The beginning of Section 10 is in the PDF file called:

Beaufort Sea Proj Description Sec 10 Part 1 of 2.

10.11.3.2 Seasonal Distribution and Movement

Bowhead whales annually migrate from the Bering Sea, where they overwinter south of the heaviest polar pack ice through the Chukchi Sea, past Point Barrow, Alaska, and into the eastern Beaufort Sea (see Figure 10-14).

After spending the summer in the eastern Beaufort Sea, bowhead whales return to the Bering Sea in the fall. The eastward spring migration begins in March and continues through to May, with bowhead whales passing Point Barrow from April through June and arriving in the eastern Beaufort Sea in May through July (Thomson et al. 1986, Richardson et al. 1987, Moore and Clarke 1991). The nearshore ice cannot be passed early in the year because the ice is landfast and the pack ice seaward of the landfast ice usually has very little open water (Braham et al. 1980). The bowhead whale spring migration follows a northern offshore route, using predictable open-water leads (Fraker 1979, Braham et al. 1980). As spring progresses, there is increased lead development west of Banks Island and north of the Tuktoyaktuk Peninsula by May, and development of the large polynya in Amundsen Gulf (Fraker 1979).

Bowhead whales remain in the Beaufort Sea for up to four months (Fraker and Bockstoce 1980) until the return migration to the Bering Sea begins in August and runs through November, depending on ice conditions (Thomson et al. 1986, Moore and Clarke 1991, Treacy et al. 2006). The purpose of the migration is believed to be for feeding, taking advantage of the high seasonal plankton production (Fraker and Bockstoce 1980, Wursig et al. 1985). There appears to be a general, large-scale pattern of bowhead whales first occupying the eastern Beaufort Sea and Amundsen Gulf, then gradually moving westward as the summer progresses (Thomson et al. 1986, Richardson et al. 1987), although there is a large variability in this pattern on an annual basis. Several studies (McLaren and Davis 1985, Thomson et al. 1986, Ford et al. 1987, Richardson et al. 1987, Koski and Miller 2009) have reported large variations in bowhead whale distribution throughout the years, most likely attributed to the variable distribution of their food sources (copepods and zooplankton) whose abundance depends on oceanographic and meteorological conditions (McLaren and Davis 1985, Wursig et al. 1985, Richardson et al. 1987). Fraker and Bockstoce (1980) suggest that the turbid freshwater plume of the Mackenzie River might inhibit primary and secondary production because of the reduction of light, which might cause bowhead whales to avoid the influence of fresh water from the Mackenzie River (Thomson et al. 1986).

Despite the interannual variability in distribution of bowhead whales in the Beaufort Sea, the following specific locations have been consistently used:

- the western half of the Amundsen Gulf and Cape Bathurst (Fraker and Bockstoce 1980, Richardson et al. 1987)
- offshore of Shingle Point, the eastern Tuktoyaktuk Peninsula and Herschel Island (Ford et al. 1987, Mate et al. 2000)
- Demarcation Bay (Mate et al. 2000)

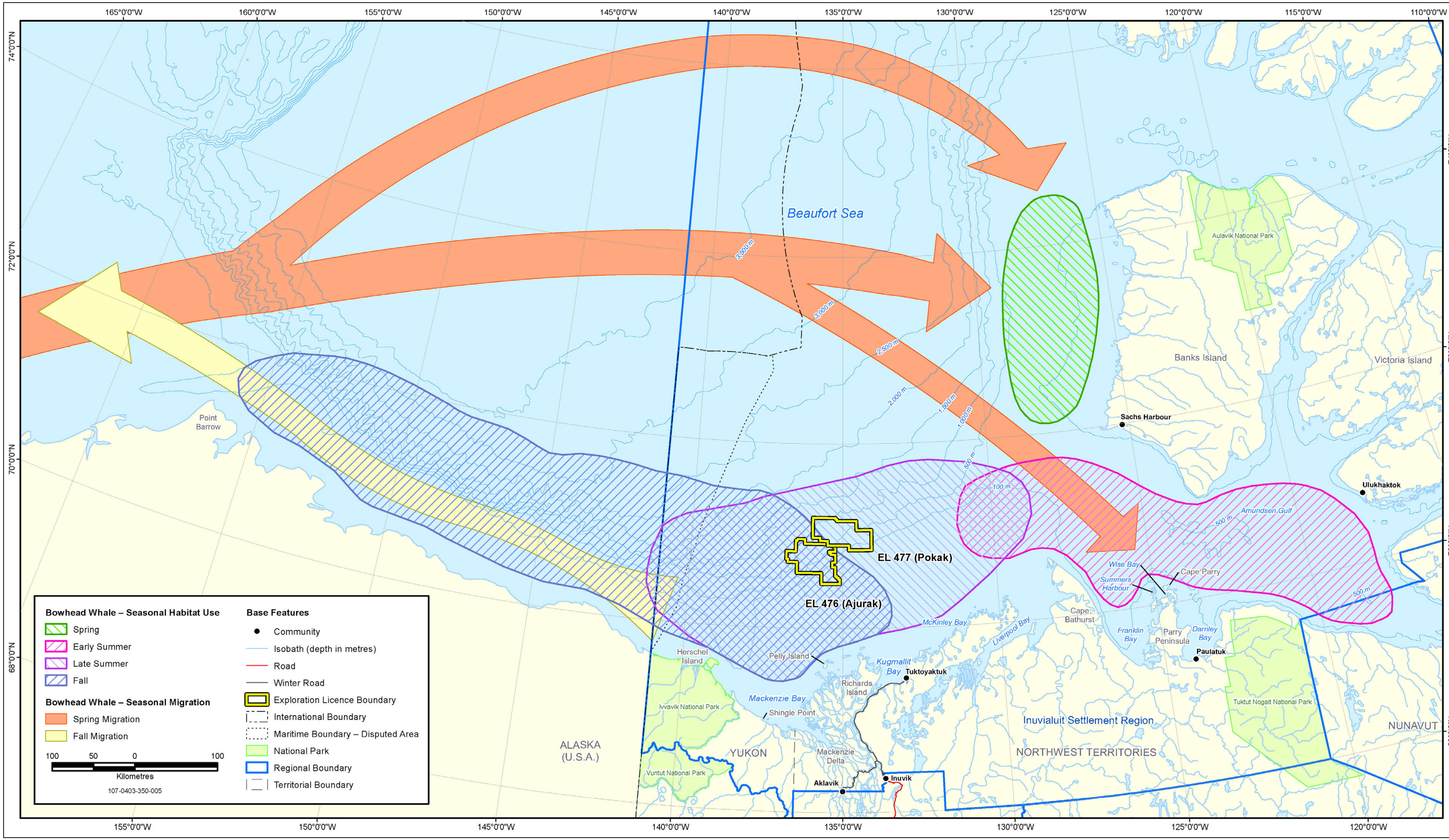

Figure 10-14: Bowhead Whale Migration Patterns and Seasonal Habitat Use in the Beaufort Sea

10.11.3.2 Seasonal Distribution and Movement (cont'd)

Offshore areas where water depth is greater than 200 m appear to be frequented more regularly than shallower waters, although younger bowhead whales tend to prefer the shallower nearshore waters (Koski and Miller 2009). Mate et al. (2000) made most (87%) of their bowhead whale observations in water less than 100 m deep. There is indication that bowhead whales select offshore waters in years of heavy ice conditions (Moore 2000). Consequently, ice conditions might be a determinate in explaining the variations in habitat selection.

During the return migration to the Bering Sea bowhead whales travel at a wide range of distances from shore (Koski and Miller 2009) because there is less obstruction from ice, and greater availability of open water. Ice conditions can modify this behaviour, where landfast ice limits availability of shallow nearshore access (Treacy et al. 2006). The length of time for bowhead whales to complete this migration to the Bering Sea varies among individuals (Mate et al. 2000). Bowhead whales are known to meander during this migratory transit, even reversing directions for short periods (Mate et al. 2000).

Aerial surveys conducted in 2007 through 2009 by Harwood et al. (2010) did not extend sufficiently offshore to encompass the EL areas. However, over the large survey area, the most consistently used feeding aggregations areas were north of Cape Dalhousie and northeast of Herschel Island (Harwood et al. 2010). Between 2008 and 2011, several vessel-based marine mammal surveys were conducted in the program area during the open-water season as part of the FDCPs. Although most sightings occurred outside the boundaries of the EL areas in water depths of less than 100 m, survey results demonstrated that bowhead whales were present in the program area during all years. During the summer and fall of 2010, Imperial worked with Cornell University to conduct a passive acoustic monitoring study at 12 underwater recording sites in the program area. Bowhead whales were detected at one or more of the recording sites in the program area during all 40 recording days (Cornell 2011).

Areas of higher sensitivity for bowhead whales during the open-water season from May 1 to October 31 are shown in Figure 10-15, as extracted from AECOM 2010. These areas are representative of key life stage and feeding areas, and movement and migratory corridors necessary for year-over-year survival (AECOM 2010).

10.11.3.3 Subsistence Harvest

Although harvested in the past, bowhead whales are not currently harvested for subsistence purposes by communities in the program area. However, bowhead whales are currently hunted by communities in Alaska and in the Canadian eastern Arctic.

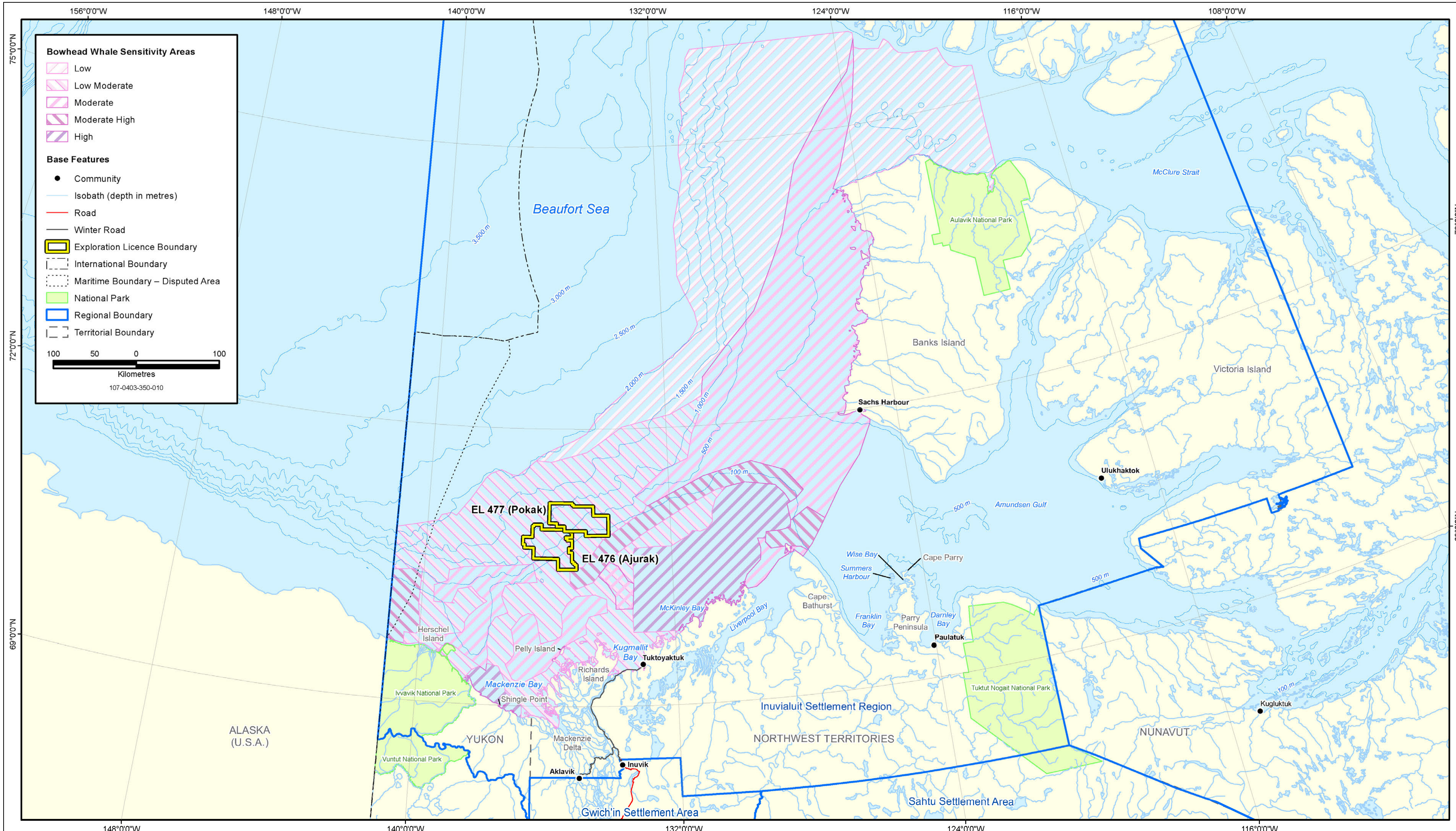

Figure 10-15: Bowhead Whale Sensitivity Areas During the Summer Season

10.11.3.4 Hearing Ability and Vocal Behaviour

All baleen whales, such as bowhead whales, vocalize at substantially lower frequencies than toothed whales, with bowhead whales using frequencies in the 0.1 to 0.8 kHz range (Ljungblad et al. 1982, Clark and Johnson 1984, Ketten 1992b), although they might perceive frequencies below 50 Hz (Ketten 1992b). However, trumpeting calls of up to 4 kHz have been recorded (Ljungblad et al. 1982, Clarke and Johnson 1984) but are infrequent.

Baleen whales are not thought to echolocate (Ketten 1992a). George et al. (1989) suggested that bowhead whales might use their calls to assess ice thickness in their path. Bowhead whale vocalizations are also used for maintaining contact between mothers and calves (Edds-Walton 1997). Bowhead whales are also known to sing, repeatedly producing one or two themes for up to 10 hours (Edds-Walton 1997). These songs appear to have a social function as they occur in winter and spring, during periods of social and sexual activity (Delarue et al. 2009, Edds-Walton 1997). There is individual variation in these songs and year-to-year variation (Edds-Walton 1997) indicating a high degree of acoustic sophistication.

10.11.4 RINGED SEAL

The ringed seal (*Phoca hispida*) was selected as a VEC because this species plays a key ecological role in the Arctic ecosystem. Ringed seals are the most abundant Arctic mammal and are the main food source for polar bears. They are also highly valued for subsistence harvesting and are of cultural significance to Inuvialuit (Bengston et al. 2005, Carlens et al. 2006, Harwood et al. 2012).

Because of the ringed seals' strong dependence on sea ice, climate change is expected to have a significant effect on this species, affecting their distribution as related to the timing of ice development and melting (Carlens et al. 2006).

10.11.4.1 Population Trend and Conservation Status

There are five subspecies recognized globally, of which *P. hispida hispida* is the sole North American Arctic subspecies (Allen and Angliss 2011b). The ringed seal is listed as not at risk (1989) by COSEWIC and is not registered in the Species at Risk Public Registry. However, in 2011, this species was listed as threatened under the US *Endangered Species Act*.

Population surveys have been conducted in the past, but the reliability of the survey data is limited (Allen and Angliss 2011b). Current estimates of abundance or population trends are not available, with the most recent available survey information dating back to 1999–2000 (Bengston et al. 2005).

For the period of 1982 to 1986, Harwood and Stirling (1992) reported annual mean densities in this area of 0.08 to 0.42 seals/km^2.

10.11.4.2 Seasonal Distribution and Movement

The ringed seal has a circumpolar distribution that is closely associated with the distribution of landfast ice. They are present year-round in the southern Beaufort (Harwood and Stirling 1992). The ability of ringed seals to maintain breathing holes in the landfast ice enables them to occupy large areas that are inaccessible to other marine mammals. During ice formation in the fall, adult males and females establish territories which they maintain and defend throughout the winter (Harwood et al. 2012). In contrast, subadults are displaced to outer pack-ice regions or to other less preferred habitat areas (Crawford et al. 2012). Many of these animals will migrate great distances (greater than 2,000 km) to the Chukchi Sea and Bering Sea (Harwood et al. 2012). Ringed seal migration is relatively rapid, typically following a nearshore route (less than 100 km), with an average transit time from Cape Parry to Point Barrow of 32 days (Harwood et al. 2012).

During winter, the ringed seals' preferred habitat consists of ice leads and polynyas where breathing holes are easiest to maintain. Ringed seals are considered a keystone species (Ferguson et al. 2005). Primary predators to the ringed seal include polar bears, Arctic fox, walrus, wolves, humans and dogs (Hammill and Smith 1991).

Juvenile ringed seals prey mainly on crustaceans under the ice while adults prey on crustaceans and small fish (e.g., Arctic cod) (Richard et al. 2001).

In spring, breeding adults occur in highest densities in areas of stable landfast ice with good snow cover where they maintain birth lairs for pup rearing (Hamill and Smith 1991). Non-breeding adults are found at the ice floe edge or in the moving pack ice (Stewart and Lockhart 2005). Pups are born in early spring (March/April) and weaned before breakup of the sea ice in late June (Evans and Raga 2001). Pups will remain in dens located in or under the snow. Pups remain in the dens during a five to eight week lactation period to avoid detection from predators, such as polar bears (Evans and Raga 2001). During the open-water season (July to October), ringed seals are commonly observed in large numbers hauled out on the sea ice (Finley 1979, Bengston et al. 2005). Higher densities of seals during this basking period have been noted near the landfast ice edge, over water 5 to 35 m deep (Moulton et al. 2002, Frost et al. 2004). Juveniles might move offshore at this time, but adults remain associated with islands and within coastal bays and fiords (McLaren 1958, Dunbar and Moore 1980).

Between 2008 and 2011, several vessel-based and aerial-based marine mammal surveys were conducted in the program area during the open-water season (July to October) as part of the FDCPs. Survey results demonstrated that ringed seals were present in the program area during all years surveyed. Figure 10-16 provides an overview of ringed seal distribution in the Beaufort Sea region based on historical sightings, current scientific knowledge and Inuvialuit traditional knowledge studies.

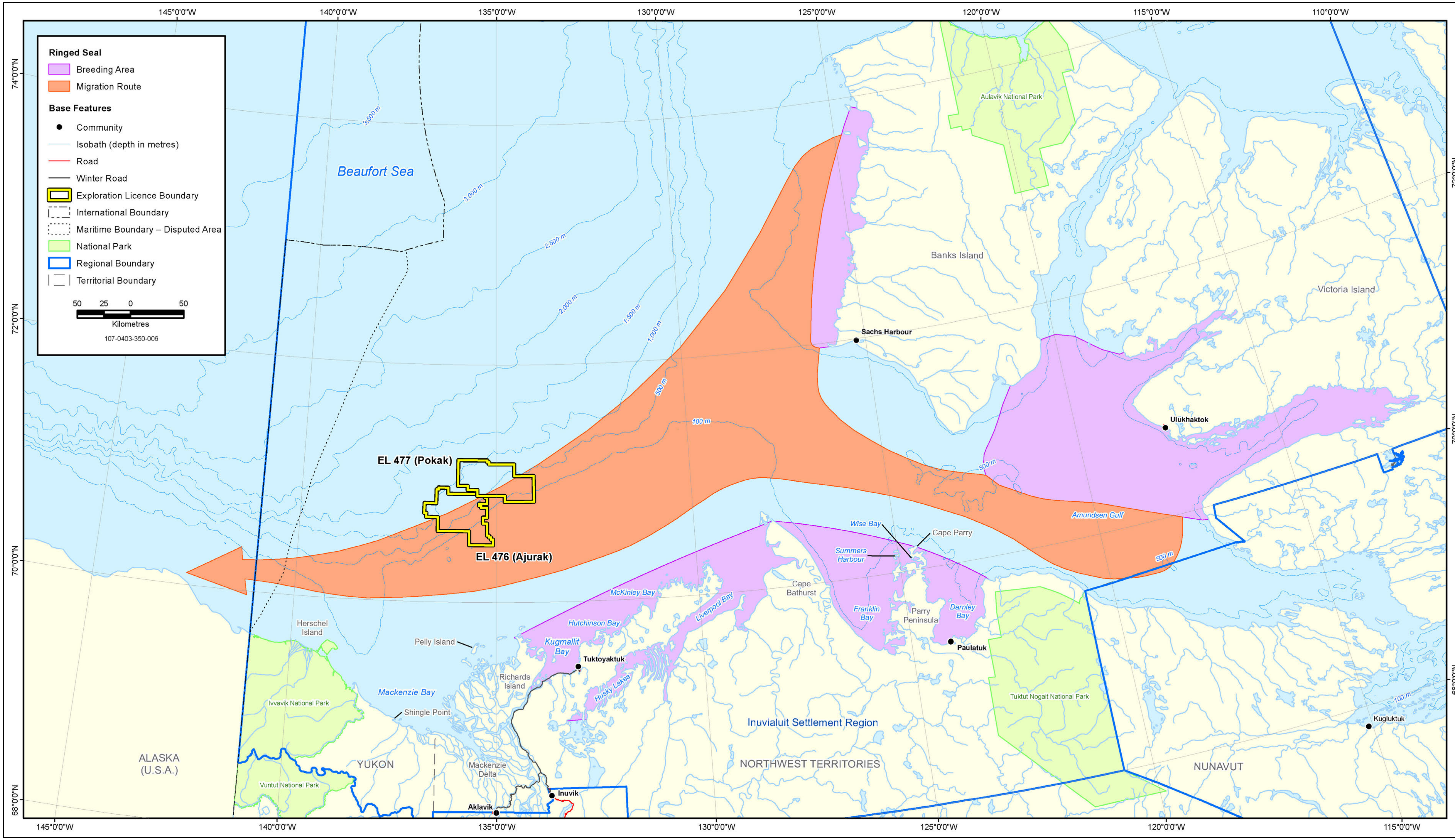

Figure 10-16: Ringed Seal Seasonal Movements in the Beaufort Sea

10.11.4.2 Seasonal Distribution and Movement (cont'd)

Areas of higher sensitivity for ringed seal during the open-water season from May 1 to October 31 are illustrated in Figure 10-17, as extracted from AECOM 2010. These areas are representative of key life stage areas, quality feeding areas, as well as movement and migratory corridors necessary for year-over-year survival (AECOM 2010).

10.11.4.3 Subsistence Harvest

The joint venture's traditional knowledge study identified ringed seals as one of the more important subsistence harvested species in the ISR because all communities are actively harvesting this species year round (Golder 2011a). The meat is considered a staple of the local diet, and seal hides are used for clothing and sold commercially. Key harvesting locations include Kugmallit Bay, the Husky Lakes Region, Hutchinson Bay and additional northern coastal areas of the Tuktoyaktuk Peninsula (Golder 2011a). The traditional knowledge study identified that the prevalence of seal hunting is declining in the region, particularly in the community of Paulatuk (Golder 2011b).

10.11.4.4 Hearing Ability and Vocal Behaviour

Underwater hearing sensitivity in seals falls between an estimated auditory bandwidth of 75 Hz and 75 kHz. Ringed seals have underwater hearing thresholds between 60 and 85 dB re 1µPa (Mohl 1968, Terhune and Ronald 1972 and 1975, Terhune 1981). Ringed seal vocalizations include barks, clicks and yelps, all of which occur in the 400 Hz to 16 kHz frequency range, with dominant frequencies concentrated above 5 kHz (Stirling 1973, Cummings et al. 1984).

10.11.5 POLAR BEAR

Polar bears (*Ursus maritimus*) occur throughout the polar basin, concentrating around more productive nearshore areas, polynyas and other areas where currents and upwellings increase productivity (Feldhamer et al. 2003). They are apex predators of the Arctic marine ecosystem feeding primarily on ringed seals (*Phoca hispida*), but their diet also includes bearded seals (*Erignatus barbatus*), harp seals (*Phoca groenlandicia*) and harbour seals (*Phoca vitulina*). They have been known to kill walruses (*Odobenus rosmarus*) and beluga whales (*Delphinapterus leucas*). They also feed on fish and carrion (Feldhamer et al. 2003). Terrestrial food (e.g., berries, human refuse) is not considered significant in the overall diet. Polar bear males and subadults have been reported to go into short-term dens (to find shelter in severe weather), but polar bears do not hibernate in the same manner as grizzly bears. The world population of polar bears is estimated to be between 22,000 and 27,000 animals in 19 separate populations. Canada has the largest population with an estimated 15,000 polar bears in 13 populations.

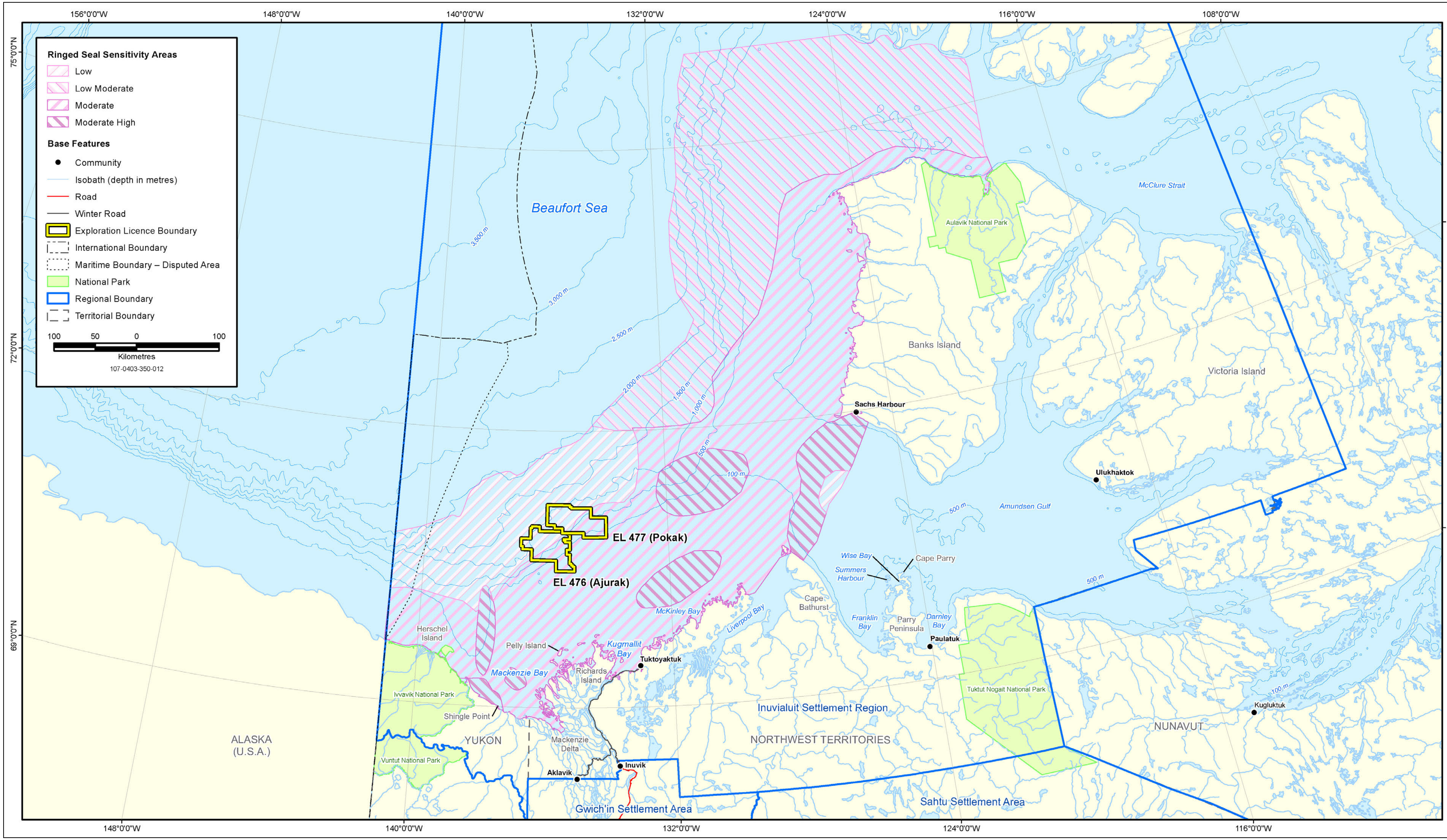

Figure 10-17: Ringed Seal Sensitivity Areas During the Summer Season

10.11.5.1 Southern and Northern Beaufort Sea Polar Bear Populations

Polar bears in the Canadian sector of the Beaufort Sea are considered to be part of two populations:

- the southern Beaufort Sea population
- the northern Beaufort Sea population

Their annual distribution is mainly linked to the distribution of multi-year pack ice and the availability of ringed seals.

For a map showing polar bear seasonal movements and denning locations, see Figure 10-18. For a map showing the polar bear population boundary, see Figure 10-19.

The southern Beaufort Sea polar bear population occupies a core area from Icy Cape, Alaska, in the west to Pearce Point, NWT (Schliebe et al. 2006), and management responsibility is shared between Alaska and Canada.

The northern Beaufort Sea population is distributed across the eastern and northeastern Amundsen Gulf, the southwest coast of Banks Island, western portions of M’Clure Strait and the west coast of Prince Patrick Island. The management responsibilities for this population are shared between the NWT and Nunavut (Stirling et al. 2011).

Recent studies suggest that the distribution of the two polar bear populations has changed so that the boundary has shifted westwards towards Tuktoyaktuk (Allen and Angliss 2010). If officially accepted by the co-management partners, this change would move a large portion of the range and about 311 bears from the southern Beaufort Sea population to the northern Beaufort Sea population.

Polar bears in the Beaufort Sea generally move north in summer, following the retreating pack ice where they concentrate along the edge of the persistent pack ice. In winter, the bears extend their range to the southern-most reach of the sea ice and to coastal areas. In early winter (between October and December), pregnant females build maternity dens from ice and snow. Most of the dens that are located onshore are situated in coastal and river banks or other pronounced landscape features, such as lake shores or slopes (Durner et al. 2003). Offshore, dens are located on landfast ice or drifting pack ice (Fischbach et al. 2007). Recent research indicates that there has been a shift in distribution of maternity dens towards terrestrial den sites (Gleason and Rode 2009). Females might give birth to one to three young in the dens between November and January and cubs emerge from dens during March and April (Amstrup and Gardner 1994). Denning is a crucial aspect of a polar bear’s life cycle because the dens provide protection for the highly dependent newborns. Consequently, denning habitat protection is a critical aspect for the species’ conservation.

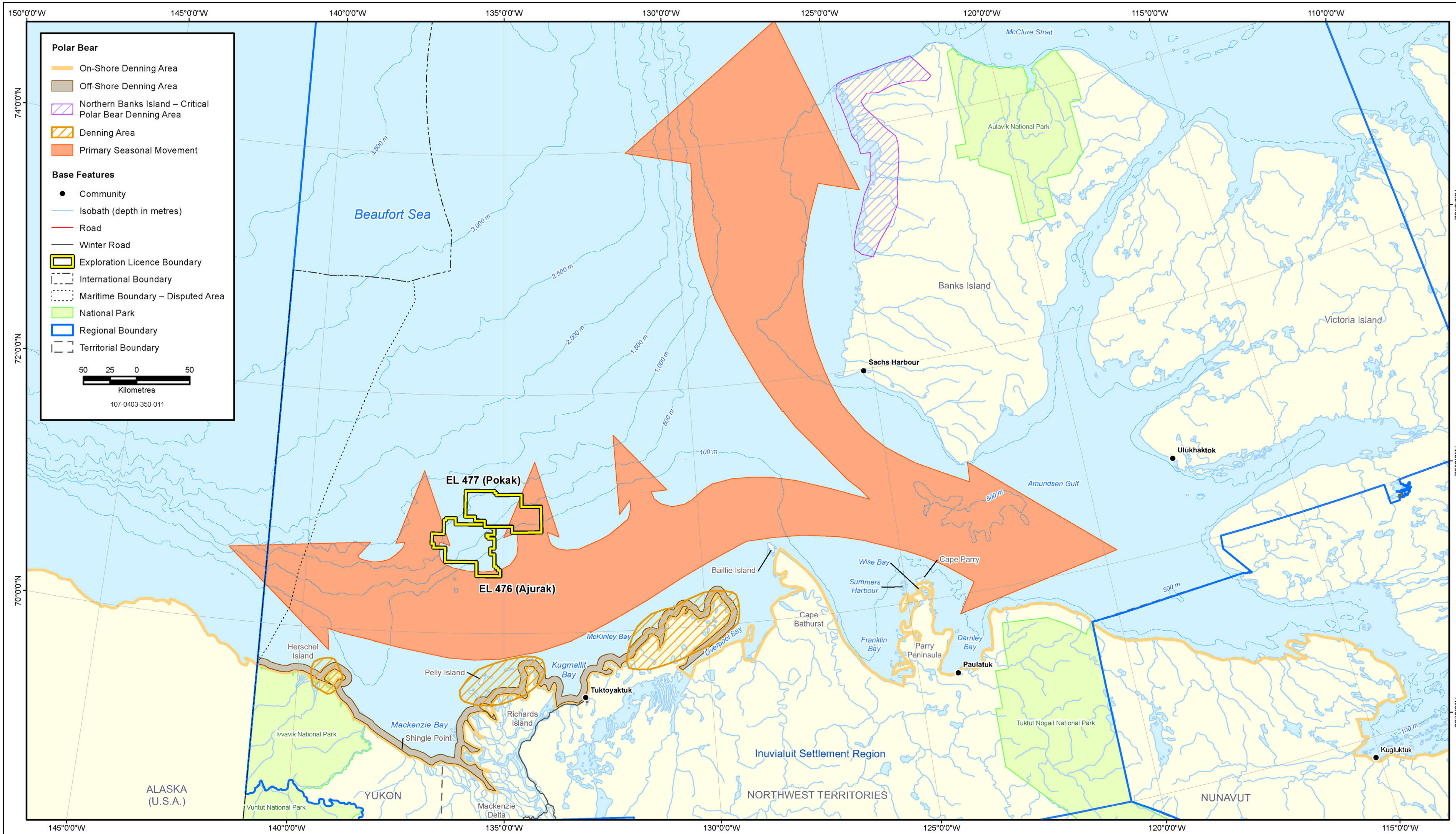

Figure 10-18: Polar Bear Seasonal Movements and Denning Locations

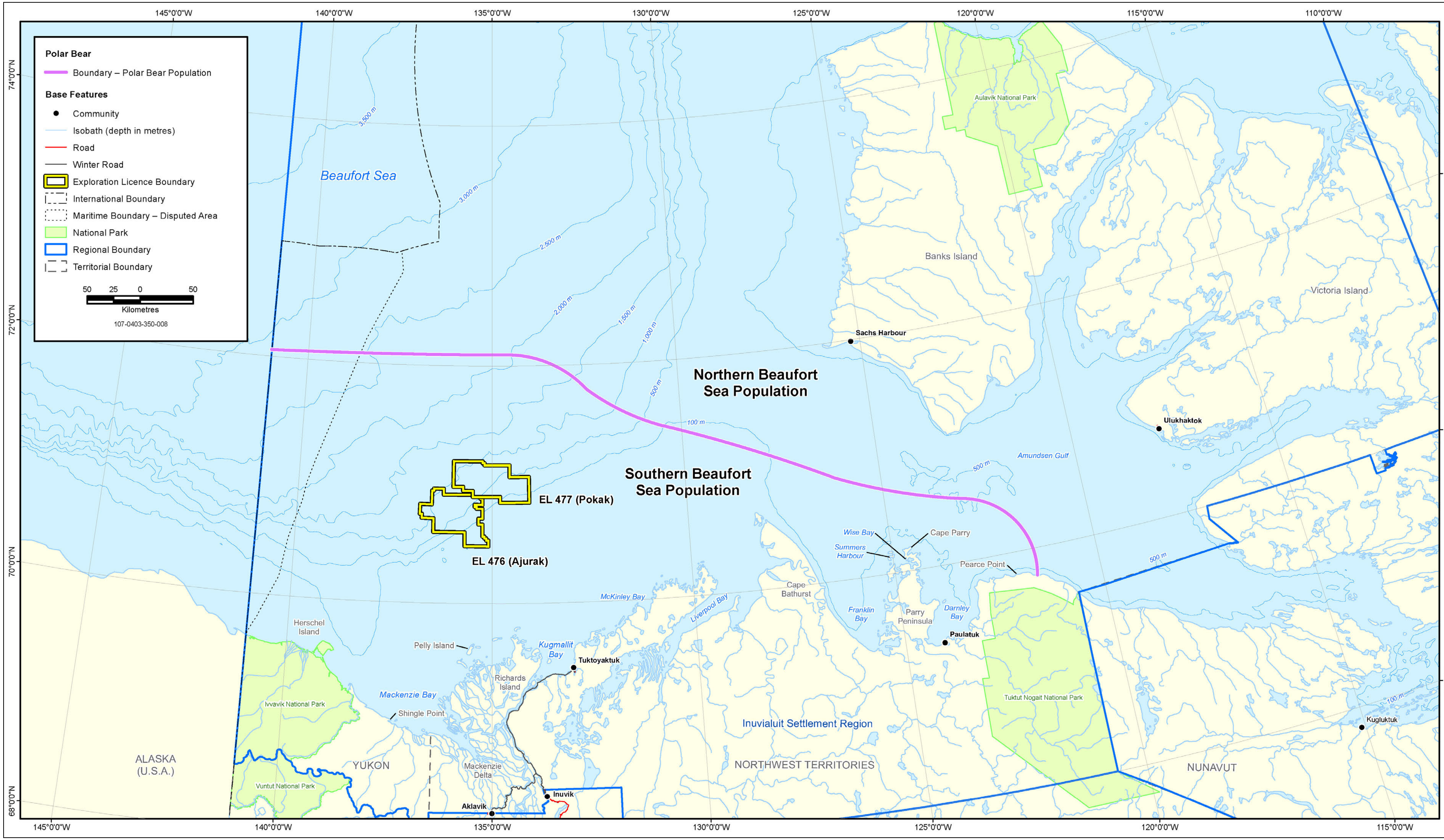

Figure 10-19: Polar Bear Population Boundary in the Beaufort Sea

10.11.5.2 Population Trend and Conservation Status

The southern Beaufort Sea population was believed to be stable with numbers of about 1,800 animals until Regehr et al. (2006) estimated it at around 1,500 animals. Regehr et al. (2006 and 2007) calculated declining survival and recruitment rates and reduced body size. Combined with low growth rates, the southern Beaufort Sea population is now believed to be declining.

The northern Beaufort Sea population was recently estimated at 1,200 and is believed to be stable or possibly increasing (Stirling et al. 2011).

Polar bears in Canada are protected under SARA, where they are listed as a species of special concern under Schedule 1. The main impact to the species is harvesting in combination with the effects of climate change (e.g., changes to their sea-ice habitat and reduction in the availability of prey).

In 2008, COSEWIC assessed the polar bear in Canada as a species of special concern. This listing is still in effect mainly because of harvesting issues and environmental changes that can affect their prey base or affect the thickness and distribution of sea ice.

The NWT Species Monitoring Infobase lists polar bears in the NWT as a sensitive species because of prominent threats to the population, such as potential overharvesting in some areas, oil spills, killing of problem bears and climate change (GNWT-ENR 2012).

Polar bears are also listed in Appendix II of the Convention on International Trade in Endangered Species, which regulates international trade in species that are or might become threatened by commercial trade.

The International Union for Conservation of Nature and Natural Resources' Red List lists polar bears worldwide as vulnerable and classifies their population trend as declining.

During the regulatory review of the Mackenzie Gas Project, the Joint Review Panel (JRP) issued two recommendations to mitigate potential impacts on polar bears from oil and gas exploration and development activities in the Beaufort Sea (JRP 2009). Recommendation 10-14 called for the development of a range management plan for the southern Beaufort Sea polar bear population, and recommendation 10-13 was to:

- *delineate potential maternity denning habitats and assessment of the potential for den disturbance*
- *assess the risk and potential impacts of offshore activities to the southern Beaufort Sea polar bear population*
- *assess the impact of nearshore activities on Inuvialuit polar bear hunting along the nearshore areas of the southern Beaufort Sea coast from Mackenzie Bay to the Tuktoyaktuk Peninsula*

10.11.5.2 Population Trend and Conservation Status (cont'd)

- *identify key feeding areas in nearshore areas that are used by family groups of polar bears, especially females with young of the year just out of their maternity dens, and prime seal and bear habitat near the outer edge of the landfast ice*
- *consider potential interaction of industrial development impacts with effects arising from climate variability and long-term climate change*
- *monitor the Beaufort Sea polar bear populations so that such data can inform the range management plan noted in Panel Recommendation 10-14*

Areas of higher sensitivity for polar bear during the open-water season are shown in Figure 10-20. These areas are representative of key life stage and foraging areas, as well as movement corridors necessary for year-over-year survival (AECOM 2010).

10.11.5.3 Seasonal Distribution and Movement

Beaufort Sea polar bears are known to use nearshore areas, but rarely venture onto the land (Amstrup et al. 2000 and 2007). Polar bears move into nearshore areas to forage when landfast ice is available. Recent trends indicate that an increasing number of polar bears have been observed on nearshore islands and the coastal mainland during open-water conditions when sea ice is far from shore (Schliebe et al. 2008, Gleason and Rode 2009). During the summer, when access to seals is limited, polar bears might fast, hunt alternative marine mammals or scavenge carrion or remains from subsistence harvests or community waste (Hansen 2004).

Studies that examined seasonal fidelity of polar bears to activity areas indicated that female polar bears in the entire Beaufort Sea region expressed the highest degree of fidelity in summer and the weakest during spring (Armstrup et al. 2000). This pattern might be explained by the distribution of seals, which is influenced by sea-ice conditions (Paetkau et al. 1995).

Female polar bears exhibit some degree of fidelity to general denning areas or substrates but not to the actual den sites, which are known to change every year because of variation in weather that influences the accumulation of drifted snow (Amstrup et al. 2000).

Between 2008 and 2011, several vessel-based and aerial-based marine mammal surveys were conducted in the program area during the open-water season (July to October) as part of the FDCPs. Survey results demonstrated that polar bears were present in the program area in 2008 and 2009.

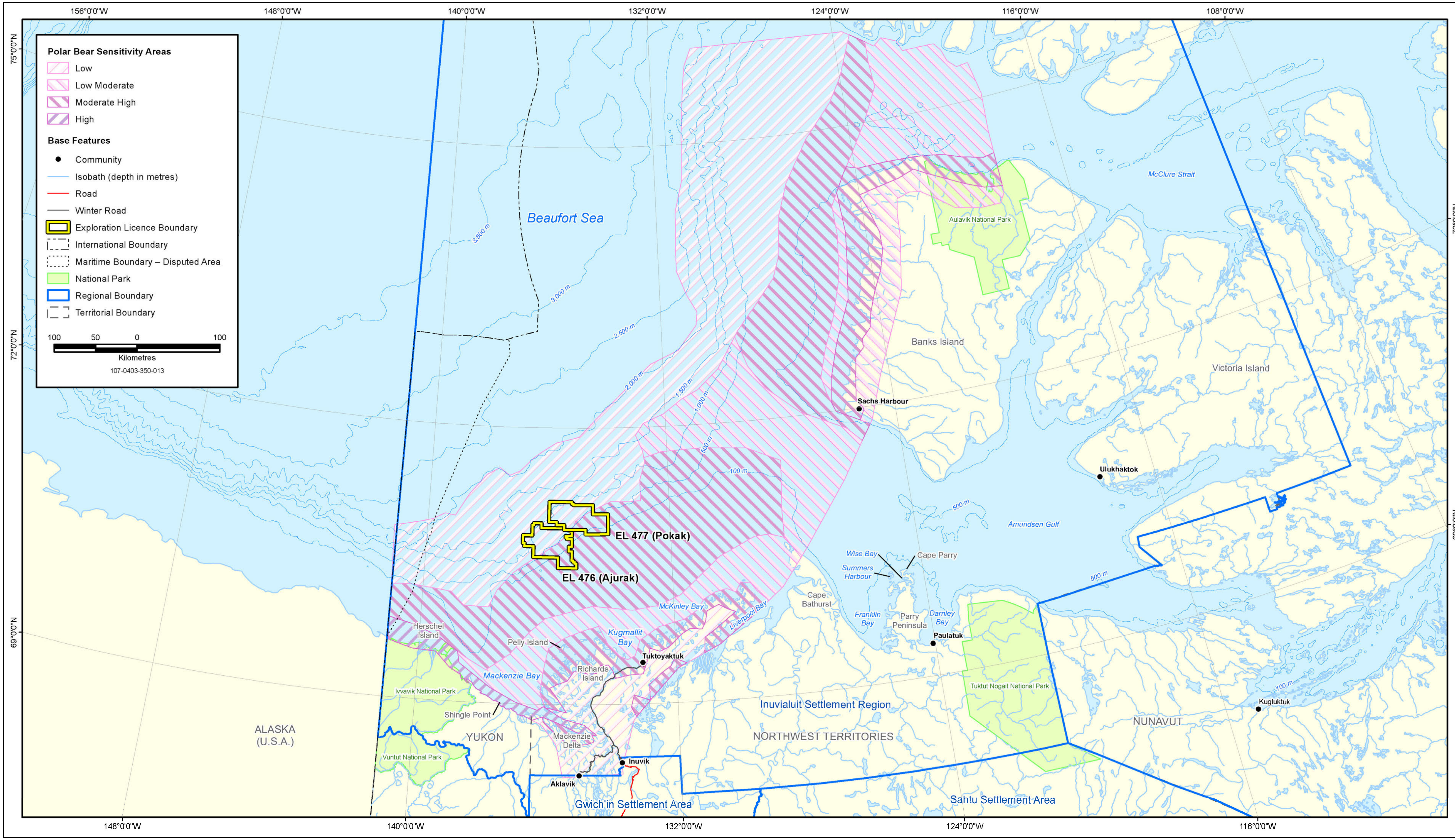

Figure 10-20: Polar Bear Sensitivity Areas During the Summer Season

10.11.5.3 Seasonal Distribution and Movement (cont'd)

Given the recent survey of results in information from the literature, there is a likelihood of encountering polar bears of both populations in the program area during all seasons. In addition, past studies have revealed suitable maternity denning habitat along the Tuktoyaktuk Peninsula and off the coast of Richards Island and Baillie Island. If program activities were to take place between November and April, it is possible that polar bear maternity dens might be present in the proposed marine resupply corridor between the drill sites and Tuktoyaktuk Harbour.

10.11.5.4 Subsistence Harvest

Polar bears are an important species for Inuvialuit subsistence harvesting, guided sport hunting and for use as clothing (Community of Inuvik et al. 2008). Sport hunts also contribute to Inuvialuit cultural identity by keeping travel by dog team active in the communities. Guided sport hunts are important sources of revenue for local communities, with an average polar bear sport hunt costing $15,000 (GNWT 2011b) and often up to $40,000 (CanWest News Services 2008).

The harvest of polar bears in the ISR is managed under annual quotas allocated to local hunters and trappers committees (HTCs). The quotas are based on a harvested sex ratio of two males to every female harvested. The HTCs can allocate 50% of the tags to locally guided sport (or trophy) hunters who are required to hunt by dog team (Freeman and Wenzel 2006). The total allowable harvest for the southern Beaufort Sea is currently 70 polar bears per year (4.5% of the population estimate) split between Alaska and the NWT. The sustainable harvest limit established for the northern Beaufort Sea population is 65 bears per year (split between NWT and Nunavut communities). However, the annual harvest has been less than 40 bears for more than 15 years (Stirling et al. 2011).

The current annual polar bear hunting seasons in the Inuvialuit Polar Bear Management Areas lasts from either October or December to May (coinciding with the maternity denning period and to protect females with cubs from being accidentally harvested). Inuvialuit hunters typically hunt polar bears in the months coinciding with the return of sunlight in February and March (Whittles 2005).

10.11.5.5 Hearing Ability and Vocal Behaviour

Little is known about the underwater hearing abilities in polar bears. Their in-air hearing has been studied on captive subjects (using auditory-evoked potentials to produce audiograms) demonstrating that polar bears can likely hear in air at a slightly wider range of frequencies than humans (up to 25 kHz) and have absolute hearing thresholds below 27 to 30 dB re 20 µPa (Nachtigall et al. 2007).

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10.12.1 OVERVIEW

The LSA includes Tuktoyaktuk Harbour and adjacent areas, where some shore-based facilities exist, the Tuktoyaktuk James Gruben Airport and the local waste disposal facility. Program activities might interact with local terrestrial wildlife potentially using these areas. In addition, some terrestrial wildlife that might use the sea ice as travel corridors could interact with program activities if program components are carried out during winter or the shoulder seasons (e.g., during icebreaking activities).

The following species were identified as terrestrial wildlife that might be encountered during program activities in the Tuktoyaktuk area or on the frozen nearshore area:

- barren-ground caribou (*Rangifer tarandus groenlandicus*)
- Peary caribou (*Rangifer tarandus pearyi*)
- grizzly bear (*Ursus arctos*)
- wolf (*canis lupus*)
- Arctic fox (*Alopex lagopus*)

10.12.2 BARREN-GROUND CARIBOU

The Cape Bathurst and Bluenose West barren-ground caribou herds' fall rutting ranges (during October and November) and winter ranges (during December through March) include the southern portion of the Tuktoyaktuk Peninsula, including Tuktoyaktuk, the Liverpool Bay area and southern portions of Cape Bathurst (Nagy et al. 2005, Community of Tuktoyaktuk et al. 2008). Animals from both herds use this region from October through March. In the spring, during their pre-calving migration, the caribou begin to move east and south, away from the area.

The populations of both herds are reported to have declined drastically during the last decades (GNWT-ENR 2013):

- the Bluenose West herd declined from an estimated herd size of 107,000 in 1987 to about 18,000 animals in 2009 and increased again to about 20,000 animals in 2012
- the Cape Bathurst herd declined from an estimated 12,500 animals in 1987 to only about 1,900 animals in 2009 and increased to about 2,400 animals in 2012

10.12.2 BARREN-GROUND CARIBOU (cont'd)

In 2005, local residents and wildlife managers established that there is a third herd using the Tuktoyaktuk area, the Tuktoyaktuk Peninsula herd (GNWT-ENR 2013). These caribou are now known to be staying on the entire Tuktoyaktuk Peninsula all year. The caribou are thought to possibly have established their presence after the local semi-domestic reindeer (*Rangifer tarandus*) herd was moved off the peninsula. They are now recognized and managed as a separate herd. It is not known how many of the animals of this herd are reindeer or reindeer-caribou hybrids. The herd size was estimated at about 3,000 caribou in 2006, about 2,800 in 2009, and about 2,200 in 2012 (GNWT-ENR 2013).

Most hunting areas in the ISR are closed for barren-ground caribou hunting except for Inuvialuit subsistence harvest. Inuvialuit in Tuktoyaktuk harvest caribou from all three herds during the fall, winter and early spring.

It is possible that caribou might be encountered either during land-based activities or during aircraft support flights between the Tuktoyaktuk airport and the EL areas.

Barren-ground caribou are not listed by SARA (2012) but are listed as special concern by COSEWIC (2013). The GNWT Infobase lists them as sensitive because of the observed decline in all herds (GNWT-ENR 2012).

10.12.3 PEARY CARIBOU

Peary caribou occupy the islands of the Arctic Archipelago and are rarely found on the mainland (except on the Boothia Peninsula in Nunavut). There are two populations of Peary caribou in the ISR:

- the Banks Island population on Banks Island and northwestern Victoria Island
- the High Arctic population on the Queen Elizabeth Islands

It is estimated that there are about 7,250 Peary caribou in the ISR, which have suffered severe declines of up to 80% over the past five decades (SARA 2012).

High Arctic Peary caribou migrate annually and seasonally between Prince Patrick, Eglinton and Melville islands (AANDC 2012). Although most interisland movements occur on sea ice, some caribou are believed to swim during the open-water season (Miller 1995). Migration is also known to occur between Banks Island and northwestern Victoria Island. Peary caribou are especially sensitive during the fall, winter and early spring because of their need for interisland movement on the sea ice. On occasion, caribou movements might be impacted by seismic activities (AANDC 2012). The availability of winter forage under deep snow and ice is likely the main limiting factor for Peary caribou across their range. In addition, hunting, predation and disturbance resulting from human activities are considered factors contributing to their decline (SARA 2012). The Banks Island population is also believed to be impacted by competition for food with the growing muskox (*Ovibus moschatus*) population (Community of Sachs Harbour et al. 2008).

Male Peary caribou in the ISR are harvested under a quota system for subsistence purposes by Inuvialuit from Sachs Harbour and Ulukhaktok (Community of Sachs Harbour et al. 2008). No other hunting is permitted.

It is highly unlikely that Peary caribou (Banks Island population) would be encountered during program activities because most of the program activities will take place more than 200 km from Banks Island and Victoria Island. However, the winter movements of the Peary caribou (Banks Island population) could overlap with the regional study area (RSA).

The High Arctic and the Banks Island populations of Peary caribou are listed as endangered by SARA and COSEWIC (SARA 2012, COSEWIC 2013) because of the ongoing decline. The GNWT Infobase lists them as at risk because of low numbers and a high level of threats in the form of climate change, predation and human development (GNWT-ENR 2012).

10.12.4 GRIZZLY BEAR

Grizzly bears occur all year in low densities throughout the ISR, including the Mackenzie Delta and Tuktoyaktuk Peninsula (Community of Tuktoyaktuk et al. 2008). Grizzly bears in the western Arctic are known to reproduce extremely slowly because of poor habitat and weather conditions (McLoughlin et al. 1999). Availability of denning habitat and the avoidance of actual den sites by human activities are important aspects for a sustainable grizzly bear population in the ISR. Grizzly bears are known to avoid:

- wetlands
- tussock and hummock tundra
- boulder fields
- exposed bedrock

They den in areas with topographic relief, such as lake and channel banks. Typically, grizzly bear dens are found on south facing slopes in sandy soils (McLoughlin et al. 1999).

Grizzly bears typically hibernate from October or November to the end of April or early May. When grizzly bears emerge from their dens, they generally spend the first days and sometimes weeks close to their den (McLoughlin et al. 1999). Grizzly bears dig new dens in the fall because dens often collapse during the previous spring breakup. Grizzly bears are known to be attracted to shore-based facility waste and petroleum products, if not managed and stored appropriately.

Inuvialuit harvest grizzly bears in the area under a quota system (Community of Tuktoyaktuk et al. 2008).

10.12.4 GRIZZLY BEAR (cont'd)

There is a limited likelihood of encountering grizzly bears during land-based program activities or aircraft support, except for shore-based facility activities, which might attract bears.

The western grizzly bear population is not listed by SARA (2012) but is listed as special concern by COSEWIC (2013). The NWT Infobase designates them as sensitive and views human development as a threat to the bears' habitat (GNWT-ENR 2012).

10.12.5 WOLF

Wolves play a major role in the western Arctic ecosystem and are an important resource for Inuvialuit. Wolves are more common in areas that are regularly used by the animals they prey on, such as caribou. Wolves might use the Tuktoyaktuk Peninsula and Richardson Island, but they are not expected to occur frequently in the area (Community of Tuktoyaktuk et al. 2008). They might be attracted to shore-based facility waste, if not managed appropriately. Inuvialuit and other residents harvest wolves regularly for their fur in late winter and spring.

There is a limited likelihood of encountering wolves during land-based program activities or aircraft support, except for shore-based facility activities, which might attract wolves.

Northern grey wolves are not listed by SARA (2012) and are listed as not at risk by COSEWIC (2013). The NWT Infobase lists them as secure (GNWT-ENR 2012).

10.12.6 ARCTIC FOX

Although the Arctic fox is typically associated with tundra habitats above the treeline, it could move out onto nearshore ice during the winter, where they are known to travel long distances (Feldhamer et al. 2003). Arctic fox den construction occurs in sites with well-drained soils, often in hillside locations. Important denning habitat for this species is found throughout the Mackenzie Delta, on the Tuktoyaktuk Peninsula and Richards Island (IEG 2002). Arctic foxes are trapped for their fur across the ISR.

There is a likelihood of encountering Arctic foxes either during land-based program activities (e.g., shore-based facility activities) or during potential winter shoulder-season activities (e.g., while using icebreaking vessels) because these foxes are known to venture onto the sea ice and often travel for long distances.

Arctic foxes are not listed by SARA (2012) or COSEWIC (2013). They are designated as secure in the NWT Species Infobase (GNWT-ENR 2012).

10.13.1 PROTECTED SPECIES IN THE RSA

The COSEWIC and SARA-listed species potentially occurring within the RSA include:

- four marine bird species
- five marine mammal species

Species at risk in the RSA and their status in 2012 are listed in Table 10-6.

Table 10-6: Species at Risk Potentially Occurring in the RSA

Common Name	Species	COSEWIC Status 2012	SARA Status 2012
Marine and Anadromous Fish			
Bering cisco	*Coregonus laurettae*	Special concern (Yukon)	No status – no schedule
Blackline prickleback	*Acantholumpenus mackayi*	Data deficient	Special concern – Schedule 3
Dolly Varden	*Salvelinus malma malma*	Special concern	No status – no schedule
Northern wolffish	*Anarhichas denticulatus*	Threatened	Threatened – Schedule 1
Marne Avifauna			
Barrow's goldeneye	*Bucephala islandica*	Special concern	Special concern – Schedule 1
Buff-breasted sandpiper	*Tryngites subruficollis*	Special concern	No status – no schedule
Harlequin duck	*Histrionicus histrionicus*	Special concern	Special concern – Schedule 1
Horned grebe	*Podiceps auritus*	Special concern	No status – no schedule
Ivory gull	*Pagophila eburnea*	Endangered	Endangered – Schedule 1
Peregrine falcon	*Falco peregrinus tundrius*	Special concern	Special concern – Schedule 1
Red knot	*Calidris canutus*	Endangered – rufa ssp. Special concern – islandica ssp.	Endangered – rufa ssp. – Schedule 1 Special concern – islandica ssp. – Schedule 1
Ross's gull	*Rhodostethia rosea*	Threatened	Threatened – Schedule 1
Marine Mammals			
Beluga whale (Eastern Beaufort Sea population)	*Delphinapterus leucas*	Not at risk	No status – no schedule
Bowhead whale (Bering-Chukchi-Beaufort population)	*Balaena mysticetus*	Special concern	Special concern – Schedule 1
Polar bear	*Ursus maritimus*	Special concern	Special concern – Schedule 1
Terrestrial Wildlife			
Barren-ground caribou	*Rangifer tarandus groenlandicus*	Special concern	Special concern – Schedule 1
Grizzly bear	*Ursus arctos*	Special concern	No status – no schedule
Peary caribou	*Rangifer tarandus pearyi*	Endangered	Endangered – Schedule 1

10.13.1 PROTECTED SPECIES IN THE RSA (cont'd)

In addition to the information in Table 10-6, the following birds are noted by Salter et al. (1980) as using the coastal plain:

- listed by COSEWIC as threatened:
  - barn swallow (*Hirundo rustica*) (2011)
  - common nighthawk (*Chordeiles minor*) (2007)
- listed by COSEWIC as special concern:
  - peregrine falcon (*Falco peregrinus tundrius*) (2007)
  - rusty blackbird (Euphagus carolinus) (2006)
  - short-eared owl (Asio flammeus) (2008)
- listed by COSEWIC as not at risk:
  - bald eagle (*Haliaeetus leucocephalus*)
  - golden eagle (Aquila chrysaetos)
  - gyrfalcon (Falco rusticolus)
  - merlin (Falco columbarius)
  - red-tailed hawk (Buteo jamaicensis)
  - rough-legged hawk (Buteo lagopus)
  - sharp-shinned hawk (Accipiter striatus)

10.14.1 PROTECTED AREAS NEAR THE PROGRAM AREA

Measures have been taken by federal, provincial and territorial governments, non-governmental organizations, and international organizations to identify, evaluate and protect areas of biological importance in the ISR's marine and coastal environment. This subject provides an overview of these protected areas in relation to the proposed program activities.

10.14.2 NORTHWEST TERRITORIES WILDLIFE ACT

A draft of a new *Wildlife Act* to replace the (NWT) *Wildlife Act* (1988) has been introduced in the legislative assembly after extensive Aboriginal and public consultations between 2010 and 2012, in an effort to ensure that the concerns of the people of the NWT are appropriately addressed. It is expected that the act will pass in 2013.

In addition to maintaining provisions in the current legislation regarding respect for wildlife (e.g., disturbance and harassment, retrieval of dead or wounded wildlife), possession of wildlife and protection of habitat, the proposed new draft *Wildlife Act* introduces the requirement for wildlife monitoring and management plans. Under subsection 95(1) of the proposed new draft *Wildlife Act*, wildlife monitoring and management plans will be required if a development, proposed development or other activity might significantly:

- disturb wildlife
- destroy or pose a threat of seriously harming habitat
- contribute to cumulative impacts on wildlife or habitat

10.14.3 TARIUM NIRYUTAIT MARINE PROTECTED AREA

The Tarium Niryutait Marine Protected Area (MPA) is the only MPA in Arctic Canada. The MPA was established in 2010 under *Tarium Niryutait Marine Protected Areas Regulations*, pursuant to Subsection 35 (3) of the *Oceans Act* (1996). The MPA covers an area of 1,800 km² in the Mackenzie Delta and estuary in the Beaufort Sea (about the area of the former beluga management zones) and is subdivided into three units:

- Niaqunnaq MPA
- Okeevik MPA
- Kittigaryuit MPA

10.14.3 TARIUM NIRYUTAIT MARINE PROTECTED AREA (cont'd)

The motivation for creating the Tarium Niryutait MPA was to conserve and protect beluga whales and other marine species, their habitats and ecosystem and to preserve Inuvialuit traditional harvesting. Stakeholders that participated in the creation of the MPA included the Inuvialuit, private industry and government.

10.15.1 BACKGROUND DATA

Evidence shows that the physical properties of the Beaufort Sea are being affected by climate change. Ice and oceanographic conditions in the Canadian sector of the Beaufort Sea are strongly influenced by oceanic and sea ice exchanges with neighbouring regions. Reductions in the areal extent and concentration of sea ice in the Canada Basin are similar to those of the full Arctic Ocean with the largest reductions resulting from the loss of old ice (second-year and multi-year ice). In the late summer and fall months, old ice concentrations are decreasing between 8 and 11% per decade as computed from Canadian Ice Service digital ice charts over the past 45 years (Fissel et al. 2013).

10.15.1.1 Changes in the Mackenzie Shelf Region

In four sub-regions of the Mackenzie Shelf region (slope, mid-outer shelf, inner shelf and Kugmallit Bay) the largest reductions for all sub-regions occurred in mid-October, with the largest reduction in the slope region of nearly 10% in sea-ice concentration per decade. The least amount of change per decade occurred in Kugmallit Bay, with mid-October results showing less than 2% reduction in sea-ice concentration. There has been no significant trend detected for significant changes in ice thickness on the Mackenzie Shelf and any trend would likely be overshadowed by year-to-year and short-term variability (Melling 2012 personal communication, Niemi et al. 2012).

10.15.1.2 Beaufort Sea Gyre

Mechanical deformation of first-year ice can create ice drafts as large as old ice. It is possible that under conditions of divergence, first-year ice thickness might be increasing. Reversals of ice in the Beaufort Sea gyre suggest that more divergence has occurred in the Beaufort Sea pack ice than occurred more than 30 years ago and that this will also increase the rate of reduction in thickness and areal extent of sea ice (Rampal et al. 2009).

10.15.1.3 Changes Over the Last 50 Years

Environment Canada weather data for Tuktoyaktuk and Sachs Harbour has shown that mean air temperatures have increased in each month over the last 50 years with the largest increase in warming occurring during the fall and winter. In the fall and winter for both Tuktoyaktuk and Sachs Harbour, there has been an increase of 0.8°C every 10 years for a total increase of 4°C over the last 50 years (Fissel et al. 2013). In addition, precipitation levels have also been increasing, but at a much reduced rate than air temperature, with a 1% increase in

10.15.1.3 Changes Over the Last 50 Years (cont'd)

precipitation every decade. The observation systems at climate stations have a relatively low precision. Consequently, this small change in precipitation should be interpreted with caution. Of greater importance than precipitation in general is accumulated snow, which might increase, especially in spring and fall, in coastal areas. Determining the amount of snow accumulation over the ocean is more complicated because of the amount of sea ice present and the losses of snow into the ocean.

Surface winds have shown only small positive or negative trends over the last 50 years. Surface wind data from coastal weather stations, available over the last 50 years or more, indicate little or no increase in wind speeds and storm frequencies along the coastline of the Beaufort Sea (Hudak and Young 2002, Atkinson 2005, Manson and Solomon 2007). A recent study of monthly Beaufort Sea winds (measured at Tuktoyaktuk and the marine weather station at Pelly Island) revealed only small trends for most months. The long-term trends in the monthly average coastal wind speeds as computed for the March-April and October-November periods had a net change of about -20% from 1958 to 2007 (Fissel et al. 2009). The analysis of monthly wind stress from reanalyzed numerical model wind results over the years 1948 to 2006 (Hakkinen et al. 2008) are consistent with negative trends for the inshore shelf waters of the western Arctic Ocean. Overall, the monthly mean wind speeds in coastal areas appear to have decreased over the past five decades. However, wind speeds might be increasing in offshore areas (Hakkinen et al. 2008). There is an increase in the depth of offshore low-pressure systems but not an increase in the frequency of cyclones (Lukovich and Barber 2006). More cyclones tend to follow the sea ice-ocean interface. Consequently, these storms are moving further offshore as the ice edge retreats. The Beaufort Sea high-pressure system has become stronger between 1996 and 2011 (Moore and Pickart 2012) leading to enhanced easterly winds in the Beaufort Sea with larger increases at more offshore locations.

Changes in ocean wave properties have occurred over the past decade as a consequence of reduced ice concentration and areal extent, resulting in a longer duration of ocean wave activity (Fissel et al. 2012a). In recent years, evidence indicates that moderate to large wave events start in early June and extend into November as compared to the previous wave season in the 1980s of mid-June to late October (Fissel et al. 2012a).

10.15.1.4 Recent Climate Changes

The FDCPs have provided evidence of moderate to large wave events starting in early June and extending into November as noted by Fissel et al. (2012a). These trends are expected to continue and increase in the future because of the expected future reduction in sea-ice cover. Long-period swell waves originating from distant storms have only rarely occurred in past decades but might become more frequent in the future (Barber et al. 2008). These waves increase the loss rates of sea ice by breaking up floes into smaller sizes, which are more mobile and melt more rapidly (Asplin et al. 2012). In addition to increased surface waves, it is thought that internal waves (i.e., within the Beaufort Sea) will increase in size and frequency as sea-ice cover decreases (Rainville and Woodgate 2009).

The considerable changes in the late summer sea-ice cover of the Arctic Ocean as a whole, and in the deep water area of the Canada Basin adjoining the program area, might be related to a change in the atmospheric circulation patterns of the western Arctic Ocean. Sea ice and ocean observations from 2001 to 2011 suggest that the characteristics of the Arctic Ocean climate are different in recent years as compared to those of 1979 to 2000 (Proshutinsky 2011). In particular, there is less sea ice and the upper part of the ocean is warmer and fresher. These changes appear to be related to "the anticyclonic (clockwise) wind-driven circulation regime (which) has dominated the Arctic Ocean for at least 14 years (1997 to 2011), in contrast to the typical 5 to 8 year pattern of anticyclonic/cyclonic circulation shifts observed from 1948 to 1996" (Proshutinsky 2011).

The decline in sea-ice extent and the large reduction in multi-year ice in the form of melting ice and other mechanisms have increased the amount of fresh water in the upper ocean in the offshore Beaufort Gyre area. Over the shelf areas, the trend of increased fresh water has not occurred (Melling 2012 personal communication). Ocean heat content typically affects the melt flux to the sea ice either through upwelling of warmer water from depth or through solar insolation heating the ocean surface mixed layer, which then adds heat to the base of the sea ice. Warming will increase the heat flux to the lower atmosphere, creating a higher probability for more intense storms, particularly in the fall and early winter period (Raddatz et al. 2011).

Enhanced upwelling at the shelf edge has been observed since 2003 under the combined effect of reduced ice extent and the increased prevalence of the anticyclonic atmospheric circulation of the western Arctic Ocean (Pickart et al. 2011 and 2013, Moore and Pickart 2012). The underlying atmospheric circulation processes are not well understood, but appear to be a combination of overall strengthening of the Beaufort Sea high (anticyclonic) pressure system and more intense cyclones penetrating the Arctic from the Pacific and Atlantic oceans (Lukovich and Barber 2006).

10.15.2 EFFECTS RELATED TO PRIMARY PRODUCTIVITY

Changes in the timing and magnitude of river discharge and sea-ice coverage, as well as fresh water nutrient concentrations and wind mixing, are predicted to have effects on primary production. During the growing season the fresh surface layer is typically nutrient depleted, with the main source of nutrients originating from the deeper Pacific water. As a result, there is a subsurface chlorophyll maximum at the top of Pacific water (Carmack et al. 2004). Increases in fresh water content will strengthen stratification, although in the nearshore environment increases in river flow will support stronger estuarine entrainment of nutrients from deeper water. With decreased ice cover, wind-driven mixing will work against the increased stratification and affect productivity in coastal, shelf and basin waters (McClelland et al. 2012). A deepening of the chlorophyll maximum in the Canada Basin from 45 m in 2003 to an average of 61 m in 2008

10.15.2 EFFECTS RELATED TO PRIMARY PRODUCTIVITY (cont'd)

has been observed (Jackson et al. 2010) and is associated with the deepening of the nutricline (McLaughlin and Carmack 2010).

With decreasing sea-ice coverage there is expected to be an increase in primary production, but this is expected to manifest mostly in nutrient-rich (diatom-dominated) regions such as the Amundsen Gulf (Ardyna et al. 2011). Evidence of this appears in a recent report by Arrigo et al. (2012) who described "massive blooms" of phytoplankton under thinning sea ice in the Chukchi Sea. However, with increased stratification, overall function and structure might shift to characteristics of more oligotrophic regions (flagellate-based). There is recent evidence that picophytoplankton-based systems are becoming more prevalent in the Arctic Ocean (Li et al. 2009). This has implications for energy transfer to higher trophic levels (Kirchman et al. 2009).

Carmack et al. (2006) argue that, should the seasonal ice cover retreat beyond the shelf break, this would set up conditions for the onset of shelf-break upwelling (Carmack and Chapman 2003), which would then draw nutrient-rich waters onto the shelf where they can be mixed into the euphotic zone, with attendant stimulation of primary production.

10.15.3 EFFECTS RELATED TO SEA-LEVEL RISE, STORM SURGES AND COASTAL EROSION

Landfast ice changes with air temperature and snow accumulation. Dumas et al. (2005) found that an increase of 4°C in annual average temperature and of 20 to 100% in snow accumulation rate will result in a 24 to 39 cm reduction in the mean maximum ice thickness and a three-week reduction in the duration of landfast ice at coastal locations in the Canadian sector of the Beaufort Sea. A recent study by Galley et al. (2012) on landfast sea-ice conditions in the Canadian Arctic reveals that the formation of landfast ice in the coastal margins of the Mackenzie Delta area of the Beaufort has undergone a delay of 2.8 weeks per decade from 1983 to 2009, which is statistically significant. Over this same 26-year period, the breakup dates of the landfast ice have advanced at 0.65 weeks per decade, also at a statistically significant level.

Coastal zone erosion in Arctic regions is a complex process affected by (Anisimov et al. 2007):

- factors common to all parts of the world, such as:
  - exposure
  - relative change in sea level
  - climate and soil properties
- factors specific to the high latitudes, such as:
  - low temperatures
  - ground ice
  - sea ice

The most severe erosion problems arise in areas of rising sea level, where warming coincides with areas that are seasonally free of sea ice or where there is widespread ice-rich permafrost (Forbes 2005 and 2011). Changes in the Beaufort Sea level are also complicated to interpret, because of the processes that increase or decrease water levels over different time scales, including:

- compaction of deltaic sediments
- ocean warming
- the possibility of larger and more frequent storm surges
- changes to fresh water input from the Mackenzie River
- changes from melting of glacial ice, which reduces the fresh water input (i.e., the Greenland ice cap)
- glacio-isostatic rebound
- monthly and longer period changes to ocean tides
- changes to atmospheric pressure patterns

Based on evidence over the past decades, it appears that sea-level rises resulting from oceanic conditions are outpacing the geological factors (Forbes 2005 and 2011). Environmental parameters that contribute to shoreline retreat are:

- wave erosion
- high summer air temperatures

Areas with bedrock near the surface of the ground, which includes much of the Canadian Arctic islands, or areas where glacio-isostatic rebound is occurring, are less vulnerable to erosion. On the north side of the Amundsen Gulf and further west, for example, at Sachs Harbour and Tuktoyaktuk, James et al. (2011) reported that subsidence is occurring at a rate of about 1 mm/yr and 2.5 mm/yr. These scientists also calculated that for every 1 mm of global sea level contributed by melting of the Greenland ice cap, the rise in sea level around Tuktoyaktuk could range between 20 cm and 1 m by 2100.

Despite common concerns expressed by community residents of increased erosion rates in the western Arctic, a regional analysis for the southern Beaufort Sea detected no significant increase in the trend in areas of rapid erosion for the 1972 to 2000 time interval. Typical erosion rates of 1.0 to 2.0 m/yr have been reasonably consistent over the past 30 years (Manson and Solomon 2007). However, further warming, combined with sea-level rise, can be expected to maintain or increase the rate of coastal subsidence (Prowse et al. 2009). This will increase the area of coastal and low-lying land that could be subject to flooding or inundation during storm surges.

10.15.3.1 Potential Effects on Oil and Gas Activities

The potential effects on oil and gas activities from climate change related to sea-level rise, storm surges and coastal erosion in a nearshore or onshore settings include:

- construction-related issues if infrastructure in Tuktoyaktuk Harbour needs to be refurbished or modified for the program
- possible increased frequency of dredging required to maintain entrances and anchorages, such as McKinley Bay (not currently used by ships) and Tuktoyaktuk Harbour

It is possible that a rise in sea level combined with coastal subsidence could lead to more onshore areas being affected by spills because nearshore or offshore spills could drift into these areas. This might occur during large storm surges that flood a greater amount of low-lying land along the shore than in the past.