BEAUFORT SEA OIL AND GAS DEVELOPMENT/ NORTHSTAR PROJECT

FINAL ENVIRONMENTAL IMPACT STATEMENT

Appendix K (Continued) Through P

CHAPTER 8.0

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

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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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