation of vapours. These releases can also have indirect effects such as a loss of or redistribution of prey species. Finally, spills may affect species movements, such that there could be increased bear-human interactions (Devon Canada Corporation 2004; Perham 2005). The potential residual effects associated with a tanker spill vary greatly and are dependent on many variables (Devon Canada Corporation 2004; Patin 1999). The composition and size of the release, distance from shore, ocean currents, response time and time of year all influence the potential for a tanker spill to produce measurable effects on its surrounding environment (Patin 1999). One ton of released oil can disperse over a 50 m radius with a 10 mm thick film in 10 minutes, and can eventually cover a 12 km^2 area with a 1 mm thick film (Patin 1999). Studies on the residual effects of a tanker spill on marine birds and mammals show that optimal population abundances can be restored several years following a spill (Patin 1999). Although large catastrophic spills have occurred, the risk is greatly reduced with appropriate mitigation.

Seismic

Available information regarding the potential biological effects of seismic activities on marine organisms was limited and somewhat contradictory, and quantitative assessments of such impacts on the total stock and reproduction of fish populations are not available (Patin 1999). Norwegian research results indicated that school pelagic fish (especially herring) responded to a seismic signal 100 km from the discharge source (Dalen and Knutsen 1997), while studies found a 90% mortality of larvae, fry and adult fish within a radius of 2 m from the seismic wave (Matishov 1992). However, other research has found that seismic activity has not produced effects beyond an 8 m radius from the waves that would adversely affect fish and fish habitat (Patin 1999). Due to the incomplete and contradictory nature of the available information, a more comprehensive study is required.

Localized Disturbance

Localized disturbances linked to oil and gas development include drill platforms, ice pads and ice roads (Table C-1). Drill ships are discussed separately below. These activities can result in smothering, localized changes in habitat and displacement. The effects of these activities vary with the receiving VEC. The extent of the effects is dependent on the size and scale of the operation under consideration.

Activities from drill platforms are predicted to produce no residual effects to habitat beyond a 1 km radius that would fish and fish habitat, beluga whales or sea birds (Devon Canada Corporation 2004). The effects to fish and fish habitat are expected to persist for less than three years, while the effects to beluga whales and sea birds are expected to persist for less than one year. The construction of ice roads is predicted to produce no residual effects beyond a 50 km radius that would affect polar bears and ringed seals and beyond a 1 km radius that would affect fish and fish habitat (Devon Canada Corporation 2004). The effects to polar bears, ringed seals, and fish and fish habitat are expected to persist for less than one year. Potential residual effects associated with seabed heating from pipelines include accelerated biological processes that could potentially lead to reductions in dissolved oxygen. However, studies have not been conducted to determine the magnitude of any impacts from seabed heating (Patin 1999).

Drill Ships

In areas where floe ice and icebergs present dangers, mobile drilling platforms are used to avoid ice collisions. Platforms include drilling ships or semi submersible rigs (i.e., platforms mounted on submerged, neutrally buoyant pontoons, which are anchored or positioned by motors over the drill site). Starting in the mid 1976, Dome Petroleum (Canmar) utilized floating drill ships during summer months in the Beaufort Sea (Timco and Johnston 2002). In 1983, Gulf Canada Resources Ltd. designed and built an inverted cone shaped floating structure (the “Kulluk”) that allowed drilling later into the winter season (Timco and Johnston 2002). Potential impacts and residual effects from drill ship activities are discussed in sections 3.2.2, 3.2.5 3.2.6 and 3.2.7. These impacts are associated with drilling activities such as drilling waste products and potential oil spills, as well as those associated with movement to and from the drilling site such as noise from marine vessels. Localized disturbance impacts are similar to those from drill platforms discussed above.

Noise Sources

Noise sources from oil and gas development include ice pad, ice road, pipe-laying and support structure construction, drill rig operations, flaring, marine transport activities and air and road transport activities (Table C-1). Effects associated with noise are often temporary (i.e., marine transport activities) but can also be persistent (Devon Canada Corporation 2004; citations within Moulton *et al.* 2003; Erbe and Farmer 1998; Fast *et al.* 1998; Harwood and Smith 2002; Perham 2005). In either case, behavioural adjustments of different magnitudes are observed and can range from avoidance to habituation. Devon Canada Corporation (2004) predicted that noise from marine transport activities would produce no residual effects beyond a 50 km radius from the marine transport vessel that would affect beluga whales or ringed seals. The effects to beluga whales are predicted to persist for less than one year, while the effects to ringed seals are predicted to persist for less than two days. At its most extreme, noise can potentially affect beluga whales by interfering with mating behaviours, communication and even cause damage to ears or other organs (Erbe and Farmer 1998).

Light Sources

Light sources from oil and gas development include portable and fixed lights, as well as flaring (Table C-1). Light sources are predicted to have limited residual effects beyond a 1 km radius, for no longer than two days, for temporary operations (Devon Canada Corporation 2004). Facility lights were identified as a potential attractant for polar bears; however, studies conducted in Canada indicated that bears were not attracted to areas lit with high intensity lights. Thus the evidence of impacts of the facility lights is limited and unclear (Perham 2005).

Biodiversity Changes

Residual effects associated with the exploration, development and production phases of oil and gas reserves have the potential to produce changes in biodiversity (Devon Canada Corporation 2004; Patin 1999). These effects can potentially reduce productivity in benthic invertebrate communities and may persist for several years (Devon Canada Corporation 2004). This can potentially produce a shift in plankton and algae towards waste tolerant species (Devon Canada Corporation 2004).

References

Dalen, J. & G.M. Knutson. 1987. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. In: Merklinger, H. M. ed. Progress in Underwater Acoustics*.* New York*:* Plenum Publishing Co.:93-102

Department of Fisheries and Oceans (DFO), 2004. Review of Scientific Information on Impacts of Seismic Sounds on Fish, Invertebrate, Marine Turtles and Marine Mammals. Habitat Status Report 2004/002. National Capital Region.

Devon Canada Corporation, 2004. Comprehensive Study Report Devon Beaufort Sea Exploration Drilling Program. Submitted to National Energy Board. URL: http://www.devonenergy.com/operations, last accessed February 9, 2007.

Dome Petroleum Ltd, Esso Resources Canada Ltd, and Gulf Canada Resources Inc., 1982. Hydrocarbon Development In The Beaufort Sea – Mackenzie Delta Region. Environmental Impact Statement – Volume 1 Summary.

Environmental Impact Review Board (EIRB), 1993. Public Review of the Gulf Canada Resources Limited Kulluk Drilling Program 1990 - 1992.

Environmental Impact Review Board (EIRB), 1989. Public Review of the Esso Chevron et al Isserk I-15 Drilling Program.

Erbe, C. and D.M. Farmer, 1998. Masked hearing thresholds of a beluga whale (*Delphinapterus leucas*) in icebreaker noise. Deep-Sea Research II 45:1373-1388.

Fast, H., J. Mathias and F. Storace, 1998. Marine Conservation and Beluga Management in the Inuvialuit Settlement Region. Prepared for the Fisheries Joint Management Committee, Inuvialuit Settlement Region.

Federal Environmental Assessment and Review Process (FEARP), 1984. Beaufort Sea Hydrocarbon Production and Transportation. Report of the Environmental Assessment Panel.

Foreman, M.G.G., L. Beauchemin, J.Y. Cherniawsky, M.A. Peña, P. F. Cummins and G. Sutherland, 2005. A Review of Models in Support of Oil and Gas Exploration off the North Coast of British Columbia. Canadian Technical Report of Fisheries and Aquatic Sciences 2612. Institute of Ocean Sciences. Fisheries and Oceans Canada.

Harwood, L.A. and T.G Smith, 2002. Whales of the Inuvialuit Settlement Region in Canada's Western Arctic: An Overview and Outlook. Arctic. Vol. 55, Supp. 1 (2002):.77-93

Matishov, G.G. 1992. The reaction of bottom-fish larvae to airgun pulses in the context of the vulnerable Barent Sea ecosystem. Fisheries and Offshore Petroleum Exploitation. 2nd International Conference, Bergen, Norway, 6-8 April 1992

Morrell, G.R., 2003. Economic and Strategic Significance of Petroleum Resources Potentially Affected by a Marine Protected Area in the Beaufort Sea. Northern Oil and Gas Directorate, Indian and Northern Affairs Canada.

Moulton, V.D., W.J. Richardson, M.T. Williams and S.B. Blackwell, 2003. Ringed seal densities and noise near and artificial island with construction and drilling. Acoustics Research Letters Online 4(4): 112-117

Patin, S., 1999. Environmental Impact of the Offshore Oil and Gas Industry. EcoMonitor Publishing.

Perham, C.J., 2005. Proceedings of the Beaufort Sea Polar Bear Monitoring Workshop. OCS Study MMS 2005-034. Prepared by U.S. Fish and Wildlife Service. Marine Mammals Management, Anchorage, AK. Prepared for the U.S. Dept. of the Interior, Minerals Management Services, Alaska OCS Region, Anchorage. 26 pp. plus appendices

Timco, G.W. and M.E. Johnston, 2002. Caisson Structures in the Beaufort Sea 1982-1990: Characteristics, Instrumentation and Ice Loads. Technical Report CHC-TR-003.

Zwanenburg, K.C.T., A. Bundy, P. Strain, W.D. Bowen, H. Breeze, S.E. Campana, C. Hannah, E. Head, and D. Gordon, 2006. Implications of Ecosystem Dynamics for the Integrated Management of the Eastern Scotian Shelf. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2652. Fisheries and Oceans Canada.