BEAUFORT SEA OIL AND GAS DEVELOPMENT/ NORTHSTAR PROJECT

FINAL ENVIRONMENTAL IMPACT STATEMENT

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CHAPTER 8.0

EFFECTS OF OIL ON THE PHYSICAL, BIOLOGICAL, AND HUMAN ENVIRONMENTS

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8.0 EFFECTS OF OIL ON THE PHYSICAL, BIOLOGICAL, AND HUMAN ENVIRONMENTS

8.1 INTRODUCTION

Chapter 8 addresses issues related to oil spills. Background information is provided about the characteristics of Northstar crude oil and the expected fate and behavior of an oil slick in different locations (e.g., onshore, in lagoons, in marine waters) during open water, solid ice, and broken ice conditions. The probability of oil spills and potential spill volumes are compared for the five project alternatives. Project design features that reduce the probability of a spill or reduce the amount of oil released in the event of an accident are discussed. Impacts of an oil spill are described in this chapter in an integrated manner, showing the interrelationship among various physical, biological, and human resources. Expected impacts to physical, biological, and human resources due to an oil spill are evaluated for different seasons of the year and areas. Although this document does not contain a spill plan, we have reviewed the Oil Discharge Prevention and Contingency Plan (ODPCP) for the Northstar Development Project (Northstar Project) (BPXA, 1998b). Components of typical response activities are discussed in this chapter as potential sources of additional impacts.

The physical and temporal locations of resources are identified based on information presented in Chapters 5, 6, and 7. Physical data such as wind speeds, ice conditions, and ocean currents presented in Chapter 5 are used in this chapter to analyze both the potential for an oil slick to contact sensitive areas and for spill response activities to be delayed or severely hampered due to physical conditions. Sensitive species and habitat identified in Chapter 6 are the focus of the impact analysis for the biological environment. Impacts of an oil spill on subsistence resource species are interrelated to effects on subsistence lifestyles of local residents. Spill response impacts to other human environment resources, such as archaeology, transportation, and visual/aesthetics are described in this chapter.

Chapter 8 addresses the following issues related to the potential impacts of an oil spill.

Issues/Concerns	Section
· If an oil spill occurs, what would be the likelihood that the oil would contact resources in the project area?	8.4.3
· What would be the potential sources of an oil spill from project facilities?	8.5.1
· What would be the probability of an oil spill for each project alternative?	8.5.2
· What project design features would be incorporated to prevent or reduce the volume of an oil spill?	8.5.3
· What (if any) additional planning, equipment, and personnel would be needed for the project? Would spill response planning involve local labor as part of the command structure?	8.6
· What oil spill response could be used in ice and broken ice conditions?	8.6.1
· What impacts would an oil spill and oil spill response have on the physical	8.7.1

Issues/Concerns	Section
environment?	
· What would be the likelihood that oil-contaminated marine mammal carcasses would be ingested by polar bears, and what would be the likely impact on the polar bears?	8.7.2.3
· What impacts would an oil spill and oil spill response have on human resources?	8.7.3.1

8.2 TRADITIONAL KNOWLEDGE

Traditional Knowledge of the local environment is valuable in assessing the fate and behavior of an oil slick in the marine environment, potential effects on resources, and response and cleanup measures. For example, Traditional Knowledge addresses how the potential combination of severe weather conditions such as sea state, fog, ice, and winds may hinder an effective spill response. In addition, Traditional Knowledge about the presence and behavior of fish, whales, birds, and terrestrial mammals establishes what resources and subsistence activities may be affected in the event of an oil spill. Traditional Knowledge applicable to oil spill impacts is included in this chapter. Additional Traditional Knowledge related to the physical, biological, and human resources can be found in Sections 5.2, 6.2, and 7.2 respectively.

Inupiat Traditional Knowledge of oil impacts on the environment is very limited due to the rarity of large oil spills in marine waters on the North Slope. However, one first hand observation was made by Thomas P. Brower Sr., a whaling captain from Barrow since 1916:

> *"In 1944, I saw the effects of an oil spill on Arctic wildlife, including the bowhead. I had been asked to be on the flagship of a Navy convoy moving along the Beaufort Sea coast. While I was on the flagship I saw twenty (20) other ships including several Navy oil tankers. In August 1944 one of the cargo ships ["Liberty"] ran aground on a sandbar off Doctor Island at Elson Lagoon southeast of Utqiagvik [Barrow]. They needed to lighten the ship to get free. To my disgust, instead of bringing up a tanker to transfer the cargo, they simply dumped the oil into the sea. About 25,000 gallons of oil were deliberately spilled into the Beaufort Sea in this operation. In the cold, Arctic water, the oil formed a mass several inches thick on top of the water. Both sides of the barrier islands in that area - The Plover Islands - became covered with oil. That first year, I saw a solid mass of oil six (6) to ten (10) inches thick surrounding the islands. On the seaward side of the islands, a mass of thick oil extended out sixty (60) feet from the islands, and the oil slick went much farther offshore than that. I observed how seals and birds who swam in the water would be blinded and suffocated by contact with the oil. It took approximately four (4) years for the oil to finally disappear. I have observed that the bowhead whale normally migrates close to these islands in the fall migration. ..... But I observed that for four (4) years after that oil spill, the whales made a wide detour out to sea from these islands."* (NSB, 1980:107-108).

8.3 ENVIRONMENTAL SETTING

Four general areas could be affected by an oil spill from Northstar Unit development facilities. For the purpose of evaluating oil impacts these are (Figure 8-1):

- Onshore land.
- Lagoons and shorelines inside the barrier islands.
- Outer island shorelines and exposed coast.
- Marine water and sea ice.

Physical conditions, habitat, and the presence of resources differ for these four areas. Each of the physical, biological, and human resources are addressed in association with the four environmental settings. Table 8-1 summarizes information presented in Chapter 6 for the four environmental settings relevant to where biological resources are located, time of year resources are present, duration of occurrence in the area, and activities (e.g., nesting, feeding and spawning).

8.3.1 Onshore Land

The onshore area is characterized by tundra wetlands with permanently saturated peaty soils and numerous shallow ponds in a mostly flat, featureless plain. Lack of natural wind barriers allows unrestricted wind flow across the terrain at an annual average of 13.3 miles per hour (21.4 kilometers [km] per hour). Blowing snow and whiteout conditions frequently restrict visibility in winter. Soils are frozen to a depth of approximately 12 inches (30.1 centimeters [cm]) by December and to permafrost depths of 18 to 30 inches (46 to 76 cm) by mid-winter. Lakes and ponds are typically frozen over by October and remain frozen until June. The Sagavanirktok, Putuligayuk, and Kuparuk Rivers and several smaller streams flow through the onshore portion of the project area and are also frozen from October through mid-May.

Caribou, grizzly bear, and Arctic fox are the large mammals commonly present in the onshore area during summer, although many smaller terrestrial mammals also are present (Table 6.8-1). During winter, most caribou migrate to the south and bears are typically denning. Arctic fox are active in the onshore area throughout the year, while polar bears may occasionally be observed in the winter. In spring, birds migrate to the Alaskan Beaufort Sea coast from their wintering areas and move to tundra nesting grounds, remaining there through summer. Wet tundra nesting areas and feeding areas are the most sensitive locations in terms of oil spill impacts due to the reliance of bird populations on this habitat.

Primary onshore subsistence activities include: hunting for caribou, moose, and waterfowl; fishing with nets set in rivers or off the shoreline; gathering eggs; trapping furbearers; and harvesting berries and other plant material. Current and traditional use areas vary by community, by resource harvested and its availability, and by season. Onshore areas in the vicinity of the project are primarily used by the residents of Nuiqsut and in recent years, subsistence activities have been focused in the Colville River drainage and delta. Problems with access and animal disturbance related to oil field development have resulted in less subsistence effort in areas with oil and gas facilities.

8.3.2 Lagoons and Shorelines Inside the Barrier Islands

This area includes lagoon waters and shorelines inside the barrier islands. Water depths generally are less than 5 feet (ft) (1.5 meters [m]) and sea ice freezes completely to the seafloor by late winter. In summer, the shallow lagoons are protected from large waves by the barrier islands. Wind generated waves induce nearshore circulation, thereby flushing the semi-enclosed waters and redistributing sediments discharged from the Sagavanirktok, Putuligayuk, and Kuparuk Rivers (Naidu et al., 1984:278).

Large numbers of sea ducks, loons, waterfowl, and shorebirds use the lagoon areas during summer for feeding and molting (Table 8-1). The inability of molting birds to escape the area in the event of an oil spill makes them particularly vulnerable to the effects of oil and spill response activities. Individual ringed and spotted seal are occasionally present in the lagoon areas during summer. Fish species typically found during summer include Arctic cisco, char, least cisco, and broad whitefish, which use coastal lagoons as feeding grounds or migrate through them on the way to spawning or overwintering areas. Floating fish eggs or planktonic larvae of various marine species are common, including those of Arctic cod, sculpin, and snailfish. Few biological resources, other than a few polar bears and Arctic foxes, are present in the area during winter due to the formation of bottomfast ice.

The lagoons and barrier islands in the project area are used by residents of Nuiqsut for subsistence hunting and fishing during various times of the year. Caribou hunting and fishing occur during summer and fall, supplemented by bird hunting, egg gathering, and berry picking. Subsistence harvesting of fish, waterfowl, and, occasionally, seals occurs in the area during the summer. The area may be used infrequently for boating, typically in conjunction with hunting or fishing activities. While offshore travel is limited during the winter, some seal and polar bear hunting takes place.

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8.3.3 Outer Island Shorelines and Exposed Coast

This area includes outer shorelines of the barrier islands and exposed coast to the east and west (Figure 8-1). Waves hitting outer shorelines of islands and exposed coast are typically larger than those inside the lagoon areas due to a more dynamic sea environment. Wave action and longshore currents continuously reshape the islands and erode the tundra coastline.

Several sea duck species (eiders, scoters), gulls, terns, and phalaropes may be found outside the barrier islands during the summer (Table 8-1). There are few mammals present, although ringed and bearded seals and polar bears may use the area throughout the year. Arctic fox are seen infrequently on the outer islands during winter. Polar bears use barrier islands and the surrounding areas in the fall, winter, and spring for denning, resting, and feeding. Polar bears have denned on the barrier islands (i.e., Pingok and Flaxman) and along ice ridges where there is sufficient relief to collect suitable snow. Based on oil spill analyses, Pingok Island could be contacted by oil within 3 days of a spill (additional details in Section 8.4.3).

Subsistence harvesting of seals, fish, waterfowl, and eggs on outer islands may occur during summer; however, this is less common due to the presence of resources closer to the villages of Nuiqsut and Kaktovik. Access to the outer islands would be primarily by boat, with a small volume of snow machine traffic expected during winter. As with the lagoon area, offshore travel is limited, although some seal and polar bear hunting takes place.

8.3.4 Marine Waters and Sea Ice

Offshore marine waters and ice seaward of the barrier islands provide the most dynamic environment of the four areas. In summer, larger waves (greater than 5 ft [1.5 m]) develop compared to inside the barrier islands, due to the greater water depths and longer fetch. Water depths seaward of the barrier islands gradually increase; Seal Island is in approximately 39 ft (12 m) of water. In winter, ice movement and under-ice currents continue to be important forces. Ice gouging is common as icebergs and ice floes are blown shoreward by winds during the summer. Seaward of the project area, the year-round presence of pack ice is accompanied by windier and colder weather conditions. Landfast ice surrounds the islands in winter, with floating ice present in water depths greater than 6 ft (1.8 m).

Various species of sea ducks (eiders, scoters), gulls, and terns may be found in marine waters of the project area in the summer (Table 8-1). Char and Arctic cisco feed in marine waters during the summer; Arctic cod are present throughout the year. Ringed seals, bearded seals, and polar bears are common on the offshore sea ice during winter, but follow the pack ice north in the spring. Oil spills would have the greatest effect on polar bears during the fall, winter, and spring when bears are on the ice, barrier islands, and adjacent coastal areas nearest to the impacted area. Leads that develop during winter months may be particularly important feeding areas for bears and ringed seals. Although polar bears follow the receding ice during the spring and summer, this does not diminish the potential impact of an oil spill on polar bear habitat. Because ice is subject to wind and current movements during the spring and fall, polar bears may move long distances with the ice. Beluga and bowhead whales migrate through the area on their way to and from the Canadian Beaufort Sea in the spring and fall.

Marine waters in the project area are used by residents of Nuiqsut for bowhead whale harvesting in the fall. Seal and polar bear hunting also may occur in conjunction with whaling activities or other travel. Nuiqsut residents travel by boat to Cross Island, where they camp and stage equipment for whaling activities. Kaktovik and Barrow residents typically hunt whales in areas far removed from the project area, at least 75 miles (121 km) to the east and 150 miles (241 km) to the west, respectively.

8.4 OIL SOURCE AND TYPE

The nature and severity of impacts to resources depend on the characteristics and behavior of the oil, as well as the volume and source of the spill. Physical and chemical characteristics of Northstar crude oil are summarized in this section in addition to weathering processes that alter these characteristics. Seasonal conditions affecting oil spill behavior and its potential migration to sensitive resource areas are also presented. Modeling performed by the Minerals Management Service (MMS) is presented as an estimate of the time required for an oil slick to contact those areas.

Chemical composition and physical characteristics such as viscosity and volatility govern, in part, the movement of an oil spill and the level of damage to a resource following its contact with oil. Fate and behavior of oil spills depend on processes such as dispersion and evaporation, which are controlled by physical parameters of the oil (e.g., viscosity and boiling point).

The chemical composition of Northstar crude oil, with the boiling points given for each of the major constituents, is presented in Table 8-2. The boiling point of a chemical represents a specific temperature and pressure at which molecules of a liquid vaporize. A comparison of ambient temperatures with boiling point temperatures presented in Table 8-2 shows percentage of oil estimated to evaporate. Based on average monthly ambient temperatures on the North Slope ranging from -20 degrees Fahrenheit (°F) (-29 degrees Celsius [°C]) in the winter to 46°F (8°C) in the summer (Section 5.4), approximately 25 to 35 percent (%) of the volume of Northstar crude oil would evaporate within the first month following a release into marine waters or onshore. A lower percentage of oil would evaporate for spills in or under ice in the winter due to the increase in viscosity, as discussed next, which self-limits the rate of molecular diffusion (Jordan and Payne, 1980:20).

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Viscosity is a measure of the resistance of a fluid to flow. Viscosity of crude oil increases as oil ages in the marine environment and as the oil's temperature decreases. Fresh Northstar crude oil has a viscosity of 7.02 pounds/hour-ft (2.9 Centipoise) at 77° F (25° C) (Ross, 1996:Appendix A[1]). Viscosity is linearly related to percent evaporation, with the oil thickening as lighter components evaporate. Oil slick behavior, affected by viscosity, includes:

- Rate of spreading as a slick or sheen (slower spreading at higher viscosities).
- Natural and chemical dispersion (less likely at higher viscosities).
- Emulsification rates and stability (higher stability at higher viscosities).

Toxicity of crude oil spilled into the environment decreases with time as the lighter, more harmful, aromatic hydrocarbons such as benzene evaporate, subsequently reducing air quality. Acute chemical toxicity (lethal effects) of the oil is greatest during the first month following a spill. Sublethal effects may be observed in surviving birds, mammals, and fish for years after the spill. Chronic sublethal effects are likely due to toxicity of high-molecular weight polyaromatic hydrocarbons, which play a minor role in immediate effects, but persist in the environment (soils and sediments) and are more important in the long-term.

8.4.1 Weathering Processes

Characteristics of oil spilled into the environment change from effects of wave action, currents, wind, and gravity, which combine to weather the oil. Based on different sea and weather conditions, oil spilled from the same source could travel different distances and potentially impact different resources. Oil spilled into marine, freshwater, and onshore habitats is subject to degradation and interrelated weathering processes, including spreading, evaporation, dispersion, dissolution, emulsification, microbial degradation, sedimentation, and photo-oxidation.

Oil slicks and sheens are spread by currents, waves, and winds into thin films floating on the surface of the water. Colder temperatures increase viscosity, resulting in slower weathering and spreading. Studies have shown that Prudhoe Bay crude oil spread on zero-degree water to a thickness of 0.2 inches (5 millimeters [mm]); further spreading requires wind (Jordan and Payne, 1980:108). It has been demonstrated that a slick can move at a rate of up to 3% of the wind speed (Jordan and Payne, 1980:6). Only small amounts of spilled oil, less than 5% (Table 8-2), would likely dissolve in the water. As weathering progresses, oil would be separated into small droplets by waves, currents, and winds, and would combine with water to form a thick, mousse-like emulsion. Emulsions are quite stable and would be moved away from the source by wind and currents.

The weathering processes of dissolution and dispersion serve to distribute spilled oil into the water column. Winds, currents, and gravitational forces spread the oil slick across a larger area, reducing the oil slick thickness. Oil spilled in open marine water (summer) will be more readily spread by these forces than oil spilled during broken ice or solid ice conditions. Oil spilled under solid ice would not be exposed to wind and would be initially trapped in pools on the rough underside of the ice. Weathering would essentially stop for oil trapped under solid ice or incorporated into new ice growth.

Long-term weathering processes include photo-oxidation (degradation of oil by sunlight into more soluble end products), bio-degradation (micro-organisms breaking down oil components in the sediments and on the shorelines), and sedimentation (settling of oil particles adsorbed to suspended particulate material in the water column). Heavy molecular weight components of oil would form tarry residues, or tar balls, through the breakup of stable emulsions. Tar balls would be resistant to microbial breakdown and other weathering processes, and could persist in the seafloor sediment for years.

Microbial degradation may account for a substantial portion of spilled oil removal from marine sediments and shorelines. This rate is uncertain, however, as literature cites conflicting information. As of October 1, 1992, approximately 50% of the oil originally spilled by the *Exxon Valdez* could be accounted for by aqueous biodegradation and photolysis products (chemical decomposition by light) (Spies et al., 1996:4). Intuitively, the success of microbial degradation for an oil spill on the North Slope would likely be lower, based on: low temperatures, limited populations of hydrocarbon utilizing microorganisms, limiting nutrient (nitrogen and phosphorus) concentrations, low oxygen tensions, and limited circulation of interstitial waters in fine-grained sediments (Haines and Atlas, 1981:91). However, a study showed little statistical difference in the hydrocarbon metabolizing microbe concentrations between the Beaufort Sea and the Gulf of Alaska (Roubal and Atlas, 1977:900). Therefore, the degree to which biodegradation would be slower in Beaufort Sea marine sediments compared to Prince William Sound is uncertain.

8.4.2 Seasonal Conditions Affecting Oil Fate and Behavior

Seasonal weather patterns influence the movement of an oil slick in marine waters and, combined with visibility conditions, affect the time and equipment required for cleanup. Weathering forces, such as wind, waves, and currents, are considered in the evaluation of the fate of an oil slick and the likelihood that oil will contact resources in the four areas. Predominant weather and sea conditions in the project area are described in Sections 5.4.1 (wind), 5.5.1 (waves and currents), and 5.6.1 (sea ice). Differences in behavior of an oil spill during the three sea/ice conditions are described below.

Open Water Season (Summer): Oil spilled into a lake or pond would be contained, eventually coating sediments on the edges and bottom of the water body. Oil spilled into rivers or streams would travel with the flow of water out to the lagoon areas. Nearshore circulation would distribute oil throughout the semi-enclosed waters of the lagoons. Due to the small tidal fluctuations during calm weather conditions, oil contacting beaches would smear across a 1- to 2-ft (0.3 to 0.6 m) vertical zone of shoreline. However, west wind storm surges could raise the water levels by a maximum of 4.1 ft (1.25 m) above sea level (based on a 100-year return period [OCTI, 1996, as cited in INTEC, 1996a:3-39]), which could carry oil hundreds of feet inland. Ice concentrations (coverage) less than 30% would enable a spill seaward of the barrier islands to migrate in response to wind and nearshore currents, rapidly moving oil away from the source (BPXA, 1997b:53). For every 1,000 barrels of oil spilled during summer, approximately 6 to 30 acres (2.4 to 12 hectares) of marine waters would be covered by oil. This estimate is based on a 25% evaporation rate and spreading of the oil on marine waters to a thickness of 0.04 to 0.2 inches (1 to 5 mm). The fate and behavior of oil for a summer spill scenario is illustrated on Figure 8-2. Weathering processes would be at a maximum during summer due to the higher ambient temperatures and long daylight hours.

Broken Ice Conditions (Spring or Fall): An oil spill during spring breakup or fall freezeup, when the sea ice concentration is greater than 30%, could result in widespread, oil-contaminated sea ice. Oil trapped under or within the ice would gradually rise to the surface as the ice melted during breakup, and would eventually lie in melt pools on top of the ice. A subsea leak after the ice has started to break up would result in oil rising to the sea surface between ice floes, and either collecting in openings or beneath the floes. During freezeup, oil would be rapidly entrapped in ice as it forms, or be spread by storms in temporary open water conditions.

Solid Ice (Winter): An oil spill during winter would deposit oil on the frozen, snow-covered tundra onshore, on the surface of the sea ice, or in marine waters and sediments under the sea ice. Movement of oil away from the source of the spill would be reduced by the low temperatures and high viscosity of the oil. Snow would act as a natural barrier to oil movement. An oil spill under solid ice would result in an oil/ice slush encapsulated by ice. Warmer oil would melt ice or heat the water immediately surrounding the area of the release. Once the spill stopped and the surrounding water cooled, the oil would be encapsulated in ice. Oil spilled into the water column beneath the ice would rise and collect into small pools on the underside of the ice (BPXA, 1997b:47). The fate and behavior of oil for a winter spill scenario is illustrated in Figure 8-3. Currents under the floating ice in the project area are generally too weak (typically less than 2.4 inches/second (sec) [6 cm/sec]; see Section 5.5.1.3) to transport oil. However, in the cases of a continued release, moving ice, or water currents greater than 7.9 to 9.4 inches/sec (20 to 24 cm/sec) (Thomas, 1983:417), moving oil may be distributed over a larger area and may be difficult to track. Tarry residues (tarballs) would not form until spring, after the oil was exposed to weathering processes, such as emulsification and evaporation. Oil spilled under the bottomfast ice in the lagoons would pool on the seafloor at the location of the release, remaining in the area until spring breakup.

8.4.3 Potential for Spilled Oil to Contact Shoreline and Marine Water Areas

Fate and transport modeling provides an understanding of the areas likely to be contacted by oil spilled in marine waters/ice. Onshore oil spills on moist or dry tundra would remain close to the origin of the release due to the absorbency of the tundra vegetation (USDOI, BLM and MMS, 1997:IV-A-36; Barsdate et al, 1980:389). However, during some years with severe spring breakup flooding, melting snow and ice could spread oil further, potentially impacting hundreds of acres. As

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oil spreads into a thinner layer, it becomes more difficult to contain and recover. Spilled oil and surface water moving toward the Putuligayuk or Kuparuk Rivers would require rapid response to prevent further spreading.

Although no marine water oil spill trajectory modeling was performed specifically for this Environmental Impact Statement (EIS), relevant information was provided by the MMS from the Oil Spill Risk Analysis conducted for Lease Sale 170 (Anderson et al., 1997: 22 through 28). Modeling data results from Lease Sale 170 were averaged for two launch areas in the middle of leases Outer Continental Shelf (OCS) Y-0179 and Y-0181 to show the areas likely to be contacted by an oil spill originating near Seal Island. Areas chosen by the MMS for modeling were large land (Figure 8-4a, b) and ice/sea (Figure 8-5a, b) segments that do not directly correspond to the four environmental settings shown in Figure 8-1. However, use of the MMS land and ice/sea segments provides an estimate of the areal extent of oil movement and the resource areas likely to be contacted. As illustrated by Figures 8-4a, b, and 8-5a, b, a large geographic area could potentially be contacted by an oil spill of 1,000 barrels or more. It is evident that any resource present in the three nearshore and offshore environmental settings (Section 8.3) could be contacted by the spilled oil within a short period of time (3 days).

The MMS analysis considered only the conditional probabilities of oil contacting land and ice/sea segments. The calculation assumes that an oil spill of at least 1,000 barrels has already occurred and it has not been contained by spill response measures. Modeling provides a prediction of how oil spilled in the marine environment would move during summer and winter conditions and what area the oil would cover. The Oil Spill Risk Analysis performed by the MMS considered winter conditions to last from October to June; thus, broken ice dynamics were included in the same category with solid ice conditions. Modeling of oil spill trajectories in ice concentrations of 80% or greater uses the movement of ice to transport the oil. A spill near Seal Island occurring in the summer would be more mobile, contacting a larger area in less time than a winter spill (Table 8-3). Oil spill trajectories in ice coverages less than 80% use ocean current and winds to transport the oil (Anderson et al., 1997:7). Within 3 days of a summer spill into marine waters, coastline and island shorelines along a 100-mile (161 km) coastal extent could be oiled if spill response actions were not taken. The areal extent of oil coverage for a 1,000-barrel spill would be 6 to 30 acres (2.4 to 12 hectares), based on a 25% evaporation rate and spreading of the oil on marine waters to a thickness of 0.04 to 0.2 inches (1 to 5 mm).

The MMS analysis addresses a low threshold chance of contact (0.5%), with the assumption of no oil spill response action taken. Only resources located within approximately 12 miles (19.3 km) of Seal Island, within land segment 34 (Figures 8-4a and 8-4b), have a probability of contact (5% within a 3-day period). Over longer time periods, the estimated probability of spilled oil extending beyond approximately 50 miles (80.5 km) from Seal Island is low. The probability of shoreline or marine water contact outside of the proximity of Seal Island (land segments 33 and 34, ice/sea segments 7 and 8) is generally less than 10% (see table data on Figures 8-4a through 8-5b).

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8.5 LIKELIHOOD OF AN OIL SPILL

This section presents four potential oil spill sources associated with the project based on common design features for project Alternatives 2, 3, 4, and 5. The statistical probability of a spill is first computed and then used to compare the chance of an oil spill related to each of the project alternatives. Specific project design features that reduce the probability and/or the severity of an oil spill are presented to illustrate the safety measures associated with project Alternatives 2, 3, 4, and 5.

8.5.1 Potential Sources of an Oil Spill

Large volume crude oil and diesel releases (exceeding 1,000 barrels) are the focus of this discussion on potential spill sources for the project. However, as shown by historic mean and median spill volumes in Table 8-4, smaller spills (typically less than 80 gallons [303 liters]) are much more common than large spills greater than 1,000 barrels. Small spills of refined products, such as diesel, aviation fuel, lube oils, or antifreeze, are likely to be caused by small leaks, vehicle accidents, and human error (e.g., leaving valves open, overfilling tank while fueling vehicle, not securing drums during transport). Impacts to biological resources contacted by small spills would be similar to those impacts described in Section 8.7 for large spills. Since the number and location of small spills occurring each year is highly variable, it is not possible to accurately predict the number of resources that may be affected.

As discussed in Section 4.4.2.1, a gas pipeline will be co-located offshore in the subsea trench with the oil pipeline. The impacts of bundled pipelines and the potential for multiple lines to be damaged at the same location has not been evaluated (INTEC, 1996c:Appendix A, page 5). However, if a leak were to develop in the gas line, it is unlikely to affect the nearby oil pipeline. A gas leak jetting onto the oil pipeline would not be of a sufficient strength or duration to wear a hole through the oil pipeline. Both pipelines have been designed to withstand the abrasion and wear anticipated from strudel scour. The gas pipeline would be shut down immediately once a leak was detected by the leak monitoring equipment or periodic internal inspection (Franklin - Pers. Comm., 1998:3). A gas pipeline leak is not considered in this EIS to be the source of an oil spill.

Potential spill sources include: a drilling blowout, failure of the diesel storage tank on Seal Island, rupture of the oil pipeline (loss greater than 0.15% of flow rates), and chronic leaks (loss less than 0.15% of flow rates) from the oil pipeline (Table 8-5). These four spill scenarios include the events most likely to result in large volumes of oil being released into the environment. Factors considered in calculating spilled oil volumes, as well as likely spill durations (Table 8-5), are discussed below for each scenario.

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Well Blowout: During routine drilling operations, the weight of the drilling mud is monitored frequently and adjusted to maintain a greater pressure from the column of fluids in the well bore than that exerted by fluids in the rock formation. Situations leading to loss of control of the well include encountering pockets of high pressure natural gas and losing excessive amounts of drilling mud to a highly permeable section of the formation (BPXA, 1997b:26-27). If all drilling safety control mechanisms such as blowout preventors fail, an oil spill may occur. Estimated maximum spill volumes, based on initial reservoir knowledge obtained during exploration drilling, are 15,000 barrels per day (barrels/day) for 15 days (BPXA, 1997b:27). However actual spill duration could be highly variable, ranging from a few days to several months, potentially requiring planning, mobilization, and drilling of a relief well. The maximum estimated spill volume from a blowout, 225,000 barrels, would be larger than the highest volume blowout during OCS program history, i.e., the 80,000 barrel Santa Barbara spill in 1969.

Diesel Spill: A large diesel spill could originate from the production facilities' 2,800 barrel diesel tank storing fuel for generators and other equipment on the island (BPXA, 1997a:3.5-4). Diesel spills due to human error of overfilling vehicles while fueling would be small volumes, and generally restricted to central oil operations fueling areas not specific to Northstar. Also, small vehicle-related drips could happen during construction, operation, maintenance, or abandonment activities on land, or on ice roads used during winter. Cumulatively, these spills would be small in volume (each spill less than 5 to 80 gallons [19 to 303 liters]) and will not be considered further in the evaluation of impacts. The largest volume for a diesel spill source is estimated at 2,800 barrels, representing complete evacuation of the diesel storage tank. The duration of a spill is assumed to be 1 day.

Pipeline Rupture: Complete failure of offshore or onshore segments of the crude oil pipeline could occur as a result of mechanical failure, ice gouging (offshore), or corrosion. Pipeline rupture is defined as an oil spill greater than 100 barrels/day (0.15% of the anticipated peak flow rate of 65,000 barrels/day) for the purpose of this EIS. This is the minimum leak detection threshold for the design leak detection systems (INTEC, 1996d:10) which would be used with automated, quick-closure isolation valves positioned at each terminus of the pipeline and at the mainland shore approach (BPXA, 1997a:3.4-1).

Project Alternatives 2, 3, 4, and 5 have offshore pipeline lengths ranging from approximately 6 miles (9.7 km) to 9 miles (14.5 km) and onshore pipeline lengths ranging from approximately 11 miles (17.7 km) to over 15 miles (24.1 km). Pipeline lengths for the onshore and offshore segments of each alternative and associated maximum spill volumes for a pipeline rupture are shown in Table 8-5. An unknown variable is seawater intrusion into a ruptured submerged pipeline which, due to the water's higher specific gravity, would displace oil into surrounding marine waters (INTEC, 1996d:14). Due to the uncertainties of this displacement volume, complete drainage of oil is assumed. The volume of oil spilled by a complete pipeline failure is calculated from:

- The volume of oil spilled before the leak is detected.
- The volume spilled during time required for operator verification of leak and automatic valve closure.
- Expansion of oil due to pressure decrease (to atmospheric pressure).
- The volume of oil drained from the pipeline after valves are closed.

Chronic Pipeline Leak: The following assessment is based on the Applicant's proposed leak detection of 0.15% of the pipeline flow rate. Based on a maximum oil flow rate of 65,000 barrels/day through the pipeline, approximately 100 barrels of oil per day could be released without immediate detection, assuming that a leak detection threshold of 0.15% of the pipeline flow rate can be achieved. Leaks smaller than 0.15% would be detected by visual observation of spilled oil (INTEC, 1996d:10). Total oil spill volume would depend on the time required for visual leak detection and source control. Note that spill volumes presented in Table 8-5 are worst case releases based on complete drainage of pipeline contents after a leak has been detected and pipeline valves shut. In reality, once the pipeline's valves are shut, most of the oil in the pipeline would be prevented from escaping by seawater intrusion. In particular, leaks at a chronic leak rate less than 100 barrels per day imply sources such as small cracks and pinholes. Following detection of a chronic leak, pressures within the pipeline will be reduced to the point that very little oil can leak from the pipeline. At these low pressures, some seawater may seep into the pipeline (termed seawater intrusion). Because this intruding seawater is heavier than the crude oil, it will eventually block the oil in the pipeline from further leaking out of the pipeline's crack or pinhole. Moreover, crude oil remaining in the pipeline can be removed and the leak site isolated using specialized pigs (see Section 8.5.3 for additional details).

8.5.2 Estimated Risk of an Oil Spill

Numerous public review comments focused on the computation and interpretation of oil spill probabilities as presented in Section 8.5.2 of the Draft EIS (DEIS). This revised section reflects many concerns raised during the public comment period. It also incorporates revisions driven by project changes and a more detailed assessment of available oil spill databases. In particular:

· With the elimination of a waterflood seawater treatment plant on Seal Island, the range of 145 - 172 million barrels of expected reserves used in the DEIS was changed to an average of 158 million barrels in this EIS.

· Spill probabilities calculated from the Conservation of Clean Air and Water in Europe (CONCAWE) oil spill database in the DEIS were based on spills of 6.5 barrels (1 m^3) or larger. This database was reexamined to calculate probabilities for spills greater than or equal to 1,000 barrels.

· S.L. Ross, a consultant for BP Exploration (Alaska) Inc. (BPXA), developed an oil spill probability computation for Northstar during the public review process which indicated an overall project spill probability less than that provided in the DEIS. However, this study did not include the onshore pipeline spill contribution to the total oil spill probability for the project. Hence, the results of this study are not included in this EIS. The S.L. Ross et al. study did, however, provide offshore pipeline spill probabilities comparable to those presented in this section.

· The DEIS provided spill probabilities for each of three project components (i.e., platform [Seal Island], offshore pipeline, and onshore pipeline) in table format. For improved reader clarity, text in this section has been revised to address the spill probability for each of the three project components separately.

8.5.2.1 Calculation of Oil Spill Probabilities

A properly developed and validated database is required for the calculation of an oil spill probability. Ideally, the database employed should include a wide range of spill volumes from oil developments resembling the prospective project for which the spill probability is required. Because there are no oil developments offshore in the Arctic, no database matches the Northstar project in engineering scope or location. Any database used must be tempered with Northstar project specifics (Section 8.5.3). Although a quantitative spill assessment can provide insight on oil spill probability, it cannot capture all applicable factors, such as engineering risk and abatement. The likelihood of a spill from a particular platform or pipeline is highly dependent on its design, maintenance, management, and monitoring program, in addition to other factors relevant to the location.

In addition to a properly developed and validated database, the computation of an oil spill probability requires an exposure variable. An exposure variable relates the probability of an oil spill to oil production and transportation. Such a variable should be defined simply and estimated readily.

For oil spills, numerous such variables have been proposed and are in use, including: historic volumes of oil produced/transported, number of wells drilled, well-years, and pipeline mile-years. Each of these exposure variables has an assigned application, e.g., “wells drilled” would be used to compute the probability of an oil blowout during development drilling. Moreover, two different variables may be used for computing the probability of a spill from the same segment of an oil development, e.g., both historic volumes of oil produced/transported and pipeline mile-years can be used to predict the probability of a spill from the same pipeline. However, in this latter case, caution must be exercised because different databases are often used when developing exposure variables.

This EIS employs two sets of exposure variables, one originating from the MMS and the other from CONCAWE, a European organization that maintains a database relevant to environment, health, and safety activities associated with the oil industry. These two exposure variables are quite different in form. The MMS exposure variable is based on historical U.S. OCS platform and pipeline data derived principally from Gulf of Mexico and Pacific coast oil developments. The median spill size from this database is 7,000 barrels for platform spills and 5,600 barrels for pipeline spills (Anderson and Labelle, 1994:11). In this U.S. OCS database, the platforms are marine and the pipelines are submarine. Platform spills include blowouts, platform damage/accidents, and spills from storage tanks on or near the platform. The MMS has used spills per billion barrels of oil produced as the exposure variable on which it bases its spill estimates. MMS’s rationale for employing this exposure variable is that the volume of oil produced is a readily available and verifiable number. As used in the Northstar DEIS and this EIS, the MMS exposure variables for oil spills greater than or equal to 1,000 barrels are:

- 0.45 platform spills per billion barrels of oil produced.
- 1.32 pipeline spills per billion barrels of oil transported.

The CONCAWE exposure variable used in the Northstar DEIS included spills greater than or equal to 35.3 cubic feet (1 cubic meter or approximately 6.5 barrels). The CONCAWE exposure variable used in this EIS includes spills greater than or equal to 1,000 barrels to be consistent with the MMS exposure variable. CONCAWE spill data is based on European pipeline oil spills and does not include a suitable platform exposure variable. The CONCAWE exposure variable used in this EIS is:

- 1.8 spills per year per 10,000 miles (16,093 km) of pipeline (or 0.00018 spills per mile-year).

The primary difference between the MMS and CONCAWE pipeline exposure variables is their use of the following parameters: pipeline length, pipeline lifetime (typically in a project lifetime sense), and pipeline annual flowrate. The MMS exposure variable is based on the product of pipeline lifetime and annual flowrate, while that developed by CONCAWE employs the product of pipeline length and annual flowrate.

These exposure variables provide the statistically expected number of spills for a segment of the project (e.g., platform [Seal Island], offshore pipeline, or onshore pipeline) over the project lifetime. These values may then be converted to the probability of one or more spills for that segment of the project by use of the Poisson distribution.

For this EIS, oil spill probabilities are categorized by region of source: Seal Island (platform), offshore pipeline, and onshore pipeline. A spill at Seal Island could be caused by drilling and production/workover well blowouts, tank overflows or ruptures, and pipe and valve failures on the island. An offshore pipeline spill may originate from the subsea sales crude pipeline, while a spill from the onshore pipeline may occur between the pipeline shore transition and Pump Station No. 1.

8.5.2.2 Seal Island

Based on the MMS exposure variable for historical U.S. OCS platform spills and an estimated Northstar production of 158 million barrels of oil (this oil production estimate has been changed from the range of 145 to 172 million barrels presented in the DEIS based on BPXA's elimination of a waterflood seawater treatment plant on Seal Island), the probability of one or more well blowouts or tank spills greater than 1,000 barrels is 7% throughout the life of the project (Table 8-6). The chance of the maximum estimated well blowout volume (225,000 barrels) being released is very low. From 1979 through 1996, there have only been five oil well blowouts worldwide of greater than 10 million gallons (238,000 barrels) (Etkin, 1997:6-7). Over the same time period, there were roughly 470 billion barrels of oil produced. This gives an approximate spill rate of 0.01 blowouts of 10 million gallons (37.8 million liters) or greater per billion barrels produced. Based on an estimated production of 158 million barrels of oil from the Northstar reservoir, the probability of the maximum blowout volume would be 0.2% over the life of the project. Because these world-wide blowouts were the result of either an act of war or drilling practices not allowed in the United States, the probability of a very large blowout at Northstar would be even lower.

When evaluating the estimated oil spill probability, it is important to consider the potential causes of spills and to determine if the project design has properly accounted for these potential events. The use of Gulf of Mexico and Pacific oil spill data for estimating Northstar oil spill probabilities has drawn criticism because of the differences in habitat, climate, boat and barge traffic, etc. Several conditions encountered in the Arctic are not included in the U.S. OCS database for the Gulf of Mexico or the Pacific. These include ice gouging, strudel scour, and permafrost. Oil spill risks due to these conditions are addressed in Section 8.5.3. Conversely, the main causes of the oil spills in the MMS OCS database are not present in the Arctic, which suggest lower risk. Large spills from OCS platforms have been due to blowouts, storage tank ruptures or leaks, and vessels colliding with offshore platforms. Oil spill risks associated with Northstar may be lower than suggested by the MMS OCS database for the following reasons:

- All five of the blowout events recorded in the OCS database occurred between 1964 and 1970. Following the Santa Barbara blowout in 1969, amendments to the OCS Lands Act and implementing regulations substantially strengthened safety and pollution prevention requirements for offshore activities. Well control training, redundant pollution prevention equipment, and subsurface safety devices not required between 1964 and 1970 are now among the provisions which have been adopted and are included in the current OCS regulatory program. The absence of an oil spill from an exploration or development well blowout since 1970 reflects the success of this more stringent and rigorous regulatory program. Likewise, there have been no such blowout spills that released crude oil from any North Slope drilling operations onshore or in state waters. Drilling procedures are comparable on the North Slope and in the Gulf of Mexico/Pacific, so data for these regions appear consistent.

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· Exploration and development well technology has substantially matured in the last two decades. Better geologic knowledge from exploratory drilling results, additional and more comprehensive three-dimensional seismic analysis, and correlation with similar reservoirs provide for improved well control during development drilling. Six exploratory wells have already been drilled into the Northstar prospect and provide substantive understanding of the geologic and engineering considerations for safe drilling activity. In addition, three-dimensional seismic data have been collected and analyzed, which further improves understanding and knowledge of the reservoir. The reservoir is analogous to the Prudhoe Bay reservoir, which has been producing for over 20 years.

· The nearly 4,000 platforms and the level of vessel traffic in the Gulf of Mexico and Pacific are orders of magnitude higher than that for the Alaskan Beaufort Sea. The risk of a spill from a vessel collision with the Northstar production island is negligible.

· The prime cause of spills on OCS platforms has been from storage tanks. The last large OCS platform spill was in 1980, due to a tank overflow. Overfill protection would be provided for the 2,800-barrel, double-wall diesel tank proposed for Northstar by the level indicator, alarm, and automatic shut-down valve. The design and nature of the Northstar gravel island does not lend itself to damage of storage tanks from causes which are external to the island and which would result in a spill entering marine waters. Moreover, tank spills would likely be contained on the island itself.

8.5.2.3 Offshore Pipeline

MMS Based Probability: The MMS OCS pipeline exposure variable of 1.32 spills per billion barrels of oil yields an estimated 19% probability of one or more pipeline ruptures or leaks releasing 1,000 barrels or more (Table 8-6). Historic OCS oil spill rates (Anderson and LaBelle, 1994:Table 1) indicate that of the 12 pipeline spills which occurred in the OCS area greater than or equal to 1,000 barrels from 1964 to 1992, anchor damage to the pipeline caused seven spills, hurricane damage caused two, trawl damage caused two, and pipeline corrosion caused one. These principal damage causes would not be applicable to Northstar because the Northstar pipeline would be buried and boat traffic in the area is minimal. If the principal causes of a pipeline break from anchor and trawler damage are eliminated, it is reasonable to expect that the chance of an oil spill occurring for the Northstar pipeline would be reduced accordingly. Adjusting for the anchor and trawler events (see following paragraph) suggests the probability of other pipeline events is approximately 5%. This approximation does not attempt to compensate for different events among OCS regions (e.g., ice keel in the Arctic versus slope stability in the Gulf of Mexico.)

Pipelines in the Gulf of Mexico or Pacific face risks from anchor and trawler damage due to high boat traffic and minimal to no backfill protecting the pipeline. The Northstar pipeline would be buried under 6 to 9 ft (1.8 to 2.7 m) of cover (Table 2.4-2 of Appendix A). Pipelines in the Gulf of Mexico usually are laid on top of the seabed or in trenches only 3 ft (0.9 m) deep, which typically are allowed to backfill naturally by seafloor sedimentation (Boesch and Robilliard, 1987:624). Trenching is accomplished by hydraulic jetting or cutting a trench under the pipe after it has been laid on the seafloor. In contrast, the Northstar pipeline will be laid during the winter into a seafloor trench already dug through the ice using backhoes. Trenching, which will be monitored with mechanical surveying equipment (INTEC, 1996e:9) prior to installation of the Northstar pipeline, will avoid bottom irregularities like those that contribute to stresses on pipelines constructed in the Gulf of Mexico. The trench will then be backfilled using trench spoils and, possibly, some select fill material. BPXA has been conducting tests on the pipeline design and have demonstrated the ability of the pipeline materials to withstand the stresses anticipated during pipeline installation and operation (Section 8.5.3).

CONCAWE Based Probability: Pipeline incident data in Western Europe has been collected for 25 years by CONCAWE. Spill rates are available from CONCAWE based on number of spills each year per length of pipeline, which allows a comparison of project alternatives with different pipeline lengths. The CONCAWE pipeline exposure variable of 1.8 spills per year for 10,000 miles (16,093 km) of pipeline yields an estimated probability of 1.6% to 2.4% for one or more offshore pipeline ruptures or leaks releasing 1,000 barrels or more (Table 8-7). A comparison of alternatives shows a difference of less than 1% for the offshore pipeline, indicating that the probability of offshore pipeline spills should be considered approximately equal for Alternatives 2, 3, 4, and 5.

As previously described in Section 4.4.2.1, a gas pipeline will be co-located offshore in the subsea trench with the oil pipeline. Due to the conservative design of the Northstar pipelines (e.g., a pipe wall thickness approximately 2.8 times greater than that required to contain the maximum operating gas pressure), the probability of a leak in the gas pipeline is considered to be low. As indicated in Section 8.5.1, a gas pipeline leak is not considered to be a potential source of an oil spill. Existing oil and gas pipelines on the North Slope are located side by side on pipe racks extending for miles. No oil spill on the North Slope has been attributed to a gas pipeline leak. Therefore, the oil spill probabilities presented above do not change due to the presence of the co-located gas pipeline.

8.5.2.4 Onshore Pipeline

Use of the CONCAWE exposure variable of 1.8 spills per year for 10,000 miles (16,093 km) of pipeline yields an estimated probability of 3.0% to 4.1% for one or more onshore pipeline ruptures or leaks releasing 1,000 barrels or more (Table 8-7). The difference of only 1.1% for Alternatives 2, 3, 4, and 5 indicates that the probabilities of onshore pipeline spills are approximately equal.

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Data from the MMS OCS database is not applicable for the onshore pipeline; however, North Slope onshore spill data can be used to qualitatively consider oil spill likelihood. An Alaskan North Slope oil spill database is maintained by ADEC. Oil spill information is provided to ADEC by private industry according to the State of Alaska Regulations 18 AAC 75. Drawbacks to application of this data are: the total spill volumes are based on initial spill reports and may not contain updated information, and the questionable reliability of the database prior to 1989. However, it can be assumed that spills larger than 1,000 barrels would be reported and tracked with a higher degree of accuracy than multiple smaller spills. The ADEC database shows that no crude oil spills greater than 1,000 barrels have occurred on the North Slope since 1970 (Table 8-4). North Slope fields have produced approximately 12 billion barrels of oil through 1997 and have over 1,100 miles of onshore pipeline.

8.5.2.5 Overall Northstar Oil Spill Probability

Based on the MMS exposure variable for platform spills and the CONCAWE exposure variable for pipeline spills (onshore and offshore), the probability of an oil spill greater than or equal to 1,000 barrels from any component of the Northstar project would be 11% to 12% (Table 8-6). Based on MMS professional judgement of the project design, the probability of an oil spill greater than or equal to 1,000 barrels for Northstar is actually lower. Although different oil spill databases could be used to estimate probabilities for Northstar, the estimated probabilities would still lack risk associated with arctic conditions (e.g., strudel scour) and the incorporation of project specific design and operational features. Design requirements and expected operational procedures of Northstar (Section 8.5.3) exceed those of most facilities represented in oil spill databases. A spill ≥1,000 bbl may not occur; in fact, there is a greater likelihood of it not occurring than there is of it occurring.

8.5.3 Project Design Features for Reduction of Oil Spill Probability and Severity

Alternatives 2, 3, 4, and 5 incorporate design features to aid in the prevention of oil spills or provide measures to minimize the amount of oil spilled. For instance, the potential for a well blow-out at the drilling site has been minimized through the use of blowout preventors. The Northstar Project would include an ODPCP for prevention and cleanup of spills as required by federal, state, and local agencies (Section 8.6). Oil transported through the pipeline would be processed on Seal Island to meet delivery specifications for the Trans Alaska Pipeline System. Processing would remove water, gas and solids, which reduces the potential for internal pipeline corrosion. Specific design features related to the production facilities at Seal Island, and the onshore and offshore pipeline segments are described below.

Seal Island: Surface discharge basins, double-walled tanks for storage of hazardous materials and fuels, and seal-welded floor buildings for storage of lubrication oils would be installed on the island. Northstar's proposed gravel production island would likely allow containment of tank spills on the island surface. Development of Northstar oil reserves utilizing common drilling practices (i.e., use of blowout preventors, well control programs, and shallow hazard surveys) and equipment successfully being operated in arctic environments, including Prudhoe Bay, reduces the likelihood of a blowout. Additional standard prevention measures include the use of well blowout protection, periodic training of personnel in well control, and routine quality control to minimize the potential for spills.

Offshore Pipeline: The three greatest risks to the Northstar pipeline integrity would be trauma, corrosion, and construction.

Ice gouges and strudel scours present potential hazards which could cause pipeline damage resulting in oil spills. The pipeline has been designed, and the burial depth planned, to withstand anticipated hazards (INTEC, 1996b:4; INTEC, 1996f:14). For example, the pipeline burial depth would be over twice the depth of the 100-year ice keel gouge (2.3 ft [0.7 m]). The State Pipeline Office (SPO), which is responsible for ensuring pipeline safety, has independently reviewed the engineering analysis and design. Although this EIS also reviewed pipeline design, the depth of this review was exceeded by the SPO review due to the level of engineering analysis required. These analyses were shared (see Appendix E for a list of technical documents).

Exterior corrosion of the pipeline would be reduced by coating the pipe's exterior with two layers of fusion bonded epoxy. The first layer prevents the bare metal from being exposed and the second layer protects the first layer. Additional safety measures, such as cathodic protection, further minimize the risk of pipeline failure due to corrosion. The pipeline would have an extensive monitoring program using smart pigs on a pre-established frequency. This preventative practice allows knowledge of pipeline conditions to be obtained before a leak could occur. Existing pipelines in the OCS are rarely pigged to monitor pipe integrity, but rather in response to an indication of a problem. This conservative, precautionary practice should lead to a reduction in the probability of a spill. Corrosion, if it occurs at all, would occur over a period of years and frequent pigging is not necessary. However, BPXA has proposed a proactive and definitive monitoring program which exceeds practices in the Gulf of Mexico and which has been reviewed and approved by the SPO as part of the quality assurance program for this pipeline.

Pipeline construction issues would be addressed through quality assurance/quality control programs that would be used during the construction phase of the project. The quality assurance program would include 100% x-ray and ultrasonic tests for all pipeline welds, reducing the potential for pipeline failure due to welding flaws. Custom material was selected for the Northstar pipeline. Everything about the pipe was designed specifically for the Northstar project, including chemistry, material testing, and pipe strength properties. Four progressive full-scale pipe bend tests were conducted in November 1998 and verified that the pipeline would not leak, even with purposely induced welding flaws and under loads an order of magnitude greater than the expected strain and over five times the design strain.

In addition to specific engineering design features described above, the following considerations would contribute to minimizing pipeline oil spill probability and the volume of oil that could be spilled:

- No subsea connectors, valves, etc. would be installed on the subsea portion of the pipeline. These are often potential sources of small leaks.

- The offshore portion of the pipeline would utilize two shut off valves, one located at Seal Island, the other at the landfall location.

- A comprehensive third party review of the pipeline was performed by individuals with expert academic and/or professional experience in all aspects of the design, i.e. ice gouging, strudel scour, thaw settlement, shore approach, corrosion protection, welding, metallurgy, geology, and mechanical engineering. In addition, the U.S. Department of Transportation provided a peer review of selected portions of the SPO analysis of the Northstar design.

- A Supervisory Control and Data Acquisition system would be installed with both a Mass Balance Line Pack Compensation system capable of detecting small leaks over a longer time period and a Pressure Point Analysis system capable of rapidly detecting large leaks. This system is designed to detect changes in flow rates of 0.15% based on volume throughput over a 24-hour period. This exceeds state regulatory standards by an order of magnitude. Periodic surveys would be conducted during both open water and frozen conditions to identify any potential small leaks in the subsea portion of the pipeline.

Monitoring to detect a pipeline leak would include weekly visual inspections of the offshore and onshore pipeline routes from boats and by air during broken ice or open water seasons (BPXA, 1997b:29). Under-ice surveys would be conducted every 30 days (starting when it is safe to work on the ice) along the offshore pipeline route in the winter when solid ice cover would conceal oil from view of aerial surveys. This survey program would consist of survey crews drilling sets of through-ice holes at approximately 450-ft intervals along the offshore route. Each set of holes would consist of one hole above the pipeline and another north or south of this first hole at a distance of 30 feet (9.1 m). Close to shore, in the zone of bottomfast ice, only one hole would be drilled to the ice/seabed interface directly over the pipeline trench (BPXA, 1998b:2-21).

The probability of detecting a chronic pipeline leak under solid ice using the through-ice sampling technique would depend on the under-ice area covered by oil. The size of this area would depend on the rate and duration of the leak. The oil spill area would also be related to the under-ice oil holding capacity. Oil spilled from a small leak in the offshore pipeline would rise vertically through the pipeline trench backfill and water column above the pipeline until it reached the underside of the solid ice sheet. Winter ocean currents that would be acting on the oil as it rises are so slight that the slick would essentially be centered over the point of release. Moreover, under-ice ocean currents measured in the project area are generally less than 2.4 inches/second (0.06 m/s) (Section 5.5.1.3) and are typically too weak to spread oil beneath the ice. In particular, the threshold water velocity for spreading oil under ice ranges from 3.9 to 7.8 inches/second (0.1 to 0.2 m/s), depending on the under-ice roughness (Thomas, 1983:417). The maximum under-ice ocean currents measured in the project area never exceeded 3.6 inches/second (9 cm/s) (Section 5.5.1.3). Under-ice holding capacities for various tests performed in the Arctic range from 0.0047 barrels/ft^2 (50,000 barrels/km^2) for smooth ice to maximum values on the order of 0.0058 to 0.0347 barrels/ft^2 (62,500 to 375,500 barrels/km^2) for ice with bottom roughness (Thomas, 1986:447). The estimated oil spill area under the ice would range from 0.1 to 0.5 acres (0.04 to 0.20 hectares) for every 100 barrels of oil spilled. Should sampling be performed every 30 days where the sampling spacing is approximately 500 ft (152 m), the probability of detecting a chronic leak (maximum 100 barrel/day) at the earliest next sampling is approximately 55% (maximum leak duration of 30 days). This probability of leak detection increases to over 90% when two sampling periods are considered, i.e, the maximum leak duration is 60 days. Increasing survey frequency and/or decreasing the spacing between the through-the-ice sampling holes can increase the probability of detecting a smaller size chronic spill.

Onshore Pipeline: Many of the pipeline engineering considerations described above for the offshore pipeline would also be applicable for the onshore pipeline segment. In addition, two manual valves would be installed at the Putuligayuk River crossing to reduce the quantity and severity of an oil spill into the river. A remotely controlled shut-down valve installed in the oil pipeline at Pump Station No. 1 also would help to reduce oil spill volumes (this design feature was considered in determining spill volumes presented in Table 8-5). Vertical support members would be located to minimize the potential for impacts from natural forces (e.g., ice flows on the Putuligayuk River). The onshore pipeline would also be visually surveyed weekly to identify any leaks or structural failures.

8.6 OIL SPILL RESPONSE

The Federal Oil Pollution Act of 1990 and the State of Alaska AS 46.04.030 and 18 AAC 75 require the owner or operator of an oil exploration or production facility to prepare an ODPCP. The plan for the Northstar Project must be reviewed and approved by ADEC, MMS, U.S. Environmental Protection Agency (EPA), U.S. Coast Guard, and U.S. Department of Transportation Research and Special Projects Administration. This ODPCP is titled “Oil Discharge Prevention and Contingency Plan, Northstar Operations, North Slope, Alaska”, and will be referred to in this EIS as the Northstar ODPCP. The Northstar ODPCP must be regularly updated to reflect changes in operations, response capabilities, calculations for worst case discharge, emergency response contact names and phone numbers, or any other information which could affect oil spill prevention and response activities. The plan will be tiered from the Alaska Clean Seas (ACS) Technical Manual, as described below.

ACS is the primary response organization for the North Slope. A joint industry and government effort is underway to expand the ACS Technical Manual with more specific detailed scenarios and response tactics for different oil spills, including onshore and offshore. The State of Alaska, North Slope Borough (NSB), U.S. Coast Guard, EPA, MMS, and industry are jointly involved in the process. ADEC has completed a preliminary review of the Northstar ODPCP and issued a document titled “Preliminary Analysis of Oil Spill Response Capability in Broken Ice” in August 1998. It is the state’s responsibility to resolve outstanding oil spill prevention and response issues before approving the Northstar ODPCP. The ACS Technical Manual is comprised of base documents to support individual facility contingency plans. Spill scenarios and response strategies are presented in the Northstar ODPCP. The Northstar ODPCP identifies the planning, equipment, and personnel needed to satisfy the oil spill response requirements outlined by state and federal regulations. Mutual aid agreements existing on the North Slope make personnel and equipment resources from other fields available for Northstar (ACS, 1998:Tactic L-8). While local labor could be utilized for spill cleanup, mandatory training requirements specified in the ACS Technical Manual (Tactic A-4) would have to be met.

The Northstar Project would install the first subsea offshore oil and gas pipelines in the Alaskan Beaufort Sea. In the event that both pipelines are ruptured (e.g., by an iceberg), response to an oil spill may be delayed due to the safety hazard presented by explosive vapors. Increased mixing of the oil and more rapid mousse formation would be anticipated due to the turbulence of gas escaping from the nearby pipeline. The Northstar ODPCP (BPXA, 1998b:1-3) indicates that the safety officer has the responsibility to determine if a threat of fire or explosion exists, and the authority to suspend response operations. The ACS Technical Manual (1998: Tactics S-1 and S-5) describes methods for air monitoring and other safety precautions that would be employed to prevent injury to spill response workers due to fire or an explosion.

8.6.1 Available Containment and Cleanup Methods

Reducing the ecological impact of an oil spill requires minimizing oil contact with sensitive areas and resources. In conjunction with cleanup methods implemented to remove oil from the environment, wildlife hazing may be used to minimize contact of biological resources with oil contaminated water, ice, or land. This also would involve the removal and disposal of oil-covered carcasses to avoid further exposure through ingestion by scavenging animals.

Cleanup actions typically start with containment of spilled oil, followed by physical or mechanical recovery. Additional options, such as in situ burning, or passive recovery, are tools used to supplement mechanical recovery. These response options would only be implemented before mechanical recovery if dictated by weather constraints, personnel safety issues, or logistical restrictions. Situations in which certain options are more effective than others are discussed below by response method.

Containment: Spreading and dispersion of spilled oil in offshore and nearshore marine waters must be restricted to ensure effective recovery and to protect additional areas from oil contamination. Booms and absorbent barriers may be deployed to form physical barriers to migration of a slick. There are a wide variety of boom types available, including open water, calm water, protected water, swamp, shoreline, and fire containment (used for in situ burning). Use of containment equipment is most productive in calm seas and away from fast currents. Deployment of booms and absorbent materials would require the use of vessels sized appropriately for the depth of water and distance offshore. Booms and absorbent barriers would also be beneficial for containment of spilled oil on the ice surface, potentially supplemented with the temporary construction of snow berms.

Application of chemical dispersants is an alternative response to containment of an oil slick. Addition of dispersants helps speed up the natural dispersion process by breaking the oil into very small droplets. These droplets disperse more readily into the water column and are more quickly degraded by naturally occurring microorganisms. Dispersant use is most applicable in warm weather conditions with low viscosity (thin) oil that has not weathered for more than 2 days. Use of dispersants on the North Slope is possible, however unlikely, due to its minimal effectiveness in cold water temperatures and biological toxicity concerns about its use.

Mechanical Recovery: Mechanical recovery involves the collection of oil/water and oil/soil mixtures using mechanical equipment. Factors affecting the success of this response method include: logistics support, weather conditions, trained personnel, temporary storage capacity, and disposal options. Sufficient numbers of personnel and vessels must be mobilized to support the deployment and maintenance of booms and skimmers. Weather and associated sea conditions must be calm enough to ensure safety of response personnel, permit access to the spill source, and permit effective use of the equipment. The type and condition of the oil must be amenable to mechanical recovery and there must be sufficient storage capacity available for the materials collected. Finally, the materials collected must be treated and/or disposed.

Mechanical recovery equipment ranges from specialized oil spill containment and collection equipment to heavy earth moving equipment. Booms would be used to contain the spill in open water or on ice. Skimmers are typically used in conjunction with booms to collect the oil, which is then transferred to bladder tanks for temporary storage. A variety of skimmer types have been developed for different environmental conditions and oil types, including: brush, disc, drum, rope mop, and weir. For a spill reaching the shoreline, or occurring on land, additional equipment types typically used include: absorbent materials; oleophilic (preferentially oil absorbent) materials; weak chemical dispersants to allow thick, weathered oil to be flushed; pumps; vacuums; sprayers; backhoes; bulldozers; and beach cleaners (solutions containing chemicals that minimize the potential for oil to stick to substrates). Some of these also can be utilized on water if appropriate. Once the oil is collected, it is typically stored in bladder tanks until is can be collected and transferred to long-term storage or to a facility for processing or disposal. Mechanical response to an oil spill is a dynamic process which provides the responder with a variety of tools to be used as the conditions of the oil, weather, climate, or location change.

In Situ Burning: A large oil spill may be mostly removed from the surface of marine water by burning. Successful application of this response method requires ignition prior to evaporation of the lighter end elements of the oil which support combustion. As weathering proceeds (evaporation and emulsification), the oil may become more difficult to ignite. The required oil slick thicknesses for combustion are 0.08 to 0.12 inches (2 to 3 mm) for fresh crude and 0.12 to 0.2 inches (3 to 5 mm) for diesel and weathered crude (ACS, 1998: Tactic B-3). A general rule is that the decision to proceed with burning should occur within 24 hours of when the oil is released. In the case of a continuous release of fresh crude oil, such as with a long-term blowout, or for an under ice pipeline release, where the rate of evaporation is slowed, burning remains a viable response even after 24 hours. In situ burning requires an approval from regional agency representatives.

The State of Alaska does not usually consider in situ burning in open water a primary response strategy because state guidelines require demonstrating response capability based on mechanical response. However, in broken ice conditions, in situ burning may be a more efficient method than physical containment and recovery.

A fire boom is used to collect the oil into a thickness that is ignitable. If it is not feasible to deploy a fire boom, as in the case of a large magnitude blowout, it is still possible to burn the oil if scattered ice acts as a boom, preventing the oil from spreading too thin to ignite. However, burn efficiencies will be lower (55% to 85% compared to 90% to 95%) and more oil residue will remain in the water when a fire boom is not used (Evans, 1989:51 through 53). Air pollutants in the local area would include emissions of small particulate matter, sulfur oxides, and nitrogen oxides.

Manual Recovery: Objectives of manual recovery are to minimize the effects of oil and accelerate the natural recovery of oiled soils and vegetation. Physical cleanup of the oil involves labor-intensive use of buckets, shovels, vacuum equipment, absorbents, and temporary storage containers. Care must be taken when conducting manual recovery to avoid damage to delicate organisms and habitats. Local labor would likely be required for the cleanup of any large spills.

Natural (Passive) Recovery: If weather conditions prevent response or endanger human life, or a response would cause more damage to the environment than the spill, it is possible that no active cleanup activities would be initiated. If no action was performed, natural and biological processes would disperse and degrade the oil over time. While microbial degradation may ultimately be responsible for disposition of a large portion of the spilled oil volume (Section 8.4.1), these processes are slow and hydrocarbons may persist relatively unaltered for several years in Beaufort Sea sediments (Haines and Atlas, 1981:91). Weathering processes would continue to age the oil, leaving a thick tarry mat on the tundra, shoreline, or sediments contacted by the oil spill.

8.6.2 Spill Response Limitations

Weather and ice conditions in the area of a spill would dictate when response actions could begin. High winds, low temperatures and visibility, high rainfall or snowfall, and the presence of pack ice could all hinder a response. Cleanup actions in progress also could be slowed or discontinued due to safety considerations for workers or effectiveness of response equipment in adverse weather. Additionally, as discussed above (Section 8.6), spill response may be delayed if fire or explosion hazards exist (such as would be the case for rupture of both the bundled gas and oil pipelines). Typical meteorologic conditions for the project area were presented in Section 5.4. North Slope weather/sea data, spill response techniques, and environmental conditions reducing oil recovery efficiency are summarized in Table 8-8. Given present oil spill response technology, broken ice, unstable ice, rough seas, or high wind conditions could hamper the ability or prevent any cleanup response for over 50% of the year. Consequently, further research and development in this area is needed to minimize the effect of a large spill.

The combination of severe weather events has been cited by local residents as a likely cause for delay or inability to respond to a spill. Skepticism and doubt has been voiced by residents about lack of proven technology for spill response for conditions other than calm waters (P. Nusunginya in USDOI, MMS, 1983:18). Local residents have participated on village response teams and have first hand knowledge of the inability to respond in severe weather and ice conditions (L. Lampe in USACE, 1996:23 and 24). Potential weather conditions limiting the ability to respond to an oil spill are summarized below for open water, broken ice, and solid ice conditions.

Open Water (Summer): Open water conditions typically last for 2 to 3 months on the North Slope. Spill response for a spill occurring in June, July, or August would be delayed by high wind and waves which limit boat traffic (for safety of personnel) in offshore marine waters. These conditions could last for a few days to several weeks. This could result in delays in deploying containment and recovery equipment. Buoys would likely be deployed to monitor the movement of the oil slick during the delay. A spill occurring seaward of the barrier islands would have the potential to spread over a wide area while response crews waited for seas to calm. With no response to an offshore pipeline spill (see Table 8-5 for estimated release volumes), the areal extent of oil on marine waters would range from 21 to 31 acres (8.5 to 12.5 hectares) for a slick thickness of 0.2 inches (5 mm) and from 106 to 152 acres (42.9 to 61.5 hectares) for a slick thickness of 0.04 inches (1 mm). If a spill occurs in the fall, the season with the highest frequency of storms, response could be delayed until winter when ice thicknesses are sufficient to allow on-ice mobilization of equipment and personnel.

Heavy precipitation or fog could restrict visibility and potentially stop air traffic for up to several days. This would hinder response actions due to personnel safety issues and the lack of aerial tracking and logistical support. Lack of airplanes or helicopters also would restrict the use of in situ burning response techniques.

Solid Ice (Winter): For approximately half the year, lakes, rivers, and marine waters are covered by ice. Oil spills detected under solid ice would have to be tracked by boring holes through the ice. Containment and recovery of oil under solid ice would require personnel and equipment to be deployed on the ice. Ice thickness would have to be great enough to support heavy equipment and personnel, which is typically from January to April. Spill response would be restricted in November and December due to unsafe ice conditions. Extremely low temperatures during winter months may hinder response by increasing the danger of frostbite and decreasing the productivity of workers. Continual darkness from November 18 to January 24 would require the use of generators and lights to perform manual and mechanical oil recovery operations.

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Broken Ice (Spring or Fall): Broken ice conditions would be expected near Seal Island for an average of 4 to 5 weeks in the fall and 3 weeks in the spring. The maximum length of time for broken ice conditions in the area would be 8 weeks in the fall and 5 weeks in the spring. Mechanical spill response activities could be restricted some years for up to one-fourth of the year (3 months) as a result of these broken ice conditions. Limitations to oil spill cleanup effectiveness are summarized in Table 8-8 for different ice/sea conditions. Waters congested with icebergs and floes (ice concentrations greater than 50%) would constrain the use of offshore containment and recovery response techniques. Icing of vessels and equipment also could slow response in low temperatures. Effective use of mechanical equipment would be diminished by the presence of ice floes, high winds, strong currents, and large waves. In situ burning could be used under these conditions.

Methods of transporting oil response equipment and personnel to an offshore spill site during open water and solid ice conditions (i.e., by marine vessel and wheeled/tracked vehicles, respectively) cannot be utilized during broken/thin ice conditions. During such conditions, icebreaking barges have been proposed as part of a shore-based oil spill response system for Northstar. In particular, an icebreaking barge pushed by a tug would be used to create a corridor from West Dock to Seal Island during periods of thin ice. Barges containing oil spill response equipment would then use this corridor to initiate a spill response in the vicinity of Seal Island. Initially, this corridor would be created in the forming ice between West Dock and Seal Island using a barge with a bow modified for icebreaking capabilities. This icebreaking barge would be pushed by a tug and would be able to break substantially more ice than a conventionally shaped barge. Two conventional tugs with barges transporting oil spill response equipment would then follow behind this icebreaking barge in the corridor. Once an icebreaking barge breaks through the fast ice band, the other barges could potentially operate in the new and young ice from mid-October through early November, or until the ice reaches a thickness of approximately 18 inches (46 cm).

These icebreaking barge operations cannot continue as the ice thickens past 18 inches (46 cm). Hence, these proposed operations would be typically restricted to a 10- to 20-day period between mid-October and early November. During normal operations, the icebreaking barge would travel between West Dock and Seal Island periodically (approximately every 48 hours) to maintain the broken ice/slush corridor. The duration of this transit is between 1.3 and 2.1 hours, depending on ice cover.

During spring breakup, barge operations could commence when the ice was sufficiently thin. It is anticipated that such operations between West Dock and Seal Island would begin during late June to early July, depending on ice conditions.

8.6.3 Application of Spill Response in Environmental Settings

Response methods available on the North Slope through ACS are discussed for application in the four environmental areas presented in Section 8.3. Sensitive areas are designated as first priority for protection from contact by oil and/or cleanup of oil already in the area. Ways to clean up the oil in each of the areas are described for different times of the year. Equipment inventories for the North Slope and for the Northstar Development Project are available in the ACS Technical Manual and the Northstar ODPCP (BPXA, 1998b:3-31 to 3-34).

8.6.3.1 Onshore Land

Onshore containment would typically be achieved by construction of earthen or snow/ice berms or trenches dug into the soil and the use of absorbent barriers. Oil on snow cover would be removed by the collection of snow and ice using shovels or front-end loaders. After removal of snow/ice cover, frozen contaminated soil would be removed using shovels or heavy construction equipment (depending on the size of the spill) and restoration of scraped tundra would be necessary. Low pressure water flushing may be used to float oil toward collection areas. Once contained, deeply pooled oil may be recovered using vacuum systems or oleophilic disc skimmers. Rope mop skimmers or absorbent pads would be required for recovery of thin layers of oil. Collected oil would be stored in mobilized holding tanks for transportation to disposal facilities. Surface water or snow contaminated with oil would be collected and processed using an oil-water separator with both the water and oil being disposed in appropriate facilities. Heavily oiled vegetation may be removed by hand cutting. Alternatively, contaminated soil or sediment may be left in place, with oil contamination managed by natural weathering and biodegradation (potentially enhanced by the addition of fertilizer and seed bacteria) due to the irreversible damage that could be done by large earth moving operations (BPXA, 1997b:60; Baker and Herson, 1994:274).

Cleanup methods for a spill contacting onshore areas would likely include mechanical, manual, and natural recovery. Location of the spill and time of year would be the main factors considered when initiating cleanup actions. Mechanical and manual recovery techniques would be more desirable during frozen ground winter conditions then during the summer; damage to tundra vegetation and disturbance of animals would be less in winter months. Potential damage to tundra from response activities involving heavy construction equipment or vehicles may include damaged vegetation, permafrost melting, subsidence, and erosion. Small spills during summer months would be cleaned up by laborers using hand tools to remove oil and contaminated soil, water, and vegetation while minimizing damage to tundra. Onshore spills in the summer would have the highest impacts in bird nesting and feeding areas, which would have the highest priority for oil cleanup. All contaminated seal, whale, and bird carcasses would be removed immediately to prevent scavenging by, and contamination of, polar bears, foxes, and birds.

Wildlife hazing may be performed to prevent birds or mammals from contacting oil on the tundra or in a river or lake. Hazing has limited success and may even have detrimental effects. Deterrents used on birds have particularly low success rates and create additional side effects. Birds will often return to contaminated areas previously used for feeding, breeding, or nesting. If hazing disturbance is successful in driving birds away, but alternate habitat is not available, some birds may not survive. Also, deterrents stress the birds and may increase their susceptibility to disease and harsh weather.

Following the detection of a spill and initiation of source control measures, equipment would be mobilized to the cleanup location. Rolligons, helicopters, and boats would be used to transport equipment to the spill location to restrict the amount of tundra disturbance. Rapid response times require that recovery equipment be staged at onshore Prudhoe Bay facilities.

8.6.3.2 Lagoons and Shoreline Inside the Barrier Islands

Mechanical recovery, manual recovery, and natural recovery would be the most likely cleanup methods used for oil contacting lagoon areas and shorelines shoreward of the barrier islands. The barrier islands would be most sensitive to spill cleanup activities in the spring, when birds nest on the islands. Hazing of birds in these months would be performed with caution, in areas away from nesting. All contaminated seal, whale, and bird carcasses would be removed immediately to prevent scavenging by, and contamination of, polar bears, foxes, and birds.

Cleanup activities on the barrier islands would follow that described above for onshore spill response. Shoreline and lagoon area cleanup in the summer would involve different cleanup techniques requiring equipment such as small boats and booms. Staged equipment from either Prudhoe Bay or project facilities would be brought to the cleanup location.

Shoreline cleanup would mimic onshore cleanup techniques, with the additional priority of preventing further spread of the oil slick on marine waters. Booms would be deployed in shallow offshore waters or on the surface of the ice (depending on the time of year) to contain oil and reduce further contamination of shorelines. Booms can be deployed using small boats for most of the open water season. Once oil is contained on nearshore water or ice, it can be collected using vacuum systems, skimmers, or rope mops. Under ice pipeline spills would require holes or trenches to be drilled through the ice for oil recovery. Collected oil, water, ice, and snow would be transferred to holding tanks for transport to separation and treatment facilities. Affected sediments would likely be left in place unless close to the shoreline, where heavily contaminated material would be removed using heavy construction equipment and hauled away for treatment and disposal.

Response in broken ice would be more difficult than in open water. As ice coverage increases, it becomes more and more difficult to operate containment booms to concentrate oil for recovery (BPXA, 1998b:3-29). Estimated boom containment efficiency in broken ice is 70% in 3/10ths ice concentration, 40% in 5/10ths, and 20% in 7/10ths (S.L. Ross, 1998:46). Heavy concentrations of broken ice could restrict boom use and operation of non-ice class vessels up to 20% of the time from May 15 to June 30, and up to 50% of the time from October 15 to May 15 when ice is not frozen solid (ACS, 1998:Tactic L-7, Table 1A).

8.6.3.3 Outer Island Shoreline and Exposed Coast

Mechanical recovery, manual recovery, and natural recovery would be the most likely cleanup methods used for oil contacting shorelines and islands seaward of the barrier islands. Similar to inside the barrier islands, bird nesting in the summer months would be the primary concern for cleanup activities on islands. Wildlife hazing would potentially be required to minimize oil exposure of seals, Arctic fox, and polar bears present in this area in the winter. Intentional hazing of marine mammals would require authorization under Section 109h1A or 112c of the Marine Mammal Protection Act of 1972. Repeated efforts to drive Arctic fox and polar bears from the area would be required due to the attraction to activities and smells associated with oil spill cleanup. All contaminated seal, whale, and bird carcasses would be removed immediately to prevent scavenging by, and contamination of, polar bears, foxes, and birds.

Cleanup activities would generally be the same in this area as onshore or inside the barrier islands, depending on the source of the spill. A large spill associated with a well blowout on Seal Island would have delayed shoreline cleanup due to safety concerns if in situ burning was implemented on the offshore waters. Hazards associated with travel on pack ice would decrease the chance that mechanical recovery of oil slicks would be performed. Response equipment would most likely be flown by helicopter to islands for shoreline cleanup.

8.6.3.4 Marine Water and Sea Ice

Mechanical recovery, in situ burning, and natural recovery would be the most likely methods used for cleanup of oil in marine waters, seasonal ice, and pack ice. Depending on the size of the spill, likelihood of effective and safe cleanup, and severity of potential impacts from the oil, a decision may be made to take no active response. Vessel traffic and noise associated with mechanical recovery and in situ burning would likely disturb marine mammals and potentially alter migration routes for some species (whales). During periods of broken and unstable ice, in situ burning may be the only active cleanup response available due to safety concerns for personnel and equipment.

A containment priority would be preventing spilled oil from contacting shorelines, or minimizing such contact. Although winter spills in or on ice would not be highly mobile, containment and recovery would still be desirable to avoid oil migration once breakup occurs. During open water or broken ice conditions, booms would be deployed using barges, tugboats, or helicopters. Fire booms would be deployed for control of in situ burning and safety of personnel, equipment, and onshore resources. Mechanical recovery would employ booms or skimming barriers; snow berms could also be used during the winter.

In situ burning could be used in broken ice, where other methods are less effective, or if oil in open marine water is far offshore (away from people, equipment, and land). Burning would be used to prevent the spread of oil to other areas. In situ burning must be initiated as quickly as possible (within 24 hours except for continuous or under ice releases) if this technique is to be implemented, as weathering processes such as evaporation and emulsification make the oil more difficult to ignite. Use of this response method requires containment measures (fire booms in the summer and ice in the spring and fall) to keep the oil concentrated enough to burn. Contained oil would be ignited using torches or aerial ignitors. Chemicals may be sprayed on the oil slick from helicopters to assist ignition. Once the oil is burning, all workers in the immediate vicinity of the burn would be moved to upwind locations to avoid inhalation of combustion byproducts. Movement of the oil slick must be continually monitored during burning. Burning may be suspended if wind direction shifts the oil slick towards shore. The fire is extinguished by opening the containment boom and allowing the oil to disperse to a thickness unable to support burning.

Mechanical recovery of offshore oil spills during winter months would use heavy equipment requiring construction of ice roads. Depending on weather conditions, construction may take weeks to a month to complete. Safety concerns limit the distance offshore that cleanup can be performed even with ice roads.

Time requirements for ice road construction could delay implementation of spill response measures. Lack of oil spill recovery estimates for several methods (Table 8-6) supports the need for research and development of new technology for oil spill cleanup.

Cleanup of spills under ice would require drilling holes or trenches through the ice for oil recovery. Absorbent booms or rope mops would be used to collect pooled oil. Oil spills on the surface of the ice would be cleaned using heavy equipment to collect contaminated snow and ice, which would be placed in holding containers and transported to treatment facilities for separation and disposal.

Offshore mechanical recovery in open water would be staged from barges mobilized to the area of the spill. Disc and weir skimmers, rope mops, and vacuum pumps would be used to collect oil. Cranes located on the barge would deploy and maneuver collection equipment. Collected oil and water would be held on the barge in storage drums or tanks. Tugboats would maintain boom positions and possibly act as additional collection points using skimmers or pumps. Aircraft could be used to direct cleanup operations to the heaviest oil concentration areas.

8.7 ENVIRONMENTAL IMPACTS OF OIL SPILLS AND OIL SPILL RESPONSE ACTIVITIES

This assessment of potential impacts of oil spills on the physical, biological, and human resources is based on the assumed occurrence of several events, none of which are certain to occur. This system employs a type of worst-case analysis. The assumptions for this analysis include:

- An oil spill greater than 1,000 barrels will occur.
- The oil spill occurs during the season each specific resource is present, or is most susceptible to adverse effects (or an earlier spill was not effectively cleaned up or sufficiently weathered to prevent resource impact).
- The spilled oil contacts the resource of concern.
- Oil spill response efforts are not considered to reduce the impact of the spill on each resource of concern.

The potential impacts to polar bears, sea ducks, and spectacled eiders represent reasonable estimates for this type of analysis and do not reflect the upper limit for injury and mortality in the event of a spill much larger than 1,000 barrels.

To properly interpret the impact information presented, readers should recognize that an impact to a specific resource could occur, but it is unlikely that all identified impacts to all described resources would occur. Individual impacts are presented in this EIS without development of a probabilistic risk assessment. This approach was utilized for this EIS to clearly present each potential impact.

If the impact information is used to develop an opinion regarding project acceptability, it is important to understand the effect of the combination of assumptions on the actual likelihood of specific impacts. For example, in the case of bowhead whale and spectacled eider, both the location of the spill site (onshore versus offshore) and season of occurrence of each species suggests that most spill scenarios would affect one, but not both species. Spill circumstances which could affect both species could include a spill under ice during winter or early in the spring breakup period. This creates heavy oiling in confined leads and results in concentrated exposure of migrating bowhead and arriving spectacled eider in that area. These circumstances presume that the spill source is the subsea pipeline (which represents less than one-fifth of the total project spill probability), that the spill occurs during winter or early spring (about one half of the year), and that the spill migrates far offshore, as well as remaining concentrated near the coast (this would probably require a spill much larger than 1,000 barrels). Even if only the first two circumstances were used to characterize the actual impact risk, the likelihood of spill occurrence from the entire project (about 12%) would be reduced by multiplying by the likelihood of these circumstances (one-fifth times one-half, or one-tenth reduction). This would result in an estimated probability of the spill impacting the resource of approximately 1.2% (one-tenth times 12%). Although available information is not sufficient to allow detailed calculation of all potential scenario-specific probabilities, this effect of assuming multiple unlikely events (e.g., a spill occurring at the same time a migratory species encounters the oil slick moving) should be understood when the projected impacts are interpreted.

Impacts to the physical, biological, and human resources are also evaluated for spill response actions. These activities represent additional sources of impacts that would occur, separate from the impacts of the oil spill. Oil spill response impacts would occur only if a response were initiated and weather conditions allowed a response.

These impacts are summarized in Tables 8-9, 8-10, and 8-11. Differences in impacts for the action alternatives are specified below for the affected disciplines (e.g., geology/hydrology and land/water use). Alternative 1 - No Action Alternative would have no impacts because oil would not be produced and would have no potential to be spilled.

8.7.1 Impacts to the Physical Environment

8.7.1.1 Geology and Hydrology

An oil spill onshore would contaminate soils, sediments and surface water bodies contacted by the oil. Contact in the summer is more direct than in the winter because

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the presence of snow and ice cover provides a buffer between the oil and soils or streams/lakes. Oil spilled into streams or rivers would be transported downstream, impacting sediments for up to several miles. Direct short- and long-term impacts of an oil spill on soils, sediments, and water would be significant because hydrocarbon contamination would be detectable at high concentrations (free product) immediately following the spill and would gradually decrease over the next 5 to 10 years following the spill.

Direct short- and long-term impacts of an oil spill to marine sediments would depend on the size, location and time of the spill. Impacts could occur in the lagoons and shorelines inside the barrier islands and exposed coast shorelines to the east and west of the barrier islands (Figure 8-1). An offshore spill could contact and contaminate bottom sediment, barrier island beach sediment, and possibly, mainland shoreline sediment. In general, marine oil spills occurring during the period of solid ice cover, November through April, would have the least impact on sediment quality. In the event of a large spill during open water conditions, currents and waves could spread the oil and worsen the extent of the spill. In this case, impacts to shoreline, lagoon, and marine sediments would be significant in that contamination would be measurable for miles and would require control measures to reduce effects.

Oil spill response would have impacts to permafrost; however, this would only occur in the onshore environmental setting. Impacts to permafrost soils would depend on the degree of vegetation damage or removal. Where vegetation is removed, permafrost soils are more susceptible to thawing (i.e., change in the active layer thickness) and erosion (Brown and Grave, 1979:9). Alteration of this surface layer would lead to long-term changes in permafrost depth and hydrology in the immediate cleanup area. Minor impacts to permafrost from oil spill response would be anticipated due to the small area (few hundred square yards) likely to be affected.

Some differences among the action alternatives exist for oil spill or oil spill response impacts. The proximity of the pipeline to thaw lakes increases the chance of oil contamination of large freshwater bodies for Alternatives 3, 4, and 5. Onshore pipeline lengths without road access for Alternatives 2, 3, 4, and 5 also vary: 9.55 miles (15.36 km), 6.7 miles (10.78 km), 3.45 miles (5.55 km), and 3.09 miles (4.97 km), respectively. If ice roads, rolligons, air cushion vehicles, helicopters, and other vehicles, approved for use by the State of Alaska Department of Natural Resources, Division of Land, are used to access a spill location, response activities would cause minimal damage or no damage to tundra vegetation (and thus, permafrost).

8.7.1.2 Air Quality

Impacts to air quality from an oil spill are predicted to be the same whether the spill occurs onshore in the lagoons, or in marine waters and sea ice (Figure 8-1). Air emissions from an oil spill would result in the vaporization of volatile organic compounds (VOCs) as discussed in Section 8.4. Approximately 25% to 35% of the spilled oil is expected to evaporate into the atmosphere directly above the surface of the oil slick. Wind is expected to disperse emissions before any of the vapors could directly affect populated areas, such as Nuiqsut or Prudhoe Bay. The concentration of VOCs above the oil slick would be measurable and constitute a minor, short-term impact to air quality.

Oil spill response activities are expected to produce local emissions in the form of criteria pollutants (carbon monoxide, nitrogen oxides, particulate matter, sulfur dioxide, and VOCs) from the operation of vehicles and other cleanup machinery. Impacts would be similar to the nonstationary source emissions associated with project construction as discussed in Section 5.4. Impacts are predicted to be short-term, lasting only during cleanup, and minor due to the slight increase in criteria pollutants as a result of machinery exhaust.

In situ burning is a response technique (Section 8.6.1) considered to produce the greatest amount of air emissions of all potential response activities. Studies indicate that airborne emissions from in situ burning of a spill less than approximately 100,000 barrels are not a serious concern, especially at distances greater than a few miles from the burn (USDOI, MMS, 1996:IV-B-82). Effective response through burning requires that the oil be contained and ignited quickly before emulsification reduces the ability to burn effectively (ACS, 1991:3-9). In situ burning is expected to produce measurable amounts of carbon monoxide, carbon dioxide, sulfur dioxide, and particulate matter, however the amount and concentration depend on the following variables:

- Wind direction and speed.
- Quality and viscosity of the oil comprising the slick.
- Chemical make-up of the oil.
- Volume or size of the oil slick.
- Rate of burn.
- Local atmospheric conditions.

In situ burning in open water offers the potential of achieving almost complete oil removal from open water under a range of conditions (i.e., fresh to lightly emulsified oil, calm winds, and low seas). A 1991 study by Fingas and Larouche concluded that "work to date has not shown that oil spill burning results in serious air pollution." Due to the remote location of the project area and the lack of local population centers, in-situ burning is not expected to cause direct human health effects (ACS, 1991:5). The three primary emissions of concern include respirable particulates in the smoke plume, VOCs, and polycyclic aromatic hydrocarbons. In situ burning would be implemented only on offshore spills and would pose no threat to coastal environments, local wildlife populations, population centers, or other sensitive natural or manmade features.

Overall, impacts to air quality are expected to be minor. Certain vapor and fume emissions, including smoke from in-situ burning, would be detectable at the spill. However, the effects are anticipated to be short-term, lasting only through the duration of the cleanup activities. No long-term impacts are anticipated.

8.7.1.3 Oceanography and Marine Water Quality

Short-term impacts of an oil spill to marine water quality during open water season would be in the form of a sheen or oil slick on the surface of the water, with limited dissolution and dispersion of hydrocarbons into the water column. The amount of oil initially entering the water column would be influenced by the nature of the release, i.e., subsea versus surface spill. The majority of toxic components in the crude oil would evaporate; however, enough oil may enter the water column to raise the hydrocarbon concentration in the immediate vicinity of the slick to levels exceeding State of Alaska water quality standards for marine waters. The State of Alaska criteria of 0.015 ppm (15 micrograms per liter) and 0.010 ppm (10 micrograms per liter) aromatic hydrocarbons represent a level above which hydrocarbon concentrations could be harmful to marine life. This concentration will decrease by further dilution, deposition on the seabed, and biodegradation. Weathering would eventually turn the slick into a thicker mousse, which would continue to degrade until tar balls form and settle to the seafloor. Effects of oil on the water column would potentially continue even after the surface sheen, slick, and/or mousse has disappeared because hydrocarbons (aromatic hydrocarbons in particular) may continue to leach into the marine waters from tar balls on the seafloor or from oiled sediments. Spills during ice season will have comparable impacts to the water column with differences mainly in time scales and concentrations. In particular, oil trapped under the ice will weather much slower, and oil trapped in and above the ice may enter the water column long after the initial spill. For oil trapped under the ice, a higher percentage of toxic hydrocarbons may enter the water column because the overlying ice hinders evaporation of these compounds.

Various cleanup methods can impact the water column. The use of mechanical recovery methods reduces dispersion and is not expected to increase dissolution; hence, these techniques should decrease the impacts of oil on the water column. Oil burning likewise reduces the dissolution of volatile aromatics into the water column by their combustion.

Overall impacts to the water column from an oil spill are expected to be minor. This is because little of the dangerous, highly toxic aromatic components of the oil are expected to enter and persist in the water column following a spill. The possible impact of these lighter toxic aromatics leaching from seafloor tars balls is also minor.

8.7.1.4 Sea Ice

Impacts on sea ice from an oil spill are influenced by the origin of the release, i.e., subsea or ice surface. Oil on the surface of the ice is absorbed by snow, pools on the ice surface, flows into cracks in the ice, drains into open water, and/or drains into ice leads (Figure 8-3). Some evaporation of the oil's lighter components is expected, although arctic temperatures will slow this process. Oil spilled under ice has numerous possible collection points and routes through the ice, including: oil pools and sessile drops of oil trapped under the ice, oil trapped in ice leads, oil encapsulated in ice, and oil migrating up through brine channels in the ice. Oil trapped under the ice in pools and droplets will remain with the ice unless ice flow and current speeds vary greatly. Trapped oil remains relatively unweathered and enters the water column as small sinking particles by dissolution and by biological uptake. Oil found in leads may remain in the lead or be pumped up onto the ice surface or under the ice sheet. In addition to these processes, oil can enter the water column by dispersion. Oil encapsulated or migrating through brine channels in the ice will most likely reenter the water column upon breakup and melting. The minor impacts of this oil entering the water column are summarized above (Section 8.7.1.3).

The areal extent of an oil spill would depend on the ice state, i.e., solid or broken. During freezeup, oil would likely be entrained in solidifying grease ice, or spread by storms in temporary open water conditions (BPXA, 1997b:49-51). The area of oiled sea ice under broken ice conditions would vary with the amount of ice cover and time of year. Ice coverages greater than 50% would reduce oil spreading because the oil would be trapped in the ice.

The principal impact to sea ice by an oil spill would be a reduction in the ice's mechanical integrity. Weakening of the ice would be initially caused by melting due to contact with warm oil, followed by oil incursion into the ice itself, either by encapsulation or migration through channels and cracks. Because both the expected areal extent of weakened ice (53.1 acres [21.5 hectares], based on an oil thickness of 3.9 inches [10 cm], a 25 to 35% volume loss due to evaporation, the absorbency of snow, and the higher oil viscosity caused by cold temperatures), and the duration of the effects (one season) is short, the impact of a 225,000-barrel blowout to sea ice is minor. However, such a reduction in ice strength could hinder cleanup activities. Potential impacts to ice during cleanup activities include removal, scraping, and/or drilling. These operations may be performed as part of oil recovery. Only a small fraction of the ice is expected to be affected by such operations.

8.7.2 Impacts to the Biological Environment

8.7.2.1 Plankton and Marine Invertebrates

Population level impacts to plankton and marine invertebrates from an oil spill are not expected in the lagoon and shoreline areas because recolonization occurs annually where bottomfast ice is present (Table 8-1). Studies performed in Prince William Sound one year after the *Exxon Valdez* oil spill have shown that levels of polyaromatic hydrocarbons in fine silt/mud benthic sediments (similar to Alaskan Beaufort Sea sediments), were once again at prespill background levels (O'Clair et al, 1996:61; Short et al., 1996:42). However, as noted in Sections 8.4.1 and 8.6.1, microbial degradation of oil would likely be slower in the colder waters of the Alaskan Beaufort Sea. Toxic components of the spilled oil, such as polycyclic aromatic hydrocarbons, which are more difficult for microbes to degrade (Atlas and Bartha, 1992:288), would potentially remain bound onto sediment particles for several years. No impacts to plankton or marine invertebrates are expected from an oil spill response.

An oil spill may alter species composition in plankton because some species are more sensitive to the effects of oil than others (Wells, 1982:67). Mortality of species contacted by oil would be expected, with the greatest effect occurring in August during the annual population bloom. If oil did not dissipate within a short period of time following the spill, mortality of large numbers of plankton would result. However, due to the patchy distribution of plankton, a 7,000-barrel (volume used in referenced study) oil spill during summer is estimated to contact and cause lethal and sublethal effects to less than 1% of the plankton and marine invertebrate populations in a 29 square mile (75 square km [km^2]) area (USDOI, MMS, Alaska, 1998:IV-B-9). For this reason, oil spill impacts to plankton and marine invertebrate populations would be minor. However, it is possible that rapid regeneration would not occur, as some plankton, including certain copepod species, may produce only one generation in a year and breed for only short periods of time (Cooney, 1987:288). In this type of situation, species population would recover within one season through immigration.

The transient epontic community, present on the underside of ice, would be impacted by an oil spill during solid or broken ice conditions. Mortality of the epontic community would be expected in the area contacted by oil. The areal extent of the spill (Figures 8-4a, b and 8-5a, b) would be dependent on the fate and behavior of the oil (Section 8.4.3). With calculations simplified to assume smooth ice and no currents or ice motion, estimates (based on experimental data) are that sea ice will hold 50,000 barrels of oil under each 0.39 square miles (1 km^2) (Thomas, 1986:414). The estimated maximum spill volume of 7,700 barrels of oil for a chronic pipeline leak under solid ice would spread to an area of 38 acres (15.4 hectares). This area would be estimated at only 5.1 to 30.5 acres (2.0 to 12.3 hectares) if the increased oil holding capacity of rough-bottomed ice (63,000 to 377,000 barrels of oil per 0.39 square miles [1 km^2] [Thomas, 1986: 447]) is considered. Impacts to epontic communities from an oil spill are considered minor since the affected area would be relatively small and this community is extensive in the surrounding ice.

The natural variations that occur in benthic populations make it difficult to predict the effects of an oil spill on these communities. Following the *Exxon Valdez* oil spill, the infaunal and epibenthic community in a heavily-oiled fjord, Herring Bay, in western Prince William Sound, was examined. Observations in Herring Bay in the fall of 1989 showed numerous dead and dying organisms (Jewett et al., 1996:440). The infauna in Herring Bay was represented by a rich assemblage of 24 taxa, but by fall 1990 it was reduced to only six taxa and was dominated by a single polychaete species. The decline of the benthic community between 1989 and 1990 was coincident with high concentrations of hydrocarbons in the sediments. When measured in 1991, hydrocarbon concentrations were reduced, very few dead organisms were observed, and the benthic community had recovered to include 32 taxa. This data suggests that the adverse impacts of oiling in 1989 and 1990, were followed by recovery. However, observations during the fall of 1993 showed an impoverished community of four taxa existing concurrently with low hydrocarbon concentrations in the sediments and depleted dissolved oxygen in the bottom waters. Data from this study suggest that while the *Exxon Valdez* oil spill was likely responsible for dead organisms and an impoverished infaunal community in 1989 and 1990, reductions of benthic infauna can also occur as a result of a lack of oxygen (Jewett et al., 1996:440).

8.7.2.2 Marine and Freshwater Fish

Fish could be affected by an oil spill in any of the four environmental settings (Figure 8-1) during any time of the year. Potential effects of oil on fish would include direct mortality from oil toxicity, chronic physiological or behavioral changes, destruction of food organisms, and habitat destruction. Impacts would depend on the species and age composition of fish present in the area of the spill. No impacts to fish would be anticipated from oil spill response activities.

In the marine waters and sea ice setting, oil spills during open water would have the greatest potential to impact fish. During solid or broken ice conditions, bottom dwelling fish would not normally be associated with the under-ice surface, and fish inhabiting the water column would likely avoid the oil that would collect under the ice. Studies of migrating salmon have shown that adult pink salmon are likely to avoid oil and search for an uncontaminated route (Martin et al., 1990:371). In the open water, the oil could spread over a wide area in a relatively short period of time, rapidly diluting oil concentrations to non-lethal levels of less than 1.3 ppm (Hepler et al., 1996:645). Lethal effects to individual fish could result from absorption through the skin or gills or respiratory distress from gill fouling. Based on laboratory studies, sublethal genetic damage to larval stages of fish has been shown to be an oil spill concern. However, information obtained for pink salmon and herring following the *Exxon Valdez* oil spill failed to conclusively distinguish between oil spill exposure and natural environmental variation as causes for any observed genetic abnormalities (Brown et al., 1996:448; Bue et al., 1996:626; Collier et al., 1996:679; Brannon et al., 1995:549; Maki et al., 1995:621).

Floating fish eggs or planktonic larvae of marine fish are more likely to suffer lethal effects from an oil spill because they are more sensitive to toxic effects and are less able to avoid the spill (Rice et. al., 1989:476). It is unlikely that an oil spill would affect fish populations of the Alaskan Beaufort Sea. Studies performed in Prince William Sound after the *Exxon Valdez* spill failed to show a statistically measurable reduction in fish survival rates or diversity (Hepler et al., 1996:645; Laur and Haldorson, 1996:659). However, in the case of a widespread oil spill, juveniles and adult fish would be exposed to oil by swimming through the contaminated water. It has been speculated that, in such a situation, high mortality of fish species could result, but due to the annual production the overall effect to the population is likely to remain minor.

Oil spills occurring in the summer in the rivers (onshore), lagoons, or nearshore waters would have the potential to affect a large number of fish. Young fish and all ages of broad whitefish would have the greatest exposure during mid-summer in the rivers, while other ages and species could be protected if oil booms keep the oil out of coastal waters. Oil in coastal lagoons between the Colville River Delta and Foggy Island Bay during mid-summer could affect virtually all ages and species of anadromous fishes (Table 8-1), although water temperatures and salinity would determine which are actually present at the time of the spill. The abundance of fish in the lagoon and shoreline areas during open water, the presence of anadromous fish, the confined habitat area, and the shallow, turbulent waters would increase fish vulnerability to an oil spill. Currents within the shallow water of the lagoon system would also tend to disperse oil throughout the water column. Direct mortality of fish beyond larval stages is usually much less important than broader ecosystem effects. Overall, impacts to anadromous fish would be considered minor.

Arctic cisco would likely be the most vulnerable fish to an oil spill because of their single stock origin and because several ages of Arctic cisco are present in Simpson Lagoon/Gwydyr Bay at some time during the summer. Contamination of a majority of Simpson Lagoon/Gwydyr Bay could affect spawning adults on their early summer eastward movement toward the MacKenzie River. Mid-summer spills would affect movements and feeding of sub-adults and juveniles from the Colville River, while a late summer spill may affect westward movement of young-of-the-year arriving from the MacKenzie River in August and September. Mortality or failure of migration of pre-spawning adults or young-of-the-year may reduce or eliminate a year-class of Arctic cisco.

Least cisco from the Colville River disperse both east and west along the coast, with some fish passing through Simpson Lagoon/Gwydyr Bay and traveling as far east as the Sagavanirktok River Delta. In the fall (late August to early September), the fish return to overwintering areas in the Colville River, again passing through Simpson Lagoon/Gwydyr Bay. While this pattern occurs in all years for larger least cisco, the movements of smaller least cisco are determined in part by wind and current. Smaller least cisco reach the east end of Gwydyr Bay only in about 1 out of every 2 years. Given the mixed year classes of least cisco in coastal lagoons, an oil spill along the coast would be unlikely to contact only a specific year class of least cisco. The impact of an oil spill to least cisco would be expected to be minor.

Broad whitefish are mostly confined to river delta areas and would be relatively unaffected unless spilled oil were to reach the Colville or Sagavanirktok River Deltas. Char are unrestricted in their movement through salt and freshwater and could avoid an oil spill. They also spend less time than other anadromous fishes in nearshore areas where oil might become confined. Juvenile Arctic cod are often present in nearshore waters in large schools containing millions of fish. Consequently, an oil spill encountering a school of cod could cause mortality of a large number of fish. Arctic cod are an important food source for ringed seals, which in turn are the primary prey for polar bears. A large die-off of cod in the local area of an oil spill could displace seals and potentially displace polar bears. However, because cod are widespread and numerous within the Alaskan Beaufort Sea, impacts would be considered minor.

There is very little over-wintering habitat in the Sagavanirktok River Delta, but the lower Colville River and Delta areas provide over-wintering habitat for Arctic and least cisco, broad whitefish, and rainbow smelt. If an oil spill occurred late in the fall and the slick reached the eastern end of Simpson Lagoon immediately prior to freezeup, oil could enter the Colville River Delta area and remain through the winter. If such an event were to occur, fish attempting to migrate into the river deltas or those overwintering in the river could be impacted by oil, resulting in some mortality. This would be considered a minor impact because the loss of a relatively small number of fish would not affect overall population numbers in the Alaskan Beaufort Sea.

8.7.2.3 Marine Mammals

An oil spill would be expected to affect marine mammals mainly in the marine water and sea ice setting. Although individual ringed seals and polar bears may be observed near shore, the main populations are located farther away from the mainland (Table 8-1). The lagoon and shoreline environments are not frequented by seals or polar bears during most of the winter due to bottomfast ice. These areas support only small numbers of ringed seals during summer months. Marine mammals could be affected by an oil spill any time of the year, but certain species would be more sensitive at particular times depending on their activities.

Polar Bears: Onshore, nearshore, and offshore habitats provide maternal den sites during winter for female polar bears. Oil spill contamination of bears, habitats, and/or their primary prey (ringed seals) are direct adverse impacts which could affect annual productivity. Although the overall polar bear density for the Southern Beaufort Sea population is one bear per 39 to 77 square miles (101 to 199 km^2), during certain times of the year bears congregate on barrier islands due to ice conditions and/or availability of food. Few individual bears remain onshore or in lagoon areas during the summer, the majority of the population generally follows the retreat of the pack ice from shore.

Direct effects of oil on polar bears would be limited to direct contact with oil and loss of fur insulative value, ingestion of oil through grooming of oiled fur, inhalation of vapors, and/or consumption of oiled carcasses. Toxic contamination of food resources also would affect a number of bears, because polar bears rely heavily on ringed seals as a primary food source. This exposure to oil could result in mortality of the affected bears (Lentfer, 1990:15). Polar bears would also be indirectly affected by a local reduction in the number of seals available for food.

The Southern Beaufort Sea (Canada and Alaska) polar bear population is likely to recover slowly after a large oil spill due to the slow reproductive potential of polar bears, the loss of ringed seals in the affected area, and the potentially persistent effects of oil in the marine ecosystem. Mortality of up to 30 bears (Section 6.1.5.5) could have substantial population effects, especially if many of the bears affected were adult females. Polar bears use coastal areas to search for mates, as feeding sites, or for denning areas in the fall. The Southern Beaufort Sea polar bear population is approximately 1,800 animals (Amstrup, 1995:199). Based on long-term population data from 1982 through 1992, the growth rate of this population was estimated at 2.4% annually. However, the U.S. Fish and Wildlife Service predicts this growth rate will slow or stabilize because the Southern Beaufort Sea polar bear population has likely reached (or will soon reach) the environmental carrying capacity (ability of habitat to support a number of individuals of a certain species). The mean subsistence harvest from the Southern Beaufort Sea population is 36 bears; the overall (Canada and Alaska) subsistence harvest could approach the maximum sustainable harvest rate of 80 bears for Canada and Alaska, but is presently at a mean harvest of 62 bears. Additional mortality from an oil spill, multiple oil spills, removal of chronic problem bears, or abandonment of dens could cause removal rates beyond those which are believed to be sustainable for this population. Therefore, additive mortality from causes other than subsistence could have a negative population effect (Section 6.5.2.2).

The rate or magnitude of a polar bear population decline as a result of a large spill from the project could be exacerbated by the occurrence of additional spills, ongoing subsistence harvest, and future industrial developments and/or disturbances. A large oil spill could have substantial population effects for polar bears and affect annual productivity and/or reduce the subsistence use of this resource.

Seals: The likelihood that seals would be contacted by an oil spill is dependent upon the species and ice conditions prevailing during the year. During light ice years, densities of ringed and bearded seals likely would be low in the vicinity of the project area. During heavy ice years the probability of a larger number of these species contacting oil would be higher because they would be more likely to be in the nearshore area. Spotted seals would only be affected by an oil slick which reached the Colville River Delta, which is not anticipated even during open water or broken ice conditions (Table 8-3 and Figure 8-4b).

Ringed seals would be most vulnerable to a large oil spill while molting or denning. During these stages, seals are already physiologically stressed and less mobile than in other stages of their lives. During the summer molt, late May to July, they spend long periods hauled out on the ice. When molting, seals have minimal insulative blubber reserves and are generally more vulnerable to disturbance and attendant metabolic demands. They would likely be more vulnerable to toxicity through contact with oil, ingestion of oil, or inhalation of vapors due to their somewhat stressed physiological condition (Geraci and Smith, 1977:402). In the winter, they are confined to breathing hole territories in the shorefast ice and would have little opportunity to move to other areas. Ringed seals in close proximity to the spill would be impacted by toxic vapors concentrated in the funnel-shaped breathing holes, in den access holes, and in dens themselves. Low temperatures and isolation from the air would allow oil under the ice to retain its volatile and toxic fractions much longer than in warmer, open water situations. Oil trapped under the ice during the pupping season (March or early April) may cause adults to abandon pups or pups could become oiled, resulting in loss of insulation and subsequent hypothermia (Geraci and Smith, 1977:407).

Ringed and bearded seals could also be impacted directly through ingestion of oiled prey and indirectly through a decline in local prey abundance. Depletion or dislocation of prey species would be expected to result in a corresponding decline or dislocation of seals, and toxic contamination of prey could affect the health and abundance of the local seal population. Bearded seals would be more prone to consumption of prey contaminated by the oil spill due to their reliance on benthic and epibenthic prey, which are generally limited in terms of mobility. Overall, impacts of an oil spill on seals would be minor because the effects on individuals would not extend to population level impacts throughout the Alaskan Beaufort Sea where hundreds of thousands of seals reside.

Beluga Whales: Beluga whales could be contacted by an oil spill in ice leads during spring migration to the Canadian Beaufort Sea or during fall migration back to the Bering Sea. However, there is a low likelihood that these animals would be contacted since they would only be in the area a few weeks out of the year. Exposure to oil would be brief and would not be expected to result in the deaths of healthy whales or have long-lasting sublethal effects (USDOI, MMS, Alaska, 1997:IV-B-48). Impacts of an oil spill occurring during spring or fall migration on stressed beluga whales resulting in mortality would be minor.

It should be clear from information presented in this section (and earlier in Chapter 6) that data on the effects of oil on several Beaufort Sea marine mammal species is limited or does not exist. There are two schools of thought regarding how to deal with this lack of species-specific data in this EIS: one is to limit the scope of the EIS to only data available for marine mammal species located in the project area; the other is to draw upon data from other marine mammals or from other areas as a way to extrapolate these data to this EIS. The latter approach has been chosen for this EIS. For example, while sea otters are not found in the project area. Lipscomb et al. (1994) documents the severe impact oil has on these mammals and it is reasonable to assume that similar impacts could occur to marine mammals in the Beaufort Sea.

Oil Response Activities: Oil cleanup actions in marine waters could potentially affect marine mammals.

Noise and activity from large numbers of personnel, boats, and aircraft could displace beluga whales from their migration route or cause a small number of seal pups to be abandoned. However, disturbance would only affect animals in the local area of the spill, which would have little effect on the population due to the wide distribution of marine mammals in the Beaufort Sea. Minor, short-term (few months) impacts to marine mammals from oil spill response would be anticipated. No long-term impacts would be expected. In addition, periodic disturbance from icebreaking barge activities required to maintain a corridor between West Dock and Seal Island during broken/thin ice conditions will have only a minor impact on marine mammals.

8.7.2.4 Coastal Vegetation and Invertebrates

An oil spill contacting lagoons and shorelines would affect coastal vegetation and invertebrates. Onshore oil spills could affect coastal saline tundra, constituting the greatest threat to wetlands and terrestrial vegetation from the project. Adverse effects of oil are more likely from a spill during the summer. In the winter, bottomfast ice covers the lagoon and shoreline areas and snow provides a buffer between oil and tundra onshore.

An onshore oil spill during summer would physically cover and kill tundra vegetation in the immediate area. Oil contacting areas of standing water would affect emergent vegetation, but the oil would only be expected to kill the portion of the plant contacted. Entire plants would die if sufficient leaf area or buds were contacted, but overall sensitivity is typically less than for terrestrial plants (Walker et al., 1978: 258). Recovery of the tundra from an oil spill would depend on the volume of oil spilled, time of year, length of exposure, vegetation community type, and restoration methods used. An August 1989 oil spill at Kuparuk Oilfield of 300 to 600 barrels contaminated approximately 1.5 acres (0.6 hectares) of a mixture of wet, moist, and tussock tundra. Nutrients were applied to promote indigenous microbial metabolism of hydrocarbons, and lime was applied to prevent acidic soil from inhibiting plant growth (Jorgenson and Cater, 1992:i). Monitoring of bioremediation restoration efforts showed that mean vascular plant cover within the affected area increased from 11% to 32% over the three summers following the spill (Jorgenson and Cater, 1992:34). Plots that failed to meet the 15% cover goal had been scraped by earth moving equipment. Impacts of an oil spill on tundra during summer would be considered minor due to the small area (few hundred square yards to up to 22 acres [8.9 hectares]) affected. It is expected that damaged areas would be used by wildlife similarly to undisturbed habitat within a year of the spill (Jorgenson et al., 1993:15). Studies performed near Fairbanks showed that revegetation may lead to recovery of disturbed areas within 5 years (Chapin and Chapin, 1980:458). However, species on the North Slope may respond differently and take longer to recover than those in the Fairbanks area.

An oil spill in marine offshore waters could affect grasses and forbs on the barrier islands along the coast. The barrier islands are subject to storm surges and periodic inundations of water that could deposit oil on the upper portions of the barrier islands. The barrier islands are a high value habitat that support invertebrates such as clams, snails, and worms, which are in turn fed on by common eiders and snow geese. An oil spill in marine offshore waters that resulted in oiling of the barrier islands would have a minor impact on the food web that they support.

Oil spills which reach freshwater aquatic habitats can impact these areas by killing the invertebrate fauna and plankton in the water, contaminating sediments, and by killing or injuring emergent vegetation. Effects of oil on invertebrate populations can be long-term, depending on the degree of contamination of the sediments, since many life stages come in contact with bottom sediments (Bergman, et al., 1977:36). Other studies on the effects of oil on the arctic ponds and lakes in the Prudhoe Bay area have shown adverse effects of petroleum on aquatic invertebrates and zooplankton (Hobbie and Pendleton, 1984:41-42). These studies indicate that contact with oil is likely to have lethal effects on coastal invertebrates. Therefore, impacts to invertebrates contacted by an oil spill would be significant.

Oil spill response actions could include cleanup of these areas using hand or mechanical methods. These activities could result in further damage to coastal marshes. Complete recovery of the vegetation would require 5 years or more, even with restoration treatments such as seeding native grasses and transplanting indigenous plants to aid in recolonization of the damaged areas (Chapin and Chapin, 1980:453). However, wildlife use of damaged areas may occur before recovery is complete (Jorgenson et al., 1993:15). Impacts to coastal vegetation from shoreline cleanup would be considered significant, although response methods would be chosen for minimal impacts to coastal vegetation (i.e., pressurized steam cleaning would not be used). The fact that response and restoration activities would require avoidance of further vegetation damage means that the impact is significant.

8.7.2.5 Birds

Migratory birds could be affected from May through September by an oil spill in any of the four environmental settings, although low densities of birds are likely to inhabit marine waters 5 to 80 miles (8 to 128 km) from the coast and barrier islands (Divoky, 1984:431). Effects of an oil spill on non-migratory birds would be similar to those described below for migratory birds. The increased likelihood of non-migratory birds contacting oil due to their presence in the area year-round is offset by the lower mobility of oil and smaller area likely to be affected in winter.

An oil spill to marine waters during the open water period would directly affect birds foraging in the offshore waters or molting sea ducks in the lagoons. Bird use of offshore marine waters during the open water season is relatively low (approximately 11.5 birds/square mile [30 birds/km^2]) (Divoky, 1984:431); however, the number of birds affected by an oil spill would depend upon how far the oil slick moved (Figure 8-4b). Mortality would likely be on the order of hundreds or thousands. Glaucous gulls, common ravens, sea ducks, and phalaropes expected to be attracted to the island would encounter oil from a spill from Seal Island before it reaches the lagoons. Glaucous gulls, loons, sea ducks, and phalaropes also would be the species most likely to contact oil if a spill occurred during summer, when they are foraging and molting in the lagoons. The highest densities of birds (primarily oldsquaw and other sea ducks) are found in the nearshore lagoons in July and August and there would be a potential for mortality of thousands of birds.

During the spring and fall, hundreds of thousands of oldsquaw and king eiders, tens of thousands of common eiders and black brant, and thousands of spectacled eiders migrate near the Beaufort Sea coastline, along nearshore barrier islands and lagoons, and in offshore waters (L. Bright - Pers. Comm., 1998:10). Offshore open water in the Beaufort Sea determines, in part, the routing and timing of spring migration of king eiders and likely other sea ducks. Spring migrating waterbirds can be expected to land on any available water in nearshore areas (Bergman et al., 1977:6; Schamel, 1978:57; Richardson and Johnson, 1981:116-117). Thus, any open water areas or leads in nearshore areas contaminated with spilled oil would likely contaminate migrating waterfowl, loons, and shorebirds. Mortality could be in the thousands to tens of thousands, depending on the timing, size, location, and persistence of the spill. Impacts to birds, especially those with already declining numbers (eiders, oldsquaw), would be considered a significant impact.

An onshore oil spill during summer would contact only a small area of tundra, due to the high dead storage capacity of tundra vegetation that would retain 300 to 1,500 barrels of oil per acre (USDOI, MMS, 1998:IV-A-40). With the exception of misting from a pressured discharge, which would spread oil further, the areal extent of tundra affected by an onshore pipeline rupture would be less than 22 acres (8.9 hectares). Birds nesting or feeding within this area are likely to become oiled. Based on an average of 166.3 nests/square mile (64.2 nests/km^2) (TERA, 1993:9) in the Prudhoe Bay area, approximately 6 nests could be affected by a spill on 22 acres (8.9 hectares) of tundra. If oil were spilled in, or spread to, adjacent wetlands and aquatic environments (i.e., braided streams, deep open water lakes, and wetland complexes), waterbirds using these areas would be adversely affected. Oil in these environments would be expected to spread quickly to other wetlands associated with these waterbodies and damage the vegetation it contacts (Walker et al., 1978:258). Oil in these wet tundra and aquatic habitats would affect more area, but would be easier to recover than oil spilled on dry or moist tundra habitat, because it would not saturate into the tundra to the same degree. In wetland and aquatic environments, the specific gravity of oil limits migration of oil into the soil. Thus, floating oil is accessible for recovery by various mechanical methods. In dry tundra environments, no barrier is present to prevent migration of oil into the soil. Recovery of the oil becomes nearly impossible without complete removal of the soil by scraping the area.

Waterfowl, particularly oldsquaw, black brant, and white-fronted goose, which congregate on large lakes to molt, would be particularly vulnerable to oil contaminated surface water (Johnson and Herter, 1989:27-28, 45-47, 100-101; Bergman et al., 1977:25- 28). Impacts could range from a few to hundreds of birds oiled. Impacts would be minor unless threatened or endangered species were involved.

Noise and traffic from oil spill response activities along the onshore segment of the pipeline have the potential to affect birds by disruption of nesting and foraging activities, but the impact would depend on the timing, nature, and duration of the oil spill response activities. Hazing birds from areas contacted by an oil spill, while intended to minimize the impacts of oil to waterfowl and shorebirds, could add stress to birds. This may result in mortality of a small number of individuals. Overall, impacts to birds from oil spill response would be minor.

8.7.2.6 Terrestrial Mammals

Impacts of an oil spill on terrestrial mammals would be expected for all four environmental settings, although Arctic fox would be the only terrestrial mammal likely to be found on the sea ice (Table 8-1).

Arctic fox could, therefore, be affected by an oil spill any time during the year. Grizzly bears and caribou would only be affected during the summer. During the winter, grizzly bears would be either denning (inactive) or absent from the area, and few caribou overwinter in the area.

Arctic foxes and grizzly bears would be affected by an oil spill if oil contact resulted in a loss of fur insulative value, or if they were to ingest oil during grooming or consumption of oiled carcasses. These scavengers would be present in the project area in the summer, which would coincide with the presence of migratory birds likely to suffer some mortality from an oil spill. This would increase the likelihood of Arctic fox and grizzly bears consuming oiled carcasses. Any oiled carcasses washing onshore would be accessible to scavengers. Oiled carcasses on barrier islands are not likely to be available to grizzly bears during the open water season. Although lethal effects from oil ingestion would be probable for individual foxes and bears, the impacts of an oil spill on Arctic foxes and grizzly bears would not likely affect the population of the Arctic Coastal Plain and, therefore, population impacts would be minor.

Onshore, caribou could be affected by contact with oiled tundra. Caribou generally frequent unvegetated coastal areas to avoid mosquito and oestridfly harassment (Roby, 1978:66). Approximately 25% less time is spent feeding during periods of insect harassment (Cronin et al., 1994:A-10), when caribou behavior includes rigid, head-down standing (Lawhead et al., 1992:2) or aberrant running (Curatolo et al., 1982:41). If an onshore oil spill contaminated tundra, caribou would not be expected to ingest oiled vegetation, as they are selective grazers and are particular about the plants they feed on. Caribou may be exposed to oil if a spill contacted coastal ice used as salt licks (F. Rexford in USACE, 1996:30). Caribou could also become oiled through contact, which would affect them by inhalation of toxic vapors and absorption through the skin. These effects could result in mortality; however, only small numbers would be expected to be affected by any spill. Therefore, impacts of an oil spill on caribou are considered to be minor.

Effects of oil spill response on terrestrial mammals include stress caused by hazing activities and displacement of animals from habitat in the immediate vicinity of oiled areas. These effects are expected to be short-term and would not cause mortality of individuals. Any effects would be to individuals and would not impact Arctic fox, grizzly bear, or caribou populations. Negligible impacts to terrestrial mammals from oil spill response would be anticipated.

8.7.2.7 Threatened and Endangered Species

Bowhead Whale: If oil moves into leads or ice-free areas frequented by migrating bowheads, a large proportion of the population could be affected. Albert (1981:950) concluded that if oil was in ice leads during the spring migration, the oil would pose a great threat by putting nearly the entire population at risk, because most of the bowhead population migrates through the same lead system during a relatively short period. Injury and/or direct mortality of bowhead whales from an oil spill during spring migration could be a significant impact. Based on acoustic and visual data, it was estimated that 665 bowheads passed Point Barrow in only 4 days (George et al., 1989:26), and 90% of bowheads passed through an area only 2.5 miles (4 km) wide (George et al., 1995:371). However, there is less than 1% probability that an oil spill from the Northstar Project would travel over 200 miles (321.8 km) and reach the Chukchi lead system (Smith - Pers. Comm., 1997:3). See Biological Assessment, Appendix B, pages 6-9 to 6-14 for more detailed information on the impacts of oil on bowhead whales.

Surveys have documented that bowhead whales navigate through offshore leads distant from the project area during their eastward spring migration (Figure 6.9-1). Annual surveys conducted from 1979 to 1994 suggest that bowhead whales are present in the project area between approximately August 31 and October 22 (Miller et al., 1996:30) during their westward, fall migration. As observed for 4 years after an oil spill in 1944, bowhead migration routes could move further out to sea as a result of an oil spill (T. Brower Sr., in NSB, 1980:107). Considering the limited number of days each year that bowhead whales would be migrating through the area near Seal Island, the low probability that a spill would occur, and the very low probability that oil would move into the migration corridor of the bowheads, it is very unlikely that bowhead whales would be contacted by oil. Impacts to bowhead whales would only be possible if all of these low probability events occurred at the same time.

Oil cleanup actions in marine waters could potentially displace whales from their migration route. Noise and activity from large numbers of personnel, boats, and aircraft would disturb bowheads passing through the area. High frequency and high intensity noise generated by tugs, barges, and ice-breaking vessels can cause deflection of bowhead whales from normal migration routes (Chapter 9). Minor, short-term (few weeks) impacts to bowhead whales from oil spill response would be anticipated. No long-term impacts would be expected.

Spectacled Eider: Eiders would be present in the project area only in the summer and could be affected by oil spills onshore, in lagoons, along the shorelines, and offshore. Male spectacled eiders, however, could become contaminated if oil drifted into the nearshore lagoons during staging prior to their southward migration during late June or early July. An oil spill during August and September, when female eiders and young are present in nearshore waters, would kill birds contacted by oil and also impact coastal habitats. Spectacled eiders stage in the lagoon waters for 1 to 2 weeks prior to departing the area (USDOI, MMS, 1996:III-B-13). An oil spill in nearshore habitats, lagoons, or offshore could kill hundreds of birds. The population would not be expected to recover from this mortality because of declining numbers on the breeding grounds and relatively low reproductive rate (USDOI, MMS, 1996:IV-B-49). Therefore, an oil spill could cause significant impacts to spectacled eiders.

An oil spill during the summer when spectacled eiders may be in nearshore waters or on tundra ponds could affect this species. However, a large spill from a well blowout or pipeline failure is considered a low probability event due to project design, safety systems, and leak detection. The more probable events are small spills from vessels and barges, pipe or valve leaks on the island or tundra, or other accidents. Table 8-5 lists the number of spills that have occurred on the North Slope from 1980 to 1996 and shows that the likelihood of small spills is much higher than large spills. The chances of individual birds contacting a small spill would be low because small spills could be contained and cleaned up much faster than large spills. Mortality would likely be limited due to the low likelihood that oil would contact nesting and brood-rearing eiders. Some spectacled eider nests could be affected by oil; however, nests occur at very low densities of 0.49 nests per square mile (0.19 nests/10 km^2) (TERA, 1995:5), and few nests would likely be affected. Impacts to spectacled eiders from small spills would be minor. However, USFWS will recommend appropriate measures to avoid or minimize potential effects of a small spill.

Impacts of oil spill response on spectacled and Steller's eiders (below) would result from intentional hazing to prevent contact with oil or from displacement due to the noise and activities of personnel involved in the cleanup. Displacement from nesting and foraging habitat would be temporary, with birds likely to return within hours. However, additional stress to birds from hazing could result in the loss of a few individuals. Such impacts from an oil spill response would be minor.

Steller's Eider: Steller's eiders are not known to nest extensively in the vicinity of the project area. There are only three recent records of broods from North Slope locations other than at Barrow, Alaska. These include: one in 1997 near the upper Chipp River, approximately 50 miles (80 km) inland from the Dease Inlet/Admiralty Bay area; one in 1993 near Prudhoe Bay; and one in 1987 along the lower Colville River (62 FR 31748). Effects of an oil spill are likely to be similar to those for spectacled eider, but would be limited to occasional Steller's eiders present in the area. Hence, the impact of an oil spill on Steller's eider is minor. However, USFWS will recommend appropriate measures to avoid or minimize potential effects of a spill on Steller's eider.

8.7.3 Impacts to the Human Environment

8.7.3.1 Subsistence

Impacts of oil to subsistence harvesting could result from direct or indirect loss of marine mammals, fish and, to a lesser extent, terrestrial mammals and waterfowl. If the level and duration of impacts are severe, lifestyles of Nuiqsut, Barrow, and Kaktovik residents would change. The most substantial changes would likely occur in Nuiqsut. The severity of lifestyle changes to residents of the three communities cannot be quantified; however, assumptions have been made using subsistence harvesting and biological information pertaining to marine mammals, waterfowl, and caribou. Adverse impacts to the subsistence lifestyle could result from destruction of individual animals, displacement of animals, increased hunting competition, loss of hunting access, decreases in harvest quotas, and concerns about contamination. Destruction of individual animals could occur as a result of direct contact with an oil spill; however, it is unlikely that such occurrences would result in decreased hunting success, unless a large portion of the population is destroyed. Displacement could result from water quality degradation or an increase in human activity and noise levels (i.e., from tugs, barges, and ice-breaking vessels) during cleanup activities. Displacement would shift species populations to other areas within the region and could concentrate hunting within more confined areas. Presence of contaminants and resulting cleanup activities could interfere with or preclude travel to and from traditional hunting and fishing locations. It could also create the need to hunt or fish in unaffected areas. Travel to unaffected areas creates an increase in time, cost, safety risks, and meat spoilage. Fears of consuming contaminated game and fish could cause less tangible, but significant, impacts to subsistence, and could continue to affect subsistence harvesting for years after the spill.

Subsistence activities could be affected significantly if a major spill (e.g., well blowout) were to occur during broken ice or open water conditions. Waterfowl and marine mammals, used for subsistence harvesting, would likely be affected. During broken ice or open water conditions, wind and wave action could spread oil to other areas of the Alaskan Beaufort Sea. An oil spill is most likely to noticeably affect least and Arctic cisco, both important subsistence resources for Nuiqsut. If an oil spill removed a year-class of Arctic cisco in conjunction with 1 or 2 years in which age-0 fish failed to reach the Colville River, few fish may be available during the following harvest years. Since harvestable fish are 5 to 8 years old (spawning fish leave for the McKenzie River by age 8), this effect may be seen for no more than approximately 2 to 3 years. The impact would be significant for the affected harvest years.

Spill response actions could limit access to traditional hunting and fishing areas. Subsistence activities displaced from the area of the spill would shift to other locations and could increase competition in areas used by other individuals and communities. Also, it is likely that subsistence harvesting efforts would shift to greater emphasis on terrestrial mammals.

Native subsistence polar bear hunting may be adversely impacted by an oil spill. Populations of polar bears may decrease or be unavailable over a period of time after an oil spill, which may affect subsistence harvest patterns. Polar bears or certain hunting areas may be viewed as tainted by a spill. If an area traditionally used for polar bear hunting were to be affected, potential indirect effects would include additional travel and costs associated with hunting in unaffected areas. If an oil spill resulted in increased mortality to polar bears, the subsistence harvest allocation of 80 bears, divided between Alaska and Canada, could be adversely affected.

An oil spill is of particular concern for subsistence harvest of bowhead whales. There is still considerable disagreement as to the probable effects of oil on bowhead whales in the Alaskan Beaufort Sea. This conclusion probably reflects the transitory nature of these animals in the region, as well as a lack of studies. Data on the anatomy and migratory behavior of bowhead whales suggest that a large oil spill is likely to adversely affect bowhead whales, especially if substantial amounts of oil were in the lead system during the spring migration (Albert, 1981:950; Shotts et al., 1990:358). Exposure of bowheads to an oil spill could result in lethal effects to an unknown number of individuals.

Any effect on bowhead whale population or reduction in harvest success could result in reduced International Whaling Commission harvest quotas. Surveys have documented that bowhead whales navigate through offshore leads distant from the project area during their eastward spring migration. As observed for 4 years after an oil spill in 1944, bowhead migration routes could move further out to sea as a result of an oil spill (T. Brower Sr., in NSB, 1980:107). Yearly surveys conducted from 1979 to 1994 suggest that bowhead whales are present in the project area between approximately August 31 and October 22 (Miller et al., 1996:30) of their westward return migration. There is a low probability that bowhead whales will be adversely affected by an oil spill, considering the short time period each year that bowhead whales would be migrating through the area near Seal Island, the low probability of an oil spill occurring, and the low probability that oil would move into the migration corridor. However, significant impacts would be expected if all these events occurred at the same time. Moreover, the presence of oil spilled on ice could adversely affect the spring bowhead whale hunt in several ways. In addition to contamination of boats and gear, the presence of oil could affect the characteristics of the ice, making it more fragile and less stable. Such effects could interfere with the spring harvest and could be significant, if they occurred. However, the likelihood of a large spill reaching the spring bowhead harvest area is low.

An oil spill on tundra wetlands or lakes would have minor impacts on subsistence harvesting because hunting is not permitted within the project area. A large release into a river (e.g., at the Putuligayuk River crossing) could adversely affect anadromous fish and spawning areas, as well as species within Prudhoe Bay. However, because the onshore portion of the project area is not used for subsistence harvesting, a spill in this area would have a minor impact on the subsistence lifestyles of the North Slope communities.

Should an oil spill occur, game and fish used as subsistence resources could become contaminated. Resources that could potentially be contaminated include migratory waterfowl, fish, and marine mammals. Contamination may create human health risks associated with subsistence consumption of contaminated fish and wildlife. Studies conducted on the *Exxon Valdez* oil spill indicated that invertebrates, such as clams and mussels, had the greatest retention of hydrocarbons from spilled oil and posed the greatest health risk (Bolger et al., 1996:838-839). These resources are not harvested by North Slope Borough residents. Studies on fish, waterfowl, and marine mammals found that they had a higher metabolic rate and were able to eliminate hydrocarbons from their systems over a relatively short period of time (Hom et al., 1996:863). Levels of hydrocarbons found were well within naturally occurring background levels. This would indicate that the long-term health risk from petroleum contamination would be low. However, fish and wildlife that were physically oiled and harvested while still contaminated would pose a health risk. Due to the real and perceived health risk, residents of Prince William Sound generally avoided harvesting marine subsistence resources (fish, invertebrates, marine mammals, and seabirds) during, and for a period of time after, the *Exxon Valdez* oil spill.

Recognizing that the potential impacts described above would be felt by North Slope Inupiat, a minority population as addressed in Executive Order 12898, questions regarding Environmental Justice are raised. For a discussion of Environmental Justice considerations, see Section 7.10.

Last, periodic localized disturbances from icebreaking barge activities required to maintain a corridor during broken/thin ice conditions between West Dock and Seal Island could impact subsistence activities should bowheads be migrating during this period. However, the impact is considered minor and can be mitigated (Section 11.10.2).

8.7.3.2 Cultural and Archaeological Resources

A release into marine waters or onshore could impact the cultural resources onshore or along the shorelines. For an archaeological resource, hydrocarbon contamination from an oil spill can affect the site's integrity and interfere with radiocarbon dating tests (Bittner, 1996:816). In addition, currently unknown cultural and archaeological resources could be damaged. If the meteorological conditions were right, an aerosol from a high pressure release could drift to the resource, resulting in significant impact. Hence, depending on the size of the oil spill, both cultural and archaeological resources in the area could be impacted significantly.

Oil spill response activities could disrupt sites onshore or along the shorelines. Any disturbance by cleanup crews, either by foot traffic or excavation, would cause significant impacts to cultural and archaeological resources. Measures taken to reduce disturbance of sites by cleanup crews could spread knowledge of the site locations and result in increased damage due to vandalism (Bittner, 1996:816). Oil spill response activities would fall under 36 CFR 800.12 "Emergency Undertakings" and would require consultation with the State Historic Preservation Officer and Advisory Council on Historic Preservation.

8.7.3.3 Land and Water Use

An oil spill from project facilities could affect the traditional uses of land in the Prudhoe Bay area. Following an oil spill, land use can be impacted in two ways: damage to the land itself, so its current use is restricted, or use of the land for spill response mobilization (e.g., as an equipment marshaling yard.) Offshore (including Seal Island) spills could result in mobilization of equipment that would affect land uses at Deadhorse and elsewhere. Response to an onshore spill could result in short-term impacts related to transportation; however, direct impacts of contamination to land use would be limited to coastal areas contacted by the spilled oil (Figure 8.4a, b).

A large spill in marine water would not directly affect land uses. However, the event would require mobilization of large amounts of equipment for spill control and cleanup. Shoreline cleanup of a spill during broken ice or open water conditions could require labor intensive recovery efforts by hundreds to thousands of response workers throughout the summer and possibly extending to subsequent years. Onshore access to equipment staging areas through currently undeveloped areas could change the use of previously undisturbed tundra.

An onshore pipeline release would impact land uses by directly affecting tundra wetland or lakes and rivers, and subsequently the use of these areas for hunting and fishing. Secondary impacts to land uses would occur during cleanup, as equipment and personnel are moved to the spill site. The majority of impacts are expected to be from vehicles moving across relatively undisturbed tundra, resulting in melting of permafrost, subsidence, soil erosion, and altered vegetation. Spill response activities would require vehicle access to the location of the release, causing damage to tundra vegetation (and thus to present and future land use) if access roads are not available. Alternatives 2, 3, 4, and 5 vary by the pipeline lengths without road access: 9.55 miles (15.36 km), 6.7 miles (10.78 km), 3.45 miles (5.55 km), and 3.09 miles (4.97 km), respectively. Thus, Alternatives 2 and 3 would result in triple or double the amount of damage compared to Alternatives 4 and 5. If the spill and oil spill response were to occur during the winter, it is likely that no impacts to land uses would result. However, even for Alternatives 2 and 3, impacts to land use from an oil spill response in the summer would be reduced if damage to tundra were minimized by using helicopters and boats as much as possible and limiting traffic to designated travel corridors. Revegetation of these corridors would be almost complete within 5 years (Chapin and Chapin, 1980:449). While impacts to the tundra and vegetation could be measured, changes in land use cannot be quantitatively correlated with this impact. Therefore, impacts of a summer oil spill and subsequent oil spill response on land use would be negligible.

8.7.3.4 Socioeconomics

For analysis of socioeconomic impacts that occur in the event of a large oil spill cleanup, the most relevant historical experience of a spill in Alaskan waters was the *Exxon Valdez* oil spill in Prince William Sound in 1989, which spilled 240,000 barrels. All the communities in Prince William Sound affected by the *Exxon Valdez* oil spill experienced disruption of their normal lifestyles (IAI, 1990:7); native communities experienced the greatest sociological and psychological impacts (IAI, 1990:xi). Effective operation of community governments were constrained by the excessive demands of responding to the oil spill, which displaced the usual business of municipal governments.

Fiscal impacts to communities affected by the *Exxon Valdez* oil spill included loss of revenues, unreimbursed direct oil spill expenses, increased insurance costs, delayed or canceled capital projects, and deferred maintenance costs. All private businesses in the affected communities had losses that exceeded gains regardless of industry type or spill cleanup involvement (IAI, 1990:xviii).

Economic impacts on communities affected by the *Exxon Valdez* oil spill were also caused by employment generated by the oil spill response. During the multi-year cleanup, more than 11,000 people and 1,400 marine vessels were involved (EVOS Trustee Council, 1995:2). Numerous local residents quit their existing jobs to work for higher wages paid to cleanup workers. This generated a sudden and substantial inflation in the local economy (Cohen, 1993:227-230). Effects on the NSB could be reduced because response activities, including administrative and cleanup actions, would be located in and supported by existing facilities. Also, fewer cleanup workers would be required for spill response since less labor intensive methods, i.e. dispersants rather than steam washing, are likely to be used (BPXA, 1997b:55 and 59). The primarily sandy beaches of the Beaufort Sea and the more open shorelines would increase the efficiency of mechanical containment and recovery compared to effort in Prince William Sound. However, overall impacts to socioeconomics of NSB communities from an oil spill response could still be significant. In the case of a large magnitude blowout that could release an oil volume (225,000 barrels) similar to the *Exxon Valdez* oil spill, thousands of workers, including many local residents, would be needed.

Recognizing that the potential impacts described above would be felt by North Slope Inupiat, a minority population as addressed in Executive Order 12898, questions regarding Environmental Justice are raised. For a discussion of Environmental Justice considerations, see Section 7.10.

8.7.3.5 Transportation

Impacts to transportation resources would result only from oil spill response mobilization; no impacts to transportation would be expected from the oil spill itself. Response workers, materials, and equipment would likely be transported via commercial and private aircraft, and traffic would increase on the Dalton Highway for a large spill. Deadhorse would experience an increase in air traffic transporting workers, materials, and equipment to the spill site. Nuiqsut residents' personal boats and vehicles would potentially be recruited for the cleanup effort. Impacts to transportation resources would likely be intense for a short duration while response efforts are initially mobilized. As efforts stabilize, impacts would lessen. The overall impact to transportation resources are expected to be minor.

8.7.3.6 Visual/Aesthetics Characteristics

Impacts to visual/aesthetic characteristics of the project area would be similar for the oil spill and oil spill response activities (e.g., staining of shoreline, presence of oil on water, etc.). Different impacts levels would be anticipated for different times of year. With some minor exceptions, most local activities do not occur during the winter in the area likely to be contacted by oil, and viewer sensitivity would be low. Therefore, impacts to visual resources from an oil spill or oil spill response are expected to be negligible. However, during the summer, the effect to scenic quality would increase (e.g., presence of spill response equipment). The action of the wind and waves would cause oil in marine waters to cover a greater area, and viewer sensitivity would be increased because more people would be in the area participating in subsistence or recreational activities. Nevertheless, a large onshore or marine water spill during summer would have a minor impact on the visual resources in the area.

8.7.3.7 Recreation

No impacts to recreation would be expected from an oil spill; however, oil spill response is expected to have an adverse effect on recreational activities that occur along the Dalton Highway during the summer. In the event of response to a large spill, vehicle traffic along the highway would likely increase. This would have an indirect impact on recreational activities along the Dalton Highway due to the fact that noise and dust created by the trucks could reduce visitors' enjoyment. Although the temporary increase in truck traffic could be measured, visitors' reduced enjoyment cannot be quantitatively correlated with this increase. Therefore, the impact of an oil spill response on recreation would be negligible.

8.8 SUMMARY

Alternative 1 - No Action Alternative, would have no oil spill impacts. Under specific circumstances described in this EIS, an oil spill or oil spill response related to Alternatives 2, 3, 4, and 5 could result in significant unavoidable adverse impacts to:

- Soil/sediment/surface water quality in the summer.
- Coastal vegetation and invertebrates.
- Marine mammals
- Bird populations.
- Threatened and endangered species (eiders and bowhead whales).
- Subsistence activities performed by local residents.
- Cultural and archaeological resources.
- Socioeconomics of North Slope communities.

An oil spill would have potential short-term effects (mortality, stress, decrease or redistribution in numbers, and changes in behavior or migration patterns) on populations of the above biological resources and quality of their habitat. The potential impacts of an oil spill could have long-term effects on polar bears. Short-term effects on subsistence activities and socioeconomics of North Slope communities, particularly those observed by younger generations, would potentially lead to long-term consequences for Native social and cultural systems.

Mortality of any biological resource as a result of an oil spill associated with the project would be an irreversible loss. Birds, spectacled eiders in particular, are the most likely biological resources to experience enough mortality to affect population numbers. Economic resources used to respond to an oil spill would be irreversibly and irretrievably committed. Permanent disturbance of subsistence lifestyles would be an irreversible and irretrievable loss to Inupiat social and cultural values.

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TABLE 8-1
PREVALENCE OF BIOLOGICAL RESOURCES IN THE FOUR ENVIRONMENTAL SETTINGS

Category	Species	April	May	June	July	August	September	October	November through March
Onshore Land									
Fish	Arctic Graying and other Freshwater Species	Present year-round in streams. Spawning occurs in shallow streams.						Overwintering occurs in deep holes of the Sagavanirktok and Kuparuk Rivers.	
	Arctic Cisco	--	--	--	--	--	--	Overwintering occurs in deep holes of the Colville and Sagavanirktok River Deltas.	
	Least Cisco	--	--	--	--	--	--	Overwintering occurs in the Colville River.	
	Broad Whitefish	--	Present in the Sagavanirktok and Colville Rivers and deltas throughout summer.					Overwintering occurs in the Colville River.	
			--	--	Spawning in tributaries	--	--		
	Char, Young	First two years of life cycle spent in freshwater.							
	Char, Adult	--	--	--	Sagavanirktok, Canning, and Colville Rivers, and tributaries are spawning and overwintering grounds.				
Mammals	Caribou	Calving occurs on the open tundra.			Caribou remain on Arctic Coastal Plain before most return to the Brooks Range in late fall.			--	--
	Arctic Fox	Year-round resident of Arctic Coastal Plain.							
	Grizzly Bears	Year-round resident of Arctic Coastal Plain; relatively inactive during winter hibernation.							
	Polar Bears	Population concentrated near the shorefast ice zone in winter. Individuals may den up to 25 miles (40 km) inland.		Some individuals may remain onshore and in lagoon areas during the summer.				Population concentrated near the shorefast ice zone in winter. Individuals may den up to 25 miles (40 km) inland.	
Migratory Birds		--	Early spring arrival of many migratory birds, after the snow melts they are present on tundra or near lakes and ponds.						--
	Loons	--	Arrive late in the spring and remain until freezing weather; nest on large ponds.						--
	Tundra Swan	--	Arrive early in the spring and remain until late September or October; nest on large ponds or lakes.						--
	White-fronted Goose	--	Nest on tundra; molt near interior lakes. Migration occurs in late August				--	--	--

TABLE 8-1 (Cont.)
PREVALENCE OF BIOLOGICAL RESOURCES IN THE FOUR ENVIRONMENTAL SETTINGS

Category	Species	April	May	June	July	August	September	October	November through March
Onshore Land (Cont.)									
Migratory Birds (Cont.)	Brant	--	Main nesting areas are located in the vicinity of the Sagavanirktok River. Rearing/molting areas located in coastal salt marshes and large Arctic Coastal Plain lakes.						--
	Oldsquaw and King Eider	--	Common nester throughout the project area.			Molt on Arctic Coastal Plain lakes.		--	--
	Raptors: Snowy and Short-Eared Owl, Golden Eagle, and Gyrfalcons	--	Individuals occasionally observed passing through the area						--
	Lapland Longspur and Shorebirds	--	Abundant tundra-nesters throughout project area.					--	--
	Snow Bunting	--	Nest in cavities often raised off the tundra (pipeline supports, debris, buildings, stored materials).						--
Non-Migratory Birds	Common Raven, Snowy Owl, Willow and Rock Ptarmigan	Present year-round.							
Threatened or Endangered Species	Spectacled Eider	--	Nest throughout oil fields, primarily in wetter and ponded areas; females and young reside in marshy areas before migration.						--
	Steller's Eider	--	--	Uncommon nesting species in the project area.				--	--
Lagoons and Shorelines Inside the Barrier Islands									
Marine Invertebrates	Epifauna and Infauna	--	Populations must recolonize yearly after ice breakup due to bottomfast ice in shallow waters; brought in by water currents as ice moves out.						--
	Phytoplankton	--	Brought in by water currents as ice moves out. Population bloom in late July to early August.						
	Zooplankton and Nekton	--	Brought in by water currents as ice moves out. Population bloom in August.						--
Fish	Arctic Cisco	--	--	Young-of-the-year depart Mackenzie River and travel as far west as the Sagavanirktok and Colville Rivers.				--	--
		--	Juveniles spend summers in lagoons and river deltas.					--	--

TABLE 8-1 (Cont.)
PREVALENCE OF BIOLOGICAL RESOURCES IN THE FOUR ENVIRONMENTAL SETTINGS

Category	Species	April	May	June	July	August	September	October	November through March
Lagoons and Shoreline Inside the Barrier Islands (Cont.)									
Fish (Cont.)	Arctic Cisco (Cont.)	--	Spawning adults migrate to MacKenzie River.		Pre-spawning fish use lagoons and river deltas.			--	--
	Least Cisco	--	Least cisco migrate both east and west from the Colville River following breakup; some pass through Simpson Lagoon and Gwydyr Bay.			Least cisco pass through Simpson Lagoon and Gwydyr Bay again in the fall, returning to overwintering areas in the Colville River.			--
	Broad Whitefish	--	Lagoons, Kuparuk River Delta, and Gwydyr Bay are used as feeding grounds During the open water season.					--	--
	Char	--	Feeding grounds during open water season.					--	--
	Arctic Cod	--	Feeding grounds during open water season; spawning occurs in nearshore environments.					--	--
Marine Mammals	Ringed Seals	Ringed seals establish birthing dens in the shorefast ice in the spring.		Individuals may occasionally be observed in lagoon areas during open water.				Ringed seals maintain breathing holes and haul out dens in drifts in shorefast ice.	
Mammals	Caribou	--	--	Caribou may stand in coastal waters for insect relief.			--		
	Arctic Fox	--							May be observed on sea ice in lagoons during winter
	Grizzly Bears	--	May be observed in shallow lagoon areas in summer.					--	
	Polar Bears	Population concentrated near the shorefast ice zone in winter.		Individuals occasionally remain onshore and in lagoon areas during the summer.					Population concentrated near the shorefast ice zone in winter.
Migratory Birds		--	Spring and fall: migrating birds use leads and open water areas to stage and feed.					--	--
		--	--	--	Critical sea duck molting area.			--	--
	Loons	--	Arrive late in spring and remain until freezing weather; nest inland but forage in coastal waters.					--	--
	White-fronted Goose	--	Non-breeders and juveniles may be in coastal areas; migrate late August.				--	--	--

TABLE 8-1 (Cont.)
PREVALENCE OF BIOLOGICAL RESOURCES IN THE FOUR ENVIRONMENTAL SETTINGS

Category	Species	April	May	June	July	August	September	October	November through March
Lagoons and Shoreline Inside the Barrier Islands (Cont.)									
Migratory Birds (Cont.)	Common Eider	--	Nest on barrier islands.					--	--
	Oldsquaw	--	--	--	Molt for several weeks in lagoons.		--	--	--
	Surf Scoter	--	--	--	Males molt in lagoon habitats.		--	--	--
	Pomarine and Parasitic Jaegers	--	Found during open water season in offshore waters and adjacent inland areas.					--	--
	Glaucous Gulls	--	Nest on barrier islands and forage in nearshore waters of Alaska Beaufort Sea.					--	--
	Arctic Terns	--	Nest on barrier islands and forage in nearshore lagoons and offshore waters.					--	--
	Shorebirds	--	May be observed in lagoon areas throughout summer; feed in coastal mud flats and along shorelines. Large numbers of post-breeding phalaropes occur in lagoons and inner shorelines of barrier islands.					--	--
Threatened or Endangered Species	Spectacled Eider	--	Early arrival in spring.		Males leave tundra nesting grounds to feed in nearshore waters.	Females/young feed in nearshore waters before migration.	--	--	--
	Steller's Eider	--	Individuals may occasionally be observed in the project area.						
	Arctic Peregrine Falcon	--	--	Forage along the Beaufort Sea coast.				--	--
Outer Island Shorelines and Exposed Coast									
Marine Invertebrates	All	Same as lagoons and shorelines inside barrier islands.							
Fish	Char and Arctic Cisco	Migration and feeding unknown distance offshore.							
Marine and Terrestrial Mammals	Arctic Fox, Polar Bears, and Ringed Seals	Same as lagoons and shorelines inside barrier islands.							

TABLE 8-1 (Cont.)
PREVALENCE OF BIOLOGICAL RESOURCES IN THE FOUR ENVIRONMENTAL SETTINGS

Category	Species	April	May	June	July	August	September	October	November through March
Outer Island Shorelines and Exposed Coast (Cont.)									
Migratory Birds	All	--	Spring and fall: migrating birds use leads and open water areas to stage and feed.					--	--
	Black Guillemots	--	Occur in small numbers in open waters of the Alaskan Beaufort Sea; nest on a few islands west of the project area.					--	--
	Lesser Snow Goose	--	--	Nest and brood-rearing on Howe Island.			--	--	--
	Common Eider, King Eider, Oldsquaw	--	Spring migration corridor.	Nest on barrier islands.			Fall migration corridor.	--	--
	Pomarine and Parasitic Jaegers	--	Found in the open water season in offshore waters and adjacent inland areas.					--	--
	Glaucous Gulls	--	Nest on barrier islands and forage in nearshore waters of Alaska Beaufort Sea.					--	--
	Arctic Terns	--	Nest on barrier islands and forage in nearshore lagoons and offshore waters.					--	--
Threatened or Endangered Species	Arctic Peregrine Falcon	--	--	Forage along the Beaufort Sea coast.				--	--
	Spectacled Eider	--	Spring and fall migration corridor.					--	--
Marine Waters and Sea Ice									
Marine Invertebrates	Phytoplankton	Present year-round; population bloom in late July to early August.							
	Zooplankton and Nekton	Present year-round; population bloom in August.							
	Epotonic Communities	Present year-round; population bloom in May; population declines as ice recedes.							
	Epifauna	Present year-round.							
	Infauna	Present year-round.							
Fish	Char	--	Feeding grounds during open water season.					--	--
	Arctic Cod	Present year-round.							
Marine Mammals	Beluga Whales	--	Migratory path to Canadian Beaufort Sea.	--	--	Migratory path back to Bering Sea.			--

TABLE 8-1 (Cont.)
PREVALENCE OF BIOLOGICAL RESOURCES IN THE FOUR ENVIRONMENTAL SETTINGS

Category	Species	April	May	June	July	August	September	October	November through March
Marine Waters and Sea Ice (Cont.)									
Marine Mammals (Cont.)	Ringed Seal	Generally follow the ice pack north in the summer. Individuals may be observed during open water.						Concentrated close to shore in winter to feed and den.	
	Bearded Seals	--	Individuals may be observed in area during open water.					Generally follow the ice pack south in the winter; a few could be present in the project area between the shorefast ice and pack ice.	
	Polar Bears	Polar bears move with the advancing ice pack in winter and with the retreating ice pack during summer.							
Migratory Birds	King and Common Eider	--	Spring migration		--	Fall migration		--	--
Threatened or Endangered Species	Bowhead Whales	--	Migratory path while traveling east.	--		Migratory path while traveling west.			--

TABLE 8-2
NORTHSTAR CRUDE OIL CHEMICAL CHARACTERISTICS

Component	Mole[1] Percent	Chemical Formula	Molecular Weight (gram/g-mole)	Weight Percent	Boiling Point °F (°C) at 1 atm	Solubility in 100 Parts of Water (cm^3)	Cumulative Percent by Weight
Carbon dioxide	5.43	CO_2	44.01	4.39	-109 (-78.5) sublimates	179.7	4.39
Nitrogen	0.61	N_2	28.02	0.31	-321 (-196)	2.35	4.7
Methane	56.88	CH_4	16.04	16.76	-259 (-161.4)	0.4	21.46
Ethane	7.12	C_2H_6	30.07	3.93	-127 (-88.6)	4.7	25.39
Propane	4.94	C_3H_8	44.09	4.00	-44 (-42.2)	6.5	29.39
Iso-butane	0.97	C_4H_{10}	58.12	1.04	14 (-10)	Insoluble	30.43
N-butane	2.26	C_4H_{10}	58.12	2.41	31 (-0.6)	Insoluble	32.84
Iso-pentane	0.94	C_5H_{12}	72.15	1.25	82 (28)	Insoluble	34.09
N-pentane	1.14	C_5H_{12}	72.15	1.51	97 (36.3)	0.036	35.6
Hexanes	1.79	C_6H_{14}	86.17	2.83	140 to 156 (60 to 69)	Insoluble	38.43
Heptane plus[2]	17.92	C_7	187	61.56	194 (90+)	Insoluble	100
Total	100	--	--	100	--	--	--

Notes:
1 = Percent of total given in moles, which are equal to 6.02×10^{23} (Avogadro's number) molecules of the substances.
2 = Specific gravity of Heptane plus is 0.83 (60°F); molecular weight is 187.
atm = Atmosphere
°C = Degrees Celsius
°F = Degrees Fahrenheit
cm^3 = Cubic centimeters

Sources: Chemical composition of crude from BPXA, 1997a:Table 3.3-1 (Appendix A)
Physical properties from Perry's Chemical Engineer's Handbook, 1984:Table 3-2

TABLE 8-3
ESTIMATED TIME FOR AN UNMITIGATED SPILL TO CONTACT RESOURCE AREAS (MINIMUM 0.5% PROBABILITY) [1]

Season of Release	Probability of Contact ≥0.5% Within 3 Days	Probability of Contact ≥0.5% Within 10 Days	Probability of Contact ≥0.5% Within 30 Days	Probability of Contact ≥0.5% Within 90 Days	Probability of Contact ≥0.5% Within 180 Days
Land Segments Contacted by Oil Release [2]					
Winter - Ice Covered	33, **34 (5%)**, 35	33, **34 (5%)**, 35	33, **34 (11%)**, 35, 36	32, 33, **34 (19%)**, 35, 36	27, 28, 29, 31, 32, 33, **34 (24%)**, 35, 36
Summer - Open Water	33, **34 (10%)**, 35, 36	33, **34 (14%)**, 35, 38	26-29, 33, **34 (19%)**, 35-42	26-29, 33, **34 (22%)**, 35-43	26-29, 33, **34 (22%)**, 35-43
Ice/Sea Segments Contacted by Oil Release [2]					
Winter - Ice Covered	**7 (1%), 8 (1%)**	**7 (2%), 8 (2%)**	6, 7, **8 (3%)**	6, 7, **8 (11%)**, 10, Simpson Lagoon	6, 7, **8 (24%)**, 10 Simpson Lagoon
Summer - Open Water	7, 8 **Simpson Lagoon/ Gwydyr Bay (19%)**	6, 7, **8 (22%)**, 9, 10 **Simpson Lagoon/ Gwydyr Bay (22%)** Lagoon Area Jago Lagoon	6, 7, **8 (34%)**, 9-11 Simpson Lagoon/ Gwydyr Bay (30%) Lagoon Area Jago Lagoon	3-7, **8 (40%)**, 9-11 Simpson Lagoon/ Gwydyr Bay (32%) Lagoon Area Jago Lagoon	3-7, **8 (40%)**, 9-11 Simpson Lagoon/ Gwydyr Bay (32%) Lagoon Area Jago Lagoon

Notes:
- 1 = Modeling data averaged by Minerals Management Service (MMS) for two launch points in the middle of leases Outer Continental Shelf (OCS) Y-0179 and Y-0181 to simulate an oil release in the vicinity of Seal Island.
- 2 = See Figures 8-4 and 8-5 for land and ice/sea segment resource areas designated in MMS Oil Spill Risk Analysis Modeling.
- Bold = Segment with highest probability of contact for season and time period.
- ≥ = Greater than or equal to
- % = Percent

TABLE 8-4
HISTORIC SPILL DATA FOR THE NORTH SLOPE [1]

Year [2]	Crude				Diesel				Other (glycol, drilling mud, seawater, etc.)			
	Total Number of Spills	Total Volume of Spills (barrels)	Median Volume of Spills (barrels)	Mean Volume of Spills (barrels)	Total Number of Spills	Total Volume of Spills (barrels)	Median Volume of Spills (barrels)	Mean Volume of Spills (barrels)	Total Number of Spills	Total Volume of Spills (barrels)	Median Volume of Spills (barrels)	Mean Volume of Spills (barrels)
1970-1979	6	157	5.9	26.2	12	3,215	16.7	267.9	4	1,268	91.0	316.9
1980	3	249	8.0	83.0	4	113	4.8	28.3	2	20	9.9	9.9
1981	23	106	2.0	4.6	50	1,364	3.6	27.3	35	455	2.5	13.0
1982	14	135	4.5	9.7	13	371	2.4	28.5	5	102	11.9	20.5
1983	20	96	2.7	4.8	39	1,009	5.0	25.9	16	465	4.5	29.0
1984	1	10	10.5	10.5	0	0	0.0	0.0	2	6	3.1	3.1
1985	58	785	3.0	13.5	51	373	2.4	7.3	45	678	2.0	15.1
1986	58	368	2.5	6.3	42	501	3.0	11.9	26	500	5.3	19.2
1987	35	231	2.0	6.6	31	87	1.8	2.8	24	504	2.5	21.0
1988	48	643	2.0	13.4	53	285	2.4	5.4	66	1,607	2.0	24.3
1989	47	2,005	2.0	42.7	41	302	2.4	7.4	40	354	2.0	8.8
1990	20	641	2.0	32.1	42	226	1.8	5.4	21	79	1.3	3.8
1991	21	47	2.0	2.3	40	308	2.9	7.7	15	109	2.4	7.3
1992	10	57	6.0	5.7	34	406	2.9	11.9	22	187	2.8	8.5
1993	41	2,053	1.3	50.1	28	420	2.0	15.0	12	239	1.4	19.9
1994	21	712	2.0	33.9	23	349	2.4	15.2	16	160	2.3	10.0
1995	21	94	1.4	4.5	33	153	0.4	4.6	108	853	0.2	7.9
1996	66	235	0.2	3.6	102	255	0.2	2.5	262	880	0.2	3.4
1997	59	298	0.2	5.1	92	637	0.2	6.9	299	24,662	0.2	82.5

Notes: 1 = Only three spills greater than 1,000 barrels have occurred on the North Slope, none of which were crude oil.
2/9/75 - 10,000 gallons (2,381 barrels) of diesel were released on a gravel pad at East Galbraith Camp when a pipeline ruptured.
8/21/88 - 50,000 gallons (1,190 barrels) of Arctic heating oil were released from a marine vessel, 8 miles (12.9 km) offshore of Brownlow.
3/17/97 - 994,400 gallons (23,676 barrels) of seawater were released from wellheads at Prudhoe Bay Drillsite 4.
2 = Low reliability of data prior to 1989. Database verification ongoing by the Alaska Department of Environmental Conservation.

Source: Stephens - Pers. Comm., 1998:1

TABLE 8-5
COMPARISON OF POTENTIAL OIL SPILL VOLUMES FOR PROJECT ALTERNATIVES

Alternative	Pipeline Length miles (km)		Oil Spill Volume							
					Pipeline Rupture		Chronic Leak			
							Offshore			
	Offshore	Onshore	Drilling Blowout	Diesel Storage Tank Rupture	Offshore	Onshore	Solid Ice	Unstable Solid Ice	Broken Ice/ Open Water	Onshore
1 [A]	0 (0)	0 (0)	0 bbls	0 bbls	0 bbls	0 bbls	0 bbls	0 bbls	0 bbls	0 bbls
2 [B]	5.96 (9.60)	11.12 (17.89)	15,000 bbls/day for 15 days [C]	2,800 bbls [C]	3,600 bbls	6,400 bbls	6,100 bbls	6,600 bbls	3,800 bbls	6,600 bbls
3	5.96 (9.60)	15.44 (24.84)			3,600 bbls	8,700 bbls [D]	6,100 bbls	6,600 bbls	3,800 bbls	8,900 bbls
4	9.03 (14.54)	11.95 (19.23)			5,300 bbls	6,800 bbls	7,700 bbls	8,200 bbls	5,500 bbls	7,000 bbls
5	8.90 (14.33)	11.78 (18.96)			5,200 bbls	6,700 bbls	7,700 bbls	8,100 bbls	5,400 bbls	6,900 bbls

Notes:
- A = No Action
- B = BP Exploration (Alaska) Inc. proposed route
- C = Same for Alternatives 2, 3, 4, and 5
- D = Actual onshore release volume for Alternative 3 would be lower due to the location of a valve approximately 3.5 miles (5.6 km) downstream of the landfall location. A pipeline rupture occurring in the upstream portion of the onshore segment would have a maximum estimated spill volume of approximately 2,300 bbls, while a rupture occurring in the downstream segment would be approximately 6,800 bbls.
- bbl = Barrels
- km = Kilometers

Pipeline rupture calculation assumptions included:
1) Oil flowrate of 65,000 barrels per day.
2) Detection time of 5 minutes (INTEC, 1997:Calc. No. 340-001, pg 5).
3) Response time of 5 minutes for operator verification for valve closure (INTEC, 1997:Calc. No. 340-001, pg 5).
4) 1 percent increase in oil volume due to pressure decrease (INTEC, 1996d:Appendix B, 6).
5) Pipeline volume of 0.0996 barrels per foot (BPXA, 1998b:1-2).

Chronic pipeline leak calculation assumptions included:
1) Oil flowrate of 65,000 barrels per day.
2) Detection time of 30 days for offshore leaks during solid ice winter conditions.
3) Detection time of 35 days for offshore leaks during unstable solid ice conditions.
4) Detection time of 1 week for offshore leaks during broken ice or open water conditions.
5) Detection time of 1 week for onshore leaks, regardless of season.

Note: Estimated spill volumes for chronic leak scenarios include a time dependent component for leak detection, as well as the complete evacuation of pipeline volume. Although drainage of the entire pipeline volume between valves would likely be prevented by seawater intrusion (offshore) and operational measures, it is presented here as the worst case spill volume.

TABLE 8-6
COMPARISON OF TOTAL PROJECT SPILL PROBABILITIES BASED ON EXPOSURE VARIABLES[1]

Probability of One or More Oil Spills Greater than or Equal to 1,000 Barrels						
Alternative	**Pipeline**		**Platform**		**Any Source**	
	CONCAWE	**MMS[2]**	**MMS**	**MMS**	**CONCAWE and MMS**	**MMS[2]**
1	0	0	0	0	0	0
2	0.045[3] (4.5%)	0.19[4] (19%)	0.07(7%)	0.07(7%)	0.111[5] (11%)	0.24[4] (24%)
3	0.056[3] (5.6%)	0.19[4] (19%)	0.07(7%)	0.07(7%)	0.121[5] (12%)	0.24[4] (24%)
4	0.055[3] (5.5%)	0.19[4] (19%)	0.07(7%)	0.07(7%)	0.120[5] (12%)	0.24[4] (24%)
5	0.054[3] (5.4%)	0.19[4] (19%)	0.07(7%)	0.07(7%)	0.119[5] (12%)	0.24[4] (24%)

Notes:
1 = Pipeline spill probabilities based on 158 million barrels.
2 = All action alternatives yield the same spill probability because exposure factor of volume of oil produced does not change for these alternatives.
3 = CONCAWE pipeline spill statistics used; based on spills exceeding 1,000 barrels.
4 = Adjusting MMS OCS spill statistics to eliminate anchor and trawler damage to offshore pipelines results in an estimated probability of 5.2% for one or more pipeline spills and 11.6%
for one or more spills from any source.
5 = CONCAWE pipeline and MMS OCS platform spill statistics used.
% = Percent
CONCAWE = Conservation of Clean Air and Water in Europe
MMS = Minerals Management Service
OCS = Outer Continental Shelf

Source: Unless otherwise indicated, MMS OCS pipeline/platform spill statistics used (Anderson and LaBelle, 1994;11).

TABLE 8-7
PROBABILITY OF A PIPELINE OIL SPILL BASED ON CONCAWE STATISTICS [1]

Alternative	Pipeline Location	Segment Length[2]		Probability of One or More Pipeline Releases in 15 Years[3]
		Miles	Kilometers	
1	N/A	0	0	0
2	Offshore	5.96	9.60	0.016
	Onshore	11.12	17.89	0.030
	Total[4]	**17.08**	**27.49**	**0.045 (4.5%)**
3	Offshore	5.96	9.60	0.016
	Onshore	15.44	24.84	0.041
	Total[4]	**21.40**	**34.44**	**0.056 (5.6%)**
4	Offshore	9.03	14.54	0.024
	Onshore	11.95	19.23	0.032
	Total[4]	**20.98**	**33.77**	**0.055 (5.5%)**
5	Offshore	8.90	14.33	0.024
	Onshore	11.78	18.96	0.031
	Total[4]	**20.68**	**33.28**	**0.054 (5.4%)**

Notes:
1 = For pipeline related oil releases greater than 1,000 barrels. Risk of releases based on CONCAWE Western European data, showing annual average of 1.8 releases per year for 10,000 miles (0.112 releases per year/1,000 kilometers) of pipeline length.
2 = Pipeline lengths shown here include only the oil pipeline. These pipeline lengths are different from the pipeline lengths shown in Figure 11-1, which also include the gas pipeline.
3 = Probability of one or more spills over 15 years is calculated based on the expected number of spills using the Poisson distribution.
4 = Probability of an oil spill for the entire pipeline length is calculated based on the total onshore and offshore length.
CONCAWE = Conservation of Clean Air and Water in Europe
N/A = Not applicable
% = Percent

TABLE 8-8
SUMMARY OF OIL SPILL CLEANUP LIMITATIONS FOR A CHRONIC PIPELINE LEAK INTO OFFSHORE MARINE WATERS AND ICE

Season	Expected Time of Year [1]	Annual Days of Occurrence	Spill Detection Method	Spill Volume[2]	Oil Recovery Techniques[3]	Recovery of Spilled Oil [4]	Environmental Conditions Reducing Oil Spill Cleanup Effectiveness [5]
Solid Ice	Dec. 16 to May 29	165	Periodic under-ice surveys by drilling holes through ice at intervals over the pipeline route and using instrumentation to detect oil. (Note: BPXA has proposed monthly sampling using 500 ft intervals.)	6,100 - 7,700 bbls	Ice roads built to the spill location; holes, slots, sumps, and trenches cut in the ice above oil pockets (ACS Tactics L-1, R-6, R-13, R-14).	--	Temperatures greater than 0ºF slow construction of ice road; lack of daylight requires use of electric lights.
					Oil recovered from water surface using pumps and rope mop skimmers until free oil no longer rises into cut ice pockets (ACS Tactics R-6, R-13, R-14).	75% [6]	Winds greater than 15 knots 28% of the time (46 days) [7].
					Vacuum trucks and rollagons with tanks transport recovered fluids to West Dock.	--	
					During pipeline repair, sorbents collect any oil appearing on water surface; excavated soil and oiled ice transported by dump truck to West Dock for storage and disposal.	No data available	
					New trenches and sumps cut in surface ice depressions in early June to divert oil; boom installed in the trenches to collect mobile oil; sorbents and shovels are used to recover oil.	No data available	
					In situ burning of pooled and residual oil during spring breakup (ACS Tactics B-2, B-3, B-5, and B-6).	14-63% [8]	Winds greater than 20 knots 13% of the time (21 days) [7].
Unstable Solid Ice	May 30 to July 3	35	None possible during this period.	6,600 - 8,200 bbls	Monitor oil movement as possible and wait until it is possible to employ broken ice recovery techniques.	--	Ice movements away from spill location; ice thicknesses less than 12 inches for light equipment and 20 inches for conventional vehicles [9]; winds greater than 15 knots 23% of the time (8 days) and greater than 20 knots 6% of the time (2 days) [7].
Broken Ice (Ice Concentration between 30%	July 4 to July 24 (maximum of 4 to 5	21 to 35	Weekly visual inspections of pipeline route by boat or by air.	3,800 - 5,500 bbls	Workboats, on inflatable boat, mini-barges, a storage barge and a tug used to recover oil in open water areas with LORI skimmer and boom (ACS Tactic	No data available	Booms may be collapsed, overrun, or damaged by drifting ice; containment efficiencies decrease with increasing ice concentrations (70% in 3/10ths ice

TABLE 8-8 (Cont.)
SUMMARY OF OIL SPILL CLEANUP LIMITATIONS FOR A CHRONIC PIPELINE LEAK INTO OFFSHORE MARINE WATERS AND ICE

Season	Expected Time of Year [1]	Annual Days of Occurrence	Spill Detection Method	Spill Volume[2]	Oil Recovery Techniques[3]	Recovery of Spilled Oil [4]	Environmental Conditions Reducing Oil Spill Cleanup Effectiveness [5]
and 100%)	weeks)				R-17).		concentration, 40% in 5/10ths and 20% in 7/10ths [S.L. Ross, 1998:46]); open leads make spill trajectory uncertain.
					Transport recovered oil and water in mini-barge to intermediate storage barge.	--	60% reduction in effective number of response hours due to barge travel [3].
					In situ burning of pooled and residual oil in broken ice while using fire booms to capture oil run-off not ignited (ACS Tactics B-2, B-3, B-4, B-5, and B-6).	55-85%[10] or 50-90%[8] in ice concentrations ≥70%	Winds greater than 20 knots 5% of the time (1 day)[7]; waves greater than 2 to 3 feet.
					Mechanical recovery of residual oil and burn materials from water; sorbents sweeps used to capture remaining sheen on rotting ice (ACS Tactic R-9).	No data available	Winds greater than 15 knots 19% of the time (4 days) [7].
Open Water (Ice Concentration 30% or lower)	July 25 to Oct. 5 (average)	73 to 109	Weekly visual inspections of pipeline route by boat or by air.	3,800 - 5,500 bbls	Workboats, mini-barges, a storage barge, and a tug used with booms and skimmers to contain and collect oil (ACS Tactic R-18, R-19, and R-20).	41-72%[11]	Ice invasions decrease containment efficiencies of booms; winds greater than 15 knots 27% of the time (20 days)[7]; waves greater than 2 to 3 feet.
	June 29 to Oct. 15 (maximum)				Transfer recovered oil and water from barges to West Dock for storage and disposal.	--	
					In situ burning of oil (ACS Tactics B-2, B-3, B-4, and B-6).	95-98% or 60-80% for up to 50% oil/water emulsion[12]	Winds greater than 20 knots 11% of the time (8 days)[7]; waves greater than 2 to 3 feet.
Broken Ice (Ice Concentration between 30% and 100%)	Oct. 6 to Nov. 10 (maximum of 6 to 8 weeks)	36 to 56	Weekly visual inspections of pipeline route by boat or by air.	3,800 - 5,500 bbls	Workboats, an inflatable boat, mini-barges, a storage barge, and a tug used to recover oil in open water areas using LORI skimmer and boom (ACS Tactic R-17).	No data available	Booms may be collapsed, overrun, or damaged by drifting ice; containment efficiencies decrease with increasing ice concentrations; open leads make spill trajectory uncertain; winds greater than 15 knots 38% of the time (14 days) [7].
					Transport recovered oil and water in mini-barge to intermediate storage barge.	--	60% reduction in effective number of response hours due to barge travel [3].

TABLE 8-8 (Cont.)
SUMMARY OF OIL SPILL CLEANUP LIMITATIONS FOR A CHRONIC PIPELINE LEAK INTO OFFSHORE MARINE WATERS AND ICE

Season	Expected Time of Year [1]	Annual Days of Occurrence	Spill Detection Method	Spill Volume[2]	Oil Recovery Techniques[3]	Recovery of Spilled Oil [4]	Environmental Conditions Reducing Oil Spill Cleanup Effectiveness [5]
					In situ burning of pooled and residual oil in broken ice while using fire booms to capture oil run-off not ignited (ACS Tactics B-2, B-3, B-4, B-5, and B-6).	55-85%[10] or 50-90%[8] in ice concentrations ≥70%	Winds greater than 20 knots 21% of the time (7 days) [7]; waves greater than 2 to 3 feet.
					Mechanical recovery of residual oil and burn materials from water; sorbent sweeps used to capture remaining sheen on rotting ice (ACS Tactic R-9).	No data available	
Unstable Solid Ice	Nov. 11 to Dec. 15	35	None possible during this period.	6,600 - 8,200 bbls	Employ broken ice oil spill recovery techniques as possible, then monitor oil spill movement and wait until ice is stable enough to support equipment and personnel and apply solid ice oil spill recovery techniques.	No data available	Ice movements away from spill location; ice thicknesses less than 12 inches for light equipment and 20 inches for conventional vehicles [9]; winds greater than 15 knots 35% of the time (12 days) and greater than 20 knots 21% of the time (7 days) [7].

TABLE 8-8 (Cont.)
SUMMARY OF OIL SPILL CLEANUP LIMITATIONS FOR A CHRONIC PIPELINE LEAK INTO OFFSHORE MARINE WATERS AND ICE

Notes:
ACS = Alaska Clean Seas
bbls = Barrels
% = Percent
°F = Degrees Fahrenheit

1 = Offshore ice data for 1953 through 1975 (Cox, 1976:Appendix); 1975 through 1989 (Vaudrey & Associates, 1998:5, 6, and 9).

2 = Range of potential spill volumes from Table 8-5 for Alternatives 2, 3, 4, and 5. Volumes presented here include oil lost through a small leak (less than 0.15% of pipeline flowrate) before detection, plus total drainage of oil in pipeline after leak is detected and pipeline is shutdown.

3 = Oil spill response techniques from ACS, 1998 and BPXA, 1998b and (1998a).

4 = Performance of oil recovery methods is dependent on spilled oil properties, water conditions, surface current speed, and oil slick thickness. Recovery efficiencies presented here represent baseline performance information from literature. Unfavorable environmental conditions that delay or hinder oil spill response could result in lower oil recovery efficiencies. Delays in oil recovery during broken ice or open water conditions would increase the area contacted by the oil slick as it disperses, requiring available oil spill cleanup resources (equipment and personnel) to be spread out over a larger area.

5 = Operating limits that apply to all seasons: ambient temperatures below -35ºF to -40ºF for equipment; wind chill temperatures below -30ºF for personnel; white out conditions for vehicle travel; reduced visibility due to fog for aircraft and vessel traffic; wind speeds exceeding 15 knots for some cleanup equipment; wind speeds exceeding 20 knots for in situ burning..

6 = From Solsberg et al., 1992:99. Recovery efficiency is for a vacuum skimmer used in ice-fast conditions to remove No. 2 fuel oil and small ice pieces near Cleveland in 1977.

7 = Monthly wind speed data (S.L. Ross, 1998:Table B-2) used to calculate average time during seasons that winds exceed 15 and 20 knots.

8 = From USDOI, MMS, 1997: 43-46.

9 = Ice weight bearing capacity relative to ice thickness (ACS, 1998:Tactic L-7, page 5).

10 = From Evans, 1989:51.

11 = From Lichte, 1989:19.

12 = From BPXA, 1997b:61-62 and Table 5-3.

TABLE 8-9
IMPACTS OF A POTENTIAL OIL SPILL AND OIL SPILL RESPONSE ON THE PHYSICAL ENVIRONMENT

Resource Affected	Frequency	Duration Construction	Duration: Operation	Scope	Direct Impacts	Indirect Impacts
Geology and Hydrology	Rare	N/A	Unknown	Area contacted by oil - up to 200 miles (322 km) of coastline (Figure 8-4)	Significant - Contamination (sheens or free product) of soils, sediments, and surface water bodies from direct oiling and deposition of tarballs, potentially lasting for 5 to 10 years.	Minor - Thawing or disturbance of permafrost for the area (few hundred square yards) of vegetation damaged or removal during spill response.
Air Quality	Rare	N/A	Unknown	Air quality above the surface of the oil slick for first few days following the spill (Figures 8-4 and 8-5)	Minor - Release of volatile organic compounds to the air from the evaporation of 25% to 35% of the spilled oil.	Minor - Emission of criteria pollutants from machinery exhaust and/or in situ burning, temporarily reducing air quality for up to a few miles from the burn.
Marine Water Quality	Rare	N/A	Unknown	Marine waters contacted by oil - up to 200 miles (322 km) from the release site (Figures 8-4 and 8-5)	Minor - Dissolution and dispersion of hydrocarbons in water column (concentration depends on ice cover and time since release); State of Alaska water quality (chronic) criteria may be temporarily exceeded in water column in close proximity to the oil slick.	Minor - Dissolution and dispersion of hydrocarbons contained in/on ice into the water column following spring breakup.
Sea Ice	Rare	N/A	Unknown	Area contacted by oil - up to 200 miles (322 km) from the release site (Figures 8-4 and 8-5)	Minor - Reduction of mechanical integrity from melting or oil incursion into the ice and from ice scraping or drilling during spill response.	None anticipated.

Notes: km = Kilometers
N/A = Not applicable
% = Percent

TABLE 8-10
IMPACTS OF A POTENTIAL OIL SPILL AND OIL SPILL RESPONSE ON THE BIOLOGICAL ENVIRONMENT

Resources Affected	Frequency	Duration: Construction	Duration: Operation	Scope	Direct Impacts	Indirect Impacts
Plankton and Marine Invertebrates	Rare	N/A	Unknown	Marine water areas contacted by oil - up to 200 miles (322 km) from the release site (Figures 8-4 and 8-5).	Minor - Mortality of organisms contacted resulting in temporary (few days) reduction in population numbers in the affected area.	None anticipated.
Marine and Freshwater Fish Resources	Rare	N/A	Unknown	Marine and fresh water areas contacted by oil - up to 200 miles (322 km) from the release site (Figures 8-4 and 8-5).	Minor - Mortality of marine and anadromous fish as a result of oil toxicity, effects from physiological or behavioral changes, destruction of food organisms, and habitat damage.	None anticipated.
Marine Mammals	Rare	N/A	Unknown	Marine waters and ice contacted by oil - up to 200 miles (322 km) from the release site (Figures 8-4 and 8-5).	Minor - Potential mortality of beluga whales, not normally present in the areas likely to be contacted by oil; mortality of seals from direct contact with oil, consumption of oiled prey, injection during grooming, inhalation of vapors. Significant – Mortality of polar bears from ingestion of oil during grooming, consumption of oiled prey, or loss of insulation and subsequent hypothermia. A major oil spill(s) or the cumulative effects of many small spills, could have negative population effects for polar bears.	Minor - Disturbance to marine mammals from spill response activities and noise. Also, disturbance from icebreaking barge activities during broken/thin ice conditions may occur even though an oil spill has not (icebreaking barge activities are not expected to coincide with the fall bowhead migration past the project area).
Coastal Vegetation and Invertebrates	Rare	N/A	Unknown	Few hundred yards of tundra for onshore spills; coastline areas contacted by oil for offshore spills - up to 200 miles (322 km) from the release site (Figure 8-4).	Minor - Damage to tundra/coastal vegetation, with recovery potentially taking more than 5 years. Significant - Mortality of freshwater invertebrates; potential long-term impact to various invertebrate life stages due to contamination of sediments.	Significant - Damage to sensitive coastline vegetation from oil spill response activities.

TABLE 8-10 (Cont.)
IMPACTS OF A POTENTIAL OIL SPILL AND OIL SPILL RESPONSE ON THE BIOLOGICAL ENVIRONMENT

Resources Affected	Frequency	Duration: Construction	Duration: Operation	Scope	Direct Impacts	Indirect Impacts
Birds	Rare	N/A	Unknown	Marine waters, lagoons, and tundra areas contacted by oil - up to 200 miles (322 km) from the release site (Figures 8-4 and 8-5).	Minor - Mortality of waterfowl and shorebirds in onshore aquatic habitats due to direct contact with oil if a spill occurred during the summer. Significant – Mortality of birds in marine waters or lagoon areas due to direct contact with oil if a spill occurred during open water period.	Minor - Disruption of nesting or staging activities from spill response activities.
Terrestrial Mammals	Rare	N/A	Unknown	Tundra or shorelines contacted by oil - up to 200 miles (322 km) from the release site (Figures 8-4 and 8-5).	Minor – Potential mortality of individual Arctic foxes or grizzly bears from loss of fur insulative value, ingestion of oil during grooming, or consumption of oiled carcasses; to individual caribou through absorption and inhalation of vapors.	Negligible - Displacement of animals from hazing or cleanup activities, reduction of prey species, and displacement of caribou from oiled vegetation areas.
Threatened and Endangered Species	Rare	N/A	Unknown	Marine waters, lagoons, and tundra areas contacted by oil - up to 200 miles (322 km) from the release site (Figures 8-4 and 8-5).	Minor – To Steller's eider (few found in project area) from contact with oil or ingestion of oil contaminated food. Significant – Mortality of spectacled eiders from contact with oil along shorelines or in the lagoon areas during migration or from ingestion of oil contaminated food; injury and/or mortality of bowhead whales from an oil spill contacting the spring lead system coincident with migration.	Minor - Disruption of bowhead whale migration from noise and boat traffic related to cleanup, displacement of birds from habitats and disruption of nesting activities from oil spill response.

Notes: km = Kilometers
N/A = Not applicable

TABLE 8-11
IMPACTS OF A POTENTIAL OIL SPILL AND OIL SPILL RESPONSE ON THE HUMAN ENVIRONMENT

Resources Affected	Frequency	Duration: Construction	Duration: Operation	Scope	Direct Impacts	Indirect Impacts
Subsistence	Rare	N/A	Unknown	Barrow, Nuiqsut, and Kaktovik hunting and fishing areas contacted by an oil spill.	Minor - An onshore oil spill could reduce subsistence harvesting in hunting and fishing areas near the project area. Significant - An offshore oil spill and spill response activities could cause partial or complete suspension of subsistence harvesting due to destruction of habitat or displacement of marine mammals, fish, and waterfowl.	Minor – Localized disturbance from icebreaking barge activities during broken/thin ice conditions may occur even though an oil spill has not. Significant - Reduced or discontinued use of subsistence resources for years after a spill due to fears of resource contamination. Any effect on the bowhead whale population or reduction in hunting success could be reflected in reduced IWC harvest quotas for bowheads.
Cultural and Archaeological Resources	Rare	N/A	Unknown	Any of the identified sites or unknown cultural resources in the area that are contacted by oil (Figure 8-4).	Significant - Irreparable damage to historic artifacts and interference with radiocarbon dating tests from contact with spilled oil.	Significant - Onshore spill response activities could damage integrity of coastal and onshore sites.
Land and Water Use	Rare	N/A	Unknown	Marine waters, shorelines, or tundra contacted by oil - up to hundreds of miles from the release site (Figure 8-4).	Negligible – Change in land use due to disturbance or damage to tundra, vegetation, or surface water bodies as a result of contamination.	Negligible – Restricted access to areas for other activities during spill response and cleanup mobilization during the summer.
Socioeconomics	Rare	N/A	Unknown	State of Alaska, NSB, Anchorage, Fairbanks.	Significant - Loss of revenues and increased costs; sudden increase in high wage paying jobs and subsequent inflation due to hiring of local labor for cleanup operations; reduced access to community services due to a rapid expansion of workforce needed for cleanup operations.	None anticipated.

TABLE 8-11 (Cont.)
IMPACTS OF A POTENTIAL OIL SPILL AND OIL SPILL RESPONSE ON THE HUMAN ENVIRONMENT

Resources Affected	Frequency	Duration: Construction	Duration: Operation	Scope	Direct Impacts	Indirect Impacts
Transportation	Rare	N/A	Unknown	Dalton Highway and Anchorage, Fairbanks, and Deadhorse Airports.	Minor - Focused commitment of transportation resources during the initial phase of spill response efforts, which would taper as efforts stabilized.	None anticipated.
Visual/Aesthetics Characteristics	Rare	N/A	Unknown	Areas contacted by oil (Figures 8-4 and 8-5).	Negligible (Winter) - Reduction of quality of visual resources if spill occurred when viewer sensitivity would be low due to darkness and reduced level of outdoor activities; impacts would include staining of shoreline and presence of oil on the water. Minor (Summer) - Degradation of quality of visual resources if spill occurred when subsistence or recreational activities were ongoing (viewer sensitivity would be high); impacts would include staining of shoreline and tundra, plus presence of oil on the water.	None anticipated.
Recreation	Rare	N/A	Unknown	N/A	None anticipated	Negligible – Reduced enjoyment of recreational activities due to increased vehicle traffic along the Dalton Highway.

Notes: IWC = International Whaling Commission
N/A = Not applicable
NSB = North Slope Borough

CHAPTER 9.0

EFFECTS OF NOISE ON THE BIOLOGICAL AND HUMAN ENVIRONMENTS

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9.1 INTRODUCTION

Chapter 9 provides background information on noise effects on marine mammals, fish, birds, terrestrial mammals, and subsistence harvesting. Reactions of project-related noise to wildlife and fish are described by animal group using information from Traditional Knowledge and data acquired from western science. Potential effects of project noise on subsistence species are addressed, largely through Traditional Knowledge, to identify potential impacts to subsistence harvesting.

Issues/Concerns	Section
· Would noise from gravel mining affect polar bears?	9.8.2.1
· Would noise from the reconstruction of Seal Island affect polar bears?	9.8.2.1
· Would noise from construction drilling activities affect polar bears?	9.8.2.1
· Would island reconstruction and pipeline installation noise affect caribou or other terrestrial mammals?	9.8.2.1
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9.2 TRADITIONAL KNOWLEDGE

Traditional Knowledge is included in this Environmental Impact Statement (EIS) in acknowledgment of the vast, valuable body of information about the Arctic that the Inupiat people have accumulated over many generations. This knowledge contributes, along with western science, to a more complete understanding of the Arctic ecosystem. Although Traditional Knowledge has been accumulating for much longer than western science, it has been maintained orally and been recorded sporadically. While such transcriptions have occurred coincident to various research efforts, such efforts rarely have been focused directly on the topics of this EIS. Therefore, in this effort to collect references to Traditional Knowledge on specific topics such as likelihood of noise from the project displacing bowhead whales from traditional migration routes, the results are fragmentary and in no way represent the complete body of Traditional Knowledge on these topics.

Traditional Knowledge on the effects of noise was obtained from testimony by village elders, whaling captains, and other individuals from the villages of Barrow, Nuiqsut, and Kaktovik at the majority of hearings on North Slope oil and gas development projects held since 1979. Information also was obtained through personal interviews with interested individuals in and around the project area. Reviews of engineering studies and environmental reports associated with previous and ongoing oil and gas exploration and development activities provided a source of additional Traditional Knowledge. Published and unpublished scientific reports and data; and environmental reports and studies conducted by universities, the oil industry, federal and state agencies, and the North Slope Borough (NSB) also were used as sources for Traditional Knowledge.

Inupiat names are spelled according to the transcripts of the hearings, and some statements have been paraphrased to make the information readily understandable.

9.2.1 Introduction

The Inupiat Eskimos of northern Alaska have pursued the bowhead whale for generations during annual subsistence hunts. As a result, successive generations of Inupiat hunters have acquired an increasingly sophisticated knowledge of the ecology and behavior of these huge animals, particularly regarding the effects of noise on bowhead whale behavior. Hunters have observed the reaction of bowheads to noise, and have adapted hunting practices to minimize noise, particularly during the spring hunt. More recently, whaling captains and crews have observed the effects of seismic testing and associated noise on whale behavior and migration. Traditional and contemporary knowledge on noise and effects on whales are presented in this section.

9.2.2 Bowheads and Noise

It is well known among Inupiat hunters that bowhead whales are extremely sensitive to noise (H. Rexford in USDOI, MMS, 1979:13; R. Ahkivgak, H. Ahsogeak, and T. Brower in NSB, 1980:103, 104, 107; H. Brower in USDOI, MMS, 1990:10). Thomas Brower, Sr., a whaling captain from Barrow, testified that:

> *"In over thirty-six years of whaling I have seen how sensitive the bowhead whale is to noise and pollution .... whales are panicked by the sound [of an outboard motor] when I am as much as three miles away from them. I observe that in the fall migration the bowheads travel in pods of sixty to one hundred twenty whales. When they hear the sound of the motor, the whales scatter in groups of eight to ten .... in every direction"* (NSB, 1980:107).

John Craighead George, representing the NSB, pointed out, *"This is still a hunted animal, ... and animals that are hunted, ... are more shy and can be more easily frightened, particularly by marine boats, as they can't tell whether it's a hunting crew or just barge traffic."* (USDOI, MMS, 1983:57). Arnold Brower, of Barrow, noted: *"These whales communicate pretty much like any other animal communicates when there is an endangerment on their lives. [They] alert the other whales that there is an obstruction and noise or something in the area and abruptly there will not be any more migration of whales [in the area] for the duration of that particular time."* (USDOI, MMS, 1986:49). Thomas Napageak, a whaling captain and President of the Native Village of Nuiqsut, stated, *"... if the sound hurts the first whale, the leading whale* *in the migration ... will report to his fellow whales, and they will not be seen in their normal migration route."* (USDOI, MMS, 1995:13). Whaling crews have observed that after they make a strike, the resulting disturbance causes other whales to temporarily avoid the area, resulting in a small change in distribution of whales. *"Then everything goes quiet again and then the whales are distributed back to the way they were [prior to the strike]."* (J.C. George in USACE, 1996:64).

Effects from noise disturbances apparently continue even after the disturbance has subsided. Burton Rexford stated that it takes at least 2 weeks before the normal bowhead whale migration route is reestablished after such a disturbance (USACE, 1996:62). Noise from sources in the ice leads during the spring migration is apparently particularly disturbing (Worl, 1980:312).

Inupiat whalers have learned that bowheads will not tolerate short-term, high-stress disturbances; therefore, various precautions are taken prior to the start of the hunt, such as curtailment of noise from snowmachines, firearms, aircraft, and outboard motors and smoke-producing activities.

9.2.3 Short-Term Displacement of Bowheads Due to Noise Disturbance From Industry

Many Inupiat have observed that noise from oil and gas exploration and development adversely affects bowheads either by deflecting the fall migration or by causing the whales to become more wary. This displacement is a major cause of concern to Inupiat (G. Ahmaogak, 1995:4). A number of Inupiat men, with many years of experience hunting bowhead whales, have testified that short-term displacement and changes in behavior of bowheads is occurring as a result of noise disturbances. Frank Long, Jr., a whaling captain and President of Nuiqsut Whaling Captains Association, has been hunting bowhead whales since 1950. At the Minerals Management Service (MMS) Arctic Synthesis Meeting in Anchorage in 1995, he stated: *"I have been told from the time that I can remember that a whale will be startled or scared by a little sound. Even tapping on a boat will cause a whale not to surface. It will go farther out and leave you behind for sure."* (F. Long, Jr., 1996:73). He has also testified that: "*... during the fall when we're out on ice .... there are four leads that open up. And when the industry is heavy in their activity, we have to go all the way out to the fourth lead in order to meet our harvest .. quota."* (USDOI, MMS, 1995:24). However, bowhead whale harvest records indicate that three whales were landed at Nuiqsut during both 1992 and 1993, when offshore petroleum activities were occurring in the vicinity of the Kuvlum Prospect, 55 miles (88.5 kilometers [km]) to the east of Cross Island. The nature and duration of industry activity associated with Kuvlum, and the resultant effects on bowhead whale location and successful subsistence harvest during specific hunting periods is unclear. In 1995, Burton Rexford (MBC, 1996:80) stated, *"Throughout my 55 years of whaling ... I have observed ... the impact of underwater noise on bowhead whales."* In response to a statement in a draft EIS, that bowheads probably would avoid approaching within several kilometers of vessels attending a drilling unit, Arnold Brower testified that: *"The whale would not go out just several kilometers. It would go as far away as possible ... That's what we've encountered, and that happens over and over ever since offshore development began in Prudhoe Bay."* (USDOI, MMS, 1986:52).

Other Inupiat hunters with years of experience as members of whaling crews have also testified on the sensitivity of bowhead whales to noise. Jonas Ningeok of Kaktovik testified that, *"If the ships are* *around, [bowheads] don't come around at all, but if the ships are gone then they come back .... as long as there is noise they don't come around at all."* (USDOI, MMS, 1986:16). Frank Long, Jr., stated, *"Some years when there is a tremendous amount of activity in the Beaufort, especially ... [from] Prudhoe Bay all the way to Kuvlum . . ., it is very hard for us to harvest even one whale in a season, whereas when this activity is limited, it does not take us two weeks to ... meet our quota of four [bowhead whales]."* (USACE, 1996:34). Billy Oyagak, a whaler from Nuiqsut, stated that during fall 1985, interference from helicopters, ships, and drilling associated with Corona and Hammerhead drill sites made it difficult to find bowhead whales where they were normally found (USDOI, MMS, 1986:11). At the MMS Arctic Synthesis Meeting in Anchorage in 1995, Joseph Kaleak, a whaling captain from Kaktovik, stated: *"In 1985, no whales were landed [at Kaktovik]. That was due to the fact that there was a drill ship located about 18 miles east and ten miles offshore of Barter Island. So it was a bad year [for subsistence whaling at Kaktovik] because of that ship .... From 1992 to 1995 we had a very good whaling season, because there was no seismic survey activity and the whales were close to shore."* (MBC, 1996:69). Frank Long, Jr., (1996:73) has stated, *"It is very difficult to find even one bowhead whale when there is a lot of industrial activity."* Thomas Napageak testified that, *"We have ... never landed whales here in our community [Nuiqsut] ... when [offshore petroleum exploration] was underway."* (USDOI, MMS, 1995:13). However, bowhead whale harvest records indicate that three whales were landed at Nuiqsut during both 1992 and 1993, when offshore petroleum activities were occurring in the vicinity of the Kuvlum Prospect, 55 miles (88.5 km) to the east of Cross Island. The nature and duration of industry activity associated with Kuvlum, and the resultant effects on bowhead whale location and successful subsistence harvest during specific hunting periods is unclear. Noise and light from gas flaring at an oil rig, and light beams from the project may also disturb the migration, resulting in displacement of bowheads (L. Lampe in USACE, 1996:24).

Noise from seismic exploration is of special concern. Speaking on behalf of the Inupiat, Dr. Tom Albert, representing the NSB, stated, *"The noise that people are by far and away the most worried about is seismic marine exploration noise."* (USACE, 1996:70). Michael Pederson, of the Arctic Slope Native Association, concluded: *"Seismic noise from this proposed development [Northstar] will impact the migration route of the bowhead whale. The bowhead whale will be forced to swim further north, and most likely whaling crews ... will probably have to travel further out to sea to scout for bowhead whales."* (USACE, 1996:48).

Field observations by whaling crews support the notion that seismic noise displaces bowheads. During seismic exploration at Kuvlum in summer 1992, Inupiat whaling crews from Nuiqsut spotted no bowhead whales in the usual migration corridor, but observed that the main fall migration had shifted 40 miles (64 km) farther out to sea than during previous years (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:16). However, bowhead whale harvest records indicate that three whales were struck within 11 miles (17.7 km) of Cross Island during 1992. It is unclear whether industrial activities offshore may have caused temporary changes in normal migration patterns within the overall migration period. Billy Adams, a subsistence whaler born and raised in Barrow, stated: *"I can remember when a seismic ship was doing some work near Barrow during the fall whaling season. In that year [1986] we did not spot any whales, because the noise was disturbing the migration route of the bowhead whale."* (USDOI, MMS, 1995:26). Harry Brower, Jr., has stated, *"I've had personal observations [of] bowhead* *whales being diverted further out from shore due to seismic activity."* (USDOI, MMS, 1995:84). He used a Global Positioning System to record the position of locations where whaling crews had killed bowheads, and observed that when drill ships were around, whaling crews did not find bowheads where they normally occur, and crews had to travel farther offshore to hunt whales.

Eugene Brower, a whaling captain from Barrow and President of the Barrow Whalers, testified that:

> *"... not too long ago, we had that experience of the "Arctic Rose," a seismic boat that did a high frequency resolution study off Cooper Island. During that fall season, my fellow whalers had to go far out to go look for the bowhead whale. .... In the following year .. the platform drilling ship "Cabot" was put out there to do some drilling. Just from the noise from that drilling ship sitting idle, you could not find the bowhead whales where you normally find them. [The whalers] had to [go] farther and farther out, ... and the four whales that were caught, when the drilling platform was out there, were caught off Cape Simpson. That's almost 60 miles to the east of us ... When the seismic activity is going on to the east, ... the migration route off ... Barrow [is] farther out than the normal migration route"* (USDOI, MMS, 1995:29-30).

Herman Aishanna of Kaktovik, a representative of the Alaska Eskimo Whaling Commission (AEWC), stated: *".. we think [seismic activity] might be diverting the migration route of the bowhead ... I'm very opposed to the seismic boats at this time of the year when the bowheads are traveling back ..."* (USDOI, MMS, 1983:39). In 1995, Burton Rexford (MBC, 1996:80) stated: *"When the oil industry was doing seismic work during the fall migration, my two colleagues and their whaling crew members completely searched these above locations and beyond. The entire month of September was spent in our attempts to locate bowhead whales, resulting in nothing. Not only were there no bowheads, there also were no belukhas nor gray whales to be seen."*

Dr. Tom Albert, of the NSB, summarized the experiences of Inupiat hunters regarding the effects of seismic studies on bowhead whales by stating, *"The hunters that go out, feel that the reaction [of bowheads to seismic noise] is on the order of 10 miles or more."* (USDOI, MMS, 1995:41).

9.2.4 Long-Term Displacement of Bowheads Due to Noise Disturbance From Petroleum Exploration

Inupiat have repeatedly testified that long-term displacement of bowheads is occurring in response to industrial activity in the Alaskan Beaufort Sea. Inupiat whaling captain Patsy Tukle testified that: *"... the whales are going around the area [with offshore drilling]. They are not seen as they used to be any more. Helicopters are interfering and ... ships are [too]."* (USDOI, MMS, 1986:23). Joash Tukle, a whaling captain from Barrow, testified that: *"...since the offshore drilling started ... near Prudhoe or east of there ...during fall ... it would seem that the bowhead[s] [have] taken another route on the Arctic Ocean ... all this began to change as the offshore drilling started."* (USDOI, MMS, 1987:47). Eugene Brower, representing the Barrow Whaling Captains Association, stated, *"Bowhead[s] [will] be displaced from their route of migration from traffic and noise associated with the exploration and development of* *oil and gas."* (USDOI, MMS, 1987:15). Whaling crews are having to travel further distances out to sea to find bowhead whales, *"Leading to spoilage of meat because we have to go another 30 miles or 40 miles."* (D. Rexford in USACE, 1996:41). This increased distance also increases the risks to the whalers, and can contribute to spoilage of meat before the whale can be butchered.

John Craighead George, representing the NSB, has stated: *"For years I have heard whalers say that industrial noise displaces bowheads in the fall migration ... and I am more and more convinced that there is a big difference between a short-term strong disturbance [from the hunt] and a long-term continuous low-level disturbance [from industrial activity]."* (USACE, 1996:63). George Ahmaogak Sr. (1989:595-596), former Mayor of the NSB, stated that, *"We [Inupiat] feel that industrial noise, especially noise due to seismic exploration, has already displaced the fall migrants seaward and is thereby interfering with the subsistence hunt at Barrow."*

Loren Ailers of Kaktovik, representing the City Council, summarized the feelings of many Inupiat who have been testifying at hearings since 1979 by stating that oil and gas exploration would, *" ... have long-term and possibly devastating effects on the bowhead whale."* (USDOI, MMS, 1982:8).

9.3 INTRODUCTION TO SOUND

The effect of industrial noise associated with the project on marine mammals, terrestrial mammals, and birds was a concern raised during the scoping process. A general discussion of noise is provided in this section to assist the reader in understanding potential effects which may result from this noise.

Sound generally is characterized by a number of variables including frequency and intensity. Frequency describes a sound's pitch and is measured in Hertz (Hz), while intensity describes a sound's loudness and is measured in decibels (dB). Hertz is a measure of how many times each second the crest of a sound pressure wave passes a fixed point. For example, when a drummer beats a drum, the skin of the drum vibrates a number of times per second. A particular tone which makes the drum skin vibrate 100 times per second generates a sound pressure wave that is oscillating at 100 Hz, and this pressure oscillation is perceived as a tonal pitch of 100 Hz. Sound frequencies between 20 and 20,000 Hz are within the range of sensitivity of the best human ear, and the decibel level measured is called the A-weighted sound level (dBA).

Sounds from a tuning fork (a pure tone) contain a single frequency, but most sound sources contain a mixture of many different frequencies. For noisy industrial sources, sound energy usually is distributed across a wide spectrum of frequencies.

Decibels are measured using a logarithmic scale such that an increase of 3 dB represents a doubling of noise intensity. The decibel is a relative measure of intensity, and it is always referenced to a standard level. Sound intensity measured in air uses a standard level of 20 microPascal (μPa), while sound intensity measured in water uses a standard level of 1 μPa. The distinction between in-air and in-water reference levels is important since sound intensity in water would appear extremely high compared to values in air. Values of sound intensity are always specified in terms of their reference level. For example, one might read that the in-air intensity of a fog horn was 130 dB relative to 20 μPa, while the in-water intensity of a boat was 142 dB relative to 1 μPa. The actual in-air equivalent of the ship's intensity, given the differences in reference levels and in the densities of air and water, would be 80 dB. Using the in-air standard, 120 dB is the threshold of pain for humans, and the equivalent sound energy level in water (but not necessarily the threshold of pain) would be 182 dB. The relationship between sound pressure level (SPL), in dB, and sound pressure, in μPa, is a relatively simple one. SPL equals 20 times the logarithm (base 10) of a given SPL (P) divided by the reference pressure (Po):

SPL = 20 log (P/Po) (Richardson et al., 1995a:19).

Sound levels for noise sources are usually reported as the sound level at 3 feet (ft) (0.9 meters [m]) from the source, referred to as the "source level," or the sound level at a known distance from the source, referred to as the "received level." Source levels usually are estimated rather than measured, using a measured received level at a known distance from the source. Source level estimation relies on using some model of reduction of sound (attenuation) as a function of distance from the source. For low frequency sounds in shallow water, such as the nearshore Alaskan Beaufort Sea, sound attenuation is complex and best determined from empirical measurements.

Most environmental noise includes a conglomeration of noise from distant sources that create a relatively steady background noise in which no particular source is identifiable. A single descriptor called the "equivalent sound level" is used. Equivalent sound level is the energy-mean sound level during a measured time interval. It is the 'equivalent' constant sound level that would have to be produced by a given source to equal the fluctuating level measured.

9.4 EXISTING NOISE ENVIRONMENT (AMBIENT NOISE)

Ambient noise is background noise that clutters, masks, or otherwise interferes with sounds of interest. Ambient noise is a key element in the analysis of the effects of petroleum development on marine mammals because, in both air and water, natural and human made sound sources contribute to the ambient noise field. Most of these sounds are continuous and fluctuating, but some are short-term. For an animal attempting to use sound for a purpose, for example, one whale trying to hear the calls of a distant whale, ambient noise in the marine environment is the background over which an animal must hear sounds of interest.

Naturally-occurring ambient noise consists of sounds from sources such as wind, rain, breaking waves, bubbles, earthquakes, turbulence from currents, certain types of marine life and, in the Arctic, ice (moving and breaking). Surf noise in nearshore areas may contribute to increased ambient noise levels, but few data have been collected to document this. Marine life also contributes to ambient noise, since many species, such as snapping shrimp, seals, and whales, produce underwater noise. Ambient noise sources in the Arctic are variable depending on season, primarily waves and marine life during summer and grinding ice and blowing snow during winter.

The ambient noise environment onshore would vary with location and is dependent on the type of noise source, distance to a source, meteorological conditions, and ice/snow cover. Ambient noise levels in remote areas without manmade sources may be less than 40 dBA. Processing and compressor equipment, separators, pumps, generators, and vehicles within the Prudhoe Bay industrial complex are dominant noise sources throughout much of the area, and noise levels are dependent upon the mix of equipment types, local meteorological conditions, equipment operating conditions, and receptor locations. Locations near processing and compressor facilities, such as the Central Compressor Plant and activities in the vicinity of field operations or administration centers, would have consistently higher ambient noise levels than those of undeveloped areas, such as Point Storkersen and the Kuparuk River delta.

Underwater ambient noise levels at and near the vicinity of the Northstar Unit have been documented. In September 1984, hydrophones were placed in three different locations on the seafloor at distances of 1 to 1.5 miles (1.6 to 2.6 km) north and east of Seal Island and monitored hourly for a 9-day period (Davis et al., 1985:4). Activity in the vicinity of Seal Island and Prudhoe Bay during the monitoring period was limited to occasional boat traffic. No drilling or other operations were occurring in the area. In absence of boat traffic, sound levels tended to reflect wind speed. As wind speed increased, underwater noise levels increased (Davis et al., 1985:28). Ambient noise levels ranged from 79 to 123 dB, with 50 percent (%) of the measured values in the 20 to 1,000 Hz band occurring at 95 dB or less (Davis et al., 1985:32).

A second ambient noise study was conducted in September 1985 near the newly constructed Sandpiper Island and approximately 10.5 miles (17 km) north-northwest of Seal Island. Hydrophone data was collected at 0.6 miles (1 km) and at 0.3 miles (0.5 km) northeast of Sandpiper Island (Johnson et al., 1986:6). Because of industrial noise emanating from nearby Seal Island, ambient noise levels did not decrease much below 86 to 90 dB even under calm conditions, and when operations on the island were limited to the use of power generators, twice daily helicopter flights, occasional construction activities, and occasional tug-propelled barge traffic (Johnson et al., 1986:45). Ambient noise levels were between 83 and 115 dB, and 50% of the noise levels were at or less than 95 dB in the 20 to 1,000 Hz band. Wind speed during the period ranged from 20 to 40 knots (37 to 44 km/hour), thus accounting for some wave-generated noise at the site.

A third study of ambient noise was conducted in September 1985 at a site 1.5 miles (2.4 km) southeast of Sandpiper Island. Of the ambient noise levels recorded in the 100 to 1,000 Hz band using two hydrophones, 50% were below 76 and 83 dB at the 10 and 33 ft (3 and 10 m) depths, respectively (Miles et al., 1987:286-287). During the monitoring period, ambient noise levels were not influenced by industrial activity (Miles et al., 1987:81); however, wind speed averaged 10 to 15 knots (18.5 to 28 km/hour).

In the shallow arctic environment, received levels for seismic pulses are highly dependent on sound transmission (propagation) conditions, depth of water at the seismic source, depth of water at the receiver, depth of the receiver, and ambient noise level (Greene et al., 1998:3-61). Received levels at ranges beyond approximately 12.4 miles (20 km) were difficult to predict and there was no obvious dependence of received level on distance (Greene et al., 1998:3-19 to 3-20). Received levels for seismic pulses have been recorded above background noise at ranges of 74.5 to 84 miles (120 to 135 km) (LGL and Greeneridge, 1987:109; Hall et al., 1994:149-150). Around the Northstar Unit, received levels for distances greater than 6.2 to 10 miles (10 to 16 km) were highly variable. In 1996, received levels for seismic pulses at 41 miles (67 km) from an 11-airgun array were around 77 dB, but these pulses were detectable only on days with low ambient noise levels (Greene, 1997: 3-38 to 3-41). In 1997, the received levels of seismic pulses at 31 miles (50 km) from a smaller array were 80 to 115 dB (Greene et al., 1998:3-15 to 3-19, 3-62).

Noise at frequencies between 20 and 1,000 Hz is of special interest for this project because many sounds produced by arctic marine mammals are in this frequency range. Bowhead whale calls occur mostly between 80 and 400 Hz (Clark and Johnson, 1984:1437-1439; Würsig and Clark, 1993:664). Frequencies in the 50 to 500 Hz band have better than average transmission in shallow arctic waters and could affect a larger area than sounds in other frequencies.

Many mammals are unable to detect sounds of interest (e.g., calls from other animals) if strong background noise is present and contains frequencies near those of the sound of interest. This phenomenon is referred to as "masking." An example of masking is noise from a refrigerator making it more difficult to hear someone talking in an adjacent room. The masking band width is approximately 23% of the center frequency of a sound, and is typically referred to as the "1/3 octave band". Background noise within 23 Hz of the 100 Hz frequency could interfere with a whale's ability to detect the call of a distant whale in the band centered at 100 Hz.

The noise level from a source when measured within a few feet of the surface is 15 to 30 dB lower than the noise level when measured at water depths of 16 to 33 ft (4.9 to 10 m) (Jensen, 1981:1397). This indicates that exposure to noise would occur at the highest levels when an animal is well below the surface.

An acoustical monitoring program that evaluated noise transmission loss in the water near Seal Island was conducted during the 1996 Northstar seismic program. Resulting data were analyzed and it was concluded that the relatively shallow water surrounding Seal Island has a substantial reducing effect on received noise level (Greene, 1997:3-29).

9.5 AFFECTED BIOLOGICAL NOISE RECEPTORS

This section discusses reaction to noise by marine mammals, marine and freshwater fish, birds, and terrestrial mammals which may be in the project area.

9.5.1 Marine Mammals

The evaluation of impacts on animals requires interpretation and integration of results from many disciplines, including the study of sound wave interaction with the environment; how animals hear sounds; and how animals use sounds for communicating, navigating, and finding food. The evaluation and prediction of noise impacts on marine mammals is particularly difficult due to complications from unpredictable animal behavioral responses (Green et al., 1994:17-18). Therefore, information presented in this section is based on available western science data which is limited to discrete studies, and

Traditional Knowledge that has been gained by the Inupiat over generations.

9.5.1.1 Bowhead Whale - Responses to Noise

It is well known among Inupiat hunters that bowhead whales are extremely sensitive to noise (H. Rexford in USDOI, MMS, 1979:13; R. Ahkivgak, H. Ahsogeak, T. Brower, Sr. in NSB, 1980:103, 104, 107; H. Brower in USDOI, MMS, 1990:10). The bowheads sensitivity to noise has been attributed to hunting pressures from subsistence harvesting, as well as industrial noise (J. Craighead George in USDOI, 1983:57). Noise from an outboard motor at a distance of 3 miles (4.8 km) has been found to cause pods of whales to scatter and small sounds such as tapping on a boat can cause diving and avoidance reactions (T. Brower, Sr. in NSB, 1980:107; F. Long, Jr., 1996:73).

The potential impact of industrial noise on bowhead whales comes from the assumption that these animals rely heavily on sound as a means of communicating and navigating in the Arctic. Bowheads produce most of their vocalizations in the 50 to 400 Hz band, and there is circumstantial scientific evidence demonstrating that bowheads use sounds for communicating and navigating (Clark et al., 1986:345-346; Clark, 1991:578-579; George et al., 1989:24; Ellison et al., 1987:329; Würsig and Clark, 1993:192). Underwater sounds from industry are predominantly in the 50 to 1,000 Hz frequency band, and lower frequencies, especially those in the 100 to 400 Hz band, propagate efficiently in the shallow water, arctic environment (Greene, 1997:3-12 to 3-41). There is no direct evidence of bowhead auditory abilities; however, indirect evidence of auditory ability comes from studies of vocalizations (Clark and Johnson, 1984:1437-1439) and ear anatomy of large whales (Ketten, 1992:727-738). This evidence strongly supports the conclusion that bowheads have very good hearing for frequencies below approximately 400 Hz and, therefore, could be disturbed by industrial noise sources.

The response of a bowhead whale to acoustic disturbances is quite variable and depends on a number of biological factors, including the activity that the whale is engaged in at the time of the exposure to the noise. This dependency of behavioral response on the social activity of the animal is important since bowheads will be migrating past, but well offshore of, the project area in the spring and past, but closer to, the project area in the fall. Communications among whales during migration and in response to danger also has been observed to alter migration patterns (A. Brower in USDOI, MMS, 1986:49; T. Napageak in USDOI, MMS, 1995:13). Whaling crews have observed that disturbances to migration as a result of a strike, a short-term event, are temporary (J.C. George in USACE, 1996:64); however, industrial noise from the project would be continuous and long-term.

Two other behavioral responses, habituation and sensitization, also are important when discussing the potential reactions of bowheads to multiple exposures to a noise stimulus. Habituation refers to the condition in which repeated experiences with a stimulus that has no important consequence for the animal leads to a gradual decrease in response. Sensitization refers to the situation in which the animal shows an increased behavioral response over time to a stimulus associated with something that has an important consequence for the animal (Walker, 1949 as cited from Richardson et al., 1995a:250).

Seismic survey activities are not part of the project. They are, however, among the loudest noises in the region and are of concern to local residents and governmental agencies. Therefore, information related to seismic survey activities and their impacts to marine mammals are included in this chapter.

Seismic surveys can be conducted using either a hydraulic vibrator system (vibroseis) for on-ice seismic exploration, or a ship-based systems. Both systems generate short, intense bursts of underwater energy which may propagate for great distances.

The vibroseis system for seismic exploration operates from trucks driven over the ice. The system has a source level in water exceeding 184 dB (Cummings et al., 1983:419) and uses a slow sweep of frequencies to change the vibration rate, in contrast to the rapid explosion of ship-based systems described below (Richardson et al., 1995a:143).

Ship based systems for seismic exploration include sleeve exploders, open-bottom gas guns, and airguns, with airguns being the most common type of high energy source used in geophysical surveys (Richardson et al., 1995a:136-144). Sleeve exploders are cylindrical devices deployed under the water surface behind the ship. The cylinders contain a mixture of propane and oxygen which is exploded to produce a strong signal focused downward. Received sound levels of 148 to 153 dB have been recorded at 5 miles (8 km) and 115 to 117 dB at 16 to 18 miles (26 to 29 km) from a sleeve exploder (Greene and Richardson, 1988:2249). Propagation of seismic acoustic energy through the water depends on a number of variables, including sound velocity profile, water depth, and bottom composition. The maximum range out to which seismic noise is detectable is a function of source level (e.g., number of guns in the array), frequency, and ambient noise level at the location of the receiver. Open-bottom gas guns produce received levels of 177 dB at a distance of 0.5 miles (0.8 km) and 123 dB at a range of 9 miles (14.5 km) (Greene and Richardson, 1988:2250). A third type of device used for seismic studies is the air gun. Airgun arrays have a variety of source levels, depending primarily on the number of airguns in the array and the total volume of each airgun (Richardson et al., 1995a:137). Airgun arrays are designed so that most of the energy propagates downward, so there is a difference in the vertical and horizontal characteristics of the sound field generated by an airgun array. Richardson et al. (1995:136) provides an equation for calculating source levels (Ls) based on peak-to-peak pressure (Pa):

$$Ls \text{ (dB re 1 } \mu\text{Pa-m)} = 20 \text{ Log (Pa)} + 220$$

In general, peak-to-peak pressure is directly proportional to total volume of the array, for example, a 1,000 in 3 airgun has a level that is 6 dB greater than a 500 in 3 airgun.

With respect to the potential effects of seismic impulses on bowhead whales, the characteristics of the seismic sound as received by the whale are of greater importance than the airgun array's source level. For seismic sources, received level, frequency content, and signal-to-noise level (ratio of seismic received level to ambient noise level) have been the acoustic characteristics of greatest interest. Single airguns have lower source levels than most arrays, producing levels of 129 dB at a distance of 3 miles (4.8 km). Received levels of 148 to 179 dB have been measured from airgun arrays at distances of 1.2 to 7 miles (1.2 to 11.3 km) (Greene, 1988:2252).

Recent analysis of empirical data collected during seismic operations in the project area provide the most appropriate information on estimating the propagation ranges for seismic pulses (Greene, 1997:3-12 to 3-41). An important conclusion was that both the frequency content of the propagating airgun signals and the rate of fall-off with range were substantially affected by the water depth in the shallow waters of the survey area (Greene, 1997:3-26). Using an empirically verified model, the estimated received levels at 2.6 miles (4.2 km) for an array of 11 airguns operating at a source level of 222 dB was 160 dB (Greene, 1997: 3-37).

As discussed previously in Section 9.4, received levels for airgun arrays have been difficult to predict at ranges beyond 6.2 miles (10 km). In 1996 and 1997, Greeneridge Sciences, Inc. collected extensive field measurements in the Northstar Unit area and documented the characteristics of seismic pulses as a function of distance from the airgun array (Greene et al., 1998). They also measured ambient noise to help predict the percentage of time that seismic pulses would be greater than ambient noise levels at different ranges. They concluded that received levels were highly variable, especially at distances greater than 6.2 miles (10 km) and that detection of the seismic pulses was even more variable because of the high variability in ambient noise (Greene et al., 1998:3-61). For both years, although different airgun systems were used and water depths varied, there was generally good agreement between the received level at different ranges as estimated from a least squares fit to the empirical data. The received levels of the best fit at different ranges were as follows:

- At 6.2 miles (10 km) - 127 to 132 dB with a range of 110 to 144 dB.
- At 12.4 miles (20 km) - 114 to 116 dB with a range of 96 to 131 dB.

- At 18.6 miles (30 km) - 105 to 106 dB with a range of 86 to 123 dB.
- At 24.8 miles (40 km) - 97 dB with a range of 78 to 116 dB.
- At 31 miles (50 km) - 90 to 91 dB with a range of 72 to 110 dB.

For bowheads, as with most animals, there is a general tendency for the level of response to manmade noises to match the level of variability and unpredictability in the sound source. Animals will show little to no response to a noise source with a relatively constant intensity level and frequency spectrum (e.g., a humming generator, operational drilling platform) but will react to a noise source that is rapidly changing in intensity or in frequency content (e.g., an exploration drilling platform, icebreaking activity).

Drilling Noise: Bowhead whale responses to noises from drilling activities are expected to depend on the type of activity and its location relative to the whales' normal migration corridors. Noise levels from a gravel drilling island are expected to be low (Richardson et al., 1995a:127). Measured noise levels in the 20 to 1,000 Hz band have been less than 109 dB, with highest noise level components below 200 Hz, and detectable under very quiet conditions only out to ranges of less than 0.6 to 6.2 miles (1 to 10 km) (Johnson et al., 1986:49; Malme and Mlawski, 1979:1). Noise source levels of top-drive rigs operating on gravel islands seem lower than for other types of equipment (Richardson and Malme, 1993:647). There are too few observations of whales near drilling islands to reach a conclusion based on direct evidence. Between September 24 and 26, 1984, three bowheads were reported 3.1 miles (5 km) east-southeast of Seal Island, more than a week after termination of exploratory drilling and during a period with only maintenance activities (Davis et al., 1985:1, 64). The study concluded that the bowhead migration pattern had not been altered as a result of drilling noise or the presence of maintenance activities; however, only a small number of whales were observed in the study and the observation of whales near the drill site was made a week after drilling activities stopped.

Bowheads will tolerate high noise levels when there are no alternatives to avoiding the high noise level (for example, when heavy ice constrains their ability to move into lower noise areas). However, when noise levels become too high or the noise is highly variable and unpredictable and other routes are available, whales will avoid moving through noisy areas. Inupiat hunters have reported that bowheads have been displaced offshore by drilling and seismic activity and avoid areas of high noise created by these activities (G. Ahmaogak, 1985:29; 1989:595-596; 1995:4; D. Rexford in USACE, 1996:41). These observations have been supported in some cases by aerial and acoustic survey results (LGL and Greeneridge, 1987:12; Miller et al., 1997:5-107).

There are no conclusive empirical data for directly evaluating the potential impact of BP Exploration (Alaska) Inc.'s (BPXA's) proposed drilling program on bowhead whales. A partial study was conducted in 1984 off Seal Island during and after drilling and well-logging operations, but sample sizes were too small to draw firm conclusions about either changes in bowhead distribution or behavioral responses (Davis et al., 1985:62-64). Studies have been conducted evaluating the potential impact of other types of drilling activity, including an offshore drillships (LGL and Greeneridge, 1987) and the floating drill rig Kulluk (Hall et al., 1994). Conclusions from these studies, although not directly applicable to the drilling program for BPXA's proposed project, provide some general insight into the impacts of offshore drilling operations on bowheads. For BPXA's proposed project, noise levels are expected to be much lower than those from offshore drillships or floating rigs operations and, therefore, potential impacts are expected to be less.

An obvious response of bowhead whales to noise from drillship drilling operations was observed in 1986 at the Corona and Hammerhead sites, approximately 60 miles (97 km) east of the project site, when monitoring was conducted up to 18.6 miles (30 km) from the drill site (LGL and Greeneridge, 1987:41). One whale appeared to avoid an active drill ship by moving in an arc around it, maintaining a distance of 13 to 15 miles (21 to 24 km). No bowheads were observed closer than 6 miles (9.7 km) from the drillship; a few were observed within 9 miles (14.5 km). Overall, the study concluded that migrating bowheads appeared to avoid the offshore drilling operation (LGL and Greeneridge, 1987:47).

Apparent avoidance reaction of bowheads to drilling operations was noted during the 1992 Kuvlum drilling project. None of the 49 whales seen during 141 hours of aerial survey were within 18.6 miles (30 km) of the drilling site, and the average distance was about 24.8 miles (40 km) (Hall et al., 1993:2-3). The whales also moved past the area of industrial activity in a narrow corridor to the north of the drilling location (Hall et al., 1993:66). Bowhead calling rates peaked at 20 miles (32 km) from the drilling area. This distance was close to the range at which the observed whales started deviating in an arc north of the drilling unit, suggesting that the whales were attempting to maintain social cohesion and group coordination before initiating the deviation (Hall et al., 1993:68). This apparent displacement continued until about 18.6 miles (30 km) west of the industrial activity, where migrating bowhead whales again formed a dispersed pattern (Hall et al., 1993:67). Although interpretation of these results was confounded by heavy ice conditions, the authors concluded that floating drilling units may cause bowheads to shift their migration distribution (Hall et al., 1993:46-48).

Bowhead whales showed no avoidance of an idle bottom-founded drilling platform during monitoring of the Fireweed prospect (Hall et al., 1991:33-38). Results from a second study with the same platform during a period when generators and pumps were running but drilling was not underway showed no obvious avoidance of the platform (Gallagher et al., 1992:41-72).

Aircraft Noise: Bowhead response to helicopters and airplanes varies with social context, distance from the aircraft, and aircraft altitude. Whales often react to an aircraft as though startled, turning or diving abruptly when the aircraft is overhead. Bowheads seem particularly responsive when they are in shallow water, which may be a result of the efficient generation of aircraft sounds in shallow water (Richardson et al., 1995a:249). Bowheads sometimes seem startled by the shadow of a plane rather than its noise. When whales are at the surface, they may detect the sound of an aircraft in the air rather than the water.

Bowhead whales reacted to a circling piston-engine aircraft frequently when it was less than 1,000 ft (305 m) altitude, infrequently when it was at 1,500 ft (457 m), and rarely when it was at greater than 2,000 ft (610 m) (Richardson et al., 1995a:249). Bowheads in shallow water were reported to be especially responsive to airplane noise, with the most obvious response being a rapid dive. Bowheads seem less responsive to helicopters, even at altitudes as low as 500 to 750 ft (150 to 230 m) (Richardson and Malme, 1993:668).

Vessel Noise: Avoidance reactions of bowhead to small boats have been observed at distances up to 2.5 miles (4 km), but most reactions have been observed at ranges of less than 1.2 mile (2 km), often when measured levels of underwater noise were less than 90 dB in the 1/3 octave band of maximum noise (Richardson et al., 1985 as cited from Richardson et al., 1995a:268). The strongest responses are for whales observed within 0.6 miles (1 km) of an approaching vessel.

Inupiat hunters have reported that bowheads are frightened by vessel noise and that bowheads would avoid approaching vessels that are attending a drilling vessel. Furthermore, hunters have noticed that whales are not present when vessels are present, but return in the absence of vessel operations. Hunters also believe that whales will avoid areas with ship activity by traveling as far as possible from the activity (A. Brower in USDOI, MMS, 1986:52; J. Ningeok in USDOI, MMS, 1986:16).

Bowheads respond to boats by spending less time at the surface, taking fewer breaths when surfacing, and changing swimming speed and direction at distances of at least 2.5 miles (4 km) from the vessel (Richardson et al., 1995a:116; Koski and Johnson, 1987:59-61). In one case a mother and calf reacted when the nearest approaching vessel was approximately 9.3 miles (15 km) away. Operating icebreakers appear to elicit the strongest avoidance responses from bowheads compared to other manmade noise sources (icebreaking barge/tug combinations make less noise than traditional icebreaking vessels; Section 9.7.4). Of 49 bowhead whales observed during the 1992 Kuvlum drilling operations, none were observed closer than 14 miles (22.5 km) from an icebreaker operating at the site, and bowhead calling rates peaked at 20 miles (32 km) from the drilling area (Hall et al., 1993:66-69). This distance was close to the range at which the observed whales started deviating in an arc north of the drilling unit (Hall et al., 1993:68). It should be noted that the year the field work was carried out (1992) was a very heavy ice year, and ice floes several miles across surrounded the icebreaker. Because of the complicating factors of ice and industrial activity, the authors of the report were unable to determine whether ice or industrial activity caused the whales to migrate to the north of the project site. They did, however, state that ice alone was unlikely to have caused the whales to arc north of the site.

Whales usually avoid an approaching vessel by trying to outswim it, and response is probably mediated more by the rate of increase in the noise level than by the absolute received level. If overtaken, the whale will turn to swim away from the path of the vessel. Bowheads seem to respond differently to a vessel depending on whether it is approaching, moving slowly, or stationary (Richardson et al., 1995a:268-270). Overall, bowheads seem to consistently stop whatever they are doing and flee from approaching vessels of all types and sizes. In contrast, vessels that are idling, moving slowly, or not approaching in the direction of a whale do not cause this flight response (Richardson et al., 1995a:268-270).

Seismic Survey Noise: Although quantitative estimates are not available, in all likelihood seismic survey sounds are among the loudest and most prevalent of any industrial noise source, are the most ubiquitous industrial noise source, and introduce more total sound energy into the arctic water than any other industrial noise source. Furthermore, a seismic survey impulse is a sound with enough acoustic energy to cause physical harm to a nearby marine mammal ear (Ketten, 1992; Ketten et al., 1993). Bowhead whales are possibly the most sensitive marine mammal to seismic survey sounds because their hearing is expected to be the most sensitive to low frequency noise (i.e., 100 to 400 Hz) that can propagate over long distances. However, this does not necessarily mean that bowheads are the species most susceptible to biological impact.

Although BPXA's proposed project does not include seismic surveys, information on whale reactions to seismic survey noise could be relevant. Recent data on seismic noise transmission and bowhead responses to seismic operations in the Northstar Unit have come from monitoring efforts carried out as part of the 1996 and 1997 BPXA Seismic Survey project (Richardson, 1997, 1998). These results show that no whales were seen within 13 miles (21 km) of the seismic site during active seismic periods, but numerous whales were seen within 1.2 to 12.4 miles (2 to 20 km) of the site during periods without active seismic operations (Richardson, 1998:5-60 to 5-62). Richardson (1998) concluded that these "results suggest that bowheads avoid waters near seismic operations." Traditional Knowledge of bowhead hunters includes strong impressions about the reactions of bowheads to seismic survey activities (T. Napageak in USDOI, MMS, 1995:13; B. Adams in USDOI, MMS, 1995:26; H. Brower, Jr. in USDOI, MMS, 1995:84; B. Rexford in MBC, 1996:80; E. Brower in USDOI, MMS, 1995:41; 17 Whalers in MBC, 1997:Attachment C).

There have been various efforts to document the type and level of responses that bowheads have to seismic survey noise. Some have relied on visual observations from an airplane or vessel to look for avoidance response or changes in distribution, and some have included acoustic monitoring to document changes in vocal behavior, as well as to measure sound levels at known distances from the seismic activity.

In 1984, the MMS supported a study during which bowhead groups were observed for up to several hours prior to the operation of a seismic vessel and then during the approach of that vessel while operating its seismic array. Obvious responses were noted. Some animals responded when the vessel was less than 6 miles (9.7 km) away, and one group showed strong avoidance at a distance of 3.1 miles (5 km) from the operating seismic vessel (Ljungblad et al., 1985:45). The most obvious responses of bowheads to the approach of the vessel were changes in dive and surface behaviors, which occurred at ranges of up to 6 miles (9.7 km). When seismic operations were within 1 mile (1.6 km) of the whales, they swam rapidly away from the vessel. Interpretation of these results, in terms of bowhead response range to seismic vessels when surveys were being conducted, is complicated by a lack of control data since other seismic vessels were operating during all phases of the experiments. Therefore, the maximum distance out to which whales were observed consistently responding should be considered the minimum range within which responses occur. Results of the study were presented to the International Whaling Commission Scientific Committee in 1984. After review, the committee recommended that additional research be conducted and the results of the 1984 study be subjected to rigorous re-analysis.

There are important recent results indicating that bowheads respond to seismic operations. Acoustic call counts from bottom-mounted recorders operating during 1996 seismic survey operations, indicate that bowhead call rates change depending upon the range from the seismic operation and whether seismic activities were occurring or not occurring. Bowhead call rates from the bottom-mounted recorder operating closest to the seismic operation were lower during hours with seismic operations than during hours without seismic operations, while call rates from the recorder furthest from the seismic activity were more than twice as high when seismic operations occurred than when it did not occur (Greene et al., 1998:3-57). These results suggest that some bowheads diverted offshore when passing the Northstar area during seismic activity or that some bowheads decreased their calling rates. Aerial survey data from 1996 and 1997 further suggest that bowhead whales avoid areas with seismic operations (Miller et al., 1998:5-59 to 5-63). When the 1996 and 1997 aerial data were combined, all 52 sightings noted during periods of seismic activity, and within 3.5 hours following seismic operations, were greater than 12 miles (20 km) from the source. The consistency between these results based on two different methods (acoustic and aerial survey) lend strong credibility to the conclusion that whales are displaced by seismic activity.

Whaling crews have noted that seismic surveys conducted near Barrow, Cross Island, and Kaktovik have been responsible for altering migration patterns and for failures in harvesting success. Unsuccessful harvesting seasons have been found to closely correlate with seismic survey activities (T. Napageak in USDOI, MMS, 1995:13; B. Adams in USDOI, MMS, 1995:26; H. Brower, Jr. in USDOI, MMS, 1995:84; B. Rexford in MBC, 1996:80). Harvest success and whaling quotas are presented in Tables 7.3.2 and 7.3.3 respectively. The extent of the migration pattern displacement has required hunting to be performed further offshore than otherwise would be the case (E. Brower in USDOI, MMS, 1995:29-30). The displacement has required whaling to be performed at least 10 miles (16 km) further offshore than would be the case without seismic survey activities (T. Albert in USDOI, MMS, 1995:41); however, migration patterns are believed to change at distances of 35 miles (56 km) from seismic source vessels and to shift the migration path as much as 30 miles (48 km) from the normal migratory path (17 Whalers in MBC, 1997:Attachment C). During the last several years, seismic and other oil exploration activities have been coordinated with the AEWC to minimize adverse effects on subsistence whaling, and have lead to stipulations in agreements with the AEWC.

Analysis of the bowhead sightings (179 whales) from the aerial surveys during BPXA's 1996 and 1997 seismic programs indicate that those programs did not greatly influence the position of the migration corridor (Miller et al., 1998:5-58). However, the power of this conclusion is limited by the small number of bowhead sightings during seismic activity (8 whales) or within 3.5 hours of seismic activity (13 whales).

9.5.1.2 Beluga Whale - Responses to Noise

Beluga whale hearing is poor below 1,000 Hz, and their best sensitivity is in the 10,000 to 100,000 Hz (10 to 100 kilohertz [kHz]) band (Awbrey et al., 1988:2274; Johnson et al., 1989:2653). This range of sensitivity is indicative of the beluga's use of high frequency sounds for echolocation (locating objects by emitting high-pitched sounds). Low frequency hearing tests by Johnson et al. (1989:2651) on one beluga did indicate it could respond to sounds as low as 40 to 75 Hz. However, more recent experiments suggest that at these low frequencies the animal is not necessarily responding to sound but may instead be responding to particle motion in the near-field of the loudspeaker (Turl, 1993:3006-3008).

Belugas are known to produce a wide variety of sounds, some of which are audible to humans and some of which are ultrasonic. Beluga whistles are in the 2 to 6 kHz range, but some are as low as 260 Hz (Schevill and Lawrence, 1949:143-144). Recent studies further described an extensive repertoire of free-ranging beluga sounds in the frequency range below 16 kHz produced during a variety of activities (Sjare and Smith, 1986:408-413).

Beluga responses to acoustic disturbances are quite variable and depend upon a number of biological factors, including the activity of the animal when exposed to the noise (Richardson et al., 1995a:247). Habituation and sensitization also are important when discussing potential reactions of belugas to multiple exposures of a noise stimulus. Belugas have often shown little to no response to loud sounds and avoidance reactions to very faint sounds. Belugas showed no responses to recorded playback of loud fishing boats or exposure to high sound levels at close range, while others showed avoidance reactions to icebreaking ships at ranges of up to 50 miles (80 km) (Cosens and Dueck, 1988:52; Richardson et al., 1995a:257-259). This may be interpreted as an example of how belugas habituate to human made noises depending on their experiences (Richardson et al., 1995a:282-283).

Construction Noise: There have been no observations made that would provide information about belugas' reaction to on-ice construction traffic, trench digging, and island construction as proposed for Northstar development. The closest similar activity may be a stationary dredging operation where belugas showed little reaction and approached to within 1,312 ft (400 m). Moving barges caused a greater reaction (Ford, 1977; Fraker, 1977 as cited from Richardson et al., 1995a:279). Interpretation of the stronger reactions to moving barges was that the moving barges blocked the free movements of the whales along a shoreline.

Belugas have been observed in close proximity to drilling operations on an artificial island, where they were seen regularly within 328 to 492 ft (100 to 150 m) of the island (Fraker, 1977 and Fraker and Fraker, 1979 as cited from Richardson et al., 1995a:282).

Beluga responses to aircraft can depend on the social context, environmental conditions, and aircraft altitude (Richardson et al., 1995a:247-248). For example, feeding belugas appeared undisturbed by an aircraft at 1,500 ft (457 m), while lone animals dived in response (Bel'kovich, 1960 as cited from Richardson et al., 1995a:247). Some belugas have been observed reacting to aircraft by swimming away or diving, but this reaction is variable and usually occurs when the aircraft is below 1,500 ft (457 m) (Finley, 1982:4-5). Inupiat hunters suspected low-flying aircraft were responsible for preventing belugas from entering a bay along the Alaskan Beaufort Sea coast (Burns and Seaman, 1985:108).

Reactions to vessels are variable depending on social context, habitat, vessel type, and movements. Some of these reactions are learned through repeated negative associations with certain types of vessel noises and movement patterns when the belugas are being hunted. Belugas migrate back to traditional areas each spring, even in areas where hunting is extensive, despite the negative association (Fraker and Fraker, 1979:4-5). Similarly, belugas can be very tolerant of disturbance when the vessels operate predictably and consistently (Fraker, 1977 as cited from Richardson et al., 1995a:256). Belugas feeding or traveling are not as likely to react to fishing boats as they are to boats with outboard motors (Frost et al., 1984). This may be because outboards produce more high frequency sound than fishing boats, and beluga hearing sensitivity improves with higher frequencies (Richardson et al., 1995a:257).

In contrast to the varied reactions of belugas to small vessels and boats, belugas have been observed responding strongly to icebreaker vessel noises at ranges of up to 31 miles (50 km) (Cosens and Dueck, 1988:52). Belugas responded at long ranges by swimming rapidly away from the approaching icebreaker vessel, changing the types of calls produced, and changing their diving behaviors. Belugas also avoided the area for up to 1 to 2 days after the vessel activity ceased. These strong reactions are unusual and are probably the result of the whales being confined by heavy ice; large ships of this type are rare in the high Arctic in the spring, and conditions were such that the ship sounds propagated a long distance (Richardson et al., 1995a:257). Estimates indicate that belugas may hear sounds in the 5 kHz band at 16 to 19 miles (25 to 30 km), whereas hearing thresholds limited the range of detection for lower frequencies and ambient noise limited the range of detection for higher frequencies (Cosens and Dueck, 1988:296).

Seismic Survey Noise: The effects of seismic survey activities on beluga whales and other marine mammals are a concern to North Slope residents (including subsistence harvesters), agencies, and industry. Although the level of concern is similar to that of the bowhead, belugas are less frequently taken in the project area as part of subsistence harvesting. The overall migration pattern of the species is similar to that of the bowhead; however, the main body of the migration pattern typically is further offshore in the project area than that of the bowhead and, therefore, less accessible to hunters.

Studies documenting reactions of beluga whales to seismic survey activities are limited to a monitoring program that was carried out as part of a fall 1996 BPXA seismic survey, which included waters from the West Dock causeway to about 28 miles (45 km) northwest of West Dock and approximately 8 miles (13 km) offshore from the barrier islands. The northern margin of the area surveyed bordered the southern margin of the usual beluga migration pattern.

Marine mammal monitoring during the seismic survey indicated that no reactions to seismic activity (including vessel movement) were noted (Miller et al., 1997:5-5 to 5-109). However, due to the relatively few whales observed and their distance from the source vessel, a conclusion regarding impacts from seismic activities on beluga whales cannot be made.

9.5.1.3 Ringed Seal - Responses to Noise

Ringed seal are sensitive to underwater sounds in the 1,000 to 60,000 Hz band; however, there are no data on hearing thresholds below 1,000 Hz (Terhune and Ronald, 1975:230). Most observations of ringed seals have been on animals hauled out on ice or inside their subnivean (under ice) lairs, as determined by radio telemetry (Kelly et al., 1986; Kelly, 1988). No data are available on their reactions to underwater sounds because of the difficulty of observing these small animals in water.

Ringed seals produce relatively low intensity sounds that are mostly calls below 5 kHz (Schevill et al., 1963:51-52; Stirling, 1973:1594). Nothing is known of the biological functions for these sounds; however, given that the calls are low intensity, in the mid-frequency range, and are not songs, they presumably are used for communication over short ranges in association with reproduction and territorial identification.

Construction Noise: Some localized displacement of ringed seals probably occurs around areas with intensive on-ice traffic and construction (Green and Johnson, 1983:22). Studies suggest that ringed seals avoid the immediate vicinity of industrial activity areas. In a study conducted by Frost and Lowry (1988:22), ringed seals were found to be less abundant within 2 nautical miles (5.9 km) of artificial islands in the central Beaufort Sea than within areas 2 to 4 nautical miles (5.9 to 11.9 km) from the islands, regardless of the level of industrial activity at the islands. However, in a similar study, Frost et al. (1988:92) found that seal density was greater within "industrial blocks" of the Beaufort Sea than within areas that are not used by industry. The higher overall concentration of seals in the industrial block suggests that some characteristics other than the presence or absence of industrial activity was responsible for the difference. The extent to which displacement occurs in response to localized industrial activity has not been determined, and there is no clear evidence that seals leave the area of disturbance or redistribute themselves permanently elsewhere (Calvert and Stirling, 1985:1241-1242).

Ringed seals, when hauled out onto the ice, sometimes react to low-flying airplanes and helicopters by diving (Burns and Harbo, 1972:283). There are no systematic observations on these responses to determine in-air noise levels. Calvert and Stirling (1985:1240) showed that ringed seal vocal activity levels were similar in areas with low-flying aircraft and undisturbed areas, suggesting that the aircraft disturbance did not affect the general distribution and density of animals. However, other evidence indicates that reactions by seals inside their subnivean dens vary as a function of aircraft altitude and distance (Kelly et al., 1986:ii).

There are no observations of ringed seal reactions when exposed to the underwater sounds of ships, boats, or dredging operations. There are some observations of short-term ringed seal reactions to ships and icebreakers (Brueggeman et al., 1992 as cited from Richardson et al., 1995a:255) showing that animals hauled out on the ice tended not to respond at ranges of several kilometers, but did respond by diving into the water at closer ranges.

There are no systematic studies documenting ringed seal reactions to drilling and related activities. Some reduction in seal density was noted within 2.3 miles (3.7 km) when drilling was underway on an artificial island (Frost and Lowry, 1988:20).

Seismic Survey Noise: Reactions of seals were recorded as part of marine mammal monitoring for the BPXA fall 1996 seismic survey. Results indicate that approximately 189 seals were within 820 ft (250 m) of the seismic array during the monitoring period, of which ringed seals comprised the majority of those counted; bearded seals and spotted seals comprised relatively small numbers, proportionally.

Studies on effects of noise disturbance on ringed seals from on-ice seismic profiling, using the Vibroseis method, have been conducted in the vicinity of Seal Island (Burns et al., 1982; Kelly et al., 1986). The noise levels were sufficient to cause seals to abandon breathing holes and lairs at a greater than normal rate (Kelly et al., 1986:530). However, the reaction of ringed seals to disturbance from these activities was found to be highly variable. Some seals' breathing holes and lairs remained active despite close proximity to seismic survey lines and helicopter and small plane flight paths, while other seals abandoned areas at greater distances from the noise (Kelly et al., 1986:531).

Most seals (all species) exposed to seismic activities reacted by either diving (36%) or avoidance (39%); approximately 18% reacted by "looking;" 5% swam parallel to the vessel; and 2% approached the vessel. During full-array seismic, most seals within 492 ft (150 m) of the source vessel dove, whereas those encountered at distances between 492 and 820 ft (150 and 250 m) avoided the source vessel. The 1996 seismic operations apparently caused some small scale displacement of seals, as indicated by the lower sighting rates within 492 ft (150 m) of the source vessel during airgun array operations. However the overall sighting rates for seals seen within a few hundred meters of the source vessel were almost identical during periods with no airguns, one airgun, and a "full array" of 8 to 11 airguns. Although Harris et al., (1997:4-37) states that there was no indication that the seismic operation caused displacement of seals on a scale that could affect accessibility to subsistence hunters, it is apparent that increased vessel movement attributable to seismic operations would result in a temporary displacement of some individuals. The duration of displacement was not observed; however, the seismic array, which was towed at 4 to 5 knots (7.4 to 9.3 km/hour), would traverse a 1,640-ft (500 m) portion of the seismic transect in 15 to 19 minutes.

9.5.1.4 Bearded Seal - Responses to Noise

Comparative data from other seals (e.g., ringed, harp, and harbor seals) suggest that bearded seals would be sensitive in the 1,000 to 40,000 Hz band, with the further suggestion that hearing would still be good down to 200 to 500 Hz (Møhl, 1986:34; Terhune and Ronald, 1972:567-568; Terhune and Turnbull, 1995:85-92).

Bearded seals are well known for their loud, unique songs in the 300 to 400 Hz tone (Ray et al., 1969:80-81; Budelsky, 1993:86-89). Aggregations of singing bearded seals can be heard at distances greater than 10 miles (16 km) (Cleator et al., 1989:1906). These songs are presumed to be a very important part of the breeding ecology for these animals due to high vocal activity, and underscore the importance of sound production and perception for their survival.

Most observations of bearded seals have been on animals hauled out on ice. There are few observations on bearded seals' reactions to underwater sounds because of the difficulty observing these animals in water.

There are no data available on the reactions of bearded seals when exposed to underwater sounds from on-ice construction activities, drilling, or vessels. There are some observations showing that animals on pack ice dove into the water when an icebreaker was working at ranges of less than 0.6 miles (1 km); however, animals seemed to be less responsive to the icebreaker when it was in transit in open water (Richardson et al., 1995a:275). Bearded seals, when hauled out on the ice, sometimes react to low-flying airplanes and helicopters by diving, and helicopters seem to be more disturbing than other types of aircraft (Burns and Frost, 1979 as cited from Richardson et al., 1995a:244).

Seismic Survey Noise: Reactions of seals were recorded during marine mammal monitoring for the BPXA 1996 seismic survey. Approximately 189 seals were identified as being within 820 ft (250 m) of the seismic array during the survey, of which bearded seals comprised approximately 4% of the population; however, the survey did not make a distinction between the reactions of bearded seals from those of ringed or spotted seals. The general reaction of seals to seismic activity is described in Section 9.5.1.3, which included diving and avoidance, followed by "looking" and swimming parallel to the source vessel.

9.5.1.5 Polar Bear - Responses to Noise

Little is known about the types of sounds produced by and the hearing abilities of polar bears. However, polar bears often react to low flying aircraft by running away. Helicopters are sometimes used to scare bears away from human habitation (Richardson et al., 1995a:252). Polar bears react inconsistently to the approach of vessels (Richardson et al., 1995a:273). There are limited data on reactions of bears to construction, offshore drilling, or production operations. However, polar bears have been known to approach stationary drill ships and drill sites on caissons and artificial islands when ice is present nearby (Richardson et al., 1995a:289).

Polar bear reactions to seismic survey activities has been documented as part of the BPXA fall 1996 seismic survey (Richardson, 1997:Appendix 1). Two adult bears were observed approximately 984 ft (300 m) from a support tug that was used to move the cable barge. When the bears were spotted, the vessel came to a stop and the bears were observed both on the ice and swimming away from the vessel. At the time, the source vessel was operating approximately 6.2 miles (10 km) from the site. A sow and cub also were observed from a jet-driven aluminum landing craft that was used to deploy, retrieve, and charge batteries and to assist in cable deployment and interconnection. The pair was observed climbing into a large ice pan as buoys were being picked up on either side of the ice pan. The bears were estimated to be about 656 ft (200 m) from the vessel and the encounter lasted about 10 minutes. Full-array seismic was ongoing approximately 2.5 miles (4 km) from the siting. Eight additional sightings, totaling 13 polar bears, were reported from monitoring aircraft; however, seismic shooting was not taking place at the time and no reactions to aircraft were observed. Seismic survey activity also was found to have minor effect on denning polar bears, largely because dry, cold snow absorbs vibrations very effectively (Blix and Lentfer, 1992:23).

Stirling (1988:6) and Shideler (1993:17-18) indicate that polar bears are attracted to drilling and similar activities for a number of reasons, including curiosity, food, scent, and potential predation of drilling personnel. Although noise was not identified as a factor in attraction, it is likely that it is a contributor.

Denning polar bears prefer to seek den sites free of disturbance (Amstrup, 1995:292). However, other studies of polar bears found them to be tolerant of some human activity (Stirling, 1988:6). If an active polar bear den was located near the mine site in the Kuparuk delta, disturbance of the den would be considered a minor impact. However, the U.S. Fish and Wildlife Service would recommend appropriate measures to avoid or minimize potential effects.

9.5.2 Marine and Freshwater Fish - Responses to Noise

There are no data documenting noise effects on fish in the project vicinity. Noise studies have been limited to the analysis of fish communication and not on noise impacts on fish. However, a 4-month pilot project in Bodega Bay, California, designed to establish collection and husbandry protocols, map the sound field of the enclosure, and conduct and analyze preliminary playback experiments for the purpose of refining future experimental protocols, has released a bi-monthly progress report (Klimley and Beavers, 1997:1). Thirteen rockfish were tested individually in an enclosure using a tape recorder, amplifier, and underwater transducer. The SPL was 145.1 dB at 3.2 ft (1 m) and 109.5 dB at 39.4 ft (12 m) from the speaker. The researchers observed little movement by the fish in the enclosure in response to the signal and little difference existed in the behavior of the fish during sound playback and “silent” control period.

Had the SPLs used in the experiments been higher, they may have elicited an alarm response among the rockfish. The general threshold of rockfish to impulsive sounds made by an air gun used in geophysical surveys was 180 dB (Klimley and Beavers, 1997:1). At this level, blue rockfish milled in tighter circles and black rockfish moved to the bottom. Olive rockfish either moved up in the water column or descended to the bottom where they became immobilized. Responses were detected in some fishes at levels as low as 161 dB.

Additional research and analysis is necessary to definitively determine the effects of noise on Alaskan Beaufort Sea fish species. Although rockfish are not present in the project area, the study provides baseline information about fish response to noise (Klimley and Beavers, 1997:1). Different fish species, however, may respond differently to noise and effects on Alaskan Beaufort Sea fish species may vary from those displayed by the various species of rockfish.

9.5.3 Avian Species - Responses to Noise

Many bird species are found in the project area; however, nearly all species are migratory and occur from May through September. Fixed-wing aircraft and helicopter traffic is expected to be the major source of noise affecting birds, but the impacts of aircraft overflights on birds are difficult to assess. Responses among birds may vary among species, populations, flocks, and individuals, as well as between different habitats and times of the year. Characteristics of overflights, such as altitude, horizontal distance, type of aircraft, duration of disturbance, engine sound level, and frequency, affect the response.

The reaction of birds to exploratory drilling activity near the MacKenzie River Delta found that 43% of common bird species were less numerous within 1.6 miles (2.6 km) of the drilling rig during drilling operations, 52% of the species were not affected by rig activity, and 5% of the species were more abundant (Hanley et al., 1981:158).

Snow geese, which are susceptible to disturbance by low flying aircraft, return to feeding within a relatively short time (Belanger and Bedard, 1989:717-718). Birds that were disturbed during the spring returned to feeding more quickly than those disturbed during the fall. The mean time to resume feeding after disturbance was about 2 minutes during the spring and 12 minutes during the fall. Reasons for the differing return times is likely related to energy reserves that differ by season. The study also found that geese habituate to reoccurring aircraft and gunfire noise, which resulted in reduced disturbance rates.

In similar studies, Wright and Fancy (1980:31 and 36) found that disturbance to oldsquaw from helicopter noise resulted in displacement of flocks. The average time of displacement was about 10 minutes.

Aircraft flying overhead at low altitudes have a greater potential to create an impact than at a greater distance and high altitude. In one study, nesting common eiders (the major nesting species on the barrier islands) showed some tolerance to helicopter overflights (Gollop et al., 1974). Based on a 2-day experimental study, the eiders appeared to be undisturbed and remained on their nests. The duration and small sample size, however, limit the applicability of the study. Aircraft or helicopter-induced stress and its affects on the energetics of incubation, is an important factor not addressed in the study (Gollop et al., 1974:193). The effect of multiple overflights in either sensitizing or habituating birds is not well understood, but there is some evidence that once exposed to disturbance, birds may be more easily disturbed subsequently (Gollop et al., 1974:189). Birds that are molting or caring for broods are most likely to react negatively to aircraft because of their vulnerability. Several studies have evaluated the behavioral reaction of birds from aircraft overflights. Brant and other geese reacted to approaching aircraft by raising their head, calling, walking, or swimming together in a group, and eventually flying away from the noise (Ward and Stehn, 1989:101).

In general, researchers have found that the response by waterfowl is related to the altitude and/or horizontal distance to aircraft. Typically, the lower and closer the aircraft, the greater the disturbance response. However, it is difficult to determine a minimum altitude that will eliminate or minimize the disturbance. Overflights at Izembek Lagoon, east of the project area, were permitted at a minimum 1,500-ft (457 m) elevation, which was sufficient to avoid disturbing black brant staging at the lagoon.

Generally, the intensity of the disturbance decreases with increased horizontal distance of aircraft to waterfowl. However, a high degree of variability has been observed.

9.5.4 Terrestrial Mammals - Responses to Noise

Caribou: Information about the effects of noise on caribou is limited to fixed-wing military aircraft which are likely to produce noise levels that are higher than those of aircraft (fixed- or rotary-wing) that would be in use in the project area. A study was conducted to evaluate behavioral responses of free-ranging caribou to low-level, subsonic jet aircraft overflights in 1991. Overflights were conducted by the U.S. Air Force during late winter (April), post-calving (June), and the insect season (July to August). The aircraft overflights consisted of A-10, F-15, and F16 jet aircraft, which emit higher noise levels than those used during project construction and operation. Approximately 50% of the caribou showed some degree of overt behavioral response to the overflights, but only 13% of the overflights caused the animals to move (Armstrong Laboratory, 1993:33-40). Activity budgets and daily distance traveled were compared between disturbed and undisturbed groups of caribou. No differences were evident in late-winter activity budgets; however, animals spent less time lying and more time either feeding or walking during post-calving and the insect seasons than at times when overflights did not take place. No differences in daily distance traveled were evident during late winter and the insect season, but disturbed caribou traveled farther than did undisturbed caribou during post-calving. The study concluded that behavioral impacts were generally mild, but that female caribou reacted to jet aircraft overflights by lying less and moving more, and these responses were most prevalent in June when newborn calves were present.

Other studies found that caribou in large numbers (greater than 20 animals) tend to be more responsive to noise than animals in small groups, particularly when calves are present (Miller and Gunn, 1981:70). Studies of animal movement found that caribou avoid or move more rapidly through areas with ongoing industrial noise than those without industrial noise. Avoidance reaction was noted at an average distance of 650 ft (198 m) from an operating gasoline compressor sound simulator; the migration patterns of post-calving herds were found to deflect from the sound simulator at an average distance of 920 ft (280 m) (Wright and Fancy, 1980:38 and 49-50).

Observations of caribou reaction to railroad and highway noise, and noise from chain saw operations and dynamite blasts indicate that caribou herds tend to habituate to such noise sources. Bergerud (1974:579), states that herds in Newfoundland wintering within 1 mile (1.6 km) of the Canadian National Railway and 2 miles (3.2 km) from the related noise sources were not affected.

A direct inverse correlation was found between jet aircraft overflights and calf survival (Harrington and Veitch 1992:213). Although there are differing opinions regarding distances from aircraft that are considered to be adequate to avoid disruption to caribou, tolerance levels appear to range from 300 to 500 ft (91.4 to 152.4 m) during rut and calving, and to 500 ft (152.4 m) at other times, including migration (Calef et al., 1976:210; Harrington and Veitch, 1991:325). Minimum "safe distances" were reported by Harrington and Veitch (1991:325) to be 1,000 ft (304.8 m).

Other Terrestrial Mammals: Very little information is available regarding the effects of noise on Arctic fox and other terrestrial species; however, Eberhardt et al. (1982:188) found that petroleum development activities do not adversely affect Arctic fox and that these foxes do not necessarily attempt to avoid areas of human activity.

Grizzly bears are present within the Prudhoe Bay industrial complex and in 1994, a total of 28 bears were estimated to occupy the area from the Colville River east to the Shaviorik River and inland to the White Hills (Shideler and Hechtel, 1995:32). Although the species typically feeds on tundra vegetation, they are attracted to the oil fields and communities to feed on human refuse found in trash containers and landfills. Bears also have been found to adapt to human activities, including learned avoidance of baited traps and the presence of helicopter traffic (Pearson, 1975:43).

9.6 EFFECTS OF NOISE ON THE HUMAN ENVIRONMENT

Industrial noise associated with oil field activity has increased ambient levels throughout a large portion of the Prudhoe Bay area over pre-industry levels. Processing and compressor equipment, separators, pumps, generators, and vehicles are common noise sources within many areas, and common underwater noise sources emanate from vessel traffic, offshore exploratory drilling, and seismic survey activity. Onshore noise potentially could affect the human environment as well as terrestrial mammals that are relied upon for subsistence harvesting. Underwater noise could affect marine mammals and subsistence harvesting success.

9.6.1 Onshore Sensitive Receptors

Onshore receptors that are sensitive to noise typically include residential areas, hospitals, nursing homes, parks, and public meeting halls. Locations of such facilities in the Prudhoe Bay area are limited to the Deadhorse community and camp facilities within the Eastern and Western Operating Areas, and residences in Nuiqsut are located farther from the project area. Although project operations and maintenance would result in increased noise levels at Seal Island, distances to sensitive receptors that are located onshore would be sufficient to preclude effects on the human population. Operations and maintenance noise at onshore locations would be limited to regular helicopter traffic between the Deadhorse Airport and Seal Island for personnel changes, materials shipments, and low-elevation helicopter overflights along the onshore pipeline corridor as part of routine inspection. Due to distances between such noise sources and sensitive receptors, noise-related impacts to onshore receptors are not anticipated.

9.6.2 Subsistence Harvesting

Subsistence harvest resources within the project area that could be affected by noise are limited to the bowhead whale and caribou (Section 7.3). Although other resources (waterfowl, fish and other marine and terrestrial mammals) are harvested by North Slope residents, they would not be affected by noise associated with construction, operations, maintenance, or abandonment of the project.

Bowhead whales are traditionally harvested by residents of Barrow, Nuiqsut, and Kaktovik; however, noise-related impacts would be limited to the fall harvest that is conducted from Cross Island by Nuiqsut whalers. Studies of bowhead whales indicate that industrial noise may cause behavioral changes at distances of as much as 62 miles (100 km), and deflection behavior at ranges of 0.5 to 14 miles (1 to 24 km), although most deflections occur at less than 6.2 miles (10 km) (George et al., 1996:5). Other studies have found avoidance behavior at a range of 1 to 9 miles (1.6 to 14.5 km) from small boats (Richardson et al., 1995a:268; Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61; LGL and Greenridge, 1987:47; and Ljungblad et al., 1985:45) which is consistent with observations by whaling captains that avoidance behavior from the noise of an outboard motor occurs within 3 miles (4.8 km) of the source (T. Brower, Sr. in NSB, 1980:107). Whalers also have noted that when industrial activity is high in the Alaskan Beaufort Sea, harvest success is low and quotas are not easily met (J. Ningeok in USDOI, MMS, 1986:11; F. Long, Jr. in USACE, 1996:34; B. Oyagak in USDOI, MMS, 1986:11; J. Kaleak in MBC, 1996:69; T. Napageak in USDOI, MMS, 1995:8). Although the range of distances in which migratory deflection and avoidance reaction is highly variable, subsistence harvesting could be affected. If the fall migration pattern within traditionally used hunting areas were altered as a result of project noise and/or activity, harvest success could be reduced or harvest failure may result. Impacts to subsistence harvesting are addressed in Section 9.8.2.2.

Caribou winter in the foothills of the Brooks Mountain Range and move to calving grounds on the open tundra in areas of the Kuparuk River Delta and near the Canning River Delta in late April and early June. During early summer, the herds move to the coast to avoid insect harassment and return inland with the abatement of the insect season. If noise from industrial activity (i.e., helicopter overflights) is sufficient to displace caribou herds, subsistence harvesting could be affected. Impacts to subsistence harvesting are addressed in Section 9.8.2.2.

9.7 PROJECT NOISE SOURCES

Noise studies in waters off the North Slope conclude that, under certain conditions, industrial sources can generate high levels of low-frequency noise which can be transmitted under water over long distances (LGL and Greeneridge, 1987:43-44; Miller et al., 1997:5-5 to 5-107). Common types of industry-related noises and documented noise levels for the project area are discussed below.

9.7.1 Transportation Activities

Vessel Movement: Ships and boats create high levels of noise both in frequency content and intensity level. Ship traffic noise can, in some circumstances, be detected at distances of over 1,150 miles (1,851 km) in deep water and is a combination of narrowband tones and broadband noise (Wenz, 1962:1949). Ice breaking vessels have source levels of 165 to 175 dB, while vessels under 98 ft (30 m) long typically have levels less than 165 dB (Richardson and Malme, 1993:637). Icebreaking activities can generate some of the highest measured levels of vessel noise (below 500 Hz) as a result of the ship's higher power levels, when the ship is pushing slowly against ice.

Tugs can emit high levels of underwater noise at low frequencies. In August 1985, underwater noise was recorded from two tugs that were keeping a barge pressed against a loading ramp at Sandpiper Island. An underwater sound level of 163 dB in the 20 to 1000 Hz band was recorded at a distance of 0.3 miles (0.5 km). Peak noise levels of 118 dB in the 20 to 1,000 Hz band were noted at a range of 1 mile (1.6 km) when tugs and barges were present at Seal Island (Davis et al., 1985:61).

Aircraft Movement: Noise effects from aircraft (helicopters and fixed-winged planes) in air and water have been reviewed earlier in this chapter. The duration of aircraft sound in water is short, and underwater sound levels are much lower than sound levels in air. Comparisons of aircraft noise levels are complicated by analysis using differing averaging times, aircraft, and flight altitudes. However, aircraft sound levels generally range from 95 to 130 dB (Richardson et al., 1995a:350). An average level of 113 dB at an altitude of 1,017 ft (310 m) was reported in a more recent study (Greene, 1997:3-48 to 3-49, Fig. 3.25).

Vehicular Movement: Sounds from vehicles such as automobiles, buses, and trucks typical range from 60 to 85 dBA at 50 ft (15.2 m) from the source in air. Frequency ranges from approximately 250 to 1,000 Hz. Noise from vehicular traffic attenuates at approximately 3 to 4.5 dBA per doubling of distance.

9.7.2 Gravel Mining Activities

Gravel mining and reclamation of the pit would be conducted during winter months. Noise from gravel mining is primarily emitted by compressors, drills, blasting operations, rock crushers, bulldozers, loaders, and miscellaneous trucks. Noise reduction of construction equipment as a function of distance may be difficult to predict in the project area; however, noise from this type of equipment decays at a rate of 6 dBA per doubling of distance from the source to receiver. This is a logarithmic relationship describing the acoustical spreading of a pure undisturbed spherical wave in air. Although construction noise may be audible for a long distance in remote areas that have low ambient noise levels, substantially higher noise levels from equipment would be limited to a relatively confined area totaling approximately 35 acres (14 hectares) at the mine site.

9.7.3 Construction Activities

Sounds from construction typically consist of noise emanating from equipment such as diesel generators, bulldozers, backhoes, and compressors, plus from activities such as pile-driving using an impact hammer. In-air noise levels from generators range between 70 and 82 dBA at 50 ft (15.2 m) from the source, and in-air noise levels from bulldozers, backhoes, and compressors range between 72 and 96 dBA (Spencer, 1996:18). Sounds generated from pile-driving or hammering are short duration, rapid onset, and high peak pressure level signals that are most like seismic survey pulses. Typically, hammering impulses occur 1 to 3 seconds apart. In the fall of 1985, hammering sounds from pile-driving were recorded near Sandpiper Island. At a range of 0.6 miles (1 km) from the hammering activity, sounds levels of 131 to 135 dB in the 25 to 125 Hz frequency range were recorded when the pipe was between 65 and 80 ft (20 to 24.4 m) deep (Johnson et al., 1986:47). Pile-driving sounds detected at a range of 0.6 miles (1 km) from an island were 25 to 35 dB above the ambient noise level in the 50 to 200 Hz frequency band (Moore et al., 1984:543-52). Results of a theoretical study to estimate the level of noise generated during construction pile-driving activity on Seal Island agree with these empirical data. In the theoretical study, the underwater sound level from pile-driving in shallow water every 1.3 to 1.7 seconds at a distance of 0.6 miles (1 km) was estimated to be 138 dB (Spencer, 1996:15). An alternative method, the vibratory hammer, would theoretically generate an underwater sound level of 119 dB at a distance of 0.6 miles (1 km) (Spencer, 1996:16).

The distance out to which impulsive construction sounds could be detected depends primarily on the source level, the local propagation conditions around the Seal Island construction site, and the ambient noise level in the low-frequency band. The median ambient noise level in the 20 to 1,000 Hz band from a shallow water site near the Northstar Unit was reported as 95 dB (Richardson et al., 1998:3-54). Using this ambient noise level data, empirical propagation data (Richardson et al., 1998:3-62), and a noise level of 138 dB at 0.6 miles (1 km), pile-driving sounds are expected to be detected out to ranges of 2.5 to 12.4 miles (4 to 20 km).

Two studies have investigated noise characteristics of construction at Seal Island. In the first study, under-ice noise levels during ice road construction in the 0 to 500 Hz band were less than 80 dB at ranges between 0.2 to 1 mile (0.3 and 1.6 km) (Greene, 1983:129). Under-ice noise levels were below 80 dB at distances of 0.5 to 2 miles (0.8 to 3.2 km) when a ditchwitch, backhoe, dump truck, D-7 Caterpillar, and gravel trucks were operating. In the second study, received levels up to 135 dB were recorded at a distance of 0.6 miles (1 km) (Spencer, 1996;18). The loudest noise was caused by a 20.9 ton impact hammer driving piles and a vibratory hammer driving sheet piling for island protection.

Noise radiating from pipeline construction and installation activities would be similar to island construction noise (Section 9.7.3). Noise sources include trucks, cranes, bulldozers, backhoes, and compactors. In air, noise from these sources emit levels ranging from 70 to 82 dBA at 50 ft (15.2 m).

9.7.4 Operation and Maintenance Activities

Drilling is expected to be one of the loudest noise sources during operation and maintenance activities. Wells would be drilled through the mass of the island which would act as an acoustic buffer, absorbing and filtering most of the acoustic energy generated by the operation before it can radiate into the water. Absorption lessens the overall level of sound energy entering the water, while filtering restricts the propagation of sound frequencies above several hundred Hz.

Estimates of expected noise levels and variability of noises from drilling activities are expected to be less than levels measured from non-island type drilling operations (i.e., drill ships and bottom-founded structures). Underwater noise levels from drill sites on manmade islands usually have been less than 109 dB, concentrated below 200 Hz, and detected at distances between 1 and 11 miles (1.6 and 17.7 km) depending on the ambient noise conditions (Malme and Mlawski, 1979:11; Johnson et al., 1986:45; Miles et al., 1987:183). Drilling noise levels measured at 40 Hz were often 10 to 20 dB greater than ambient noise levels at 0.6 miles (1 km) from Seal Island (Johnson et al., 1986:49). Source levels of top-drive rigs (such as that to be used for the project) operating on gravel islands seem lower than for other types of equipment (Richardson and Malme, 1993:647).

During fall and spring broken/thin ice conditions, icebreaking barges would periodically travel between Seal Island and West Dock in order to maintain a corridor that might be required in the event of an oil spill. These icebreaking barges would be propelled by marine tugs. Noise levels from an icebreaking barge/tug combination is not as high as those from a traditional icebreaker. Noise sources from the tugs themselves are primarily due to propulsion, namely propeller and engine. In addition, the icebreaking barge being pushed by the tug will be a noise source as it breaks and pushes aside thin ice.

In summary, construction, operation, and maintenance activities would generate noise from multiple sources within a variety of locations in the project area. Gravel mining and hauling would generate noise within the vicinity of the Kuparuk River Delta and along the ice road to Seal Island. Noise sources from the vicinity of Seal Island would result from the use of heavy machinery for pile driving, drilling, drill waste disposal, production equipment, and marine vessel traffic.

9.8 ENVIRONMENTAL CONSEQUENCES

The effects of noise on marine mammals, fish, birds, and terrestrial mammals are described for the No Action Alternative and for project construction. Due to similarities in project alternatives, noise impacts related to Alternatives 2, 3, 4, and 5 are identical; therefore, potential impacts to biological resources from these alternatives are discussed together.

9.8.1 Alternative 1 - No Action Alternative

Marine mammals, fish, birds, and terrestrial mammals currently are impacted by noise from oil field operations on the North Slope and it is likely that the current level and frequency of impacts will continue into the foreseeable future. Noise sources are likely to shift from location to location as producing reservoirs become depleted and facilities are decommissioned and as new fields are developed and new facilities become operational. Increased onshore development potentially could generate noise that would affect nesting birds and displace caribou and other mammals from important habitat; noise from new offshore development is likely to affect marine mammals, including the bowhead whale, regardless of development of the Northstar Unit.

Ambient noise levels are likely to be less than 40 dBA in undeveloped areas without manmade noise. In the vicinity of Seal Island, noise levels below the water surface would be expected to range from 79 to 123 dB, with 50% of the values in the 20 to 1,000 Hz band at 95 dB or less when no human activity is present. However, the variability of actual ambient noise levels would be dependent upon a variety of factors, including meteorological conditions, wave action, and the presence of ice.

9.8.2 Alternatives 2, 3, 4, and 5

Impacts of noise to biological resources from Alternatives 2, 3, 4, and 5 are presented in Table 9-1. Project-related impacts to subsistence resources and harvesting are addressed as part of Chapter 7 (Affected Human Environment and Impacts).

9.8.2.1 Construction Noise Impacts

Construction noise would originate from gravel mining, ice road construction, the reconstruction of Seal Island, and pipeline installation.

Bowhead Whale:

Ice Road Construction and Operation and Offshore Pipeline Installation: Bowhead whales would not be present in the area during ice road construction or operation or during offshore pipeline installation. Therefore, impacts from such activities are not anticipated.

Island Construction Noise: No studies have been conducted on the responses of bowheads to offshore island construction activities (Richardson et al., 1995a: 276-281); however, construction during winter will eliminate biological impact on bowhead whales because none would be present in the area (Section 6.9).

Scheduling construction activities during periods when whales are not expected to be in the region greatly reduces the chances that bowheads will be exposed to levels of island construction noise to which they will respond. Tables 4-7 and 4-8 provide a listing of project activities; including island construction, barge and vessel traffic, offshore pipelines, and drilling operations. It indicates that many of the activities expected to have the greatest possible impact (e.g., island construction, vessel traffic) are scheduled to occur either in the winter or early summer when whales are not in the area, or during the spring when whales are migrating past the project site, but at ranges of greater than 44 miles (70 km) (Miller et al., 1996:18-35). This schedule dramatically reduces the chances of whales being exposed to project activity noises so that whales will not be effected by project activities.

Pile-driving for the installation of island slope protection would represent one of the greatest noise impacts to bowhead whales, if it were to occur during the migration period. However, pile-driving is scheduled to be completed approximately 2 weeks prior to the fall migration period in the vicinity of Seal Island, and impacts

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related to pile driving noise are not anticipated. However, if this high noise level activity was to coincide with fall migration and subsistence harvest activities, and if the harvest success was reduced, the impact could be significant to subsistence.

Other construction activities at Seal Island that could affect bowhead whales are barge traffic associated with module and drilling rig movement to the island. The modules for Northstar will be placed on the island during 1999/2000. Barges will arrive during summer from the west ahead of the bowhead migration, and will move directly to Seal Island inshore of the main bowhead migration corridor (and before many bowheads are present). Offloading will be completed before early September. There will be no travel along or across the bowhead migration route or near subsistence whaling activities. A drill rig will be moved from West Dock to the island during the first summer after island construction. Rig movement will only occur in the nearshore shallow water zone and will not go along or across the whale migration corridor. If barge offloading was to extend into fall migration and subsistence harvest activities, and if the harvest success was reduced, the impact could be significant to subsistence.

Whales react most noticeably to erratically moving vessels with varying engine speeds and gear changes, and to vessels in active pursuit (Richardson et al., 1985; Richardson and Malme, 1993). During this project, however, most operations by support vessels and sea lifts of process modules and a drill rig will be by slow-moving vessels. Bowhead reactions to slow-moving vessels are much less dramatic. Bowheads often tolerated the approach of slow-moving vessels to within a few hundred meters, especially when the vessel is not directed toward the whale and when there are no sudden changes in direction or engine speed (Richardson et al., 1995a:269). Vessel traffic supporting Northstar construction and operations will largely occur between Seal Island and the mainland, and would not approach or pursue whales. Any vessel impacts would be restricted to an area close to or inshore of Seal Island; since bowhead whales only occasionally occur that close to shore, any impacts of this vessel traffic to bowhead whales would be minor.

Although barge activity for the transport of major components is scheduled to be completed in the vicinity of Seal Island prior to the arrival of the fall bowhead migration, work boat traffic may be ongoing. The reaction of bowhead whales to vessel noise is well documented through observations from Inupiat hunters and from marine mammal surveys. Although avoidance reaction due to noise from a small boat has been noted at distances as small as 1.2 to 2.5 miles (1.9 to 4.0 km) (Richardson et al., 1995a:268), observations related to outboard motor operations noted avoidance reactions at approximately 3 miles (4.8 km) (T. Brower, Sr. in NSB, 1980:107) and reactions to other vessels have ranged from 6 miles (9.7 km) (Ljungblad et al., 1985:45, 509) to 9.3 miles (15 km) (Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61). Therefore, although a few bowheads might avoid vessel traffic at ranges of up to 10 miles (16 km), most will avoid vessels at ranges of 0.6 to 2.5 miles (1 to 4 km). In addition to avoidance behavior, Inupiat hunters have also noticed noise-related changes in whale behavior that make them more difficult to hunt, but do not appear to jeopardize the whales themselves (F. Long Jr., 1998:1 to 8; S. Taalak, 1998:1 to 2). The impacts to bowheads from the level of the proposed activity are expected to be minor.

Evidence suggests that the number of bowhead whales expected to be present within a radius of several miles around Seal Island is very small, but some whales are expected to migrate through the broader offshore corridor within 10 miles (16 km) of the site. Some of these animals may hear underwater noises generated by certain types of construction activities. The expected noise levels and the variability in noises are not known at this time, but can be estimated based on existing noise level data from island-based drilling activities (Johnson et al., 1986:83-86), and empirically-based sound transmission loss data (Greene, 1997:24-42). These data indicate that noise levels within 0.5 miles (0.8 km) are expected to be high enough that disturbances to bowhead whales are possible. Levels at greater ranges are less predictable due to variable noise levels and transmission losses. Construction noise might be above ambient noise levels at ranges of 3 to 4 miles (4.8 to 6.4 km) under some conditions. The short-term behavioral reactions of bowheads to these noises could be avoidance within 3 to 4 miles (4.8 to 6.4 km) of Seal Island. A 5-day acoustical study conducted near Seal Island in 1984 using an array of four hydrophones detected only 42 bowhead calls. A few calls were located and indicated that three whales passed within 1.7 to 3.7 miles (2.8 to 6 km) of the island. These whales were closer than any whales seen during aerial surveys, and the ranges of these whales from the island indicate that not all whales avoided the area within a few miles of the island during drilling and well-logging and after operations had ended. This indicates that such attenuated noise would have a minor impact on this species.

Most sounds produced by construction activities on the island are not expected to propagate very far and are only expected to be detectable above natural background noise levels within ranges of several kilometers from the island. Several island construction activities such as pile driving and hammering, have been shown to generate high sound levels that can be considerably greater than ambient noise (Spencer, 1996; Greene, 1987). The worst case impact of a high noise level activity would happen when a combination of events occurred simultaneously. This includes a high noise level activity such as installation of sheet piles, low ambient noise conditions so that the activity's noise is detectable at greater than normal range, and whales migrating within 6.2 to 9.3 miles (10 to 15 km) of the site. The chances of all three conditions occurring during the project are extremely small. Island construction is scheduled to occur between mid-January through August, with the loudest activities restricted between mid-March and mid-May (Table 4-7). This is during the whales' spring migration when animals rarely come within 40 miles (64.4 km) of the coast (Figure 6.9-3). In the fall when the whales are migrating closer to the coast, low ambient noise conditions (less than 70 dB in any 1/3 octave band below 100 Hz) occur less than 5% of the time (Richardson et al., 1998:3-49 to 3-54). Because island construction activities are scheduled for the spring period when the closest whales are expected to be many tens of miles from the site, no impact is expected during the spring migration period. Most island construction activities would be scheduled for completion before fall migration, and impact to bowhead whales would be minor. However, if construction activities were to extend and coincide with fall migration and subsistence harvest activities, and the harvest success was reduced, the impact could be significant to subsistence. Because no island construction activities are scheduled for the fall period when only a few whales are expected to come within 6.2 to 9.3 miles (10 to 15 km) of the site and very quiet ambient conditions are rare, no impact is expected during the fall migration period.

Construction activities at Seal Island would require helicopter flights from onshore locations. Overall, aircraft overflights can cause a rapid short-term response from bowheads, but evidence does not suggest that this type of disturbance causes bowheads to avoid an area with aircraft activity. However, extensive helicopter activity during installation of modules could contribute to overall avoidance of Seal Island during fall migration due to industrial noise. The biological impact from helicopter and airplane noise is expected to be minor. However, the National Marine Fisheries Service would recommend appropriate measures to avoid and minimize potential effects to bowhead whales during construction.

Beluga Whale:

Ice Road Construction and Operation and Offshore Pipeline Installation: Beluga whales would not be present during ice road construction or operation or during the offshore pipeline installation. Therefore, no impacts to the species as a result of such activities are anticipated.

Island Construction: Beluga whales are expected to be present in the project area from mid-spring through mid-fall. The number of belugas expected near the Seal Island site is very small, as the majority migrate further offshore in the fall. Most of the sounds from the site are expected to be low-frequency and few belugas moving through the area will be able to hear the underwater noises generated from construction activities and vessel noise. Estimates indicate that mid- to high-frequency noise levels within 0.5 miles (0.8 km) are expected to be sufficient for belugas to avoid the immediate area around the construction site (Johnson et al., 1986:83-86; Greene, 1997:3-24 to 3-42). Sound levels at greater distances are expected to be much less due to the effects of frequency dependent transmission loss. Impacts to beluga whales are expected to be negligible.

Animals that come within about 0.3 miles (0.5 km) of Seal Island are expected to hear the mid- to high-frequency underwater noises generated by drilling activities and might avoid the noise area. Impacts to beluga whales from drilling would be minor.

Seals: The zone of potential noise impact for seals is expected to be on the order of 0.6 to 1.2 miles (1 to 2 km), depending on ambient noise conditions and seal responsiveness. Seals would be likely to be affected only during ice road construction and operation activities, they are expected to avoid the area during island reconstruction and related activities.

Ringed Seal: Construction activities, particularly pile installation, would create noise and vibration sufficient to cause disturbance to ringed seals, possibly resulting in abandonment of dens and territories established in the bottomfast ice. Animals are expected to be temporarily displaced from construction areas. Loss of habitat for individual ringed seals due to construction is expected to be small because of the large areal extent of a seal's territory (Section 6.5). A temporary displacement of ringed seals also could occur as a result of the displacement of fish due to underwater noise caused by pile driving. The displacement and any impacts to individual breeding success would be temporary (limited to the late winter/early spring construction period). Impacts to ringed seals would be minor.

Bearded Seal: Due to the low population density of bearded seals in the nearshore Alaskan Beaufort Sea during winter, impact of Seal Island reconstruction on this species is likely to be limited to temporary and localized disturbance of the small number of bearded seals. Some animals might temporarily avoid areas of construction activity. The impact on bearded seals is expected to be negligible.

Spotted Seal: Spotted seals spend most of their time in nearshore ice-free waters and may be disturbed by noise from vessels and construction. Most spotted seal concentrations in the nearshore Alaskan Beaufort Sea lie west of BPXA's proposed project area; the nearest major haulout sites are more than 30 miles (48 km) west of the study area in the Colville River delta. Spotted seals likely would not be affected by construction, with the possible exception of disturbances by increased vessel traffic. Impacts to spotted seals would be negligible.

Polar Bear: No polar bear dens have been reported near the mine site; however, occasional dens have been located in the project area. Disturbance to denning polar bears as a result of noise from gravel mining on the Kuparuk River delta may occur. Disturbance of female bears from maternity dens could result in either abandonment of cubs or premature exposure of cubs (Amstrup, 1993:249). Should denning polar bears be disrupted near the mine site, the impact would be considered minor. However, it is unlikely that the polar bear population would be affected by gravel mining in this area.

Polar bears may avoid the immediate vicinity of the construction area or they may be attracted to it, depending upon the circumstances and the temperament of individual bears. Bears could avoid areas with high levels of in-air noise that is expected from construction equipment. Avoidance of the area is expected to have benefits since it would reduce the number of encounters between bears and humans, thereby reducing the chances of human injury or the need to kill bears. A shift in ringed seal distribution as a result of construction noise also could cause polar bears to avoid the area because of a lack of its primary prey. Avoidance or attraction to the construction site by bears is expected to have a minor impact on bears.

Fish: Gravel hauling, island reconstruction, and pipeline construction activities would be expected to generate noise from construction equipment and transportation sources that may be transmitted through water as described in Section 9.7. Most construction activities would take place during the winter and only affect marine fish (Section 6.4). Island slope protection and facilities installation and associated transportation activities would generate noise during the open water season that could affect marine and anadromous fish. Additional research and analysis is necessary to definitively determine the effects of noise on fish. Although rockfish are not present in the project area, studies on their reaction to noise indicate that impacts from noise on fish are expected to be negligible. However, impacts to fish in the project area may be different due to differences in species.

Birds:

Ice Road Construction, Island Construction, and Pipeline Installation: Construction activities associated with gravel mining and hauling, trenching and burial of the offshore pipelines, and installation of the onshore oil pipelines would take place in the winter. Winter construction activities would create noise and disturbance in the general area from blasting (mining) and use of heavy equipment, but few birds if any would be in the project area during the winter months. Only a few species of terrestrial birds, such as common ravens and ptarmigan, would be present in winter and in very low numbers. The proposed offshore pipeline route would pass between two barrier islands (Egg and Stump Islands) but would not affect the nesting habitats of common eiders and glaucous gulls on these islands since construction activities would be completed prior to the arrival of these birds in late spring/early summer. The overall effect of noise and disturbance on birds from winter construction activities would be temporary to individual ravens or ptarmigan and the impact is considered to be negligible. Spectacled eiders are not expected to be affected by winter construction activities at Seal Island because they are absent from the Alaskan Beaufort Sea during the winter.

Island Slope Protection Installation and Open Water Construction Period Activities: Island slope protection and island infrastructure construction would take place during the open water period when waterfowl and seabirds are present. The major source of noise affecting waterfowl during open water construction activities are helicopters flying to the island. Helicopter flight path and altitude is an important factor for waterfowl during the summer post-breeding season and staging for fall migration.

Information provided by BPXA and ERA Aviation, Deadhorse (Glover - Pers. Comm., 1998:1) indicates that helicopter support for Northstar primarily will be provided from the Deadhorse Airport; however, the Prudhoe Bay airstrip (operated by ARCO Alaska, Inc.) also will be used, if necessary. Helicopter flights between the Kuparuk airstrip and Seal Island are not planned (Glover - Pers. Comm., 1998:1), occasional trips may take place. Overflight restrictions currently are in place for Howe Island to avoid harassment of nesting snow geese. Pilots are requested to avoid harassment of wildlife elsewhere by either altering flight paths or maintaining sufficient altitude. Round trip flights to Seal Island (Chapter 4) are expected to total 1,100 during island construction, range from 1,140 to 1,380 during module installation (depending upon single-season and two-season construction), and total about 30 during drilling. The majority of flights during island construction would take place during April through August; flights associated with module installation would take place from late-August through November; and flights associated with drilling activities would take place throughout the year. Flights during the summer to early-fall would coincide with nesting, brood-rearing, and molting periods and could disturb birds. Flight paths between the airports and Seal Island and typical brant and snow goose nesting colony locations are shown on Figure 9-1. Impacts from fixed-wing aircraft to nesting and brood-rearing birds in the Kuparuk River Delta are not anticipated because the area is not within the approach or landing pattern of the airport and because it is not along flight paths (Perry - Pers. Comm., 1998:1). Nesting sites of spectacled eiders may be distributed throughout the area, but are not as well known as the goose colonies.

Figure 9-1 (Page 1 of 2)

Figure 9-1 (Page 2 of 2)

During spring migration and prior to fall migration, male and female spectacled eiders may be impacted both by construction activities at Seal Island and helicopters flying construction materials/personnel to and from the mainland. Post-breeding male spectacled eiders depart Arctic Coastal Plain wetlands approximately 22 June (+/- 11 days) and stage/migrate offshore a median distance of 4.2 miles (6.7 km) (+/- 6.9 miles [11 km]) (Petersen, in Bright, 1998:15). Post-breeding spectacled eider females depart Arctic Coastal Plain brood-rearing sites about 29 August (+/- 10.5 days) and stage/migrate 10.3 miles (16.6 km) (+/- 10 miles [16.4 km]) offshore. Because post-breeding females are in poor physiological condition, harassment during feeding in these areas may reduce accumulation of fat needed for migration and may have an adverse affect on survival. Therefore, if present, both male and female spectacled eiders would be impacted both by construction activities on Seal Island and helicopter flights to and from the island,

Low-elevation helicopter flights between Deadhorse Airport and Seal Island over tundra nesting areas may flush nesting birds, which may expose eggs to predation and chilling (Gollop et al., 1974:202-232). Multiple flushing events could result in reduced nest success in areas within the helicopter flight paths. The project area supports relatively low densities of eider nests in comparison to other tundra-nesting species (TERA, 1993:9).

Densities of spectacled eider breeding pairs in the Prudhoe Bay area have ranged from 0.21 to 0.49 per square mile (0.08 to 0.19 per square km [km^2]) from aerial surveys (TERA, 1996:3). Based on the mean density of spectacled eider breeding pairs for the Prudhoe Bay area, a 1-mile (1.6 km) wide flight corridor between the Deadhorse Airport and Seal Island would be expected to overfly approximately four to eight breeding pairs. Ground surveys have not been systematically conducted along all proposed pipeline routes and helicopter flight corridors. Low-elevation helicopter flights from Kuparuk Airport would be expected to affect similar numbers of breeding pairs, based on surveys of that area (TERA, 1996:3). Eiders with broods may be tolerant, to some degree, of noisy human activities, as shown by studies of radio-collared eiders with broods in the Prudhoe Bay and Kuparuk oil fields that have not demonstrated avoidance of oil field facilities (TERA, 1995:14; TERA, 1996:9). Nesting, brood rearing, and staging spectacled eiders are expected to be within the area affected by aircraft, and could be directly affected; however, this impact is considered minor and measures to avoid or minimize potential effects would be recommended by the U.S. Fish and Wildlife Service.

Brant have been shown to react negatively to helicopters, and they are likely to be affected by air traffic if colonies are overflown (Derksen et al., 1992:ii). Flight paths to and from Seal Island from the Kuparuk airstrip, the Prudhoe Bay airstrip, and Deadhorse Airport would not fly over brant nesting areas at the mouth of the Kuparuk River. Impacts to brant would depend on the aircraft type, exact flight path, as well as aircraft elevation. However, impacts to the low number of nesting brant (11 to 30 nests) within the flight path are expected to be minor.

The density of foraging birds in offshore waters near the island during the open water period is typically low, approximately 64.8 birds/square mile (25 birds/km^2) (Divoky, 1979:355). Activities on Seal Island during the open water period would likely attract scavenging glaucous gulls and jaegers, increasing the density of birds near Seal Island. Although this is expected to be a minor effect to gulls and jaegers, and noise impacts would be negligible, secondary impacts to other species may occur. This is because an increase in the population of scavengers due to an artificial food source may result in increased predation on nesting waterfowl and shorebirds.

Oldsquaw, common eiders, and surf scoters are also affected by low-level overflights (Gollop et al., 1974:202). Molting seaducks in lagoons tend to seek out sheltered areas during inclement weather, and if they are displaced from these areas, stress levels would increase (Gollop et al., 1974:202-232). Birds may move away from better feeding sites or protected areas because of the disturbance. Repeated low-level flights over molting aggregations of oldsquaws could displace those oldsquaws within the flight corridor. Foraging birds on the water or on land, and seabirds between the barrier islands and Seal Island, are more widespread and likely to suffer only temporary adverse impacts to individuals. Peak densities of molting oldsquaws in nearshore lagoons may reach 1,465 birds/square mile (566 birds/km2), a total of approximately 50,000 birds (Johnson and Herter, 1989:100). It can be assumed that up to 22,000 oldsquaw could be present in the eastern boundary of Simpson Lagoon and Gwydyr Bay based on the maximum density of 1,466 birds/square mile (566 birds/km2)(Johnson and Herter, 1989:100), and could potentially be affected by aircraft overflights of this area. If impacts to the species were to occur during the molting period, which extends from mid-July through mid-September, energy demands could increase and affect the growth of new flight feathers. Furthermore, populations of oldsquaw in Canada and parts of Alaska are declining (Conant et al., 1997:n.p.). Since large portions of these oldsquaw populations migrate through coastal lagoons in the project area, disruption from helicopter traffic through Simpson Lagoon could contribute to their overall declining numbers (Section 6.7.2.2). Overall impacts to oldsquaws and common eiders from aircraft overflights would be significant during construction, and minor during operation. Impacts to most other seabirds and sea ducks would be negligible.

Terrestrial Mammals: Gravel mining and hauling, island reconstruction, and onshore and offshore pipeline construction would take place during winter. Installation of island slope protection and facilities would take place during the open water season. An increase in the ambient noise level is expected during island and pipeline construction activities. The primary noise sources associated with pipeline construction would include vehicles such as trucks, cranes, bulldozers, backhoes, and compactors. Sound levels from these sources are similar to mining equipment.

Approximately 15 vehicle trips would be required daily during the construction period. Trucks would use existing roadways or the ice roads. Sound levels from a truck passing by may be as high as 85 dBA at 50 ft (15.2 m) from the road. An increase in the ambient noise level is expected but pipeline construction is a dynamic process whereby increased noise will be short-term and temporary in any one location.

Caribou: A small number of caribou winter on the Arctic Coastal Plain, most winter in the foothills of the Brooks Range (Child, 1973:4; Gavin, 1978:13). Gravel mining activities would create noise and disturbance in the general gravel pit area from blasting activities and equipment used for loading and transporting gravel. The disturbance may result in some displacement of caribou if any were overwintering in the surrounding area during the mining activities. Caribou move considerable distances to forage on the Arctic Coastal Plain during winter; displacement of wintering caribou would not, therefore, be expected to have an effect on health of these animals and any disturbance would be short-term. Much of the noise and activity associated with mining and gravel hauling would be similar to other industrial activities which periodically occur in the Prudhoe Bay area during the winter months. Impacts to caribou would be minor.

Noise associated with offshore construction is not expected to affect caribou onshore due to the substantial distance from the source, and onshore construction will be limited to winter months. Noise from helicopter inspection overflights during construction of the island and pipelines may cause a mild behavioral effect and, possibly, some movement, as identified in an Air Force study (Armstrong Laboratory, 1993:33-40). Therefore, impacts to caribou are considered minor.

Arctic Fox: Arctic fox are primarily scavengers during the winter and may be attracted to construction activity in order to obtain food scraps. These areas would include gravel mining sites and any areas where human activity would occur. Arctic fox do not typically avoid construction sites and are unlikely to be disturbed by noise. Impacts are considered minor.

Sensitive Receptors: Adverse impacts to sensitive receptors as a result of noise from project construction are expected to be short-term and largely limited to vehicle movement within the Prudhoe Bay industrial complex. Therefore, noise-related impacts to residential, hospital, meeting halls, or similar sensitive receptors are not anticipated.

Subsistence Harvesting: Subsistence resources that are most likely to be affected by construction activities are the bowhead whale and caribou. Although residents harvest several species of marine and terrestrial mammals, fish, and birds, harvesting has not been permitted within the Prudhoe Bay area since the 1970s. Among the Alaskan Beaufort Sea communities, spring harvesting of bowhead whales during their west to east migration is only practiced by Barrow residents, approximately 150 miles (241 km) west of the project area. Construction activities during the spring would not impact bowhead migration patterns or subsistence harvest success. Noise associated with fall construction activities could impact the fall subsistence harvest of Nuiqsut residents who use Cross Island as a base camp. The fall bowhead hunt from Kaktovik, located approximately 100 miles (161 km) east of the project area, would not be impacted by construction noise.

Most construction activities would be completed in the spring and fall. Fall construction would be scheduled for completion prior to the fall (late August - early October) bowhead migration period. However, activities that may continue into the fall and potentially coincide with migration during the first year include grading, installation of filter fabric and slope protection, preparation for and offloading of modules, module installation and hook-up, and drilling rig mobilization at Seal Island. The resupply of drilling consumables by boat would take place during the fall of the second year, and drilling and well completion would be ongoing during three fall seasons.

Although noise generated from such activities would be variable and dependent upon the types of vessels and equipment used, pile-driving and ocean-going tugs are likely to elicit the greatest reaction from migrating bowheads. Tugs can emit high levels of underwater noise at low frequencies. Tugs are one of the loudest types of vessels, so their sounds could travel farther than other vessels. In August 1985, underwater noise was recorded from two tugs that were keeping a barge pressed against a loading ramp at Sandpiper Island. An underwater sound level of 163 dB in the 20 to 1,000 Hz band was recorded at a distance of 0.3 miles (0.5 km) (Miles et al., 1987:106). Peak noise levels (118 dB) in the 20 to 1,000 Hz band were noted at a range of 1 mile (1.6 km) when tugs and barges were present at Seal Island (Davis et al., 1985:61).

Avoidance reactions of bowhead whales to small boats have been observed at distances up to 2.5 miles (4 km), however, most reactions have been observed at ranges of less than 1.2 miles (1.9 km), often when measured levels of underwater noise were less than 90 dB in the 1/3-octave band of maximum noise (Richardson et al., 1985a). The negative response is probably learned by association at these ranges and sound levels, and the animals probably represent the more sensitive segment of the population. The most overt responses are those for whales observed within 0.6 miles (1 km) of an approaching vessel. Whales usually avoid the approaching vessel by trying to outswim it, and response is probably mediated more by the rate of increase in the noise level than by the absolute received level. If overtaken, the whale will turn to swim away from the path of the vessel. These animals probably represent the segment of the population that is less sensitive to vessel noise since they are the animals seen closest to vessels. Whales tend to show little response to vessels that move slowly and are not heading toward them (Richardson et al., 1995a:268-270).

Inupiat hunters have also reported that bowheads are frightened by vessel noise and that bowheads would avoid approaching vessels that are attending a drilling vessel. The direct relationship of avoidance is further demonstrated by observations that whales are not present when vessels are present, but return in the absence of vessel operations. The avoidance response is such that whales have been observed to travel as far as possible from ship activity (A. Brower in USDOI, MMS, 1986:52; J. Ningeok in USDOI, MMS, 1986:16).

Bowheads respond to boats by spending less time at the surface, taking fewer breaths when surfacing, and changing swimming speed and direction. These types of reactions were evident at distances of at least 2.5 miles (4 km) from a vessel (Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61). The underwater noise levels to which the reacting animals were exposed were often not any higher than noise levels experienced during Sea States 1 to 2, and in one case a mother and calf reacted when the nearest approaching vessel was approximately 9.3 miles (15 km) away (Richardson et al., 1985a:116; Koski and Johnson, 1987:59).

If large ships are active near Seal Island during fall bowhead whale migration, deflection behavior could occur at the western border of Nuiqsut's bowhead harvest area. If the whales are deflected at a distance of 25 miles (40 km), and if no whales were harvested within the eastern range of the Cross Island whaling area, impacts to the fall whale harvest could be significant to subsistence. Although unlikely because of the planned schedule of island construction activities, there is a chance that some bowheads that are close enough to hear large vessel noises might move offshore from their normal migration path. If this happened, there is a possibility that some whales near the western boundary of the Cross Island whaling area might deflect offshore, making them unavailable to the hunters. The impact of a major reduction in the subsistence harvest of bowhead whales could be significant to Nuiqsut.

Onshore pipeline construction would be carried out during the winter and is not expected to displace caribou harvested for subsistence. Therefore, impacts to caribou subsistence harvesting is not anticipated.

9.8.2.2 Operation and Maintenance Impacts

Bowhead Whale: Many Inupiat have observed that noise from oil and gas development adversely affects bowheads by deflecting the fall migration or by causing the whales to become more wary. Displacement of bowheads offshore is a major cause of concern to Inupiat whalers who have stated that hunters are forced to travel further to meet harvest quotas and it has been the reason for unsuccessful whaling seasons (Ahmoagak, 1995:4; and F. Long, Jr., 1996:73; USDOI, MMS, 1995:13; USACE, 1996:34). The 1985 harvest failure at Kaktovik has been attributed to exploratory drilling operations (J. Kaleak in MBC, 1996:69). Two offshore drilling activities during open water that year were the Hammerhead Prospect, 34 miles (55 km) east of Cross Island, drilled by ship between August 10, 1985 and September 24, 1985, and the Harvard Prospect, spudded from a gravel island within the Sandpiper unit in September. The location of the drilling vessel may have been considered to cause disturbance within the path of the fall migration pattern, near the Kaktovik subsistence harvest area (Section 7.3).

Impacts to bowhead whales from noise during drilling operations are expected to be similar to noise impacts from drilling during construction, except that during operations, drilling noise would be continuous. Underwater noise from in-air gas flaring is expected to be a negligible impact.

The predicted impacts of drilling operations and maintenance activities are not based upon direct evidence because there is not adequate data documenting bowhead responses to island drilling activities. There is sufficient data indicating that whales are sensitive to offshore industrial activity (e.g., drilling platforms and seismic surveys) and that some whales respond by avoiding the industrial activity and possibly by decreasing vocal activity rate (Richardson et al. 1997; 1998). These results, however, are for cases where the noise level was either very loud (e.g., seismic survey) or the noise source was offshore in moderately deep water. Noises produced at the drilling island site during normal operations and maintenance activities are expected to have substantially lower sound levels than both seismic survey and offshore drilling activities. Furthermore the island site is in shallow water near the coast in an area through which very few bowheads are known to migrate.

Long-term impact on bowhead whales, should it occur at all, as a result of operational drilling activities, would be limited to some displacement of individuals away from Seal Island for three reasons. First, available data from previous studies suggest that noise from drilling machinery on artificial islands is not transmitted effectively through the substrate into the water column (Richardson et al., 1995a:127). The anticipated range at which the drilling noise would be greater than ambient noise is approximately 1.2 miles (1.9 km) up to 6.2 miles (10 km) during periods of unusually low ambient noise conditions. Second, the drilling noise associated with Seal Island operations is expected to be fairly constant, and whales appear to show less response to constant noise sources than variable ones.

Third, evidence suggests that a small number of bowhead whales would occur within a several mile radius of Seal Island (Section 6.9). Measured noise levels during island drilling operations and measured ambient noise levels for Seal Island suggest that, under quiet noise conditions bowheads could hear drilling noises at distances of not more than 6.8 miles (11 km) (Johnson et al., 1986:86; Malme and Mlawski, 1979:1; Richardson et al., 1995a:127-129). The worst case impact would be that the bowhead whales which swim near Seal Island would tend to avoid swimming within 6 miles (10 km) of the site.

Impacts to migrating bowhead whales from routine island operations would generally be limited to noise disturbance emanating from tugs and supply barges. Some Native hunters believe that bowheads change their migration patterns in response to helicopter noise (P. Tukle in USDOI, MMS, 1986:23; E. Brower in USDOI, MMS, 1987:15). Bowheads are known to sometimes react to helicopters by turning or diving abruptly, but these reactions are limited to animals directly below the aircraft (Richardson et al., 1995a:103 and 249). Given that project-related helicopter traffic will mostly take place during freeze-up when ice road and boat access is restricted, noise impacts from routine island helicopter operations would be minor.

Displacement of bowhead whales might occur as a result of Seal Island operations (including drilling). The whaling community firmly believes that displacement of the bowhead migratory path and the whales' avoidance of the Prudhoe Bay area have occurred as a result of industrial activities (J. Tukle in USDOI, MMS 1987:47; P. Tukle in USDOI, MMS, 1986:23), and these experiences lead to the concern that long-term displacement will occur as a result of Seal Island operations. In the past, displacement of the migration resulted in the need to hunt in areas as far as 40 miles (64 km) from traditional hunting areas (Section 7.3.2.2) and led to meat spoilage due to extended haul distances and times (D. Rexford in USACE, 1996:41). This increased distance also greatly increased the risk to the whalers and requires greater fuel expenditures. However, significant long-term displacement is not expected to occur as a result of Seal Island operations. Operations will occur on an island and, as a result, the range at which noise generated by the operations will be above ambient level is expected to be much less than the range for seismic or drillship operations. Therefore, any displacement is expected to be on the order of a few miles and involve only a few animals. This displacement might occasionally have a some effect on subsistence harvesting, but would have minor impacts on the whales.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island as part of a shore-based response system during the broken/thin ice period of spring breakup and fall freezeup. During freezeup there would potentially be a period of time from mid-October through early November (between 10 to 20 days, depending on the ice growth), when the ice would be thin enough (less than 18 inches [46 centimeters]) to allow icebreaking barges pushing a tug to maintain the corridor. Scenarios for Northstar have suggested that it would be necessary to travel between West Dock and Seal Island every 48 hours in order to maintain a partially-consolidated channel. The duration of the trips would be approximately 1 to 2 hours each way, depending on the ice cover. Assuming that such activities were possible over a 10- to 20-day period, with round trips occurring every 48 hours, only 5 to 10 round trips would occur between West Dock and Seal Island during this time frame in the fall.

Since tugs are one of the loudest types of vessels and their sounds travel farther than other vessels and with the additional sound created by the ice-breaking during a time of low ambient noise, it is possible that during the fall migration of bowheads that the whales passing Seal Island could hear the noise created by the ice-breaking barge activities. A tug pushing a barge in thin ice conditions means that there is no full-astern situation, which is noisier than a bow-forward situation. True icebreaking (assumed in relatively thin ice) has an estimated source level in the 165 to 177 dB relative to 1 μPa-m range, or 172 dB at the 50 Hz spectrum level (Richardson et al., 1995:117-121). The tug and barge are expected to have a peak spectrum level of around 162 dB in the 100 to 1,000 Hz band, compared to icebreaking with peak spectrum level of around 170 dB (Richardson et al., 1995: 112 and Figure 6.5). However, icebreaking activity showed greatest peak spectrum level (180 dB) in the 10 to 40 Hz band, not the 100 to 1,000 Hz band, where these high levels represent tones due to shaft and blade rates. Therefore, the mechanism of using a tug pushing a barge to break thin ice is not expected to produce greater noise levels than a tug operating alone. This tug and barge combination is expected to create on the order of 10 to 15 dB less noise than an icebreaker operating under comparable conditions. Because an estimated 5 to 10 round trips could potentially occur between West Dock and Seal Island, with a duration of 1 to 2 hours each way, it is unlikely that a large number of whales passing by Seal Island would be affected. If icebreaking barge noise did result in bowheads deviating from their normal fall migratory route, the impact on the whales is considered minor. If the noise caused a migration or behavior deviation that reduced the success of subsistence bowhead harvesting, the effect could be considered a significant impact to subsistence. However, the proposed icebreaking barge operations are not expected to commence prior to October 15. Although bowhead whales have been observed in the project area between August 31 to October 22, very few bowhead whales are expected to be in the project vicinity or to its east after October 15; such icebreaking barge operations should not effect the fall subsistence harvesting of bowheads. Spring icebreaking barge activities do not coincide with the spring bowhead migration past the project area. The National Marine Fisheries Service would recommend appropriate measures to avoid and minimize potential effects to bowhead whales associated with operation and maintenance activities.

Beluga Whale: Beluga whales migrate north of the project area and generally would not be affected by project noise. Those that come within about 0.3 miles (0.5 km) of the operational site are expected to hear the mid- to high-frequency underwater noises generated by operation activities. There is good reason, however, to conclude that belugas would not hear noises from the operation at distances beyond 0.3 to 0.6 miles (0.5 to 1 km) because the sound energy would be restricted to low frequencies and belugas have poor hearing in the low frequency range (Awbrey et al., 1988:2274). The short-term behavioral reactions of belugas to the expected low-frequency noises probably would be a modest avoidance effect within approximately 0.5 miles (0.8 km) of the site if underwater mid- to high-frequency noises are produced. Impacts to beluga whales would be minor.

Transportation of personnel and supplies during routine island operations would generate noise from the use of trucks on ice roads during winter (November to April), helicopters during broken ice seasons (May/June and October/November), and barges during open water (May/June to September/October). These activities likely would cause some temporary disturbance of marine mammals and possibly temporary displacement from the immediate vicinity of Seal Island and along the ice road corridor; the noise impacts to beluga whales from transportation activities during routine island operations would be negligible.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island as part of a shore based response system in the broken ice period during spring breakup and fall freezeup. Although the use of the icebreaking barges propelled by a tug may not generate the same noises as a true icebreaking vessel, impacts to belugas can be inferred from observations of icebreaking vessels. Beluga whales have been observed responding strongly to icebreaker vessel noises at ranges of up to 31 miles (50 km) (Cosens and Dueck, 1988:52). However, since most belugas tend to concentrate further offshore (Section 6.5) it is unlikely that they would hear such noises. If oil spill response activities required the use of icebreaking barges with tugs, and displacement of belugas occurred as a result of these activities, it would still be considered a minor impact to these whales.

Seals: Impacts from noise during operation drilling would be similar to those during construction, except that noise would exist over a longer period. The zone of potential noise impact for seals during operation drilling would be the same as for construction, on the order of 0.6 to 1.2 miles (1 to 2 km), depending on ambient noise conditions and seal responsiveness. Noise from operations would be more constant and not as variable as noise from construction, so fewer animals are expected to respond to operation noises than to noises from construction activities. Long-term effects are not known, but based on observations of short-term responses of these seals to manmade noise, seals would either avoid a limited area around the site or habituate to the additional noise; therefore, impacts to ringed and bearded seals would be minor.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island as part of a shore-based response system during the broken ice period of spring breakup and fall freezeup. Although the use of the icebreaking barges propelled by a tug may not generate that same noises as a true icebreaking vessel, impacts to ringed and bearded seals can be inferred from observations of icebreaking vessels. There have been some observations of short-term ringed seal reactions to ships and icebreakers (Brueggerman et al., 1992 as cited from Richardson et al., 1995a:225) showing that animals hauled out on the ice tended not to respond at ranges of several kilometers, but they did respond by diving into the water at closer ranges. There are some observations of bearded seals on pack ice diving into the water when an icebreaker was working at ranges of less than 0.6 miles (1 km); however, these animals seemed to be less responsive to the icebreaker when it was in transit in open water (Richardson et al., 1995a:275). Therefore, it is likely that these activities could cause disturbance to bearded seals and result in displacement when the icebreaking barge propelled by the tug passed through the corridor. Although this activity may occur as only 5 to 10 round trips, it would be considered a minor impact on bearded and ringed seals if displacement away from the corridor occurred. The opening of a corridor between West Dock and Seal Island may also attract seals to the open water corridor when icebreaking barges are not present. If this attraction resulted in seals congregating in the open water corridor, this would be considered a minor impact.

Polar Bears: Polar bears appear to be relatively tolerant of industrial disturbance in general and may approach the project site out of curiosity (Amstrup, 1993:249). Bears could avoid areas with increased in-air noise levels that is expected from such things as drilling generators and compressors. Polar bears could avoid or be attracted to Seal Island, depending on the age/sex/reproductive status, physiological condition, and temperament of the individual bear. No bears have been killed during the last 25 years of oil field development, and only one bear has been killed in more than 20 years of exploration (S. Amstrup - Pers. Comm., 1998:1). Avoidance of the site by bears would not have any adverse impact on bears. Impacts would be negligible.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island as part of a shore-based response system during the broken ice period of spring breakup and fall freezeup. The open water lead created by the icebreaking barge may attract seals and, as a consequence, polar bears may be attracted to the corridor as well. Should attraction of polar bears to the area occur as a consequence of maintaining the corridor, it would be considered a minor impact. It is also likely that icebreaking barges propelled by tugs could disturb and displace polar bears as the vessels pass through the corridor. Although this activity may occur as only 5 to 10 round trips of about 1 to 2 hours each way, any displacement due to disturbance from noise would be considered a minor impact to polar bears.

Fish: Fish are not expected to be present within the area between the shoreline and the barrier islands during the winter; therefore, there would be no impacts from noise. However, if the area between the shoreline and the barrier islands did not entirely freeze and fish were present and exposed to noise, impacts to fish would be negligible. Noise from boat and barge traffic during open water periods would cause some displacement of fish; however, impacts would be minor.

Birds: Noise from operation would be limited to offshore activity with the exception of aircraft and vessels necessary to ferry personnel and supplies. Noise from compressors, drilling equipment, the gas flare, grinding and injection equipment, and generators on Seal Island would create sounds that some birds may avoid. Other species may be attracted by noise they have learned is associated with the presence of human garbage. Birds that would frequent garbage sites are likely to include gulls and ravens. The attraction to a new food resource would result in an increased number of gulls and ravens in the project area. As a result of increased survival rates due to an additional food source, the distribution and densities of these birds could increase, which would result in minor impact to population numbers. Pipeline operation does not generate noise and, therefore, any impacts.

Impacts to birds from drilling activities during the operation phase would depend on the season. During winter, impacts would be limited to a few individuals. Birds attracted to the island during the summer open water period to feed or for shelter would include oldsquaw, common eider, king eider, and glaucous gull. However, habituation to drilling activities would lessen impacts to these species, thus, impacts from noise would be considered negligible.

Impacts from routine operation of the production facilities at Seal Island on birds would depend on the season and would involve noise and disturbance from activity on the island and transportation of personnel and material to the island. During the winter months (October to April) very few birds are present in the Alaskan Beaufort Sea; therefore, noise impacts to birds from facilities operating at Seal Island in the winter are not anticipated.

Some birds (oldsquaw, phalaropes, eiders, gulls) are expected to gather in the lee of the island during broken ice and openwater; however, due to the low density of birds 6 miles (9.7 km) offshore, large numbers are not expected. It is expected that birds would become accustomed to operation noises and, except for particularly loud events, would not be disturbed by on-going activities. Disturbance or displacement of these birds by operational noise during broken ice or open water would have negligible impacts. Helicopter and barge traffic ferrying personnel and supplies to the island during the broken ice and open water periods has the potential to disturb birds onshore and in nearshore waters. These noise effects would be similar to those from island slope protection and summer construction activities. Overall impacts to spectacled eiders, oldsquaws, common eider, and surf scoters from aircraft overflights in nearshore waters would be minor. Impacts to most other seabirds and sea ducks would be negligible. Impacts to brant and spectacled eiders from onshore helicopter overflights are expected to be minor.

No studies on the effects of noise on spectacled eiders have been conducted. It can only be inferred from studies of distribution of radio-collared eiders with broods in the Prudhoe Bay and Kuparuk oil fields that spectacled eiders have not demonstrated avoidance of oil field facilities or high noise areas (TERA,, 1995:14; TERA, 1996:9). TERA (1995:10-11) noted that at "the present stage of understanding it is difficult to formulate defensible hypotheses as to what would be expected regarding what spectacled eiders would do in the absence of facilities, largely because of the uncertainty as to what constitutes brood rearing habitat." TERA (1995:11) also noted that "qualitatively, the movements documented for our marked broods (6 broods) do not suggest avoidance of facilities or obstacles to movements." However, it is of importance to note that noise and activity may result in avoidance of facilities, whether or not they pose obstacles to brood movement (TERA, 1995:11-12).

Spectacled eiders appear to tolerate some degree of noise from industrial sources throughout the Prudhoe Bay region. Most broods observed in the Prudhoe Bay area spent part of their time within 656 ft (200 m) of high-noise production facilities, and some broods were located near Deadhorse airport (TERA, 1996:IV). Ground surveys of spectacled eiders within 1,640 ft (500 m) of the Kuparuk and Milne Point oil fields showed eiders to be present at an average distance of 722 to 732 ft (220 to 233 m) from oil field facilities, with one pair as close as 32.8 ft (10 m) (Anderson and Cooper, 1994:24). Anderson and Cooper (1994:58) noted that spectacled eiders were widely distributed in the Kuparuk and Milne Point oil fields but were not abundant at any single location. During the brood-rearing period, eiders with broods were also found to move extensively through the region and did not appear to avoid high noise areas (TERA, 1995:7-9). Anderson (1992) reported potential avoidance by spectacled eiders of the GHX-1 facility at Prudhoe Bay (as cited in TERA, 1995:12). However, the Prudhoe Bay area supports low densities of eider nests and broods, ranging from 0.34 to 0.51 nests/square mile (0.13 to 0.22/km^2) (TERA, 1995:5), based on aerial and ground surveys conducted from the Kuparuk River to the Sagavanirktok River, an area of approximately 463.3 square miles (1,200 km^2) (TERA, 1995:1-2). Effects of noise from project operations would be considered a minor impact.

Given the similarities in ecology between Steller's and spectacled eiders, it is expected that industrial noise would result in a minor impact to both species.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island during the broken ice period, until the ice becomes greater than 18 inches (46 centimeters) thick and movement between the two sites is not feasible. As a result, during the spring bird migration oldsquaws, king eiders, common eiders, and spectacled eiders may become attracted to these created open leads and congregate there (however, the fall migration is not expected to coincide with these operations because icebreaking activities should not occur prior to October 15). The open water leads created by such an activity would enable these birds to feed more easily off the epontic community beneath the ice. Icebreaking barges moving periodically through the leads would flush these birds from these feeding areas. However, assuming that fall freezeup allows for only 5 to 10 roundtrips, with a duration of only about 1 to 2 hours each way, it is unlikely that a noticeable disturbance would occur to birds that congregated in the created open leads. However, if such activity resulted in decreased productivity or survival of these birds, it would be considered a minor impact.

Terrestrial Mammals: Noise from operation will be limited to offshore activity, with the exception of aircraft necessary to ferry personnel and supplies and vehicular traffic. Pipeline operation would not generate noise. No impacts would occur to terrestrial mammals from noise emitted on the island due to the substantial distance from the source.

The effects of noise from helicopter inspection overflights to caribou, Arctic fox, and grizzly bear would be similar to those described for construction activity. Helicopter inspection overflights may elicit a mild behavioral effect, but this would be temporary. Impacts would be minor.

Sensitive Receptors: Adverse impacts to sensitive receptors as a result of noise from project operation is not expected because processing, gas compression, and related activities would be at the Seal Island facility. Furthermore, noise impacts from transportation activities would be limited to the Prudhoe Bay industrial complex and not in proximity to residential, hospital, meeting halls, or similar sensitive receptors.

Subsistence Harvesting: Impacts to the bowhead whale subsistence harvest as a result of operations and maintenance are likely to be less than those of construction and the same, regardless of alternative. However, the sensitivity of bowhead whales to low frequency sound indicates that operational noise would be heard at distances of 5 to 10 miles (8 to 16 km) under quiet ambient conditions.

The reaction of bowhead whales to vessel noise is documented through observations from Inupiat hunters and from marine mammal surveys. Although the avoidance reaction due to noise from a small boat has been noted at distances as small as 1.2 to 2.5 miles (1.9 to 4.0 km) (Richardson et al., 1995a:268), observations related to outboard motor operations noted avoidance reactions at approximately 3 miles (4.8 km) (T. Brower, Sr. in NSB, 1980:107), and reactions to moderate-sized vessels have ranged from 6 miles (9.7 km) (Ljungblad et al., 1985:45) to 9.3 miles (15 km) (Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61). Observations of bowhead avoidance due to large noise sources (i.e., drilling vessels) have been noted at 13 to 15 miles (21 to 24 km) (LGL and Greenridge, 1987:41) and have been found to affect subsistence harvesting (T. Napageak in USDOI, MMS, 1995:13; B. Adams in USDOI, MMS, 1995:26; H. Brower, Jr. in USDOI, MMS, 1995:84; B. Rexford in MBC, 1996:80; J. Kaleak in

MBC, 1996:69; B. Oyagak in USDOI, MMS, 1986:11). Although most noise-related activities that would cause displacement at distances sufficient to impact subsistence harvesting are likely to be related to logistics resupply and island grading and slope protection maintenance (each requiring annual usage of three barges), if such activities coincided with the fall migration, impacts resulting in a reduction in bowhead subsistence harvest could be significant.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island as part of a shore-based response system during the broken ice period of spring breakup and fall freezeup. Should such activities result in the displacement of bowhead whales, beluga whales, ringed and bearded seals, polar bears, and birds, subsistence users of these resources would be impacted. Although such displacements may last for only a short period of time (i.e, the period of time of the activity), if these activities resulted in the reduction of subsistence bowhead whale harvest for the local residents, it could be considered a significant impact to subsistence. However, these proposed icebreaking barge operations are not expected to commence prior to October 15. Because very few bowhead whales are expected to be either in or east of the project vicinity after October 15, such icebreaking barge operations should not effect the fall subsistence harvesting of bowheads. Spring icebreaking barge activities do not coincide with the spring bowhead migration past the project area.

Impacts to caribou herds within the project area could affect subsistence harvesting if productivity were to be reduced or migration patterns to traditionally used subsistence harvest areas were disrupted. Although helicopter overflights for periodic inspection of the onshore pipeline through open tundra could have a greater impact on caribou than those that parallel existing pipelines, flight elevations would be sufficient to avoid disruption of migration patterns. Lease stipulations for Northstar require that aircraft operations within 30 miles (48 km) of the coast between the Colville And Kuparuk Rivers avoid caribou by an altitude of at least 1,500 ft (457 m) or a lateral distance of 1 mile (1.6 km). Although a greater potential exists for migration pattern disruption along Alternative 2 and the link between Point Storkersen and Point McIntyre (Alternative 3) than those of Alternatives 4 and 5, no impacts to caribou subsistence harvesting are anticipated, regardless of the alternative selected.

9.8.2.3 Abandonment Impacts

Noise impacts related to abandonment are likely to be similar to those of construction. If the facility were decommissioned, vessel and barge traffic would be required for removal and transport to onshore locations or to other ports. Removal of the island protection would result in greater noise-related impacts than those of abandonment in place.

9.9 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

The project would generate noise from construction, operation, maintenance, and abandonment activities. Major noise sources would include ships, boats, helicopters, drilling equipment, trucks and busses for ferrying supplies and personnel. Construction of the island and pipeline will require diesel generators, bulldozers, backhoes, compressors, and pile drivers. Noise-related impacts would only occur during some circumstances, such as those related to maintenance or oil spill cleanup. In such cases, displacement of subsistence species could have a significant impact on subsistence harvesting.

- The bowhead whale may experience some degree of behavioral reactions and avoidance of Seal Island during migration due to noise, but the impact is considered minor. However, if such behavioral reactions were to result in long-term changes in bowhead migration patterns (over the life of the project and beyond), impacts to subsistence harvesting activities would be considered significant.

- Impacts on other marine mammals (ringed and bearded seals, beluga whale, and polar bear) due to noise from offshore sources are considered minor and limited to behavioral reactions and avoidance of Seal Island. Minor impacts would be expected from onshore noise sources.

- Impacts due to noise from offshore sources on fish are considered negligible. No impacts to fish would be expected from onshore noise sources.

- Impacts on birds due to noise from onshore and offshore sources is considered negligible, with four exceptions: 1) noise from helicopter overflights during construction could affect molting common eiders and oldsquaw, which may result in a significant impact; 2) noise from helicopters that may overfly nesting areas may affect nesting brant and result in a minor impact; 3) noise from helicopter overflights may have a minor impact to nesting eiders, waterfowl, and shorebirds in tundra areas, and molting sea ducks in nearshore waters; 4) barge traffic to the island during broken ice and open water periods may disturb foraging birds, and result in a minor impact; and 5) repair of the concrete mat armor protection system could displace some foraging birds from activities on the island slopes, which may result in a minor impact.

- Impacts from noise from offshore sources would have no effect on terrestrial mammals due to distance to the source. Noise from onshore construction sources would not impact denning grizzly bears and impacts from operation would be negligible. Impacts to Arctic fox from construction and operation activities would be negligible. Noise from aircraft overflights during construction and operation may result in a disturbance to some caribou, resulting in minor impacts during calving, migration, and insect-relief periods.

- If industrial noise were to occur as a result of an oil spill cleanup or offshore maintenance and repair activities during a period that coincided with the fall bowhead migration, the migration pattern could be deflected. A pattern deflection that would result in decreased harvest success or failure of the fall bowhead harvest would result in a significant impact to local whaling communities, such as Nuiqsut and Kaktovik.

- Impacts from noise during abandonment would be similar to those of construction. If the island slope protection were removed as part of abandonment, noise related impacts would be greater than if the slope protection were to remain in place.

Recognizing that the potential impacts described above would be felt by North Slope Inupiat, a minority population as addressed in Executive Order 12898, questions regarding Environmental Justice are raised.

For a discussion of Environmental Justice considerations, see Section 7.10.

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TABLE 9-1
IMPACTS OF NOISE GENERATED UNDER ALTERNATIVES 2, 3, 4, AND 5 ON THE BIOLOGICAL AND HUMAN ENVIRONMENTS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads – Construction	Once	All winter	Seal Island to landfall location and access roads to water supply.	Minor – Possible attraction of Arctic fox due to noise of traffic on ice roads.	None anticipated.
Ice Roads – Operations	Annually	All winter	Seal Island to landfall location and access roads to water supply.	Minor – Temporary displacement of overwintering caribou; possible attraction of Arctic fox due to noise of traffic on ice roads.	None anticipated.
Island – Construction	Once	3 Months	Vicinity of Seal Island and onshore areas.	Negligible - Displacement of beluga, bearded seals, and spotted seals from general construction activities; disturbance to marine fish; disturbance to ravens, ptarmigan, and most seabirds and sea ducks. Minor - Displacement/avoidance of beluga whales due to drilling and of bowhead whales due to helicopter/vessel traffic and drilling; displacement of ringed seals during late winter/early spring; avoidance/attraction of polar bears to construction site; mild behavior effects on caribou from helicopter overflights; disturbance of nesting brant and spectacled eiders from helicopter overflights. Significant – Disturbance to molting oldsquaw and common eiders from helicopter overflights.	Minor – Temporary displacement of prey species, impacting ringed seals. Significant – Impacts to subsistence harvesting of the bowhead whale if high noise-level activities in the vicinity of Seal Island coincided with the fall migration period and resulted in a reduced harvest.
Island – Operation/ Maintenance	Annually	15 years	Vicinity of Seal Island.	Negligible - Avoidance of the area by bowhead whales due to noise from gas flaring; disturbance to oldsquaw, common eider, king eider, and glaucous gull during open water and broken ice seasons. Minor – Displacement/avoidance of beluga whales due to drilling and of bowhead whales due to routine helicopter/ boat traffic and drilling; avoidance of area by ringed and bearded seals due to general activities on the island; to marine mammals and birds from noise due to icebreaker activity; disturbance to nesting brant and spectacled eiders from helicopter overflights; disturbance to molting oldsquaw and common eiders from helicopter and barge traffic.	Minor –Attraction of gulls and ravens to Seal Island could increase their productivity, which could cause increased predation on their prey species. Significant – Impacts to subsistence harvesting of the bowhead whale if high noise-level activities at Seal Island coincided with the fall migration period and resulted in a reduced harvest.

TABLE 9-1 (Cont.)
IMPACTS OF NOISE GENERATED UNDER ALTERNATIVES 2, 3, 4, AND 5 ON THE BIOLOGICAL AND HUMAN ENVIRONMENTS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Offshore Pipeline – Construction	Once	3 Months (Winter)	Offshore pipeline corridor from Seal Island to landfall.	Minor – Temporary displacement of ringed seals, polar bears, and non-migratory birds; possible attraction of Arctic fox due to the noise of offshore pipeline construction.	Negligible – Temporary displacement of prey species, impacting ringed seals.
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Offshore pipeline corridor from Seal Island to landfall.	Minor – To marine mammals from noise and activities during maintenance.	None anticipated.
Onshore Pipeline – Construction	Once	6 Months (Winter)	Onshore pipeline corridor from landfall to Pump Station No. 1.	Minor – Displacement of overwintering caribou and Arctic fox.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	Onshore pipeline corridor from landfall to Pump Station No. 1.	Minor – Disturbance to tundra nesting birds, Arctic fox, grizzly bears, and caribou from low-elevation helicopter inspection overflights; disturbance to nesting brant and spectacled eiders from low-elevation helicopter inspection overflights.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	Kuparuk mine site.	Minor – Displacement of caribou that overwinter in the area; to denning polar bears if mining of gravel results in abandonment of a den.	None anticipated.
Large Oil Spill	Rare	Unknown	Marine waters, lagoons, and tundra areas contacted by oil - up to 200 miles (322 km) from release site (Figures 8-4 and 8-5).	Minor - If noise from increased boat and aircraft movement for cleanup and mobilization result in displacement of marine mammals, terrestrial mammals, fish, and bird species.	Significant – Impacts to bowhead subsistence harvesting if noise from spill response activities during fall resulted in a reduced harvest.
Abandonment	Once	3 to 6 Months	Onshore and offshore pipeline corridors and vicinity of Seal Island.	Negligible to Minor – Temporary and similar to construction activity impacts.	Negligible – Temporary displacement of prey species, impacting ringed and spotted seals. Significant – Impacts to bowhead subsistence harvesting if high noise-level activities at Seal Island during fall resulted in a reduced harvest.

Notes: km = kilometers

CHAPTER 10.0

CUMULATIVE EFFECTS

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10.0 CUMULATIVE EFFECTS

10.1 INTRODUCTION

This chapter presents an evaluation of the cumulative effects associated with development of the Northstar Unit in addition to existing development and future actions. Cumulative effects are defined in 40 CFR 1508.7 as effects on the environment which are expected to result, "...from the incremental impacts of an action when added to other past, present, and reasonably foreseeable future actions... Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time."

The Council on Environmental Quality provides additional guidance concerning the evaluation of cumulative effects. In its handbook, Considering Cumulative Effects Under the National Environmental Policy Act (NEPA) (January 1997), the Council on Environmental Quality suggests the following:

- "determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative effects of other past, present, and future actions;
- identify significant cumulative effects and focus on truly meaningful effects;
- address additive, countervailing and synergistic effects;
- exclude future actions from the cumulative effects analysis if the actions are outside the geographic boundaries established for the cumulative effects analysis; and
- address uncertainty through monitoring."

This cumulative impacts analysis involved four distinct activities, including:

- Determination of the geographic scope of the past, present, and reasonably foreseeable future actions considered.
- Describe the individual actions which may contribute to cumulative effects.
- Assess available information concerning environmental resources, Northstar Development Project (Northstar Project) effects, and identified past, present, and foreseeable future actions for the purpose of identifying potential issues which require further evaluation.
- Investigate identified potential issues and present the results of that investigation.

The geographic scope of actions considered in this analysis is discussed in Section 10.2. The determination of specific actions addressed is described in Section 10.3, and a specific list of foreseeable future actions is presented. Sections 10.4 through 10.8 present the determination of potential cumulative effects issues, and an evaluation of those issues identified. As explained in greater detail in the remainder of this Environmental Impact Statement (EIS) chapter, the principal issues identified by this process and review of comments from the public during the EIS scoping and draft review processes include:

Issues/Concerns	Section
· What is the geographic area addressed by the cumulative analysis?	10.2
· What activities other than oil and gas development are considered in the cumulative impacts analysis?	10.3
· What past, present, and reasonably foreseeable future actions are expected to contribute to cumulative impacts?	10.3
· Would the Northstar Project contribute to cumulative effects by facilitating the development of other foreseeable future projects?	10.3
· Would the Northstar Project contribute to cumulative impacts of oil transportation on TAPS or the Valdez Terminal?	10.3
· What cumulative effects to the physical environment are expected?	10.4
· Are cumulative freshwater demands expected to result in substantial changes in lake water quality?	10.4
· How would the proposed action and other North Slope oil developments contribute to regional air quality problems, especially arctic haze?	10.4
· Are cumulative air quality impacts likely to cause adverse health effects?	10.4
· How would the proposed action contribute to concerns regarding cumulative effects on global climate?	10.4
· What cumulative effects to the biological environment would be expected?	10.5
· Would cumulative activity result in disturbances to polar bears and ringed seals?	10.5
· Would cumulative construction activity and routine project operations result in a significant loss of tundra vegetation?	10.5
· Would cumulative construction activity, freshwater demands, and gravel extraction result in a significant loss of wetlands?	10.5
· Would cumulative activity result in disturbances to caribou?	10.5
· Would cumulative activity (especially helicopter operations) result in disturbances to spectacled or Steller's eiders, both threatened species?	10.5
· Would cumulative activity and related noise result in significant disturbances to bowhead whales?	10.5
· What cumulative effects to the human environment are expected?	10.6
· How would cumulative activity or access restrictions affect subsistence hunting?	10.6
· How would cumulative activity and related noise affect subsistence whaling?	10.6
· What cumulative, long-term land use changes are expected?	10.6
· What cumulative effect on the visual character of the North Slope is expected?	10.6
· What cumulative effect on State of Alaska revenues is expected from existing and foreseeable future actions?	10.6
· What is the cumulative probability of a major oil spill, and what is the Northstar Project	10.7

Issues/Concerns	Section
contribution to this probability?	
· What is the cumulative probability of two or more major oil spills within a 5-year period, and what is the Northstar Project contribution to this probability?	10.7
· Would any biological resources be affected differently from cumulative exposure to multiple spills than as described for individual spills in Chapter 8.0 of the EIS.	10.7
· What cumulative effects would result from two major spills within a 5-year period, with specific consideration of population effects on spectacled eiders, other sea duck species (common eiders, oldsquaw, king eiders), polar bears, and bowhead whales?	10.7
· Could a single spill or multiple oil spills adversely affect subsistence hunting of polar bear?	10.7
· What cumulative volume of oil is likely to be released from chronic, small spills from all existing and foreseeable future projects?	10.7
· What cumulative effects of noise are expected?	10.8
· Could multiple offshore noise disturbances cause large-scale whale migration path changes and resulting effects on subsistence whaling?	10.8
· Could helicopter activities associated with multiple projects result in significant combined noise disturbances in common travel corridors?	10.8

The remainder of this chapter presents the results of the cumulative impact analysis process, and specifically addresses each of the issues listed above.

10.2 GEOGRAPHIC AREA ADDRESSED IN THE CUMULATIVE EFFECTS ANALYSIS

The geographic area addressed in this cumulative effects analysis was determined by evaluating the potential impacts of the Northstar Project described elsewhere in this EIS, and considering the geographic distribution of other past, present, and reasonably foreseeable future actions that could result in cumulative effects. This effort resulted in the determination of a geographic area (referred to as the cumulative impact area) including an onshore area from the Harrison Bay area (including the National Petroleum Reserve, Alaska [NPRA]) to the Kaktovik area, and extending seaward to include state waters and federal Outer Continental Shelf (OCS) lease areas encompassed by federal Lease Sales 144 and 170 (Figure 10-1). This geographic area was used to identify the activities addressed in the cumulative effects analysis, but it does not limit the geographic scope of the impacts evaluated. The geographic area was defined based on what is known about past, current, or foreseeable development activities.

The geographic range of impacts addressed varies according to the specific resource and nature of impacts under consideration. In some cases, the impact area addressed may extend beyond the boundaries of the geographic limits of the cumulative impact area. For example, the cumulative effects of noise could affect bowhead whale migration and, thereby, adversely affect subsistence whaling and Inupiat culture both in the immediate vicinity of the project as well as points along the whales' migratory path. It is conceivable that cumulative effects on whales could adversely impact subsistence whaling as far west as Points Barrow, Hope, and Lay (although it is highly unlikely that these effects could extend this far). Other cumulative impact issues may focus on a smaller geographic area within the cumulative impact area. This variation of geographic scope of the impact analysis is intended to allow the EIS to present a complete view of cumulative effects to which the Northstar Project contributes, and to provide a focus on meaningful cumulative effects. The specific geographic range of each impact evaluation was determined by a review of the nature of the cumulative issues (regional concerns generally required broader geographic consideration), and an evaluation of the specific contribution of the Northstar Project. In addition to the focused evaluation of potential combined effects of the Northstar Project and other actions within the cumulative impact area, this analysis considers common oil transportation systems (Trans Alaska Pipeline System [TAPS], Valdez Terminal, and west coast tankering routes), potential regional effects on subsistence whaling, and global climate issues.

In addition to the cumulative impact analysis in this chapter, the cooperative agencies have also reviewed the Biological Assessment (Appendix B), which was prepared to satisfy a different regulatory requirement. Under the Endangered Species Act (ESA), the Biological Assessment evaluates potential Northstar Project impacts on any endangered or threatened species found in the immediate vicinity at the project, as well as along foreseeable Northstar oil transportation routes. Two of the cooperative federal agencies participating in the preparation this EIS, the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) have carefully reviewed the Biological Assessment and have prepared their Biological Opinions concerning project impacts on ESA-listed species (Appendix M).

10.3 PAST, PRESENT, AND REASONABLY FORESEEABLE FUTURE ACTIONS

Past and present development within the cumulative impact area, ongoing community growth, and subsistence hunting and whaling activities were considered, along with oil and gas development, in the evaluation of potential cumulative effects. No substantial community growth or specific non-oil related future projects were identified which would materially influence the cumulative effects analysis. Subsistence

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activities are addressed as traditional activities subject to potential cumulative effects of oil development. The cumulative impacts analysis also evaluates potential combined effects on resources associated with oil development-related impacts and traditional subsistence activities. If these impacts are expected to result in resource management actions which could adversely affect traditional subsistence activities, they are identified as potential adverse effects on subsistence.

10.3.1 Past Oil and Gas Activity

Oil and gas exploration and production activities have occurred in the Alaska North Slope/Beaufort Sea region for over 30 years. The Prudhoe Bay oil reservoir was discovered in 1968 and generated substantial interest in the exploration for, and development of, oil and gas resources in this area. Since the first State of Alaska lease sale in December 1959, the State has leased over 32 million acres (13 million hectares) through sales that primarily offered North Slope/Beaufort Sea leases. Currently, active state leases north of the Brooks Range total approximately 16.43 million acres (6.65 million hectares). The most recent state sale on the North Slope was Lease Sale No. 87, held June 24, 1998. There have been approximately six federal oil and gas lease sales within federal waters of the Alaskan Beaufort Sea, beginning with the Joint State Federal Sale held in December 1979. The most recent federal sale in the Alaskan Beaufort Sea was Lease Sale 170, held in August 1998. These sales resulted in the leasing of 688 tracts, of which 96 remain active. Approximately 30 wells have been drilled in these leases, of which nine have been determined producible (USDOI, MMS, 1998:IV-1-21).

Since the first production well was drilled in the Prudhoe Bay unit, North Slope oil reservoirs have produced a cumulative total of 11.57 billion barrels of oil through the end of 1996 (USDOI, BLM, 1998: IV-A-43). Production from North Slope reservoirs peaked in 1988 at 2 million barrels per day (barrels/day) of oil, and declined to 1.45 million barrels/day of oil by 1995 (ADNR, 1996:5-40; USDOI, MMS, 1998:IV-A-21). The activities associated with oil and gas industrial development which occurred in association with this historic production included the creation of an industry support community and airfield at Deadhorse, as well as an interconnected industrial infrastructure including roadways, pipelines, production and processing facilities, gravel mines, and docks. (For an overview of present and reasonably foreseeable future activities associated with oil development in the Arctic, refer to Sections 3.4.2.1, 10.3.2, and 10.3.3). TAPS was developed to transport North Slope crude oil to a year-round marine terminal in Valdez, Alaska. TAPS operations were initiated in 1977, and this pipeline is used to transport the entire production from the North Slope. TAPS currently operates with substantial available capacity.

10.3.2 Present Oil and Gas Activity

The industrial facility infrastructure referred to above currently includes interconnected facilities from the Oliktok Point area in the west to the Sagavanirktok River in the east. Recent construction of the Badami facilities at Mikkelsen Bay, located about 25 miles (40 kilometers [km]) east of Prudhoe Bay, and its pipeline connection to the Endicott common carrier pipeline, represent the easternmost extent of current oil production activities. No year-round roadway connections between this area and other existing industrial areas exist. Recently developed Tarn facilities are located approximately 18 miles (29 km) west of the Kuparuk River Unit, and are connected to Kuparuk Unit facilities by a new gravel roadway and pipeline. Industrial facilities currently in place produce, transport, and process production from the Kuparuk, Milne Point (including Schrader Bluff and Cascade), Prudhoe Bay, Lisburne (including Niakuk and Point McIntyre), and the nearshore Duck Island (Endicott) Units. Approximately 1,123 miles (1,807 km) of pipelines connect producing wells to production processing facilities, and then to the TAPS. Approximately 7,000 acres (2,833 hectares) of land are developed for drill pads and processing facilities, and facilities are connected by approximately 360 miles (579 km) of gravel roads. Fifteen gravel mines totaling approximately 1,600 acres (648 hectares) have been developed for source material; however, only seven of the mine sites are currently in use (or active). The North Slope has on the order of 1,800 oil production wells, 100 gas injection wells, and 600 water injection wells.

From 1977 through 1996, approximately 11.57 billion barrels of oil have been produced from these reservoirs. As of 1995, North Slope production was approximately 1.45 million barrels/day of oil, 9 billion standard cubic feet per day of gas, and 2 million barrels/day of water (BPXA, 1997:24). Oil production is forecast to continue from currently developed oil fields at diminishing rates through at least 2020 (ADNR, 1997: 5-40). Detailed descriptions of the facilities are presented in Section 3.3.2 and summarized in Table 10-1. Existing facilities are shown on Figure 10-2.

Crude oil produced from all existing fields is transported to world markets via the TAPS. As of 1995, TAPS throughput was 1.45 million barrels/day oil. The TAPS is expected to continue to operate through the year 2015 (Thomas et al., 1993:1-8).

10.3.3 Reasonably Foreseeable Future Actions

Reasonably foreseeable future actions addressed in the analysis of cumulative effects include the projected decline in production from existing oil fields, all currently identified proposals for new development, and an estimate of potential exploration and development associated with recent and presently proposed lease sales. This cumulative analysis is focused upon identifiable existing and future oil and gas activities which are reasonably expected to occur during the life of the proposed Northstar Project, a period of approximately 15 years. A summary of the reasonably foreseeable future actions addressed by this analysis is presented in Table 10-2.

The 1995 oil production rate of 1.45 million barrels/day from existing North Slope development is projected to decline to 0.944 million barrels/day oil by 2005, and to 0.292 million barrels/day oil by 2020 (ADNR, 1997:5-40). This decline will result in substantial available capacity in TAPS, as long as this system remains operational. The U.S. Department of the Interior has suggested that TAPS would require extensive modification to continue to operate at less than the projected 2015 throughput of 0.384 million barrels/day

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(USDOI, MMS, 1998:IV-A-23). Capacity also may become available in many oil field facilities and pipeline systems during this period, although only common carrier pipelines would be readily accessible to all operators.

Remaining oil reserves for the North Slope/Beaufort Sea area are forecast to be substantial. Producible reserves between 6 and 11 billion barrels have been estimated in state leased areas, and another 0.57 to 1.22 billion barrels are estimated in areas leased or proposed for leasing by the federal government. Total production from currently operating and identified fields which are expected to be developed is estimated to be 6.47 billion barrels from 1997 to 2020 (USDOI, BLM, 1998:IV-A-43). In addition to the continued enhancement of production from the existing fields described in Section 10.3.2, these projected future production estimates consider additional future development.

10.3.3.1 Foreseeable Future Development

Alpine: Plans to develop ARCO Alaska Inc.'s (ARCO's) Alpine Unit, located 34 miles (55 km) west of Kuparuk in the western Colville River Delta, were announced October 2, 1996 (ARCO, 1996:1-4). Original oil in place is estimated at 800 million to 1 billion barrels, with 250 to 300 million barrels potentially recoverable using current technology (Nelson, 1996:30). A portion of the interest in Alpine is owned by the Arctic Slope Regional and Kuukpik Corporations, which makes it the first North Slope oil discovery with Native-owned mineral and surface rights. Part of the development plan may provide the nearby town of Nuiqsut with natural gas from the Alpine development.

Six wells, four side-track wells (a well drilled from an existing wellbore that is directionally drilled to another point), and a three-dimensional seismic survey indicate that the reservoir is approximately 10 miles (16 km) long, covering approximately 40,000 acres (16,188 hectares). Development is proposed from two gravel pads connected by 3 miles (4.8 km) of gravel road. One gravel pad, Alpine Pad 1, is approximately 85 acres (34.4 hectares) in size and will be used for the central oil processing facility, employee accommodations, maintenance facilities, and some drilling equipment. The second gravel pad, Alpine Pad 2, will be used for wellheads. A 34-mile (55 km) long pipeline will connect Alpine production to the Kuparuk pipeline, and TAPS. Daily production is expected to peak between 50,000 and 80,000 barrels/day oil, and production could start as early as the year 2000 (ARCO et al., October 1996:2-1). The oil transport pipeline would cross the Colville, Kachemak, and Miluveach Rivers. The pipeline will be installed under the Colville River by directional drilling for a distance of approximately 4,000 feet (ft) (1,219 meters [m]). The right-of-way was granted by the Alaska Department of Natural Resources on December 15, 1998. In addition, a seawater pipeline will transport water for waterflood from Oliktok Point to water injection wells.

Review of local, state, and federal permit applications required for the Alpine project was completed in early 1998. Construction activities began soon thereafter, and gravel fill has been placed for Pad 1 and the airstrip. Directional drilling of two holes for the pipeline has also been accomplished. Further construction is planned during the 1998/99 winter season.

Liberty Prospect: Lease Sale No. 144 resulted in a $10.6 million bid from BP Exploration (Alaska) Inc.

(BPXA) for the reservoir discovered in 1982 by Shell Oil Company from Tern Island. Tern Island is a manmade gravel island built for exploration drilling. It lies off of Foggy Island Bay about 20 miles (32 km) east of Prudhoe Bay, 10 miles (16 km) east of Endicott processing facilities, and 5 miles (8 km) north of the mainland in federal waters. The water depth averages about 20 ft (6.1 m) over the reservoir. Three exploration wells were drilled by Shell from Tern Island, which is currently abandoned and eroding. The Minerals Management Service (MMS) classified the three wells as containing producible quantities of oil. BPXA drilled an additional well in the winter of 1996/1997 from Tern Island. Based upon the results of the exploration wells, BPXA has proposed that the Liberty Prospect be developed from a new gravel island. BPXA estimates the Liberty reservoir has 120 million barrels of recoverable crude oil. Construction activities are proposed by BPXA for the 1999/2000 winter season, with first production anticipated by the end of 2000. A buried subsea pipeline is being considered to bring production to shore. The length and route of the offshore and onshore pipeline has not yet been determined. Development/production activities from Liberty require an EIS for compliance with NEPA. The MMS is in the process of preparing an EIS on the proposed development project.

10.3.3.2 Additional Potential Projects During the Northstar Project Lifetime

Additional projects are expected to be proposed and developed during the Northstar Project lifetime. Although the precise nature of individual projects cannot be accurately determined, the location of known discoveries provides information that may help identify the general location of future development. These discoveries are listed in Table 10-2, and are shown on Figure 10-2. Collectively, they are estimated to contain up to 1.38 billion barrels of oil (USDOI, BLM, 1998:Table IV.A.5-6). This total oil resource estimate is approximately double the amount associated with currently identified projects (Northstar, Alpine, and Liberty). Development of the discoveries listed in Table 10-2 is expected to occur in approximately 10 years, and would overlap with the last 5 years of the Northstar Project. These include the Point Thomson, Sourdough, Sandpiper, Hammerhead, and Kuvlum prospects.

10.3.3.3 Recent and Planned Lease Sales

Although less definite than the previously discussed foreseeable future developments, results of the most recent lease sales for federal and state lands may also lead to development. Seismic surveys and exploratory drilling are expected to occur during the Northstar Project life, and projections included in lease sale documents anticipate discoveries and production operations during this period.

State Lease Sales: State Sale No. 86A resulted in a total of five bids received from ARCO, Anadarko Petroleum Corporation, and Union Texas in the Colville River area. Thirteen tracts totaling approximately 15,484 acres (6,266 hectares) were offered for lease. The highest bid was $903,528 for a single tract. A total of 5,901 acres (2,388 hectares) were leased by the three companies (ADNR, 1996:1). An announcement by ARCO, Anadarko Petroleum Corporation, and Union Texas on October 2, 1996, revealed that the newly leased property lies adjacent to the Alpine discovery (ARCO, 1996:1-4). Specific development/production expectations associated with this lease sale are not available.

Proposed State Sale Beaufort Sea Areawide 1999 (combination of proposed Sales 83 and 89) scheduled for October 1999, consists of approximately 2 million acres (809,400 hectares) of state-owned tidal and submerged land in the Alaskan Beaufort Sea, between the Canadian border and Point Barrow, and some coastal uplands acreage located along the Beaufort Sea between the Staines and Colville Rivers. Hydrocarbon potential is considered low to moderate. Additional Beaufort Sea areawide sales are planned by the State in 2000 and 2001.

State Sale No. 87, the state's first area-wide lease sale, occurred in June 1998. Approximately 5.1 million acres (2 million hectares), divided into 1,225 tracts, between the Colville and Canning Rivers were offered. The sale resulted in a total of 168 bids on 139 tracts by 13 bidders. A total of 558,080 acres (225,855 hectares) were leased at an average price of $98.67 per acre (ADNR, 1998).

The State of Alaska has also announced plans to offer North Slope Foothills leases in 2001. The area under consideration for lease offerings includes State-owned lands between the NPRA and Arctic National Wildlife Refuge (ANWR), south of the Umiat Baseline and north of the Gates of the Arctic National Park and Preserve. The gross proposed sale area is in excess of 7 million acres (2.8 million hectares). Hydrocarbon potential is considered moderate.

Federal Lease Sales: Federal Offshore Lease Sale No. 170 was held by the MMS on August 5, 1998, focusing on the central portion of the Beaufort Sea. Thirty-one bids were received on 29 bidding units. Companies participating in the bidding were ARCO with Chevron U.S.A. Inc., BPXA separately and jointly with Chevron U.S.A. Inc., Petrofina Delaware, Inc., and Phillips Petroleum Company. BPXA submitted the highest bid, $911,922, for an area approximately 4 miles (6.4 km) offshore and 20 miles (32 km) to the east of Prudhoe Bay, north of the Duck Island Unit. This bid was rejected based on a determination that the bid was below the fair market value.

Phillips placed bids on 13 bidding units. Eight of them are in federal waters north and east of Cross Island. The remaining five are north of the McClure Islands. Petrofina bid on seven bidding units. One of the bidding units is located adjacent to and immediately northwest of the Sandpiper Unit, three bidding units are east of the McClure Islands, and the remaining three bidding units are north of Maquire/Flaxman Islands, one of which is adjacent and immediately south of the Hammerhead Unit. BPXA placed bids on seven bidding units. Two bids placed jointly with Chevron were for bidding units located in Federal waters offshore of the Point Thomson Unit. The remaining five bids were submitted by BPXA alone and were for two bidding units immediately east of the Northstar Unit, and three bids were placed on bidding units north of the Duck Island Unit, one of which was the rejected bid. ARCO and Chevron bidding jointly placed bids on two bidding units east of Cross Island.

The MMS has estimated total producible reserves from existing federal leases to be 0.22 to 0.55 billion barrels of oil. MMS estimates of oil resources to be discovered and developed associated with the proposed Lease Sale No. 170 are 0.35 to 0.67 billion barrels. These potential resources are based on estimates of production from fields that have not yet been discovered and are somewhat uncertain. However, these estimates have been considered in the cumulative analysis in this EIS.

The current federal 5-year lease sale plan for OCS waters covers sales to be conducted between 1997 and

2002. Federal Lease Sale No. 176 in the Alaskan Beaufort Sea has been scheduled for the year 2000. Specific offerings of this lease sale and related production potential are not presently known.

Future federal lease sales could result from a U.S. Supreme Court Dinkum Sands decision. The Dinkum Sands lawsuit was filed in U.S. Supreme Court by the U.S. Department of the Interior against the State of Alaska to settle 13 questions of merit, including one that defined the seaward boundary of ANWR. The state claimed that it owned the lagoon areas stretching across the northern coast of the refuge; the U.S. government claimed state ownership began at the barrier islands. The U.S. Supreme Court decision stated that the lagoon area belongs to the federal government. The amount of acreage involved may be as much as 100,000 acres (40,470 hectares) (Cashman, 1996:1).

Federal NPRA land is currently under evaluation for oil resource potential. An Integrated Activity Plan and EIS has been prepared for the Northeast Planning Area of the NPRA, and lands within this planning area will be offered for sale in the summer of 1999. An additional evaluation west of the Northeast Planning Area may also be considered in future planning efforts. Oil resources expected in the Northeast Planning Area total 130 to 600 million barrels. An additional 130 to 1,200 million barrels of oil are estimated to occur in the western NPRA (USDOI, BLM, 1998:Table IV.A.5-7).

10.3.3.4 Resource Evaluation Activities

Arctic National Wildlife Refuge: ANWR encompasses 19 million acres (7.7 million hectares), extending from the Canning River to the Canada border. ANWR was established in 1980 as part of the Alaska National Interest Lands Conservation Act. Congress set guidelines for the study of a 1.55 million-acre (627,285 hectare) area referred to as Section 1002. Petroleum exploration and development activities and support infrastructure are prohibited in ANWR. One exploration well was drilled in 1986 by Chevron on Native-owned land near the village of Kaktovik adjacent to Section 1002. All results from the exploration well, Kaktovik Inupiat Corporation (also known as the Jago River-1) remain confidential.

10.3.3.5 New Regional Pipeline Systems

Trans Alaska Gas Pipeline System: The Trans Alaska Gas Pipeline System has undergone NEPA review and construction permit application approval; however, it is considered highly speculative. The project has been proposed for many years, yet no agreement exists to purchase gas from North Slope producers or to sell gas to customers in commercial quantities. The gas pipeline would be an approximately 800-mile (1,287 km) pipeline that follows the existing TAPS corridor to transport natural gas in the North Slope to a new liquefied natural gas facility at the Port of Valdez. Yukon Pacific Corporation is the permit holder.

Alaska Natural Gas Transmission System: The Alaska Natural Gas Transmission System has undergone permit application review and approval. The Canadian portion of this project is in place. The installation of the Alaska portion is considered highly speculative, and no gas purchase agreement with North Slope producers currently exists which would justify the construction of the Alaskan segment of this system.

In addition to these two proposed gas pipeline systems, other potential delivery systems for North Slope natural gas have been discussed, such as using gas-to-liquid (white crude) technology and transporting the white crude through the TAPS system. Such options are also highly speculative at this time.

10.3.4 Northstar Development Project Effect in Combination with Past, Present, or Reasonably Foreseeable Future Actions

A concern has been raised regarding the Northstar Project's potential influence on other prospective oil developments on the North Slope. This concern is related to two primary topics: the potential that technical development and agency approval of a subsea pipeline from an offshore island could result in additional development of this type; and the potential that the development of an industrial infrastructure could facilitate further developments, such as Sandpiper (offshore) and Gwydyr Bay (nearshore and onshore).

With regard to the influence of the Northstar subsea pipeline technology, the technological issues have already been addressed by BPXA's project design. Agency approval or denial of the Northstar Project could influence the design proposed for other future projects if the agency action is clearly associated with the subsea pipeline project element. An action to deny Northstar would not necessarily eliminate other offshore projects, but it could affect project economics or influence project design details. Approval of the Northstar Project would not obligate agencies to approve any other project, but it could suggest to potential project developers that subsea pipelines are generally acceptable. Because approval of Northstar does not create an agency obligation concerning other projects, it is not considered a precedent that would remove any obstacle or environmental control currently applicable to other projects. The cumulative impacts analysis in this EIS does, however, presume that these projects will proceed (i.e., they are reasonably foreseeable).

Development of additional industrial infrastructure could improve project economics associated with the development of other prospects, such as Sandpiper and those in Gwydyr Bay. Currently available information concerning those prospects is not sufficient to allow an evaluation of the likelihood that they would or would not be developed in the absence of the Northstar infrastructure. The presence of the Northstar Project infrastructure, such as a production island and undersea pipeline, would not, however, obligate the development of these resources. The development of these prospects is considered in the cumulative impacts analysis, as reasonably foreseeable, and it is reasonable to expect that the Northstar infrastructure would be used if sufficient capacity is available.

The current oil transportation system, including TAPS and the Valdez Marine Terminal, were used to transport the peak North Slope oil production of 2.0 million barrels/day in 1988, and 1995 production of 1.45 million barrels/day. The State of Alaska estimates the combined production from existing and to-be-developed fields will result in progressively declining production, to a rate of 0.384 million barrels/day by 2015 (USDOI, MMS, 1998:IV-A-23). The TAPS and Valdez facilities are expected to continue to operate throughout the projected Northstar Project lifetime, regardless of the decision concerning the Northstar Project. The contribution of oil produced from the Northstar Unit will not offset the overall decline in

North slope oil transported through the TAPS. Therefore, production from the Northstar Unit will not increase the current risk of an oil spill. The analysis of potential effects of the TAPS pipeline and tankering system is incorporated by reference from Chapter IV of the "Outer Continental Shelf Oil and Gas Leasing Program: 1997-2002, Final Environmental Impact Statement, August 1996."

That analysis included consideration of impacts on physical, biological, and human resources associated with accidental oil spills from tankering TAPS oil to west coast ports. The analysis concluded that some degree of impact is likely on most environmental and socioeconomic resources. However, in virtually all cases, these impacts should not result in permanent change or loss of these resources.

10.3.5 Cumulative Impact Evaluation Process

The evaluation of potential cumulative impacts involves consideration of combined effects from multiple impact sources. The past, present, and reasonably foreseeable future actions described in Sections 10.3.1, 10.3.2, and 10.3.3 provide information concerning activities which may result in cumulative impacts. Although the specific location, timing, and level of activity associated with some of the individual actions listed are uncertain, the listed activities provide an overall view of the extent and level of industrial activity within the cumulative impact area coincident with the Northstar Project. To evaluate the combined effects of these activities, the EIS considers these activities as a collection of individual impacts distributed across the geographic range of the cumulative impact area (Figures 10-1 and 10-2). Several features of these impacts are considered to evaluate potential cumulative impacts, including:

- Intensity (magnitude of each individual impact).
- Scale (geographic area subject to each individual impact).
- Duration (persistence of each impact over time).
- Timing and frequency (schedule of impact occurrence, and consideration of potential impact recurrence).
- Synergy (potential interaction of different impacts to different, but related, environmental resources).
- Likelihood (effects that are uncertain are considered in the context of cumulative risk to identify potential impact concerns that might be overlooked in a single-project analysis).

The cumulative impact evaluation is intended to provide information concerning environmental effects that may be significant when the cumulative contributions of past, present, and reasonably foreseeable future actions are considered, even though the effects of individual actions may be minor. In some cases, this analysis addresses issues which have not been extensively studied, and may involve substantial professional judgement. This effort is further complicated by the level of detail available concerning future actions. As a result, many of the conclusions regarding cumulative effects are presented as a qualitative statement based on a general level of future activity, rather than a quantitative impact analysis addressing multiple clearly defined projects. The reasoning applied to each environmental issue is explained, along with the cumulative analysis results, to communicate the basis of the conclusions presented.

Decisions concerning the evaluation of cumulative effects using individual development-specific details, or more general regional-scale information, are accomplished based on the nature of potential impacts under consideration and the availability of specific information. Where the analysis of impacts is focused on the location and timing of specific activities, information concerning past, present, and foreseeable future actions presented in Sections 10.3.1, 10.3.2, and 10.3.3 provides the basis of this analysis. Environmental topics which require a broader consideration of the level of industrial activity are addressed by consideration of expected overall oil production rates and evaluation of the related exploration and development activity.

Regional-scale information used in the determination of cumulative impacts accepts the potential scale of oil development projected by the State of Alaska. The state estimates that production from existing development and known fields will total 6.47 billion barrels of oil from 1997 to 2020 (USDOI, BLM, 1998: IV-A-46). Based on the relative reserves associated with expected and possible sources of future production presented in Table 10-3, this production is expected to be derived from the following sources:

- Existing developed onshore fields - 59 percent (%)
- Existing developed offshore fields - 2%
- Proposed or possible new onshore fields - 21%
- Proposed or possible new offshore fields (including Northstar) - 18%

Table 10-3 (page 1 of 1)

In other words, future production estimates assume that approximately 39% of total production will be derived from new development, which is nearly evenly divided between onshore and offshore prospects. The Northstar Project would represent approximately 2.4% of the total currently projected North Slope oil production between 1997 and 2020.

The remainder of this EIS chapter presents the results of the cumulative effects analysis. As indicated in the following text, these impacts are not necessarily limited by the geographic boundaries of the cumulative impact area. Impacts of multiple activities which extend beyond the cumulative impact area are described fully where they are identified. In some cases, the cumulative analysis focuses on a smaller geographic area, and may specifically address overlapping or additive effects of a small number of identified existing and future actions to clearly present a specific issue. This flexible nature of the cumulative analysis is intended to accomplish the NEPA goal that the potential meaningful cumulative effects should be clearly presented. The specific analysis conducted in relation to each environmental issue is addressed in the issue-specific text in the remainder of this chapter.

10.4 CUMULATIVE EFFECTS TO THE PHYSICAL ENVIRONMENT

Existing and reasonably foreseeable future actions have the potential to result in cumulative effects to the geologic and hydrologic environment, air quality, marine water quality, and sea ice. The nature and significance of these effects and the expected Northstar Project contribution are discussed below.

10.4.1 Geology and Hydrology

With the exception of a large oil spill, no significant impacts to geologic conditions, soils and sediments, hydrologic processes, or freshwater quality were identified in connection with the Northstar Project (Section 5.3.2). Minor impacts were identified in relation to several concerns, including: disturbance and deposition of sediments on the seafloor, localized erosion at the pipeline landfall site, permafrost thaw-related subsidence at the island site and pipeline landfall, altered subsurface geology from injection of wastes, riverbed and bank modification, reduced sediment and soils quality, and water quality effects of freshwater withdrawals. Most of these effects are localized, and no specific overlapping effects associated with reasonably foreseeable future projects have been identified. The primary areas of potential cumulative impacts involve the potential for additional gravel extraction in the Kuparuk River associated with future Gwydyr Bay or Sandpiper projects, and potential water quality effects of cumulative freshwater requirements associated with these projects in combination with Northstar requirements. On a regional scale, the increasing number of localized disturbances and geographic expansion of the range of these disturbances beyond the existing industrial areas is another cumulative concern.

Gravel extraction, fill placement, and other soil disturbances associated with the construction of oil field facilities have the potential to affect surface runoff patterns and modify the soil's thermal regime. This can result in minor changes to drainage patterns or permafrost, and may cause an expansion of the affected area beyond the original disturbance. The specific details of the foreseeable future actions have not been clearly defined, and the total amount of gravel fill and extraction cannot be determined. Advances in project design based on over 20 years of experience have resulted in the development of successful approaches to help minimize these impacts. The Northstar Project have been designed to minimize trenching and placement of gravel fill in onshore areas, and the location of the proposed gravel extraction site near the Kuparuk River mouth is expected to prevent the alteration of local drainage patterns. Project design incorporates winter pipeline construction and does not include new gravel roadways.

Extraction of freshwater for use in the construction of ice roads to support onshore and offshore oil and gas activities would increase as new actions are developed. Water withdrawal from authorized water sources (e.g., lakes, rivers) occurs during the winter in accordance with permit restrictions on water volume. Because freshwater is replenished during the spring and summer months, the cumulative effect on lake water quality due to increased freshwater use for road construction would be negligible.

The geographic expansion of oil field facilities outside of existing developed areas, related future development of gravel extraction sites, and reconstruction of roadways and pipelines to connect these facilities to the existing industrial infrastructure, will result in the cumulative effect of increasing the soil area disturbed and the number of water courses exposed to these impacts. However, proper facility design and application of construction practices that minimize this effect (such as winter construction) are expected to reduce these effects to temporary and localized impacts. As a result, regional cumulative effects are expected to be negligible.

10.4.2 Air Quality

No significant impacts to air quality were identified in connection with the Northstar Project (Section 5.4.2). Minor impacts were identified in relation to air pollutant emissions from construction and project operations. These emissions contribute to cumulative air quality issues related to the presence of industrial emissions in an otherwise undeveloped area, local residents' concerns regarding regional air quality degradation and related health effects, and contribution to global greenhouse gas emissions.

10.4.2.1 Regional Air Quality

Existing oil field development and related facilities have contributed to industrial emissions sources in an otherwise undeveloped area. By regulatory standards, to date this cumulative effect is not significant since the North Slope area complies with all National Ambient Air Quality Standards and State of Alaska Ambient Air Quality Standards. The cumulative introduction of multiple industrial emissions sources in an undeveloped area is, however, considered significant by some observers without regard to regulatory standards. Whether such emissions from Northstar (or combined with reasonably foreseeable future projects) would contribute to arctic haze is not known. Arctic haze is a circumpolar problem with many sources, and Northstar's contribution would be an incrementally very small addition. A similar situation exists in terms of Northstar's (and the cumulative air quality effects of the North Slope) affect on global climate change (See Section 10.4.2.3).

10.4.2.2 Human Health

Project compliance with current federal Clean Air Act requirements is mandatory, and the Alaska Department of Environmental Conservation administers a comprehensive permit program to protect air quality in this area. Achievement of air quality goals has been complicated by the transport of pollutants from other areas, and local residents have expressed concerns that “arctic haze” associated with regional air pollutants has affected human health by increasing the incidence of cancer and respiratory ailments. Studies which clearly link health statistics to arctic haze have not been conducted. Production associated with existing and reasonably foreseeable future actions is projected to decline during the life of the Northstar Project. As a result, cumulative contributions of air pollutant emissions from oil development are not expected to increase above current levels. The Northstar Project will contribute to the extension of industrial emissions sources into offshore areas, but its onshore emissions will be consolidated within the existing industrial developed area.

10.4.2.3 Global Climate Change

Industrial activities on the North Slope contribute to global greenhouse gas emissions, and the Northstar Project will add to this contribution. These contributions result from the direct combustion of fossil fuels by North Slope facilities, the combustion of fossil fuels associated with the transport and refining of produced oil, and the ultimate combustion of most of the oil produced as a fuel. Gas emissions resulting from hydrocarbon fuel combustion have been suggested as a potential contributor to atmospheric changes that could cause global climatic warming. Estimates of the importance of fossil fuel combustion to the total atmospheric burden of greenhouse gases vary widely, and resolution of this controversy is beyond the scope of this EIS. However, an attempt to summarize this issue and its relation to Northstar is offered below.

Earth’s Changing Climate: Evidence from ice cores, geological strata, lake beds, and other sources indicate that the earth’s climate is changing constantly. For any specific location, the climate likely has been both warmer and colder in the past than at the present. It also is certain that, in the future, climate at most locations can be expected to vary from what is generally considered normal today. Such changes will occur with or without human influence. However, human activity may alter natural changes and cycles, either by augmenting or suppressing natural processes.

Knowledge currently available is inadequate for a full understanding of the dynamics of climate change and, at least in the near term, future changes will be difficult to predict with any level of confidence. It is known, however, that ice ages have occurred at approximately 100,000-year intervals for the last 3 million years. Apparently, the globe is currently experiencing a warm interval between successive cold periods. Moreover, concentrations of certain gases in the earth's atmosphere are changing. At present, levels of carbon dioxide are higher than they have been in the past 100,000 years. Carbon dioxide is one of the atmospheric gases frequently referred to as "greenhouse gases."

Human activities, beginning with the Industrial Revolution, are seen as the primary cause for the rapid increase in atmospheric carbon dioxide. Other greenhouse gases, including methane, chlorofluorocarbons, nitrous oxide, and water vapor also have been increasing. These "greenhouse gases" are assumed to be contributors to a "global warming" scenario or global increase in temperature. Computer models known as Global Climate Models (GCMs) indicate that increases in temperature will not be distributed equally around the globe, but are likely to be accentuated at higher latitudes, such as in the Arctic, where temperatures may rise more than the global average. Warming during the winter months is expected to be greater than warming during the summer.

On a regional basis, temperatures in Alaska and throughout the Arctic appear to have fluctuated considerably over the last few centuries. Since at least the mid-1970s, temperatures have warmed throughout much of Alaska. Most of the observed warming has occurred during the winter and spring. Overall, the temperature increases have been in the range of 3.6 degrees Fahrenheit (2 degrees Celsius), and the pattern has been similar to that predicted by the GCMs based on the increase in atmospheric greenhouse gases.

A climate that continues to change, as predicted by the GCMs, could have effects on the tundra ecosystem of the North Slope. The ultimate advantages and disadvantages of climate change for individual species of plants and animals are difficult to predict, and the structure of the future arctic ecosystem is not entirely clear. A warmer and wetter environment with a longer growing season is likely to have a strong positive effect on migratory birds by providing an increased period of time to raise their young. More productive aquatic food chains could benefit some ducks and loons. Conversely, an increase in abundance of deciduous shrubs, especially birch (less favorable caribou forage), and a decline in the abundance of grasses and sedges such as *Eriophorum vaginatum* (a particularly important food of calving caribou) could reduce the productivity of caribou habitats on the North Slope. Over decades, warming temperatures could result in the invasion of tundra habitat by taiga woody plants (taiga forests), a less favorable habitat for tundra mammals and some bird species, thereby adversely affecting their populations.

The rate of glacier, permafrost, and ice cap shrinkage remains a topic of scientific investigation. It appears fairly certain that many of the glaciers in the northern latitudes are receding. Century old records also suggest a reduction in the volume of permafrost. The respective contributions of natural and human generated causes remain unknown; as noted above, natural variability, on the century-scale, is large in the Arctic.

Cumulative Contribution of North Slope/Northstar Oil Production: For the Northstar Project, methane emissions will occur primarily as leaks from facility components and evaporation from storage vessels. The dominant mechanism for carbon dioxide production will be combustion of fossil fuels in equipment (e.g., gas powered turbine compressors). Carbon dioxide will be generated in much larger quantities than methane on a mass emission basis.

Assuming the presumed connection between emissions of greenhouse gases and global warming is valid, the proposed project activities will contribute incrementally to this effect. The direct emissions of carbon dioxide and methane due to project construction and operation will be modest, consisting mostly of temporary fuel firing by construction equipment and ongoing fuel combustion by boilers, heaters, turbines, and mobile equipment (e.g., vehicles) at the project site. The project design includes reinjection of produced gas, rather than flaring. In terms of cumulative impacts in combination with all North Slope activities, it should be noted that overall oil production in the region is declining and is projected to decline further, with or without the addition of the Northstar Project. This implies that production decreases at other operating units and corresponding decreases in emission of greenhouse gases will offset the incremental effect of the project's emissions. Thus, in a regional sense, there will be a net decrease in greenhouse gas emissions relative to current and recent levels.

In particular, of the greenhouse gases produced locally on the North Slope, Northstar will contribute less than an estimated 1%. To accomplish this low emission level, Northstar's design incorporates measures such as the use of efficient turbine drivers, minimized flaring, waste heat recovery techniques, fuel gas pretreatment to reduce carbon dioxide content, etc., to reduce the emission of such gases. On a regional basis, the entire North Slope is an attainment area, i.e., National Ambient Air Quality Standards (national standards) are "attained" in this region.

The total greenhouse gas emissions due to Northstar (technically referred to as the total downstream emissions budget), including emissions related to crude oil production, tanker shipments, refinement, product transportation, product utilization, etc., have not been precisely computed, in part because the eventual end products (e.g., plastics, gasoline, paving materials, etc.) are not known. However, an estimate can be made of at least the end product contribution of greenhouse gas emissions. As a worst case, assume the entire carbon content of Northstar derived crude oil, as produced at the peak production rate, were to be completely converted to atmospheric emissions in the form of carbon greenhouse gases (notably, methane and carbon dioxide). The ratio of these carbon emissions to the estimated annual global carbon emissions due to the burning of fossil fuels would be on the order of 0.037%. Averaged over the 15-year project life of the Northstar Project, this worst case ratio is reduced by roughly a factor of two.

The calculations offered above overestimate the actual budget for carbon emissions from the consumption of possible end products of Northstar crude oil because many of the end products are not burned (e.g., solvents, paving materials, etc.). However, these calculations do not include emission contributions from the production and shipping of crude oil, refining, end product transportation, and so forth, (i.e., the total downstream emissions budget). A recent study required by the World Bank computed the total downstream carbon emissions budget related to an oil development in Chad. This study included items such as those noted above and may be used to estimate the total downstream emissions budgets due to the Northstar Project. The carbon emissions budget for the Chad oil field development included: oil field operations including flaring, the use of a long overland pipeline with pump stations, tanker loading, marine shipping of crude from Africa to other continents, product refining, transportation of end products to bulk terminals and thereafter to marketing facilities, and finally the combustion of these end products by consumers. Linear scaling of the peak 225,000 barrels/day (Chad) production rate to that of a peak Northstar production rate (65,000 barrels/day) provides an estimate of peak annual downstream emissions budget, due to all activities ranging from Northstar production to end product consumption. This estimate is 0.045% of annual carbon greenhouse gas emissions from the worldwide production and use of fossil fuels.

The same linear scaling approach used in the World Bank Chad study can be applied to the total North Slope industrial activity and related oil production. The current cumulative North Slope industrial activity and resulting 1.45 million barrels/day oil production (and downstream use) represents approximately 1% of the global fossil fuel greenhouse gas emissions. During the life of the Northstar Project, North Slope oil production is projected to decline steadily. If reasonably foreseeable future development projects proceed, the North Slope oil production rate at the end of the Northstar Project's life (in 2015) is projected to be 1.21 million barrels of oil per day. This production rate and related fossil fuel combustion would represent approximately 0.83% of the current global fossil fuel greenhouse gas emission rate. Overall, the cumulative contribution of North Slope oil production to global greenhouse gas emissions is expected to decline, and the Northstar Project contribution is negligible. It should also be noted that one of the principal sources of greenhouse gas emissions associated with oil production activities, routine flaring of produced gas, has been eliminated from the Northstar Project by the BPXA design which incorporates the reinjection of produced gas.

As stated previously, estimates of the importance of fossil fuel combustion to the total atmospheric burden of greenhouse gases vary widely. From the results presented above, it is clear that North Slope cumulative activities and related production represent a small portion of the worldwide fossil fuel-related contribution, and Northstar specific contributions represent such a small component as to be nearly immeasurable.

10.4.3 Marine Water Quality and Sea Ice

No significant impacts to marine water quality were identified in connection with the Northstar Project (Section 5.5.2). Minor impacts, associated with project construction and maintenance, to water quality in the vicinity of Seal Island and along the offshore pipeline route were identified. Other cumulative water quality issues have been identified in relation to operational discharges from industrial activities and water circulation effects of shore access structures, spoils disposal, and construction dewatering. BPXA's

Northstar Project is currently designed to eliminate these impacts by eliminating most of the discharges to water originally proposed.

Turbidity caused by gravel placement, trenching and burial of marine pipelines, creates temporary localized turbid plumes during the construction period, and possibly during portions of the first open water period following construction, by resuspension of disturbed sediments. The extent of these turbidity effects has been estimated to affect about 1 square mile (2.6 square km [km^2]) by the MMS (USDOI, MMS, 1998:IV-G-1). Sediment monitoring conducted as part of the Northstar Project will provide data to confirm the expected effects from construction of the island and pipeline (Section 11.10.3). Because the reasonably foreseeable future projects are expected to be several miles apart and will not be installed at the same time, cumulative effects associated with combined turbidity plumes are not expected to occur.

Operational discharges from exploration and production facilities are not expected to result in cumulative impacts because these effects are localized (USDOI, MMS, 1998:IV-G-1). Analysis conducted as part of the Environmental Protection Agency's National Pollutant Discharge Elimination System review process concluded that impacts to marine water quality as a result of direct discharges from the Northstar Project into the marine environment will be negligible (Appendix O). In addition, BPXA intends to utilize an Underground Injection Control well for underground disposal of drilling muds and all other non-hazardous wastes, as well as surface runoff and domestic/sanitary wastewater (Appendix N). As a result, the project's operational discharges would have limited and very localized effects.

No significant impacts to sea ice were identified in connection with the Northstar project (Section 5.6.2). The only minor impact identified was associated with an oil spill contacting sea ice; all other impacts on sea ice by the project were negligible. Given the spacial separation of reasonably foreseeable future projects, cumulative effects on sea ice is expected to be negligible.

10.5 CUMULATIVE EFFECTS TO THE BIOLOGICAL ENVIRONMENT

Several potential biological issues were investigated concerning cumulative and project-related impacts. As addressed in the project-specific impacts analysis, issues of concern include: plankton and marine invertebrates, marine and freshwater fish, marine mammals, coastal vegetation and invertebrates, birds, terrestrial mammals, and threatened and endangered species. Potential cumulative impacts related to these topics are discussed below.

10.5.1 Plankton and Marine Invertebrates

Project-related impacts to plankton and marine invertebrates would be negligible to minor, and are associated with direct burial and water column turbidity associated with project construction and maintenance (Section 6.3.2.2). The effects of individual impacts associated with reasonably foreseeable future actions would be similar to those associated with the proposed project. As with the Northstar Project, these effects would be localized and temporary. No measurable overlapping or additive effect on plankton and marine invertebrates caused by the Northstar Project and other reasonably foreseeable future actions is expected.

10.5.2 Marine and Freshwater Fish

No significant direct impacts to marine or freshwater fish are expected to result from the Northstar Project. Minor impacts to marine fish are expected to result from turbidity and dewatering discharges associated with project construction and operational maintenance. No impacts to freshwater fish are expected from drawdown of freshwater lakes and rivers that are permitted for use as water sources for ice road construction. Total volume of water is restricted as a condition of a state water-use permit. These effects would be localized and temporary, and are not expected to result in measurable overlapping or additive effects in combination with other reasonably foreseeable future actions. Cumulatively, the impacts to fish would be similar to those described in Section 6.4.2.2 and are not expected to result in any significant impacts.

10.5.3 Marine Mammals

Cumulative effects associated with noise impacts on migrating bowhead whales could occur, and are discussed in Section 10.5.7.

Noise-related disturbances associated with Northstar Project construction and operation could displace bearded seals and ringed seals, and may attract polar bears to the island site (Section 6.5.2). Similar effects could result from other foreseeable future offshore developments, but these effects would be localized and would not result in overlapping or additive impacts.

The Southern Beaufort Sea polar bear population has been subjected to disturbance from past and existing oil industry activities in the Alaskan Beaufort Sea, mainly associated with noise disturbance. Noise disturbance can cause avoidance and loss of denning habitat. Mortality from human-polar bear encounters overall has been very low (one bear killed in 25 years of exploration and production in Alaska [S. Amstrup - Pers. Comm., 1998:1]), and future activities are expected to result in only a small increase in mortality to polar bears. However, any small increase in mortality could result in a minor reduction in the subsistence harvest (USDOI, MMS, 1997:IV-G-17). However, future actions, in combination with past and present activities, could result in displacement of polar bears due to noise disturbance. This disturbance would be associated with seismic activity; ice roads; ice road construction; facilities construction, operation, and maintenance; icebreaking barges; gravel mine sites; offshore drilling rigs and islands, and could be significant. The incremental contribution from the Northstar Project is expected to be minor.

Cumulative disturbances associated with past and existing offshore oil and gas activities has had little impact on ringed seals. However, future actions, in combination with past and present activities, could be expected to result in displacement of ringed seals due to noise disturbance. This disturbance would be associated with seismic activity; ice road construction; facilities construction, operation, and maintenance; icebreaking barges; and offshore drilling rigs and islands, and could be significant. The incremental contribution from the Northstar Project is expected to be minor.

10.5.4 Coastal Vegetation and Invertebrates

With the exception of a large oil spill, no significant impacts to coastal vegetation and invertebrates would result from the Northstar Project (Section 6.6.2). Minor impacts could result from tundra removal associated with the installation of gravel pads and vertical support members required for the Northstar Project. The Northstar Project (Alternatives 2, 3, 4, or 5) would result in a net loss of less than 2 acres (0.8 hectares) of tundra as a result of vertical support member placement and gravel pad construction (Section 6.6.2.2). Approximately 14 square miles (36.3 km^2) of tundra have been directly disturbed by previous onshore oil and gas activities on the North Slope (Franklin - Pers. Comm., 1998:1). Therefore, the cumulative amount of tundra loss as a result of the Northstar Project, although measurable, would be small when compared to previously disturbed acreage. Each new development, which would have onshore requirements, would also likely result in a net loss of riverine and tundra habitat associated with installation of onshore pipelines, gravel mining, and construction of gravel pads. This loss would vary depending upon the size, location, and complexity of future development/production activities.

Most of the tundra habitats described above are classified as wetlands as defined by the regulatory program for Section 404 of the Clean Water Act. The development of reasonably foreseeable future projects would result in additional disturbances to wetland habitats. Disturbances associated with individual offshore projects are expected to be similar to the Northstar Project, and onshore projects (such as the Alpine proposal) may disturb up to 100 acres (40.5 hectares). The cumulative area of potential disturbance associated with all currently identified discoveries would represent a small portion of the total wetland habitat in the cumulative impact area. Losses of wetland habitat associated with past development are substantial in certain areas, such as Deadhorse. As stated above, the Northstar Project contribution to this cumulative effect would be minor, and overall the loss of wetlands in the cumulative impact area is not significant. The Northstar Project design incorporates the placement of a gravel mine on a sparsely vegetated river bar area, which minimizes the adverse effect of this project feature. Following completion of gravel extraction activities, this area will remain as an open water lake which could provide a beneficial fish overwintering habitat.

10.5.5 Birds

Impacts to migratory birds (sea ducks) due to offshore helicopter overflights during construction are significant (Section 6.7.2.2). Avoidance or minimization of these impacts would be recommended by USFWS. Minor impacts were identified associated with disturbances to tundra-nesting birds from helicopter overflights, bird mortality associated with bird strikes on offshore structures, and loss of tundra wetland habitat. Impacts associated with attraction to a new food source at Seal Island include a minor increase in abundance of predatory bird species, which in combination with other artificial food sources from existing and reasonably foreseeable future actions, could result in a cumulative effect on tundra nesting birds. Cumulative effects associated with other disturbances are discussed below.

Helicopter overflights associated with routine pipeline inspections, island operations, and access for pipeline repair during the breeding season could result in displacement of birds from nests or interruption of feeding/brood-rearing activity. Disturbances from helicopter activity associated with the Northstar Project in combination with other reasonably foreseeable future actions, especially activities in Simpson Lagoon, the Gwydyr Bay and Point Storkersen area, and other offshore projects (such as Sandpiper), are presumed to be a significant cumulative effect (E. Taylor - Pers. Comm., 1998:1). These impacts would be most substantial if flight paths cross the Simpson Lagoon area or follow the shorelines of the barrier islands. Brant at nesting colonies or brood-rearing areas are the most likely affected species, and adverse effects could also occur to molting oldsquaw and common eiders in the lagoons. These cumulative impacts could be reduced to minor levels by prohibiting low-level helicopter flight over concentrations of sensitive species during critical time periods.

Bird strikes on offshore structures during periods of fog could result in the loss of individual birds. Although the number of birds potentially affected by this impact cannot be estimated using presently available data, these numbers would likely increase as additional offshore structures are developed. Because the combination of all reasonably foreseeable future actions involving new offshore structures represents a very small portion of the cumulative offshore impact area, the likelihood of this impact affecting a substantial proportion of any bird population is expected to be extremely small. This cumulative effect is not expected to be significant.

The construction of existing oil field facilities in the Prudhoe Bay - Kuparuk area is estimated to have directly affected over 58 square miles (150 km^2) of prime waterfowl wetland habitat, including the destruction of over 14 square miles (36.3 km^2) of this habitat. Cumulative habitat losses could affect the nesting distribution or density of some species for more than one generation. The planned construction of BPXA's proposed project (Alternative 2) during winter, and installation of a pipeline on vertical support members without new gravel roadway development, will result in a minor contribution to this cumulative effect (less than 2 acres [0.8 hectares]). Alternatives 3, 4, and 5 would result in a lesser contribution to this cumulative effect by routing onshore pipelines in existing disturbed corridors for most of their length.

10.5.6 Terrestrial Mammals

No significant impacts to terrestrial mammals are expected to result from the construction and operation of the Northstar Project (Section 6.8.2). Minor impacts to Arctic fox could occur as a result of vehicle collisions on project ice roads, attraction to construction areas, and disturbance from occasional low-level helicopter overflights associated with operations. Helicopter overflights could also result in temporary displacements of caribou and grizzly bear. Northstar facilities could also result in minor impacts to caribou insect-relief movement during summer. Disturbances to the Arctic fox are expected to be localized and very limited, and cumulative impacts are not expected to result in substantial additive or overlapping effects. Similarly, cumulative disturbances to grizzly bear associated with low-level helicopter overflights are expected to be infrequent and localized, since low-level flights are generally restricted by conditions applied to project approvals.

Concerns regarding potential disruption of caribou movements have led to the development of several measures intended to reduce impact to the species. The Northstar Project has incorporated these design elements, and other foreseeable future actions are expected to do likewise. These features include elevation of onshore pipelines at least 5 ft (1.5 m) above the ground and minimizing the construction of permanent roads alongside pipelines. The Northstar pipeline landfall valve station is well inland of the coast (150 ft [46 m]). This provides caribou an unimpeded movement corridor at the coastline. It is reasonable to expect that these measures will also be applied to future projects, and the resulting cumulative impacts to caribou will be minor.

10.5.7 Threatened and Endangered Species

Four threatened or endangered species occur in or near the Northstar Project area: delisted Arctic peregrine falcon, threatened Steller's eider, threatened spectacled eider, and endangered bowhead whale (Section 6.9.1). No Arctic peregrine falcon nesting sites are known to occur in the vicinity of the Northstar facilities, and disturbances associated with project activities (including noise) are not expected to adversely affect this species (Section 6.9.2.2). The Northstar Project would not contribute to any adverse cumulative effects to the Arctic peregrine falcon.

Among the purposes of the ESA are to conserve ecosystems on which listed species depend and to provide a program for the conservation of these species. The ESA defines an endangered species as, "any species which is in danger of extinction throughout all or a significant portion of its range." The ESA defines a threatened species as one that, "is likely to become endangered within the foreseeable future." Threatened and endangered species are those fish, wildlife, or plants listed under Section 4 of the ESA.

Only one Steller's eider nest site is known to occur in the Northstar Project area. Impacts to Steller's eiders associated with cumulative project activity is not expected. Spectacled eiders are known to nest within 0.5 miles (0.8 km) of the Northstar pipeline routes (TERA, 1995: 7-9 and Appendix 2) and two or more nest sites could be affected by helicopter overflights along the pipeline route. This species appears to be somewhat tolerant of noisy human activities (TERA, 1995: 14; TERA, 1996: 9); however, there is a potential for adverse noise disturbance impacts from low-level helicopter overflights. Because this species has exhibited declining populations in recent years, an extra measure of protection is required under the ESA and measures to avoid or minimize impacts have been suggested by the USFWS. The USFWS has evaluated the potential project and cumulative impacts on spectacled and Steller's eiders in its Biological Opinion (Appendix M). The USFWS will recommend that helicopter flight corridors not cross breeding habitat from June through August to avoid or minimize potential effects.

Cumulative effects to the bowhead whale could be caused by regional increases in offshore oil and gas activity. Other than potential oil spill effects (Section 10.7), impacts associated with offshore oil and gas activities are primarily from noise generated during facilities construction, drilling, operations, and seismic surveys. Bowhead whales exhibit avoidance behavior in the vicinity of vessels, seismic survey activity, and aircraft at altitudes below 984 ft (300 m). Observations vary of bowhead response to disturbances, and the typical response to a single disturbance is avoidance behavior involving movements of up to a few miles. Recorded avoidance movements last a few minutes in the case of vessel and aircraft noise, and up to 30 to 60 minutes in response to seismic survey activity (USDOI, MMS, 1997: IV-CJ-21).

Cumulative offshore activity associated with current and reasonably foreseeable future projects could represent substantial increases above current levels. Seismic survey activities associated with leases issued in recent and currently planned federal lease sales could introduce substantial new noise-related disturbances. Because the bowhead are typically found in offshore waters during the open water months when these activities occur, any such activities would be expected to directly affect the bowhead. If multiple disturbances were to occur at several offshore locations over multiple years coincident with the fall bowhead migration, the reaction of the species could result in a migratory path deflection, either temporary or long lasting. This effect can be eliminated or substantially reduced by coordination of the timing and location of seismic activities and offshore facility access vessel and helicopter paths to minimize operations in the vicinity of migrating whales. Such mitigation measures have been proposed and are presented in Section 11.10.2.

Although the potential migratory path deflection would not likely represent an adverse effect on bowhead populations, it could result in a significant impact to subsistence whaling. This topic is discussed in Section 10.6.1.

NMFS has reviewed the current status of the bowhead whale population (the environmental baseline for the project area), the potential effects of the Northstar Project, and its cumulative effects, and concluded that the activity will not jeopardize this population. For more information, see NMFS's Biological Opinion (Appendix M).

10.6 CUMULATIVE EFFECTS TO THE HUMAN ENVIRONMENT

Cumulative effects on the human environment are expected to affect subsistence, land and water use, socioeconomics, and visual/aesthetic resources. As discussed in Sections 7.4.5 and 7.9.2.2, the Northstar Project is not expected to contribute to cumulative effects on living cultural resources. Expected cumulative effects and Northstar Project contributions are discussed below.

10.6.1 Subsistence

Subsistence activities potentially affected by existing and reasonably foreseeable future projects include onshore hunting of terrestrial mammals and waterfowl, and offshore harvesting of bowhead whales and other marine mammals (Section 7.3.2). The geographic expansion of industrial activity and development in both onshore and offshore areas could have significant effects on local communities, as discussed below.

Traditionally, all access for subsistence hunting has been restricted in the oil fields for security and safety reasons. Recently, ARCO has agreed to permit access at its Alpine and Tarn developments for subsistence hunting and fishing purposes, with the exception of reasonable security and safety procedures. Such mutual agreements between the oil companies and Native subsistence users would mitigate local adverse and cumulative impacts on subsistence, and similar agreements may be reached in the NPRA and elsewhere along the North Slope in the future. Specifically related to the Northstar Project, onshore facilities for Alternatives 2 and 3 would have negligible adverse cumulative effects on subsistence hunting and game availability. Onshore facilities for Alternatives 4 and 5 are not expected to contribute to any new cumulative adverse effects to subsistence hunting and game availability, since these routes lie within areas that have already been restricted.

Subsistence whaling is expected to experience adverse cumulative effects. These effects are associated with the bowhead whale's avoidance response to noise and activity. As discussed in Section 10.5.7, seismic survey activities and foreseeable future offshore exploration and development could create multiple offshore noise disturbances extending over a broad geographic area. The principal concern regarding this cumulative disturbance is the possibility that migrating whales avoiding multiple noise disturbances could alter their migration route to a location further offshore. If such an effect was to occur, this could significantly affect whaling communities in the cumulative impact area, including Barrow, Nuiqsut, and Kaktovik. The unavoidable and non-mitigable noise which will be generated by the Northstar production island facilities and associated contractor and operational activities are not predicted to cause significant disturbance of bowhead whales or the bowhead whale subsistence harvest (Section 9.8.2 and 6.9.2.2). As noted in Section 11.10.2, monitoring of the noise signature of the Northstar production island and related activities is a mitigation measure which will be considered and likely adopted by responsible agencies as a means of verifying the absence of any significant effect. While it is likely any additional offshore production islands of similar design proposed in the future will have a comparable noise signature, the cooperating agencies recognize that a primary public concern regarding offshore cumulative impacts is the potential for multiple developments. To deflect the bowhead migration path and reduce subsistence harvest success.

The potential for future developments to cause or contribute to any deflection of the migration or impact the harvest will depend largely upon the proposed location with respect to the traditional migratory path and traditional harvest areas. Accordingly, proposed future projects will have to be analyzed on a case-by-case basis to determine whether and how they may cause or contribute to any effects on the bowhead migration or subsistence harvest. It must also be recognized that periodic and predictable offshore seismic operations have the potential alone to disrupt the whale migration and subsistence harvest, if not restricted in time and location (Section 9.5.1.1). Conducting a seismic operation during the fall bowhead migration near subsistence harvest areas in proximity to the Northstar production island could compound the minor impact of the island. Timing and location restrictions of any seismic operations proposed during Northstar construction and operations could eliminate or minimize these potential adverse cumulative effects.

Recognizing that the potential impacts described above would be felt by North Slope Inupiat, a minority population as addressed in Executive Order 12898, questions regarding Environmental Justice are raised. Although it is impossible to predict whether North Slope residents would support future oil development, the other reasons stated in Section 7.10 suggest that potential adverse cumulative effects on North Slope Inupiat would not be, on balance, disproportionately high.

10.6.2 Land Use

The projected development of onshore areas associated with the reasonably foreseeable future projects (Alpine and Tarn) have been rezoned. North Slope Borough (NSB) land management regulations include several policies regarding project design, seasonal restrictions, and protection of other land uses that are intended to minimize environmental effects (Section 7.5.1). Application of these regulations is expected to reduce impacts associated with individual projects that might otherwise combine to create cumulative effects.

One cumulative land use impact that would not be avoided is the geographic expansion of industrial uses beyond the existing developed Prudhoe Bay - Kuparuk area. This represents a cumulative, large-scale change in the designated land use of this area. Northstar Project onshore facilities associated with Alternative 2 are not located within the existing developed area. This alternative would contribute to the geographic expansion of industrial land uses, and would represent a minor contribution to cumulative impacts to onshore land use. Other Northstar Project alternatives would not contribute to this cumulative impact.

Reasonably foreseeable development of offshore areas includes the Liberty prospect. Subsea pipelines built through state waters would involve the rezoning of land and waters currently zoned as a Conservation District to a Resource Development District. This rezoning would require a revision to the approved Master Plan for the area and review for compliance with the NSB Coastal Management Plan. Therefore, this would have a cumulative impact on the existing onshore Resource Development Area, thereby extending this land use to a Conservation District not presently utilized in this manner. However, this cumulative effect would be minor due to limited actual use of the seafloor by industry.

In addition, the project could represent the first of several developments between existing Prudhoe Bay and Kuparuk area developments. The presence of a pipeline landfall at Point Storkersen associated with Alternatives 2 and 3 could facilitate potential future Gwydyr Bay development, and allow consolidation of potential future Gwydyr Bay development by establishing an accessible common carrier pipeline in proximity to this area. The development of the Gwydyr Bay area would result in an industrial expansion into a presently undeveloped area. It is not presently known whether Gwydyr Bay development economics would be substantially affected by the presence of the Northstar pipeline facilities. Gwydyr Bay area development would represent a substantial land use change, and Northstar's Alternative 2 would contribute to this cumulative effect by establishing a pipeline corridor through this area.

The cumulative offshore land and water use impact that is reasonably foreseeable is the geographic expansion of industrial uses to offshore areas north of the barrier islands. Successful permitting, development, and production of the Northstar Project could contribute to development of other offshore projects. However, because other existing uses of this offshore area are minor, the cumulative impact to land use would be minor.

10.6.3 Visual Resources/Aesthetics

Existing development in the Prudhoe Bay-Kuparuk area has substantially altered the visual character of this area. The presence of industrial structures in an otherwise undeveloped area and introduction of artificial lighting over broad areas where none previously existed are generally perceived as adverse effects of existing North Slope development. Reasonably foreseeable future projects will result in the geographic expansion of these visual effects. The Northstar Project would contribute to the expansion of geographic effects of artificial lighting by adding a light source in offshore waters and short-term lighting at the gravel mine site (Section 7.8.2.2). The onshore pipeline route specified in Alternative 2 would contribute to the cumulative visual impact of the Prudhoe Bay development area. Other action alternatives would lessen this effect by routing onshore pipelines primarily along existing disturbed areas. The Northstar Project would represent a minor contribution to the visual existing cumulative impacts in the Prudhoe Bay area.

10.6.4 Socioeconomics

Existing and reasonably foreseeable future projects are expected to reduce the rate of decline of State of Alaska revenues associated with North Slope oil production. As discussed in Section 10.3.3, the 1995 North Slope oil production rate of 1.45 million barrels/day is expected to decline to 0.292 million barrels/day by the year 2020. A similar decline in revenues to the NSB and local villages would be a reasonable expectation. The Bureau of Land Management (BLM) estimates total production from existing development and known fields could be 6.47 billion barrels from 1996 to 2020 (USDOI, BLM, 1998:IV-A-43-46). The BLM estimates that up to 1.22 billion barrels could be produced from resources on existing and proposed federal leases, most of which have not yet been discovered. Although these production rates would still result in a net decline in oil production, they would partially offset state revenue declines. This represents a substantial beneficial impact on State of Alaska revenues, since North Slope oil and gas revenues represent the primary source of state revenues (ADNR, 1997:5-40) (Section 7.6). The Northstar Project would represent approximately 2.4%of the total currently projected North Slope oil production during its project life.

Cultural values of Native communities along the North Slope could be affected by changes in population, social organization and demographic conditions, economy, and alterations of the subsistence cycle. While subsistence is the core value and central feature of Inupiat culture, a trend toward displacement of the community social institutions could lead to a short-term decreased emphasis on other values, such as the importance of the family, cooperation, and sharing. Increasing offshore oil development activity, when combined with the increasing encroachment of onshore development, could increase access to urban communities and cause more interaction with oil-industry workers, resulting in the introduction of new values and ideas, as well as increased racial tensions. Tensions could be created and could result in increased incidents of socially maladaptive behavior and family stress, potentially straining the traditional Inupiat institutions' abilities to maintain social stability and cultural continuity.

Long-term change depends on the relative weakening of traditional stabilizing institutions through prolonged stress and disruptive effects that could be exacerbated by activities associated with the Northstar Project. These changes already are occurring to some degree on the North Slope as a result of the cumulative effects of onshore oil and gas development, more dependence on a wage economy, higher levels of education, improved technology, improved housing and community facilities, improved infrastructures, increased presence of non-Natives, increased travel outside of the North Slope, and the introduction of television and the Internet. Generally, NSB institutions, such as the school district that promotes teaching Inupiat language and culture, the Alaska Eskimo Whaling Commission that negotiates with industry to protect subsistence whaling interest, the Borough Department of Wildlife Management, and other regional and village Native corporations and organizations, work vigorously and quite successfully at preventing any weakening of traditional cultural institutions and practices.

Recognizing that the potential impacts described above would be felt by North Slope Inupiat, a minority population as addressed in Executive Order 12898, questions regarding Environmental Justice are raised. Although it is impossible to predict whether North Slope residents would support future oil development, the other reasons stated in Section 7.10 suggest that potential adverse cumulative effects on North Slope Inupiat would not be, on balance, disproportionately high.

10.7 CUMULATIVE EFFECTS OF OIL SPILLS

A large oil spill could have significant impacts on several resources in the project area. These impacts were discussed in Chapters 5, 6, and 7 and include: contamination of soils, sediments, and surface water bodies (Section 5.3.2), mortality to polar bears, birds, and freshwater invertebrates (Sections 6.5.2, 6.6.2, and 6.7.2), damage to coastal vegetation during the spill response (Section 6.6.2), and injury/mortality to bowhead whales (Section 6.9.2). Such an oil spill could also have significant impacts to subsistence activities (Section 7.3.2 and 9.8.2), cultural and archaeological resources (Section 7.4.5), and North Slope socioeconomics (section 7.6.2). In addition to potential significant impacts to individual resources by an oil spill, the Northstar Project contributes to the cumulative risk of oil spill occurrence associated with existing North Slope development and additional future development expected to occur. The BLM has estimated that existing developments and expected new developments will result in a total production of 6.47 billion barrels of oil from 1997 to 2020 (USDOI, BLM, 1998: IV-A-43-46). As will be shown in this section, this production rate would result in a cumulative probability of one or more major oil spills (greater than 1,000 barrels) of 95.2% over the entire period of 1997 to 2020. Comparable cumulative spill probability over the same 23-year period in the absence of the Northstar Project would be 93.7%.

These probabilities were calculated using the MMS OCS spill history statistics discussed in Chapter 8. These calculations are based on actual North Slope oil spill occurrence observations for all existing operations, and for all proposed onshore production operations and related pipelines. Because offshore production facilities and subsea pipelines have not yet been developed on the North Slope, the MMS oil spill occurrence rates based on Gulf of Mexico data were used to calculate spill rates and related probabilities associated with future offshore development. Although these rates appear to be substantially higher than observed North Slope onshore spill rates, and may over-estimate the actual spill risk, no statistical data directly applicable to arctic offshore production facilities and subsea pipelines are currently available. Expected oil production rates from individual development activities were determined by proportionally adjusting the 6.47 billion barrel projection using the oil reserve estimates in Table 10-3 associated with expected and possible future production. Tables 10-4 and 10-5 present the production rates associated with different development features, and calculated cumulative statistically expected number of spills. Table 10-6 presents oil spill probabilities calculated using this information.

In addition to concerns regarding the cumulative risk of an oil spill, comments from the public related to potential cumulative effects expressed a concern that multiple oil spills could result in cumulative impacts. To fully evaluate this concern, an understanding of the likelihood of multiple spills is necessary.

The potential for two or more spills within a 5-year period was evaluated to address a time period which is expected to result in additive effects caused by a second disturbance to resources which have not fully recovered from the initial oil spill. Multiple spill probabilities were calculated assuming a total 5-year production of 1.425 billion barrels of oil (based on 22% of the expected production of 6.47 billion barrels from 1997 to 2020), and approximately 0.053 billion barrels of oil production from the Northstar Project (33% of total Northstar production). Based on these assumptions, the cumulative probability of two or more major spills during a 5-year period (including Northstar) is 15.4%. Without the contribution of the Northstar Project, the cumulative probability of multiple spills within a 5-year period is 12.2%. Table 10-7 presents details associated with the determination of these probabilities. These cumulative probabilities include both onshore and offshore spills, and multiple spills would not necessarily affect the same resources.

Multiple spills could adversely affect biological resources if subsequent disturbances occur while populations are still recovering from an earlier disturbance. This effect is of greatest concern with regard to species with limited or declining numbers of individuals, such as: spectacled eider, Steller's eider, common eider, oldsquaw, and King eider. This potential for additive effects is also a concern with regard to threatened and endangered species and subsistence species, such as the bowhead whale. As indicated by the results in Table 10-7, the likelihood of two or more spills within time frames likely to result in overlapping effects is relatively low (about 15.4%). This probability would change very little (12.2%) in the absence of the Northstar Project.

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As indicated above, the cumulative likelihood of two or more major spills within a 5-year period is 15.4%. The occurrence of multiple spills and resulting multiple disturbance of the same resources would be even more unlikely. However, if this did occur, the effects could be substantial. Impacts would be most severe with respect to populations that are already declining, such as spectacled eiders.

As stated previously, the overall likelihood of multiple spills within a 5-year period is relatively small, and the Northstar contribution to this probability is minor.

Oil spills could affect subsistence hunting of polar bears in several ways. In the event of direct mortality caused by ingestion of contaminated food (such as oiled ringed seals) or mortality associated with reduced food availability, reductions in the allowable subsistence harvest could be implemented. Spill response and cleanup activities could also conflict with access and hunting activity during hunting periods. These effects are most likely to occur as a result of a single spill, since overlapping effects caused by multiple spills within relatively short time-frames (5 years) are considered unlikely as explained above.

Small oil spills are likely to occur with or without the development of the identified reasonably foreseeable future projects. In the MMS analysis conducted for Lease Sale 170, it is estimated that 287 to 571 small releases are statistically expected to occur over the 30-year time frame addressed by their study. The MMS analysis estimates a total release volume of 3,295 to 6,420 barrels from all releases combined (an average per spill release of 11.5 barrels). The MMS concluded that these small releases would result in localized water quality impacts, and that cumulative effects would not be significant (USDOI, MMS, 1998: IV-G-2-5). The Northstar Project represents a contribution of less than 2% of the total oil production considered by the MMS in determining these chronic oil spill volumes.

10.8 CUMULATIVE EFFECTS OF NOISE

Disturbance impacts resulting from helicopter overfllight during construction could have significant impacts on molting oldsquaw and common eiders. Significant impacts to subsistence harvesting of the bowhead whale could occur if construction or operation noise/activities coincided with the fall migration period and resulted in a reduced harvest. These impacts were discussed in Section 9.8.2.

Existing and reasonably foreseeable future projects are located across a broad geographic area, and additive effects of noise associated with onshore facility operations are not expected. Potential cumulative noise effects could result from multiple offshore noise sources and activity and related effects on bowhead whale migration. Use of common or overlapping helicopter transport corridors by multiple projects could startle sensitive bird species.

As discussed in Sections 10.5.7 and 10.6.1, offshore seismic survey activities and future offshore development could create multiple offshore noise disturbances extending over a broad geographic area. The principal concern regarding this cumulative disturbance is the possibility that migrating bowhead whales would respond to these disturbances by altering their migration route to a location further offshore. Multiple project locations and survey sites could result in multiple avoidance responses by migrating whales. As the whales experience increasing numbers of disturbances, it has been hypothesized that they may adopt a migration route located further offshore, rather than a meandering route based on multiple disturbance responses. If such an effect was to occur, this could significantly affect whaling communities beyond the cumulative impact area, including Barrow, Nuiqsut, and Kaktovik. The combined effect described has not been documented by scientific studies, and is only a hypothesis at present. Measures that could be implemented to reduce the potential for such a cumulative effect include: prohibition of seismic survey activities during bowhead whale migration periods; coordination of helicopter activities to establish minimum transit altitudes and to minimize the length of overwater transit routes to offshore sites during the fall whale migration; prohibition of fall icebreaking barge activities prior to October 15; and coordination of vessel activity during the whale migration period to minimize the length of offshore transit routes. These requirements could be relaxed during other portions of the year.

Helicopter activities from multiple projects in common or overlapping travel corridors could create combined or repeated noise disturbances that could be significant. Of particular concern is the potential for combined helicopter activities of the Northstar Project, other future activities in the Gwydyr Bay/Point Storkersen area, and future offshore developments such as Sandpiper. Helicopter overflights of the Northstar Alternative 2 pipeline route and Simpson Lagoon area could displace birds from nests and interrupt feeding, staging, and molting activities. Brant are the most likely affected species, although adverse effects to spectacled eiders, oldsquaw, common eiders, and other birds could also occur. Those impacts could be effectively reduced by restricting flight paths to avoid sensitive nesting areas (particularly spectacled eider breeding areas) during active breeding and brood-rearing periods (June through August), and establishing minimum helicopter flight altitudes to reduce ground-level noise.

10.9 REFERENCES

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TABLE 10-1
EXISTING OIL AND GAS DEVELOPMENT, NORTHSTAR PROJECT CUMULATIVE IMPACT AREA[1]

				Facilities								
							Gravel Mines		Reserve Pits			
Unit or Area/Field	Initial Production (Year)	1996 Oil Production (MMBBL)	Estimated Remaining Reserves (end of 1996) (MMBBL)	Disturbed Area (Roads, Pads, & Airstrips) (Acres)	Gravel Roads (Miles)	Pipelines (Miles)	(No.)	(Acres)	(No.)	(Acres)	Wells (No.)	Pads/ Platforms (No.)
Duck Island												
Endicott	1987	27.663	258	392	15	29	1	179	0	0	105	2
Sag Delta N.	1989	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Sag Delta	1989	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Prudhoe Bay												
Prudhoe Bay	1977	312.609	3,443	4,590	200	145	6	726	106	560	1,256	38
Lisburne	1981	5.139	57	213	18	50	--	--	10	16	81	5
Niakuk	1994	11.045	90	22	--	5	--	--	--	--	18	--
West Beach	1994	0.499	30	--	--	--	--	--	--	--	1	--
N. Prudhoe Bay	1993	0.129	75	--	--	--	--	--	--	--	1	--
Pt. McIntyre	1993	58.751	312	33	--	12	--	--	--	--	47	--
Kuparuk												
Kuparuk	1981	99.459	1,275	1,435	94	134	5	564	126	161	835	34
West Sak	1998	--	279	--	--	--	0	0	--	--	50	--
Milne Point												
Milne Point	1985	12.686	210	205	19	40	1	43	--	--	110	4
Cascade	1996	--	50	31	--	--	--	--	--	--	--	--
Schrader Bluff	1991	1.068	281	--	--	--	--	--	--	--	22	--
Sag River	1994	0.346	19	--	--	--	--	--	--	--	3	--
NPRA												
East Barrow	1981	--[3]	--[3]	--	--	--	--	--	--	--	--	--
South Barrow	1950	--[3]	--[3]	--	--	--	--	--	--	--	--	--
Walakpa	1993	--[3]	--[3]	--	--	--	--	--	--	--	--	--
Badami												
Badami	1998	--	120	85	4.5	35	1	89	0	0	50	2
Tarn												
Tarn	1998	--	50	73	10	10	1	--	0	0	40	2

Notes:
1 = Information in this table was developed from USDOI, BLM, 1998: IV-A-44-45. The cumulative development area and existing developments are shown on Figure 10-2.
2 = Included in Endicott details
3 = These developments produce natural gas, and do not contribute oil production to North Slope oil transportation facilities
-- = Not applicable
MMBBL = Million barrels
No. = Number
NPRA = National Petroleum Reserve, Alaska

TABLE 10-2
FORESEEABLE FUTURE ACTIONS, NORTHSTAR PROJECT CUMULATIVE IMPACT AREA[1]

Unit or Area/Field	Initial Production Expected (Year)	Estimated Reserves (MMBBL)	Nature of Activity Expected from 1999 Through 2015	Facilities								
				Disturbed Area[2] (Acres)	Gravel Roads (Miles)	Pipelines (Miles)	Gravel Mines (No.)	Gravel Mines (Acres)	Reserve Pits (No.)	Reserve Pits (Acres)	Wells (No.)	Pads/ Platforms (No.)
Currently Proposed Projects												
Northstar	2001	158	Development Drilling & Production (active proposals currently under consideration)	20	0	28	1	36	0	0	23	1
Alpine	2000	250-300	Development Drilling & Production (active project currently under development)	97	3	34	0	0	0	0	150	2
Liberty	Before 2015	120	Development Drilling & Production (active proposal currently under consideration)	16	0	6	1	45	0	0	23	1
Known Discoveries/Potential Future Projects												
Colville River Fiord	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Kuukpik Kalubik	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Colville Delta	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Point Thomson Sourdough	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Pt. Thomson	Before 2015	200-300	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Flaxman 1	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Gwydyr Bay Gwydyr Bay	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Mikkelson	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Yukon Gold	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Pete's Wicked	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]

TABLE 10-2 (Cont.)
FORESEEABLE FUTURE ACTIONS, NORTHSTAR PROJECT CUMULATIVE IMPACT AREA[1]

Unit or Area/Field	Initial Production Expected (Year)	Estimated Reserves (MMBBL)	Nature of Activity Expected from 1999 Through 2015	Facilities: Disturbed Area[2] (Acres)	Gravel Roads (Miles)	Pipelines (Miles)	Gravel Mines (No.)	Gravel Mines (Acres)	Reserve Pits (No.)	Reserve Pits (Acres)	Wells (No.)	Pads/ Platforms (No.)
Known discoveries/Potential Future Projects (Cont.)												
Sandpiper	Before 2015	--[3]	Three delineation wells planned for Year 2000. DPP submitted to MMS	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Kuvlum	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Hammerhead	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Lease Sales and Resource Evaluation Areas												
Alaska State Lease Sales No. 87	--[4]	Moderate to High Potential	Seismic exploration, exploration and delineation wells, production facilities	--	--	--	--	--	--	--	--	--
North Slope Areawide	--[4]	Moderate to High Potential	Seismic exploration, exploration and delineation wells	--	--	--	--	--	--	--	--	--
Beaufort Sea Areawide	--[4]	Moderate to High Potential	Seismic exploration, exploration and delineation wells	--	--	--	--	--	--	--	--	--
North Slope Foothills Areawide	--[4]	Moderate Potential	Seismic exploration, exploration and delineation wells	--	--	--	--	--	--	--	--	--
Federal NPRA Northeast Planning Area	--[4]	130-600	Seismic exploration, exploration and delineation wells	--	--	--	--	--	--	--	--	--
Western Planning Area	--[4]	130-1200	Seismic exploration, exploration and delineation wells	--	--	--	--	--	--	--	--	--

TABLE 10-2 (Cont.)
FORESEEABLE FUTURE ACTIONS, NORTHSTAR PROJECT CUMULATIVE IMPACT AREA[1]

Unit or Area/Field	Initial Production Expected (Year)	Estimated Reserves (MMBBL)	Nature of Activity Expected from 1999 Through 2015	Facilities: Disturbed Area[2] (Acres)	Gravel Roads (Miles)	Pipelines (Miles)	Gravel Mines (No.)	Gravel Mines (Acres)	Reserve Pits (No.)	Reserve Pits (Acres)	Wells (No.)	Pads/ Platforms (No.)
Lease Sales and Resource Evaluation Areas (Cont.)												
Federal OCS Lease Sales Lease Sale 176	2006	350-670	Seismic exploration, shallow hazards surveys, exploration and delineation wells, production facilities	--	--	96-258	--	--	--	--	87-111	3-5
Lease Sale 176	--[4]	To be determined	Seismic exploration, shallow hazards surveys, exploration and delineation wells	--	--	--	--	--	--	--	--	--

Note: 1 = The cumulative development area and proposed and future projects are shown on Figure 10-2.
2 = Roads, pads and airstrips
3 = Specific reserve estimates and development proposals are not presently available.
4 = No specific projects have been identified and initial production dates cannot be accurately estimated. Most production associated with these lease sales is likely to occur after 2015.

-- = No specific information is currently available.
MMBBL = Million barrels
No. = Number
NPRA = National Petroleum Reserve, Alaska
OCS = Outer Continental Shelf

Source: USDOI, BLM, 1998: IV-A-41-52.

TABLE 10-3
OIL RESERVES AND RESOURCES ESTIMATES,
NORTHSTAR PROJECT CUMULATIVE IMPACT AREA

Activity	Oil Production (MMBBL)
Past Production (Through 1996)	
Onshore	11,230
Offshore	340
Subtotal	11,570
Expected Future Production	
Onshore – existing fields	6,320
Offshore – existing fields	260
Onshore – planned fields	365
Offshore – planned fields	265
Subtotal	7,210
Possible Future Production	
Onshore	1,850
Offshore	460
OCS projects in currently unleased areas	1,200
Subtotal	3,510
Future NPRA Leasing	
Northeast Planning Area	130-600
Western Planning Area	130-1,200
Subtotal	260-1,800
Speculative Future Production	
Onshore	4,000
Offshore	2,000
Subtotal	6,000

Notes: MMBBL = Million barrels
NPRA = National Petroleum Reserve, Alaska
OCS = Outer Continental Shelf

Source: USDOI, BLM, 1998: Tables IV.A.5-4 and IV.A.5-7

TABLE 10-4
CUMULATIVE SPILL RISK (NORTHSTAR INCLUDED)
1997 TO 2020

Development	Production Rate (Bbbl)	Spill Rate (spills/Bbbl)	Data Source	Expected Value (8)
Existing				
Onshore production pads	3.814	0.0599	North Slope [3]	0.2285
Onshore pipelines [1]	3.971	0.086	North Slope	0.5564
Offshore pads	0.157	0.0599	North Slope [3]	0.0094
Subtotal				0.7943
Proposed/New				
Onshore production pads	1.337	0.0599	North Slope [3]	0.0801
Onshore pipelines [1]	2.499	0.086	North Slope	0.2149
Offshore pads	1.162	0.45	MMS	0.5229
Offshore pipelines [2]	1.162	1.32	MMS	1.5338
Subtotal				2.2518
Cumulative, statistically expected value				3.046

Notes:

1 = This entry presents spill risk associated with existing and proposed/new production separately, though some of the new production will be transported through existing onshore pipelines. This is intended to illustrate the contribution of proposed/new development to pipeline spill risk, though some of the pipelines may already exist.

2 = This volume is double-counted in the onshore pipeline total, since all offshore production will ultimately be transported in onshore pipelines. To avoid double counting, the onshore pipeline contribution to the total expected value was reduced by the offshore throughput. For this reason, the total (cumulative) expected value is not the sum of all entries in the expected value column.

3 = This spill rate was calculated based on the observed occurrence of zero large spills (>1,000 bbls) during the history of North Slope oil production. Since 11.57 billion barrels of oil have been produced and no major production pad spills have occurred, this spill rate was computed as the spill rate which results in a 50 percent probability that zero large spills (>1,000 bbls) would be observed with a total production of 11.57 billion barrels.

bbls = Barrels

Bbbl = Billion barrels

TABLE 10-5
CUMULATIVE SPILL RISK WITHOUT NORTHSTAR
1997 TO 2020

Development	Production Rate (Bbbl)	Spill Rate (spills/Bbbl)	Data Source	Expected Value (8)
Existing				
Onshore production pads	3.814	0.0599	North Slope [3]	0.2285
Onshore pipelines [1]	3.971	0.086	North Slope	0.5564
Offshore pads	0.157	0.0599	North Slope [3]	0.0094
Subtotal				0.7943
Proposed/New				
Onshore production pads	1.337	0.0599	North Slope [3]	0.0801
Onshore pipelines [1]	2.341	0.086	North Slope	0.2013
Offshore pads	1.004	0.45	MMS	0.4518
Offshore pipelines [2]	1.004	1.32	MMS	1.3253
Subtotal				1.9722
Cumulative, statistically expected value				2.767

Notes:

1 = This entry presents spill risk associated with existing and proposed/new production separately, though some of the new production will be transported through existing onshore pipelines. This is intended to illustrate the contribution of proposed/new development to pipeline spill risk, though some of the pipelines may already exist.

2 = This volume is double-counted in the onshore pipeline total, since all offshore production will ultimately be transported in onshore pipelines. To avoid double counting, the onshore pipeline contribution to the total expected value was reduced by the offshore throughput. For this reason, the total (cumulative) expected value is not the sum of all entries in the expected value column.

3 = This spill rate was calculated based on the observed occurrence of zero large spills (>1,000 bbls) during the history of North Slope oil production. Since 11.57 billion barrels of oil have been produced and no major production pad spills have occurred, this spill rate was computed as the spill rate which results in a 50 percent probability that zero large spills (>1,000 bbls) would be observed with a total production of 11.57 billion barrels.

bbls = Barrels

Bbbl = Billion barrels

TABLE 10-6
CUMULATIVE OIL SPILL PROBABILITIES (ONE OR MORE SPILLS)
1997 TO 2020

Development	Cumulative Probability Without Northstar		Cumulative Probability With Northstar	
	Expected Value (8)	Probability 1 or more spills >1,000 bbl	Expected Value (8)	Probability 1 or more spills > 1,000 bbl
Existing Development				
Onshore spills	0.7849	54.5%	0.7849	54.4%
Offshore spills	0.0094	0.9%	0.0094	0.9%
Subtotal - Existing	0.7943	54.8%	0.7943	54.8%
Proposed/New Development				
Onshore spills	0.2814	24.5%	0.2950	25.5%
Offshore spills	1.7771	83.1%	2.0567	87.2%
Subtotal - Proposed/New	1.9722	86.1%	2.2518	89.5%
Cumulative Probability	2.767	93.7%	3.046	95.2%

Notes: > = Greater than
bbl = Barrels
% = Percent

TABLE 10-7
CUMULATIVE PROBABILITY OF MULTIPLE SPILLS WITHIN A 5-YEAR PERIOD [1]

Development	Cumulative Probability Without Northstar			Cumulative Probability With Northstar		
	5-Year Production (Bbbl)	Expected Value (8)	Probability of 2 or more spills >1,000 bbl	5-Year Production (Bbbl)	Expected Value (8)	Probability of 2 or more spills >1,000 bbl
Existing Development						
Onshore spills	0.829	0.1706	1.3%	0.829	0.1706	1.3%
Offshore spills	0.034	0.0020	0.0%	0.034	0.0020	0.0%
Subtotal – Existing		0.1727	1.3%		0.1727	1.3%
Proposed/New Development						
Onshore spills	0.291	0.0612	0.2%	0.291	0.0658	0.2%
Offshore spills	0.218	0.3859	5.8%	0.271	0.4797	8.4%
Subtotal – Proposed/New		0.4283	6.9%		0.5221	9.7%
Cumulative Probability		0.6010	12.2%		0.6948	15.4%

Notes: 1 = Total production within a 5-year period is computed as 21.74% of the total production projected for the period 1997 to 2020. Total Northstar production over a 5-year period is estimated as 33.3% of the 158-million barrel total Northstar production, as 52.7 million barrels.

bbl = Barrels

% = Percent

> = Greater than

Bbbl = Billion barrels

CHAPTER 11.0

COMPARISON OF PROJECT ALTERNATIVES AND THEIR IMPACTS

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CHAPTER 11.0 COMPARISON OF PROJECT ALTERNATIVES AND THEIR IMPACTS

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11.0 COMPARISON OF PROJECT ALTERNATIVES AND THEIR IMPACTS

11.1 INTRODUCTION

This chapter summarizes and compares the magnitude and significance of environmental impacts of the alternatives developed in this Environmental Impact Statement (EIS). This comparison is intended to highlight the important environmental issues and principal differences among the alternatives. This chapter is derived from the detailed analyses presented in Chapters 5 through 10.

As explained in Chapter 3, development of the Northstar Unit, or any other oil and gas reservoir, involves several distinct components. Selection of these components will be based on consideration of several factors, including environmental, technical, and economic concerns. As a result, no single alternative consisting of all the essential development components will necessarily be "best" with respect to all factors. Decision-makers selecting a preferred alternative must consider the positive and negative impacts of each alternative with respect to the key concerns, along with consideration of the relative importance of each key concern. This presentation will help focus that effort.

11.2 OVERVIEW OF PROJECT ALTERNATIVES

Analyses presented in Chapter 3 provide the basis for project action alternatives identified in Chapter 4 and evaluated in Chapters 5 through 10. Principal project components, including the redevelopment of Seal Island, installation of buried subsea pipelines, onshore construction using vertical support members (VSMs), etc. are the same or similar among the four action alternatives considered for the Northstar Development Project (Northstar Project). The principal differences among these action alternatives are the pipeline routes and shoreline crossings. Figure 11-1 illustrates these alternatives; specific details are presented in Section 4.4. In addition to these action alternatives, the No Action Alternative is addressed in accordance with the requirements of the National Environmental Policy Act (NEPA).

The BP Exploration (Alaska) Inc. (BPXA) Northstar development proposal (Appendix A) was identified as a reasonable alternative by the selection process used in Chapter 4. Chapter 4 also identified alternative pipeline routing which better meets pipeline route criteria, as developed in Chapter 3. Because each alternative route creates potential impacts that could be avoided by other alternatives, a range of alternatives was developed which allowed consideration of feasible impact tradeoffs. The substantial design differences represented by these alternatives include alternative landfall locations (Point Storkersen area, Point McIntyre area, and West Dock causeway) and onshore routing options (minimum distance/overland routing and maximum use of routing along existing disturbed corridors). These alternatives are presented as specific pipeline routes to allow the evaluation and comparison of impacts, but each should be considered representative of possible variations which include the same general landfall location and approach to onshore routing. An overview of each alternative is presented below.

Alternative 1 - No Action: This alternative eliminates all project-related environmental impacts. It does not accomplish the objective of production of oil from the Northstar Unit.

Alternative 2 - Point Storkersen Landfall/BPXA Proposal: This alternative (the Applicant's preferred alternative) represents the shortest pipeline option with the lowest range of costs. Principal concerns involve: a subsea pipeline in arctic waters (including the control of thaw-induced subsidence wherever expected, as determined by site-specific geotechnical data); subsea pipeline routing through Gwydyr Bay; issues relating to a trenched shoreline crossing through the permafrost transition zone, and a 9.55-mile (15.37 kilometer [km]) overland pipe installation through undeveloped tundra.

Alternative 3 - Point Storkersen/West Dock Staging Pad Pipeline Route: This alternative is identical to the BPXA proposal from Seal Island to the Point Storkersen landfall and includes the issues described above. The subsea pipeline thaw-induced subsidence must be controlled wherever expected, as determined by site-specific geotechnical data. The onshore pipeline route is directed eastward approximately 3.6 miles (5.8 km) across undeveloped tundra before reaching an existing pipeline corridor, which it then follows to the West Dock Staging Pad and on to the Central Compressor Plant and Pump Station No. 1. Approximately 3.1 miles (5 km) of undeveloped tundra are crossed near the southern end of the alignment. This alternative maximizes the use of existing pipeline and roadway corridors within the Prudhoe Bay industrial complex, while maintaining the Point Storkersen landfall.

Alternative 4 - Point McIntyre/West Dock Staging Pad Pipeline Route: Compared to Alternatives 2 or 3, this alternative involves a longer offshore pipeline route to a new trenched shoreline landfall near Point McIntyre. The subsea pipeline thaw-induced subsidence must be controlled wherever expected, as determined by site-specific geotechnical data. The offshore pipeline routing would be through the eastern portion of Gwydyr Bay. The landfall is adjacent to existing Prudhoe Bay area pipelines and roadways, and most of the onshore pipeline is routed along existing disturbed corridors. Approximately 3.1 miles (5 km) of corridor extend through undeveloped tundra near the southern end of the alignment.

Alternative 5 - West Dock Causeway Landfall: This alternative includes nearly the same offshore pipeline route as Alternative 4, but avoids the shoreline permafrost transition zone by routing the pipeline to the West Dock causeway. The subsea pipeline thaw-induced subsidence must be controlled wherever expected, as determined by site-specific geotechnical data. This offshore pipeline routing would avoid Gwydyr Bay. The West Dock causeway would be widened from the landfall location to the shoreline to accommodate the pipelines. Most of the onshore pipeline route is located along existing Prudhoe Bay area pipeline corridors and roadways, identical to Alternative 4 from the West Dock Staging Pad to the Central Compressor Plant and Pump Station No. 1. Approximately 3.1 miles (5 km) of corridor extend through undeveloped tundra near the southern end of the alignment.

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Figure 11-1 (page 2 of 2)

The specific environmental characteristics of each alternative are summarized in the remaining sections of this chapter and in Table 11-1.

11.3 ALTERNATIVE 1 - NO ACTION

The No Action Alternative would not produce any of the project-specific impacts which result from the action alternatives. This alternative would leave Seal Island in its present condition, and no environmental disturbance associated with island reconstruction and related onshore gravel mining operations would occur.

Impacts associated with Northstar offshore facilities operation or the construction and operation of related pipeline facilities would not occur. This alternative would not accomplish BPXA's project objective of producing the Northstar Unit oil and gas resources, which have been projected at an average 158 million barrels of recoverable oil over the 15-year project life. The No Action Alternative would not contribute any of the socioeconomic benefits associated with the action alternatives. These benefits include an estimated $478.9 million gross revenue to the State of Alaska, $306.3 million in revenue to the federal government, $64.3 million in revenues to the North Slope Borough (NSB), and $3 million in revenue to the Municipality of Anchorage (MOA) over the project life. Additionally, the project will create 730 construction jobs, 100 annual operation and project support jobs, and over $307 million in wages.

In addition to action-specific impacts, NEPA requires the consideration of potential cumulative impacts. As defined by 40 CFR 1508.7, cumulative impacts include the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Alternative 1 (No Action) would not contribute any incremental increase to the cumulative impact of other actions. However, none of the cumulative impacts identified would be avoided by selection of Alternative 1. Alternatives 2, 3, 4, and 5 would each result in comparable contributions to the cumulative impacts of other actions, which include:

- Cumulative impacts from other offshore development proposals on subsistence whaling caused by bowhead whale avoidance of industrial noise and resulting potential migration corridor deflection. This potential effect could result in longer travel distances and increased time requirements to achieve a comparable catch, with an increased likelihood of meat spoilage. Whaling is inherently hazardous, and increased time and travel distances correspond to increased personal safety risks. In addition, any increased impact on or risk to the bowhead whale population could result in a reduction of the bowhead whale harvest quota set by the International Whaling Commission (IWC). The contribution to this cumulative effect associated with offshore seismic survey activities could be effectively reduced by management of this activity to avoid whale disturbance.

- Existing and potential future offshore oil and gas development (state and federal) was estimated to result in a 95.2 percent (%) chance of a large oil spill (greater than 1,000 barrels) (Section 10.7). Without Northstar, cumulative spill risk is calculated as 93.7%.

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· Cumulative impacts to visual resources associated with increased industrialization in natural areas and addition of artificial lighting in a broader geographic area.

· Cumulative impacts to the land use associated with the geographic expansion of industrial operations beyond the existing developed Prudhoe Bay/Kuparuk area, and the intensification of operations in developed areas.

· Cumulative revenue decline associated with a projected decline in North Slope oil production from a 1995 level of 1.45 million barrels per day (barrels/day) to 0.384 million barrels/day by the year 2015 (Section 10.2.3). Expanded production from existing development and known fields over this period has been estimated to deliver up to 6.47 billion barrels from 1997 to 2020, which would not fully offset the projected decline. The Northstar Unit development would contribute to this partial offset, and would represent approximately 2.4% of total oil production during the project life.

11.4 ALTERNATIVE 2 - POINT STORKERSEN LANDFALL/BPXA PROPOSAL

Alternative 2, the Applicant's (BPXA's) preferred alternative, would result in several direct impacts that distinguish it from the other identified alternatives (Table 11-1). Construction costs associated with this alternative are the lowest of all action alternatives (total construction cost of approximately $405 million, which includes between $52.8 and $73.48 million estimated costs associated with pipeline and ice road construction). Impacts common to Alternative 2 and all other action alternatives (Alternatives 3, 4, and 5) include the following:

· Addition of visible lighting in an offshore area, and contribution to cumulative visual impacts associated with predicted increased offshore development.

· Project-related impact on subsistence whaling caused by bowhead whale avoidance response to noise generated at Seal Island and project-related vessel and helicopter noise and activity. This response to noise is subject to disagreement among experts, but reports of whale avoidance of similar noise and activity suggest that bowhead whale avoidance of the Seal Island area to a distance of 6 miles (9.6 km) could occur under unusually quiet conditions during their migration through this area. This avoidance is considered significant to subsistence harvesting because it could expose whalers to increased hazards associated with greater travel distances from shore and more time spent at sea. It would also increase the likelihood of meat spoilage and, should increase risks to whales be perceived by the IWC, the subsistence harvest quota could be reduced. However, significant long-term displacement of bowhead whales is not expected to occur as a result of Northstar operations.

· The number and timing of offshore helicopter overflights during construction would result in significant impacts to common eiders and oldsquaw.

· Potential volumes of a large oil spill associated with Northstar Unit development and production facilities, including 15,000 barrels/day for 15 days from a well blowout, and a total of 2,800 barrels from a Seal Island diesel tank rupture (single discharge). Potential oil spill volumes associated with pipelines vary by alternative, and are addressed separately.

- Within a 3-day period following a spill event, only marine resources located within approximately 12 miles (19.3 km) of Seal Island, have a higher than 3% probability of contact; beyond about 50 miles (80 km) from Seal Island, probability of contact with oil (up to 180 days after a large spill) is generally much less than 10%.

- Possible contact of 100 miles (160 km) of the coast within 3 days by a large oil spill if response actions are not taken.

- The calculated total probability of one or more large oil spills (greater than 1,000 barrels) from any source is approximately 11% to 24% over the 15-year project life (Table 8-6).

- Minor contribution to the cumulative probability (95.2%) of a large oil spill (greater than 1,000 barrels) over the project lifetime. Northstar Unit production would represent 2.4% of the cumulative oil production during the project life, and represents an increased cumulative risk which is less than the uncertainty inherent in this calculation. For this reason, the cumulative spill risk associated with Alternative 2 is considered essentially the same as the ongoing risk associated with the No Action Alternative.

- Project-related socioeconomic benefits over the project life include contribution of $478.9 million gross revenue to the State of Alaska, $306.3 million in federal revenue, $64.3 million in revenue to the NSB, and $3 million in revenue to the MOA. Additional socioeconomic benefits include 730 construction jobs, 100 annual operation and project support jobs, and total wages of over $307 million. This project would contribute 2.4% of the total projected North Slope oil production during the 15-year project life, and would reduce the projected rate of production decline and associated decline in state and NSB revenues.

Alternative 2 would also result in several impacts which distinguish it from one or more of the other action alternatives. These impacts are:

- The offshore pipeline route is directly through Gwydyr Bay and the nearshore lagoon system (common impact with Alternative 3, but not common with Alternatives 4 or 5). In the unlikely event of an oil spill, this route would limit the effectiveness of booming to protect the lagoon habitat from oil contamination.

- Oil spill response equipment would be staged at West Dock. In the event of an oil spill, response time to the nearshore pipeline for Alternative 2 (common with Alternative 3) would be greater than for Alternatives 4 and 5.

- Pipeline landfall issues (common impact with Alternatives 3 and 4, but not common with

Alternative 5) include a concern that trenching across the shoreline transition zone could result in local thaw bulb creation and associated subsidence and instability. An additional concern regarding a trenched shoreline crossing is the possibility of local erosion. Both these concerns (subsidence and erosion) could represent a hazard to pipeline integrity. This may require increased monitoring and maintenance and may pose an increased risk of pipe failure and resulting oil spill, as compared to a causeway shoreline crossing, such as in Alternative 5.

· Contribution to cumulative land use impacts by establishing a new industrial corridor from Point Storkersen which could facilitate the development of the Gwydyr Bay area. This impact also would result from Alternative 3. Alternatives 1, 4, and 5 would not facilitate new development in the Gwydyr Bay area.

· The onshore pipeline route from Point Storkersen to Pump Station No. 1 traverses 9.55 miles (15.37 km) of undeveloped tundra in a roadless area. This pipeline route would add an industrial facility across a large area of presently undisturbed wildlife habitat. The pipeline itself does not represent a significant biological impact, but routine inspections by helicopter could cause disturbances to several species of wildlife. Also of concern is the potential damage associated with equipment and personnel access to the pipeline in response to unplanned maintenance or an oil spill during the summer.

· Project-specific impacts and contribution to onshore cumulative visual impacts by geographic expansion and intensification of industrial development, including the addition of a 9.55-mile (15.37 km) long pipeline route across an undeveloped area. Though other action alternatives also contribute to the cumulative visual impact, Alternative 2 represents the greatest contribution due to the onshore pipeline route.

· The calculated maximum volumes of potential oil spills associated with Alternative 2 pipelines (assuming complete drainage of oil from the pipeline length between valves) include: 3,600 barrels from an offshore pipeline rupture, 6,400 barrels from an onshore pipeline rupture, and 6,600 barrels from an offshore or onshore chronic pipeline leak. Potential volumes from pipeline spills associated with this alternative are the least of all action alternatives. Other potential volumes from a spill are identical for all action alternatives.

· The probability of one or more pipeline spills greater than 1,000 barrels is 4.5% to 19% (Table 8-6). These calculated probabilities do not reflect concerns related to permafrost thawing at the trenched shoreline crossing, which may increase the risk of pipe failure and oil spillage in this area. No statistics are available to calculate spill probabilities associated with this site-specific hazard. A similar site-specific hazard and related spill risk is associated with Alternatives 3 and 4.

11.5 ALTERNATIVE 3 - POINT STORKERSEN LANDFALL TO WEST DOCK STAGING PAD

Alternative 3 includes the same offshore facility (reconstruction of Seal Island) and the same offshore pipeline route (including the Point Storkersen landfall) as discussed for Alternative 2. The onshore pipeline route, however, is directed eastward from Point Storkersen and traverses approximately 3.6 miles (5.8 km) of undeveloped land prior to reaching existing pipeline corridors and roadways in the Prudhoe Bay industrial complex. The remainder of the pipeline mostly follows existing roadways and pipeline corridors to Pump Station No. 1. This alternative involves a total construction cost of approximately $415 million, including pipeline and ice road construction costs of between $57.44 and $83.52 million. Offshore and landfall related impacts of this alternative would be identical to those described for Alternative 2, but onshore impacts would be reduced. (Table 11-1). Additional features of this alternative which distinguish it from other alternatives include:

· The offshore route is directly through Gwydyr Bay and the nearshore lagoon system (common impact with Alternative 2, but not common with Alternatives 4 or 5). In the unlikely event of an oil spill, this route would limit the effectiveness of booming to protect the lagoon habitat from oil contamination.

· Oil spill response equipment would be staged at West Dock. In the event of an oil spill, response time to the nearshore pipeline for Alternative 3 (common with Alternative 2) would be greater than for Alternatives 4 and 5.

· Impacts related to unplanned maintenance access to the Point Storkersen landfall during the summer and potential landfall subsidence and erosion hazards described for Alternative 2 would also apply to this alternative. These concerns do not apply to Alternatives 1 and 5.

· Contribution to cumulative land use impacts by establishing a new industrial corridor to Point Storkersen which could facilitate future development in the Gwydyr Bay area. This impact could also result from Alternative 2. Alternatives 1, 4, and 5 would not facilitate development in the Gwydyr Bay area.

· The onshore pipeline route from Point Storkersen to the existing pipeline and roadway corridor to the east would cross 3.6 miles (5.8 km) of undeveloped land in a roadless area. An additional overland segment approximately 3.1 miles (5 km) long is located in the southern portion of this pipeline route, but this area is in a developed industrial area within 1.5 miles (2.4 km) of existing roads and is not expected to result in impacts comparable to the other open land pipeline corridors. The 3.1-mile (5 km) southern segment is also part of Alternatives 4 and 5.

· Wildlife disturbance from pipeline inspection helicopter overflights would occur along the 6.7-mile (10.7 km) route in undeveloped habitat. This represents less undeveloped tundra habitat disturbance than Alternative 2, and greater disturbance than Alternatives 1, 4, and 5.

· Project-specific impacts and contribution to onshore cumulative visual impacts by geographic expansion and intensification of industrial development, including the addition of a 3.6-mile (5.8 km) pipeline segment which would extend the onshore industrial development approximately 2.7 miles (4.3 km) west of the existing Prudhoe Bay developed area. This impact would be less substantial than that associated with Alternative 2, due to the shorter length of pipeline in undeveloped areas and proximity to existing development, but represents greater visual impact than that associated with Alternatives 4 and 5.

· The calculated maximum volumes of potential pipeline spills (assuming complete drainage of oil from the pipeline length between valves) include: 3,600 barrels from an offshore pipeline rupture, 8,700 barrels from an onshore pipeline rupture, 6,600 barrels from an offshore chronic pipeline leak, and 8,900 barrels from an onshore chromic pipeline leak. Potential offshore pipeline spill volumes are comparable to Alternative 2, and less than Alternatives 4 and 5. Potential onshore pipeline spill volumes are the greatest of all alternatives.

· The probability of one or more pipeline spills greater than 1,000 barrels is 5.6% to 19% (Table 8-6). These probabilities do not reflect the concern regarding permafrost thawing at the trenched shoreline crossing which may increase the risk of pipe failure and resulting oil spillage. Considering the level of uncertainty inherent in spill risk calculations, the calculated risk of an oil spill associated with this alternative should not be viewed as substantially different than the risk associated with Alternatives 2, 4, or 5.

11.6 ALTERNATIVE 4 - POINT MCINTYRE LANDFALL TO WEST DOCK STAGING PAD

Alternative 4 includes the same offshore facility (reconstruction of Seal Island) as Alternatives 2, 3, and 5, but incorporates a different offshore pipeline route, a different landfall location (near Point McIntyre), and an onshore pipeline route which is located entirely within the existing Prudhoe Bay industrial complex. This alternative involves a total construction cost of approximately $413 million, including pipeline and ice road construction costs of between $54.37 and $81.3 million. Offshore impacts associated with construction and normal operations would be comparable to Alternatives 2, 3, and 5. The pipeline landfall involves a trenched shoreline crossing, and involves the same concerns regarding hazards, repeated maintenance, and possible spill risk associated with permafrost thaw bulb subsidence and shoreline erosion as discussed in relation to Alternatives 2 and 3. Additional features of this alternative which distinguish it from other alternatives include:

· The offshore pipeline route mostly avoids Gwydyr Bay, except for that portion off the eastern end of Stump Island to the shoreline landfall (not common with Alternatives 2, 3, or 5). In the unlikely event of an oil spill, this route would limit the effectiveness of booming to protect the lagoon habitat from oil contamination.

· Oil spill response equipment would be staged at West Dock. In the event of an oil spill, response time to the nearshore pipeline for Alternative 4 (common with Alternative 5) would be less than for Alternatives 2 and 3.

· Although the trenched shoreline crossing could require repeated maintenance associated with shoreline erosion and thaw-related subsidence, the proximity of the Point McIntyre landfall site to existing roadways substantially reduces potential access-related damage associated with repeated maintenance at the landfall site. The overall onshore impact from Alternative 4 would be less than that of Alternatives 2 or 3. Similar impacts are not associated with Alternatives 1 and 5.

· This alternative would not facilitate the development of the Gwydyr Bay area through the westward extension of the industrial pipeline corridors. Alternatives 2 and 3 could facilitate Gwydyr Bay development; however, Alternative 5 does not.

· Onshore visual impacts would be minimized by routing the onshore pipeline within an existing industrial area.

· Helicopter overflights along the onshore pipeline route would be less likely to disturb wildlife than Alternatives 2 and 3 because the route is in an existing industrial area. Alternative 5 represents a comparable, access-related advantage.

· The location of the onshore pipeline within an existing industrial area in proximity to roadway access reduces access-related damage associated with unplanned pipe maintenance and spill response during the summer. Alternative 5 represents a comparable access-related advantage.

· The calculated maximum volumes of potential pipeline spills (assuming complete drainage of oil from the pipeline length between valves) include: 5,300 barrels from an offshore pipeline rupture, 6,800 barrels from an onshore pipeline rupture, 8,200 barrels from an offshore chronic pipeline leak, and 7,000 barrels from an onshore chronic pipeline leak. This alternative involves the greatest potential volume of spillage from the offshore pipeline, and potential onshore pipeline spill volumes comparable to Alternatives 2 and 5.

· The probability of one or more pipeline spills greater than 1,000 barrels is 5.5% to 19% (Table 8-6). This alternative involves similar concerns regarding permafrost thaw bulb subsidence and shoreline erosion at the landfall site as discussed for Alternatives 2 and 3. Alternative 5 would avoid this risk of pipeline damage associated with permafrost thaw bulb subsidence and shoreline erosion.

11.7 ALTERNATIVE 5 - WEST DOCK LANDFALL

Alternative 5 includes the same offshore facility (reconstruction of Seal Island) as Alternatives 2, 3, and 4, and follows an offshore pipeline route nearly identical to Alternative 4. Instead of crossing a natural shoreline in a pipeline trench, however, this alternative would be routed to a location on West Dock free of permafrost (typically at a water depth greater than 6.5 ft [2.0 m]), as determined by site-specific geotechnical data. The pipeline would be installed on a widened, filled causeway, and would cross the natural shoreline buried within this fill. The pipeline landfall would be within the gravel fill of the widened West Dock causeway and, once through the riser, would continue aboveground on VSMs to the onshore elevated, pipeline facilities. From the West Dock Staging Pad, the onshore pipeline route would follow the same route as Alternatives 3 and 4. The shoreline crossing on the West Dock causeway and elimination of the Alternative 4 pipeline segment from Point McIntyre to the West Dock Staging Pad are the only differences between this alternative and Alternative 4. Alternative 5 involves the most costly construction, with a total construction cost of approximately $418 million (including between $58.07 and $86.58 million associated with pipeline and ice road construction). Widening of the causeway itself would cost approximately $5.7 million. Offshore impacts of construction and normal operations are comparable to Alternatives 2, 3, and 4. The distinguishing characteristics of Alternative 5 include:

- The offshore pipeline route completely avoids Gwydyr Bay and the nearshore lagoon system. In the unlikely event of an oil spill, Gwydyr Bay could be protected from oil contamination by booming off the lagoon (i.e., placing oil containment booms between West Dock and Stump Island, and between Stump and Egg Islands).

- Oil spill response equipment would be staged at West Dock. In the event of an oil spill, response time to the nearshore pipeline for Alternative 5 (common with Alternative 4) would be less than for Alternatives 2 and 3.

- Alternative 5 would require the widening of the West Dock causeway by the addition of fill. This would cause approximately 5.5 acres (2.2 hectares) of the shallow, previously disturbed seafloor adjacent to the causeway to be covered, which would be considered a minor impact. If this fill activity occurs during summer, temporary water quality impacts would occur that are not associated with the other three action alternatives. Because this fill placement involves the widening of an existing causeway, and the existing causeway breach would not be affected, no impact on local water circulation is expected. Although the shoreline crossing associated with this alternative is different than the other three action alternatives, local water quality effects of this alternative are relatively minor and do not distinguish Alternative 5 from other action alternatives.

- Pipeline landfall on a solid-fill causeway eliminates the permafrost thaw bulb subsidence hazard and shoreline erosion hazard common to all other action alternatives. This represents an advantage in terms of reduced risk of pipeline damage that could result in an oil spill, and elimination of maintenance activity in a natural shoreline area.

- This alternative would not facilitate the development of the Gwydyr Bay area through the westward extension of industrial pipeline corridors. Alternatives 2 and 3 may facilitate Gwydyr Bay development, but Alternative 4 would not.

- Onshore visual impacts would be eliminated by routing the onshore pipeline within an existing industrial area.

- Helicopter overflights along the onshore pipeline route would be less likely to disturb wildlife than Alternatives 2 and 3, because the entire route is in an existing industrial area. Pipeline inspection by vehicle would be accommodated by existing roadway access along this route. Alternative 4 represents a comparable access-related advantage.

- Location of the onshore pipeline entirely within an existing industrial area and in proximity to roadway access reduces access-related damage associated with unplanned pipe maintenance and spill response during the summer. Alternative 4 represents a similar advantage.

- The calculated maximum volumes of potential pipeline oil spills (assuming complete drainage of oil from the pipeline length between valves) include: 5,200 barrels from an offshore pipeline rupture, 6,700 barrels from an onshore pipeline rupture, 8,100 barrels from an offshore chronic pipeline leak, and 6,900 barrels from an onshore chronic pipeline leak. These volumes are comparable to the spill volumes associated with Alternative 4, and involve greater potential volumes of spillage from the offshore pipeline than those associated with Alternatives 2 and 3.

- The probability of one or more pipeline spills greater than 1,000 barrels is 5.4% to 19% (Table 8-6). Concerns related to permafrost thawing at the shoreline crossing and associated spill risk which are common to Alternatives 2, 3, and 4 would be eliminated with this alternative.

11.8 COMPARATIVE IMPACTS OF ALTERNATIVES

The principal differences among alternatives are discussed in relation to specific impacts below. Impacts include both those due to expected general operations of the project and those due to accidental events which are probabilistic (such as large oil spills) and may not occur. Unless otherwise indicated below, Alternative 1 would not result in the impacts discussed.

11.8.1 Shoreline Landfall Issues

Alternatives 2, 3, and 4 all include pipeline landfall sites at natural shorelines. The installation of a buried seafloor pipeline in an excavated trench across the permafrost transition zone could result in local thaw bulb creation and associated subsidence. Such subsidence could result in increased maintenance requirements at the landfall site, including the addition of fill to maintain the shoreline. Repeated maintenance activities could result in repeated disturbances of local vegetation and increase local erosion. Stresses on the pipeline caused by subsidence could also increase the risk of pipe failure and a resulting oil spill. The magnitude of this increased risk and its potential effect on the total probability of a major oil spill associated with Alternatives 2, 3, and 4 cannot be calculated with presently available data. Alternative 5 does not involve pipeline installation across a natural shoreline, and these related impacts would not occur.

11.8.2 Maintenance Impacts on Vegetation

Impacts associated with routine maintenance activities would differ among the alternatives. Alternative 2 is expected to result in the greatest routine maintenance impact, primarily as a result of potential overland access to the 9.55-mile (15.37 km) overland pipeline segment in a presently inaccessible area. Access to this pipeline during summer months could result in damage to native vegetation well beyond the immediate vicinity of the pipeline. Alternative 3 would result in similar potential disturbances along the

3.6-mile (5.8 km) pipeline segment from Point Storkersen to existing oil facility roadways, but access in this area could be confined to the pipeline route itself. Alternatives 3, 4, and 5 all include a 3.1-mile (5 km) onshore pipeline segment on currently undeveloped land, but this segment is within the existing industrial area and intersects existing roadways at either end. For this reason, access to this pipeline segment could be confined to the pipeline corridor, and is not expected to result in substantial routine maintenance impacts.

Additional routine maintenance impacts could be associated with the maintenance of natural shoreline crossings, as mentioned in Section 11.8.1. Alternatives 2 and 3 present the greatest impact in this regard as a result of the location of the Point Storkersen landfall site approximately 2.7 miles (4.3 km) from the nearest roadway (straight line distance). Because access to the landfall site could require overland access during summer months, vegetation disturbances could extend beyond the immediate vicinity of the Alternative 2 pipeline route. Access could be confined to the pipeline corridor in the case of Alternative 3, but this would result in repeated disturbance of natural vegetation along the 3.6-mile (5.8 km) pipeline route from the landfall site to existing roadways. The Point McIntyre landfall site associated with Alternative 4 is located in close proximity to existing roadways (0.3-mile [0.5 km]) within the existing industrial area, and access-related vegetation disturbance in this area would be minor. The Alternative 5 landfall at the West Dock causeway would avoid all landfall maintenance impacts to natural vegetation.

11.8.3 Operational Disturbance of Wildlife

Disturbance of wildlife from operations activities is associated with weekly helicopter overflights along the pipeline route, helicopter transport of personnel/supplies to Seal Island during the spring and fall, and vessel transport to Seal Island during open water. Helicopter overflights along the pipeline associated with Alternative 2 represent the greatest level of impact, as a result of the 9.55-mile (15.37 km) overland pipeline segment across largely undeveloped tundra. These overflights, during the summer months, could result in minor impacts to caribou in the area and to tundra nesting birds (including threatened spectacled eiders) in a corridor along the onshore pipeline. However, appropriate measures to avoid or minimize the potential effect will be recommended by the U.S. Fish and Wildlife Service (USFWS). Alternative 3 would result in similar impacts; however, these would be to a 6.7-mile (10.8 km) pipeline, including the 3.5 mile (5.8 km) pipeline segment from Point Storkersen to the existing road system near Point McIntyre. Alternatives 4 and 5 would require helicopter overflights along the pipeline of approximately 3.1 miles (5 km) for routine inspections.

The impact of helicopter overflights between the mainland and Seal Island will be common to all alternatives routes. These impacts would involve disturbances to nesting common eiders on the barrier islands and occasional disturbances to nesting or brood-rearing brant if flight paths include the Kuparuk River Delta. Helicopter overflights also have the potential to disturb nesting or brood-rearing activities of spectacled eiders within the flight path, which would be considered a minor impact. Noise and activity associated with the operation of the Seal Island facility, and related vessel transport operations, could result in bowhead whale avoidance response during migration periods. This impact is not expected to directly harm individual whales or whale populations, but may be important to the consideration of potential subsistence activity impacts (discussed separately in Section 11.8.4).

Cumulative impacts to sea ducks (common eiders and oldsquaw) due to helicopter flights during construction are considered significant. All action alternatives (Alternatives 2, 3, 4, and 5) would result in the same potential minor bowhead whale avoidance impact.

11.8.4 Impacts of Facility Operations on Subsistence

All action alternatives would have comparable operational impacts to subsistence activities. During normal operation of the Seal Island facility, bowhead whale avoidance of industrial noise and activity could require whalers to travel further offshore in search of whales. This would represent several significant effects on the subsistence activity, including: increased safety risks to whalers, reduced harvest success caused by longer time required for each whale, and potential meat spoilage associated with longer transport distances. In addition, should the IWC perceive any increased impact on or risk to the whale population, the bowhead harvest quota could be reduced. Project-related activities would contribute to cumulative effects on the bowhead whale migration route associated with increased offshore development, which could be significant to subsistence activities.

11.8.5 Expansion of Developed Area

All action alternatives would result in the addition of a new industrial facility in the offshore area. However, these alternatives are distinctly different with regard to onshore land use impacts. Alternative 2 represents the greatest onshore land use impact, and would establish a new overland pipeline corridor in an existing undeveloped area from Point Storkersen to Pump Station No. 1. In addition to the expansion and intensification of the industrial complex in the Prudhoe Bay - Kuparuk area, Alternative 2 could contribute to the further development in the Gwydyr Bay area by establishing a pipeline corridor closer to that area. Alternative 3 would also expand industrial land uses by extension of Prudhoe Bay area pipeline corridors westward to Point Storkersen, but the consolidation of most of the Alternative 3 onshore pipeline along existing industrial corridors reduces the overall impact in comparison to Alternative 2. Alternative 3 is comparable to Alternative 2 in the potential contribution to future development in the Gwydyr Bay area. The consolidation of the onshore pipeline routes with existing industrial corridors represented by Alternatives 4 and 5 effectively eliminates new onshore land use impacts associated with these alternatives. Alternatives 4 and 5 also do not contribute to potential future development in the Gwydyr Bay area.

11.8.6 Socioeconomics

All action alternatives are expected to generate comparable contributions to State of Alaska, federal, and local revenues and create the same number of jobs. This includes the contribution of $478.9 million gross state royalty and tax revenues, $306.3 million in federal tax and royalty revenues, $64.3 million in NSB tax revenues, and $3 million in MOA tax revenues over the 15-year project life. This represents a substantial beneficial impact on State of Alaska revenues, since North Slope oil and gas revenues represent the primary source of state revenues (ADNR, 1997:5-40) (Section 7.6). The Northstar Project would represent approximately 2.4% of the total currently projected North Slope oil production during its project life. Construction employment would generate 730 jobs, and 100 annual long-term (15-year) facility operation and project support jobs, and total wages of over $307 million.

None of the revenue and employment benefits would result from the No Action Alternative (Alternative 1).

11.8.7 Visual/Aesthetic Impacts

All action alternatives would result in comparable offshore visual impacts associated with the addition of artificial lighting and industrial facilities on Seal Island. However, onshore visual impacts would be substantially different. Alternative 2 would result in the greatest visual impact associated with the addition of a 9.55-mile (15.37 km) elevated pipeline across a currently undeveloped area. Alternative 3 would result in similar impacts along a shorter elevated pipeline segment (3.6 miles [5.8 km]) from Point Storkersen to existing Prudhoe Bay industrial facilities. Alternatives 4 and 5 would not result in new onshore visual impacts because their onshore pipeline routes are within or close to existing industrial corridors of the Prudhoe Bay industrial area.

11.8.8 Likelihood of a Large Oil Spill

Each action alternative presents a risk of 11%/12% to 24% (any cause) over the 15-year project life of an oil spill greater than 1,000 barrels (Table 8-6). Calculated probabilities of one or more pipeline spills greater than 1,000 barrels over the entire project lifetime are: Alternative 2 – 4.5% to 19%; Alternative 3 – 5.6% to 19%; Alternative 4 – 5.5% to 19%; and Alternative 5 – 5.4% to 19%. The calculations used to develop these probabilities consider a large database, including facilities in non-arctic locations. As a result, they are subject to substantial uncertainty and the relatively minor differences resulting from these calculations are not considered substantial enough to effectively distinguish between the action alternatives.

Specific design features of individual facilities are important to the level of spill risk associated with those facilities. The natural shoreline landfalls at Point Storkersen and Point McIntyre associated with Alternatives 2, 3, and 4 are expected to represent some increased risk as compared to the West Dock causeway landfall for Alternative 5. As explained in Section 11.8.1, this increased risk is associated with thaw bulb related subsidence and shoreline erosion at the landfall site. No data are presently available which can be used to verify this impact conclusion, or to quantify the contribution of this impact to spill occurrence probabilities.

11.8.9 Potential Oil Spill Volumes

The potential volume of spilled oil varies among alternatives. This variation is entirely related to differences in pipeline lengths, since Seal Island facilities would be identical for all alternatives. Maximum spill volumes assume complete drainage of oil from the pipeline lengths between valves. The potential pipeline spill volumes would be least for Alternative 2, with calculated rupture/chronic leak volumes of 3,600/6,600 barrels from the offshore pipeline segment and 6,400/6,600 barrels from the onshore pipeline segment. Alternative 3 would result in the same offshore pipeline spill volume as Alternative 2 (3,600/6,600 barrels), but could result in a substantially greater onshore spill volume of 8,700/8,900 barrels. Alternatives 4 and 5 present substantially greater potential offshore spill volumes (5,300/8,200 barrels and 5,200/8,100 barrels, respectively). Use of buried, remotely operable pipeline valves to reduce these volumes could introduce considerable operational difficulty concerning valve inspection and maintenance, and may introduce a design feature with a much higher risk of failure (and resulting spillage) than a continuously welded steel pipeline. For these reasons, installation of valves along the offshore portion of these pipelines is not considered appropriate. Onshore pipeline spill volumes associated with Alternatives 4 and 5 would be slightly greater than Alternative 2 (6,800/7,000 and 6,700/6,900 barrels, respectively), and these differences are not considered significant.

11.8.10 Potential Oil Spill Impacts

Although the action alternatives could result in different volumes of offshore pipeline spills (refer to Section 11.8.9), other offshore spills associated with Seal Island facilities would be identical. In addition, even the smallest of the calculated offshore pipeline spill volumes of 3,600 barrels could be substantial enough to result in significant adverse impacts, as previously identified in this EIS. However, the offshore pipeline route for Alternative 4 would mostly avoid Gwydyr Bay, except for that portion off the eastern end of Stump Island to the shoreline landfall. Alternative 5 would completely avoid Gwydyr Bay. This would likely reduce the potential oil spill related impacts to the birds and fish using Gwydyr Bay. For Alternative 5, oil spill response tactics for an offshore spill would include the placement of booms which could preclude oil from entering the Gwydyr Bay/Simpson Lagoon system. Additionally, since oil spill response equipment would be staged from West Dock, a more rapid response would be possible for the nearshore portions of the pipeline for Alternatives 4 and 5. Offshore spill responses for Alternative 2 and 3 would not be as rapid, because the nearshore portions of those pipelines would be further from West Dock.

Significant adverse impacts which could occur in connection with a major offshore spill from any of the action alternatives include: direct mortality and injury to birds (e.g., oldsquaw and common, king, Steller's and spectacled eiders); direct mortality of bowhead whales (if oil contacts the spring lead system coincident with migration); mortality of polar bears (caused by oil contact, thermoregulation loss, ingestion of oil-contaminated prey); elimination or severe disruption to subsistence activities; and potential long-term adverse effects on offshore subsistence activities (due to deflection of whales, reduced populations of subsistence resources, and possible oil contamination of available subsistence resources such as bowhead whales, seals, birds, and fish).

Onshore spill impacts vary substantially among the action alternatives. Although the onshore spill volume associated with Alternative 2 is the least of all action alternatives, this alternative would result in the greatest onshore spill impact. The Alternative 2 pipeline route across 9.55 miles (15.37 km) of existing undeveloped land, removed from existing industrial development, would expose relatively undisturbed vegetation and wildlife resources to the impacts of an oil spill. Alternatives 3, 4, and 5 cross 3.1 miles (5 km) of undeveloped tundra near the southern terminus of the alignment. In addition, access to the onshore spill site by response equipment would require overland access. If a spill occurs during summer months, disturbances to vegetation caused by equipment access could extend the disturbed area well beyond the immediate vicinity of oil contamination. Similar disturbance of vegetation and overland access impacts could occur in connection with Alternative 3, but this impact is not as great as Alternative 2 because only 3.6 miles (5.8 km) of the Alternative 3 pipeline route is located outside the existing developed industrial area. The remainder of the Alternative 3 onshore pipeline route, and all of the Alternatives 4 and 5 onshore pipeline routes, are located within the existing industrial area. These routes follow existing roadways and pipeline corridors over most of their lengths, and one overland segment in the southern portion of these routes occurs near existing roadways and is surrounded by industrial development. Spill impacts in the existing industrial area are considered less substantial than those in undeveloped areas due to available year-round access and the level of existing disturbance already present in the industrial area.

11.8.11 Cumulative Impacts

As discussed in Section 11.3, ongoing and reasonably foreseeable future oil industry activities will result in cumulative impacts in the Alaskan Beaufort Sea, regardless of Northstar development. These impacts, some of which may be significant, include industrial noise and oil spill impacts on subsistence bowhead whaling, mortality and habitat displacement impacts for polar bears from oil spills and noise, noise impacts to molting sea ducks from mortality caused by oil spills or offshore helicopter overflights during construction, mortality of spectacled eiders from oil spills, and habitat displacement of ringed seals from noise. Although Alternatives 2, 3, 4, and 5 add different incremental impacts to the cumulative impacts, the differences are negligible from the perspective of overall cumulative impacts.

11.8.12 Unavoidable Adverse Effects, Relationship Between the Local Short-Term Uses and Long-Term Productivity, and Irreversible and Irretrievable Commitment of Resources

Unavoidable adverse effects, the relationship between local short-term uses and long-term productivity, and irreversible and irretrievable commitments of resources issues are essentially the same among all action alternatives. Therefore, distinctions among individual alternatives have not been identified.

Geology and Hydrology: Primary issues or concerns for resources within the physical environment are related to the potential for direct and long-term impacts to soils, permafrost, sediment quality, accelerated coastal erosion, and hazards that could affect Seal Island and pipeline integrity. However, no unavoidable adverse impacts to geology or hydrology from project construction, operation, maintenance, or abandonment were identified.

The project would require an irreversible commitment of geologic resources (i.e., oil and gas reserves and fossil fuels used for construction and fabrication of facilities). Ground disturbances associated with installation of the subsea pipeline, the onshore VSMs, and gravel mining for reconstruction of the island and associated onshore facilities would be irreversible, as it would be a direct effect to soils and permafrost during the life of the project.

Meteorology and Air Quality: No significant unavoidable adverse impacts to air quality from the project were identified. Short-term impacts would include those from localized construction activities' emissions, which are negligible. Long-term impacts include emissions from facility operations and vehicles delivering supplies to the offshore site. These air quality impacts are negligible and would occur as a result of routine facility operations and periodic maintenance activities. Irreversible or irretrievable impacts to air quality from construction or operations are not anticipated.

Physical Oceanography and Marine Water Quality: No unavoidable impacts with respect to physical oceanography or marine water quality were identified as a result of the project. This includes any direct or indirect impacts due to construction activities, operational characteristics (with the exception of a large oil spill), maintenance procedures, or abandonment options. No irreversible or irretrievable commitment of resources related to the physical oceanography and marine water quality of the Alaskan Beaufort Sea would result from the project.

Sea Ice: No significant unavoidable adverse effects to sea ice would result from construction and operation activities. All identified effects would be short-term, partly due to the limited duration of activities, and partly due to the seasonal presence of sea ice. The project would not require any irreversible or irretrievable commitment of resources with respect to the sea ice. Project components have been designed to anticipate, accommodate, and alleviate potential impacts from sea ice during all phases of the project.

Plankton and Marine Invertebrates: No significant adverse impacts from the development of the proposed project were identified for phytoplankton, zooplankton and benthic marine invertebrates, or the epontic community, which lives under the sea ice. Impacts to plankton and marine invertebrates identified as a result of Seal Island reconstruction, and trenching and burial of the pipeline include mortality from direct burial, smothering, and displacement.

Reconstruction of Seal Island, trenching and burial of the offshore pipeline, and placement of gravel at West Dock (Alternative 5) could result in short-term impacts to plankton and marine invertebrates. Plankton would be rapidly replaced from production or from adjacent areas. Recolonization of the disturbed bottom substrates would occur after construction, and long-term productivity of the impacted area would not be adversely affected. Pipeline and facilities operation would have no long-term impacts on plankton or marine invertebrates. Maintenance activities that require offshore pipeline repair would result in short-term impacts to plankton and marine invertebrates.

The development of any of these alternatives would not result in irretrievable or irreversible commitment of marine invertebrate resources. Recolonization of the areas affected would replace lost biomass.

Marine and Freshwater Fish: No significant unavoidable adverse impacts to fish resources from project development would occur. The local fishery would continue to experience fluctuations in population levels within the range of natural variation. Reconstruction of Seal Island and trenching of the buried pipeline would result in a temporary increase in turbidity and subsequent short-term displacement of local fish populations in water deeper than 6 ft (1.8 m). Similar impacts could occur from the placement of gravel at West Dock Causeway under Alternative 5.

Overall, construction of the project is expected to result in minor, short-term impacts to local fish populations due to displacement and loss of habitat. No adverse effects which would affect the long-term productivity of the local fishery are anticipated.

Reclamation of the mine site on the Kuparuk River Delta and the side slopes of Seal Island would be beneficial to fish. Creation of additional deep water and overwintering habitat would result in a positive increase in long-term productivity due to a potential improvement to fish habitat.

Marine Mammals: The development of Alternatives 2, 3, 4, or 5 would result in some minor impacts to ringed seals and polar bears during the stable ice period (e.g., noise and construction disturbance on ringed seals). Polar bears may be either attracted or displaced by activity on the ice, but the impacts are considered minor. Impacts to denning polar bears are not expected due to the lack of documented denning in the area affected by the project. Beluga whales are only present during the open water period in fall, and no impacts are anticipated. Reconstruction of Seal Island, construction of the offshore pipeline, and ice road traffic could result in direct, short-term impacts from disturbance and displacement of seals from the vicinity of Seal Island and disturbance or attraction of polar bears to Seal Island. No long-term adverse impacts to marine mammals from planned construction, operation, or maintenance activities have been identified. The abandonment of Seal Island would not create any additional habitat for marine mammals or affect the use of the area by marine mammals. Mortality of polar bears from oil spills would be considered a significant impact.

Coastal Vegetation and Invertebrates: No significant unavoidable adverse impacts were identified for coastal vegetation and invertebrates as a result of the project. Tundra vegetation would be impacted from late melting of ice roads, fill of wetlands for the installation of the valve stations, and placement of the VSMs. Oil spills could potentially have significant adverse impacts on small areas of coastal tundra along the onshore pipeline or on saline tundra vegetation in low-lying areas on the coast. The development of any of Alternatives 2, 3, 4, or 5 would result in the loss of river bar habitat on the Kuparuk River Delta in the gravel mine area, and would also result in the filling of small areas on tundra for the valve station.

Such impacts would result in the long-term loss or commitment of habitat and would be an irreversible commitment of resources. Ice road construction would result in some compression and late green-up of tundra the first year after construction for Alternatives 2, 3, 4, and 5. The impacts would be short-term and would not impact long-term productivity. The onshore pipeline would not require fill, and after abandonment and pipeline removal, this area could be restored to its former habitat.

Birds: Displacement of nesting birds from late melting ice roads on tundra would be considered a minor impact. Impacts from a large oil spill could significantly affect several species of waterfowl, including sea ducks, such as common eiders and oldsquaw, which molt in Simpson Lagoon/Gwydyr Bay during mid-summer. Significant impacts to sea ducks (not including spectacled eiders) would be expected offshore from helicopter overflights during construction. Impact to birds from a spill on land would be considered minor and would only affect a localized area.

Development of the gravel mine and construction of the onshore pipeline could result in a short-term impact on nesting habitat and a long-term increase in aquatic habitat with the restoration of the mine (a negligible beneficial impact for some species). Operation and maintenance of the pipeline and facilities would have no long-term impacts to birds, either onshore or in offshore waters. However, an increase of predatory avian species resulting from additional food sources on the island is likely to occur. Low elevation helicopter overflights to Seal Island and pipeline inspection flights could result in adverse impacts to nesting common eiders on the Barrier Islands, and molting sea ducks in Simpson Lagoon. Collision with structures on Seal Island by migrating birds could potentially be significant to some species.

The development of any of the project alternatives would require commitment of river bar habitat at the gravel mine and the filling of small areas of tundra for the valve stations which would result in an irreversible commitment of habitat. Removal of the onshore pipeline during project abandonment would allow return of the habitat for use by birds and, therefore, would not be considered an irreversible commitment of the resource.

Terrestrial Mammals: No significant unavoidable adverse impacts were identified for terrestrial mammals including caribou, grizzly bears, and Arctic fox, as a result of development of the project. Development of the gravel mine and construction of the onshore pipeline could result in negligible short-term displacement of any caribou wintering in the area. The operation and maintenance of the pipeline and facilities would have no long-term impacts on terrestrial mammals.

Alternatives 2, 3, 4, and 5 require an irreversible commitment of resources for the gravel mine and, for Alternatives 2, 3, and 4, would require the filling of small areas of tundra for the valve stations. Pipeline removal during project abandonment would allow return of the habitat for terrestrial mammals and, therefore, would not be considered an irreversible commitment of resources.

Threatened and Endangered Species: Alternatives 2, 3, 4, or 5 would have similar impacts on threatened and endangered species. Ice road and Seal Island construction would not impact bowhead whales, Steller's eiders, or spectacled eiders because these activities would occur in winter. Construction and abandonment would also take place during the winter. Operational and maintenance activities and drilling at Seal Island would create noise which might be heard by bowheads several miles away from Seal Island. Impacts of such noise on bowheads may alter the migration pattern of whales within the area. Actual impact to whales from the sound is considered minor and limited to the period of project operation.

Disturbance of nesting spectacled eider along sections of the onshore pipeline from late melting ice roads would result in a short-term impact to this species. However, nest site loss would have a negligible impact because of the abundance of suitable nesting habitat in the project area. Low-level helicopter overflights would result in the potential disturbance and minor impacts of a small number of nesting spectacled eiders along each onshore pipeline corridor.

After project abandonment, there would be no further impacts to endangered or threatened species. Project construction or operation would not result in loss of threatened or endangered species habitat. Consequently, irretrievable commitments of resources are not expected.

Subsistence: Construction, operation, and maintenance noise could cause behavioral changes in bowhead whales. However, project design and scheduling would reduce the likelihood of adverse impacts to subsistence harvesting. If large ships were active near Seal Island during the fall bowhead migration and subsistence hunting period, the whale migration pattern could be deflected in the extreme western portion of the Nuiqsut harvest area. Although highly unlikely because of the planned schedule for island construction activities, there is a slight chance that some bowheads could be deflected from their normal migration path. If this were to occur within the western portion of the harvest area and if hunting was unsuccessful within the eastern and central portions of the harvest area, impacts to the fall subsistence harvest during construction would be considered significant. The loss of hunting success would be short-term if it were limited to a single-season (construction), but long-term if it continued throughout the duration of the project as a result of island maintenance or operations. The loss of subsistence harvesting also would be considered to be an irretrievable and irreversible loss of the resource for the period during which such losses occurred. Deflection or mortality of migrating bowhead whales from oil spills or project-related noise could result in significant impacts to subsistence.

Cultural/Archaeological Resources and Human History: Unavoidable adverse impacts to cultural resources as a result of construction, operation, maintenance, or abandonment activities are not anticipated. If such resources are encountered during construction, they will be either avoided or mitigated. However, significant impacts to such resources may result in the event of a large onshore or offshore oil spill (Chapter 8). Contamination of important cultural resources could cause irreparable damage to historic artifacts, and cleanup operations could cause physical damage to existing sites.

Land and Water Use: Unavoidable, adverse impacts as a result of changes to the status of jurisdiction or changes in ownership were identified as minor. The onshore portion of the pipeline for Alternatives 2, 3, 4, and 5 would cross access roads, existing pipelines, and utility lines. Some short-term and minor impacts to land use would occur during construction due to road closures or detours, and interruptions to pipeline flow or utility service. There would be no impacts to onshore industrial land use due to project operation. Because traditional land use of the onshore portion of the project area is infrequent, onshore construction and operation would have a negligible impact on traditional land use.

There would be no impacts on use of submerged lands during project construction or operation. Boat traffic associated with project construction and operation would cause negligible impacts to boat access associated with offshore subsistence uses.

Onshore pipeline route lands will be used for industrial purposes for the duration of the project. However, the area could be used for other purposes following depletion of oil and gas resources. Therefore, short-term uses of the area would not preclude returning land uses to pre-construction condition.

Designated easements would result in temporary commitment of resources for project development and operation. However, corridors could be used for other purposes following completion of oil and gas production, thus long-term effects of land use changes resulting from this project are not anticipated.

Socioeconomics: Project construction and operation would have a beneficial impact to employment and to local, state, and federal governments through the creation of jobs and oil-related royalty and tax revenues. Short-term benefits would result from the creation of construction jobs for gravel mining, island reconstruction, pipeline installation, facilities fabrication, and drilling. Project construction would generate 730 Alaska construction jobs with estimated wages of $52 million. Long-term benefits would result from the addition of operations personnel and the generation of tax and royalty revenues. Project operation would generate 100 Alaska operation and project support jobs annually, with estimated wages of $255 million over a 15-year project life. Total project revenues from oil and gas taxes and royalties are estimated at $478.9 million for the State of Alaska, $306.3 million in revenue to the federal government, $64.3 million in revenue to the NSB, and $3 million to the MOA, over the 15-year project life. Approximately $64.3 million would be generated in property taxes for the NSB over the 15-year life of the project.

Transportation: Significant adverse impacts to transportation are not anticipated. Increases in equipment and materials transported through the Ports of Seward, Whittier, and Anchorage are expected to represent 1% to 26% of current levels, and incremental increases in truck traffic along the Dalton Highway are expected to be 2% of current levels. Barge and boat traffic associated with project construction would result in a short-term increase in traffic between Seal Island and West Dock, and bus and truck traffic would increase for the transport of materials and workers, which would result in minor impacts to transportation facilities in the project area. Northstar crude oil would total approximately 4% of the Trans Alaska Pipeline System throughput during peak project production years, and contributions to the throughput of the system would be a beneficial impact.

Visual/Aesthetic Characteristics: Construction of Alternatives 2, 3, 4, and 5 would erect structures that would interrupt horizontal views. Construction of facilities on Seal Island and the onshore pipeline approach would be visible for the life of the project (15 years) and would affect the long-term visual resources if not dismantled during abandonment. The glow caused by the lighting and occasional use of the flare seen beyond the horizon from Nuiqsut would be visible for the life of the project, as well; however, visual resources would return to pre-construction levels when the project is decommissioned.

Recreation: Recreation activities that would be affected by the project are limited to those along the Dalton Highway, and significant impacts are not anticipated.

11.9 IDENTIFICATION OF THE PREFERRED ALTERNATIVE

NEPA requires that the lead and cooperating agencies identify their preferred alternative and document the reasons supporting this determination. This selected alternative is commonly referred to as the "agency preferred alternative."

11.9.1 Agency-Preferred Alternative

The agency preferred alternative is that alternative which the agency believes would fulfill its statutory mission and responsibilities, giving consideration to environmental, economic, technical, and other factors. The agency preferred alternative is distinct from the "environmentally preferred alternative." The environmentally preferred alternative is ordinarily the alternative which causes the least damage to the biological and physical environment and best protects historic, cultural, and natural resources. Although the agency preferred alternative and the environmentally preferred alternative may be the same, this is not always the case. Due to the differing missions, responsibilities, and regulations of the cooperating agencies, their perspectives on an "agency preferred" alternative are different. The following information is provided to clarify the agencies' perspectives and the processes followed to reach agency decisions.

11.9.1.1 U.S. Army Engineer District, Alaska

The U.S. Army Engineer District, Alaska (Corps) is neither an opponent nor a proponent of the applicant's proposed alternative action. For the proposed Northstar development, the applicant's final proposal has been identified as Alternative 2 (applicant's preferred alternative) and is fully described in Appendix A to this document.

In order to make a permit decision for activities involving discharges under Section 404 of the Clean Water Act, the Corps applies the U.S. Environmental Protection Agency's (EPA's) 404(b)(1) guidelines on evaluation of alternatives for disposal sites for dredged or fill material (40 CFR Part 230). This EIS has evaluated the applicant's proposal (Alternative 2), the No Action Alternative, and three additional action alternatives. The Corps will also use the range of alternatives in this document when conducting its 404(b)(1) alternative analysis. If the Corps determines that one or more of the alternatives is a substantially less damaging, practicable alternative as compared to the applicant's proposal, the Corps may deny the applicant's request for a permit for Alternative 2. From a NEPA perspective, the Corps could select from the range of all alternatives evaluated in this document. A preliminary 404(b)(1) analysis for the applicant's proposal (Alternative 2) is included in the Corps' public notice soliciting comments on the Final EIS (FEIS).

The Corps also conducts a public interest review of all relevant factors (33 CFR Part 320.4(a)) in order to make a permit decision. The public interest review is still in progress, with the release of this FEIS, the solicitation of public comments on the FEIS, and the solicitation of public comments on the decision of whether or not to grant a permit for the applicant's proposal. This public interest review portion of the decision whether to issue a permit will be based on an evaluation of the probable impacts, including cumulative impacts of the proposed activity and its intended use on the public interest. Evaluation of the probable impacts which the proposed activity may have on the public interest requires a careful weighing of all those factors which become relevant in each particular case. The benefits which reasonably may be expected to accrue from the proposal must be balanced against its reasonably foreseeable detriments. The decision whether to authorize a proposal and, if so, the conditions under which it will be allowed to occur, are therefore, determined by the outcome of the general balancing process. That decision should reflect the national concern for both protection and utilization of important resources. All factors which may be relevant to the proposal must be considered, including the cumulative effects thereof. Among those are: conservation, economics, aesthetics, general environmental concerns, wetlands, cultural values, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs, considerations of property ownership, and, in general, the needs and welfare of the people.

The Corps' permit decision, which includes the public interest review and final 404(b)(1) guidelines analysis, will be completed in the Corps' Record of Decision (ROD). Decision options available to the District Engineer will be to issue the permit, issue with modifications and/or conditions, or deny the permit. The Corps cannot take a position on a proposed project until the evaluation of the project using the 404(b)(1) guidelines is finalized, the public interest review is completed, and a ROD has been prepared and approved. Therefore, the Corps cannot identify its agency preferred alternative in the EIS (see 33 CFR Part 325, Appendix B). The Corps will make its permit decision after the ROD has been approved, which will occur after the 30-day comment period on the FEIS. For activities involving 404 discharges, a permit will be denied if the discharge that would be authorized by such permit would not comply with the EPA's 404(b)(l) guidelines. Subject to the preceding sentence and any other applicable guidelines or criteria (see 33 CFR 320.2 and 320.3), a permit will be granted unless the District Engineer determines that it would be contrary to the public interest.

11.9.1.2 U.S. Environmental Protection Agency

The EPA is proposing to issue a National Pollutant Discharge Elimination System permit as described in Appendix O. Because of the responsibilities that the EPA has under the Clean Water Act, the EPA does not promote the selection of one project alternative over another. The EPA will review and act according to its Clean Water Act authorities following the Corps' decision-making process (Section 11.9.1.1).

11.9.1.3 Minerals Management Service

Under the Outer Continental Shelf (OCS) Lands Act of 1953 (67 Stat. 462), as amended (43 U.S.C. et seq. [1994]), the U.S. Department of the Interior is required to manage the leasing, exploration, development, and production of oil and gas resources on the Federal OCS, and requires that the Secretary oversee the OCS oil and gas program. The Secretary is also charged with balancing orderly resource development with protection of the human, marine, and coastal environments, while simultaneously ensuring that the public receives an equitable return for these resources. As an agency of the Department of the Interior, the Minerals Management Service (MMS) is responsible for the mineral leasing of OCS lands and for the supervision of offshore operations after lease issuance. A lease gives the lessee the exclusive right and privilege to drill for, develop, and produce oil and gas resources on that lease, subject to existing laws and regulations. Once a lease is awarded, the MMS' Regional Supervisor for Field Operations is responsible for approving, supervising, and regulating operations conducted on the lease.

As required by 30 CFR 250.204, the MMS will carefully analyze the information submitted by BPXA for this project, as well as the analysis presented in the FEIS and any comments received, prior to making any final decision on the Development and Production Plan (DPP). In this context, the MMS is a cooperating agency on this EIS. This EIS has evaluated the applicant's proposal (Alternative 2), plus the No Action Alternative and three additional action alternatives related to pipeline routing. Upon completion of this review, the MMS will either approve, disapprove, or require modifications to the DPP. This action will not take place until after the FEIS is released. The MMS has up to 60 days following release of the FEIS to take action on the proposed DPP pursuant to 250.204(l). No OCS development and production activities can be conducted unless and until a DPP is approved, and the project has received coastal consistency concurrence by the State of Alaska.

Based on available information, the MMS identifies Alternative 2 as its preferred alternative. Among the five alternatives analyzed in the EIS, Alternative 2 meets MMS's legal and regulatory responsibilities for the timely and safe development of offshore oil and gas resources. Two principal benefits are discussed below.

Shortest Offshore Pipeline Segment: One of the most significant public concerns raised throughout the public process has been the risk of oil spills from the proposed subsea pipeline. Although the FEIS finds that there is not a significant difference in the statistical oil spill probability among the alternatives, the MMS concludes that adopting the shortest offshore pipeline segment is prudent and the most responsible alternative given the public's concerns. None of the action alternatives analyzed in the FEIS clearly provide a greater level of safety or reduce oil spill risk.

The State of Alaska, in its comments on the Draft EIS (DEIS), endorsed Alternative 2. The state noted that the shortest offshore segment is preferable. The state, which has direct regulatory authority on project pipelines, also noted that an exhaustive review of the Alternative 2 pipeline route had been completed and that the state was prepared to issue a right-of-way lease for the proposed pipeline route.

The NSB has also endorsed Alternative 2. The NSB Assembly has recommended approval to re-zone the area around Northstar which will allow the project to proceed. The NSB stated that the greater the length of pipeline under water, the greater the risk of a leak or damage to this pipeline. The NSB endorses BPXA's proposal to install offshore pipelines in a trench of sufficient depth to avoid contact with extreme event ice gouge, and to be below the maximum incision depth to avoid damage due to soil motions beneath the ice keel, and placing backfill material over the pipelines will provide protection from ice pounding and ice gouging. The NSB believes BPXA's proposal is consistent with the NSB's policy requiring offshore oil transport systems to be specifically designed to withstand geological hazards, specifically sea ice.

Timely Development Schedule and Lost Royalty Income: Alternative 2 is BPXA's preferred alternative. Site-specific surveys, facilities design, and engineering have been completed for this alternative and have been under review by appropriate state and federal agencies for several years. Construction schedules and first production are directly tied to these efforts. Any and each of the action alternative pipeline routes analyzed in the FEIS (except Alternative 2) would require a new and complete re-engineering of the pipeline, including additional field surveys to support design. The State of Alaska noted in its comments on the DEIS that any and each of the alternative pipeline routes would require submittal of a new right-of-way application, which would require the state right-of-way process to start over. Conducting additional field studies, pipeline and other facilities re-design, and initiating a new right-of-way application review could delay the project construction schedule another 1 to 2 years. None of the alternative pipeline routes analyzed in the FEIS show a clear or significant environmental benefit or savings over Alternative 2, which would suggest that an additional 1 to 2-year delay in the project start up is not justified.

The Northstar Project will provide direct and significant royalty revenue to the federal government and the State of Alaska. The state in its comments on the DEIS, endorsed Alternative 2 on the basis that it would provide for the most timely completion of the project and, accordingly, royalty income to the state.

Delay of the project would also directly affect employment. The FEIS concludes that 730 jobs will be created and will generate approximately $52 million in Alaskan wages during the construction phase alone. Project operation, with an estimated 100 annual jobs and payroll of $255 million, could be similarly delayed. Substantial public comment was directed at the employment benefits of the project.

The MMS notes that, in selecting an agency preferred alternative in the FEIS, it is providing the public with some anticipation on how the project could proceed. Preferred alternatives are based on regulatory authorities and responsibilities and the information presented within the FEIS. The MMS's final decisions may or may not match the agency preferred alternative, pending any resulting information following publication of the FEIS and completion of their DPP review, and completion of the MMS' ROD.

11.9.1.4 National Marine Fisheries Service

The National Marine Fisheries Service (NMFS) does not promote the selection of one project alternative over another as the preferred action alternative. Rather, since all the alternatives (with the exception of Alternative 1 - No Action) will have impacts on the NMFS' trust resources, the NMFS promotes the incorporation of mitigation measures to avoid, minimize, and/or compensate for impacts to trust resources. The NMFS will provide this information to the Corps and cooperating agencies under the Endangered Species Act, the Marine Mammal Protection Act, and the Fish and Wildlife Coordination Act.

11.9.1.5 U.S. Fish & Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) will not select an alternative for publication in this EIS. The USFWS is presently evaluating the potential impacts of this project on trust resources, particularly migratory birds (including the threatened spectacled eider) and marine mammals (polar bears). Because the management and responsibility of these wildlife resources and the habitats on which they depend are responsibilities of the USFWS as mandated by the Fish and Wildlife Coordination Act, Migratory Bird Treaty Act, Endangered Species Act, and the Marine Mammal Protection Act, the USFWS will not recommend an alternative until publication and review of the FEIS. If the USFWS recommends an alternative other than Alternative 1 (No Action), they will recommend mitigation measures to avoid, minimize, or compensate for impacts to trust resources.

11.9.1.6 North Slope Borough

The NSB has been a non-federal cooperating agency in the preparation of this EIS and has been constrained by the requirements of its zoning ordinance to render a decision on the Northstar Project prior to publication of the document. BPXA submitted a rezone and Master Plan application to the NSB on September 15, 1998, and did not waive NSB compliance with the review and action timelines specified for such requests in the NSB Municipal Code. Without reliance upon or reference to this FEIS, the NSB Assembly, on December 1, 1998, approved the applicant's proposed rezone of the project area, which included BPXA's proposed project (Alternative 2). The Assembly's approval included several mitigation measures and becomes effective upon final approval of this FEIS.

11.9.2 The Environmentally Preferred Action Alternative

The environmentally preferred alternative(s) [40 CFR 1505. 2(b)] is the alternative that will promote the national environmental policy as expressed in NEPA's Section 101. Ordinarily, this means the alternative that causes the least damage to the biological and physical environment; it also means the alternative which best protects, preserves, and enhances historic, cultural, and natural resources. An action alternative must satisfy the applicant's purpose and need [33 CFR 325, Appendix B, 9b (5a)]. In this case, only Alternatives 2 through 5 meet this criteria (e.g., Alternative 1 – the No Action Alternative does not meets the applicant's purpose and need). In addition, identification of an environmentally preferred alternative considers only impacts to the physical, biological, and human environments; it does not take into account agency statutory missions or project cost factors. These two factors are considered by each agency in their determination of a preferred alternative (See Section 11.9.1). The agency preferred alternative need not be the same as the environmentally preferred alternative or the applicant's preferred alternative.

Alternative 5 was identified as the environmentally preferred alternative in the DEIS. A large number of comments regarding the environmentally preferred alternative were received and the need to further describe and discuss the rationale for choosing the environmentally preferred alternative was recognized . After reviewing all comments from the DEIS, and reevaluating the assessment of alternatives and related impacts, the lead and federal cooperating agencies (except for the MMS) are reconfirming Alternative 5 as the environmentally preferred action alternative for the following reasons (for a more complete comparison of alternatives and impacts see the previous sections in Chapter 11, in particular Sections 11.7 and 11.8):

· Although the offshore pipeline length is longer than Alternatives 2 and 3, and the corresponding probability of an oil spill is slightly higher (1.6%, 1.6%, 2.4%, and 2.4% for Alternatives 2, 3, 4, and 5, respectively), considering the level of uncertainty inherent in spill probability calculations, the calculated risk of an oil spill associated with all action alternatives would be similar (starts at 4.5%, 5.6%, 5.5%, and 5.4% for Alternatives 2, 3, 4, and 5, respectively, and ranges to 19% for all action alternatives). Additionally, pipeline design and maintenance considerations could reduce the probability of an oil spill for any of the action alternatives (Section 8.5.3).

· Although the potential offshore pipeline spill volume is greater for Alternative 5, as compared to Alternatives 2 and 3 (3,600, 3,600, and 5,200 barrels for a pipeline rupture of Alternatives 2, 3, and 5, respectively), even the smallest of the calculated offshore spill volumes of 3,600 barrels could be substantial enough to result in significant adverse impacts. Thus, the offshore pipeline spill volumes for all of the action alternatives could cause significant adverse impacts.

· The offshore pipeline route completely avoids Gwydyr Bay and the nearshore lagoon system, an important area for migrating, rearing, and feeding marine and anadromous fish; and for molting, staging, and brood-rearing migratory birds. In the unlikely event of an oil spill, Gwydyr Bay could be protected from oil contamination by booming off the lagoon (i.e., placing oil containment booms between West Dock and Stump Island, and between Stump and Egg Islands). In comparison, Alternatives 2 and 3 offshore pipelines would be routed directly through the heart of the nearshore lagoon, while Alternative 4 would be routed through the eastern end of the lagoon.

· Oil spill response equipment would be staged at West Dock. In the event of an oil spill, this would allow for a more rapid response to the nearshore pipeline for Alternatives 4 and 5, as compared to spill response to the nearshore pipeline for Alternatives 2 and 3.

· The pipeline landfall on the West Dock causeway is intended to avoid the permafrost thaw bulb subsidence and shoreline erosion issues, which eliminates the permafrost thaw bulb subsidence hazard and shoreline erosion hazard common to all other action alternatives. This could be an advantage in terms of reduced risk of pipeline damage from differential thaw settlement that could result in an oil spill. In addition, this pipeline landfall on to West Dock would result in the elimination of maintenance activity that would otherwise be necessary in a natural shoreline area. In comparison, Alternatives 2, 3, and 4 would not avoid the natural shoreline issues of permafrost and erosion.

· Although approximately 5.5 acres (2.2 hectares) of shallow seafloor adjacent to West Dock causeway would be covered, this impact would be minor. Additionally, the causeway breach, a 650-foot (198 meter) bridged opening, would not be affected and no additional impacts to local water circulation would be expected.

· Location of the onshore pipeline entirely within an existing industrial area and in proximity to roadway access would: increase the probability of leak detection, reduce oil spill response time, and reduce access-related damage associated with oil spill response and unplanned pipe maintenance during the summer.

· Routine inspections and maintenance of onshore pipelines would be performed from existing roads, as opposed to the use of helicopters for Alternatives 2, 3, and 4. This would decrease the disturbance to wildlife from helicopter overflights.

· Locating onshore pipelines in an existing corridor would likely decrease impacts to caribou moving through the area; other alternatives would require caribou to cross new onshore pipeline corridors.

· Onshore visual impacts would be reduced by routing the onshore pipeline within an existing industrial area.

Because NEPA rules allow more than one alternative to be identified as environmentally preferable, the MMS considers Alternatives 2 and 3 as its preferences for environmentally preferred alternatives. The MMS believes that there are substantive differences between the route of the offshore portion of the pipeline under Alternatives 2 and 3 compared to the Alternative 5 route outside the barrier islands. A major concern identified for the Northstar Project has been the offshore pipeline segment, especially since this is the first such design. MMS believes it is preferable to minimize the length of the offshore segment for this first application. Pipeline construction and monitoring issues, especially as they relate to the different ice characteristics within and outside the barrier islands, will be more manageable within the barrier islands. Alternatives 2 and 3 provide the shortest route to reduce the size and likelihood of an offshore oil spill and associated impacts. These differences lead the MMS to conclude that the offshore segment used in Alternatives 2 and 3 is environmentally preferable. The differences in impacts between Alternatives 2 and 3 are not sufficient to define which of the two would be environmentally preferable at this time. As required by NEPA rules, the MMS will make a final judgment on its environmentally preferred alternative in its ROD for the Northstar Project.

The NEPA process provides each federal agency with the opportunity to state its environmentally preferred alternative(s) in the DEIS, FEIS, and ultimately, in its ROD.

11.10 MITIGATION MEASURES

Mitigation measures are the means by which the range and intensity of project induced changes to the existing baseline conditions are compensated for, avoided, or reduced. In the case of this EIS for the Northstar Project, the cooperating agencies have developed a list of mitigation measures aimed at reducing or avoiding the identified significant environmental impacts expected to result from the project. This EIS is the appropriate means to present environmental impacts and associated mitigation measures.

The mitigation measures identified in this section represent a list of possible means to reduce impacts. If an action alternative is chosen, the mitigation measures will include some or all of the measures identified in this section. However, federal agencies are not limited to selecting mitigation measures from this list. Public comment on the FEIS may identify new mitigation measures. Each federal agency with decision-making authority on the Northstar Project will incorporate its own set of mitigation measures into its ROD that may become conditions or stipulations on their permit or action.

11.10.1 Federal Lease Sale Stipulations

There have been a number of federal offshore lease sales in the Alaskan Beaufort Sea since 1979. The most recent federal lease sale on the North Slope was Lease Sale 170, held August 5, 1998. The granting of any lease to a private party is accompanied by a list of stipulations addressing issues, such as: the protection of historic and archaeological sites, environmental training, the requirement to use pipelines for transporting oil if technically feasible, special measures to protect biological and subsistence resources, and discharges into marine waters. The original federal lease stipulations for Northstar presently in effect are summarized in Appendix D of this EIS, and must be complied with by the lease holders when developing the Northstar Unit.

11.10.2 Mitigation Measures Under Active Consideration by Cooperating Agencies

Potential mitigation measures were identified by the cooperating agencies participating in the direction of this EIS based on their assessment of the likely environmental consequences of the Northstar Project. It is important to note that many potential environmental consequences of this project have already been minimized or avoided through integration of Traditional Knowledge and modern science into the applicant's project design (See Table 1-3). These design features have been assessed in the impact analyses of Chapters 5 through 11. However, the cooperating agencies identified the following measures to further reduce or avoid the remaining environmental consequences identified in Chapters 5 through 11. The intent of each measure is described; the actual wording of a measure will be developed by each agency according to their regulatory authority and responsibility. Mitigation measures that may be developed as part of the ROD are summarized as follows:

· Avoid potential injury and mortality to migratory birds, especially sea ducks (including threatened spectacled eiders), the applicant will lower and orient in an east-west direction, the construction crane (and any additional equipment of significant height) when equipment is not in use.

· Modify (via paint or lighting) structures or facilities to decrease the potential of bird strikes because Seal Island is within the migratory corridor of spring, fall, and molt-migrating waterfowl (king, common, and spectacled eiders, oldsquaw, black brant) and other birds (Pacific, red-throated, and yellow-billed loons, red and red-necked phalaropes).

· Require the purchase of *Breco* buoys (Navenco Marine Company) or other similar acoustic scaring devices to disperse sea ducks and other migratory birds from an oil spill area to augment secondary oil spill response capabilities.

· Prepare and implement bear-interaction plans to minimize conflicts between bears and humans. These plans shall include measures to: (a) minimize attraction of polar bears to Seal Island; (b) organize layout of buildings and work areas to minimize human/bear interactions; (c) warn personnel of bears near or on Seal Island and along offshore/onshore pipeline routes and identify proper procedures to be followed; (d) if authorized, deter bears from Seal Island and along offshore/onshore pipeline routes; (e) provide contingencies in the event bears do not leave the site or cannot deterred by authorized personnel; (f) discuss proper storage and disposal of materials that may be toxic to bears; and (g) provide a systematic record of bears on the site and in the immediate area. The applicant shall develop educational programs and camp layout and management plans as they prepare operations plans. These plans shall be developed in consultation with appropriate federal, state, and NSB regulatory and resource agencies.

· Because polar bears are known to den predominantly within 25 miles (40 km) of the coast, operators shall consult with the USFWS (907-786-3800) prior to initiating activities in such habitat between October 30 and April 15.

- Establish flight corridors for helicopter traffic to and from Seal Island. The objective of this measure is to minimize the impact of helicopter noise on nesting spectacled eiders, nesting brant, common eiders on the barrier islands, and molting waterfowl in nearshore lagoons. It is also intended to minimize noise impacts on denning seals, polar bears, and migrating whales.

- Establish vessel corridors to maximize separation between vessels and migrating whales. These would likely be seasonal restrictions and would apply during the fall whale migration. In particular, icebreaking barge operations related to maintaining a corridor between West Dock and Seal Island during broken/thin ice conditions cannot commence in the fall prior to October 15.

- Activities shall not be conducted nor pass within 1 mile (1.6 km) of any known polar bear dens and all observed dens shall be reported to the Marine Mammals Management Office, USFWS (907-786-3800) within 24 hours. This buffer zone will remain in effect from the time of detection, until the female bear/cubs leaves the denning area in the spring. The USFWS will evaluate these instances on a case-by-case basis to determine the appropriate action. Potential responses may range from cessation or modification of work to conducting additional monitoring.

- Require the preparation of an agency approved plan that demonstrates: 1) a reduction in oil spill risk, 2) increased leak detection under ice, and 3) increased oil spill response capability.

- Require use of the agitation technique for pile installation instead of pile driving during certain periods. Such a measure is intended to reduce noise impacts on marine mammals.

- Require a barge-based oil spill response plan. Three icebreaking barges would be used as the foundation of an on-site oil spill response plan. The barges would support oil cleanup crews, house equipment, and serve as a holding facility for recovered oil.

- Require complete shutdown of the pipeline during broken ice conditions. Such a measure is intended to minimize the risk of an oil spill when clean-up efficiencies are likely to be low.

- Require pre-staging of oil spill response equipment to protect biologically important sites, such as river deltas, lagoons, and barrier islands. This measure is intended to reduce the risk of an oil spill reaching and adversely affecting sensitive species in these important habitats.

- Require a well relief plan for a well blowout event. This measure is intended to ensure that emergency equipment is close by in the event of a well blow out, so that control of the well will be regained as quickly as possible, to maximize safety and reduce harm to the environment.

- Restrict construction and operation activities that may affect marine mammals (e.g., drilling, ball mill, pile driving). This measure is intended to reduce noise impacts to marine mammals and potential effects on subsistence.

- Prohibit drilling the first development well into the targeted hydrocarbon formation(s) during broken ice conditions. Such a requirement is intended to provide the applicant and the permitting agencies with an opportunity to test well integrity prior to the next development step and reduce the chance of an oil spill.

- Prohibit the drilling of exploration wells into untested formations during broken ice conditions. Such a measure is intended to reduce the chance of an oil spill occurring when oil spill cleanup efficiencies are likely to be low.

- Establish time periods for certain construction activities to minimize environmental consequences. Such activities would likely include: pipeline trenching, onshore and offshore gravel placement, spoil disposal offshore, gravel hauling, road construction, pipe construction, and pipeline testing.

- Establish a citizen's advisory board to address impacts to subsistence and to recommend to the government and the applicant solutions to any identified problems.

· Require additional site-specific geotechnical data prior to construction along the pipeline route in the shoal area and at the pipeline landfall. This data will be employed in a geotechnical analysis as specified in a plan requiring approval prior to construction. This plan will also specify the geotechnical sampling methodologies and sites.

· Require the use, if practicable, of arctic grade, low sulfur (0.05%) diesel fuel during the first year of drilling.

11.10.3 Monitoring Programs and Studies

Where environmental information is lacking, or where monitoring is required as a prerequisite to enforcement of permit conditions, federal agencies may require that the applicant conduct or financially support monitoring programs or further studies on various issues. The following have been identified as potential monitoring programs for the project:

- A monitoring program to investigate avian injury and mortality at Seal Island. The issue centers on whether facilities (towers, buildings, wires, and seawall) on Seal Island pose a hazard to birds. The study would need to be conducted from approximately May 1st through November 15th for a minimum of 5 years to monitor bird collisions during various ice conditions and lead patterns during bird migration periods.

- An acoustic monitoring program to measure actual frequency and noise level at various distances from Seal Island during the construction and initial operation of facilities on Seal Island. The program should be conducted for at least 3 years, beginning with initial gravel placement on the island. This study is intended to better understand noise impacts to marine mammals and to determine the noise signature from project operations.

· Conduct or support studies that investigate the impact of noise from the project on bowhead whale migration. The intent is to both understand the effects of the Northstar project and to provide information necessary for consideration of future offshore development.

· A monitoring program to characterize pre- and post-construction sediment chemistry. This would be conducted along the pipeline trench with location reference sites.

· A monitoring program to track disposed material from trench excavation. The objective is to document how far these sediments travel and to determine if excessive subsea mounding occurs to determine compliance with permit conditions.

· A monitoring program to measure water quality and sediments around Seal Island. The objective is to gather data that can be used by the applicant and the agencies in determining whether the project is in compliance with permit conditions. In addition, this data may be used to inform the decision-maker when permit reissuance may be sought by the applicant.

· Require an erosion monitoring and remedial action plan to protect the pipeline landfall site in the event of unexpectedly large erosion events or rates. This plan should include both a monitoring component and a description of the remedial actions that may be employed in the event the landfall shoreline requires stabilization.

· Require an ice-override monitoring and action plan to protect the pipeline transition site in the event of unexpectedly large ice-override events.

· Because the specific timing of migration and distribution of sea ducks (common, king and threatened spectacled eiders, oldsquaws) and other migratory birds (e.g., Pacific, red-throated, and yellow-billed loons, red and red-necked phalaropes) have been inadequately described, and because this offshore development may impact these resources, the applicant may be required to conduct research using aerial surveys, migration watches, ground surveys of barrier islands, and the use of radar to describe spring, fall, and molt migrations and potential staging/molting areas of migratory birds.

· The applicant may be required to conduct aerial surveys of polar bears during certain times of the year around Seal Island and along the offshore/onshore pipeline corridors to minimize effects of the proposed development.

TABLE 11-1
COMPARISON OF PROJECT ALTERNATIVES

Environment/ Resource	Alternative 1 No Action	Alternative 2 Point Storkersen/BPXA Proposal	Alternative 3 Point Storkersen/WDSP	Alternative 4 Point McIntyre/WDSP	Alternative 5 West Dock Causeway
Physical Environment					
Geology and Hydrology - Permafrost	No impact.	Alternatives 2, 3, and 4 all involve comparable impacts associated with potential thaw bulb creation and related subsidence caused within the shoreline permafrost transition zone.			Landfall on causeway and crossing the permafrost transition zone on fill avoids potential thaw bulb creation and related subsidence.
Coastal Erosion	No impact.	Alternatives 2, 3, and 4 all involve comparable impacts associated with potential shoreline erosion and pipe damage hazard caused by construction across a natural shoreline. Potential repeated maintenance of these landfalls could add recurring shoreline impacts.			Landfall on causeway avoids potential shoreline erosion and pipe damage hazard. Maintenance activity is expected to be minimal, and would be comparable to existing maintenance of the causeway.
Spill-related Impacts to Soils and Coastal Erosion	No impact.	Alternatives 2, 3, 4, and 5 could all result in significant oil spill contamination of onshore soils and/or seafloor sediments.			
Biological Environment					
Coastal Vegetation and Invertebrates - Vegetation Impacts	No impact.	Impacts to coastal vegetation at the Point Storkersen and Point McIntyre landfalls would be the same for Alternatives 2, 3, and 4 (impacts would be minor). Periodic maintenance of shoreline landfall may be required.			Coastal vegetation would not be impacted. Periodic maintenance of the landfall would not affect coastal vegetation.
Spill-related Impacts to Invertebrates	No impact.	Alternatives 2, 3, 4, and 5 could all result in significant oil spill mortality of freshwater invertebrates.			
Biological Environment (Cont.)					
Birds - Noise-related Impact	No impact.	Minor disturbance impacts to nesting birds from helicopter inspection overflights would be greater for Alternative 2 than those of Alternative 3 because the Alternative 2 crosses more undisturbed nesting habitat. Approximately 310 and 275 nesting birds (black brant, common eiders, oldsquaw, and surf scoters) would be within a 0.25-mile (0.4 km) corridor along Alternative 2 and 3 pipelines, respectively.		Minor disturbance impacts to nesting birds from helicopter inspection overflights would be similar for Alternatives 4 and 5, but less than Alternatives 2 and 3 because most of the corridors parallel existing pipeline and vehicle corridors. Approximately 140 and 127 nesting birds (black brant, common eiders, oldsquaw, and surf scoters) would be within a 0.25-mile (0.4 km) corridor along Alternative 4 and 5 pipelines, respectively.	

TABLE 11-1 (Cont.)
COMPARISON OF PROJECT ALTERNATIVES

Environment/ Resource	Alternative 1 No Action	Alternative 2 Point Storkersen/BPXA Proposal	Alternative 3 Point Storkersen/WDSP	Alternative 4 Point McIntyre/WDSP	Alternative 5 West Dock Causeway
		Significant impacts to sea ducks (common eider and oldsquaw) from offshore helicopter overflights during construction only.			
Spill-related Impacts -	No impact.	Because nearshore lagoons could be more easily protected via booms, Alt. 5 would provide more protection to molting, staging, and brood-rearing migratory birds. If a major spill was to occur, direct mortality is expected and could include spectacled and Steller's eiders (threatened species). Reduced populations of several bird species could be evident for several years following the spill.			
Spectacled eiders	No impact.	Minor disturbance impacts from helicopter overflights to spectacled eider nesting pairs within 0.25 miles (0.4 km) of the Alternative 2 and 3 onshore corridor. Total of 6 for each alternative.		Minor disturbance impacts from helicopter overflights to spectacled eider nesting pairs within 0.25 miles (0.4 km) of the Alternative 4 and 5 onshore corridor. Total of 2 for each alternative.	
Terrestrial Mammals Noise-related Impact	No impact.	Minor caribou disturbance from helicopter overflights along 9.55 miles (15.37 km) of pipeline in undeveloped area.	Minor caribou disturbance from helicopter overflights along 6.7 miles (10.8 km) of pipeline in undeveloped area.	Helicopter overflights associated with Alternatives 4 and 5 would occur in an existing industrialized area and would result in minor effects on caribou. Undisturbed habitat is present along 3.4 and 3.1 miles (5.5 and 5 km) of Alternatives 4 and 5, respectively.	
Marine Mammals Noise-related Impacts	No impact.	Alternatives 2, 3, 4, and 5 would have comparable impacts on the bowhead whale, including bowhead whale avoidance of Seal Island and support activity noise, including a 3- to 6-mile (4.8 to 9.6 km) migration path deflection. This behavioral response would not harm individual whales or whale populations, but could affect subsistence harvesting.			
Spill-related Impacts	No impact.	Alternatives 2, 3, 4, and 5 could have comparable spill-related impacts to marine mammals. Depending on the season, size of spill, and response effectiveness, a large oil spill could result in injury and/or mortality of bowhead whales from an oil spill contacting the spring lead system coincident with migration. Other species, such as polar bears, could be adversely affected by ingestion of oil during grooming, consumption of oiled prey, or loss of insulation and subsequent hypothermia.			
Human Environment					
Subsistence - Noise-related Impacts	No impact.	Alternatives 2, 3, 4, and 5 would have comparable impacts on subsistence whaling. This impact is associated with bowhead whale avoidance of noise, which could reduce harvest success or increase safety risk to whalers. If this impact occurs, it would represent a significant adverse effect on subsistence harvest activities by reducing harvest success and increasing whaler safety risk. Decreased harvest could result in changes to IWC harvest quotas.			
Subsistence - Spill-related Impacts	No impact.	Alternatives 2, 3, 4, and 5 would have comparable impacts to subsistence whaling if a major offshore spill was to occur. Depending on the season of spill occurrence and size of spill, a large oil spill could significantly adversely affect whaling vessel operations, response efforts could create noise and activity that could result in whale avoidance behavior and reduced whaling success, and oiling of whales could taint the subsistence harvest. Other subsistence resources also would be significantly affected, including direct mortality and oil tainting of seals, birds, and fish.			
Cumulative Impacts	No contribution to cumulative impacts.	Alternatives 2, 3, 4, and 5 would have comparable contributions to cumulative impacts to subsistence whaling. Increased offshore industrial activity could cause bowhead whale avoidance and result in longer travel distances, increased safety risk, and reduced harvest success of subsistence whaling activity.			
Land and Water Use	No impact or land use conflicts.	Existing Conservation District policies applicable to offshore and onshore project areas are	Existing Conservation District policies applicable to offshore and onshore project areas are	Alternatives 4 and 5 would result in similar land use impacts associated with offshore project elements which are comparable to the offshore impacts	

TABLE 11-1 (Cont.)
COMPARISON OF PROJECT ALTERNATIVES

Environment/ Resource	Alternative 1 No Action	Alternative 2 Point Storkersen/BPXA Proposal	Alternative 3 Point Storkersen/WDSP	Alternative 4 Point McIntyre/WDSP	Alternative 5 West Dock Causeway
		incompatible with the proposed alternative and required rezoning. This affects the island site and 9.55 miles (15.37 km) of onshore pipeline.	incompatible with the proposed alternative and required rezoning. This affects the island site and 3.6 miles (5.8 km) of onshore pipeline.	described for Alternatives 2 and 3. Alternatives 4 and 5 would not result in onshore land use impacts.	
Cumulative Impacts	Alternative 1 does not contribute to cumulative impacts.	Alternative 2 would contribute to the intensification of industrial development by adding a pipeline across a currently undeveloped area and contributing to Gwydyr Bay development.	Alternative 3 would contribute to the intensification of industrial development by extension of a pipeline corridor closer to Gwydyr Bay and contributing to development in that area.	Alternatives 4 and 5 would contribute less to onshore cumulative impacts than would be contributed by Alternatives 2 and 3. Pipeline routing would mostly follow existing development corridors.	
Socioeconomics - Revenue Impact	No beneficial effect of federal, state, and local revenue generation.	Alternatives 2, 3, 4, and 5 would all result in the generation of revenue for the State of Alaska, including $478.9 million gross state revenues, $306.3 million in federal revenues, $64.3 million in NSB revenues, and $3 million in revenue to the Municipality of Anchorage over 15 years.			
Human Environment (Cont.)					
Development Costs	No development cost to the project proponent, and complete loss of investment in offshore leases and project planning and engineering.	$52.8 to $73.48 million pipeline and ice road construction cost. $405 million total construction cost.	$57.44 to $83.52 million pipeline and ice road construction cost. $415 million total construction cost.	$54.37 to $81.30 million pipeline and ice road construction cost. $413 million total construction cost.	$58.07 to $86.58 million pipeline and ice road construction cost. $418 million total construction cost.
Employment Impacts	No new employment opportunities.	Alternatives 2, 3, 4, and 5 would all result in comparable employment including the creation of approximately 730 construction jobs and 100 facility operations jobs, with a total payroll of $307 million.			
Cumulative Impacts	No contribution to currently declining oil production revenues.	Alternatives 2, 3, 4, and 5 would result in comparable contributions of government revenue to partially offset projected declines. This contribution represents 2.4% of the total North Slope oil production (and related revenues) over the 15-year project life.			
Visual/Aesthetic Characteristics	No impacts.	Project-specific and contribution to cumulative impacts associated with visible lighting offshore and a 9.55-mile (15.37 km) long pipeline in an undeveloped area.	Project-specific and contribution to cumulative impacts associated with visible lighting offshore and a 3.6-mile (5.8 km) long pipeline in an undeveloped area.	Alternatives 4 and 5 would result in the same offshore project-specific and contribution to cumulative offshore visual impacts as discussed in connection with Alternatives 2 and 3.	
Oil Spills					
Probability of Spill Occurrence -- Total Project[1]	No project-related risk of spill occurrence.	Any Source - 11% to 24% Pipeline - 4.5% to 19%	Any Source - 12% to 24% Pipeline - 5.6% to 19%	Any Source - 12% to 24% Pipeline - 5.5% to 19%	Any Source - 12% to 24% Pipeline - 5.4% to 19%

TABLE 11-1 (Cont.)
COMPARISON OF PROJECT ALTERNATIVES

Environment/ Resource	Alternative 1 No Action	Alternative 2 Point Storkersen/BPXA Proposal	Alternative 3 Point Storkersen/WDSP	Alternative 4 Point McIntyre/WDSP	Alternative 5 West Dock Causeway
Pipeline[2]		Offshore - 1.6% Onshore - 3%	Offshore - 1.6% Onshore - 4.1%	Offshore - 2.4% Onshore - 3.2%	Offshore - 2.4% Onshore - 3.1%
Maximum Potential Pipeline Spill Volume -- Onshore[3]	No potential for any project-related oil spillage.	Pipeline Rupture - 6,400 bbls Chronic Leak - 6,600 bbls	Pipeline Rupture - 8,700 bbls Chronic Leak - 8,900 bbls	Pipeline Rupture - 6,800 bbls Chronic Leak - 7,000 bbls	Pipeline Rupture - 6,700 bbls Chronic Leak - 6,900 bbls
Offshore[3]		Pipeline Rupture - 3,600 bbls Chronic Leak[4] - 6,600 bbls	Pipeline Rupture - 3,600 bbls Chronic Leak[4] - 6,600 bbls	Pipeline Rupture - 5,300 bbls Chronic Leak[4] - 8,200 bbls	Pipeline Rupture - 5,200 bbls Chronic Leak[4] - 8,100 bbls
Oil Spills (Cont.)					
Spill Response Actions -- Onshore	No need for spill response and no response-related impacts.	Spill response access damage associated with 9.55 miles (15.37 km) of pipe in undeveloped area without roadway access.	Spill response access damage associated with 3.6 miles (5.8 km) of pipe in undeveloped area without roadway access.	Alternatives 4 and 5 present small risk of onshore spill response access damage because the onshore pipeline route is accessible from or within 1.5 miles (2.4 km) of existing roadways.	
Offshore		Since spill response equipment would be staged at West Dock, offshore spill responses for Alternatives 2 and 3 would not be as rapid as those for Alternatives 4 and 5.			
Contribution to Cumulative Oil Spill Probability	No contribution to cumulative major spill risk, which would be approximately 93.7% considering other North Slope oil and gas operations from 1997 to 2020.	Alternatives 2, 3, 4, and 5 would all result in a comparable contribution to the overall cumulative spill risk associated with North Slope oil development. Because the Northstar Project represents a relatively small component of the total North Slope development (approximately 2.4% of the total North Slope oil production over the project lifetime), each of these alternatives would result in a 1.5% contribution to the total cumulative spill risk of 95.2% from 1997 to 2020.			

Notes: 1 = Total project spill probabilities are based on CONCAWE and MMS OCS spill statistics for spills from any source (Table 8-6).

2 = Pipeline spill probabilities are based on CONCAWE spill statistics (Table 8-7).

3 = Maximum pipeline spill volumes for a rupture or a chronic leak are based on specific calculation assumptions given in Table 8-5. These include: an oil flow rate of 65,000 barrels per day, pipeline lengths between check valves for the different alternatives, and complete drainage of oil from the pipeline. Although drainage of the entire pipeline volume between valves would likely be prevented by seawater intrusion (offshore) and operational measures, it is presented as the worst case spill volume.

4 = Maximum offshore pipeline spill volumes are based on the chronic leak scenario during unstable solid ice conditions, with the detection time assumed to be 35 days.

bbls = Barrels
BPXA = BP Exploration (Alaska)
gals = Gallons
km = Kilometers

TABLE 11-1 (Cont.)
COMPARISON OF PROJECT ALTERNATIVES

MMS	=	Minerals Management Service
NSB	=	North Slope Borough
OCS	=	Outer Continental Shelf
%	=	Percent
WDSP	=	West Dock Staging Pad

CHAPTER 12.0

LIST OF PREPARERS

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CHAPTER 12.0 LIST OF PREPARERS

Section Title Page

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12.0 LIST OF PREPARERS

Name/Project Responsibility	Qualifications/Experience
Regulatory Agencies	
Terry A. Carpenter U.S. Army Corps of Engineers (Lead Agency)	M.S. - Biological Oceanography with 6 years' experience as a regulatory project manager and 8 years' experience with fisheries and bird studies related to oil development on Alaska's North Slope.
Jeanne L. Hanson National Marine Fisheries Service	B.S. - Marine Biology and graduate work in Environmental Policy and Management with 11 years' experience in wetland and fisheries resource management in Alaska.
Timothy R. Jennings U.S. Army Corps of Engineers (Lead Agency)	M.S. - Fisheries Biology with 20 years' experience in Alaska; 12 years' experience in regulatory programs, EA and EIS preparation, NEPA compliance, and wetlands and water resources issues; 9 years' experience in fisheries and environmental studies.
Thomas L. Lohman North Slope Borough, Department of Wildlife Management	B.A. - Public Policy with 10 years' experience in natural resources, wildlife, and environmental policy formulation for the North Slope Borough.
Paul L. Lowry Minerals Management Service	B.S. - Earth Science and graduate work in Marine Environmental Studies with 18 years' of NEPA experience in pre- and post-lease oil and gas exploration projects in offshore Alaska.
Theodore Rockwell Environmental Protection Agency	B.S. - Ecology with more than 20 years' experience in wetlands ecology, regulation programs, EIS preparation, NEPA compliance, and 16 years' experience in Alaska oil and gas industry and development.
Eric J. Taylor, Ph.D. U.S. Fish and Wildlife Service	Ph.D. - Wildlife and Fisheries Sciences with 15 years' experience addressing wetland and waterfowl ecology in arctic and subarctic Alaska.
Dames & Moore	
Michael L. Foster, P.E. Project Director/Project Manager	M.S. - Arctic Engineering with 15 years' experience in applied engineering associated with facilities in northern climates.
Tara E. Bellion Biological Environment Biological Assessment	B.S. - Marine Biology with 4 years' experience in environmental studies.
Leslie A. Boughton, P.E. Effects of Oil 103 Evaluation	B.S. - Chemical Engineering with 5 years' experience in chemical, process, and environmental engineering.
Dames & Moore (Cont.)	
Nancy J. Darigo, C.P.G. Physical Environment	M.S. - Geology with 14 years' experience in geologic investigations, marine geology, and onshore and offshore geophysics.
Steven K. Davis Biological Environment Biological Assessment	M.S. - Fisheries Science with over 16 years' experience preparing environmental assessments and impact statements. Expertise in biological studies and ecosystem analysis.

Name/Project Responsibility	Qualifications/Experience
Dave E. Erikson Biological Environment Biological Assessment	M.S. - Biology with 20 years' experience in wildlife studies involving resource development in the Arctic and interior of Alaska.
Larry M. Foster, Ph.D. NPDES Permitting Ocean Discharge Criteria Evaluation/Modeling	Ph.D. - Mathematics, M.S.E. Mechanical Engineering, M.S.E. Civil/Environmental Engineering with 18 years' experience in operations research, modeling engineering systems, and numerical analysis.
Jeff Fuller Effects of Noise	B.S. - Environmental Health with 15 years' experience in acoustical assessments and environmental impact statements.
Michael D. Gray Physical Environment	B.S. - Geology with 10 years' experience in geology and earth resources studies.
P. Dean Hargis Cumulative Impacts	B.S. - Zoology with 21 years' experience in NEPA compliance, environmental studies management, permit analysis, technical studies, and providing expert testimony.
Gary L. Hayward Alternatives	M.S. - Marine Geology with 15 years' experience in offshore oil and gas exploration and production projects and project management.
George R. High Human Environment	B.S. - Biology with 23 years' experience preparing environmental assessments and impact statements.
Jonathan D. Isaacs, A.I.C.P. Human Environment Public Scoping	B.A. - Environmental Studies with 20 years' experience in socioeconomic analysis, planning, and coastal management in Alaska.
Joe D. Kuebler, P.E. Air Quality	B.S. - Chemical Engineering with 23 years' experience in air emissions inventories and evaluations, air quality compliance, and Title V permit applications.
Ulf Marquard-Petersen Biological Environment Biological Assessment	M.S. - Wildlife Biology with 6 years' experience as a research biologist.
Sasha S. McIntosh Biological Environment	B.S. - Biology with 3 years' experience preparing environmental assessments and impact statements.
Dames & Moore (Cont.)	
Clark R. Milne, P.E. Engineering Analysis	M.C.E. - Civil Engineering with 21 years' experience in project management and environmental and civil engineering.
Tamera R. Phillips Air Quality Beaufort Sea Environment	M.E. - Petroleum Engineering with 13 years' experience in oil and gas process operations, environmental engineering, and air quality permitting.
Gwendo-Lyn Turner Technical Editor	M.S. - Ecology with 22 years' experience in environmental studies and technical editing.
Kristina N. Swanson Effects of Oil	B.S. - Civil Engineering with 2 years' experience in project management, quality assurance, and Civil/Environmental engineering.
Debbie J. Vreeland Senior Technical Editor	B.A. - Journalism with 10 years' environmental and oil and gas development project management experience and oil spill response planning.

Name/Project Responsibility	Qualifications/Experience
Kinnetics Laboratories, Inc.	
Paul J. Barter Physical Oceanography	B.A. - Biology with 9 years' experience in oceanographic studies and environmental monitoring.
Gary Gillingham Marine Biology	B.A. - Zoology with 20 years' experience conducting zoological studies.
Janet M. Kennedy Marine Biology	A.S. - Marine Biology and Oceanography with 12 years' experience in marine studies.
Mark A. Savoie Physical Oceanography/Modeling	M.S. - Ocean Engineering with 15 years' experience in environmental assessments and impact studies in the marine environment.
Stephen R. Braund & Associates	
Stephen R. Braund Cultural Resources, Subsistence, Traditional Knowledge	M.A. - Anthropology with 24 years' experience in socioeconomic and subsistence research in rural Alaska communities.
Elizabeth L. Moorehead Subsistence, Traditional Knowledge	M.A. - Anthropology with 11 years' experience in socioeconomic and subsistence research in rural Alaska communities.
Karen A. Shemet Traditional Knowledge	M.A. - Cultural Anthropology with 12 years' experience conducting anthropological research.
Richard O. Stern, Ph.D. Cultural Resources, Subsistence	Ph.D. - Anthropology with 20 years' experience in conducting archaeological and cultural resource surveys and evaluations.
Beringian Resources, Inc.	
Samuel W. Stoker, Ph.D. Marine Biology, Marine Mammals	Ph.D. - Biological Oceanography with 21 years' experience in marine biology and subsistence studies.
Biological Acoustics, Inc.	
Christopher W. Clark, Ph.D. Marine Mammalogy and Acoustics	Ph.D. - Biology with 12 years' experience in marine mammalogy.
Northern Ecological Services	
John W. Morsell Fish Resources	M.S. - Zoology with 21 years' experience in aquatic biology and fishery research projects.
Community Planning	
Gordon Lewis Management and Ownership Status	M.S. - Land Resources with 25 years' planning experience.
ResourcEcon, Inc.	
James A. Richardson Socioeconomics	M.S. - Resource Economics, 19 years' experience specializing in regional fiscal impacts.
Techcon, Inc.	
Alan E. Gay NPDES Permitting, Ocean Discharge Criteria Evaluation/Modeling	M.S. - Environmental Engineering with 14 years' experience in environmental engineering studies

CHAPTER 13.0

CONSULTATION AND COORDINATION

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CHAPTER 13.0 CONSULTATION AND COORDINATION

Section Title Page

TABLES

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13.0 CONSULTATION AND COORDINATION

13.1 DEVELOPMENT OF THE ENVIRONMENTAL IMPACT STATEMENT

During preparation of this Environmental Impact Statement (EIS), federal, state, and local agencies; industry; and the public were consulted to obtain descriptive information, to identify significant effects and issues, and to identify effective mitigation measures and reasonable alternatives to the proposed action. Information received during scoping meetings held in Barrow, Nuiqsut, Kaktovik, Anchorage, Fairbanks, and Valdez has been considered in preparing this EIS.

13.2 INCORPORATION OF TRADITIONAL KNOWLEDGE

During EIS scoping meetings for the project held in spring 1996 in the North Slope communities of Barrow, Nuiqsut, and Kaktovik several people testified that residents of the North Slope have been commenting on the same issues and concerns regarding oil and gas development over the last 20 years. The cooperating agencies and BP Exploration (Alaska) Inc. committed to reviewing and summarizing pertinent past testimony for use in this EIS. Available written and taped transcripts were collected from previous federal and state oil and gas lease sales, EISs, and applicable hearings. As a result of scoping testimony, additional meetings were scheduled in Kaktovik, Nuiqsut, and Barrow to gather Traditional Knowledge. The work plan for addressing Traditional Knowledge was reviewed by an informal peer review committee assembled by the North Slope Borough.

13.3 LIST OF CONTACTS FOR EIS

The major federal, state, and local government agencies; special interest groups; and members of the public who provided comments and information during the scoping process are listed in Table 13-1.

13.4 AGENCIES, ORGANIZATIONS, AND INDIVIDUALS WHO RECEIVED COPIES OF THE DRAFT EIS

(Refer to Mailing List in Appendix C)

GLOSSARY

GLOSSARY

active layer: The zone, near the surface of the soil in a permafrost area, that is subject to seasonal thawing.

advection: Change in property caused by motion of fluid.

Alaska Clean Seas: An oil spill response organization sponsored by oil companies and active in Alaska.

Alaskan Beaufort Sea: The southern part of the Arctic Ocean from the Alaska-Canada border west to the Chukchi Sea.

algae: Any of various chiefly aquatic, photosynthetic organisms, ranging in size from single-celled to giant kelp.

alluvial: Relating to, composed of, or found in sedimentary material which was deposited by running water.

amphipods: Small crustaceans of the order Amphipoda, having a laterally compressed body with no carapace.

anadromous: Refers to fish which spend part of their life in salt water but which spawn in freshwater steams.

anti-foaming agents: Chemicals added to filtered seawater during processing for waterflood injection. They allow more efficient processing of the water through the various treatment stages.

API: An arbitrary measure, called "API gravity," established by the American Petroleum Institute. It is the commonly used gravity scale for crude oil. API gravity is related to specific gravity as follows:

$$\text{API} = \frac{141.5}{\text{specific gravity}} - 131.5$$

aquatic: Living in or frequenting the water.

arctic: Pertaining to, located in, or relating to high latitude areas which have climates dominated by sub-freezing temperatures; characteristic of very cold, snow, windy weather. Region lying north of the Arctic Circle.

Arctic Coastal Plain: The flat stretch of land extending from the foothills of the Brooks Range to the Alaskan Beaufort Sea.

Arctic char: A type of salmonid anadromous fish (*Salvelinus malma*) found in the Beaufort Sea; a northern form of Dolly Varden.

Arctic cod: A type of marine fish (*Boreogadus saida*) found in the Beaufort Sea.

Arctic fox: A furbearing, carnivorous, dog-like mammal (*Aloplex lagopus*) found along the Beaufort Sea coastline.

arctic haze: A large-scale atmospheric pollution phenomenon occurring in the winter and spring that affects the entire Arctic area. Most of the pollution originates from Europe and the Soviet Union, thousands of miles away.

baleen: Plates found in the mouths of certain species of whales to strain plankton from the water; those species of whales which have such baleen plates.

bar: A ridge of sand or gravel along a shore or stream bed that is formed by the action of tides or currents.

barrier island: A naturally-occurring island (usually part of a chain of islands) found a few miles offshore from the mainland. In the Arctic, they protect lagoonal areas to shoreward from most of the effects of ice movement.

bathymetry: Underwater topography.

bearded seal: A large solitary seal (*Erignathus barbatus*) found in low densities (compared with the ringed seal) throughout the Arctic.

Beaufort Gyre: The overall clockwise movement of currents in the northern hemisphere.

beluga whale: A cetacean (*Delphinaptenis leucas*) about 10 feet (ft) (3 meters [m]) long and white when an adult.

benthic: Refers to the seafloor environment.

benthos: Biota utilizing the seafloor sediments as habitat.

biocides: A chemical agent, such as a pesticide, that is capable of destroying living organisms.

bottomfast ice: Ice which is frozen to the bottom of a body of water (See FAST ICE and SHOREFAST ICE)

Boulder Patch: An anomalous cluster or field of cobbles and boulders on the seafloor. One location found in Stefansson Sound near the mouth of the Sagavanirktok River, provides a substrate which supports biological communities not found elsewhere in the area.

bowhead whale: A species of baleen whale (*Balaena mysticetus*), ranging in size up to a maximum of about 60 ft (18.3 m); classed as an endangered species. The only significant remaining population of bowheads spends its summers in the Canadian Beaufort Sea and its winters in the Bering Sea near the southern extent of the pack ice.

braided stream: A river, such as found on the Arctic Coastal Plain, that tends to form multiple channels which separate and rejoin in a complex pattern.

breakup: Season of the year when the annual accumulation of snow and ice melts and runs off the land.

brine: Concentrated seawater.

Canadian Beaufort Sea: The southern part of the Arctic Ocean from the Alaska-Canada border east to Banks Island, Canada.

caribou: A large ungulate migratory species (*Rangifer tarandus*) found in the Arctic tundra habitat.

cetacean: Any one of a number of whale and porpoise species; referring to whales, or whale-like in character.

cofferdam: A temporary, watertight enclosure that is pumped dry to expose the bottom of a body of water so that construction may take place.

conglomerate: A rock composed of pebbles and gravel embedded in a loosely cementing material.

continental shelf: The shallow underwater extension of a continent; usually limited in depth to 656 ft (200 m).

continental slope: The steeply descending slope between the edge of the continental shelf and the abyssal plain; the ocean bottom between 656 and 13,123 ft (200 and 4,000 m).

copepods: Any of numerous small marine or freshwater crustaceans of the subclass Copepoda, having an elongated body and a forked tail.

Coriolis effect: The observed effect of moving water being deflected to the right of wind direction in the Northern Hemisphere as a result of the earth's rotation.

corrosion inhibitors: Chemicals injected into pipelines (oil or water) to reduce material loss on the interior of the pipe. They help maintain the integrity of the pipeline by slowing down the chemical deterioration of the metal.

crustacean: Any of various predominantly aquatic arthropods of the class Crustacea, having a segmented body, chitenous exoskeleton, and paired, jointed limbs (Shellfish).

dBA (A weighted sound level): A weighting system which reflects that human hearing is less sensitive at low and extremely high frequencies than at the mid-range frequencies.

DEW Line: Acronym for Distant Early Warning Line - A system of radar stations near the 70th parallel across the North American continent, maintained by the U.S. and Canada to give advance warning of approaching enemy aircraft and missiles.

diatom: Any of various microscopic one-celled or colonial algae having cell walls of silica consisting of two interlocking symmetrical valves.

dipterans: Any of the large order (Diptera) of insects that includes true flies and mosquitos characterized by a single pair of membranous wings and a pair of club-shaped balancing organs.

downwelling: Downward flowing current.

drained lake basin: A shallow depression where there was formerly a lake. (Lakes on the Arctic Coastal Plain go through a geologic cycle of formation and subsequent drainage.)

drilling mud: A slurry circulated through the wellbore while drilling an oil or gas well.

echolocation: A sensory system in certain animals in which usually high-pitched sounds are emitted and their echoes interpreted to determine the direction and distance of objects.

Ekman Transport: Water movement in an offshore direction as a result of surface currents, easterly winds, and the Coriolis effect.

emulsion breakers: Chemicals used to increase the efficiency of crude oil processing. They reduce the process time and tank size required to separate the oil/water/gas mixture produced by the wells.

epibenthos: Biota using the seafloor as habitat.

epifauna: Organisms living on top of bottom sediments.

epontic: Organisms living on the underside of sea ice.

estuarine: Pertaining to or located in an area where the sea meets a river mouth.

estuary: A partially enclosed coastal area where freshwater and seawater meet and mix.

euphausiid: Moderate-sized crustaceans which include shrimp or krill, an important food source of the bowhead and other baleen whales.

fast ice: Sea ice of any origin which remains attached with little horizontal motion along a coast or to some other fixed object.

fetch: The length of water surface across which the wind blows.

first-year ice: Sea ice of not more than one winter's growth, generally 1 to 9 ft (0.3 to 2.7 m) thick.

flaw: A narrow separation zone between pack ice and fast ice, where the pieces of ice are in a chaotic state, that forms when pack ice shears under the effect of a strong wind or current along the fast ice boundary.

flaw lead: A lead (fracture or passage) between pack ice and fast ice.

floe: A segment of ice that has broken away from either first year or multi-year ice sheets.

flooded ice: Sea ice which has been flooded by melt water or river water and is heavily loaded with water and wet snow.

floodplain: The relatively flat area near a watercourse which is subject to periodic flooding.

flow station: A petroleum processing facility where crude oil from the ground is depressurized and where water and gas produced with the oil are separated (See GATHERING CENTER).

fluvial: Caused by the action of flowing water (rivers and streams).

food web: The food dependency relationship network among animal species in an ecological unit.

fourhorn sculpin: A type of marine fish (*Myoxocephalus quadricornis*) found in the Beaufort Sea.

fracture: Any break or rupture through very close, compact, or consolidated pack ice, fast ice, or a single floe resulting from deformation processes (lead). Fractures may contain pieces of ice and be covered with a thin layer of ice; length may be a few feet or many miles.

frazil ice: Fine spicules or plates of ice, suspended in water.

freezeup: Period in the fall when water freezes in rivers and nearshore areas.

frost heave: The expansion of soil due to freezing, usually accompanied by the growth within it of an ice lense, which causes displacement of the soil surface.

frost jacking: Soil, bonded to an object moves upward through frost heaving and carries the object with it; upon thawing, the object does not return to its original elevation.

gathering center: A petroleum processing facility where well fluids (gas and water) produced are separated from crude oil (See FLOW STATION).

genera: Plural of genus - A taxonomic category ranking below family and above species, generally consisting of a group of species exhibiting similar characteristics.

General Fund: That portion of state revenue over which the legislature and governor have complete discretion and upon which no restrictions on spending have been placed. For fiscal year 1997, 78% of the money in the General Fund came from oil revenues.

geomorphic: Surface configurations of the earth.

gray whale: A medium-sized (up to 46 feet) baleen whale (*Eschrichtius robustus*) which primarily utilizes summer feeding grounds in the Bering and southern Chukchi Seas.

greenhouse gas emissions: Greenhouse gases are assumed to contribute to a “global warming” scenario or global increase in temperature and include such gases as methane, carbon dioxide, and water vapor.

grizzly bear: A large omnivorous mammal (*Ursus arctos*) found in northern regions. The arctic coast of Alaska is the northern extent of the grizzly bear range.

haulout: An area where marine mammals (generally pinnipeds) come onto land to rest and socialize.

high-centered polygon: High-centered polygons are produced when soil at the perimeter of a polygon subsides into the surrounding ice wedge trough leaving the center higher than the edges (See ICE WEDGE).

hummocky terrain: A landform characterized by a lumpy, irregular surface. Hummocky terrain is found on slopes in permafrost areas.

hydrography: Salinity and temperature of water.

iceberg: A massive piece of ice of greatly varying shape with a freeboard of more than 16 ft (5 m), which has broken away from a glacier and may be afloat or aground.

ice breaker: A ship built for breaking a passage through icebound waters.

ice gouge: Grooves cut in the seafloor by the keels of floating ice.

ice floe: Fragmented pieces of either first or second year ice sheets.

ice island: Large piece of ice broken off of an ice shelf.

ice pile-up: The vertical buildup of ice at the shore which occurs when moving ice sheets contact steep slopes or bluffs, resulting in buckling and pile-up of the ice.

ice ride-up: A process wherein large sheets of wind-driven sea ice become pushed up onto the land, sometimes for a considerable distance past the shoreline.

ice road: A temporary road constructed in winter by spraying water on the intended roadway. The resulting ice buildup improves the load-bearing capacity. The technique can be used for road construction on tundra or sea ice surfaces.

ice sheet: Laterally continuous, relatively undeformed piece of sea ice with lateral dimensions of 33 ft (10 m) or larger.

ice shelf: Floating ice sheet of considerable thickness, showing 6 to 164 ft (2 to 50 m) or more above sea level and attached to a coast.

ice wedge: An underground, wedge-shaped prism of ice such as commonly found in permafrost areas.

infauna: Organisms living within bottom sediments.

invertebrate: Refers to animals without back bones, e.g. insects, shellfish, etc.

isobath: A line on a map or chart that connects points of equal water depth.

insolation: Exposure to sunlight causing a change in water temperature; the amount of solar radiation per surface area.

isopods: Any of numerous crustaceans of the order Isopoda, characterized by a flattened body bearing seven pairs of legs.

keel: The underside of an ice ridge that projects downward below the lower surface of the surrounding sea ice.

kelp: Any of various brown, often very large algae of the order Laminariales.

krill: Small marine crustaceans of the order Euphausiacea that are the principal food of baleen whales.

lacustrine: Relating to lakes.

lagoon: A shallow body of water separated from the sea by sand bars, barrier islands, or coral reefs.

landfast: Ice which is attached to a shoreline, generally consisting of grounded and floating ice zones.

lead: Any fracture or passage through sea ice that is generally too wide to jump across. A lead may contain open water (open lead) or be ice covered (frozen lead).

least cisco: A type of anadromous fish (*Coregonus sardinella*) found in rivers and lakes of Northern Alaska and the Beaufort Sea.

lemming: A small, burrowing rodent which lives in the arctic tundra.

lithology: The physical character of a rock or rock formation.

low-centered polygon: A polygonal landform found in permafrost areas, consisting of a low center with raised rims. Low-centered polygons are formed when expanding ice wedges cause upward displacement of adjacent soils (See ICE WEDGE).

marine: Of the sea or ocean.

meteorology: The study of weather.

midges: Any of various small flies of the families Chironomidae and Ceratopogonidae, frequently occurring in swarms near ponds and lakes.

muskox: A large woolly species of wild ox (*Ovibos moschatus*) found in arctic tundra areas of Greenland and North America.

multi-year ice: Ice which has survived more than two summers made up of multiple layers of annual ice formed during successive winters.

mysids: Any of various small, shrimplike, chiefly marine crustaceans of the order Mysidacea, the females of which carry their eggs in a pouch beneath the thorax.

National Petroleum Reserve, Alaska (NPRA): Formerly the Naval Petroleum Reserve - Alaska.

nautical mile: A unit of length used in sea and air navigation, based on the length of one minute of arc of a great circle; equal to about 1.15 miles (1.8 km).

nearshore: Located in water adjacent to the shoreline.

offshore: Located at a distance from shoreline.

oligochaetes: Any of various annelid worms of the class Oligochaeta, including earthworms and a few small freshwater forms.

onshore: Located on the land.

open water: A large area of freely navigable water in which sea ice is present in less than 1/10 concentration.

oriented lake: A lake with its long axis oriented at right angles to the prevailing wind. This phenomenon is commonly observed on the Arctic Coastal Plain where lakes are relatively shallow and certain wind directions are strongly predominant.

overwinter: To spend the winter.

pack ice: Area beyond the continental shelf consisting of multi-year ice with first-year ice forming in open leads during the winter.

passerine: Of or relating to birds of the order Passeriformes, which is largely comprised of song birds.

peat: Partially decomposed vegetative matter. Tundra soils commonly contain large amounts of peat.

pelage: The coat of a mammal, consisting of hair, fur, wool, or other soft covering, as distinct from bare skin.

pelagic: Of, relating to, or living in open oceans or seas rather than waters adjacent to land or inland waters.

permafrost: Soil which remains continuously frozen for more than one year.

pH: A measure of the hydrogen ion concentration and an indicator of relative acidity or aklalinity.

phytoplankton: Small plants (millimeter size range and smaller) suspended in the sea (See ZOOPLANKTON).

Pig (Pigging): A mechanical device designed to travel within and monitor or clean a pipeline.

pingo: A small, conical mound or hill which has been pushed up by the action of freezing soil moisture which was confined in the bed of a former lake.

pinniped: Of or belonging to the Pinnipedig, a suborder of carnivorous aquatic mammals that inlcudes seals and walruses.

polar bear: A large creamy-white bear (*Ursus maritimus*) which spends most of its life on the pack ice.

polar ice pack: The dense accumulation of sea ice found in arctic marine areas.

polygon: Ground which is segmented into polygonal shapes by ice wedges at the polygon boundaries (See ICE WEDGES).

polynya: Any nonlinearly shaped opening surrounded by ice.

porosity: A property which indicates the ratio of the volume of voids to the total volume of a solid mass.

pressure ridge: Ice ridges formed at the contact area between two ice fields or along cracks or leads in an ice sheet when they close under pressure.

Pump Station No. 1: The first pump station of the Trans-Alaska Pipeline System, located at the Prudhoe Bay oil field, which collects the oil from the North Slope oil fields and starts pumping it down the pipeline.

pycnocline: An area where an abrupt change in density occurs between two layers of water.

raptor: A bird of prey.

relict: Something that has survived from an earlier time in an environment that has changed considerably.

ridge: Linear accumulations of ice rubble caused by interaction of ice floes and sheets.

ridging: The process whereby ice is deformed into ridges.

ringed seal: A pinniped (*Phoca hispida*) found widely in the Arctic. Ringed seals are the major prey of polar bears.

riverine: Of or with reference to rivers.

rookery: The onshore breeding areas of birds or animals; where they birth and raise their young.

saline advection: Movement, or transport, of salt water through sediment.

salinity: The salt content of a material.

sand dune: A wind-formed mound of sand.

seal: Carnivorous sea mammal.

sealift: Annual transport of equipment and supplies to the North Slope by barge; generally used to transport large items which cannot be trucked or flown in.

seasonal pack ice: Floating sea ice which accumulates in winter but melts and dissipates in summer.

sedimentation: The accumulation of particulate material which has been relocated through the action of wind or water.

setdown: Fall in water level.

setup: Rise in water level.

shear ridge: Long, straight ice ridges produced by lateral movement between fixed landfast and seasonal pack ice.

shear zone: The boundary between the moving pack ice and the fixed "fast ice" which is attached to the shore. An area in which a large amount of shearing deformation has been concentrated. (See STAMUKHI)

shoal: A shallow area in a body of water, often constituting a hazard to navigation; a sandbank or sandbar.

shorefast ice: Floating ice which is held in place by being frozen to a shoreline or locked in place by the shape of the shoreline. (See FAST ICE, BOTTOMFAST ICE).

spit: A narrow point of land extending into a body of water.

stamukhi zone: The boundary zone between the moving pack ice and the essentially stationary fast ice near shore characterized by large accumulations of ice rubble. (See SHEAR ZONE)

storm surge: Variation in the sea surface elevation caused by wind, large ice movements, and/or atmospheric pressure changes.

strangmoor: Refers to tundra areas characterized by irregular linear markings.

stratigraphy: The study of rock layers, especially their distribution, deposition, and age.

strudel scour: Depressions in the seabed created by the scouring effect of the downward flow of overflood water through cracks or holes in overlying ice. Typically occurs within a 10-mile (16-km) radius of river mouths along the Alaskan Beaufort Sea.

subsistence: Refers to the source of the essential resources for life, i.e. food, clothing, and shelter. Subsistence hunting and fishing provide a substantial share of food needs for people living in remote arctic areas.

suprapermafrost: Layer of soil above the permafrost.

TAPS: Acronym for Trans-Alaska Pipeline System - An 800-mile (1,288 km) pipeline which transports North Slope crude oil from Pump Station No. 1 at Prudhoe Bay to a marine terminal at Valdez, Alaska.

terrace: A flat, narrow stretch of ground, often having a steep slope, facing a river, lake, or ocean.

terrestrial: Of or referring to the land or users of land habitat.

terrigenous: Sediments derived from the terrestrial environment.

thaw bulb: Permanently unfrozen soil found beneath the beds of lakes in permafrost areas.

thaw lake: A lake produced by thawing and subsidence of ice-rich permafrost.

Thaw-Lake Plains: Thaw-lake plains are areas characterized by the presence of numerous permafrost-related lakes and ponds.

throughput: Volume or flowrate of fluids flowing through a pipeline or processing facility.

tundra: An arctic, subarctic, or alpine area characterized by low-growing vegetation and virtual absence of trees.

upwelling: A process in which cold, often nutrient-rich waters from the ocean depths rise to the surface.

VSM: Acronym for Vertical Support Member - Consists of a vertical pole driven into the ground with a cross-piece welded to the top upon which pipelines lay.

walrus: A large, bottom-feeding pinniped (*Odobenus rosmarus*) with a discontinuous circumpolar range.

waterfowl: A bird (ducks, geese, and swans), especially a swimming bird, that uses the water as an important part of its habitat.

well pad: Earth- or gravel-filled embankments placed at an oil well location to support drilling and maintenance operations.

whale: Large sea mammal (order Cetacea) which spends all its life in the ocean.

wind chill factor: A measure of the cooling effect which takes wind velocity as well as air temperature into account.

wind stress: Force applied to water or ice which can result in horizontal movement or currents.

wolverine: A carnivorous mammal (*Gulo gulo*) of the weasel family.

zooplankton: Small animals (millimeter range and smaller) found in the sea (See PHYTOPLANKTON).

INDEX

INDEX

TRADITIONAL KNOWLEDGE INDEX

Provides an index to the Traditional Knowledge used in this EIS by the topics listed below. Each section where a comment/statement utilizing Traditional Knowledge on a particular topic appears is listed in order to facilitate finding Traditional Knowledge information and seeing how it was used in relation to western science. Full quotes and citations are presented in the X.2 section of each chapter.

TABLE 13-1
LIST OF CONSULTATION AND COORDINATION CONTACTS FOR THE EIS

Affiliation/Location	Name/Agency
Government	
Federal	Department of the Army U.S. Army Engineer District, Alaska Cold Regions Research and Engineering Laboratory Department of Commerce National Oceanic and Atmospheric Administration National Marine Fisheries Service Auke Bay Fisheries Laboratory National Marine Mammal Laboratory Marine Mammal Commission Department of the Interior Fish and Wildlife Service Northern Alaska Ecological Services Minerals Management Service Environmental Protection Agency
State of Alaska	Office of the Governor Division of Governmental Coordination Department of Commerce & Economic Development Division of Measurement Standards Department of Environmental Conservation Division of Air and Water Quality Department of Fish and Game Division of Habitat and Restoration Subsistence Division Department of Natural Resources Division of Land Division of Oil and Gas Department of Transportation & Public Facilities Northern Region Joint Pipeline Office
Local	North Slope Borough Department of Wildlife Management
State of California	Department of Fish and Game
Organizations/Industry	
Native	Arctic Slope Native Association Limited Alaska Whaling Captains Association
Industry	Arco Aviation BP Exploration (Alaska) Inc. Carlisle Enterprises Crowley Industries Deadhorse Airport Lynden Air Freight Lynden Logistics Northern Stevadoring

TABLE 13-1 (Cont.)
LIST OF CONSULTATION AND COORDINATION CONTACTS FOR THE EIS

Affiliation/Location	Name/Agency
Traditional Knowledge Consultation/Meetings	
Communities	Kaktovik - June 19 - 21, 1996 Nuiqsut - July 30 - 31; August 1, 1996 Nuiqsut - August 13 - 15, 1996 Barrow - August 27 - 29, 1996
Other	Traditional Knowledge Work Plan Peer Review Meeting - April 19, 1996
Individuals	
Written Comments	Max Ahgeak Isaac K. Akootchook Mark Ames William Ashton Bud & Martha Helmericks Edward S. Itta Thomas W. Mortensen Charles A. Okakok Karen Toland David van den Berg
Individuals - Oral Testimony Barrow - March 25, 1996	James Ahsoak Bart Ahsogeak Tom Albert Mark Ames Elsie Crow, Inupiaq Translator Earl Finkler Craig George Edward Itta Michael Pederson Burton Rexford Delbert Rexford
Kaktovik - March 26, 1996 Fairbanks - March 28, 1996	Isaac Akootchook Susie Akootchook Herman Aishanna Thom Frank George Paulsberg Fenton Rexford Lon Sonsalla Marilyn Traynor Robert Cacy Steve Fortelny Don Lowell William Sackinger Karen Toland David van den Berg

TABLE 13-1 (Cont.)
LIST OF CONSULTATION AND COORDINATION
CONTACTS FOR THE EIS

Affiliation/Location	Name/Agency
Individuals (Cont.)	
Anchorage - April 1, 1996	William Ashton Jerry McCutcheon
Valdez - April 2, 1996	Chris Clark Dave Dengel Greg Williams
Nuiqsut - May 7, 1996	Johnny Ahtuangaruak Susan Atos Elsie Crow Bernice Kaigelak Leonard Lampe Frank Long Hattie Long, Jr. Isaac Nukapigak Joseph Nukapigak Lois Simmonds Patsy Tukle Alice Woods