SECTION IV

ENVIRONMENTAL CONSEQUENCES

Section IV Environmental Consequences

A. Basic Assumptions For Effects Assessment

1. Alternative I, Basic Exploration, Development and Production, and Transportation Assumptions
   a. Description of Alternative I
   b. Activities Associated with Alternative I
      (1) Basic Exploration, Development and Production, and Transportation Assumptions for Effects Assessment
      (2) Activities Associated with Exploration Drilling
         (a) Seismic Activity
         (b) Exploration Drilling
      (3) Activities Associated with Seismic Activity
         (a) Seismic Activity
         (b) Production Platforms and Production Drilling
         (4) Activities Associated with Oil Transportation
         (a) Pipelines
         (b) Tankers
2. Oil Spills
   a. Oil-Spill-Risk-Analysis Model for Oil Spills Greater Than or Equal to 1,000 Barrels
      (1) Estimated Chance of One or More Spills Greater Than or Equal to 1,000 Barrels Occurring and Spill-Size Assumptions
      (2) Conditional Probability of Oil-Spill Contact Assuming a Spill has Occurred
      (3) Combined Probability of Oil-Spill Occurrence and Contact
   b. Spills Less Than 1,000 Barrels
3. Spilled Oil Behavior and Fate in Marine Waters
   a. Environmental Considerations
   b. Sale 170 Weathering Assumptions
   c. Extent and Persistence of Oiled Shoreline
4. Aspects of Spill Prevention and Response
   a. Contingency Plans
   b. Applicability of Oil-Spill-Response Technology in the Sale 170 Area
      (1) Solid Ice
      (2) Broken and Moving Pack Ice
      (3) In Situ Burning
      (4) Open-Water Containment and Recovery
      (5) Detection and Tracking
      (6) Dispersants and Other Chemicals
      (7) Shoreline Response
      (8) Storage/Disposal
   c. Response Deficiencies
   d. Oil-Spill Response
      (1) Locally Available Spill-Response Equipment
      (2) Response Time
      (3) Effectiveness of Oil-Spill Cleanup in the Open Ocean
      (4) The Role of the Federal Government During an Oil-Spill Response
5. Major Projects Considered in the Cumulative Case
   a. Current and Projected North Slope Oil Production
   b. Past and Projected State Oil and Gas Lease Sales
   c. OCS Lease-Sale Activity
   d. National Petroleum Reserve-Alaska
   e. Resource Contribution of the OCS to the Cumulative
   f. Infrastructure and Transportation
   g. Trans-Alaska Gas System (TAGS)
6. Constraints and Technology
   a. Sea Ice
   b. Other Constraints
      (1) Permafrost
      (2) Natural Gas Hydrates
      (3) Waves, Currents, and Storm Surges—Flooding and Erosion
      (4) Faults and Earthquakes
      (5) Unstable Sediments

B. Effects of Alternative I on

1. Water Quality
2. Lower Trophic-Level Organisms
3. Fishes
4. Endangered and Threatened Species
5. Marine and Coastal Birds
6. Pinnipeds Polar Bears and Belukha Whales
7. Caribou
8. Economy of the North Slope Borough
9. Subsistence-Harvest Patterns
10. Sociocultural Systems
11. Archaeological Resources
12. Air Quality
13. Land Use Plans and Coastal Management Programs

C. Effects of Alternative II - No Lease Sale

D. Effects of Alternative III - Kaktovik Deferral on

1. Water Quality through
13. Land Use Plans and Coastal Management Programs

E. Effects of Alternative IV - Cross Island Area on

1. Water Quality through
13. Land Use Plans and Coastal Management Programs

F. Effects of Alternative V - Area Offshore the Arctic National Wildlife Refuge on

1. Water Quality through
13. Land Use Plans and Coastal Management Programs

G. Effects of the Cumulative Case on

1. Water Quality through
13. Land Use Plans and Coastal Management Programs

H. Unavoidable Adverse Effects on

1. Water Quality through
13. Land Use Plans and Coastal Management Programs

I. Relationship Between Local Short-Term Uses and Maintenance and Enhancement of Long-Term Productivity

J. Irreversible and Irretrievable Commitment of Resources

1. Water Quality through
12. Air Quality

K. Effects of Natural Gas Development and Production on

1. Water Quality through
13. Land Use Plans and Coastal Management Programs

L. Effects of a Low-Probability, High-Effects, Very Large Oil-Spill Event on

1. Water Quality through
13. Land Use Plans and Coastal Management Programs

IV. ENVIRONMENTAL CONSEQUENCES

A. BASIC ASSUMPTIONS FOR EFFECTS ASSESSMENT:

In this environmental impact statement (EIS), the alternatives are analyzed on the basis of a field-development time profile called a scenario. The MMS traditionally bases the EIS scenarios on both geologic possibilities and on what is expected to be leased, discovered, developed, and produced in the sale area under consideration. The location of any oil deposits is purely hypothetical, until oil is proven to be there by drilling (Appendix A). The assumed location of these geologic possibilities is a key factor in the proposed scenario. The scenario forms the basis for the analysis of the anticipated effects. This subsection details the scientific, economic, geologic, and other assumptions upon which are based the exploration and development scenarios in this EIS.

1. Alternative I, Basic Exploration, Development and Production, and Transportation Assumptions:

a. Description of Alternative I (the entire proposed sale area): Alternative I would offer for lease those parts of the Beaufort Sea Planning Area identified in Figure II.A.1. The proposed lease area consists of 363 whole and partial blocks encompassing approximately 688,000 hectares (ha) (1.7 million acres). It is located between about 5 and 40 kilometers (km) (3-25 miles [mi]) offshore in water depths that range up to 37 meters (m) (120 feet [ft]).

In addition to Alternative I, four other alternatives are considered in this EIS: Alternative II, No Lease Sale (Sec. IV.C); Alternative III, the Kaktovik Deferral (Sec. IV.D); Alternative IV, the Cross Island Area (Sec IV.E); and Alternative V, the Area Offshore the ANWR (Arctic National Wildlife Refuge [Sec IV.F]).

b. Activities Associated with Alternative I:

(1) Basic Exploration, Development and Production, and Transportation Assumptions for Effects Assessment:

(a) Assumed Resources: The environmental analysis in this section is framed by a resource range. In this instance, the Minerals Management Service (MMS) assumes that, within the boundaries of Alternative I, the proposed sale area contains discoverable resources that may range from 350 million barrels (MMbbl) to 670 MMbbl of oil. This range is called the "resource estimate" and is based on the assumption that the price of a barrel of oil may fluctuate between $18 and $30 over the life of Alternative I. Within the discussion of Alternative I, an "exploration-only" situation also is considered, whereby no economically recoverable quantities of oil are found, and development does not occur. An expanded discussion of the resource estimate of Alternative I is found in Section II.A. Table IV.A.1-1 and Appendix A show the levels of infrastructure and resources that have been estimated for the analyses of the effects of the resource estimate and the exploration-only situation of the alternatives. The development of natural gas resources is not considered economic for proposed Sale 170 and is not discussed.

(b) Timing of Activities: The level of activities and the timing of events associated with the resource estimate for Alternative I are shown in Table IV.A.1-1 and Appendix A. Exploratory drilling is expected to begin in 1999 and continue through 2006. During these years, a total of 12 to 16 exploration and delineation wells would be drilled with a maximum of two drilling rigs operable in any one exploratory year. Between 2004 and 2009, three to five production platforms are expected to be installed, while pipeline laying is expected to begin in 2005 and conclude in 2010. Drilling of production and service wells is expected to begin in 2004 and continue through 2010, with a total of 87 to 111 wells drilled. Production is expected to begin in 2006 and continue through 2027. These calculations are based on a 45-day open-water season. In the Beaufort Sea, this season generally ranges from mid-August to early October.

(2) Activities Associated with Exploration Drilling:

(a) Seismic Activity: In support of the proposed exploration and production activities, the lessee/operator is required to conduct surveys of sufficient detail to define shallow hazards or the absence thereof; these surveys should incorporate seismic profiling. The projected level of seismic activity is based on the nature and extent of the surveys that may be required and the predicted number of wells that may be drilled. Surveys of the exploration- and delineation-well sites would be conducted during the ice-free seasons of the years of the exploratory phase. For this EIS, it is assumed that each of the 12 to 16 exploration and delineation wells would be covered by site-specific surveys. These surveys would cover an approximate area of 23 square kilometers (km^2) (8.9 mi^2) of data for each well; the total area covered by seismic surveys could equal 507 km^2 (196 mi^2). These surveys usually are conducted 1 year prior to drilling and would have to be conducted within the Arctic's brief open-water season. The average time needed to survey each site should range between 2 and 5 days, allowing for downtime for bad weather and equipment failure.

(b) Exploration Drilling: For Alternative I, the six to eight exploration and six to eight delineation wells are expected to be drilled between the years 1999 and 2006. Because of the short open-water drilling season in

Table IV.A.1-1 Summary of Basic Exploration, Development and Production, and Transportation Assumptions for Alternatives I, III, IV, and V

PHASE Activity/Event	Alternative I		Alternative III	Alternative IV.a	Alternative V.a
	350–670 MMbbl	Exploration-Only	240–480 MMbbl	280–550 MMbbl	210–450 MMbbl
	Timeframe and Assumed Number	**Timeframe** and Assumed Number	**Timeframe** and Assumed Number	**Timeframe** and Assumed Number	**Timeframe** and Assumed Number
EXPLORATION					
Well Drilling	**1999-2006**	**1998–2006**	**1999–2006**	**1999-2006**	**1999-2006**
Exploration Rigs	2	1	2	2	2
Exploration Wells	6–8	3	5–6	5–6	3–5
Delineation Wells	6–8	1	5–6	4–6	3–5
Drilling Discharges [1]					
Drilling Muds (Short Tons, dry)	7,560–10,080	2,520	6,300–7,560	5,670–7,560	3,780–6,300
Cuttings (Short Tons, dry)	9,840–13,120	3,280	8,200–9,840	7,380–9,840	4,920–8,200
Support Activities (Phase Totals)					
Helicopter Flights [2]	1,080–1,440	360	900–1,080	900–1,080	540–900
Supply-Boat Trips [3]	150–205	50–52	128–150	128–150	75–127
Shallow-Hazards Site Surveys					
Blocks Surveyed	6–8	3	5–6	5–6	3–5
Total Area Covered (km^2) [4]	138.4–184.4	69.15	115.2–138.3	115.2–138.3	69–115.2
DEVELOPMENT AND PRODUCTION					
Platforms Installed	**2004–2009** 3–5		**2004–2009** 2–4	**2004–2009** 2–4	**2004–2009** 2–3
Production/Service Wells	**2004–2010** 87–111		**2004–2010** 74–94	**2004–2010** 70–89	**2004–2010** 52–67
Oil Production					
Total (MMbbl)	**2006–2026** 350–670		**2006–2026** 240–480	**2006–2026** 280–550	**2006–2026** 210–450
Peak Yearly (MMbbl)	**2011–2012** 39–65		**2011–2012** 30–53	**2011–2012** 31–52	**2011–2012** 23–39
Monthly Support Activities					
Helicopter Flights: Development [5]	46–59		39–50	39–50	27–35
Helicopter Flights: Production [5]	26–43		17–36	17–36	17–27
Supply Boat Trips [6]	See Footnote		See Footnote	See Footnote	See Footnote
Drilling Discharges [7]					
Drilling Muds (Short tons, dry)	13,050–75,480		11,100–63,920	10,500–60,520	7,800–45,560
Cuttings (Short tons, dry)	102,660–130,980		87,320–110,920	82,600–105,020	61,360–79,060
Shallow-Hazards Surveys					
Total Area Covered (km^2) [8]	276–460		184–368	184–368	184–276
Total Days Required [9]	21–35		14–28	14–28	14–21
TRANSPORTATION					
Oil Pipeline Installation					
Offshore Length (km)	64–96.5		48–80	48–80	32–64
Onshore Length (km)	32–161		32–48	32–161	32–48
OIL SPILLS	See Table IV.A.2-2				

Source: Appendix A of this EIS
[1] Amounts are based on each exploration and delineation well using 630 tons (dry weight) of drilling muds and producing 820 tons (dry weight) of cuttings. [2] The number of helicopter flights is based on the assumption that there will be 1 flight per day per well; drilling of an exploration or delineation well is estimated to take 3 months. [3] The number of supply-boat trips is based on the assumption that there will be 1 trip per drill unit per week; drilling of an exploration or delineation well is estimated to take 3 months. Support-boat trips would be for offshore bottom-founded rigs only. [4] MMS's site-clearance seismic-survey requirements specify a minimum area of 23 km^2 (about 8.9 mi^2, an area that is about equal to 1 full OCS lease block) for a site-specific survey. [5] The number of helicopter flights is based on the assumption that after the conclusion of development drilling, there will be 2 flights per week per platform. During development drilling, the assumption is there will be 1 flight per drilling unit (rig) for each day of drilling. *For the development period, the monthly figure is an average for the 7-year developmental period.* [6] For the production phase, it is assumed that platforms will resupplied by barge and that support/supply boats will be on standby for special or emergency use. [7] Amounts are based on each production or service well using between 150 and 680 tons (dry weight) of drilling muds and producing 1,180 tons (dry weight) of cuttings. [8] MMS's site-clearance seismic-survey requirements specify a minimum area of 92 km^2 (about 35.5 mi^2) for a block-wide survey. [9] The time required to complete a site-clearance survey is estimated to be 7 days.

the Beaufort Sea, it is likely that only one drilling rig will be used at a drilling site in any one year, and that only one well will be drilled from that rig. However, in the event of a discovery, delineation wells are assumed to be drilled by the same exploration rig immediately afterwards. In such an event, two wells could be drilled from a rig in a single drilling season. The type of units that may be used in exploration drilling will depend on water depth, sea-ice conditions, ice-resistant capabilities of the units, and availability of drilling units. In the Beaufort Sea, most depths within the sale area range up to 37 m (120 ft). Water depth will determine what type of platform is used for exploration drilling. In depths less than (<)12 m (40 ft), gravel islands likely will be built by either barges (in summer) or gravel-hauling trucks (in winter). Artificial ice islands (constructed like ice roads by flooding water over the sea ice) could be used in water depths <15 ft. Personnel and material will be carried to and from the platforms over ice roads (in winter) and by boats (in summer). Some leases could be drilled from existing gravel islands using extended-reach drilling methods. In water 12 to 24 m (40-80 ft) deep, movable platforms resting on the seafloor likely will be used for exploration. These platforms are designed to withstand winter-ice forces, so drilling can occur year-round. In water deeper than 80 ft, drillships or floating platforms will be used. These floating systems can operate only in open-water and broken-ice conditions and not in midwinter pack-ice conditions. They will be supported by icebreakers and supply boats during the summer months and stored in protected inshore areas when not in use.

A dredge would prepare the pad on which the bottom-founded structure would rest.

It is unlikely that gravel islands will be constructed for nearshore exploratory-drilling operations. However, if a gravel island were selected as a platform type from which to drill an exploratory well, construction is expected to take place during the winter. Gravel used to construct the island would be hauled over ice roads from onshore sources. An island constructed in 15 m (50 ft) of water would require 645,000 cubic meters (m^3) (844,000 cubic yards [yd^3]) of fill material; it would have a surface diameter of about 122 m (400 ft), freeboard of 6 m (20 ft), side slopes of 1:3, and a base diameter of 248 m (815 ft). The area of the base would be about 48,300 m^2 (520,000 ft^2).

Drilling of each exploratory or delineation well would require the disposal of about 630 short tons of drilling muds and produce approximately 820 short tons (dry weight) of drill cuttings. The estimated total amount of muds and cuttings to be disposed of for all exploration and delineation wells is expected to be 3,780 to 5,040 short tons (dry weight) of drilling muds. The total amount of bore cuttings expected to be produced is approximately 4,920 to 6,520 short tons (dry weight). These materials would be disposed of primarily at the drill site under conditions prescribed by the U.S. Environmental Protection Agency's (USEPA's) National Pollution Discharge Elimination System (NPDES) (Rathbun, 1986; Clean Water Act of 1977, as amended [33 U.S.C. 1251 et seq.). Exploration and development wells would average between 1,525 and 4,570 m (5,000-15,000 ft) in depth.

Support and Logistic Activities: Offshore exploration-drilling operations in the Sale 170 area would require onshore support facilities. Where possible, existing facilities within the Prudhoe Bay or Kuparuk unit areas would be used or upgraded. These onshore facilities would have to provide (1) a staging area for construction equipment, drilling equipment, and supplies; (2) a transfer point for drilling and construction personnel; (3) a harbor to serve as a base for vessels required to support offshore operations; and (4) an airfield for fixed-wing aircraft and helicopters.

Also, existing systems would be used to transport equipment, material, supplies, and personnel. The description of North Slope Transportation Systems as contained in Section III.D.2 of the Sale 87 Final EIS (FEIS) (U.S. Department of the Interior [USDOI], MMS, 1984) is incorporated by reference and updated where appropriate; a summary of this description follows.

The North Slope Borough (NSB) is linked to interior Alaska by the Dalton Highway. The majority of the vehicles traveling the Dalton Highway are commercial-freight vehicles associated with oilfield activities, although privately owned vehicles and commercial-tour operators also travel the Dalton Highway. Not unexpectedly, summer-traffic levels for the Dalton (June- August) are substantially higher than traffic levels for the rest of the year. During summer months, the monthly average daily traffic count at milepost 134, Yukon River Bridge, varied between 385 and 400 vehicles; however, the annual average daily traffic (AADT) count at the same check point for the year combined is 150 to 200 vehicles. Further north on the Dalton Highway, AADT levels fall rapidly. At the Atigun River checkpoint, AADT levels are 100 to 125 (State of Alaska, Dept. of Transportation/Public Facilities, 1996). On the North Slope, regional surface transportation is via gravel roads within and between unitized oilfields and through an extensive system of trails, river drainages, and ice roads.

Barges transport most heavy and bulky cargo associated with petroleum-related activities in the NSB (NSB Contract Staff, 1989). Prudhoe Bay has three barge docks—one at the east dock and two at the west dock. Oliktok dock was constructed in 1982 to expedite shipping to the Kuparuk Field. Barge traffic in support of continued development on the North Slope of Alaska typically has ranged from 10 to 15 barges per year. During the initial development of the Prudhoe Bay Unit in 1970, 48 barges were used. With the new generation of barges, an equivalent tonnage could be shipped on 32 barges (Louis Berger and Associates, 1984).

Air transportation is the primary means of travel into the NSB. All public airstrips, except those at Barrow and Deadhorse, are gravel. The NSB continuously has been upgrading local roads and airports.

The principal transportation mode for routine supplies and materials to be transported to ice islands and/or nearshore gravel islands is expected to be ice roads. For drilling platforms farther offshore in the broken-ice zone, material and supplies would be transported via support/supply boats (with icebreaking capacity if necessary) during the open-water season and by helicopter at all other times. For both types of drilling structures, personnel would be moved by helicopters certified for instrument flight. The number of helicopter trips flown in support of exploration- and delineation-well drilling is estimated to range from about 90 to 360 each year, depending on the number of wells (1-4) that are drilled. This estimate is based on the assumptions that, for each well, there will be one flight per drilling unit for each day of drilling and, as noted previously, the time required to drill and test a well is about 90 days. During the period from 1999 to 2006, the total number of helicopter flights supporting drilling operations is estimated to range between 1080 and 1440. The estimation of total helicopter flights does not include flights that may be necessary for rig demobilization or emergencies.

The number of required support vessels for each bottom-founded drilling unit will depend, at least in part, on the type and characteristics of the unit and the sea-ice conditions. If there are drilling operations during the open-water season, MMS requires the operator to maintain an emergency-standby vessel within the immediate vicinity of the drilling unit. (Immediate vicinity is defined as being within 8 km [5 mi] or a 20-minute steaming distance of the unit, whichever is less.) The primary reason for this requirement is to ensure emergency evacuation of personnel, but the standby vessel also could assist in the deployment of the oil boom in the event of an oil spill. Depending on ice conditions, two or more icebreaking vessels may be required to perform ice-management tasks for the floating units. The number of potential drilling units that might be operating during the open-water period could range from one to two.

Also during the open-water season, it is estimated that there will be 1 supply-boat trip per drilling unit per week; for exploration drilling, the total number of supply-boat trips per year is estimated to vary between 0 and 24. The level of support-boat traffic would depend on whether the drilling rigs are on road-supported ice islands or farther offshore gravel Islands. Between 150 and 205 support-boat trips are estimated to occur between 1999 and 2006, assuming that all exploration is conducted from gravel islands not supported by ice roads. The estimate of total support-vessel trips does not include operations that may be necessary for rig demobilization or for emergencies.

(3) Activities Associated with Development and Production: Assumptions associated with development and production strategies are highly speculative. Because of this, the scenario described here is meant to be characteristic of the type of development that could accompany production. Under this scenario, work on offshore and onshore production and transportation facilities would not begin until the engineering and economic assessments of the potential reservoirs had been completed and the conditions of all the permits had been evaluated. The first delineation well is projected to be drilled in 2000, with production beginning by at least 2006. Production is assumed to peak approximately between 2011 and 2012 and cease in 2026 (see Appendix A).

(a) Seismic Activity: A three-dimensional, multichannel, seismic-reflection survey would be conducted for the production platforms. The survey would cover approximately 276 to 460 km^2 (106-177 mi^2). The platform sites may be surveyed several years prior to the installation of the platform; surveys would be conducted during open-water, ice-free periods. High-resolution seismic-reflection data for shallow hazards would be collected prior to laying the offshore pipeline. The total trackline distance, estimated to be four times the length of the offshore trunk pipelines assumed for the scenario, would equal approximately 65 to 95 km (40-60 mi).

(b) Production Platforms and Production Drilling: If commercial discoveries are made in the Sale 170 area, the hydrocarbons would be produced from three to five platforms installed on the seafloor between 2004 and 2009. Depending on the water depth, seafloor conditions, ice conditions, and size of the reservoir, several types of platforms could be used. In water depths less than or equal to (≤) 11 m (35 ft), artificial (gravel) and caisson-retained islands may be used as production platforms. Production platforms set in water depths between 11 and 38 m (35-125 ft) are likely to be bottom-founded structures designed for extreme ice conditions. Floating concrete structures anchored to the seafloor are the most feasible design for production facilities in water depths greater than (>) 38 m (125 ft).

A variety of steels are available for construction use in low-temperature environments, and concrete has been used to construct many different types of structures that resist seawater, ice, and freeze-thaw cycles. These bottom-founded production platforms would be constructed and outfitted in ice-free harbors outside of Alaska. After staging, the platforms would be moved to the production site, where installation would be completed during the open-water season. These production platforms would have to be designed so that installation, which might require the assembly of modular units, could be accomplished within a relatively short time—probably <45 days. In addition to the vessels (8-10 tugs) used to tow the platform components to the site, installation also might require a large-capacity derrick barge and a vessel to accommodate the workers. The artificial and caisson-retained islands that may be used as production platforms would be larger than similar islands used for exploratory drilling. Each platform could employ two rigs to maximize development drilling and shorten startup times.

Between 2005 and 2010, a total of 87 to 111 production and service wells are estimated would be drilled from the production platforms. In 2006 and 2008, a field maximum of four production drilling rigs could be in operation. The drilling of each production and service well would require 150 to 680 short tons of drilling mud per well (dry weight). This assumes that between 20 and 80 percent of the mud is recycled. Some of the muds used in drilling production and service wells may be recycled through each subsequent well drilled on the platform. Depending on the amount recycled, the amount of disposed drilling muds could range from 13,050 to 75,480 short tons (dry weight) for all wells drilled. Each well also is expected to produce approximately 1,180 short tons of rock cuttings (dry weight), with the total amount of disposed cuttings amounting to about 102,660 to 130,980 short tons (dry weight). The disposal of muds and cuttings would be in accordance with approved USEPA NPDES permits for development-well drilling; muds and cuttings also could be transported to shore and disposed of at approved sites. Production-well depth would average about 3,962 m (13,000 ft).

Support and Logistics Activities: For the purpose of this scenario, it is assumed that the infrastructure at Prudhoe Bay will provide the major support for construction and operation activities associated with the development and production and transportation of crude oil in the Beaufort Sea. An average of between 46 and 59 helicopter flights per month are estimated to be flown in support of the drilling of production and service wells during the 7-year developmental period (2004-2010). During the production phase, average monthly helicopter operations could range between 26 and 43 flights. With regard to waterborne support, major resupply of offshore drilling platforms would occur during the open-water season from barges originating outside the sale area. Support/supply vessels would be on standby for specialty or emergency use during the open-water season; however, their use would be sporadic. Production islands emplaced nearshore in shallow waters may be resupplied during winter via ice roads. A significant number of nearshore platforms being supported by ice roads could reduce the number of helicopter flights, particularly during the years of peak drilling activity.

(4) Activities Associated with Oil Transportation:

(a) Pipelines: The installation of offshore pipelines between production platforms and onshore facilities would take 1 to 2 years, considering that route surveying, trenching, and pipeline laying would take place only during the relatively short open-water season. New onshore-pipeline sections would take 2 to 3 years to complete, with construction activities taking place simultaneously with the offshore-pipeline emplacement. Offshore, it is assumed that pipelines would be trenched, in water depths <45 m (<150 ft), as a protective measure against damage by ice keels. For the sake of analysis, it is assumed in this scenario that all offshore pipeline emplaced will be trenched and brought to shore via gravel-filled jettylike structures approximately 90 m (100 yd) in length that would protect the pipelines from erosion. At the landfalls, the pipelines would be elevated (stilted) and insulated. Much of the pipeline and shore-facility construction would occur at the same time as offshore-platform installation and development-well drilling. Pipeline construction is expected to begin by 2005 and finish by 2010. The amount of pipeline emplaced could range between 95 and 257 km (60-160 mi) of pipe. Of that amount, between 65 and 95 km (40-60 mi) would be laid offshore.

For economic and logistical reasons, future offshore developments would attempt to use the existing onshore infrastructure (processing facilities and pipeline networks) whenever possible. Consequently, produced oil would be gathered by existing pipeline systems within the Prudhoe Bay/Kuparuk Field areas and transported to Pump Station No. 1 of the Trans-Alaska Pipeline System (TAPS). For the resource estimate of Alternative I, landfalls are assumed at Oliktok Point (using the Kuparuk Field infrastructure), in the Point McIntyre/West Dock area (using the Prudhoe Bay infrastructure), the Endicott Causeway and, if necessary a new location near Flaxman Island. A summary of estimated new pipeline development as a result of Sale 170 is shown in Table IV.A.1-1. The hypothetical locations of the onshore pipelines are indicated in Figure IV.A.1-1.

(b) Tankers: Crude oil produced from Sale 170 leases would be transported via pipeline to the oil terminal at Valdez, where it would be commingled with crude produced from other North Slope sources. Once at Valdez, the oil would be loaded into tankers for transport primarily to the U.S. West Coast, with smaller quantities traveling to the Kenai Peninsula, Hawaii, the Gulf of Mexico, the Far East, or refineries in the Virgin Islands. Tankers loaded with oil produced from Alternative I are assumed to depart Valdez at some point during 2005. Valdez tanker-transport traffic from Alternative I is expected to vary from 10 to 19 tanker loadings in 2005 (field startup), to 45 to 74 in 2011 to 2012 (field maximum), to 18 to 40 in 2017 (late maturity/decline). Assuming the use of 100,000 deadweight-ton tankers, Figure IV.A.5-2 shows the general movement patterns of Valdez tanker traffic to the U.S. West Coast. Figure IV.A.5-3 shows probable tanker routes to the Far East.

2. Oil Spills: This section summarizes information from the Sale 144 FEIS and OCS Report, MMS 97-0039, *Revised Oil-Spill-Risk Analysis: Outer Continental Shelf Lease Sale 170, Beaufort Sea.* The OCS Report MMS 97-0039 describes the oil-spill-risk analysis (OSRA) and the oil-spill trajectory modeling and contains the probability tables. A copy of this report can be obtained by calling 1-800-764-2627; requesting by email through akwebmaster@ mms.gov; downloading a copy from the MMS, Alaska OCS Region homepage at http://www.mms.gov/ omm/alaska/lease/170sale/170index.html; or by writing or visiting the Minerals Management Service at 949 East 36th Avenue, Room 300, Anchorage, AK 99508-4363.

The oil-spill analysis for this EIS considers three spill-size categories: (1) spills greater than or equal to (≥) 1,000 barrels (bbl), (2) spills ≥1 and <50 bbl, and (3) spills ≥50 and <1,000 bbl. The OSRA model addresses the movement of spills ≥1,000 bbl. The OSRA-model-trajectory results are appropriate only for "large" spills ≥1,000 bbl (Anderson et al., 1997). The cumulative case and "small spills," spills ≥1 and <50 bbl, and spills ≥50 and <1,000, are analyzed without the use of the OSRA model. The estimated resources for the cumulative case are shown in Table IV.A.5-1 and discussed in Section IV.A.5.

a. Oil-Spill-Risk-Analysis Model for Oil Spills Greater Than or Equal to 1,000 Barrels: The OSRA uses a historical oil-spill database and statistical methods to derive information about oil-spill patterns. This statistical information includes estimates of how often a spill occurs for every billion barrels of oil produced (oil-spill rates); the chance of one or more oil spills occurring; the mean number of oil spills; and the size of oil spills from platforms, pipelines, and oil tankers. The OSRA also uses oil-spill-movement modeling to investigate the movement of hypothetical oil spills (trajectories) and estimate the chance of contact from oil spills to areas of concern. The OSRA information provides EIS analysts with some estimate of the chance of one or more oil spills occurring, the estimated size of a spill, where an oil spill may go, and how long it may take to contact an area of concern.

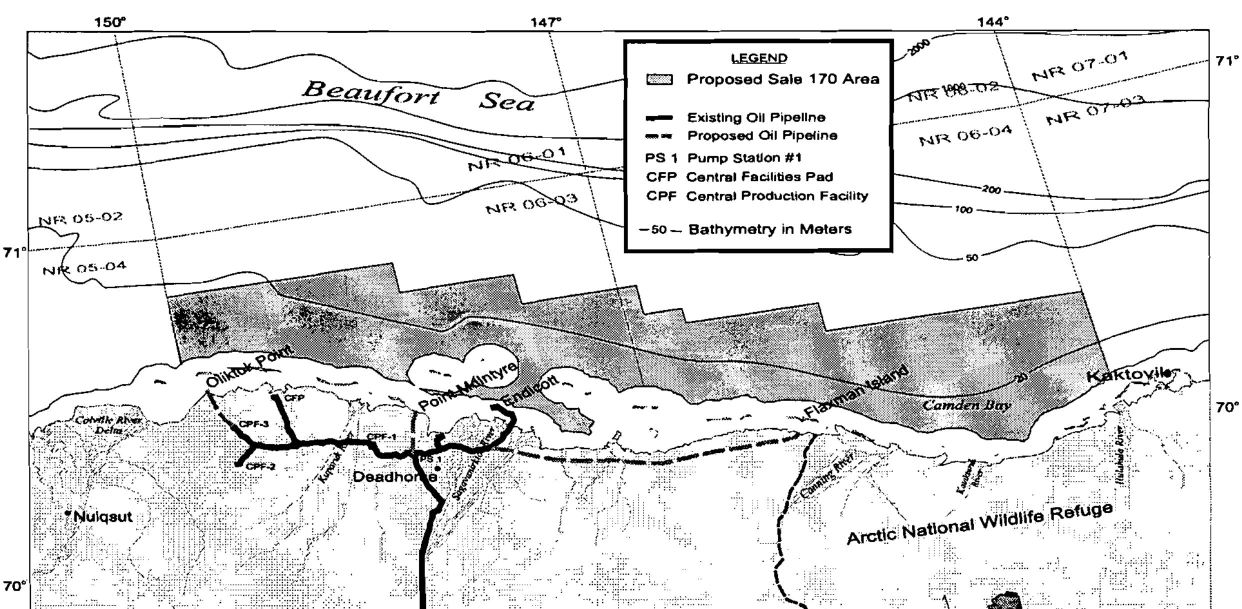

Figure IV.A.1-1 Hypothetical Pipelines, Landfalls, and Onshore Oil Transport

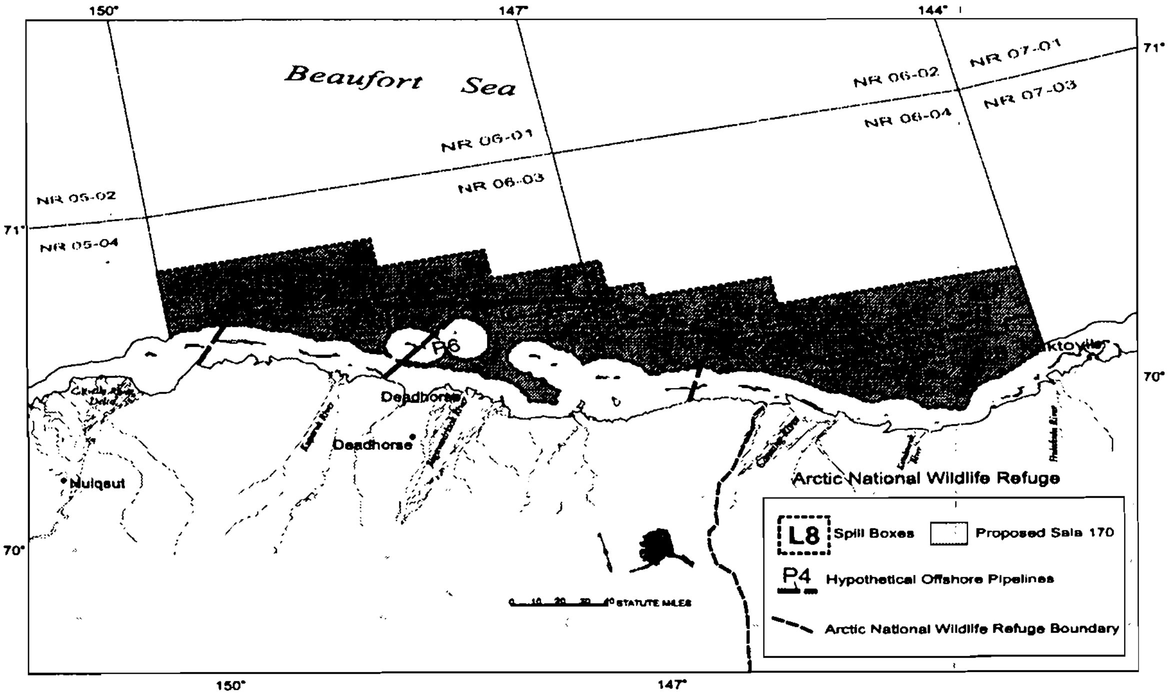

Figure IV.A.2-1 Location of Hypothetical Spill Boxes L1–L8 and Pipelines P1–P7 Used in the Oil-Spill-Risk Analysis for Sale 170

The OSRA-model-input assumptions include: (1) the total estimated amount of oil produced as a result of exploration, development and production, and transportation from Alternative I (see Sec. II and Appendix A); (2) the assumed locations of the oil estimated to be produced (Fig. IV.A.2-1 [uniformly distributed]); (3) the assumed production processing and transportation scenarios for Alternative I (see Sec. IV.A.1 and Fig. IV.A.2-1); and (4) the location of land and boundary segments and environmental resource areas (ERA's) (Figs. IV.A.2-2 to IV.A.2-7). The OSRA model considers the entire production life (2006-2026, 21 years [Appendix A, Table A-2]) of Alternative I and assumes (1) commercial quantities of hydrocarbons are present in the sale area; (2) these hydrocarbons will be developed and produced at the estimated resource levels, and (3) oil spills occur and move without consideration of oil spreading or weathering and without any cleanup.

Uncertainties exist, such as (1) the estimates required for the previously mentioned assumptions; (2) the actual size of the oil spill or spills if they did occur; (3) the wind, current, and ice conditions at the time of a possible oil spill; or (4) whether or not production occurs.

The Sale 170 OSRA estimates the chance of (1) one or more spills occurring; (2) a spill contacting land and boundary segments and environmental resource areas assuming a spill has occurred at a specific location (conditional probabilities); and (3) one or more spills occurring and contacting land and boundary segments and environmental resource areas from Sale 170 activities (combined probabilities) (Anderson et al., 1997).

(1) **Estimated Chance of One or More Spills Greater Than or Equal to 1,000 Barrels Occurring and Spill-Size Assumptions:** Table IV.A.2-1 shows the estimated mean number of spills and the chance of one or more spills ≥ 1,000 bbl occurring for Alternative I, Alternative III, Alternative IV.a, Alternative V.a, and the cumulative case. Table IV.A.2-2 shows the most likely number of spills and the chance of one or more spills ≥ 1,000 bbl occurring from State and Federal projects included in the cumulative case.

For Alternative I, Alternative III, Alternative IV.a, Alternative V.a, and the cumulative case, the median pipeline or platform spill is assumed to be 7,000 bbl. In the cumulative case, the average TAPS tanker spill is assumed to be 30,000 bbl.

(2) **Conditional Probability of Oil-Spill Contact Assuming a Spill has Occurred:** The location of land and boundary segments and ERA's discussed below are shown in Figures IV.A.2-2 to IV.A.2-7. For the Sale 170, area annual conditional probabilities (expressed as percent chance) of an oil spill ≥ 1,000 bbl starting at a certain location show the following patterns of contact within 30 days.

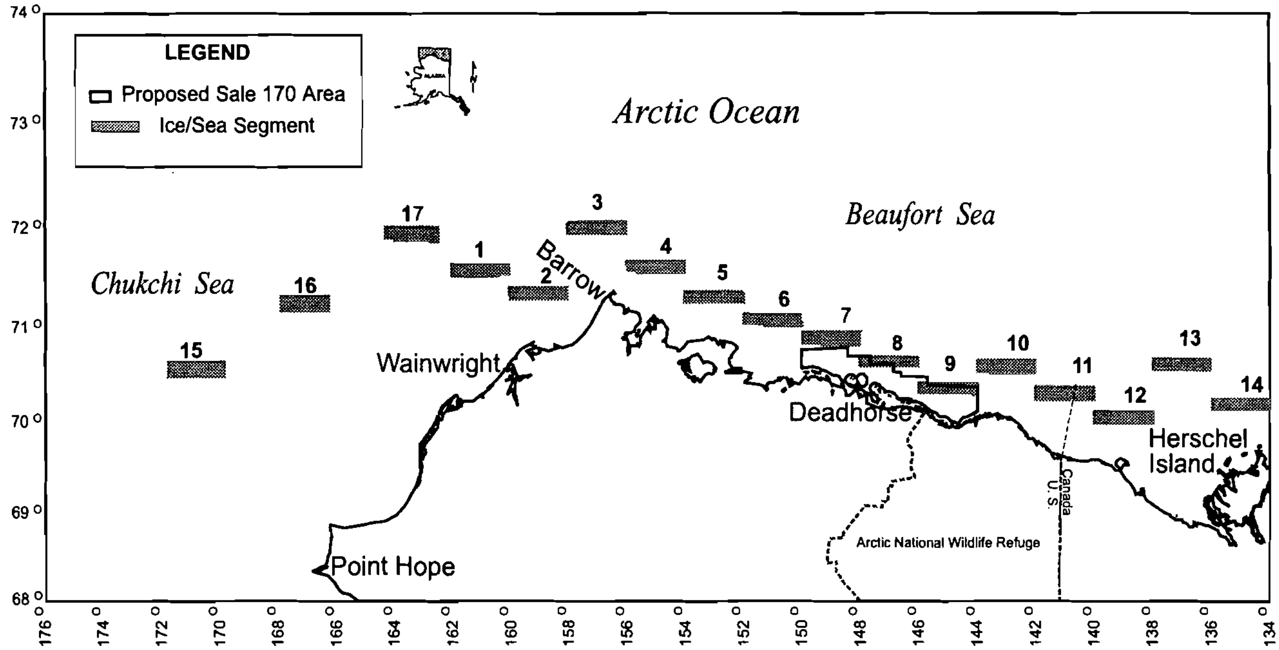

Figure IV.A.2-2 Location of Ice/Sea Segments 1-17 Used in the Oil-Spill Risk Analysis for Sale 170

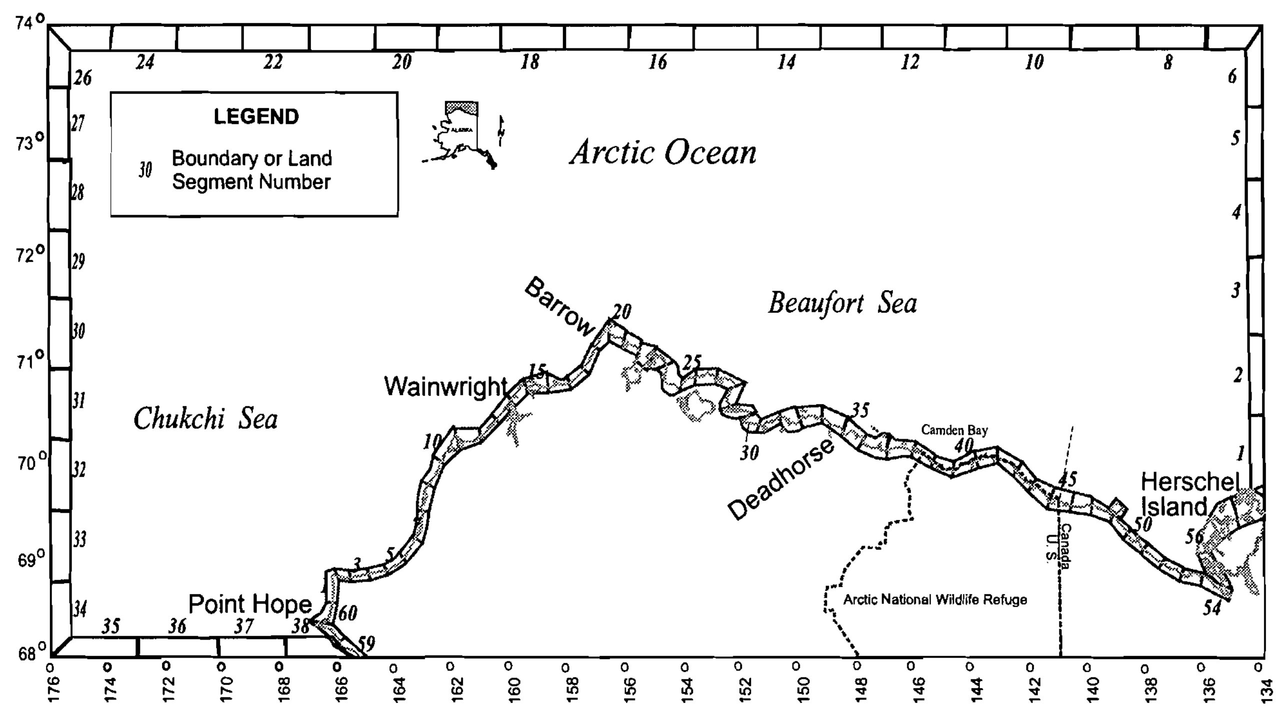

Figure IV.A.2-3 Location of Land and Boundary Segments Used in the Oil-Spill Risk Analysis for Sale 170

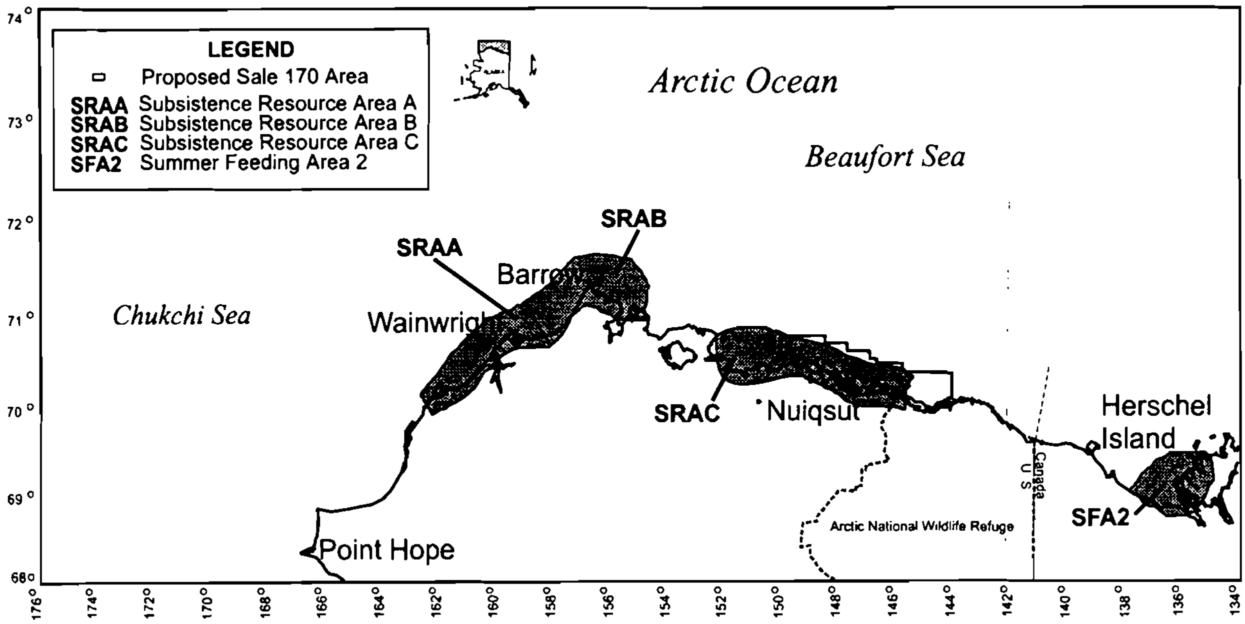

Figure IV.A.2-4 Location of Environmental Resource Areas SRAA, SRAB, SRAC, and SFA2 Used in the Oil-Spill Risk Analysis for Sale 170

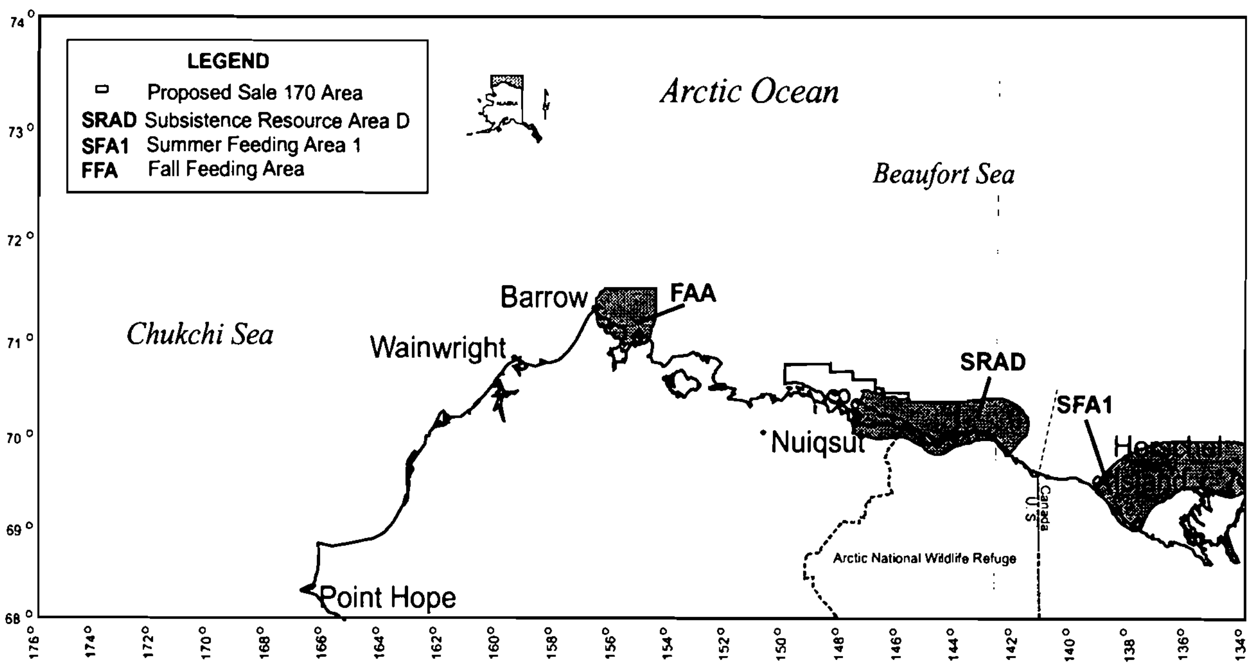

Figure IV.A.2-5 Location of Environmental Resource Areas FAA, SRAD, and SFA1 Used in the Oil-Spill Risk Analysis for Sale 170

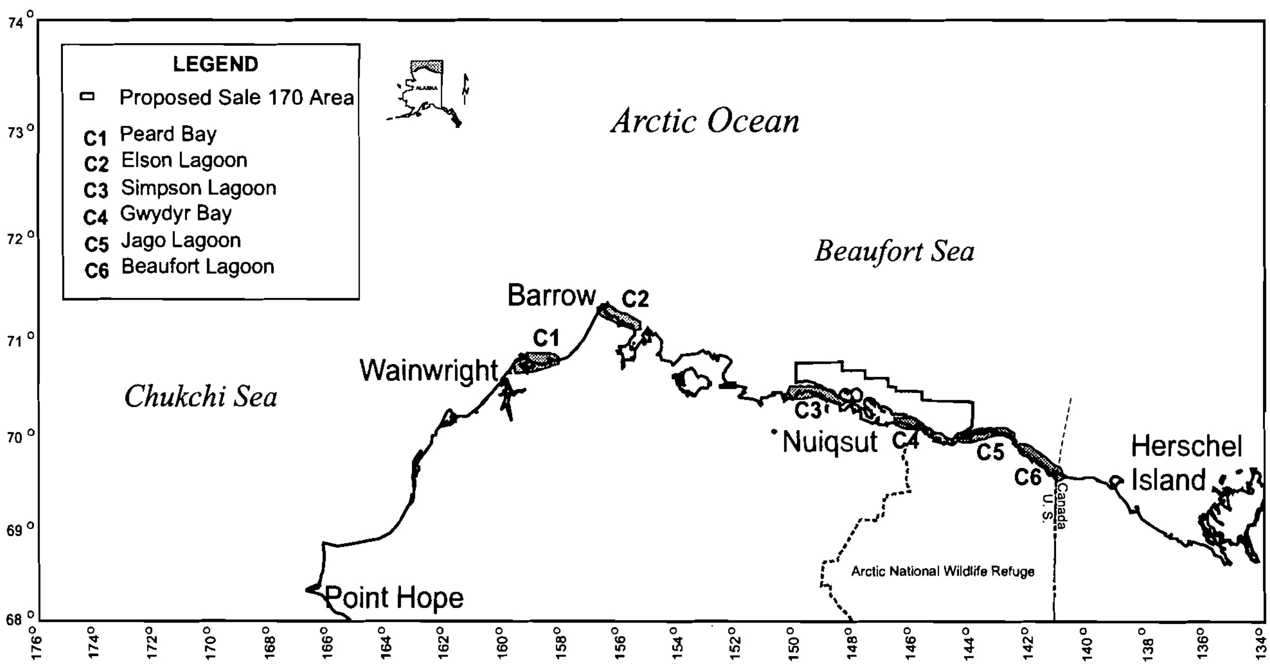

Figure IV.A.2-6 Location of Environmental Resource Areas C1, C2, C3, C4, C5, and C6 Used in the Oil-Spill Risk Analysis for Sale 170

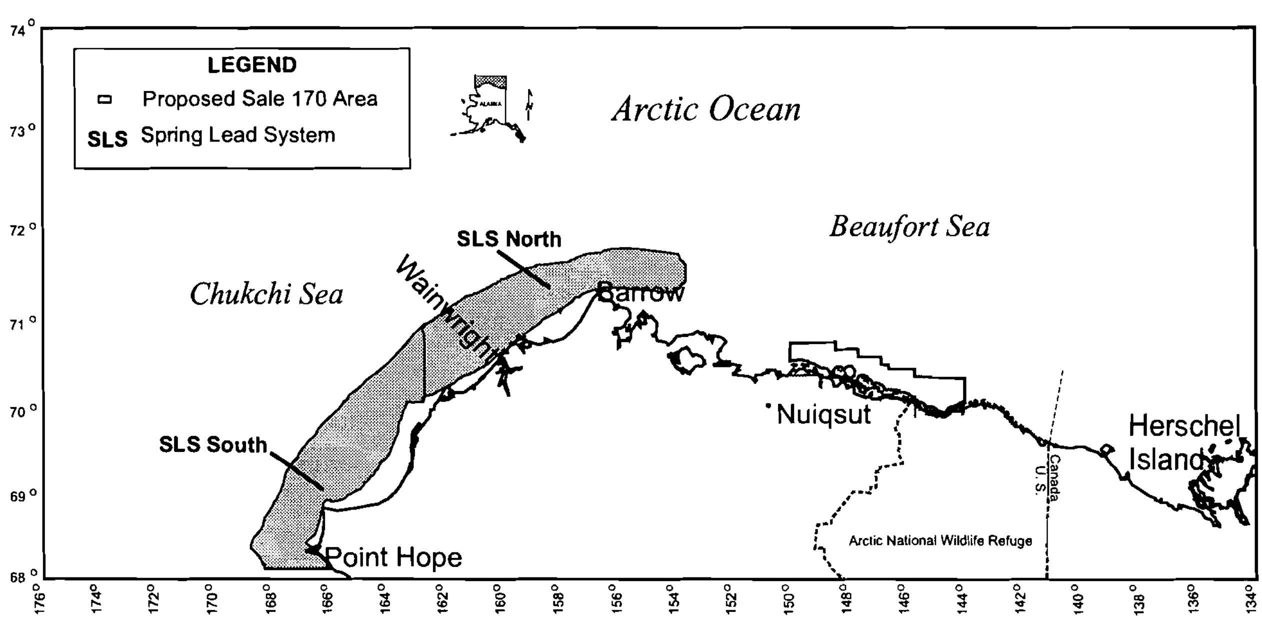

Figure IV.A.2-7 Location of Environmental Resource Areas SLS South and SLS North Used in the Oil-Spill Risk Analysis for Sale 170

(a) Technical Results: The OSRA conditional probability data show that oil spills originating from offshore and nearshore areas have a <0.5- to 3-percent chance and a <0.5- to 11-percent chance of contact to land segments, respectively. The chance of contact from platforms or pipeline spills to land segments (LS's) 34 through 38 ranges from <0.5 to 16 percent and is the highest throughout the study area.

The chances of contact to ERA Land from platforms or pipelines within the sale area ranges from 12 to 35 percent. Nearshore and offshore areas have a 21- to 35-percent chance and a 12- to 15-percent chance of contact to ERA Land respectively. The chance of contact to Ice/Sea Segments (I/SS's) 5 to 13 ranges from <0.5 to 70 percent. The I/SS's 7, 8 and 9, in or adjacent to the northern portion of the sale area, have about two to three times the chance of being contacted (2-70%) from offshore regions of the sale than nearshore regions (1-22%). The I/SS's 1 to 4, 14 to 17, and 1 to 4 SLS; Peard Bay; Elson Lagoon; Subsistence Resource Areas (SRA's) A and B; Fall Feeding Area; Summer Feeding Areas 1 and 2; Southern and Northern SLS Areas; and Northern SLS all have a <0.5-percent chance of contact from a spill from platforms or pipelines within the sale area. Boundary Segment 2 is the only boundary segment with a chance of contact >0.5 percent. The chance of contact to Boundary Segment 2 ranges from <0.5 to 1 percent. The chance of contact to SRA's C and D ranges from 4 to >99.5 percent. The chance of contact to SRA's C and D is great due to the large size of these digitized environmental resource areas. These environmental resource areas lie directly on top of or immediately adjacent to the hypothetical spill sites, thus ensuring contact.

The ANWR coastline is represented in the OSRA by LS's 38 through 45 and ERA's Beaufort Lagoon, and Jago Lagoon. Annual conditional probabilities (expressed as percent chance) that an oil spill starting at a particular location (L1-L8 and P1-P7) will contact the ANWR shoreline (LS 38-45) range from <0.5 to 8, <0.5 to 9, and <0.5 to 16 for 3, 10, and 30 days, respectively. The highest chance of contact to LS's 38 through 45 is from L8 directly north of the ANWR shoreline. Annual conditional probabilities (expressed as percent chance) that an oil spill starting at a particular location (L1-L8 and P1-P7) will contact the Beaufort Lagoon range from <0.5 to <0.5, <0.5 to <0.5, and <0.5 to 1 for 3, 10, and 30 days, respectively. Annual conditional probabilities (expressed as percent chance) that an oil spill starting at a particular location (L1- L8 and P1-P7) will contact Jago Lagoon range from <0.5 to 8, <0.5 to 9, and <0.5 to 12 for 3, 10, and 30 days, respectively.

(b) Discussion: Offshore areas have lower chances of contact to land segments than nearshore areas. Land segments located where pipelines come ashore show an increased chance of contact from a pipeline spill over land segments where pipelines do not come ashore. The LS's 34 through 38, directly adjacent to the Sale 170 area, are the most vulnerable to oil spills occurring throughout the sale area from platforms or pipelines.

The chances of contact to ERA Land from platforms or pipelines within the sale area ranges from low to moderate. Lease areas closer to shore have higher chances of contact to ERA Land than offshore areas. Offshore areas represented by I/SS's 5 to 13 have chances of contact ranging from negligible to high, depending on their proximity to the sale area. The closer to the sale area, the higher the chance of contact. The I/SS's 7, 8, and 9 in or adjacent to the northern portion of the sale area have about two to three times the chance of being contacted from offshore regions of the sale area than nearshore regions. Environmental resource areas in the Chukchi Sea, Canadian Beaufort Sea, and west of Barrow in the U.S. Beaufort sea have chances of contact that are negligible. The chance of contact to SRA's C and D ranges from low to very high, because SRA's C and D lie directly on top of or immediately adjacent to the hypothetical spill sites, thus ensuring contact. Individual land segments along the ANWR coastline have a low chance of spill contact but, collectively, the chance of a spill contacting any portion of the ANWR coastline is moderate.

Spills that occur in the winter and persist for up to 180 days show similar contact patterns as described above.

(3) Combined Probability of Oil-Spill Occurrence and Contact: Annual combined probabilities (expressed as percent chance) of one or more oil spills ≥1,000 bbl show the following patterns of occurrence and contact for Alternative I within 30 days. Where multiple environmental resource areas are discussed, the combined probabilities are expressed for the low and the high end of the resource range, respectively.

(a) Technical Results: The annual combined probability (expressed as percent chance) of one or more spills ≥1,000 bbl occurring and contacting any ERA ranges from <0.5 to 40 percent to <0.5 to 63 percent (Table IV.A.2-3). The SRA's C and D have the highest chance of occurrence and contact, because they are digitized as large areas and are either on top of hypothetical spill sites or directly adjacent to them. The chance of contact and occurrence to the ERA Land ranges from 12 to 21 percent. The I/SS's 6 to 11 are most vulnerable to spills from Alternative I. The chance of contact and occurrence to these Ice/Sea Segments ranges from 1 to 8 percent to 1 to 15 percent. The chance of occurrence and contact to Gwydyr Bay is 2 to 4 percent, to Simpson Lagoon is 2 to 4 percent, and to Jago Lagoon is 1 to 2 percent. All other environmental resource areas have a <0.5-percent chance of one or more spills ≥1,000 bbl occurring and contacting.

Table IV.A.2-1 Large Spills ≥1,000 Barrels: Estimated Mean Number and Chance of Occurrence

Alternative	Mean Number of Spills ≥1,000 bbl	Chance of One or More Spills ≥1,000 bbl Occurring
Alternative I (Proposed Action)[1]	0.62–1.19	46–70%
Alternative III (Kaktovik Deferral)[1]	0.43–0.85	35–57%
Alternative IVa (Cross Island Area)	0.50–0.97	39–62%
Alternative Va (Area offshore of the ANWR))	0.37–0.79	31–55%
Cumulative Case Total [2]	5.68–10.83	>99.9–>99.9%

Source: Anderson et al., 1997, and USDOI, MMS, Alaska OCS Region, 1997.
[1] For Alternatives I, III, IVa and Va no spills are assumed to occur during the exploration phase. For Alternatives I III, IVa and Va the entire estimated oil resource volume is assumed to be produced during the production phase.
[2] The cumulative case assumes production over the life of Sale 170 from oil resources under Federal lease, including Sales 144 and 170, as well as State onshore and offshore production. (See Section IV.A.5 and Table IV.A.5-1 for a discussion of resource and reserve estimates used in the cumulative case.)

Table IV.A.2-2 Large Spills ≥1,000 Barrels in the Cumulative Case: Most Likely Number and Chance of Occurrence by Source

Cumulative Case [1]	Pipeline and Platform Spills ≥1,000 bbl in the Alaskan Beaufort Sea		Tanker Spills ≥1,000 bbl Along the TAPS Route	
	Most Likely Number of Spills	Chance of One or More Occurring	Most Likely Number of Spills	Chance of One or More Occurring
Federal Offshore	1–2	64–88%	0–1	27–49%
State Offshore	1–2	65–86%	0–1	28–45%
State Onshore	na	na	3–5	95– >99.9%
Totals	2–4	87–98%	3–7	97– >99.9%

Source: USDOI, MMS, Alaska OCS Region, 1997.
[1] The cumulative case assumes production over the life of Sale 170 from resources under Federal lease, including Sales 144 and 170, as well as State onshore and offshore production of proven and known reserves. See Section IV.A.5 and Table IV.A.5-1 for a discussion of resource and reserve estimates used in the cumulative case.

Table IV.A.2-3 Probability (as Percent Chance) of one or more Large Oil Spills (≥ 1,000 barrels) Occurring and Contacting Coastline, Nearshore, and Offshore Areas [1]

Environmental Resource Area or Land Segment	Days (after spill)	Alt. I Proposal	Alt. III Kaktovik	Alt. IV.a Cross Island	Alt. V.a ANWR
Any Portion of Coastline					
Land	30	12–22	8–16	10–18	7–15
Land	180	23–40	17–31	19–34	15–29
Specific Coastline (Land Segments [2])					
LS 32 through 41	30	<0.5–5	<0.5–5	<0.5–3	<0.5–5
LS 28 through 41	180	<0.5–10	<0.5–9	<0.5–5	<0.5–9
Nearshore (Lagoons and Bays [3])					
Simpson, Jago, Gwyder	30	1–4	<0.5–4	1–4	<0.5–4
Simpson, Jago, Gwyder	180	2–8	1–8	2–6	<0.5–8
Nearshore (Subsistence Resource Areas [4])					
SRA "C" (east of Nuiqsut) and "D" (near Kaktovik)	30	31–63	17–56	29–55	12–54
SRA "B" (near Barrow), "C" and "D"	180	<0.5–65	<0.5–56	<0.5–57	<0.5–54
Offshore (Sea/Ice Segments [5])					
I/SS 6–11 and 13	30	<0.5–15	<0.5–10	<0.5–9	<0.5–10
I/SS 4–13	180	<0.5–26	<0.5–22	<0.5–25	<0.5–22

Note: All environmental resource areas and land segments with all probability values less than 0.5.
[1] The range of combined probabilities (expressed as percent chance) of one or more spills greater than or equal to 1,000 barrels occurring and contacting the Beaufort Sea coastline, lagoons and bays, subsistence resource use areas, and offshore marine areas (ice/sea segments) as a result of Sale 170 development—summarized from Anderson et al., 1997.
[2] Coastal land segments (LS) adjacent to the Sale 170 area are shown in Figure IV.A.2-3.
[3] Location of Simpson and Jago lagoons and Gwyder Bay is shown in Figure IV.A.2-6.
[4] Subsistence resource areas (SRA-B,C, and D) are shown in Figures IV.A.2-4 and 5.
[5] Location of offshore sea/ice segments (SS) is shown in Figure IV.A.2-2.

Table IV.A.2-4 Small Offshore Spills <1,000 Barrels: Estimated Number and Volume

	Exploration		Production					
	≥1 and <1,000 bbl		≥1 and <50 bbl		>50 and <1,000 bbl		**Total ≥1 and <1,000 bbl**	
	Estimated Number of Spills	Total Volume (bbl)	Estimated Number of Spills	Total Volume (bbl)	Estimated Number of Spills	Total Volume (bbl)	**Estimated Number of Spills**	**Total Volume (bbl)**
Alternative I	1–1	9–9	82–157	410–785	3–7	480–1,120	85–164	890–1,905
Alternative III	1–1	9–9	56–112	281-562	2-5	320–800	59–118	610–1,371
Alternative IVa	1–1	9–9	66–129	330–645	3–5	480–800	70–135	829–1,454
Alternative Va	1–1	9–9	49–105	246–527	2–4	320–640	52–110	575–1,176
Cumulative Case								
Federal Offshore	–	–	133–287	665–1,435	6–12	960–1,920	139–299	1,625–3,355
State Offshore	–	–	142–261	710–1,305	6–11	960–1,760	148–272	1,670–3,065
Cumulative Case Total	**–**	**–**	**275–548**	**1,375–2,740**	**12–23**	**1,920–3,680**	**287–571**	**3,295–6,420**

Source: USDOI, MMS, Alaska OCS Region, 1997.

Table IV.A.2-5 Small Onshore Spills <1,000 Barrels: Estimated Number and Volume

	North Slope and Trans-Alaska Pipeline Spills					
	> 0 and <50 bbl		≥50 and <1,000 bbl		**Total ≥1 and <1,000 bbl**	
	Estimated Number of Spills	Total Volume (bbl)	Estimated Number of Spills	Total Volume (bbl)	**Estimated Number of Spills**	**Total Volume (bbl)**
Alternative I	452–866	271–519	2–4	620–1,188	454–870	881–1,707
Alternative III	310–621	186–372	2–3	425–851	312–624	611–1,223
Alternative IVa	362–711	217–426	2–4	496–975	364–715	713–1,401
Alternative Va	271–582	163–348	1–3	372–798	273–585	535–1,146
Cumulative Case						
Federal Offshore	737–1,577	441–945	4–8	1,010–2,163	741–1,585	1,451–3,108
State Offshore	776–1,422	465–852	4–7	1,064–1,950	780–1,429	1,529–2,802
State Onshore	6,981–12,799	4,182–7,667	35–64	9,572–17,549	7,016–12,863	13,754–25,216
Cumulative Case Total	**8,494–15,798**	**5,088–9,464**	**43–79**	**11,646–21,662**	**8,537–15,877**	**16,734–31,126**

Source: USDOI, MMS, Alaska OCS Region, 1997.

The LS's 32 to 41 (Colville River Delta to Jago Lagoon) have a <0.5 to 3 and <0.5 to 3 chance of one or more spills ≥1,000 bbl occurring and contacting.

For Alternative III, the combined probabilities show small reductions (1-19%) in the chance of one or more spills ≥1,000 bbl occurring and contacting ERA's I/SS's 8 to 10, Gwydyr Bay, Jago Lagoon, and LS's 37, 39, and 40. The largest reductions (14-19%) are to SRA D. For Alternative IV.a, the combined probabilities show small reductions (1-12%) in the chance of one or more spills ≥1,000 bbl occurring and contacting ERA's I/SS's 6 to 9, Simpson Lagoon, SRA's C and D, and LS 34. The largest reductions (8-12%) are to SRA C. For Alternative V.a, the combined probabilities show reductions (1-24%) in the chance of one or more spills ≥1,000 bbl occurring and contacting ERA's I/SS's 6 and 8 to 11, Gwydyr Bay, SRA's C and D, and LS 34. The largest reductions are (10-9%) to SRA C and (19-24%) to SRA D.

(b) Discussion: For Alternative I environmental resource areas in the Chukchi Sea, Canadian Beaufort Sea, and west of Barrow in the U.S. Beaufort Sea the chances of contact and occurrence are negligible. The coastline form the Colville River Delta to Jago Lagoon (LS's 38-41) is most vulnerable but has a very low chance of occurrence and contact. Offshore areas adjacent to the sale area and slightly to the east and west are vulnerable but have very low to low chances of occurrence and contact. The chance of contact and occurrence to bays and lagoons adjacent to and within the ANWR is very low. Alternative III slightly reduces the chance of contact and occurrence to offshore areas north and northeast of the sale area and portions of the coastline within the ANWR. Alternative IV.a slightly reduces the chance of contact and occurrence to offshore areas north and northwest of the sale area, Simpson Lagoon, Gwydyr Bay, and SRA C adjacent to and northeast of Nuiqsut. Alternative V.a slightly reduces the chance of contact and occurrence to offshore areas directly north and slightly to the east and west of the sale area, Gwydyr Bay and SRA C and SRA D, which is adjacent to Kaktovik.

b. Spills Less Than 1,000 Barrels: The estimated number and volume of spills <1,000 bbl occurring from Sale 170 are shown in Tables IV.A.2-4 and IV.A.2-5.

(1) Outer Continental Shelf Spills Less Than 1,000 Barrels: The OCS data show an OCS production-spill rate of 9.8 spills ≥50 and <1,000 bbl in size/billion barrels (Bbbl) produced, with an average 160-bbl-spill size (Tracey, 1988; Francois 1993; Anderson, 1994, pers. comm.). The OCS data show an OCS production-spill rate of 234 spills ≥ 1 and <50 bbl in size/Bbbl produced with an average 5-bbl-spill size. Table IV.A.2-4 shows the estimated offshore small spills for Alternatives I, III, IV, and V.

(2) North Slope and TAPS Spills Less Than 1,000 Barrels: The 1989-1994 North Slope-spill rate for (1) petroleum <50 bbl is 1,003 spills/Bbbl and 50 to <1,000 bbl is 6 spills/Bbbl and (2) crude oil <50 bbl is 247 spills/Bbbl and 50 to <1,000 bbl is 5 spills/Bbbl. The TAPS-spill rate for (1) petroleum <50 bbl is 232 spills/Bbbl and 50 to <1,000 bbl is 1 spill/Bbbl and (2) crude oil <50 bbl is 25 spills/Bbbl. Table IV.A.2-5 shows the estimated small onshore spills for Alternatives I, III, IV, and V.

3. Spilled Oil Behavior and Fate in Marine Waters:

The behavior and weathering of oil spills, as contained in Section IV.A.3 of the Sale 144 Final EIS (USDOI, MMS, 1996a), is herein incorporated by reference. A summary, supplemented by additional material, as cited, follows.

Several processes alter the chemical and physical characteristics and toxicity of spilled oil. Collectively, these processes are referred to as weathering or aging of the oil and, along with the physical oceanography and meteorology, the weathering processes determine the oil's fate. The major oil-weathering processes are spreading, evaporation, dispersion, dissolution, emulsification, microbial degradation, and sedimentation to the seafloor or stranding on the shoreline.

a. Environmental Considerations: The type of spill and the environment it occurs in, such as a surface spill, subsurface spill, spring ice-overflow spill, summer broken-ice spill, winter under-ice spill, or winter broken-ice spill, will affect how an oil spill behaves and weathers. In ice-covered waters, many of the same weathering processes are in effect; however, the sea ice changes the rates and relative importance of these properties (Payne, McNabb, and Clayton, 1991).

Oil spills spread less in cold water than in temperate water due to the increased oil viscosity. An oil spill in broken ice would spread between icefloes into any gaps greater than about 8 to 15 centimeters (cm). An oil spill under ice would spread into under-ice hollows and freeze into the ice. The oil-contaminated area may be increased, should ice movement occur during a spill.

The lower the temperature, the less crude oil evaporates. Both Prudhoe Bay and Endicott crudes have experimentally followed this pattern (Fingas, 1966). Oil between or on icefloes is subject to normal evaporation. Oil that is frozen into the underside of ice is unlikely to undergo any evaporation until its release in spring. In spring as the ice sheet deteriorates, the encapsulated oil will rise to the surface through brine channels in the ice. Oil will be released by ablation of the ice surface down to the level of the lens. As oil is released to the surface, evaporation will occur.

Dispersion of oil spills occurs from wind, waves, currents, or ice. Any waves within the ice pack tend to pump oil onto the ice. Some additional oil dispersion occurs in dense, broken ice through floe-grinding action. More viscous and/or weathered crudes may adhere to porous icefloes, essentially concentrating oil within the floe field and limiting the oil dispersion.

Emulsification of some crude oils is increased in the presence of ice. With floe grinding, Prudhoe Bay crude forms a mousse within a few hours, an order of magnitude more rapidly than in open water.

b. Sale 170 Weathering Assumptions: Using the oil-weathering model of Kirstein, Payne, and Redding (1983), calculations were run for a 7,000-bbl Prudhoe Bay crude-oil spill for summer open-water and winter meltout for 3, 10, and 30 days to estimate the oil remaining, dispersed, and evaporated and the thickness and area of the slick. Table IV.A.3-1a shows the oil-weathering-model results. The oil-weathering model estimates a 7,000-bbl spill of Prudhoe Bay crude oil in open water of the Beaufort Sea physically could cover 1 to 2 km^2 of continuous area (Table IV.A.3-1a). A 7,000-bbl meltout spill could cover one-half to 1 km^2 of continuous area (Table IV.A.3-1a). Winds, movement of the slick, and other forces would tend to spread the oil discontinuously over an area 20- to 200-fold greater than this actual area of oiled surface. Using the equations of Ford (1985), the discontinuous area of an open-water 7,000-bbl spill could cover 20 to 397 km^2, and a meltout spill could cover 15 to 312 km^2 (Table IV.A.3-1a). Dissolution accounts for approximately 5 percent of slick mass; most spilled oil evaporates, grounds on the shoreline, or eventually forms tarballs or pancakes. Roughly 45 to 53 percent of Prudhoe Bay crude oil would remain after initial weathering in the form of dispersed tarballs or pancakes (Table IV.A.3-1a). Table IV.A.3-1b shows the oil-weathering-model results for a 30,000 bbl spill of Prudhoe Bay crude oil in the Gulf of Alaska.

c. Extent and Persistence of Oiled Shoreline: If an oil spill occurred and contacted shore, two important but nonbiological questions arise: (1) How much shoreline would be contaminated? and (2) How long would the

Table IV.A.3-1a Fate and Behavior of a Hypothetical Oil Spill, 7,000 Barrels in Size, from a Platform or Pipeline in the Beaufort Sea

	Summer Spill[1]			Meltout Spill[2]		
Time After Spill in Days	3	10	30	3	10	30
Oil Remaining (%)	80	67	53	75	57	45
Oil Dispersed (%)	7	16	27	17	32	42
Oil Evaporated (%)	13	16	19	6	10	12
Thickness (mm)	1.3	0.5	0.3	1	0.5	0.3
Area of Slick (km^2)[4]	0.8	1.4	2.2	0.5	0.9	1.3
Discontinuous Area (km^2)[5]	20	96	397	15	75	312
Estimated Coastline Oiled (km)[6]	60			65		

For Alternative I,III, IV.a and V.a the median pipeline and platform spill is assumed to be 7,000 bbl.

Table IV.A.3-1b Fate and Behavior of a Hypothetical Oil Spill, 30,000 Barrels in Size, from a Tanker in the Gulf of Alaska

	Annual Spill[3]		
Time After Spill in Days	3	10	30
Oil Remaining (%)	79	65	50
Oil Dispersed (%)	7	18	30
Oil Evaporated (%)	14	17	20
Thickness (mm)	1.7	0.8	0.4
Area of Slick (km^2)[4]	2.2	3.7	5.6
Discontinuous Area (km^2)[5]	122	580	2,406
Estimated Coastline Oiled (km)[6]	83		

In the cumulative case, the average Trans-Alaska Pipeline System (TAPS) tanker spill is assumed to be 30,000 bbl.

Source: USDOI, MMS, Alaska OCS Region, 1996.
Notes: Calculated with the SAI oil-weathering model of Kirstein, Payne, and Redding (1983) and Kirstein and Redding (1987), assuming a Prudhoe Bay crude type.

[1] Summer (July through September), 12-kn wind speed, 2 °C, 0.4-m wave height.
[2] Meltout Spill. Spill is assumed to occur in May into first-year pack ice, pools 2-cm thick on ice surface for 2 days at 0 °C prior to meltout into 50-percent ice cover, 11-kn wind speed, and 0.1 wave heights.
[3] Annual (January through December), 15-kn wind speed, 8 °C, 1.5-m wave height.
[4] This is the area of oiled surface.
[5] Calculated from Equation 6 of Table 2 in Ford (1985) and is the discontinuous area of a continuing spill or the area swept by an instantaneous spill of a given volume. Note that ice dispersion occurs for about 30 days prior to meltout.
[6] Calculated from Equation 17 of Table 4 in Ford (1985) and is the results of stepwise multiple regression for length of historical coastline affected.

contamination persist? In winter, landfast ice along the shorelines of the Beaufort Sea would keep spills offshore away from the shoreline, and any oil that did reach shore would not penetrate into the frozen beach. For Beaufort Sea shorelines, the relevance of these questions is much greater for spills during the open-water season than for spills during the winter.

Based on Equation 17 (Ford, 1985), if a 7,000-bbl spill occurred and contacted land, about 60 km of coastline would be oiled. The 60 km of coastline is approximately equal to the length of two land segments in the OSRA model.

Stranded-oil persistence results from oil remaining after cleanup or where cleanup may cause more environmental damage than if the oil were left in place. Collectively, the coastal environments from Oliktok Point to Barter Island adjacent to the Sale 170 area have approximately 0.3 percent steep cliffs (Environmental Sensitivity Index [ESI]1); 3.2 percent steep beaches and bluffs (ESI 2); 25 percent exposed, nonvegetated barriers (ESI 3); 8 percent vegetated, low barriers (ESI 4); 30 percent lagoons facing mainland shores (ESI 5); 4 percent peat shores (ESI 6); 20 percent sheltered tidal flats (ESI 7); and 10 percent marshes (ESI 8). The ESI is used as an estimate of oil retention and persistence. The retention and persistence of oil would be low for ESI's 1 and 2, moderate for ESI's 3 through 5, and high for ESI's 6 through 8.

The OSRA estimates a chance of contact ranging from <0.5 to 16 percent to LS's 28 through 42 from an oil spill starting at a particular location within the sale area within 30 days. Each land segment (28-42) contains variable percentages of each ESI type. If oil were to contact LS's 28 through 42, each land segment has some percentage of moderate and high persistence and retention. Oil could remain for 5 to 10 years on peat shores, sheltered tidal flats, and marshes.

4. Aspects of Spill Prevention and Response: The petroleum industry and government have separate responsibilities for oil-spill prevention, contingency planning, and response. The MMS has established stringent requirements for spill prevention and response and employs an inspection program to ensure industry compliance. To complement the regulatory programs in place, the petroleum industry uses state-of-the-art technology for prevention equipment and the most current operating procedures while conducting operations on the OCS. Additionally, the petroleum industry must maintain a constant state of readiness for oil-spill response to meet the MMS's stringent response requirements. If an oil spill should occur, it is the responsibility of the spiller to respond to the spill with the oversight of the Federal and, depending on the location of the spill, State governments.

A detailed discussion of MMS prevention and response responsibilities is contained in Section 4(a) of the Sale 144 Final EIS (USDOI, MMS, 1996a). Section 4(a) discusses MMS procedures for the permitting of exploration and development activities to minimize the risk of accidental releases of oils or other pollutants into the marine environment. The MMS also provides an inspection program that monitors industry compliance with government regulations relating to safety and the protection of the environment.

Included in Section 4(a) is a discussion of MMS requirements for oil-spill-contingency measures. The goal of the MMS oil-spill program is to ensure that the lessee is prepared to respond to any size spill, from a small operational spill to a large, worst-case spill. To achieve this goal, MMS requires oil-spill-contingency plans (OSCP's) be prepared for all operations. Further, MMS uses inspections, equipment deployment, and tabletop communication exercises to ensure that the lessee has trained, knowledgeable crews and well-maintained equipment to respond to a spill.

a. Contingency Plans: Before conducting exploratory drilling operations, MMS's oil-spill regulations (30 CFR 250.42 and 30 CFR 254) require each lessee to submit an OSCP to the MMS Regional Supervisor, Field Operations, for approval with, or prior to, the submission of an Exploration Plan or Development and Production Plan. The OSCP is developed for the site-specific operations based on the type, timing, and location of the proposed activities. The OSCP must satisfy the content requirements and provisions identified in 30 CFR 250.42 and 30 CFR 254 and the Planning Guidelines for Approval of Oil Spill Contingency Plans developed jointly by the MMS and U.S. Coast Guard (USCG).

b. Applicability of Oil-Spill-Response Technology in the Sale 170 Area: The technical capability to contain and clean up offshore oil spills in ice-covered waters and broken sea ice depends on the oil type; amount of oil spilled; and sea, ice, and meteorological conditions at the time of the spill. Many of the spill-response measures developed for arctic areas have been evaluated in test facilities and/or demonstrated during field trials and oil-spill-response exercises. However, there has not been a major crude-oil spill of any significant magnitude in arctic ice-covered waters or in broken sea ice to provide historical data on the effectiveness of this technology for a major spill event. For this reason, there continues to be a diversity of opinions among industry and regulatory and environmental groups on the actual effectiveness of oil-spill response in ice-covered waters and in broken sea-ice conditions.

(1) Solid Ice: Most would agree that current technology successfully can clean up oil spilled onto solid landfast-ice areas during the winter months (typically from mid-November through mid-May). Solid-ice recovery operations center on the removal of oil and oil-contaminated snow that can be scraped from the surface of thick ice sheets with hand tools and earth-moving equipment such as loaders, graders, and plows. If a spill occurred early in the winter before the ice is solid enough to support response equipment, the response could be delayed until the ice thickens. For spills that occurred late in the winter when the ice is beginning to thaw, the oil would pool and collect in melt ponds on the surface of the ice where it easily could be burned using in situ-burning equipment, such as the Helitorch.

Oil spilled under the ice in solid landfast-ice regions is more difficult to locate and clean up than surface spills; however, it is technically viable under many conditions. Oil spilled under solid ice usually will rise to the bottom of the ice sheet and be contained in a relatively small area, providing that there are no strong currents (>.5 knots [kn]) under the ice. The mean storage capacity of oil under the ice is estimated to be 195,000 bbl/km^2 inside the barrier islands and on the order of 1.8 MMbbl/km^2 under multiyear ice (Kovacs, 1977). Several techniques have been demonstrated in field trials over the years and include physically removing the ice, boring into or channeling the ice to allow the oil to move to the surface where it can be either mechanically recovered or burned, and burning the oil when it migrates to the surface through brine channels and collects in melt pools during the spring thaw. Oil has been shown to easily migrate to the surface of annual or first-year ice during the spring and can be burned very effectively. Oil encapsulated into multiyear ice, however, may take several years to surface through brine channels; and recovery operations would be much more difficult.

(2) Broken and Moving Pack Ice: Oil spilled in broken ice usually can be expected to spread between icefloes. In closely packed ice, the movement of the ice in response to wind and waves could force some of the oil onto the surface of icefloes; however, most of the oil is expected to remain on the water between the icefloes. Mechanically recovering spilled oil in moving pack ice, dense broken ice, and newly forming ice under dynamic sea states is a difficult task. Current technology is limited to the deployment of skimmers in small open-water areas, leads within the ice pack, and in the lee of drilling/icebreaking vessels. Access to these areas generally is limited to ice-strengthened ships and barges. When the oil is highly concentrated in leads and small open-water areas within the ice pack, mechanical recovery can be very effective if deployed from ice-strengthened vessels that are capable of maneuvering in the ice pack. As the oil becomes spread over a larger area, intermixes with the ice, and becomes emulsified or solidified, mechanical recovery of a spill becomes ineffective.

The oil and gas industry almost unanimously has adopted in situ burning as the primary response technique for oil trapped and intermixed with ice. In situ burning reduces or eliminates the need for recovery, storage, transportation, and disposal of a large percentage of the spilled oil.

(3) **In Situ Burning:** In situ burning is defined as the burning of oil on the surface of the water in situ (in place). Because of the high removal rate and efficiency of this technique, it is becoming more widely accepted as a response technique. In situ burning also has been demonstrated to be an extremely useful spill-response tool in open water with the use of fire-resistant containment boom. The effectiveness of the technique has been demonstrated in the laboratory, test tanks (Walton et al., 1993), and in the field during the *Exxon Valdez* spill (Allen, 1991). Because of the validity of this response tool, the Alaska Regional Response Team (ARRT) has provided conditional preapproval for the Federal On-Scene Coordinator (FOSC) to approve in situ burning in Cook Inlet, Prince William Sound, and the Beaufort Sea.

In situ burning likely would be used for a large spill in the Sale 170 area, because it greatly reduces the need for recovery, storage, transportation, and disposal of spilled oil, and it is effective and efficient (Allen and Ferek, 1993). Additionally, suitable equipment is in place as is the avenue for approval of in situ burning. However, until additional information is available concerning the transport of the smoke plume, this technique is not likely to be used if the trajectory of the smoke plume is predicted to move toward populated areas, depending on the distance away from said populated area.

Tests have shown that in situ burning can be very effective, providing the oil is concentrated and nonemulsified. Ice actually can be a benefit to in situ burning, because oil tends to concentrate in leads, small open-water areas, and melt pools and against large icefloes. Wind and air temperature are factors that can reduce the effectiveness of in situ burning, primarily by restricting initial combustion of a slick. Winds >20 kn and winter temperatures increase the amount of effort and energy required to ignite spilled oil.

One of the major concerns expressed in the past has been that a large oil spill in moving pack ice would result in hundreds of thousands of small pools of oil, each requiring ignition. Industry has responded to this need by obtaining and testing an air-deployable ignition system, the Helitorch. The Helitorch is deployed from a helicopter and emits globs of ignited gelled gasoline or diesel fuel. It can operate from altitudes of 15 to several hundred feet with forward speeds of 40 to 60 mi per hour. The Helitorch is very suitable for use in responding to a large spill spread over a wide area.

(4) **Open-Water Containment and Recovery:** During the short summer season, mechanical containment and recovery generally are accepted as the primary means for containing and recovering an oil spill in open-water conditions. Equipment employed in a mechanical response generally consists of a boom for spill containment; skimmers for spill recovery; and vessels to tow the boom act as operating platforms and store the recovered oil and water.

The purpose of containing spilled oil is to prevent spreading and to concentrate the oil for more efficient mechanical recovery or in situ-burning operations. Oil-spill-containment booms are the primary tool used for offshore containment during open-water or limited broken-ice conditions (less than approximately 25% ice coverage). Booms are classified according to their containment capabilities. Calm-water booms can be used to contain oil through an International Sea State (ISS) of 1 (significant wave height to 1 ft), harbor booms through an ISS of 2 (significant wave height to 0.9 m [2.9 ft]), and offshore booms with some success through an ISS of 4 (significant wave height to 2.1 m [6.9 ft]). Other booms, such as sorbent booms, fire-resistant booms, and ice-deflection booms, are categorized by their special use. For operations in the Sale 170 area, industry would be expected to maintain or have available a state-of-the-art offshore-containment boom as well as an offshore fire-resistant containment boom for in situ-burn operations.

Recovery is defined as the mechanical removal of oil from the shoreline, water, or ice environment. For oil on water, recovery techniques can be divided into two groups—the use of skimmers and the use of sorbents. Because in situ burning generally is not regarded as a recovery technique, it is discussed separately.

Sorbents are made of oleophilic materials designed to absorb up to 30 times their weight in oil. Sorbents are available in a number of forms and primarily are used to recover small oil spills and films from the water surface. Other sorbent applications include spill recovery in small melt pools, on shorelines, and around industrial equipment; they also have been used to recover burn residue after in situ-burn testing. It is expected that sorbents would be used, as described above, in the Sale 170 area.

Skimmers are mechanical devices designed to float on the surface of the water and recover oil. They generally are categorized as suction devices, weir devices (blocking the water so oil flows over the top), centrifugal devices, oleophilic devices (the oil adheres to the material), and hybrid devices (which use a combination of the above principles). The effectiveness of a skimmer depends on the characteristics of the oil, slick thickness, oceanographic conditions (especially sea state), oil-encounter rate, throughput efficiency, and recovery efficiency. As a general rule, optimum efficiency is reached when the slick is thick and the sea is calm. Increasing the oil's viscosity, the amount of debris encountered, and/or the sea state reduces the effectiveness of the skimmer, causing increased water recovery and downtime. Local oil-spill cooperatives, such as Alaska Clean Seas, maintain a number of each type of skimmer. In the event of a large spill in open water or limited broken ice, any or all such skimmers would be expected to be used in the Sale 170 area.

(5) **Detection and Tracking:** There are a number of methods and devices that may be used in the Sale 170 area for spill detection and tracking. Among the most widely used is visual detection by trained personnel from the drilling structure, support vessels, or spotter aircraft. When the oil is at the surface, it usually is visible from the air, although its appearance has wide variations in color depending on the thickness of the slick, the viewing angle and altitude, and light conditions. To the untrained eye, naturally occurring materials such as silt-on-ice, seaweed, cloud shadows, and ocean-surface ripples may be confused with oil slicks. Additionally, oil may be difficult to visually detect on dark-colored shorelines, when mixed with biogenic materials, and when located under ice or snow. Sophisticated remote-sensing equipment can help discern the differences between naturally occurring anomalies and oil slicks and recently has been used to enhance the information gathered by visual means.

Remote-sensing systems include still and video cameras; scanners, infrared sensors; ultraviolet and fluorosensors; and radar, microwave, and satellite imagery. A number of remote-sensing systems currently are available. The USCG maintains an aircraft-deployed oil-spill-surveillance system known as the Aireye. The Aireye is an airborne, real-time, all-weather, day/night, remote-sensing system. The Aireye system's primary sensor is a Side Looking Airborne Radar with an oil-slick-detection range of 24 to 40 km (15-25 mi). Other Aireye sensors include infrared/ultraviolet scanners and an aerial-reconnaissance camera and low-light-video equipment. In a large-spill event, it is likely that this system would be used to detect the extent of the oil.

In addition to remote sensing, real-time-tracking and -trajectory modeling are extremely important tools for monitoring spill movement and for spill-response planning. Spill-tracking buoys that are designed to move with the oil are available commercially. The spill-tracking buoys use either a radio-tracking device or a satellite to detect their position. The buoys are deployed in the leading edge of the slick and used to monitor spill movement and to determine resources that may be at risk. Real-time-trajectory models, such as the National Oceanic and Atmospheric Administration's (NOAA's) Oil Spill Simulation Model, also may be used in the Sale 170 area to determine what resources are at risk and to target areas for the most efficient use of spill-response equipment. Once the spill is located, spill-specific-containment and -recovery operations may be planned and initiated.

(6) **Dispersants and Other Chemicals:** The term "chemical agents" is an all-encompassing term that describes chemicals that may be used during an oil-spill response. Numerous chemical agents have been commercially produced and sold over the past two decades. These chemical agents include dispersants, gelling agents, emulsion breakers and preventers, biodegradation agents, and several other miscellaneous products.

Dispersants are chemical agents that contain surfactant for breaking up oil into small droplets in the water column. They are the most common of all the chemical agents available for spill response. Dispersants decrease the interfacial tension between the oil and the water, thus reducing the cohesiveness of the slick. Aided by wind and waves, the oil is dispersed into the water column in the form of small droplets. Breaking the slick into small droplets increases the surface area available for natural degradation and reduces the concentration of the oil. Dispersants are not widely accepted, despite their claimed benefit, primarily because of biological concerns and because their effectiveness has not been proven in field trials or actual spill events. The ARRT conditionally has preapproved the use of dispersants in the Cook Inlet and Prince William Sound areas, but not for the Sale 170 area. Cold air and water temperatures tend to reduce the effectiveness of dispersants; for this reason, dispersants probably would not be used in the Sale 170 area.

Gelling agents, emulsion breakers, oil herders, and several other chemicals have been marketed for spill response but are not widely used during offshore-spill responses. None are currently anticipated for use in the event of a large spill in the Sale 170 area.

(7) **Shoreline Response:** If a large spill occurred in the Sale 170 area, some shoreline contacts probably would occur. The techniques for removing oil from shorelines in Alaska are varied depending on the physical properties of the oil, the extent of shoreline oiling, environmental conditions, the type of shoreline to be cleaned, and the logistical requirements. In general, the shoreline-response methods expected to be used in the Sale 170 area include direct suction, small skimmers for pooled oil, the use of sorbent material, cool and warm, high- and low-pressure-water flushing, direct removal of contaminated material and sediments, mixing/aeration of oiled sediment, burning, bioremediation, chemical treatment, and natural degradation (i.e., no response where cleanup action would cause more damage than the oil itself).

(8) **Storage/Disposal:** An important consideration for both planning and executing an oil-spill

response is the interim storage and disposal of recovered oil and oil-contaminated debris. While recovered oil and oil-contaminated debris may be stored in small, collapsible containers that are normally stored as part of the onsite equipment, the problem becomes much larger as the spill size increases. For larger spills, limited storage is available on work boats and drilling units, and additional storage can be made available by using barges in the area of operations. Flexible bladder-type tanks are available from local cooperatives and may be in the inventory of the lessee's onsite-spill-response equipment. For extraordinary spills, additional barges could be moved to the Sale 170 area from other areas of Alaska to facilitate the necessary storage.

Once the oil and debris are collected, disposal options include the use of incinerators, flare burners, and transport to refineries for fluid processing or landfills approved to accept oily waste. Currently, there are no incinerators or disposal sites approved in Alaska that can accept large amounts of oil or oily debris.

c. **Response Deficiencies:** There are several conditions for which current technology cannot effectively clean up an oil spill in the Arctic. The most obvious deficiency would be when both mechanical recovery and in situ burning are not effective. If the oil becomes emulsified, it is difficult to burn. Ignition of an oil slick also is difficult in strong winds. If a spill contaminates an extremely large area of broken or pack ice, and the oil is not concentrated in leads or open areas between the ice, only a very small percentage of the oil can be expected to be recovered by mechanical means. A few skimming systems have been proposed that use ice-strengthened hulls to break up oiled ice and recover the oil. While prototypes of some of these systems have been built and others are planned, they have not been extensively field tested in the Arctic.

In extremely dynamic conditions, especially during early winter storms, freezing ice particles may break up an oil slick into fine droplets and incorporate them into a freezing ice sheet spread over a very large area. Both burning and mechanical recovery would be difficult if not impossible in this condition. In general, if the oil becomes intermixed with the ice and widespread over a large area, and if the oil cannot be burned, then only a very small percentage of the oil could be expected to be recovered.

There also is a need to improve remote-sensing capabilities for oil spilled under ice and in broken-ice conditions. Remote sensing would be a crucial element for successful response to a large spill.

d. **Oil-Spill Response:**

(1) **Locally Available Spill-Response Equipment:** The Alaska OCS Region policy requires that spill-response equipment be staged at the site of operations and that additional equipment be available in the area of operations for a worst-case spill. The onsite equipment is used to clean up operational spills and to serve as the first response effort for a large spill event. The response teams normally are composed of personnel assigned to the platform, drilling vessel, support boat, or barges serving the offshore facility. For a large spill, additional equipment, response personnel, and other resources would be obtained through oil-spill cooperatives and other companies working on the North Slope and throughout Alaska.

Currently, there are three oil-spill cooperatives located in Alaska that have equipment inventories and personnel for mechanical, dispersant, and in situ-burning response. Alaska Clean Seas serves the North Slope, Cook Inlet Spill Prevention and Response Inc. (CISPRI) serves the Cook Inlet Region, and Alyeska Pipeline Service Company/Ship Escort Response Vessel System is responsible for the pipeline corridor and the tanker traffic in Prince William Sound. All three oil-spill cooperatives substantially have increased their equipment inventories since the *Exxon Valdez* ran aground in March 1989. Alaska Clean Seas is well equipped to deal with an offshore spill from OCS operations, although equipment from CISPRI or Alyeska could be used. The USCG also maintains a small cache of equipment in Anchorage that may be used in the event of a spill.

(2) **Response Time:** The Guidelines for Approval of OSCP's set a 6- to 12-hour target-response time for initiating recovery operations with prestaged or onsite response equipment, if local conditions and geography permit. Response time is defined by the guidelines as the time interval between when the spill occurs and when the response equipment initiates recovery at the spill site. When reviewing OSCP's for possible approval, MMS takes numerous factors into account such as slick location with proximity to land or sensitive resources and the predicted spill trajectory from the site of operations. The MMS may increase or decrease the required response time, depending on the outcome of the analysis. Additionally, while neither the guidelines nor the 30 CFR 250.42 contingency-planning regulations require onsite equipment, requirements outlined in the guidelines for onsite oil-spill-response equipment usually are necessary for operators to achieve the response time. Such a requirement, in conjunction with trained spill-response teams at the site of operations, reduces the probability that sensitive areas will be contacted should a spill occur.

(3) **Effectiveness of Oil-Spill Cleanup in the Open Ocean:** There are four accepted approaches for responding to an oil spill in the open ocean—mechanical containment and recovery, chemical dispersion, in situ burning, and the monitor-and-wait/natural-dispersion and evaporation approach. The monitor-and-

wait approach may be used during an oil spill, because the meteorologic and sea conditions preclude safe response operations or because the spill does not and is not predicted to persist or cause effects. However, if the monitor-and-wait response is used because of environmental conditions, some of the natural weathering processes may be increased (i.e., dispersion, evaporation, dissolution, and biodegradation). The effectiveness of each, however, depends on timing, weather, and sea conditions; available manpower and equipment; and a trained response team. Several of the listed factors that affect the recovery of spilled-oil cannot be changed by spill responders. However, the remaining factors—response timing and the availability of equipment and manpower—may greatly affect the effectiveness of a spill response in the open ocean.

Once oil is spilled onto the surface of the water, it spreads by gravity, wind, and currents. As the oil spreads, the slick breaks up into smaller, thinner pieces that cover an increasingly larger area. As such, the most effective mechanical response would be conducted during the early hours following a spill, while the slick is still relatively thick and small in areal extent. Under these conditions, mechanical equipment could spend the majority of time booming and skimming oil rather than chasing individual slicks. Historically, mechanical response has removed 5 to 15 percent (USDOI, MMS, Gulf of Mexico Region, 1983) of the spilled oil from the water surface. For example, during the *Exxon Valdez* oil spill, at-sea recovery of oil was estimated by Exxon at 0.01 percent through the first 2 weeks and 7 percent through the first 3 weeks (Oil Spill Intelligence Report, 1989a,b). The USCG Pollution Reports (U.S. Dept. of Transportation, USCG, 1989) indicate a minimal mechanical-response effort during the first 24 hours of the spill, when the slick was thick, small in areal extent, and conditions were near ideal for a mechanical response. Had a sufficient amount of equipment and personnel been available to respond to this incident during the early hours of the spill before a large amount of spreading had occurred, the initial volume of oil recovered mechanically could have been much higher.

While in situ burning may remove a large quantity of oil from the sea surface with high efficiency (>90% in laboratory and tank tests), it is limited by wind speed (approximately 20 kn); the degree of emulsification of the oil (oil will burn if it contains less than approximately 20-30% water); the current and wave constraints for conventional containment boom and, to a lesser extent time (Allen and Ferek, 1993). In situ burning also may be limited by permit restrictions, such as the direction of the wind and the proximity of the potential burn site to populated areas. Such limitations likely would be established during the permitting process. The 5- to 15-percent recovery figure referenced above does not include the use of in situ burning. Oil-spill-response capabilities have advanced considerably since the 1983 reference providing for improved detection, containment, recovery, and removal options (USDOI, MMS, Alaska OCS Region, 1991). Recent advances in fireproof containment-boom technology have made the in situ burn response a much more attractive option for spill responders. Such advances in spill-response technology, coupled with the increased state of readiness in the sale area and evaporation and natural dispersion, could increase the overall oil removal from the water surface to >50 percent, provided meteorologic and oceanographic conditions allowed a mechanical response. Areas with states of readiness and equipment caches similar to those available in the sale area have experienced such removal during spills. During the *American Trader* spill offshore Huntington Beach, NOAA and the USCG estimate that 69 percent of the spilled oil was removed mechanically, naturally dispersed, and evaporated. In this case, a mechanical response was initiated within 12 hours of the spill, and conditions favorable for mechanical response occurred for 6 days (Card and Meehan, 1991). While cases such as the *American Trader* are not common, the nationwide increase in equipment and readiness likely will cause an increase in such successful responses.

(4) The Role of the Federal Government During an Oil-Spill Response: The Federal Government may become involved in an oil-spill response, depending on the size and location of the spill. The Federal mandate for Federal involvement is set forth in the National Contingency Plan (NCP), 40 CFR 300. The plan sets forth requirements for an ARRT comprised of representatives of Federal Agencies with jurisdiction over the resources at risk. The primary task of the ARRT is to ensure that in the event of an oil or hazardous-material spill, a prudent cleanup effort is launched and spill cleanup is balanced with environmental effects. The policies and procedures that guide the ARRT are set forth in the Alaska Regional Contingency Plan.

In the event of a spill, an FOSC would be appointed based on the location of the spill—for all offshore areas, the FOSC is appointed by the USCG. If the spill threatened State resources, a State On-Scene Coordinator would be appointed by the State of Alaska and would be consulted by the FOSC for all decisions that potentially affect State resources. Prior to the Oil Pollution Act of 1990 (OPA '90), it was the FOSC's mandate to ensure that the spill was being removed in the best possible manner. If the FOSC determined that the spiller was not providing an effective response, the FOSC would either require the spiller to commit additional resources or "federalize" the spill (the Federal Government takes over direction of the response). If the spill were "federalized," it would be the Federal Government's responsibility to clean up the spill to the best of its abilities. The OPA '90 changed the FOSC's authority to allow Federal Government spill mitigation prior to any determination of responsibility or adequacy of the response currently under way.

Included in the FOSC's duties is the regulation of chemical and in situ burning use. Such regulation includes bioremediation chemicals, dispersants, herding agents, and a host of other chemical agents listed on the NCP Product Schedule. According to the NCP, potential approval of the use of chemical agents or burning, where feasible, must be reviewed by the ARRT. While such ARRT approval is prudent, it is time consuming and may preempt the spiller's use of a chemical or burning response. To avoid such delays, the ARRT created dispersant and in situ burn preapprovals for selected areas within Alaska, one of which includes Prince William Sound. The preapprovals provide the FOSC with ARRT concurrence for dispersant or in situ-burning use, depending on the location of the spill and the time of the year. The ARRT continues to examine these and other areas of preapproval to enhance spill response.

5. Major Projects Considered in the Cumulative Case: The analysis of major projects considered in the cumulative case is based on the cost of a barrel of oil ranging between $18 to $30. This range applies only to infrastructure and resources of existing fields. Accordingly, Alternative I is analyzed largely in its relation to existing and producing fields; this analysis does not speculate on development from myriad potential off- and onshore fields. The timing, location, development, resource levels, and infrastructure requirements of these yet undeveloped (if not undiscovered) fields are a matter of extreme conjecture. Therefore, scenarios developed for them may be overdrawn and unrealistic.

a. Current and Projected North Slope Oil Production: Resources forecast for the North Slope (excluding the OCS) range between 6 Bbbl (at $18/bbl) and 11 Bbbl (at $30/bbl). The 6-Bbbl estimate refers to a production forecast for reserves in known and developed fields. The 11-Bbbl estimate refers to reserve additions (acquired by infill drilling and enhanced recovery) in known fields, the development of satellite pools adjacent to existing infrastructure, and the accelerated development of heavy oil accumulations. Ten percent of this range is attributed to offshore State lands. Table IV.A.5-1 shows estimated cumulative-case resource and reserve estimates.

Table IV.A.5-1 Resource and Reserve Estimates Used for Analytical Purposes in the Cumulative Case

	Bbbl Estimated to be Leased, Developed, and Produced
Federal Offshore	0.57 – 1.22
State Offshore	0.60 – 1.10
State Onshore	5.40 – 9.90

Source: USDOI, MMS, 1996, Alaska Report, 1996, and State of Alaska, DNR, 1996.

Since the first production well was drilled on the Prudhoe Bay structure, North Slope fields produced a cumulative total of 10.483 Bbbl of oil (by the end of 1995). Production output on the North Slope peaked in 1988 at 2.0 MMbbl of oil per day and subsequently has declined to 1.4 MMbbl per day. Of the 11 producing fields on the North Slope, the most productive, in order, have been Prudhoe Bay, Kuparuk River, Endicott, and Pt. McIntyre. Figure IV.A.5-1 indicates the location of some of the producing fields as well as recent discoveries within the North Slope petroleum province. The State of Alaska estimates that the combined production from the presently operating and to-be-developed fields will decline to a daily output of 384 MMbbl in 2015. The State expects that cumulative production of oil during 1996 to 2015 will be approximately 6.13 Bbbl (State of Alaska, Department of Natural Resources [DNR], 1996).

During 1996, ARCO announced that the Alpine Prospect, located in the Colville River Delta, was producible and contained an estimated 250 to 300 MMbbl of recoverable reserves. Also, British Petroleum (BP) is developing plans to produce the offshore Northstar Unit. A Developmental EIS is being written, because some of the production would be from Federal tracts. British Petroleum estimates that Northstar will produce 145 MMbbl of oil over 15 years. Additionally, there are a number of ongoing drilling efforts in the Prudhoe-Kuparuk region. Some of the locations of new wells are shown in Figure IV.A.5-1.

b. Past and Projected State Oil and Gas Lease Sales: Since the first State of Alaska lease sale in December 1959, the State has leased tracts of land for oil and gas leasing in excess of 29 million ha. Of that amount, approximately 13.19 million ha were leased through State sales that primarily offered North Slope/Beaufort Sea leases. In the past 11 years, the State has conducted 22 lease sales in the North Slope/Beaufort Sea area, leasing some 7.88 million ha. Currently, active State leases north of the Brooks Range total approximately 6.65 million ha. Of this amount, 934,038 ha are offshore leases, 5.11 million ha are onshore leases, and 609,643 ha are leases composed of both on- and offshore properties.

c. OCS Lease-Sale Activity: Since December 1979, the USDOI has conducted six lease sales in Federal Beaufort Sea waters. The most recent was Sale 144 in September 1996. During this time, 660 leases have been sold totaling 1.14 million ha. Some 28 wells have been drilled on Federal leases, with 9 wells determined as producible. All wells have been plugged and abandoned, because field economics have not been favorable for production. Currently, there are 76 active leases on Federal submerged lands in the Beaufort Sea. Potentially

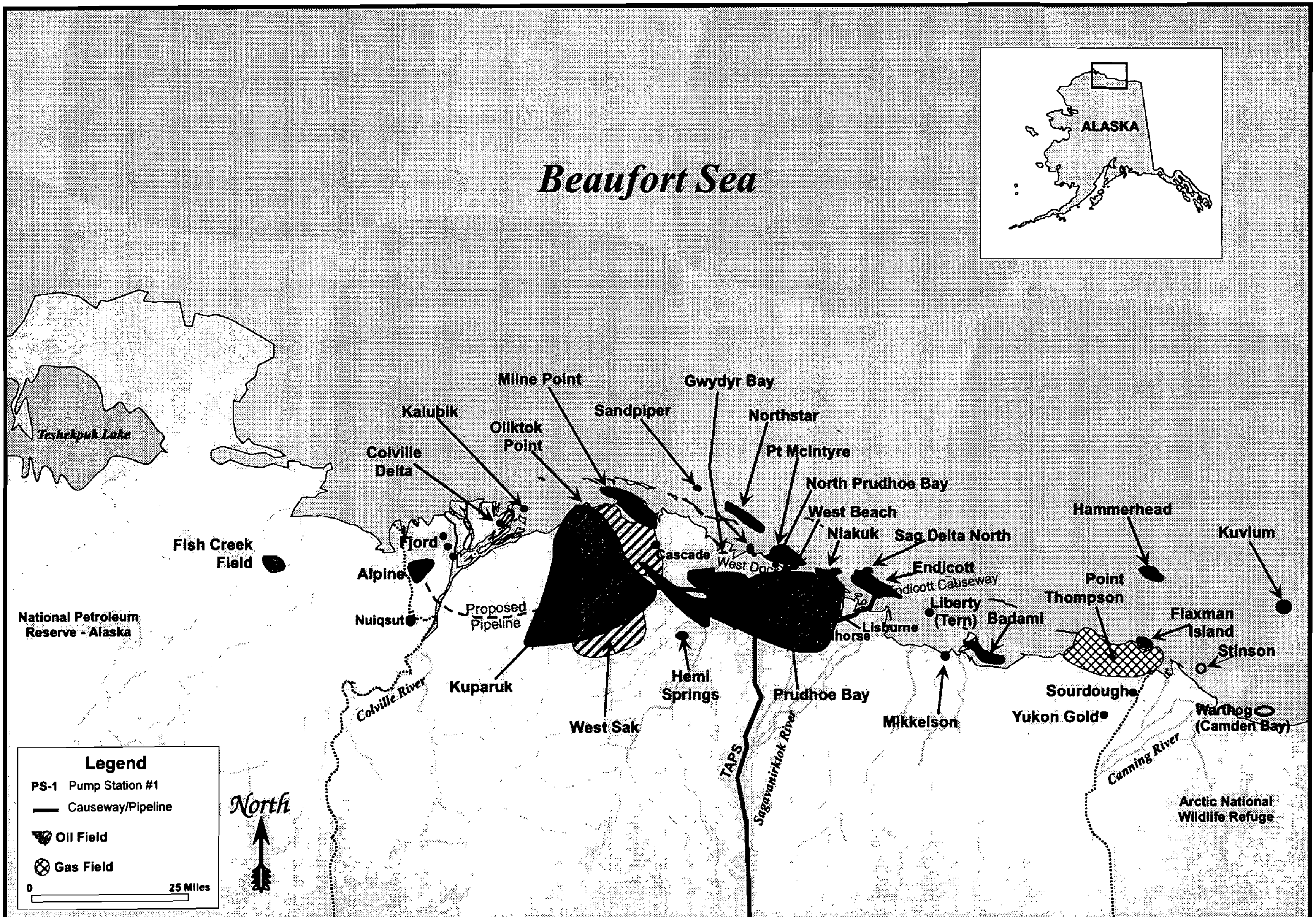

Figure IV.A.5-1 North Slope Oil and Gas Fields

producible prospects within Federal waters lie in the Kuvlum and Hammerhead units (see Fig. IV.A.5-1). However, no adequate resource assessment is available for these two units. The Northstar Unit contains some Federal tracts and, although the majority of submerged tracts comprising this unit lie under State waters, the amount of Federal oil to be produced by this development has yet to be determined. Should the Northstar Unit be developed, a pipeline shore-approach abutment may be constructed just west of Point McIntyre to protect the pipe from nearshore ice forces.

d. National Petroleum Reserve-Alaska: The Bureau of Land Management has announced an intent to prepare an Integrated Activity Plan/EIS on the management of the northeastern portion of the National Petroleum Reserve-Alaska (NPR-A). The 18-month planning process is expected to identify if there are any lands within the planning area suitable for oil and gas development and whether there are any lands within the planning area suitable for additional resource protection. The Record of Decision identifying management actions and activities is scheduled to be published in August 1998.

e. Resource Contribution of the OCS to the Cumulative Case: The Federal OCS contribution to the cumulative case would consist of resources from the Sale 144 area and the full resource range of Sale 170. Beaufort Sea OCS resources under lease, including Sale 144 and existing leases, are 220 to 550 MMbbl. The low end of the range represents potential development at the $18- per-barrel estimate and includes the Liberty Prospect (Tern Island). The $30-per-barrel figure includes discovered but noncommercial fields (e.g., Kuvlum), which are likely to be developed at higher prices. Remaining oil resources available and estimated to be leased, discovered, and developed in Sale 170 are 350 to 670 MMbbl. See Table IV.A.5-1 for cumulative-case resource estimates.

f. Infrastructure and Transportation:. Unless the present level of decline is reversed, North Slope oil production could reach a point, sometime between 2015 and 2020 when, due to falling oil output and rising operational costs, the TAPS may be forced to shut down (perhaps earlier, depending on operational costs). Before 2020, the TAPS flow rate will fall below 350,000 bbl per day. For the system to carry further reduced flow, extensive modifications would be required for both the pipeline and the pump stations. Alternative I (coupled with Sale 144 projected production and other fields such as Alpine), should it occur, could extend the life of the TAPS; however, if more fields were not brought on to support and expand on the resources of Alternative I, the TAPS would become nonoperational or require reconstruction sometime between 2015 and 2020, or perhaps earlier, depending on operational costs. This timeframe is well before the Sale 170 estimated field-termination date of 2027. Given the decline of the North Slope fields and the uncertainty of the North Slope's output being replaced by any other oil formation, it is more than likely that as long as the TAPS is operational, the system will have surplus capacity to process and transport any hydrocarbons produced by Sale 170, Sale 144, or any other projected developmental activity. Regarding the TAPS, it should be noted that State of Alaska estimates for daily North Slope production in the year 2010 were revised from 374 thousand barrels (Mbbl) (estimated in March 1995), to 560 Mbbl per day (April 1996), and then to 645 Mbbl (April 1997) (State of Alaska, DNR, 1995; 1996, 1997).

The contribution of Valdez tanker-transport traffic resulting from Alternative I is expected to range from 10 to 19 tanker loadings in 2004 (field startup), to 45 to 74 in 2011 to 2012 (field maximum), and to 18-40 in 2017 (late maturity/decline). Currently, approximately 600 tanker trips are made annually from Valdez. Given an optimistic estimation of future North Slope production (including offshore) by 2008, oil-tanker traffic from Valdez still could be in the range of 500 to 600 trips annually. Tanker trips generated by Sale 170 may equal 7.5 to 12 percent of all oil transported by tanker from Valdez. By 2017, the transport of oil produced from the proposed Sale 170 area may equal 5 to 10 percent of all oil moved from Valdez. Should all sources (including those from currently undeveloped sources) be recovered, the percentage of tanker traffic related to Alternative I would fall substantially and would become a minor percent of oil-related traffic (see Fig. IV.A.5-2 for oil-tanker routings).

g. Trans-Alaska Gas System (TAGS): If the price per barrel of crude oil reaches or remains close to the high end of the price range ($30), the economic climate may be such that the TAGS may be constructed. Discussed for several years, the TAGS would deliver North Slope natural gas at a rate of 2.3 billion cubic feet per day (bcfd) to a liquefaction plant/terminal located in Valdez. The natural gas would be delivered in a 42-inch (in) pipeline that would be constructed across Alaska immediately adjacent to the TAPS. The proposed project would consist of a 2.1 bcfd natural gas-liquefaction plant, four 800,000 bbl liquefied natural gas- (LNG-) storage tanks, a marine loading facility, and a cargo/personnel loading dock. The proposed LNG plant would be sited in Anderson Bay 3 mi east of the Valdez narrows on the south shore of Port Valdez. The site is 3.5 mi west of the existing TAPS terminal and 5.5 mi from the community of Valdez. When and if completed, the facility would occupy 390 acres of a 2,630 acre site owned by the State of Alaska. A fleet of 15 LNG tankers, each with a capacity of 125,000 m^3, would transport the LNG to destinations in Japan, Taiwan, and Korea. Full project development would require 275 tanker loadings a year (Federal Energy Regulatory Committee, 1995). A final EIS was issued for the TAGS system in

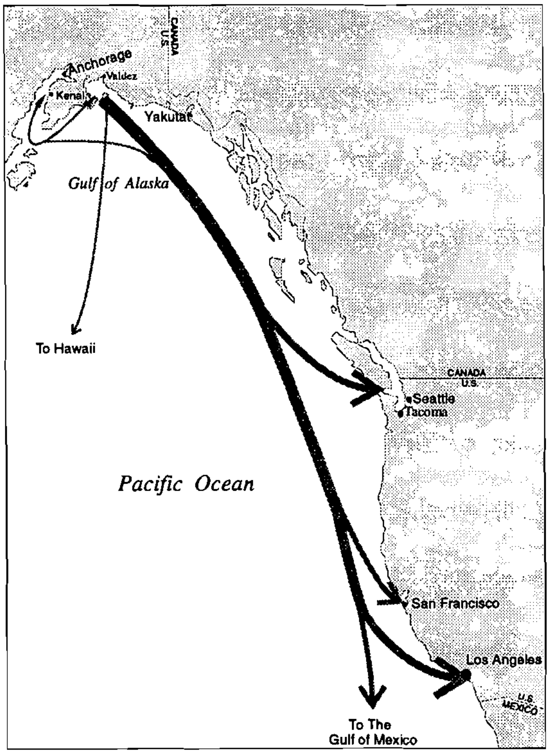

Figure IV.A.5-2 General Tanker Routes and Ports of Entry

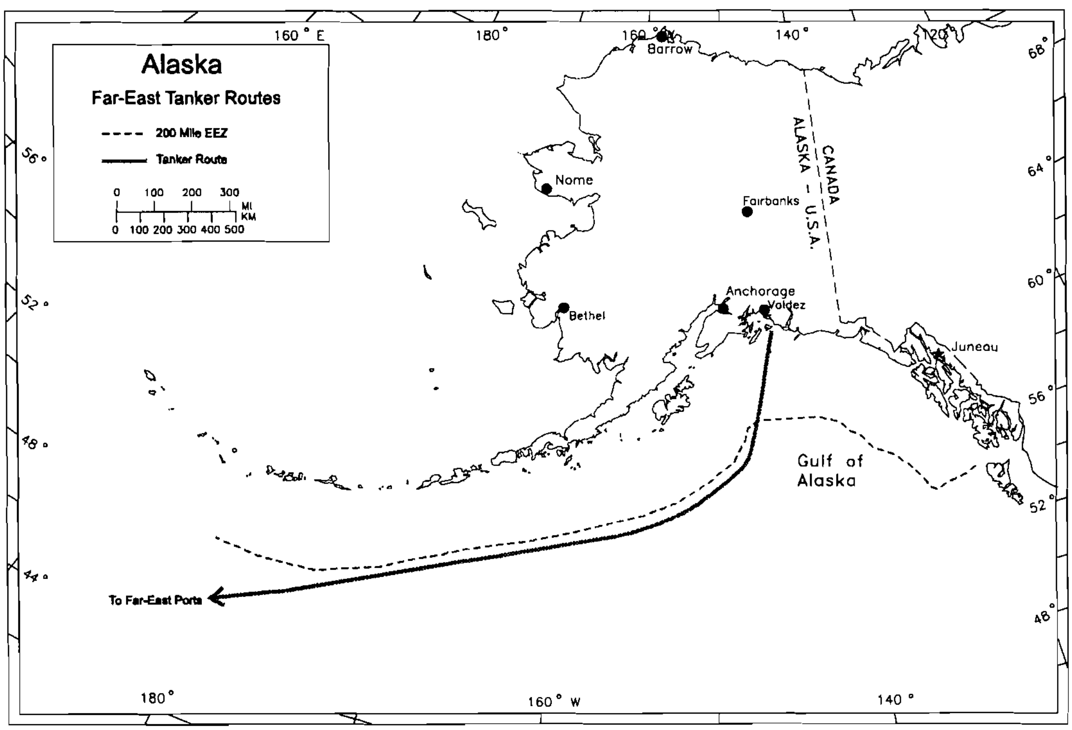

Figure IV.A.5-3 Potential Valdez to Far East Tanker Route

March 1995; however, no agreements have been reached yet with the resource holders.

Potential crude-oil (and possibly LNG) tankerage from Valdez to the Far East will join existing LNG tanker traffic from the LNG plant in Nikiski, Alaska. The Nikiski plant is the U.S.'s only facility that liquefies natural gas. Every 10 days, the Nikiski facility loads an 80,000-m^3 LNG tanker for a round trip to Tokyo. The Nikiski facility has been transporting LNG via tanker to Japan since 1968 without significant spillage. Because LNG would boil off and disburse quickly when exposed to normal air temperatures and North Pacific winds, it is not considered a substantive environmental threat along the tanker route.

On November 28, 1995, President Clinton signed legislation (30 U.S.C. 185(s)) that authorizes the export of Alaskan North Slope crude oil when transported in U.S. flag tankers, unless the President should find such exports are not in the national interest. The lifting of the oil-export ban raises the possibility of some tanker traffic to the Far East from production generated under Alternative I. Figure IV.A.5-3 indicates the probable route that tankers bound from Valdez to the Far East would be traveling, including tankers carrying oil produced under Alternative I. Alaska-generated crude oil being shipped to the Far East along the indicated tanker route is expected to range between 60 and 90 MMbbl through the balance of this century. However, such estimates are highly speculative, as much of the eastbound oil may rely on opportunistic short-term contracts. The routing indicated in Figure IV.A.5-3 would bring the tankers more than 200 mi offshore of the Aleutian Islands. At such a distance, any pollution event is expected to have a minimal effect on the biological resources of the Aleutian Chain.

6. Constraints and Technology: This section incorporates by reference and summarizes the information presented in Section IV.A.5 of the Sale 144 FEIS (USDOI, MMS, 1996a), which describes those environmental features that are considered hazards to petroleum exploitation in the Sale 170 area and the strategies and technologies used to mitigate their effects. The environmental features identified as potential hazards include sea ice, permafrost, waves and currents—especially during storm surges, faults and earthquakes, unstable surface sediments, natural gas hydrates, shallow gases, and erosion. These features are part of the physical environment described in Section III.A of this EIS.

a. Sea Ice: Sea ice is the principal environmental factor affecting the offshore development of petroleum resources in the Beaufort Sea Planning Area. The large, lateral forces that can be exerted by moving ice are a major concern in the design and operation of offshore facilities. The force that moving sea ice exerts on a structure is limited by the strength, size, and shape of the ice and the magnitude of the driving forces. Other concerns associated with sea ice include rideup, pileup, override, and seafloor gouging. The strategies used to mitigate the effects of sea ice are discussed in relation to the technologies and activities associated with exploration, development and production, and transportation of oil.

(1) Exploration: The drilling units that have been used to drill exploration wells in the Beaufort Sea include (1) artificial islands, (2) caisson-retained islands, (3) ice islands, (4) bottom-founded mobile-drilling units, and (5) floating units. Sea-ice forecasting has developed as a strategy to maximize drilling time and to reduce the risks presented by moving sea ice. The ice information is combined with weather forecasts and historical ice movement, wind, and current data to predict sea-ice motion. These forecasts allow time for a well to be safely shut in, if weather and sea-ice conditions become severe enough to threaten the operation. To reduce the threat that sea ice poses to the floating drilling units, icebreakers and icebreaking-supply boats perform ice-management tasks that include breaking up ice around the drillship and breaking, towing, or pushing large floes so that their drift trajectories miss the drillship. To protect the equipment installed at the wellhead on the seafloor from collisions with the keels of drifting ice masses, MMS requires placement of the subsea-blowout preventor (BOP) stacks that are used in areas subject to ice gouging in excavations (glory holes) deep enough so that the top of the stack is below the deepest probable gouge depth.

(2) Development and Production: Production platforms would be larger than exploration units, because space must be provided for (1) drilling a number of production and service wells; (2) locating facilities to separate oil, gas, and water that is produced from the wells; and (3) locating the equipment and wells that may be needed to inject gas and water. Production platforms in the landfast-ice zone may be larger versions of gravel or steel and/or concrete bottom-founded units used for exploratory drilling. Structures contemplated for year-round use in the stamukhi and pack-ice zones would have to resist the forces exerted by thick, first-year and multiyear ice floes and sheets, ridges, and ice islands.

(3) TransportationOffshore Pipelines: The threat that sea ice poses to a marine-pipeline system in the Sale 170 area is indicated by the presence of ice gouges. The area of most intense gouging is the stamukhi zone; the frequency of ice gouging decreases shoreward and seaward of this zone. Burial of the pipeline beneath gouge depth would afford protection from moving ice. Those segments of offshore pipelines that cross the shoreline also must be protected from such sea-ice hazards as gouging, pileups, or rideups. Three of the methods that might be used are burial of the pipeline (1) beneath the offshore sediments and onshore soils, (2) in a causeway, or (3) in a frozen berm.

b. Other Constraints:

(1) Permafrost: Potential hazards associated with the presence of permafrost include thaw subsidence and frost heave; studies to date indicate that the subsea permafrost usually is warmer and more saline than the subterranean permafrost and, thus, is more easily disturbed by thermal disruptions. Thaw subsidence may be caused by activities that disrupt the thermal balance of the permafrost. Such activities include: (1) drilling wells through existing permafrost layers, (2) laying and maintaining crude-oil pipelines, (3) placing and operating bottom-founded gravity structures, and (4) constructing artificial islands and berms. Insulating or isolating facilities from permafrost layers may be one strategy to minimize the potential risk of operating in permafrost areas. Platform sites or pipeline routes may be selected to avoid shallow permafrost areas.

(2) Natural Gas Hydrates: Natural gas hydrates have been encountered in boreholes drilled not only in arctic offshore and onshore environments but also in holes drilled in the seafloor in many other areas throughout the world in recent years. During drilling, the rapid decomposition of the hydrates may cause a rapid increase in pressure in the wellbore, gasification of the drilling mud, and the possible loss of well control. Hydrate zones also may be detected by seismic surveys prior to drilling. The hydrate zone also can be detected by continuously monitoring the drilling muds for gas increases.

(3) Waves, Currents, and Storm Surges—Flooding and Erosion: Excluding storms, available information indicates that waves and currents should not be a major problem affecting offshore operations. In the absence of long-term measurements, it is possible to statistically hindcast the characteristics of wind-driven waves, currents, and storm surges at potential operating sites. Through careful analyses of regional and site-specific environmental data, protective measures can be taken to reduce the effects of moving water.

(4) Faults and Earthquakes: As noted in Section III.A.1.b(5), seismic activity in the Sale 170 area occurs mainly off Camden Bay. Data indicate that the magnitude of the seismic events in this area may not be sufficient to cause structural failure of properly designed platforms or pipelines buried in the seafloor sediments. Because fault surfaces can be detected by seismic surveys, facilities could be located away from potentially active faults or fault systems. The risk of locating facilities near faults is greatly reduced, if they are no longer active. The determination of active faults or fault systems would have to be made, at least in part, by correlating faults with known earthquake epicenters.

(5) Unstable Sediments: The ability of the seafloor sediments to support the weight of the heavy, bottom-founded structures and to resist sliding when sea ice interacts with the structure is an important consideration. Sediment instability and mass movement are related to relatively high seafloor gradients, low sediment strength in fine-grained sediment that retains high amounts of water, sediment loading from waves during the passage of storms, and ground motion during earthquakes. On the continental shelf inshore of the 50-m isobath, the slope of the seafloor generally is very low. Except in the vicinity of Camden Bay, ground motions associated with earthquakes generally are low.

(6) Shallow-Gas Deposits: Sediments in which gas has accumulated are a potential hazard, if they underlie manmade structures or are penetrated during drilling. The presence of gas may lower the shear strength of the sediments and reduce their ability to support structures. If the pressure is high enough, the gas may cause a blowout during drilling. The presence of shallow gas in the sediments of the continental shelf can be determined from seismic profiles.

B. EFFECTS OF ALTERNATIVE I ON:

1. Water Quality:

The agents associated with petroleum exploitation that are most likely to affect water quality are the permitted discharges from exploration drilling units and production platforms, turbidity from construction activities, and hydrocarbons from oil spills. The generic effects of these agents on water quality are described in Sections III.A.5 and IV.B.1.a of the Sale 149 FEIS (USDOI, MMS, 1996b) and Sections III. A.5 and IV.B.1 of the Sale 144 FEIS (USDOI, MMS, 1996a). This information is incorporated by reference into this EIS; a detailed summary of these descriptions, as augmented by additional material, as cited, follows. In the context of this analysis, "regional" effects are those encompassing at least 1,000 km^2 (292 nautical mi^2 [nmi^2]), and "local" effects are those encompassing smaller areas, most frequently a few square kilometers (km^2 = 0.29 nmi^2) or less.

a. Effects of Permitted Discharges:

The permitted discharges would be associated with exploration and development and production operations. Drilling muds and cuttings and produced waters are the most significant discharges associated with offshore operations and have received the most attention; the analysis in this section primarily focuses on these two discharges.

(1) Muds and Cuttings:

The drilling of each exploration or delineation well is expected to result in the discharge of an estimated 630 short tons (dry weight) of mud and 820 short tons (dry weight) of cuttings (Appendix A). During the drilling of production and service wells, the discharge of drilling muds and cuttings is expected to introduce, on a dry-weight basis, an estimated 150 to 680 short tons of drilling-mud components and 1,180 short tons of cuttings per well into the marine environment (Appendix A). The drilling of the production and service wells from the same platform involves recycling some of the drilling muds to drill subsequent wells, and this amount varies from well to well; the amount of mud recycled is assumed to range from 20 to 80 percent (Appendix A).

(a) Exploration:

If only exploration occurs, the total dry-weight discharge for drilling the four exploration and delineation wells is estimated to be 2,520 short tons of drilling-mud components and 3,280 short tons of cuttings during a 8-year period (Table IV.A.1-1). Drilling of the 12 to 16 exploration and delineation wells in the exploration phase of Alternative I is expected to result in the discharge of an estimated 7,560 to 10,0080 short tons of drilling-mud components and 9,840 to 13,120 short tons of cuttings during a 7-year period (Table IV.A.1-1).

Drilling muds used offshore of Alaska are limited to a low level of toxicity by USEPA NPDES permits; in the current permit, the toxicity limit is 30,000 parts per million-(ppm) LC_{50} (concentration at which half the test organisms die within 4 days) (USEPA, 1995). The USEPA will prohibit drilling mud and cutting discharges in water depths <5 m (2.7 fathoms) (USEPA, 1995) in future offshore Arctic exploration. The USEPA estimates this restriction should ensure that Federal water-quality criteria will be met at the edge of the mixing zone (Appendix H: USDOI, MMS, 1996a) and also should lessen the likelihood of elevated trace-metal concentrations persisting in shallow marine sediments (see Snyder-Conn et al., 1990). However, barium discharged in the drilling mud may persist in the marine sediments in deeper waters, and the concentrations may be more than 100 times greater than the concentrations that occur naturally in marine sediments. Natural concentrations of barium in Beaufort Sea coastal sediments range from 185 to 745 (Crecelius et al., 1991). The barium in drilling mud is in the form of barium sulphate—the mineral barite. Barite has a low solubility and relatively high specific gravity, which makes it useful as a material to add weight to a drilling mud. (The solubility of barium sulphate in cold, freshwater is about 0.00222 grams per liter [g/l], which is quite low when compared to the solubility of salt [NaCl]—357 g/l.)

Based on the above information and additional analysis provided by Tetra Tech (1994), the USEPA determined that exploratory discharges are not likely to exceed applicable water-quality criteria outside of a 100-m (328-ft) radius, or 0.03 km^2 (7 acres) around each drilling-discharge site. In drilling the four exploration/delineation wells for an exploration-only situation, it is assumed only one well will be drilled at a time (Table IV.A.1-1); thus, 0.03 km^2 (7 acres) is estimated to be the maximum area where water quality temporarily would be degraded at any one time. For Alternative I, the maximum number of exploratory drilling units that may be present during a single year is estimated to be two; and water quality within an area 0.03 km^2 (7 acres) around each drilling unit, for a total of 0.06 km^2 (15 acres), could be temporarily degraded at any one time.

(b) Development and Production:

1) Muds and Cuttings:

The total dry-weight discharges from drilling 87 to 111 production and service wells are estimated to be between 13,050 and 75,480 short tons of drilling-mud components and 102,660 to 130,980 short tons of cuttings during a 6-year-drilling period (Table IV.A.1-1). These quantities projected to be discharged during the drilling of the production and service wells are small compared with the natural sediment load of the Beaufort Sea Planning Area. Inshore waters of the Beaufort Sea are naturally turbid. The Colville River alone annually carries 9 million metric tons (10 million short tons) of sediment into the Alaskan Beaufort Sea. In addition to the riverborne sediments, coastal erosion, resuspension of sediments by waves and bottom currents, movement of ice keels along the seafloor, and strudel scouring contribute suspended particulate matter (SPM) to the coastal waters of the Beaufort Sea. High turbidity from runoff following breakup on land extends to the 13-m (7-fathom) water-depth contour and limits coastal marine primary production during early summer.

The effects on water quality from discharges of muds and cuttings during production and service well drilling should be about an order of magnitude greater than during exploration, but still only local and short term—on the order of square kilometers [km^2 = 0.29 nmi^2] or less—and would persist over a 6-year period of drilling. As noted in Appendix A, part of the drilling muds can be treated and used to drill other wells. Also, rock cuttings can be pulverized and place in disposal wells; these actions would reduce the amount of cuttings estimated to be discharged into the marine environment. Muds and cuttings that are discharged into the marine environment must comply with the standards in the NPDES permit that authorizes discharges.

2) **Produced Waters:** Produced waters include formation water, injection water, and any chemicals added downhole or during the oil/water separation process; formation waters contain dissolved minerals and soluble fractions of the crude oil. Process equipment installed on the production platform separates the formation water from the oil and treats it for disposal. Treated formation waters may be discharged into the open ocean, reinjected into the oil-producing formation to maintain pressure, or injected into underground areas offshore. Discharge of formation waters would require a USEPA permit and would be regulated so that water-quality criteria, outside an established mixing zone, are not exceeded. To date, for exploration in the Beaufort Sea, the USEPA has prohibited discharge of formation waters into waters <10 m (5.5 fathom) deep. Reinjection and injection projects to maintain field pressure have become almost standard operating procedure. Of the 12 active oilfields in Alaska in 1994, 10 had water-injection projects (State of Alaska, AOGCC, 1995). Formation water from the Endicott Reservoir, the first offshore-producing field in the Beaufort Sea, is reinjected into the oil formation as part of a waterflood project.

The major constraint to underground injection is finding a formation at shallow depth that (1) has a high enough permeability to allow large volumes of water to be injected at low pressure and (2) can contain the water. Also, injection should not be into a formation that might otherwise be a future potable-water supply. If formation waters were reinjected or injected into a different formation, no discharge of formation waters into the marine environment would occur.

Oil and grease concentration in produced waters discharged into offshore areas (i.e., seaward of the inner boundary or the territorial seas) from new facilities are limited to 42 milligrams per liter (mg/l) (42 ppm) daily maximum and 29 mg/l (29 ppm) monthly average for exploration test discharges (40 CFR 435, 1994). The USEPA-approved analytical procedures used to measure oil and grease exclude lower molecular-weight hydrocarbons (<C14), which pose most of the risk to the biota (National Research Council [NRC], 1985). The NRC has estimated that formation waters average 20 to 50 ppm of lower molecular-weight hydrocarbons and 30 ppm of higher molecular-weight hydrocarbons. As noted in Section IV.B.1.c, State of Alaska water-quality standards for marine waters specify that total aqueous hydrocarbons in the water column may not exceed 15 micrograms per liter (μg/l) (0.015 ppm), and total aromatic hydrocarbons in the water column may not exceed 10 μg/l (0.010 ppm).

As oil is pumped from a field, the ratio of water to oil being produced generally increases. The ratio of water to oil for (1) Prudhoe Bay in 1971 was <0.01 while in 1994 the ratio was 1.26, and (2) Kuparuk in 1982 was <0.01 while in 1994 the ratio was 1.14; Prudhoe Bay oil production began in 1969 and Kuparuk began oil production in 1981 (State of Alaska, DNR, Div. of Oil and Gas, 1971; State of Alaska, AOGCC, 1982, 1994). The ratio of total water produced to total oil produced for (1) Prudhoe Bay is 0.35 after 26 years of production and (2) Kuparuk is 0.62 after 14 years of production (State of Alaska AOGCC, 1994). Assuming the water-to-oil ratio is between 0.35 and 0.62, the production of formation waters over the 20 years of production is estimated to range from about 122 to 415 MMbbl. If the oil and grease content in the treated produced waters is 29 mg/l (USEPA monthly average limit), the maximum amount of oil and grease in the produced waters is estimated to range from 562 to 1,913 metric tons (620-2,109 short tons) over 21 years.

If formation waters were discharged into the Beaufort Sea, the effect on water quality would be local but would last over the life of the field(s).

3) **Other discharges:** In addition to the drilling muds and cuttings and formation waters, there are a variety of other permitted discharges associated with exploration drilling and development and production activities. These discharges are expected to represent only small pollutant loadings when properly designed and functioning equipment is used (Appendix J, USDOI, MMS, 1996b). Dispersion in the receiving waters furhter would decrease the concentration of any additives. Seawater is the principal component of most of the discharges—in some cases it is the only constituent.

b. Effects of Disturbances:

(1) **Dredging and Pipelaying:** Dredging would be used primarily for trenching and burial of subsea

pipelines. Dredging also might be used to prepare foundations for the three to five projected production platforms (Table IV.A.1-1), but this latter use would be comparatively small. Pipeline installation would involve greater volumes of dredged materials and greater areal disturbance. The greatest effect on water quality from dredging would be to locally increase the turbidity by increasing the amount of SPM in the water column.

Suspended sediments have very low direct toxicity for sensitive species, with expected toxicity somewhere between that of a clay such as bentonite (LC_{50} >7,500 ppm for the eastern oyster) and that of calcium carbonate (LC_{50} >100,000 ppm for the sailfin molly) (see NRC (USA), 1983). These are very low toxicities, falling into the ranges generally described as slightly toxic to nontoxic. Direct toxicity from suspended sediments, therefore, has not been considered a regulatory issue, and toxic or acute marine standards have not been formulated by either the State of Alaska or the USEPA.

Both State standards and the Federal criterion are directed toward protecting biota from chronic stresses rather than from acute toxicity, but the limits are very different in formulation. One State standard is 25 nephelometric-turbidity units, and the Federal criterion and a second State standard are no more than a 10-percent decrease in the seasonally averaged compensation depth for photosynthetic activity. A third State standard is no more than a 10-percent reduction in maximum secchi disk depth.

For the purpose of analysis, this EIS uses 7,500-ppm suspended solids as an unofficial, acute (toxic) criterion for water quality. This value is the lowest (most toxic) LC_{50} for a clay or calcium carbonate reported in the NRC (USA) (1983) assessment of drilling fluids in the marine environment. Note that USEPA limits drilling-mud effluent to a 30,000-ppm LC_{50} limit prior to discharge dilution in its Arctic General NPDES permit (USEPA, 1995). Thus, exploration drilling mud necessarily will fall into the slightly toxic to nontoxic range and will not pose an acute toxicity risk to the Beaufort Sea.

If oil is found, 64 to 96.5 km (40-60 mi) of offshore pipeline could be laid over a 5-year period (Table IV.A.1-1); trenching and pipelaying rate is estimated to be about 1.3 km (0.62 mi) per day. Experiences with actual dredging or dumping operations in other areas show a decrease in the concentration of suspended sediments with time (2-3 hours) and distance downcurrent (1-3 km [0.5-2 nmi]) from the discharge. Similarly, in the dredging operations associated with artificial-island construction and harbor improvement in mostly sandy sediments of the Canadian Beaufort Sea, the turbidity plumes also tended to disappear shortly after operations ceased; they generally extended a few hundred meters to a few kilometers (km = 0.54 nmi) (Pessah, 1982).

The size, duration, and amount of turbidity depend on the grain-size composition of the discharge, the rate and duration of the discharge, the turbulence in the water column, and the current regime. However, turbidity would not be expected to extend farther than 3 km (2 nmi) from the trenching and dumping operations.

Because pipeline trenching and laying operations are estimated to occur at a rate of 1.3 km (0.7 nmi) per day, the extent of the turbidity plumes would be about 3.9 km^2 (390 ha [960 acres]) at any one time (a 1.3- by 3-km [0.7- by 2-nmi] plume). Pipeline trenching is not expected to introduce or mobilize any chemical contaminants. Sediments in the Beaufort Sea Planning Area contain elevated levels of hydrocarbons, but these levels appear to be natural background and are not derived from atmospheric or North Slope industrial contaminant sources (Sec. III.A.5).

Based on the analysis in this EIS, the increased turbidity from offshore construction activities would be local and short term, exceeding the chronic criterion of a 10-percent temporary change in photocompensation depth over a distance of ≤3 km (≤2 nmi), a local water-quality effect.

(2) **Offshore Structures:** Offshore structures associated with the activity scenario for Alternative I would include platforms to support exploratory drilling operations or development and production facilities and shore-access structures.

As noted in Appendix A of this EIS, manmade gravel islands could be used in waters shallower than about 12 m (40 ft) to support exploratory drilling operations or production platforms. In waters deeper than about 12 m, bottom-founded mobile offshore drilling units may be used to depths of about 25 m (80 ft) for exploratory drilling, and bottom-founded structures may be used to depths of about 38 m (125 ft) to support development and production activities.

Material for constructing the manmade gravel islands probably would be mined at permitted onshore sites and hauled to the island location by truck over ice roads in the winter or by barge in the summer; most of the manmade gravel islands in the Beaufort Sea have been constructed in the winter. Dumping the gravel would create a plume of suspended material with characteristics generally similar to those described for suspended sediments in the preceding section. In the winter, when the under-ice currents generally are less than are the open-water currents of the summer, the plume of suspended material may not last as long nor extend downcurrent from the dump site as far as noted in the preceding section. Also, most of the material used to construct the islands will be gravel, which would decrease the amount of material available for suspension.

Manmade gravel islands used for exploration and/or development and production eventually would be abandoned, and abandonment would include removal of the material used around the island perimeter to prevent erosion. With the removal of the shoreline-protection material, erosion of abandoned manmade islands can result in local but persistent turbidity plumes as the sediments of the islands are reworked by waves and currents for a few to several years.

For some bottom-founded structures, preparatory dredging may be necessary before a structure can be placed on the seafloor. Other bottom-founded structures may have to sit on a gravel berm; construction of the berm would be similar to construction of a gravel island and most likely would occur in the summer. The turbidity associated with these activities would be similar to the material suspension associated with pipeline trenching or gravel island construction previously noted.

Jetties for shore-access may be constructed to protect offshore pipelines in the nearshore/coastal environments from waves, alongshore currents, and moving ice. Long causeways, such as Endicott, are not anticipated because of (1) the cost of construction (including that for breeches), (2) difficulties in getting causeways approved by regulatory agencies' concerns over causeway effects, and (3) improvement of long-reach drilling techniques that allow nearshore structures to be drilled from land. Where possible, offshore pipelines will use existing facilities in the nearshore/coastal area. However, if new shore access structures are required, it is anticipated they will be relatively short (less than several hundred meters long) so as not to significantly affect the nearshore circulation regime. Material for a new jetty would be mined at a permitted onshore site. The waters in a jetty-construction zone are, as previously noted, likely to be turbid, and the increase in turbidity in the water column caused by dumping of the material would be similar to that previously noted for gravel island construction.

c. **Oil Spills:** Accidental oil spills may occur in the sale area as the result of exploration activities and development and production activities; Section IV.A.2. The OSRA estimate (1) for spills <1,000 bbl indicates one spill of 9 bbl during exploration and 85 to 163 spills of 890 to 1,905 bbl during production (Table IV.A.2-3); and (2) for spills ≥ 1,000 bbl, there is an estimated 46- to 70-percent chance of one or more such spills occurring (Table IV.A.2-1). The average size of platform/pipeline spill ≥ 1,000 bbl is assumed to be 7,000 bbl (Sec. IV.A.2.a(1)). The analysis of the effects of these spills on water quality does not consider the effects oil-spill-cleanup measures could have in reducing the volume of oil that has been released into the water column; effectiveness of oil-spill-cleanup measures are discussed in Section IV.A.4. The fate of petroleum in seawater is discussed in Section IV.A.3.

Following spills, water-column concentrations of hydrocarbons are difficult to compare to Federal water-quality standards because of ambiguity in the standards. Federal standards are set at 0.01 of the applicable LC_{50}: no absolute Federal concentration standard exists for hydrocarbons (USEPA, 1986). The LC_{50} is the continuous- flow, 96-hour lethal concentration at which half the organisms die. "Applicable" in this case refers to lifestages of species identified as the most sensitive, biologically important species in a particular location. Applicable ambient-water-quality standards for marine waters of the State of Alaska are (1) total aqueous hydrocarbons in the water column may not exceed 15 μg/l (0.015 ppm); (2) total aromatic hydrocarbons in the water column may not exceed 10 μg/l (0.010 ppm) and (3) surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration (State of Alaska, Dept. of Environmental Conservation [DEC], 1995). The State of Alaska criterion of a maximum of 0.015 ppm of total aqueous hydrocarbons in marine waters—about 15-fold background concentrations—provides the readiest comparison and is used in this discussion of water quality. This analysis considers 0.015 ppm to be a chronic criterion and 1.5 ppm—a 100-fold higher level—to be an acute criterion.

Major spills generally result in peak dissolved-hydrocarbon concentrations that are only locally and marginally at toxic levels—parts per million or more. The concentration of oil from the *Argo Merchant* spill (0.18 MMbbl) ranged relatively low, from 0.090 to 0.170 ppm at the surface and up to 0.340 ppm in the water column (NRC, 1985). At several of the sampling stations, the concentrations were uniform to a water depth of 20 m (11 fathoms). Concentrations of oil in water from the *Amoco Cadiz* spill (1.64 MMbbl) ranged from 0.002 to 0.2 ppm in the nearshore area to 0.03 to 0.5 ppm in the estuaries (Gundlach et al., 1983). Volatile liquid hydrocarbons in the *Ixtoc* spill (3.33 MMbbl) decreased from 0.4 ppm near the blowout to 0.06 ppm at a 10-km (5.4-nmi) distance and to 0.004 ppm at a 19-km (10-nmi) distance (NRC, 1985). Similarly, relative and rapid decreases also were found for specific toxic compounds such as benzene and toluene. Concentrations of volatile-liquid hydrocarbons—present mostly as oil-in-water emulsion—within 19 km (10-nmi) of the *Ekofisk Bravo* blowout in the North Sea ranged up to 0.35 ppm (Grahl-Nielsen, 1978). Lesser amounts of oil (probably <0.02 ppm) were detectable in some samples at a 56-km (30-nmi) distance but not at an 89-km (48-nmi) distance.

In the *Exxon Valdez* oil spill (EVOS) (0.258 MMbbl), concentrations of hydrocarbons in the water were not measured in the first 6 days of the spill. However, Wolfe et al. (1994) used an earlier version of the MMS weathering model (Payne et al., 1984) to estimate water concentrations after passage of the storm on the third day of the spill, arriving at an average value of 0.8 ppm within the top 10 m (5 fathoms) of the water, within the "effective" or discontinuous spill area. Wolfe et al. also summarize the actual measurements made in Prince William Sound. Seven to 11 days after the spill, residual concentrations ranged from 0.067 to 0.335 ppm petroleum hydrocarbons, 0.0015 ppm volatile organic analytes (mostly mononuclear aromatics), and 0.001 to 0.005 ppm polynuclear aromatic hydrocarbons (PAH). Concentrations in Prince William Sound decreased to levels below the chronic criteria levels of concern, to between 0.001 and 0.006 ppm petroleum hydrocarbons and 0.0001 ppm PAH after 21 to 41 days. The concentration decreases within these timeframes were attributable to advection and dilution, not decomposition.

In restricted waters under very calm seas, lack of vertical mixing and dilution can result in higher concentrations, 1 to 3 ppm, within the top 1 to 3 m and persist for a day a layer (Baffin Island Oil Spill Project; Humphrey et al., 1987).

The concentrations of oil in the water column are relatively low, because oil is only slightly soluble in water and vertical—and especially horizontal—dispersion and consequent dilution would rapidly decrease hydrocarbon concentrations for all but the largest spills in several hours. For spills of the magnitude of the EVOS, hydrocarbon concentrations could remain elevated above chronic criteria for as long as 10 to 20 days. Aromatic compounds are the most toxic constituents of crude oil, partly because they are the most soluble constituents. The highest rates of dissolution of aromatics from a slick and, consequently, accumulation in underlying water occur in the first few hours after a spill (Payne, 1987). The bulk of these volatile compounds are lost in <3 days; and 3-day trajectories (Sec. IV.A.2) have been judged the appropriate length to approximate the initial, higher toxicity of spills in Alaskan waters.

At sea, water depth and shoreline do not restrict movement of slick or water, and the slick and underlying water generally move at different angles to the wind. The rate of horizontal dispersion or mixing in the ocean is orders of magnitude greater than the rate of vertical dispersion. By the time dissolved oil worked down 10 m (5 fathoms) in the water column, it would have spread horizontally and been diluted over a distance of perhaps 10,000 m (33,000 ft). The slick itself would become patchy, with the total area containing the widely separated patches of oil being orders of magnitude larger than the actual amount of surface area covered by oil.

If the spilled oil were of a composition similar to that of Prudhoe Bay crude, about 40 percent of the spilled oil could persist on the water surface, dispersed into individual tarballs, after the slick disappeared. Slow photo-oxidation and biological degradation would continue to slowly decrease the residual amount of oil. Through 1,000 days, about 15 percent of the tarballs would sink, with an additional 20 percent of slick mass persisting in the remaining tarballs (Butler, Morris, and Sleeter, 1976, as cited by Jordan and Payne, 1980). Because of the drift of the oil over distances of hundreds or thousands of kilometers (1000 km = 540 nmi) during the slow process of sinking, individual, sunken tarballs would be extremely widely dispersed in the sediments, at concentrations on the order of some fraction of a tarball per hectare (per 2 acres).

The "average" levels of local or regional contamination in sediments would be insignificant. Suspended loads of sediment away from the shoreline (<100 ppm dry weight) are not high enough to significantly enhance oil removal from the slick or water column (see Payne et al., 1989; Boehm, 1987). Only if oil were mixed into the shoreline and then dispersed offshore could elevated concentrations of hydrocarbons locally occur. Regional contamination of offshore sediments would not be detectable.

Under ice, the volatile compounds from a spill would be more likely to freeze into the ice within hours to days rather than dissolve or disperse into the water underneath the ice. After onset of melt, oil spilled under ice generally tends to reach the ice surface in an unweathered state. However, once formed, a hydrocarbon plume in the water column underneath the ice would persist above ambient standards and background over about a 5-fold greater distance than under open water (see Cline, 1981).

The characteristics of a 7,000-bbl oil spill in the summer and during meltout are shown in Table IV.A.3-1.a. Based on these characteristics, the estimated concentration of oil dispersed in the water column for a summer spill after (1) 3 days is estimated to be 1.74 ppm (assuming a 2-m dispersal depth), (2) 10 days is estimated to be 0.33 ppm (assuming a 5-m dispersal depth), and (3) 30 days is estimated to be 0.07 ppm (assuming a 10-m dispersal depth). If the spill occurred in the spring during melting, the environmental conditions affecting the characteristics of a spill would be different than those of summer (Table IV.A.3-1a). The estimated concentration of oil dispersed in the water column for a meltout spill after (1) 3 days is estimated to be 5.65 ppm (assuming a 2-m dispersal depth), (2) 10 days is estimated to be 0.88 ppm (assuming a 5-m dispersal depth), and (3) 30 days is estimated to be 0.13 ppm (assuming a 10-m dispersal depth).

The high concentrations of oil associated with estimating dispersal in the water column may represent an upper range of dispersed-oil concentrations reached during the first several days following a large spill. These concentrations are greater than the 0.015 ppm that was assumed to be the total hydrocarbon chronic criterion and, after 3 days, less than the 1.50 ppm that was assumed to be the acute criterion. Both the summer and meltout concentrations of oil that are estimated to be dispersed in the water column after 30 days, 0.07 and 0.13 ppm, respectively, are within the range of concentrations reported for the larger *Argo Merchant* and *Amoco Cadiz* spills noted previously in this section. However, these concentrations are much greater that the previously noted concentrations of petroleum hydrocarbons, 0.001 to 0.006 ppm, in Prince William Sound 21 to 41 days after the EVOS. The estimated concentration of dispersed oil in the water 30 days after both the summer and meltout spills is >0.015 ppm and indicates a relatively long period of time, perhaps about a month or more, before dilution of the dispersed oil reduces the concentrations below the chronic criterion.

Summary: The agents associated with petroleum exploitation that are most likely to affect water quality are the permitted discharges from exploration drilling units and production platforms, turbidity from construction activities, and hydrocarbons from oil spills. The permitted discharges are regulated by USEPA such that any effects on water quality would be local; water-quality criteria must be met at the edge of the mixing zone established by the USEPA-issued NPDES permit.

For exploration only, the total dry-weight discharge for drilling the four exploration and delineation wells is estimated to be 2,520 short tons of drilling-mud components and 3,280 short tons of cuttings during a 8-year period. Drilling of the 12 to 16 exploration and delineation wells in the exploration phase of Alternative I is expected to result in the discharge of an estimated 7,560 to 10,080 short tons of drilling-mud components and 9,840 to 13,120 short tons of cuttings during a 7-year period. The total dry-weight discharges from drilling 87 to 111 production and service wells are estimated to be between 13,050 and 75,480 short tons of drilling-mud components and 102,660 to 130,980 short tons of cuttings during a 6-year-drilling period.

Water quality within an area 0.03 km^2 around each exploratory drilling unit or production platform could be temporarily degraded during active discharge of drilling muds and cuttings. The toxicity of the drilling muds generally is low, and the concentrations of the bulk constituents become nontoxic at the dilutions reached shortly after discharge. Most of the solids in the discharges settle rapidly to the seafloor, where bottom currents disperse the finer particles. During exploration, the area affected by drilling-muds and cuttings discharges could range from 0.03 to 0.06 km^2 at any one time. Discharges from drilling the production and service wells could affect, at any one time, a total area of 0.06 to 0.12 km^2.

Produced waters constitute the largest source of substances discharged into the marine environment, and their discharge is an issue of significant concern because of the types and amounts of naturally occurring substances they may carry and the manmade substances that may be added. As oil is pumped from a field, the ratio of water to oil being produced generally increases. The toxicity of produced waters mainly is caused by hydrocarbons that include nonvolatile hydrocarbons (EPA oil and grease) and aromatic hydrocarbons. Oil and grease concentrations in formation waters discharged into the Arctic marine environment would be limited to 29 mg/l (29 ppm) monthly average by the current Arctic NPDES General Permit. Assuming the water-to-oil ratio over the life of the field is between 0.35 and 0.62, the production of formation waters over the life of the field is estimated to range from about 122 to 415 MMbbl. Based on this monthly average concentration limit, the produced waters would contain as estimated 562 to 1,913 metric tons of oil and grease. Produced waters, if discharged into the marine environment, would result in local pollution but the discharge would be regulated by USEPA NPDES permit.

The turbidity in the water column would be increased over several square kilometers km^2 = 0.29 nmi^2 in response to (1) trenching and laying 64 to 96.5 km of offshore pipeline; (2) dumping gravel to construct shore-access structures or manmade gravel islands or foundations for bottom-founded mobile offshore drilling units, if these structures are used to drill any of the exploratory/delineation wells; and (3) dredging if the characteristics of the seafloor need to be altered for the installation of the three to five production platforms. The increased turbidity would last only while the activity persisted.

The number (86-164) of exploration and production small spills (<1,000 bbl) anticipated over the production life of the field could result in local, chronic hydrocarbon contamination of water within the margins of the oilfield. A spill of 7,000 bbl could temporarily, about a month, contaminate water in an estimated area <400 km^2 above the chronic criterion of 0.015 ppm. Concentrations above the 1.5-ppm-acute criterion may occur in an area <75 km^2 during the first several days of a spill. Regional, long-term degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely.

Conclusion: Contaminants from permitted discharges over the life of the field and offshore construction activities for several years could exceed sublethal levels over a few square kilometers. Hydrocarbons from (1) small spills (<1,000 bbl) could result in local, chronic hydrocarbon contamination of water within the margins of the oilfields; and (2) a large oil spill (≥1,000 bbl) could exceed the 1.5-ppm-acute toxic criterion during the first several days of a spill and the 0.015-ppm-chronic criterion for about a month in an area of about 400 km^2. A spill ≥1,000 bbl is estimated to have a 46- to 70-percent chance of occurrence. Regional water quality would not be affected.

2. Lower Trophic-Level Organisms: Lower trophic-level organisms (phytoplankton, zooplankton, epontic, and benthic) in the Beaufort Sea are described in Section III.B.2. Activities that may affect lower trophic-level organisms include drilling discharges, seismic surveys, construction, and those associated with an accidental oil spill. The short-term effects of these activities and the chemical agents associated with them, have been discussed in former Beaufort Sea EIS's (USDOI, MMS, 1996a is the most recent), which are herein incorporated by reference and summarized below. The following analysis focuses on differences in the amount of exposure lower trophic-level organisms would have to these activities and agents, for the specific resource-recovery range associated with Alternative I (350-670 MMbbl).

a. Effects of Discharges: The types of material discharged while drilling include drilling muds and cuttings; during production, the main discharge is produced waters. These discharges contain small amounts of hydrocarbons and create plumes of material that disperse rapidly in the water column. In most continental shelf areas, most drilling muds and cuttings land on the sea bottom within 1,000 m of the discharge point. The effect of drilling discharges on lower trophic-level organisms appears to be restricted to benthic organisms living nearest the discharge source. There is no evidence of effects on plankton from drilling muds (Neff, 1991).

Based on studies results, drilling discharges associated with both the low and high ends of the resource-recovery range are estimated to affect <1 percent of the benthic organisms in the sale area and none of its plankton. Benthic organisms within 1,000 m of a platform are expected to experience mostly sublethal effects, with some lethal effects on immature stages. Within this distance, some changes are expected in the species composition of affected benthic areas. Recovery of the affected benthic communities is expected to occur within 1 year after drilling discharges cease.

b. Effects of Disturbances:

(1) Effects of Seismic Surveys: Seismic surveys are expected to have little or no effect on plankton, because the energy sources (airguns) do not appear to have any adverse effect on this group of organisms. In general, even high explosives have had relatively little effect on marine invertebrates. In an experiment by Aplin (1947, as cited by Falk and Lawrence, 1973), lobsters 15 m (50 ft) away from a 90-pound (lb) dynamite charge showed no ill effects. Airguns, which are much more innocuous for fish than explosives, also were shown to have no effect on caged oysters placed close to the airgun (Gaidry, unpublished, cited by Falk and Lawrence, 1973). Based on the lack of apparent effect of seismic surveys on lower trophic-level organisms, and the relatively small amount of expected seismic activity, seismic activities associated with the low and high ends of the resource-recovery range are expected to have little or no effect on lower trophic-level organisms.

(2) Effects of Construction: This activity involves the placement of bottom-founded production platforms and pipeline laying. These activities normally would affect only benthic invertebrates and marine plants in the immediate vicinity. Construction is expected to have little or no effect on phytoplankton or zooplankton communities in the Sale 170 area. However, dredging can affect benthic invertebrates and marine plants by physically altering the benthic environment, increasing sediments suspended in the water column, and killing organisms directly through mechanical actions (Lewbel, 1983). Platform placement and pipeline laying is expected to kill the less-mobile benthic organisms in their path. The more-mobile organisms are expected to avoid these areas of disturbance and are not expected to be affected. On the beneficial side, platforms add a three-dimensional structure to the marine environment, thereby providing additional habitat for those marine invertebrates and plants that require a hard, secure substrate for settlement. Hence, the overall effect of a platform would be to alter species diversity near the platform in favor of organisms requiring hard substrates over those that do not.

Most locations within the sale area support few benthic invertebrates and marine plants. No construction activities are expected in areas where benthic invertebrates and marine plants are more concentrated (e.g., boulder patch areas). Less than 1 percent of the immobile benthic organisms in the sale area would be affected by platform and pipeline construction associated with Alternative I. Because of the small area affected by platform and pipeline construction and the low density of benthic marine organisms in the sale area, construction is expected to have little adverse effect on lower trophic-level communities. Less than 1 percent of the immobile benthic organisms would be affected (mostly sublethal effects). Immobile benthic communities affected by pipeline construction are expected to recover in <3 years. Production platforms would benefit marine invertebrates and plants requiring attachment and would be colonized by them within 1 or 2 years. The beneficial effects at the high end of the resource-recovery range would be nearly twice that at the low end of the resource-recovery range, because production at this level involves five production platforms rather than three.

c. Effects of Oil: This section addresses the potential effects of an accidental 7,000-bbl oil spill on lower trophic-level organisms. The following analysis (1) summarizes the effect of exposing lower trophic-level organisms to petroleum-based hydrocarbons, (2) factors in the estimated amount of contact associated with the low and high ends of the resource-recovery range, and (3) estimates the corresponding overall effect on lower trophic-level communities.

(1) Planktonic Communities: Some hydrocarbons are naturally produced by phytoplankton; and many have been found to be the same as, or similar to, those found in crude oil (Davenport, 1982). Some hydrocarbons, therefore, are considered a normal part of the chemical makeup of phytoplankton. Hence, hydrocarbons occurring in the water column that are similar to those occurring naturally in phytoplankton are expected to have little effect on phytoplankton. Other petroleum-based hydrocarbons (e.g., chlorinated hydrocarbons) are not of natural origin and may have adverse effects on some phytoplankton, even at low concentrations.

Effects on phytoplankton vary widely, depending on the concentration and type of oil or compounds used in the experiments and on the species being tested (NRC, 1985). Nevertheless, general patterns do exist, and both laboratory and field studies have shown that hydrocarbons typically inhibit phytoplankton growth at higher concentrations, but sometimes enhance growth at lower concentrations. Growth inhibition and/or mortality in phytoplankton have been noted to occur at hydrocarbon concentrations of 1 to 10 ppm. Growth enhancement has been noted at concentrations of ≤ 0.1 ppm (NRC, 1985). In terms of data collected during an oil spill or field study, large-scale adverse effects on plankton have not been reported (NRC, 1985). Observations of phytoplankton biomass and primary productivity following the *Tsesis* spill (in Sweden in 1977) revealed no significant differences between noncontaminated and contaminated areas (Johansson et al., 1980, as cited in NRC, 1985:442). In cases where studies have been conducted following an oil spill, this lack of substantial adverse effects on plankton populations from spilled oil is common. Even if it is assumed that a large number of phytoplankton are contacted by an oil spill in an open-ocean area, the regeneration time of the cells (9-12 hours) and the rapid replacement of cells from adjacent waters are expected to preclude any major effect on phytoplankton communities (NRC, 1985). Further, the vertical distribution of most phytoplankton in the water column typically is below the area where they would be adversely affected by hydrocarbons associated with an oil spill. For these reasons, a large oil spill associated with Alternative I is not expected to have a significant effect on phytoplankton. Recovery from the effects of a large oil spill is expected to take only 1 to 2 days.

The effects of petroleum-based hydrocarbons on zooplankton have been observed in the field at spill sites and also in the laboratory. It should be noted that some zooplankton have the ability to metabolize and detoxify some types of hydrocarbons, and that this ability varies between species. The observed vulnerability of zooplankton to hydrocarbons (dispersed and dissolved) in the water column varies widely. Lethal hydrocarbon concentrations for zooplankton range from about 0.05 to 10 ppm, which is similar to that expected for other small floating organisms (e.g., fish eggs and larvae and crustacean larvae). Sublethal crude-oil concentrations for zooplankton range from about 1 ppm to well below 0.05 ppm (NRC, 1985). Sublethal effects include lowered feeding and reproductive activity, altered metabolic rates, and community changes. Lethality and sublethality are dependent on exposure time, hydrocarbon toxicity, species, and lifestage involved (early stages are most sensitive).

Field observations of zooplankton communities at oil spills and in chronically polluted areas have shown that the communities were affected, but that these effects appeared to be short-lived (Johansson et al., 1980). Individuals within chronically polluted areas have experienced direct mortality, external contamination by oil, tissue contamination by aromatic constituents, inhibition of feeding, and altered metabolic rates. However, because of their wide distribution, large numbers, rapid rate of regeneration, and high fecundity, zooplankton communities exposed to oil spills or chronic discharges in open-water areas appear to recover (NRC, 1985). In areas where flushing rates and water circulation are reduced, the effects of an oil spill are expected to be greater, and recovery of zooplankton biomass and standing stocks are expected to take somewhat longer.

In general, the fate of the oil associated with a large oil spill would depend on wind speed and duration, air and water temperature, and the composition of the oil. However, based on the assumptions associated with weathering 7,000-bbl of Prudhoe Bay crude oil (Table IV.A.3-1), within 10 days of the 7,000-bbl spill (winter), 10 percent of the oil would have evaporated, 57 percent would remain on the surface, and 32 percent would be dispersed into the water column. Dispersed and/or dissolved oil in the water column has the greatest potential of adversely affecting phytoplankton and zooplankton. Surface oil and that fraction that evaporates rarely would contact plankton, because plankton typically are beneath the surface.

The area most likely to be contacted by a 7,000-bbl oil spill would be some portion of the sale area (6,883 km^2). If it is assumed that the surface slick from a 7,000-bbl oil spill is about .5 millimeters in thickness, a winter-meltout spill would cover a discontinuous surface area of about 75 km^2 after 10 days (Table IV.A.3-1). If it is further assumed that all of the dissolved and dispersed oil from a 7,000-bbl spill is found in the first 5 m of the water column, that the hydrocarbon concentration in this 5-m zone is about 0.1 ppm, and that all of the water under this area is phytoplankton and/or zooplankton habitat, the spill would contact about 1.1 percent (75/6,883 x 100) of the available plankton habitat in the sale area down to 5 m in depth. Based on the same assumptions, a summer spill (the period when plankton would be most numerous) would cover an estimated discontinuous surface area of 96 km^2 after 10 days, or about 1.4 percent of the available plankton habitat down to 5 m in depth.

These estimates assume that all plankton under the affected surface areas (1.1% of the sale area in winter or 1.4% in summer) are inhabiting the assumed 5-m zone. However, this is unlikely to occur, because plankton typically are distributed much deeper than this in the summer, and in the winter their habitat size is greatly reduced (light limited) by ice cover. More realistically, summer phytoplankton and zooplankton in the area would be found to depths from 10 to 30 m (depending on water clarity). Hence, in areas where plankton were found to 10-m depths, only 50 percent of their number under the oiled surface area—or about .7 percent (.50 x 1.4%)—of the sale area's summer plankton population would be contacted. In areas where plankton were found to 30-m depths, only 16.7 percent (5/30 x 100) of their number under the oiled surface area—or about .23 percent (.167 x 1.4%)—of the sale area's summer plankton population would be contacted. This of course assumes that all of the plankton are evenly distributed throughout these depths and that the concentration of hydrocarbons in the first 5 m of the water column is uniform at 0.1 ppm. However, prior oil-spill measurements have shown that the concentration of hydrocarbons in the water column falls off rapidly just under an oil slick, is not uniform throughout the water column (vertical mixing greatly reduces it), and seldom would be much above background levels below 20 m in depth. Further, phytoplankton and zooplankton typically are very patchy in their horizontal distribution; and in many cases, there would be few plankton under portions of an oil slick.

Hence, it can be seen that contact with either .7 percent of the area's summer plankton for 10-m depths, or .23 percent where they exist down to 30 m, is conservative. More realistically, it is expected that the actual percentage of phytoplankton and zooplankton contacted by an oil spill (summer or winter) would be even less than these percentages. Regarding the actual concentration of oil in the water column from a 7,000-bbl spill, extensive water sampling following the (EVOS revealed that hydrocarbon levels in the water column were well below (about 10-1,000 times below) the levels known to be toxic, or to cause sublethal effects in plankton, and returned to background levels (0.20 parts per billion) in less than a month (Neff, 1991). However, because the water samples were taken a week or more after the spill, it is unclear what the actual hydrocarbon concentrations were during and immediately following the EVOS. Thus, for purposes of this assessment, hydrocarbon concentrations in the water column during and immediately following a 7,000-bbl oil spill are conservatively assumed to be initially harmful to phytoplankton and zooplankton (exceeding 0.1 ppm but for <5 days; Meyer, 1990).

The likelihood of plankton populations being adversely affected by a 7,000-bbl oil spill would be greatest during the summer, when they are most abundant. If a large spill occurred during this period, <1 percent of the plankton in the sale area are estimated to experience sublethal and/or lethal effects, as explained above. Phytoplankton are expected to recover within 1 or 2 days through regeneration and replacement from adjacent waters, whereas zooplankton recovery may require up to 1 week. Recovery in embayment areas where water circulation is reduced is expected to take up to 2 weeks. Small oil spills may adversely affect plankton in the area immediately around the spill, but they are not expected to have a measurable effect at the population level.

(2) **Epontic Communities:** Epontic (under-ice) communities are transient in the nearshore areas of the Beaufort Sea. Oil spilled onto the surface of the ice would reduce the light reaching the epontic algae, resulting in lowered productivity. If oil were spilled under the ice and trapped directly beneath it, most epontic organisms living there likely would be killed. Oil trapped in this way is expected to become encapsulated within the ice with increasing time. If oil on, in, or under the ice is released during breakup, effects of this nature could occur in other nearby epontic communities. However, if a large oil spill occurred, it is estimated that <5 percent of the epontic community in the sale area would be affected this way.

(3) **Benthic Communities:** This section considers the effects of petroleum-based hydrocarbons on marine plants (other than phytoplankton) and invertebrates associated with Alternative I. Benthic communities are higher in the marine food web than plankton, with some forms feeding on plankton and others feeding at higher trophic levels. Many benthic species are fed upon by higher food-web species, such as marine fishes, birds, and mammals. Benthic flora, such as that found in the Boulder Patch, also provides shelter for small fish and invertebrates and decreases erosion and turbidity. Hence, any significant effect on benthic-level organisms (natural or unnatural) would be expected to have an effect on higher trophic levels as well.

In the marine environment, hydrocarbons resulting from an oil spill are broken up by wave action into floating surface oil, dispersed and dissolved oil within the water column, and oil that is incorporated into bottom sediments. Marine plants and animals are affected most by floating surface oil and oil that is being incorporated into bottom sediments through wave action. In marine environments that have distinct intertidal and subtidal floral and faunal communities, the most persistent effects often occur when intertidal and shallow subtidal benthic communities are contacted by oil, particularly in areas where water circulation is restricted (e.g., bays, estuaries, mud flats, and rock armored shorelines).

(a) **Marine Plants:** What is known about the effect of crude oil on marine plants has come largely from observations following oil spills. Both lethal and sublethal effects have been observed. Effects vary considerably depending on plant species, type and concentration of oil, and the timing and duration of exposure. Following the EVOS, the recolonization of heavily oiled intertidal rocky habitat began the first year after the spill (Duncan, Hooten, and Highsmith, 1993; van Tamelen and Stekoll, 1993), and complete recovery was expected in 5 to 6 years. It should be noted that most areas that were oiled by the EVOS but were not high-pressure washed recovered to prespill conditions by 1991. Further, all dominant flora and fauna (except barnacles) that were high-pressure washed suffered 60 to 100 percent mortality and, to date, have not recovered (Houghton et al., 1996). Hence, the high-pressure shoreline treatment associated with the EVOS appears to have had a much greater effect on lower trophic-level populations than the oil itself. Observations like these have shown that while marine plants often are adversely affected by oil, they are not always affected in a substantial way. Further, in the areas that were substantially affected by oil, recovery to prespill conditions were likely to occur within 3 years (much longer if high-pressure washed).

However, in the Beaufort Sea there is no intertidal zone in the traditional sense. This is due to the annual predominance of shorefast ice, which precludes marine plant life and most fauna along the shoreline. Nevertheless, marine plants do exist subtidally at a few locations in the Beaufort Sea, such as the Boulder Patch community in Stefansson Sound. The estimated effect of a large oil spill on subtidal marine plants in the Beaufort Sea area depends on the type and amount of oil reaching them. However, the only type of oil that can reach marine plants in the subtidal zone (most are 5-10 m deep) would be highly dispersed oil having no measurable toxicity due to heavy wave action and vertical mixing. The amount and toxicity of oil reaching subtidal marine plants is expected to be so low as to have no measurable effect on them.

(b) **Marine Invertebrates:** Dominant marine invertebrates in the Beaufort Sea area include gastropods, mollusks, annelids, echinoderms, and crustaceans. Crude oil can have lethal effects on marine invertebrates from either a short-term exposure to high hydrocarbon concentrations or a long-term exposure to lower hydrocarbon concentrations. Laboratory studies indicate that oil concentrations ranging from 1 to 4 ppm can be lethal to both adult and larval crab and shrimp after 96 hours of exposure (Starr, Kuwada, and Trasky, 1981). Large oil spills often have resulted in mortality of bivalves (Teal and Howarth, 1984), which are fed on by many species of marine birds, fishes, and mammals. Effects on bivalves can be almost immediate, but declines in numbers may continue for years (6 years) (Thomas, 1976).

Studies following the EVOS in 1989 showed that significant hydrocarbon concentrations in shoreline sediments were found at heavily oiled sites followed by an apparent migration of the oil into the shallow subtidal zone in 1991 (Wolfe et al., 1993). However, significant concentrations of oil were not found in the subtidal zone. Regarding the toxicity of shoreline areas contaminated by the EVOS, Gilfillan et al. (1993) have shown that the toxicity of oiled intertidal sediments declined rapidly after the spill. Within 18 months, about 75 percent of the oiled shoreline had recovered. In fact, toxicological results indicate that the oiled shoreline was at toxic hydrocarbon levels for only a few months to 1 year. The remaining hydrocarbons were found to be generally nontoxic and are thought to serve as a food source for some biota (e.g., bacteria).

The OSRA estimates that LS's 32 to 41 are the only land segments having a probability of contact >.5 percent. The OSRA also estimates that these same land segments have only a 1- to 3-percent combined probability of one or more spills ≥1,000 bbl occurring and contacting them within 10 days (Table 11, Anderson et al. 1997). Nevertheless, for purposes of assessment, it is assumed that some of these land segments would be contacted by a 7,000-bbl oil spill. Because of the amount of time elapsed in reaching the shore (10 days), the more toxic hydrocarbon fractions would have evaporated and are not expected to have toxic effects on marine invertebrates that seasonally inhabit the shoreline. As mentioned earlier, the predominance of shorefast ice along the shoreline of the Beaufort Sea precludes all but seasonal shoreline invertebrate fauna down to about 1 m in water depth. Subtidal organisms deeper than this would not be contacted either, because they live below the zone where oil is likely to measurably affect them.

Hence, the only marine invertebrates likely to be contacted by floating or dispersed oil associated with an oil spill would be those closest to the surface. These include zooplankton (e.g. copepods, euphausiids, mysids, and amphipods) as well as the larval stages of marine invertebrates such as annelids, mollusks, and crustaceans. Because of similarities in habitat use and distribution, the percentage of marine invertebrate larva contacted by floating or dispersed oil is likely to be similar to that expected for plankton (i.e., <1%). Due to their wide distribution, large numbers, and rapid rate of regeneration, the recovery of marine invertebrate larva is expected to take less than a month. Recovery in embayment areas where water circulation is reduced is expected to take up to a year. Small oil spills are not expected to have a perceptible effect on lower trophic-level organisms at the population level.

Effectiveness of Mitigating Measures: The mitigating measures likely to have the most beneficial effect on lower trophic-level organisms are Stipulations 1 and 3, and ITL's 1, 12-14, and 19. With these mitigating measures in place, there is an increased probability that (1) less oil would come in contact with lower trophic-level organisms following a large oil spill, (2) discharges due to OCS activities into the marine environment would be minimized, and (3) onsite monitoring of OCS activities would take place by residents in the area. To the degree that they are implemented, these mitigating measures are expected to benefit lower trophic-level organisms; however, their absence is not expected to substantially increase adverse effects.

Summary: Alternative I and associated resource-development activities could affect lower trophic-level organisms (phytoplankton, zooplankton, epontic, and benthic) by exposing them to drilling discharges, seismic surveys, construction, and petroleum-based hydrocarbons. In general, effects associated with the low and high ends of the resource-recovery range are expected to be similar in most cases (one large oil spill was evaluated for both). Drilling discharges are estimated to affect <1 percent of the benthic organisms in the sale area and none of its plankton. Affected benthic organisms are expected to experience mostly sublethal effects, but some (mostly immature stages) would be killed. Recovery is expected to occur within 1 year after the discharges cease. Seismic surveys are expected to have little or no effect on lower trophic-level organisms. Construction is expected to have little or no effect on plankton communities. Less than 1 percent of the immobile benthic organisms would be affected by construction (mostly sublethal effects). Immobile benthic communities affected by pipeline construction are expected to recover in <3 years. Marine organisms needing a hard substrate for settlement are expected to benefit from the production platforms (particularly those associated with the high end of the resource-recovery range) and to colonize them within 1 or 2 years.

The effect of petroleum-based hydrocarbons on phytoplankton, zooplankton, epontic, and benthic organisms depends on the species and lifestage, the type and concentration of hydrocarbon, and the duration of exposure. Where flushing times are longer and water circulation is reduced (e.g., rock-armored shorelines, bays, estuaries, and mudflats), the recovery of the affected communities is expected to take longer. Assuming that a large number of phytoplankton were contacted by an oil spill, the rapid replacement of cells from adjacent waters and their rapid regeneration time (9-12 hours) would preclude any significant effect on phytoplankton communities. Large-scale effects on plankton from petroleum-based hydrocarbons have not been reported to date. Observations in oiled environments have shown that zooplankton communities experienced short-lived effects due to oil, although individual organisms experienced either direct mortality, external contamination, tissue contamination by aromatic constituents, inhibition of feeding, or altered metabolic rates. Affected communities appear to recover rapidly from such effects because of their wide distribution, large numbers, rapid rate of regeneration, and high fecundity.

An oil spill associated with Alternative I is estimated to have sublethal and lethal effects on <1 percent of the phytoplankton and zooplankton populations in the sale area. Recovery is expected to take 1 or 2 days for phytoplankton and up to 1 week for zooplankton. Recovery within the affected embayments is expected to take up to 2 weeks. During a winter oil spill, if oil were spilled under the ice and trapped directly beneath it, epontic organisms living there are likely to be killed. Less than 5 percent of the epontic community in the sale area is expected to be affected this way.

Because of the predominance of shorefast ice along the shoreline of the Beaufort Sea, most of the shoreline supports little or no resident flora or fauna down to about 1 m in depth. Subtidal marine plants and invertebrates are not likely to be contacted by an oil spill, except for floating larval forms, which may be contacted anywhere near the surface in the water column. The organisms likely to be contacted by floating or dispersed oil include zooplankton (e.g., copepods, euphausiids, mysids, and amphipods), as well as the larval stages of annelids, mollusks, and crustaceans. In general, the percentage of marine invertebrates contacted by floating or dispersed oil is expected to be similar to that expected for plankton (<1% of those in the sale area). Because of their wide distribution, large numbers, and rapid rate of regeneration, the recovery of marine invertebrate populations from a 7,000-bbl oil spill is expected to take less than a month. Recovery in embayment areas where water circulation is reduced is expected to take up to a year. Small oil spills are not expected to have a significant effect on lower trophic-level organisms.

Conclusion: Drilling discharges are estimated to adversely affect <1 percent of the benthic organisms in the sale area. Recovery is expected within a year after the discharges cease. Platform and pipeline construction are estimated to adversely affect <1 percent of the immobile benthic organisms in the sale area. Recovery is expected within 3 years. Marine organisms needing a hard substrate for settlement are expected to benefit from the production platforms and to colonize them within 2 years. If a large oil spill occurred, it is estimated to have lethal and sublethal effects on <1 percent of the phytoplankton and zooplankton in the sale area. Recovery is expected within 2 days for phytoplankton and within a week for zooplankton (2 weeks in embayment areas). The spill also is estimated to have lethal and sublethal effects on <5 percent of the epontic community (assuming a winter spill) and <1 percent of the marine invertebrate larva nearest the surface. Recovery is expected within a month (within a year where water circulation is significantly reduced).

3. Fishes: The following assessments are based in general on the descriptive information in Section III.B.2. For exploration and exploration/development/production, fishes probably would be affected by seismic operations, drilling, oil spills, and by construction of offshore production platforms and pipelines.

a. Potential Effects of Discharges: The effects to fishes from discharges are based on the figures in Table IV.A.1-1. The resulting discharges from exploration and production wells will contain minimal amounts of hydrocarbons. Upon discharge, the muds and cuttings will produce plumes. The discharged material likely will settle to the sea bottom in close proximity to the discharge point or it will remain suspended in the seawater, be transported with the ambient sedimentation, and settle out at a later time farther from the discharge point. Due to dilution, transportation of the discharges away from the point of discharge will have less of an effect on fishes than if the muds and cuttings settled in close proximity to the discharge point. Muds and cuttings settling near the discharge point could result in localized effects to fishes. Direct effects could include displacement and relocation of fishes, particularly benthic species, and indirect effects could include the covering of small, local areas having benthic and epibenthic organisms that are fish-prey organisms.

Many of the wells for both exploration and production are likely to be drilled in shallow, nearshore waters. The additional amounts of drilling muds and cuttings that might be released from drilling operations are small compared to the natural suspended sediment load from rivers, coastal erosion, runoff from breakup, and the mixing of inshore waters in the Sale 170 area. Although fishes use these waters, especially in the summer months, it is unlikely that discharges from the wells would significantly affect these fishes because of the dilution and localization of the discharges.

b. Potential Effects of Noise and Disturbance: Noise-producing exploration and production activities that could disturb and affect fishes include geophysical-seismic surveys, aircraft and vessel traffic, and drilling.

(1) Effects of Seismic Surveys: Seismic surveys, used to locate structures that may contain oil and/or gas reserves, are a potential source of noise disturbance for fishes. Two types of seismic surveys are used: (1) low-resolution, deep-seismic and (2) high-resolution, shallow-seismic. Low-resolution, deep-seismic surveys using strings of vibrators or airguns emit loud pulsed, noncontinuous sounds. These sounds can propagate long distances from their source. Most of the energy is directed downward, and the total energy is limited by the short duration of each pulse. High-resolution, shallow-seismic surveys are conducted on leases following the lease sale to evaluate potential shallow hazards to drilling. These surveys are relatively quiet, because they are lower energy surveys. For exploration or delineation well sites, surveys most likely would be conducted during the ice-free summer season.

Fishes may avoid sudden noise. However, they may ignore the same noise if it is continuous over a long period of time. Fishes are affected by sound waves and their resulting pressure (Bell, 1990). Seismic surveys could alter the natural processes of fishes. Fishes receive acoustic stimuli through their lateral line and inner ear. Gas bladders, which are vibrated by underwater sound, may be acoustically connected to the inner ear.

Impacts to fishes found in marine waters in the summer and winter seasons probably would be minimal because of their wide distribution in the marine habitat. High-resolution seismic surveys could injure nearby marine fishes with gas bladders, but the impulses likely would dissipate to a nonlethal level within a short distance. Seismic activities could disturb fishes, but their free-swimming movements would allow them to move about and avoid the disturbance area. However, the increased movement during the winter season could adversely affect their food reserves and their chances for overwinter survival.

During the winter season, fishes found in freshwater and brackish water overwintering habitats have limited avoidance responses to alterations due to their dependency on these habitats and their inability to move from these areas. These habitats are scarce and critical to the survival of arctic fishes. The fishes are essentially captives in these areas until spring breakup. Disturbances in delta areas possibly could alter spawning behavior and result in decreased survival of young, or the fishes may not spawn at all, depending on the range the disturbances encompass. The disturbances also could stress fishes that cannot avoid them and/or adversely impact their food reserves, possibly causing a decrease in overwinter survival.

A large portion of arctic marine fishes might be affected where they are concentrated in relatively small, special habitats, such as the kelp snailfish and leatherfin lumpsucker in the Stefansson Sound Boulder Patch.

(2) Effects of Aircraft Activities: Aircraft activities associated with the exploration and development/ production of Sale 170 involve an increase in helicopter flights in the area (see Table IV.A.1-1). Fishes respond to sudden noise and movement by attempting to avoid them; however, fishes may ignore the noise if it continues over a long period of time. Fishes are affected by the noise and the resulting pressure. Fishes appear to be sensitive to changes within the range of 5 to 1,000 Hertz (Hz). However, because aircraft noise is transient, it would be unlikely that it would have more than a minimal effect on fishes. The effects from aircraft noise probably would only temporarily relocate fishes. However, the possibility does exist that such relocation during critical overwintering periods could adversely affect some fishes in the immediate flight paths.

(3) Effects of Vessel Activities: There would be an increase in vessel activities from both Sale 170 exploration and development/production (see Table IV.A.1-1). Vessel traffic generally would be limited to routes between the exploratory drilling units and the shore base. Noise from vessel activities could affect fishes; however, as with aircraft activities, vessel noise should have minimal effects on the fishes. It is improbable that any fishes would be affected during their critical overwintering period because of the total freezeup of the Beaufort Sea during this time period.

(4) Effects of Drilling Activities: The consideration of effects to fishes from drilling activities is based on information provided in Table IV.A.1-1. In many cases, drilling activities are likely to be in shallow, nearshore waters. Many of these wells would be drilled from an ice or gravel island or other bottom-founded structure that would not require the use of an icebreaker. If icebreakers are used to attend drillships, which is typically done during the fall in the Beaufort Sea, the icebreaker noise may mask the drillship noise, because it is louder (Miles, Malme, and Richardson, 1987).

Fishes seem to ignore the same noise or movement, if it continues over a long period of time (Bell, 1990). Therefore, it is likely that they would become accustomed to the stationary noise from the drilling units and avoid it versus the more disruptive noise from vessel activities. Fishes likely would be more affected when icebreakers are used or if the activities disturb them in their critical overwintering habitat. Disturbance during the overwintering period could affect the survival of various species. However, it is unlikely that a significant number of fishes or fish species would be adversely affected by drilling activities.

(5) Effects of Construction Activities: Onshore construction activities for Sale 170 should not impact fishes. However, impacts to area fisheries could result from offshore construction activities.

Oil is expected to be transported between offshore and onshore development and production facilities via undersea oil pipelines (see Table IV.A.1-1). Trenching would be involved in laying the pipeline, which could displace bottomfish. Dirt will remain after the completion of the undersea pipeline. This excess dirt would be disposed of temporarily, until the ice melts, in storage areas away from the construction site. The dirt is placed on the ice surface approximately 1 ft deep. Residual dirt is left for disposal along the corridor paralleling the pipeline route. The effects of offshore pipeline installation on fishes are expected to be localized and of temporary duration. Fish and the epibenthic invertebrates on which they feed annually recolonize shallow environments that are seasonally disturbed. Therefore, disruption of the bottom substrates should not significantly affect their abundance and should only temporarily disturb fishes in the immediate area. However, it is likely that adverse effects to fishes could result from the excess dirt stored on the ice surface. This deposited dirt could have an insulation effect on the underlying ice causing a significant lag in the area's natural processes and/or interfere with the important summer, nearshore coastal band of water process, which would adversely affect fish migration and/or feeding in the area.

Future offshore developments will attempt to use existing onshore pipelines, when possible. Available facilities include Oliktok Point, Point McIntyre/West Dock area, and Endicott/Duck Island. The effects of short causeways or jetties, such as East Dock at Prudhoe Bay, have not been as controversial (Colonell and Gallaway, 1990). East Dock apparently has had no effect on the diversity or local distribution of anadromous/amphidromous fish species.

A similar low level of effects on fishes is anticipated from the proposed short dock for the Badami Development Project near Bullen Point in Mikkelsen Bay (Wilson and Colonell, 1995). However, the actual siting of a proposed jetty or causeway and its design would greatly affect its potential for having effects on fishes. Site-specific modeling would enable better prediction of potential effects on fishes. Without such site-specific information and appropriate modeling, projecting the possible effects on fishes of such construction activities is quite difficult. Site-specific effects of short jetties or causeways that might be proposed as part of the Sale 170 activities would be more appropriately addressed in a development and production EIS.

It is unlikely that any long docks or causeways will be constructed as part of this lease sale. The needed pipelines most likely will be installed in trenches below the sea floor. Therefore, the effects of controversial long docks and causeways (e.g., West Dock and Endicott Causeway) are minimal. Their effects and the possible effects of the operation of the undersea pipelines are covered in the section on Cumulative Effects on Fishes (Sec. IV.G.3).

In general, the construction of undersea pipelines in the Sale 170 scenario means that the magnitude of hydrographic and oceanographic changes could be less than for long causeways sited at the same locations. The effects on fish movements, migrations, and feeding activities are likely to be only localized and short term, except in areas where excess undersea pipeline dirt is disposed. Fishes in these areas could incur adverse, possibly significant effects. However, these effects should not result in losses of entire year-classes of the affected fishes.

(6) Effects of Oil-Spill Cleanup: If an oil spill occurred in the Sale 170 area, specially trained personnel and vessels and aircraft from the immediate surrounding Beaufort Sea area would be available to conduct cleanup operations. Oil-spill-cleanup operations would result in increased activity, noise, and disturbances that could affect fishes in the area. Noise and other disturbances would result from increased vessel and aircraft traffic and other cleanup necessities. The intensity of the cleanup operations would depend on the size of the spill, with a main trunk-pipeline oil spill from the higher resource estimate, or a spill from more than one location having increased-intensity cleanup activities. Effects to fishes would continue for the duration of the cleanup operations, causing possible displacement of and disruption to the fishes. Some fish species could be significantly affected, if the cleanup operations occur during the fish-migration period, especially in the warmer, less saline, nearshore band of water that forms along the Beaufort Sea coastline. Otherwise, the effects likely would be minor.

c. Potential Effects of Oil Spills: The effects of an oil spill on Beaufort Sea fishes are not fully known. Variability in the effects to fishes depends on the season and their habitat and lifestage.

(1) General Effects: If an oil spill occurred, the numbers and species of fishes affected would depend on the season; lifestage of the fish (adult, juvenile, larval, or egg); and the time of contact. Egg, larval, and juvenile lifestages of fishes are more likely to be affected by an oil spill due to increased sensitivity to pollutants and less mobility to avoid a spill. Fishes could experience the following adverse effects from an oil spill: skin contact; respiratory distress from gill fouling; localized reduction in food resources; consumption of contaminated prey; displacement from migratory routes; and temporary displacement from local habitat.

The fish family Salmonidae includes the following fishes: whitefishes, chars, salmon, ciscoes, grayling, trouts, and inconnu. Some species of salmon have shown the ability to avoid concentrations of oil. Laboratory experiments have demonstrated that juvenile pink salmon can detect and will avoid sublethal concentrations of oil (Rice, 1973). Laboratory experiments have suggested that coho salmon can detect the presence of dissolved petroleum hydrocarbons at levels magnitudes lower than those resulting from an oil spill. Their sensory ability is such that they could avoid oil spills. However, coho salmon may have impaired sensory ability to detect and avoid oil-contaminated areas, if they have been exposed to levels of water-soluble fraction of Alaska North Slope crude oil above 10^{-3} mg/l (Pearson, Woodruff, and Johnson, 1990). All salmonids require chemosensory detection for migration orientation. Therefore, the effects of oil exposure are likely to be similar for all the species in this family (Martin et al., 1990).

(a) Effects of Contact: If fishes contacted oil, their skin and gills likely would be adversely affected. Numerous microscopic openings of skin sensory organs develop on the surface of the fishes' skin. In most fishes, a series of these pores along each side from the head to the tail comprise the lateral line. The lateral line is essential for fishes. It informs fishes of localized disturbances; the location of moving objects, such as predators and prey; and the sensing of fixed objects. A few fishes have taste buds and integumentary tactile sensory structures in their skin (Lagler, Badach, and Miller, 1962). Should oil contact fishes, it likely would adhere due to the roughness of the fishes' surface. Oil could foul the lateral line, and the fishes then would be unable to avoid predators, locate food, etc., which could lead to death over a period of time. Fishes also could contact oil through their gills. Adherence of oil to the gills could affect the transfer of oxygen, causing a lack of oxygen, and possibly causing death by suffocation. However, fish may avoid the oil, and it would seem unlikely that the contact would be of a sufficient amount to disable the functions of the entire lateral line, significantly foul the gills, or be of a long-enough duration to cause the death of the fishes.

(b) Effects of Ingestion/Inhalation: It is unlikely that fishes would ingest spilled oil directly. Oil could be ingested by fishes coming to the surface where spilled oil was present and attempting to obtain food there or by accidently mistaking dispersed oil from a spill for food. Fishes would inhale spilled oil through their gills, which could inhibit their oxygen exchange (oxygen requirements vary from one species to another) and cause death by suffocation. Fish larvae and juveniles would be affected more than adults because of their higher sensitivity. The possibility of a significant effect on fishes would be low; however, some mortality could occur depending on the location, magnitude, and season of the spill.

(c) Indirect Effects: Fishes feed on insect larvae, fish, fish eggs, zooplankton, and various invertebrates. The possibility exists that some fishes could ingest spilled oil indirectly from oil-contaminated prey items. Juvenile fish would be more affected than adults, because they are more sensitive and less mobile. It is likely that fewer fishes would be adversely affected by the ingestion of oil-contaminated prey than by direct ingestion, inhalation, or contact with an oil spill.

(2) Sale-Specific Effects: As discussed in Section III.B.2, Fishes, anadromous, amphidromous, and marine fishes are present in the Beaufort Sea after breakup and before freezeup. Therefore, more species could be affected by an oil spill during this period. Fewer species, only marine and some anadromous fishes, are found in the Beaufort Sea during the winter months. These species are dispersed and found farther from shore due to the bottomfast freezing of the nearshore waters. Amphidromous and anadromous fishes migrate to inland/upstream overwintering habitat. Their access to overwintering habitat is via river deltas. An oil spill significantly would increase the adverse effects to amphidromous and anadromous fishes during migration periods in the delta areas. Fishes also would be affected by an oil spill in nearshore areas during the summer months. During the summer season when a warmer, less saline nearshore band of water forms along the Beaufort Sea coastline, fishes would be significantly affected by an oil spill, because they concentrate in this band to feed on the abundance of invertebrates found there. An oil spill contacting this band could affect fishes both directly and indirectly by killing food that is essential to fish for the accumulation of overwintering food reserves.

Sale-specific effects basically are the same as those described under the General Effects section above. The possibility of a significant fish dieoff from contact would seem to be low except for fish eggs, larvae, and juveniles, which likely would be more susceptible to the effects. However, some mortality could occur, depending on the magnitude and location of the spill.

(a) Probability of Contact: No oil spills should occur during the exploration phase. The analysis contained in this section is based on a development scenario described in Section IV.A.1-1 and Appendix A of this EIS. The reader is referred to these sections for a discussion of resource-recovery rates and quantities, timing of infrastructure development, platform emplacement, wells drilled, resource production timeframes, and other information relevant to the development of the resources of Alternative I.

The OSRA model estimates a 46- to 70- percent probability for the occurrence of one or more spills ≥ 1,000 bbl over the assumed production life of Alternative I. The OSRA model for combined probabilities estimates a 3- to 15-percent chance of one or more spills ≥ 1,000 bbl occurring and contacting I/SS's 7 through 9, depending on whether or not fishes are located in these areas, within 30 days over the production life of Alternative I. The probability of contact to I/SS's 7, 8, and 9 are 3 to 6 percent, 6 to 12 percent, and 8 to 15 percent, respectively. The likelihood of oil spills significantly affecting fish resources in these areas is low due to fish dispersal, mobility, and avoidance ability.

For the OSRA model conditional probabilities, I/SS's 7 through 9 (in the winter season) have probabilities ranging from 5 to 66 percent (at the launch boxes) and 5 to 16 percent (at the pipeline segments), and I/SS's 7 through 10 (in the summer season) have probabilities ranging from 5 to 82 percent (at the launch boxes) and 5 to 62 percent (at the pipeline segments). As stated above, an oil spill in these areas would minimally affect fish resources.

However, fish resources could be affected by a summer oil spill in ERA's C3 (Simpson Lagoon), C4 (Gwydyr Bay,) and C5 (Jago Lagoon). The OSRA model estimates a 7- to 28-percent chance of a spill contacting fish resources in ERA C3 at launch boxes (L1-L4) and an 11- to 51-percent chance at pipeline segments (P1-P2 and P5-P6). In ERA C4, the OSRA model estimates a 5- to 17-percent chance at L3 to L6, a 6-percent chance at P2 to P4 and P6, and a 50-percent chance at P7. For ERA C5, the OSRA model estimates a 9- to 46-percent chance in L5- to L8 and for P3, P4, and P7, a chance of 8, 22, and 7 percent, respectively.

(b) Site-Specific Effects: An oil spill would affect both fishes and their habitat. The effects experienced would depend on the season and location of the spill, the lifestage of the fish, and the duration of the oil contact with the fishes and their habitat. Fishes could experience adverse effects from an oil spill resulting from skin contact, respiratory distress from gill fouling, localized reduction in food resources, consumption of contaminated prey, displacement from migratory routes, and temporary displacement from local habitat. Effects from an oil spill could vary between species and will vary between lifestages (egg, larval, adult) of a species. Some fishes may be killed or injured as the result of exposure to an oil spill. Effects to some of the fishes and their habitats in the Sale 170 area are discussed below.

In the marine coastal area, the abundance of arctic cod is sometimes very high in surface waters. Thorsteinson (1996) estimated that a peak of 75 million juvenile arctic cod inhabited the 580-km^2 surface-water area of Camden Bay during one summer. An oil spill in an area with juvenile arctic cod probably would displace them downward in the water column and possibly kill a small portion. Arctic cod and other species with floating eggs could suffer extensive mortality, depending on the extent and amount of spilled oil, etc. However, given the small number of spills projected and the broad distributions of marine fishes in general, oil-spill effects are expected to be insignificant for marine species in Beaufort Sea sale area.

The shallow, nearshore zone is used extensively by anadromous and amphidromous fishes. An oil spill contacting the nearshore environment could affect several species of anadromous and amphidromous fishes as they move and migrate alongshore to feeding, overwintering, or spawning grounds. As noted earlier, adult salmonid fishes are likely to avoid an oil spill and not suffer great mortality. However, larvae, eggs, and juveniles are more vulnerable, because they are more sensitive and less mobile.

If an oil spill occurred in the summer open-water season and affected a segment of the nearshore region, it could adversely affect the ability of fish to reach feeding or overwintering areas or to reach spawning streams and the fishes' ability to feed. During the summer season, fishes feeding in the nearshore, warmer, less saline water band that forms as a result of river runoff could be significantly affected in their ability to adequately feed and accumulate food reserves for overwintering. Adverse effects are likely for fishes that make extensive migrations from natal streams (e.g., arctic cisco), for fishes with high fidelity to natal streams (e.g., Dolly Varden char), and for fishes that overwinter in nearshore environments (such as the major river deltas, e.g., rainbow smelt). Anadromous and amphidromous fishes in nearshore areas, especially juvenile fishes, would be susceptible to spilled oil.

The portion of the nearshore habitats of greatest importance to anadromous and amphidromous fishes are the major river deltas in which they overwinter and reproduce, such as the Colville, Sagavanirktok, and Canning river deltas. A relatively large percentage of the population could be affected by an oil spill, if a delta were impacted. Most anadromous and amphidromous fishes make spawning runs and outmigrations during a limited period of time. It is unlikely that an entire population would be affected, but a significant portion of the population could be affected. For example, if broad whitefish, with a lifespan of 7 years, were affected by an oil spill, a significant fish kill would reduce the population for longer than 7 years, because fewer fish would be recruited into the population for a minimum of 7 years. It is unlikely that the bays or major river deltas would be entirely contacted by oil, given the broad expanses of the bays and deltas. The effect on fishes would depend on the locality of the oil spill and whether passage through the delta areas could be achieved. Therefore, in the unlikely event an oil spill contacts nearshore waters, it could be lethal to small or large numbers of anadromous and amphidromous fishes, depending on the circumstances.

Overall, the most serious effects of an oil spill would be the death of a few marine and/or the death of numerous anadromous and amphidromous fishes. However, the probability of such a spill is small.

Effectiveness of Mitigating Measures: Mitigating measures that address the probable effects on fishes are the stipulation on Protection of Biological Resources and the ITL on Information on Sensitive Areas to be Considered in the Oil-Spill Contingency Plan. The stipulation is expected to provide additional protection from construction projects and drilling discharges to special benthic habitats, such as the Stefansson Sound Boulder Patch, where leatherfin lumpsuckers and other snailfish are found. The ITL is expected to provide additional oil-spill protection to listed habitat such as the Colville River Delta, where many anadromous fish overwinter. The ITL informs lessees that these areas should receive special protection in the event of an oil spill. If these two mitigating measures are not part of the development of Alternative I, the effects on fishes are expected to be slightly higher.

Summary: The effects of drilling muds and cuttings discharges and formation water are expected to be minimal because of the natural suspended sediment load present in the Sale 170 area. Seismic-activity effects would be minimal to fishes in marine waters in both the summer and winter seasons. However, during the overwintering period, fishes in freshwater and brackish-water areas, particularly the river-delta areas, possibly could incur greater adverse effects. This is because of the inability of the fishes to move from and avoid the disturbance(s). Disturbances alone could cause the altering of spawning behavior and increased stress levels, adversely impacting their overwintering food reserves and possibly causing a decrease in winter survival. Aircraft, vessel, and drilling activities should have minimal effects on fishes. However, fishes would be affected more by these activities during their overwintering period. Fishes would be expected to avoid and/or temporarily relocate due to these activities. Pipeline construction could disrupt fish migration, if it is done after breakup and before freezeup. However, excess dirt resulting from the undersea pipeline construction that is temporarily stored on the ice surface could alter the area's natural processes and/or interfere with the summer, nearshore coastal water band. This could adversely affect fish migration and/or feeding in the area.

Discharges and seismic, aircraft, and vessel activity likely would be substantially less for exploration than for development/production. Exploration activity would be limited to a maximum of four wells. Exploration only would have no undersea pipeline construction, and no oil spills likely would occur.

Should a large oil spill occur under the development/ production scenario, both fishes and fish habitat could suffer effects from contact. The numbers and species of fishes affected would depend on the season, lifestage (adult, juvenile, larval, egg), and the time of contact. Egg, larval, and juvenile lifestages are more likely to be affected from the increased sensitivity to pollutants and less mobility to avoid a spill. Fishes could experience one or more of the following effects from an oil spill: skin contact; respiratory distress from gill fouling; localized reduction in food sources; consumption of contaminated prey; displacement from migratory routes; and temporary displacement from local habitat. Some fishes may die as a result of a spill, depending on the location and season. Fishes overwintering in nearshore habitats (e.g., brackish waters), especially river-delta areas, likely would suffer the most lethal effects due to the limited habitat available and their inability to relocate and/or avoid the spill. A spill could affect a significant portion of populations in the area. Recovery of the affected species would require the minimum time period of their lifespan or a greater time period, depending on the recruitment level from the surviving year-classes. During the summer season, fishes feeding in the nearshore, warmer, less saline water band that forms as a result of river runoff could be significantly affected by an oil spill, preventing them from feeding in this productive band area, and consequently affecting their ability to accumulate food reserves for overwintering and their continued survival. Marine fishes likely would sustain minimal damage from a spill in either the winter or summer season, because they are relatively widely dispersed and able to avoid the spill by moving.

Conclusion: Overall, fishes exposed to discharges of drilling muds and cuttings and aircraft, vessel, and drilling activities most likely would experience temporary, nonlethal effects. Fishes temporarily may avoid areas where seismic surveys are being conducted and where vessel, aircraft, and drilling activities and construction are occurring during exploration and development/production. The possibility exists that fishes could be adversely affected from the placement on the ice surface of excess dirt from undersea-trenching activities. Some fishes are likely to suffer nonlethal effects from an oil spill. Some species could incur significant losses should a spill occur in critical overwintering habitats and in summer feeding areas. However, the probability of an oil spill occurring in general, or specifically occurring in critical overwintering habitat and summer feeding areas, is small. The recovery of these populations could take a minimum lifespan time period, e.g., as long as 21 years for least cisco, 17 years for humpback whitefish, and 18 years for broad whitefish, depending on the recruitment from the surviving fishes.

4. Endangered and Threatened Species: The endangered bowhead whale, the threatened spectacled and Steller's eider, and the recently delisted arctic peregrine falcon (considered here as a candidate species) may occur year-round or seasonally in the Beaufort Sea Planning Area and may be exposed to OCS exploration and development/production activities associated with Alternative I. The OCS activities under Alternative I and the development of its resource estimate will result in noise and disturbance, altered habitat, and contaminants such as discharges of drilling muds and cuttings and could result in spilled oil. These OCS activities could adversely affect the behavior, distribution, and abundance of individuals or populations occurring in or adjacent to the Sale 170 area. It is assumed that crude oil would not be spilled during exploration.

The following analysis of potential effects was extracted from pertinent sections of the Biological Evaluation for Threatened and Endangered Species with Respect to the Proposed Beaufort Sea Oil and Gas Lease Sale 170 and from the Sale 144 FEIS (USDOI, MMS, 1996a).

Pursuant to requirements under the Endangered Species Act (ESA) of 1973, as amended, the MMS Alaska OCS Region has consulted with the USDOI, Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) on a previous proposed lease sale in this region (Beaufort Sea Planning Area Oil and Gas Lease Sale 144). In the Sale 144 Biological Opinion, the FWS concluded that Sale 144 and associated activities would not be likely to jeopardize the continued existence of the spectacled eider, Steller's eider, or the arctic peregrine falcon. The NMFS considered Sale 144 as a reoffering of previous Beaufort and Chukchi Sea sales that were previously addressed in the Arctic Regional Biological Opinion (ARBO). The NMFS concluded that leasing and exploration activities were not likely to jeopardize the continued existence of endangered whales.

In accordance with the ESA, Section 7 regulations governing interagency cooperation, MMS notified FWS and NMFS by letter dated October 22, 1996, of the endangered, threatened, and proposed threatened species that would be included in a Biological Evaluation for Section 7 consultation. The NMFS responded on October 29, 1996, confirming the bowhead whale as the species under their jurisdiction to be included in the evaluation. The FWS responded on November 26, 1996, confirming spectacled and Steller's eiders as the appropriate species under their jurisdiction to be discussed in the evaluation; inclusion of the arctic peregrine falcon, while not required of a delisted species, was considered appropriate because the FWS will monitor its population for 5 years. The FWS also referenced polar bears, especially denning bears, although not threatened or endangered, as species of concern that could be affected by activities in the proposed sale area. The biological evaluation was completed and, in accordance with Section 7(a) of the ESA, formal consultations on the proposed Beaufort Sea Sale 170 were initiated with the FWS and NMFS by letters dated March 4, 1997. The NMFS responded with a letter dated July 1, 1997, determining that the ARBO satisfies the requirements of Section 7 of the ESA for the Sale 170 planning process. The ARBO, dated November 23, 1987, concluded that the proposed lease sale and exploration activities in the Beaufort Sea are not likely to jeopardize the continued existence of any endangered or threatened cetaceans. The biological opinion from the FWS, dated October 10, 1997, concluded that the proposed lease sale and associated activities are not likely to jeopardize the continued existence of the spectacled and Steller's eiders. Appendix B contains a copy of the final biological opinions.

The analysis of oil-spill risk on species along transportation routes south of the proposed sale area (Fig. IV.A.5-2), particularly the southern sea otter and the marbled murrelet, can be found in the Cook Inlet Planning Area Oil and Gas Lease Sale 149 FEIS (USDOI, MMS, Alaska OCS Region, 1996b, which is incorporated here by reference. That FEIS discusses potential effects of an oil spill on these species as a result of tankers transporting oil from the Cook Inlet sale area to California ports. Potential effects include oil contamination of their insulative capabilities resulting in hypothermia, inflammation/lesion of sensitive tissues following oil contact, tissue or organ damage from ingested oil, emphysema from inhaled vapors, and possibly death. Potential indirect effects from an oil spill include a reduction in available food resources due to mortality or unpalatableness of prey organisms. Mortality of southern sea otters resulting from any spill of oil (estimated probability of occurrence is 6% in the potentially affected area) tankered from southern Alaska to southern California is expected to be moderate (an estimated 23 individuals), with an estimated 1-year-recovery time (<1 generation), although conditions prevailing at the time of a spill could cause much greater mortality to occur. Mortality of marbled murrelets resulting from any spill of oil (estimated probability of occurrence is 6% in the potentially affected area) tankered from southern Alaska to northern California is expected to be high (estimated 30-144 individuals, 2-9% of the California population), with an estimated 3- to 15-year (2-8 generations) recovery time.

The analysis of oil-spill risk on species along transportation routes to ports in the Far East (Fig. IV.A.5-3), including the threatened Aleutian Canada goose, the proposed (threatened) Steller's eider, the endangered short-tailed albatross, the threatened Steller sea lion, and several species of endangered whales, can be found in the Beaufort Sea Planning Area Oil and Gas Lease Sale 144 FEIS (USDOI, MMS, 1996a), which is incorporated here by reference. In Alaskan waters, the probable oil-tanker route lies seaward of the 200-mi Economic Exclusion Zone boundary except in the northcentral Gulf of Alaska, where it exits Prince William Sound. Oil spilled along most of this route would tend to be moved parallel to the Alaska Peninsula and Aleutian Islands, particularly by the Alaskan Stream, rather than towards the coast where vulnerable populations might be contacted. Oil spilled from a tanker soon after exiting Prince William Sound could contact the Kodiak and Alaska Peninsula areas. Aleutian Canada geese, which nest in the Aleutian and Semidi islands, do not appear to spend significant time in marine habitats during the breeding period, suggesting little risk of oiling from a tanker spill. However, occasional sightings of this goose in the Kodiak area during the spring-migration period, and the presence of Steller's eiders during the winter season in coastal areas from the eastern Aleutian Islands to Cook Inlet, suggest that small portions of these populations could be vulnerable to a spill in the northern Gulf of Alaska during the spring and winter, respectively. Because short-tailed albatrosses are rare anywhere outside the breeding area south of Japan, it is unlikely that significant numbers would be contacted by a spill along the tanker route. Rookeries and haulouts of Steller sea lions are scattered from Prince William Sound to the western Aleutians. Sea lion pups are more vulnerable than juveniles and adults but remain at the rookery and thus are not likely to be oiled directly. Several species of endangered whales also occur in waters adjacent to the route, but they are not likely to experience any mortality from exposure to spilled oil. It is anticipated that most of the oil produced as a result of Sale 170 will be shipped to southern ports rather than to Far East ports. Overall, for the reasons listed above, the effects on the listed species are expected to be minimal.

The analysis contained in this section is based on a development scenario presented in Section IV.A.1 and Appendix A of this EIS. The reader is referred to these sections for a discussion of resource-recovery rates and quantities, timing of infrastructure development, platform emplacement, wells drilled, resource production timeframes, and other information relevant to the development of the resources of Alternative I. The scenarios range from exploration only to development/production with oil resources in the 350- to 670-MMbbl range, which is considered a reasonable range of resource development and activity level for Sale 170. Differences in effects to the species as a result of noise and disturbance over this range of scenarios are expected to be minor. Differences in effects to the species as a result of an oil spill during the development/production scenario (350-670-MMbbl-resource range) also are expected to be minor.

a. Effects on the Bowhead Whale: Bowhead whales may be present in the Sale 170 area generally from early April to mid-June during their spring migration from the Bering Sea to the Canadian Beaufort Sea and from August through October during their fall migration back to the Bering Sea. The following discussion describes how bowhead whales may be affected by oil and gas exploration activities.

(1) Potential Effects of Discharges: There will be a number of discharges into bowhead habitat as a result of Sale 170 exploration. The types of material discharged from drilling operations include drilling muds and cuttings. For exploration only, it is estimated about 2,520 short tons of drilling muds and about 3,280 short tons of cuttings would be discharged during a 7-year period. For development/production, it is estimated that from 13,050 to 75,480 short tons of drilling muds and from 102,660 to 130,980 short tons of cuttings would be discharged during a 6-year period. These discharges create plumes of material that disperse rapidly in the water column. In most continental shelf areas, most drilling muds and cuttings land on the sea bottom relatively close to the discharge point, depending on the water depth and current. Discharge of drilling muds and cuttings during drilling operations are not expected to cause significant effects either directly through contact or indirectly by affecting prey species. Any effects would be very localized around the drill rig due to rapid dilution/deposition of these materials. Drilling muds and cuttings may cover small areas of the sea floor that support epibenthic invertebrates used for food by bowhead whales.

The effects of discharges are expected to be negligible to bowhead whales, because many of the wells likely will be drilled in relatively shallow nearshore waters outside of the main migration route. Also, bowheads feed primarily on pelagic zooplankton, and the areas of sea bottom that are impacted would be inconsequential in relation to the available habitat.

(2) Potential Effects of Noise and Disturbance: Concern has been expressed that manmade noise affects bowheads by raising background noise levels—which could interfere with detection of sounds from other bowheads or from important natural sources—or by causing disturbance reactions, which could cause the migration route to be displaced farther from shore. Sound is transmitted efficiently through water. Hydrophones often detect underwater sounds created by ships and other human activities many kilometers away, far beyond the distances where human activities are detectable by senses other than hearing. Marine mammals use calls to communicate and probably listen to natural sounds to obtain information important for detection of open water, navigation, and predator avoidance. There also has been speculation that, under some conditions, extremely loud noise might cause temporary or permanent hearing impairment of bowheads.

Sound transmission from noise-producing sources is affected by a variety of things, including water depth, salinity, temperature, frequency composition of the sound, ice cover, bottom type, and bottom contour. In general terms, sound travels farther in deep water than it does in shallow water. Sound transmission in shallow water is highly variable, because it is strongly influenced by the acoustic properties of the bottom material, bottom roughness, and surface conditions. Ice cover also affects sound propagation. Smooth annual ice cover may enhance sound propagation compared to open-water conditions. However, as ice cracks and roughness increases, sound transmission generally becomes poorer than in open water of equivalent depth. The roughness of the under-ice surface becomes more significant than bottom properties in influencing sound-transmission loss (Richardson and Malme, 1993).

Noise-producing exploration activities, including geophysical-seismic surveys, aircraft traffic, icebreaking or other vessel traffic, drilling, and construction activities are the activities most likely to affect bowhead whales.

(a) Effects from Seismic Activities: Sound from seismic exploration is a potential source of noise disturbance to bowhead whales. The Inupiat are very concerned that as the whales swim toward the distance noise source, many whales are displaced seaward so that by the time they reach the subsistence hunters, the whales are farther offshore and more difficult to hunt. Marine seismic exploration uses underwater sounds with source levels exceeding those of other activities that will be discussed here. Seismic surveys are of two types: (1) low-resolution, deep-seismic and (2) high-resolution, shallow-seismic surveys.

Deep-seismic surveys emit loud sounds, which are pulsed rather than continuous, and can propagate long distances from their source. Overall source levels of noise pulses from airgun arrays are very high, with peak levels of 240 to 250 decibels relative to 1 microPascal at 1 meter (dB re 1 μPa-m). However, most energy is directed downward, and the short duration of each pulse limits the total energy. Received levels within a few kilometers typically exceed 160 dB re 1 μPa (Richardson et al., 1995a).

High-resolution seismic surveys, which are of much lower energy, generally are conducted on leases following the lease sale to evaluate potential shallow hazards to drilling. Equipment used to conduct high-resolution seismic surveys/shallow-hazard seismic surveys includes sidescan sonar, subbottom profiler, boomers, sparkers, gas exploders, water guns, airguns, etc. The energy level of many of these are from one to three orders of magnitude less than for some of the equipment used in deep-seismic surveys. For example, a 2,000 cubic in (in^3) airgun used in deep-seismic surveys has approximately 2x1 million foot-pounds of energy compared to an 80 in^3 airgun that would likely be the largest used in high-resolution seismic surveys, which has approximately 9x10,000 foot-pounds of energy. Boomers, sparkers, and gas exploders range from about 8x100 to 9x10,000 foot-pounds of energy. The majority of equipment used in these surveys have <5x1,000 foot-pounds of energy. For additional comparison, the 2,000 in^3 airgun has an energy equivalent of slightly >1 pound of 60 percent dynamite at 30 ft depth, while the 80 in^3 airgun has energy equivalent of .06 pound of 60 percent dynamite at 30 ft depth (Telford et al., 1978). Some high-resolution seismic, such as airguns, emit loud sounds but would not be as loud as deep-seismic nor would the sound be likely to propagate as long a distance as deep-seismic. Shallow-hazard seismic surveys for exploration-delineation-well sites most likely would be conducted during the ice-free season. Since high-resolution seismic surveys are lower energy and sound would be less likely to travel as far as sound from deep-seismic surveys, these activities are less likely to have significant effects on endangered whales.

The zone of responsiveness around a noise source is the area within which the animal would react to the noise. This zone generally is much smaller than the zone of audibility, which is the area within which an animal can hear the noise. According to Richardson et al., (1995a), seismic pulses can be detectable 100 km (62.2 mi) or more away. Strong pulses of seismic noise are often detectable 25 to 50 km (15.5-31-mi) from seismic vessels. Bowheads likely will temporarily change their individual swimming paths as they approach or are closely approached by seismic vessels, but strong avoidance may occur when received levels of seismic noise are 150 to 180 dB re 1 μPa. Besides avoidance, whales may exhibit significant tendencies for reduced surfacing and dive durations, fewer blows per surfacing, and longer intervals between successive blows. Bowheads' surface-respiration-dive characteristics appeared to recover to pre-exposure levels within 30 to 60 minutes following the cessation of the seismic activity. Inupiat subsistence whalers have stated that industrial noise, especially noise due to seismic exploration, has displaced the fall bowhead migration seaward and is thereby interfering with subsistence hunts. The North Slope Borough, in a letter dated July 25, 1997, stated that "From years and years of observations by dozens of hunters we know that fall migrating bowheads can be affected by seismic noise many, many miles away (30-35 miles)." The next few paragraphs provide a brief discussion of a number of studies on the effects of noise from seismic operations on bowhead whales.

Reeves, Ljungblad, and Clarke (1983) conducted aerial surveys to observe bowhead whale behavior in the presence of active seismic vessels. Whales were observed as close as 3 km (1.86 mi) and as far away as 135 km (83.9) from active seismic vessels. A pair of whales observed at a distance of 3 km (1.83 mi) were not moving while at the surface, although the two whales' heads were in contact. This pair of whales was closer to a shooting seismic vessel than any other whales observed during the study. No obvious response was apparent, but the observation time was brief. (The received levels of low-frequency underwater sound from an underwater source, are generally lower by 1-7 dB near the surface [depth 3 m] than at deeper [≥9 m] depths [Richardson et al., 1995a]. It is possible these whales may have been at the surface to avoid the louder noise in deeper water.) For the group of 20 whales at a distance of approximately 135 km (83.9 mi), the blow frequency per surfacing and time at the surface were greater during the period immediately after the seismic vessel began shooting than before it began shooting. The authors stated that no major changes in whale behavior (e.g., flight reactions) were observed that could unequivocally be interpreted as responses to seismic noise. They noted a possible exception of "huddling" behavior, which they thought may have been caused by the onset of seismic sounds. The authors concluded that although their results suggest some changes in behavior related to seismic sounds, the possibility that unquantified factors could be correlative dictates caution in attempting to establish causative explanations from the preliminary findings.

Ljungblad et al. (1985) conducted a set of four experiments where bowhead whales were approached by an operating seismic vessel. In the first experiment, the *Western Beaufort* was actively shooting approximately 12 km (7.5 mi) from the whales position. A sonobuoy dropped near the whales indicated a received level of seismic sound near the whales of 131.1 dB re 1 μPa at 12 km (7.5 mi). Additional seismic sounds from an unknown source also were received at the sonobuoy with a received level of 133.0 dB re 1 μPa. The *Western Beaufort* approached to within 1.3 km (0.81 mi) with received sound level of 152.4 dB re 1 μPa. At 3.5 km (2.18 mi), milling and social behavior ceased. Surfacing, respiration, and dive characteristics changed significantly and were accompanied with avoidance behaviors as the vessel approached to within 1.3 km (0.81 mi). Because the vessel had been shooting prior to the beginning of the experiment, predisturbance observations were not obtained, and postdisturbance observations were confounded by other geophysical vessels that had become active in the area. The second experiment involved a sudden seismic startup by the *Western Aleutian* at a range of 7.2 km (4.47 mi), with a received sound level of 164 dB. The *Western Aleutian* was about 12.4 km (7.7 mi) from the whales and had been inactive. A sonobuoy revealed some low-level seismic sound (<120 dB re 1 μPa) from an unknown source. The whales responded to the sudden startup of the *Western Aleutian* by changing their surfacing behavior and, as the vessel approached 3.5 km (2.18 mi), the surfacing, respiration, and dive characteristics changed significantly. In the third experiment, the *Arctic Star* was approximately 15.5 km (9.6 mi) from the whales and was actively shooting prior to the experiment. A sonobuoy dropped near the whales measured received sound levels of 148.4 dB re 1 μPa. After completing the survey line, the vessel's airguns were shut down, and the vessel changed course to begin approaching the whales. The vessel activated 18 of the 24 airguns at 11.6 km (7.2 mi) from the whales, with an estimated sound source level of 246 dB re 1 μPa and a received level at the of 154.9 dB re 1 μPa. Surfacing, respiration, and dive characteristics changed significantly as the *Arctic Star* approached from 12 to 5 km (7.5-3.1 mi) with received sound levels ranging between 154.9 and 171.2 dB, respectively. Two whales remained until the vessel approached to within 3.5 km (2.18 mi). In the fourth experiment, seismic sounds from the *Western Polaris* were initiated at a distance of 11.7 km (7.3 mi), with received levels of 154 dB re 1 μPa. The *Western Polaris* had been inactive prior to the experiment, although the *Mariner* was actively shooting at a distance of 28 km (17.4 mi) from the whales, with received sound levels at the whales of 120 dB re 1 μPa. Surfacing, respiration, and dive characteristics began to change at a range of 7 km (4.35 mi), with a received sound level of 158.1 dB; partial avoidance behavior began at 3.5 km (2.18 mi), with a received sound level of 163.1 dB; and complete avoidance reactions were exhibited at 1.8 km (1.12 mi), when the estimated received sound level was 169 dB. This study concluded that (1) whales responded to seismic sounds at ranges <10 km (6.2 mi), with the strongest responses occurring when whales were within 5 km (3.1 mi) of the sound source, and (2) that a period of 30 to 60 minutes is required before whales recover from the effects of close seismic disturbance. No discernable behavioral changes occurred during exposure to seismic sound at ranges >10 km (6.2 mi). It also was concluded that the findings in this study were consistent with the findings of several earlier studies. A subcommittee of the Scientific Committee of the International Whaling Commission (IWC) reviewed these data, and some members were critical of the methodology and analysis of the results.

> Comments included reference to: the small sample size; inconsistencies between the data and the conclusions; lack of documentation of calibration of sound monitoring; and possible interference from other active seismic vessels in the vicinity. The sub-committee acknowledged the difficulty of performing experiments of this kind, particularly in the absence of a 'control' environment free of industrial noise. The sub-committee recommended that additional research taking into account the concerns expressed above be undertaken, and that the 1984 experimental results be subjected to rigorous reanalysis, before it can draw any conclusions on the effects of seismic activity on this species (IWC, 1987).

In Fraker et al. (1985), an active seismic vessel traveled toward a group of bowheads from a distance of 19 km (11.8 mi) to a distance of 13 km (8.18 mi). The whales did not appear to alter their general activities. Most whales surfaced and dove repeatedly and appeared to be feeding in the water column. During their repeated surfacing and dives, they moved slowly to the southeast (in the same direction as seismic-vessel travel) and then to the northwest (in the opposite direction of seismic-vessel travel). The study first stated that a weak avoidance reaction may have occurred, but then stated there was no proof that the whales were avoiding the vessel. The net movement was about 3 km (1.86 mi). The study found no evidence of differences in behavior in the presence and absence of seismic noise, but noted that observations were limited.

In another study (Richardson, Wells, and Wursig, 1985) involving a full-scale seismic vessel with a 47-liter airgun array (estimated source level 245-252 dB re 1 μPa), bowheads began to orient away from the approaching ship when its airguns began to fire 7.5 km (4.7 mi) away. The GSI *Mariner* had been shooting seismic about 10 km to the west of a group of six whales. Prior to the start of the experimental seismic period, the whales were surfacing and diving and moving at slow to medium speeds while at the surface. The vessel ceased shooting and moved within 7.5 km of the whales and began firing the airgun array while approaching the whales. There was no conspicuous change in behavior when the *Mariner* resumed shooting at 7.5 km away. The bowheads continued to surface and dive, moving at slow to medium speeds. The received level was estimated at 134-138 dB at 7 km (4.35 mi). Some near-bottom feeding (evidenced by mud being brought to the surface) continued until the vessel was 3 km (1.86 mi) away. The closest point of approach to any whale was approximately 1.5 km (0.93 mi), with the received level probably well over 160 dB. When the seismic vessel was within 1.5 km of whales at the original location, at least two of the whales were observed to have moved about 2 km to the south of the original location. The movements of the whales, at least while they were at the surface, were at the usual slow to moderate speeds. No conspicuous changes in behavior were noted when the *Mariner* ceased shooting at 6 km beyond the whales. The whales began feeding again about 40 minutes after the seismic noise ceased.

While conducting a monitoring program around a drilling operation, Koski and Johnson (1987) noted that the call rate of a single observed bowhead whale increased after a seismic operation had ceased. During the 6.8 hours of observation, the whale was within 23 to 27 km (14.3-16.8 mi) from the drillship. A seismic vessel was reported to be from 120 to 135 km (74.58-83.9 mi) from the sonobuoy, and the two loudest calls received were determined to be approximately 7 km (4.35 mi) and 9 km (5.6 mi) from the sonobuoy, with received levels of 119 dB and 118 dB, respectively. Approximate signal to noise (S:N) ratios were 24 dB and 22 dB, respectively. No information is provided regarding the exact distance the whale was from the operating seismic vessel. The increase in call rate was noted within 25 minutes after seismic noise ceased. It also needs to be noted that there were few, if any, calls heard during the 2 hours prior to the start of seismic operations, so it is unclear whether the increase in call rate relates to cessation of seismic noise, the presence of the operating drillship, the combination of both activities, or some other factor that occurred in the late afternoon. During this same study, a subgroup of 4 to 7 whales within a larger group (15-20 whales) was noted moving rapidly away from an approaching seismic vessel at a distance of 22 to 24 km (13.7-14.9 mi). The received level of seismic pulses was at least 137 dB at 19 km (11.8 mi). The surfacings and dives were unusually brief, and there were unusually few blows per surfacing. No information was available regarding the time required for these whales to return to normal behavior. Richardson and Malme (1993) noted that this apparent avoidance response is the longest-distance avoidance of a seismic vessel documented in the studies they reviewed.

As mentioned earlier, high-resolution seismic surveys are of much lower energy (a 2000 in^3 airgun used in deep-seismic surveys has approximately 2x1 million foot-pounds of energy compared to an 80 in^3 airgun that would likely be the largest used in high-resolution seismic surveys, which has approximately 9x10,000 foot-pounds of energy) and generally are conducted on leases following the lease sale to evaluate potential shallow hazards to drilling. Because sound is not likely to travel as far as with deep seismic, these activities are less likely to have significant effects on endangered whales. In the study by Richardson, Wells, and Wursig (1985, as cited in USDOI, MMS, 1996a) four controlled tests were conducted by firing a single 40-in^3 (0.66-liter) airgun at a distance of 2 to 5 km (1.2-3.1 mi) from the whales. Bowheads sometimes continued normal activities (skim feeding, surfacing, diving, and travel) when the airgun began firing 3 to 5 km (1.86-3.1 mi) away, with received noise levels at least 118 to 133 dB re 1 μPa. Some bowheads oriented away during an experiment at a range of 2 to 4.5 km (1.2-2.8 mi), and another experiment at a range of 0.2 to 1.2 km (0.12-0.75 mi), with received noise levels at least 124 to 131 and 124 to 134 dB, respectively. Frequencies of turns, predive flexes, and fluke-out dives were similar with and without airgun noise, and surfacing and respiration variables and call rates did not change dramatically during the experiments.

Richardson and Malme (1993), while synthesizing data on the effects of noise on bowheads, concluded that collectively, scientific studies have shown that when an operating seismic vessel approaches within a few kilometers, most bowheads exhibit strong avoidance response and specific changes in surfacing, respiration, and dive patterns and temporarily may change their individual swimming paths. They stated that most bowheads usually show strong avoidance when an operating seismic vessel is within 6-8 km (3.8-5.0 mi), and there probably are some effects at greater distances. The authors noted that surfacing, respiration, and dive cycles may be altered in the same manner as those of whales closer to the vessels. Dr. Tom Albert, NSB, testifying at the Barrow public hearing on the Beaufort Sea Sale 144 Draft EIS, said the whaling captains believe most bowheads are likely to show avoidance response to seismic operations at greater distances. "[T]he hunters that go out, feel that the reaction is on the order of a 10 miles or more" (Albert, 1995, as cited in USDOI, MMS, 1995c).

The NSB stated in a letter dated July 25, 1997, that the studies cited were different from the real-world situation. Most did not involve actively migrating whales, and those whales were being approached by the seismic vessels; whereas in the real world, the fall-migrating whales are actively moving to the west, and they are approaching a distant seismic boat that is firing. Subtle shifts in direction could be occurring that cause the bowheads to be farther from shore as they gradually migrate toward the west. The MMS notes the studies referenced were observational and involved opportunistic sightings of whales in the vicinitiy of seismic operations. No definitive conclusions can be drawn from them on whether or not the overall fall migration is displaced by seismic activity. The studies were not designed to show whether more subtle reactions are occurring that can displace the migration corridor.

The MMS has funded aerial surveys since 1979 to determine the distribution and abundadnce of bowhead whales in the Beaufort Sea during their fall migration. These surveys, while not designed to measure short-term bowhead whale displacement within a given year due to site-specific industrial noise, have been used for comparing the axis of the bowhead whale migration between years. As a followup to work described in Ljungblad et al. (1988), Moore and Clark (1992) analyzed between-year data from 1982 to 1989 to determine the mean distance from shore of the fall migration of bowhead whales near Barrow, Alaska, irrespective of industrial activity. Because sample sizes in 1982, 1985, 1986, 1988, and 1989 were too small for calculating Confidence Intervals (CI) for the median distances, only ANOVA and Tukey tests on mean values were applied (Moore, pers. comm.). A power analysis showed that a 12-km (7 statute mi) shift in mean bowhead whale distance from shore would give a 90-percent chance of finding a significant difference ($\alpha = 0.05$) using these tests. Moore and Clark (1992) found that annual mean distances from shore ranged between 25 and 36 km (15-22 statute mi) and they detected no difference between possible pairs of years. Because the ANOVA test requires large sample sizes for detecting small shifts in whale migrations, the MMS Bowhead Whale Aerial Survey Project (BWASP) also uses the Mann Whitney U test, one of the most powerful nonparametric tests for testing the significance of between-year differences in water depth used by bowhead whales during their fall migrations across the Alaskan Beaufort Sea. Using larger sample sizes (for which CI's were calculated) obtained over a larger study area, the BWASP found many between-year (1982-1996) differences in the median water depth at whale sightings that were highly significant (P <0.05) (Treacy, 1997). Median depths ranged between 18 m (59 ft) in 1989 and 347 m (1,138 ft) in 1983, with an overall cumulative depth of 37 m (121 ft, CI = 37-38 m). The BWASP has reported a potential association between water depth of the bowhead migration and general ice severity, especially in 1983, when severe ice cover may have forced the axis of the migration into waters 347 m (1,138 ft) deep. To address short-term bowhead whale displacement within a given year from site-specific industrial noise, other monitoring efforts are required when industrial activity occurs during fall-bowhead migrations (Sec. II, Stipulation 4).

A report by LGL Ltd., Environmental Research Associates and Greeneridge Sciences Inc. (1997) on a marine mammal monitoring program for the Northstar Development Project provides the most recent information regarding the effects of seismic activity on bowhead whales as it may be affecting the migration axis. The number of bowhead sightings within the Northstar region during LGL and MMS surveys in 1996 was small, with nine sightings occurring during periods of seismic operations and eight sightings occurring within 3.5 hours after periods of seismic operations. The authors stated that it was not appropriate to draw general conclusions about the effects of seismic exploration on the position of the bowhead whale corridor based on the 1996 monitoring study alone. However, the authors concluded that the following points were evident from the data available: If westbound bowheads were displaced offshore by the seismic operation, distances from shore would be expected to be greater at times with than at times without seismic. Bowheads tended to be seen both closer to shore and farther offshore without seismic than with seismic. The modal distance from shore was ~10 km farther offshore with seismic, consistent with the possibility of seaward displacement by seismic, when data collected under poor-sightability conditions were included. However, the distributions with and without seismic overlapped broadly, and when poor-sightability data were excluded, sightings tended to be closer to shore with seismic than without seismic. The main migration corridor during periods potentially influenced by seismic was apparently 20 to 30 km (12.4-18.6 mi) from shore, or ~10 to 20 km (6.2-12.4 mi) from the northern edge of the area of seismic exploration. If westbound bowheads were displaced offshore by the seismic operation, distances from shore would be expected to be greater in 1996 than in years with similar ice cover but little offshore industrial activity. In comparing years when seismic was occurring (1996) with years that no seismic was occurring (1994-95), the study found no evidence that bowheads were distributed farther from shore in 1996 (either overall or during times with seismic) than in 1994-95 (years with little or no offshore industrial activity). If anything, bowhead migration tended to be closer to shore during 1996, the year with seismic. If westbound bowheads were displaced offshore by the seismic operation, distances from shore would be expected to be greater in the western than in the eastern part of the Northstar region. In comparing distances of whales offshore to the east and to the west of Northstar, the study found there was no evidence that distances from shore were greater in the western than in the eastern part of the Northstar region. Bowhead sightings tended to be slightly farther offshore during 5 light-ice years with substantial industrial activity than during 2 light-ice years without activity. This difference was statistically significant (P <0.05). Available data are insufficient to determine whether the tendency for the southern edge of the main bowhead migration corridor to be farther offshore with seismic or other industrial activities is indicative of a causal relationship. The tendency was not statistically significant for seismic. However, considering the larger sample of data from the 5 light-ice years having substantial amounts of offshore industrial activity (seismic and/or drilling), bowheads were distributed significantly farther offshore during those years than in 2 light-ice years without much industrial activity. The observed tendencies, although statistically weak, are qualitatively consistent with the experience of bowhead hunters, who have reported that seismic exploration and other industrial activities displace the migration corridor of bowhead whales. However, there was much overlap between the migration corridors in years with versus without seismic or other industrial activities. Also, most bowheads seen during periods with seismic exploration were within ~20 to 30 km (12.4-18.6 mi) from shore and, thus, apparently passed within ~10 to 20 km (6.2-12.4 mi) of the northern edge of the seismic area. (The closest direct sightings during or immediately after periods of airgun array operations were 22-27 km [13.7-16.9 mi] from the airguns.) The study concluded that data from additional years with seismic exploration will be required to confirm statistically that nearshore seismic has measurable effects on the fall migration corridor of bowheads and to estimate the magnitude of any effects.

The study also recorded bowhead whale calls. The number of calls detectable per hour near Northstar was lower, both overall and relative to the Narwhal Island count, during hours when seismic pulses were detectable on the Northstar recorder. Near Northstar, ensonification of waters by seismic sounds apparently had one or both of the following effects: it reduced the number of calls emitted by an average bowhead per hour, and/or reduced the number of bowheads within a several kilometer distance of the recording unit off Northstar.

Inupiat subsistence whalers have stated that industrial noise, especially noise due to seismic exploration, has displaced the fall bowhead migration seaward and is thereby interfering with the subsistence hunt at Barrow (Ahmaogak, 1989). Fred Kanayurak and 16 other whaling captains from Barrow, Nuiqsut, and Kaktovik, in written testimony at the Arctic Seismic Synthesis and Mitigating

Measures Workshop on March 5-6, 1997, in Barrow, Alaska, stated: "... Factual experience of subsistence whalers testify that pods of migrating bowhead whales will begin to divert from their migratory path at distances of 35 miles from an active seismic operation and are displaced from their normal migratory path by as much as 30 miles." Also at the March, 1997 workshop, Mr. Roxy Oyagak, Jr., a Nuiqsut whaling captain, stated in written testimony: "Based on the industrial activity, there is an unmitigable adverse impact on the village of Nuiqsut on subsistence whaling. i.e. 1) by causing the whales to abandon the hunting area, and 2) directly displacing the subsistence whalers, and 3) placing physical barriers between the subsistence whalers and marine mammals, including altering the normal bowhead whale migration route."

Mr. Eugene Brower, a Barrow whaling captain, testified at the Barrow Public Hearing on the Beaufort Sea Sale 144 Draft EIS in November 1995, that noise associated with seismic exploration activities will disturb the migration of the bowhead whale. He stated that "... seismic activities are going to have a likely effect on the bowheads..." and noted that when seismic activity is going on to the east of Barrow, the migration route off Barrow is farther out than the normal migration route. Mr. Brower also referenced a high-resolution seismic survey conducted by the *Arctic Rose* near Barrow in 1989, stating that "During that fall season, my fellow whalers had to go far out to look for the bowhead whale." The Barrow Whaling Captain's Association provided written testimony pertaining to the *Arctic Rose* at the March 1997 workshop.

Frank Long, Jr., a whaling captain from Nuiqsut testifying at the public meeting on the Kuvlum Prospect in Barrow, stated: "The G&G work from July through October is very critical. The seismic work will affect the whale. As long as activity is going on in Camden Bay, the whale migration will change; it's changing already. The migratory route is changing each season" (USDOC, NOAA, NMFS, 1993).

Mr. Thomas Napageak, Commissioner of the Nuiqsut Eskimo Whaling Commission, testifying at the Nuiqsut Public Hearing on the Beaufort Sea Sale 144 Draft EIS in November 1995, also was concerned about seismic activities. "Because of seismic though traffic (sic), helicopters overflights, these were the cause of the whales migrating further north out to the ocean, 20 miles further north than their usual migration route." Mr. Burton Rexford, Chairman of the Alaska Eskimo Whaling Commission (AEWC), stated in written testimony at the March 1997 workshop: "During the fall of 1979, 1980 and 1981 at least 3 hunting boats were actively searching for bowhead whales north and northeast of Point Barrow. Unfortunately we saw no bowhead whales." He further stated: "We were firmly convinced that the reason we did not see whales, where we should have seen whales, was because the noise from the seismic boat displaced the whales." During the Alaska OCS Region Arctic Synthesis Meeting in 1995, Mr. Rexford said that his recommendation for the Cross Island area and the whalers from Nuiqsut would be to insist on no seismic activity after September 1. "We have done that before; we have shut down seismic activity."

The incident involving seismic surveys by the *Arctic Rose* in 1989 has been raised by Inupiat whalers on several occasions. In a recent letter from the NSB dated March 17, 1997, MMS was asked to cite a report by Harry Brower, Jr. (1996), which documents the location of whales harvested in the fall of 1989. As described at the March, 1997 workshop and shown in Brower's report four whales were taken near Cape Halkett that year. The report states that seven bowhead whales were harvested during the 1989 fall hunt but provides locations for only four whales. It does not provide locations or any information on the three other whales that were taken much closer to Barrow. According to a letter from the NSB dated November 22, 1989, whale 89B8 was taken approximately 12 mi due north of Point Barrow by William Leavitt, Sr. on October 10, 1989; whale 89B9 was taken approximately 30 mi southwest of Point Barrow by Johnny Aiken on October 25, 1989; and whale 89B10 was taken approximately 13 mi southwest of Point Barrow by Edward Itta on October 28, 1989. The two whales harvested to the southwest of Barrow were taken outside of the normal fall subsistence hunting area. The data for 1989 were identified as preliminary and subject to revision. In a telephone conversation with Dr. Tom Albert and Harry Brower, Jr. on July 28, 1997, it was indicated there was insufficient information available to precisely identify the location of these whale harvests so these whales were not included as part of the harvest record in the report by Harry Brower, Jr. (Brower and Albert, 1997, pers. comm.).

Sale-specific effects generally are expected to be similar to those discussed above. However, there should be less of an effect on whales from seismic activity in the Sale 170 area than from previous sales in the area, because a substantial amount of seismic work, especially low-resolution, deep-seismic, already has been conducted in the area, and because much of the seismic work that is needed may be conducted over the ice during the winter, when whales are not present in the area. For exploration only, it is estimated that shallow-hazards seismic surveys would cover an area ranging from 69.15 to 184.4 km^2 (26.7-71.2 mi^2) and would require from 6 to 16 days to complete the survey. For development/production, it is estimated that shallow-hazards seismic surveys would cover an area ranging from 276 to 460 km^2 (106.6-177.7 mi^2) and would require from 21 to 35 days to complete the survey. The amount of seismic activity likely would decrease slightly under exploration only. Seismic surveys are not expected to be conducted in or near the spring-lead system through which bowheads migrate because (1) degraded ice conditions would not allow on-ice surveys, (2) insufficient open water is present for open-water seismic surveys, and (3) the Sale 170 area is far removed from the spring-lead system.

Overall, no definitive conclusions can be drawn on the effects of seismic activities on the overall migration corridor of the bowhead whale. A committee of the National Research Council, in commenting on the effects of industrial noise on marine mammals, including bowhead whales, stated that it is possible to argue at great length about the validity of individual studies, but the overriding issue is that there is widespread distrust of the results and dissatisfaction with the design of studies in arctic communities and others. Because the issue is so complicated—compounded by small sample sizes and interannual variability—further studies are unlikely to resolve it soon (NRC, 1994). The committee stated that the best (and perhaps only) solution is for MMS, the industry, and North Slope residents to attempt to reach agreement on the controversial matters and how they should be adjusted, remedied, or mitigated—as specific times and places that various activities occur—in lieu of or concurrent with additional studies. Along those lines, the MMS has included as part of Alternative I, Stipulation 5, which requires the lessee to consult with potentially affected subsistence communities to discuss siting, timing, and methods of proposed operations and safeguards or mitigating measures that could be implemented by the operator to prevent unreasonable conflicts. Since 1995, consultations between the AEWCand lessees have resulted in conflict avoidance agreements that require operators to cease geophysical operations east of Cross Island after August 31 until subsistence whaling activities in the area have been completed. Measures such as these are intended to help ensure that disturbance to the subsistence bowhead whale hunt will be minimized.

(b) **Effects from Aircraft Activities:** Most offshore aircraft traffic in support of the oil industry involves turbine helicopters flying along straight lines. Underwater sounds from aircraft are transient. According to Richardson et al. (1995a), the angle at which a line from the aircraft to the receiver intersects the water's surface is important. At angles >13° from the vertical, much of the incident sound is reflected and does not penetrate into the water. Therefore, strong underwater sounds are detectable for roughly the period of time the aircraft is within a 26° cone above the receiver. Usually, an aircraft can be heard in the air well before and after the brief period it passes overhead and is heard underwater.

Observations indicate that most bowheads are unlikely to react significantly to occasional single passes by low-flying helicopters ferrying personnel and equipment to offshore operations. Observations of bowhead whales exposed to helicopter overflights indicate that most bowheads exhibited no obvious response to helicopter overflights at altitudes above 150 m (164 yd) (Richardson and Malme, 1993, as cited in USDOI, MMS, 1996a). If bowheads were overflown at altitudes <150 m (164 yd), some probably would dive quickly in response to the aircraft noise. Fixed-wing aircraft overflights at low altitude (≤300 m [328 yd]) often cause hasty dives. Reactions to circling aircraft are sometimes conspicuous if the aircraft is below an altitude of 300 m (328 yd), uncommon at 460 m (503 yd), and generally undetectable at 600 m (656 yd). Aircraft noise generally is audible for only a brief time (tens of seconds) if the aircraft remains on a direct course, and the whales should resume their normal activities within minutes. The effects from such an encounter would be brief, and the whales should resume their normal activities within minutes. For development/production, it is estimated that from 46 to 59 helicopter flights per month will be flown during the 7 years of field development, and from 26 to 43 helicopter flights per month will be flown during the 20 years of production from the field.

Ms. Susan Akootchook from Kaktovik, providing testimony regarding the Beaufort Sea Northstar project in March 1996, commented on aircraft noise: "One time I was on ship and I had the headsets on and then heard an airplane, mind you, from under the water, listening in. I can hear an airplane flying over. And when I went out there and checked, it was way up there. And that noise, whether you use choppers or airplanes, it's going to be disruptive."

In general summary, bowheads are not affected much by any aircraft overflights at altitudes above 300 m (328 yd). Below this altitude, some changes in whale behavior may occur, depending on the type of plane and the responsiveness of the whales present in the vicinity of the aircraft. The effects from such an encounter with either type of aircraft generally are brief, and the whales should resume their normal activities within minutes. Also, for Lease Sale 170, many of the flights will be over shallow, nearshore waters outside of the main bowhead-migration route.

(c) **Effects from Vessel Activities:** Most bowheads begin to rapidly swim away when vessels approach rapidly and directly. Avoidance usually begins when a rapidly approaching vessel is 1 to 4 km (0.62-2.5 mi) away. A few whales may react at distances from 5 to 7 km (3-8 mi), and a few whales may not react until the vessel is <1 km (<0.62 mi) away. Received noise levels as low as 84 dB re 1 μPa or 6 dB above ambient noise may elicit strong avoidance of an approaching vessel at a distance of 4 km (2.5 mi). In the Canadian Beaufort Sea, bowheads observed in vessel-disturbance experiments began to orient away from an oncoming vessel at a range of 2 to 4 km (1.2-2.5 mi) and to move away at increased speeds when approached closer than 2 km (1.2 mi). Vessel disturbance under experimental conditions caused a temporary disruption of activities and sometimes disrupted social groups when groups of whales scattered as a vessel approached. Reactions to slow-moving vessels, especially if they do not approach directly, are much less dramatic. Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period. After some disturbance incidents, at least some bowheads return to their original locations (Richardson and Malme, 1993).

Thomas Brower, Sr. from Barrow began whaling in about 1916. He described precautionary measures taken to minimize noise during the subsistence whale hunt. He noted that in the spring whale hunt, the whaling crews are very careful about noise. He explained that the use of skin boats and paddles to pursue the whale was for the purpose of minimizing noise that would scare off the whale. Hunters later started using motors on their small boats for hunting whales during the fall hunt during the 1960's and 1970's. He said:

> In the fall, we have to go as much as sixty-five miles out to sea to look for whales. I have adapted my boat's motor to have the absolute minimum amount of noise, but I still observe that the whales are panicked by the sound when I am as much as 3 miles away from them. I observe that in the fall migration the bowheads travel in pods of sixty to one hundred twenty whales. When they hear the sound of the motor, the whales scatter in groups of eight to ten and they scatter in every direction (Brower, 1980).

Bowhead whales probably would encounter a few vessels associated with Sale 170 activities during their fall migration through the Alaskan Beaufort Sea , although most of the activity would be in nearshore waters. Vessel traffic generally would be limited to routes between the exploratory drilling units and the shore base. Each floating drilling unit probably would have one vessel remaining nearby for emergency use. Depending on ice conditions, floating drilling units may have two or more icebreaking vessels standing by to perform ice-management tasks. It is likely that vessels actively involved in ice management or moving from one site to another would be more disturbing to whales than vessels idling or maintaining their position. In either case, bowheads probably would adjust their individual swimming paths to avoid approaching within several kilometers of vessels attending a drilling unit and probably would move away from vessels that approached within a few kilometers. Vessel activities associated with the sale are not expected to delay or block the bowhead migration, and any deflections in individual bowhead-swimming paths and a reduction in use of one to several small areas of bowhead-feeding habitat near exploration units should not result in significant adverse effects on the species. During their spring migration (April through June), bowheads are expected to encounter few, if any, vessels along their migration route because ice at this time of year typically would be too thick for drillships and supply vessels to operate in.

For exploration/development, an estimated 150 to 205 supply-boat trips could occur. For the production phase, it is assumed that platforms will be resupplied by barge, and that support/supply boats will be on standby for special or emergency use.

In general summary bowheads may exhibit avoidance behavior if approached by vessels at a distance of 1 to 4 km (0.62-2.5 mi). Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period. In some instances, at least some bowheads returned to their original locations. In many cases, vessel activities are likely to be in shallow, nearshore waters outside the main bowhead-migration route.

(d) Effects from Drilling Activities:

Stationary sources of offshore noise (such as drilling units) appear less disruptive to bowhead whales than moving sound sources (such as vessels). Some bowheads in the vicinity would be expected to respond to noise from drilling units by slightly changing their migration speed and swimming direction to avoid closely approaching these noise sources. Under open-water, mean ambient-noise conditions, it has been estimated that bowheads might respond to drilling noise at 1 to 8 km (0.62-5 mi) from a drillship but only 0.2 to 1.8 km (0.12-1.12 mi) from an artificial-island drilling site (Miles, Malme, and Richardson, 1987). Bowhead whales exhibiting normal behavior while on their summer-feeding grounds have been observed on several occasions within a few miles of operating drillships, well within the zone where drillship noise is clearly detectable. In playback experiments, some bowheads showed a weak tendency to move away from the sound source at a level of drillship noise comparable to noise that would be present several kilometers from an actual drillship. Reactions to drilling sound from artificial islands and caisson-retained islands have yet to be observed, but underwater-sound levels at various distances from a caisson-retained island (with support vessels nearby) in the Canadian Beaufort Sea were similar to those produced by a drillship. In general, it appears that bowhead avoidance behavior is less around an unattended structure than one attended by support vessels. The following paragraph provides a brief discussion of a number of studies on the effects of noise from drilling operations on bowhead whales.

The distance at which bowheads may react to drillships is difficult to gauge, because some bowheads would be expected to respond to noise from drilling units by changing their migration speed and swimming direction to avoid closely approaching these noise sources. For example, in the study by Koski and Johnson (1987), one whale appeared to adjust its course to maintain a distance of 23 to 27 km (14.3-16.8 mi) from the center of the drilling operation. Migrating whales apparently avoided the area within 10 km (6.2 mi) of the drillship, passing both to the north and to the south of the drillship. The study detected no bowheads within 9.5 km (5.9 mi) of the drillship and few were observed within 15 km (9.3 mi). The principal finding of this study was that migrating bowheads appeared to avoid the offshore drilling operation in fall 1986.

In other studies, Richardson, Wells, and Wursig (1985) observed three bowheads 4 km (2.48 mi) from operating drillships, well within the zones ensonified by drillship noise. The whales were not heading away from the drillship but were socializing, even though exposed to strong drillship noise. Eleven additional whales on three other occasions were observed at distances of 10 to 20 km (6.2-12.4 mi) from operating drillships. On two of the occasions, drillship noise was not detectable by researchers at distances from 10 to 12 km (6.2-7.4 mi) and 18 to 19 km (11.2-11.8 mi), respectively. In none of the occasions were whales heading away from the drillship. Ward and Pessah (1988, as cited in Richardson and Malme, 1993) reported observations of bowheads within 0.2 to 5 km (0.12-3 mi) from drillships.

While conducting aerial surveys over the Kuvlum drilling location, Brewer et al. (1993) showed that bowhead whales were observed within about 30 km (18.6 mi) north of the drilling location. The closest observed position for a bowhead whale detected during the aerial surveys was approximately 23 km (14.3 mi) from the project icebreakers. The drilling rig was not operating on that day, but all three icebreakers had been managing ice during the day. Bowhead whale-call rates peaked when whales were about 32 km (19.9 mi) from the industrial activity. There was moderate to heavy ice conditions throughout the monitoring area, with heavy, grounded icefloes to the west, north, and east of the drilling site. Generally, whales tend to be located in deeper waters during years of moderately heavy ice cover (Treacy, 1993). Brewer et al. (1993) were unable to determine if either ice or industrial activity by themselves caused the whales to migrate to the north of the drilling location, but concluded that ice alone probably did not determine the observed distribution of whales.

Miles, Malme, and Richardson (1987) predicted that roughly half of bowheads are expected to respond at a distance of 1 to 4 km (0.62-2.5 mi) from a drillship drilling when the signal-to-noise ratio (S:N) is 30 dB. A smaller proportion would react when the S:N is about 20 dB (at a greater distance from the source), and a few may react at an S:N even lower or at a greater distance from the source. They predicted that roughly half of the bowheads are expected to respond at a distance of 0.02 to 0.2 km (0.12-1.12 mi) from drilling from an artificial-island drilling site when the S:N is 30 dB. For development/production, it is estimated that from 87 to 111 wells would be drilled during a 6-year period.

Hall et al. (1994) conducted a site-specific monitoring program around the Kuvlum drilling site in the western portion of Camden Bay during the 1993 fall bowhead whale migration. Results of their analysis indicated that bowheads were moving through Camden Bay in a significantly nonrandom pattern but became more randomly distributed as they left Camden Bay and moved to the west. The results also indicated that whales were distributed farther offshore in the proximal survey grid (near the drill site) than in the distant survey grid (an area east of the drill site), which is similar to results from previous studies in this general area. The authors noted that information from previous studies indicate that bowheads routinely are present nearshore to the east of Barter Island and are less evident close to shore from Camden Bay to Harrison Bay (Moore and Reeves, as cited in Hall et al., 1994). The authors believed that industrial variables such as received level were insufficient as a single predictor variable to explain the 1993 offshore distribution of bowhead whales, and they suggested that water depth was the only variable that accounted for a significant portion of the variance in the model. They concluded that, for 1993, water depth, received level, and longitude accounted for 85 percent of the variance in the offshore distribution of the whales. Based on their analyses, the authors concluded that the 1993 bowhead whale distribution fell within the parameters of previously recorded fall-migration distributions.

Davies (1997) used the data from the Hall et al., study in a geographic information system model to analyze the distribution of fall migrating bowheads in relation to an active drilling operation. He also concluded that the whales were not randomly distributed in the study area, and that they avoided the region surrounding the drill site at a range of approximately 20 km (12.4 mi). He also noted that the whales were located significantly farther offshore and in significantly deeper water in the area of the drilling rig. As noted above by Hall et al. (1994), the distribution of whales observed in the Camden Bay area is consistent with previous studies (Moore and Reeves, 1993), where whales were observed farther offshore in this portion of the Beaufort Sea than they were to the east of Barter Island. Davies concluded, as did Hall et al., that it was difficult to separate the effect of the drilling operation from other independent variables. The model identified distance from the drill rig and water depth as the two environmental factors that were most strongly associated with the observed distribution of bowheads in the study area. The Davies analysis, however, did not note that surface observers (Hall et al., 1994) observed whales much closer to the drilling unit and support vessels than did aerial observers. In one instance, a whale was observed approximately 400 m (436 yd) from the drill rig. Hall et al., suggests that bowheads were, on several occasions, closer to industrial activity than would be suggested by an examination of only aerial-survey data.

Concerns have been expressed about noise generated from the SSDC, the drilling platform used to drill two wells on the Cabot Prospect east of Barrow in 1990 and 1991. The two wells drilled for the Cabot Prospect were spudded on October 19, 1990, and November 1, 1991, respectively. Mr. Jacob Adams, Mr. Burton Rexford, Mr. Fred Kanayurak, and Mr. Van Edwardson, with the Barrow Whaling Captain's Association, stated in written testimony at the Arctic Seismic Synthesis and Mitigating Measures Workshop on March 5-6, 1997, in Barrow, Alaska:: "We are firmly convinced that noise from the Cabot drilling platform displaced whales from our traditional hunting area. This resulted in us having to go further offshore to find whales."

Mr. Burton Rexford, Chairman of the AEWC, testified that loud noises drive the animals away and spook them. Mr. Rexford, who has >53 years experience in subsistence whaling, was testifying at a public meeting in Barrow, Alaska, on the Letter of Authorization at the Kuvlum Prospect in the Beaufort Sea (1993): "We know where whales can be found; when the oil industry comes into the area, the whales aren't there. It is *not* the ice; it is the noise."

Sounds recorded 130 m (426 ft) from the actual *Karluk* drill rig were used as the stimulus during disturbance test playbacks (Richardson et al., 1991). For the overall 20 to 1,000 Hz band, the average source level was 166 dB re 1 μPa in 1990 and 165 dB re 1 μPa in 1989. In 1989, the study observed 18 bowheads within the area ensonified by the sound projector. This number included two cow/calf pairs. The authors concluded that, while the observations of whales in 1989 provided some information about the movements of bowheads toward and past the operating projector, the number was too small to allow any statistical analysis of distribution or movements. In 1990, the study observed an estimated 132 bowheads (about 90 groups) within the area ensonified by the sound projector while the projector was broadcasting normal, undistorted drilling sounds. The largest quantity of data was collected on May 13, 1990, when a stream of bowheads migrated along a long, narrow lead through otherwise heavy pack ice. Bowheads continued to pass the projector, while normal *Karluk* drilling sounds were projected. During the playback tests, the source level of sound was 166 dB re 1 μPa. One whale came within 110 m (360 ft) of the projector. Many whales came within 160 to 195 m (525-640 ft), where the received broadband (20-1000 Hz) sound levels were about 135 dB re 1 μPa. That level was about 46 dB above the background ambient level in the 20 to 1000 Hz band on May 13. Bowhead-movement patterns were strongly affected when they approached the operating projector. When bowheads were still several hundred meters away, most began to move to the far side of the lead from the projector, which did not happen during control periods while the projector was silent. Bowhead whales also were observed on one occasion while distorted *Karluk* sounds were being projected. Too few data are available to allow a statistical analysis of distribution or movements during the distorted playback versus other occasions. However, the closest point of approach distribution of bowheads observed by ice-based and aerial observers during the distorted playback appeared similar to that during projection of normal *Karluk* sounds later on the same day.

In a subsequent phase of this continuing study, Richardson et al. (1995b) concluded that migrating bowheads tolerated exposure to high levels of recorded continuous drilling noise, if it was necessary to continue their migration. Bowhead migration was not blocked by projected drilling sounds, and there was no evidence that bowheads avoided the projector by distances exceeding 1 km (0.54 nmi). However, local movement patterns and various aspects of the behavior of these whales were affected by the noise exposure, sometimes at distances considerably exceeding the closest points of approach of bowheads to the operating projector. Some migrating bowheads diverted their course enough to remain a few hundred meters to the side of the projector. Surfacing and respiration behavior and the occurrence of turns during surfacings were strongly affected out to 1 km (0.62 mi). Turns were unusually frequent out to 2 km (1.25 mi), and there was evidence of subtle behavioral effects at distances up to 2 to 4 km (1.25-2.5 mi). The study concluded that the demonstrated effects were localized and temporary and that playback effects of drilling noise on distribution, movements, and behavior were not biologically significant.

The authors stated that one of the main limitations of this study (during all 4 years) was the inability of a practical sound projector to reproduce the low-frequency components of recorded industrial sounds. Both the *Karluk* rig and the icebreaker *Robert Lemeur* emitted strong sounds down to ~10 to 20 Hz, and quite likely at even lower frequencies. It is not known whether the underrepresentation of low-frequency components (<45 Hz) during icebreaker playbacks had significant effects on the responses by bowheads. Bowheads presumably can hear sounds extending well below 45 Hz. It is suspected but not confirmed that their hearing extends into the infrasonic range below 20 Hz. The authors believed the projector adequately reproduced the overall 20 to 1,000 Hz level at distances beyond 100 m (109 yd), even though components below 80 Hz were under represented. If bowheads are no more responsive to sound components at 20 to 80 Hz than to those above 80 Hz, then the playbacks provided a reasonable test of the responsiveness to components of *Karluk* sound above 20 Hz.

The authors also stated that the study was not designed to test the potential reactions of whales to nonacoustic stimuli detected via sight, olfaction, etc. At least in summer/autumn, responses of bowheads to actual dredges and drillships seem consistent with reactions to playbacks of recorded sounds from those same sites. Additional limitations of the playbacks identified by the authors included low sample sizes and the fact that responses were only evident if they could be seen or inferred based on surface observations. The numbers of bowhead whales observed during both playback and control conditions were low percentages of the total Beaufort Sea population. Also, differences between whale activities and behavior during playback vs. control periods represent the incremental reactions when playbacks are added to a background of other activities associated with the research. Thus, playback results may somewhat understate the differences between truly undisturbed whales versus those exposed to playbacks.

Richardson and Malme (1993) point out that the data, although limited, suggest that stationary industrial activities producing continuous noise, such as stationary drillships, result in less dramatic reactions by bowheads than do moving sources, particularly ships. Most observations of bowheads tolerating noise from stationary operations are based on opportunistic sightings of whales near ongoing oil-industry operations, and it is not known whether more whales would have been present in the absence of those operations. Because other cetaceans seem to habituate somewhat to continuous or repeated noise exposure when the noise is not associated with a harmful event, this suggests that bowheads will habituate to certain noises that they learn are nonthreatening. However, in Canada, bowhead use of the main area of oil-industry operations within the bowhead range was low after the first few years of intensive offshore oil exploration began in 1976, suggesting perhaps cumulative effects from repeated disturbance may have caused the whales to leave the area. In the absence of systematic data on bowhead summer distribution until several years after intensive industry operations began, it is arguable whether the changes in distribution in the early 1980's were greater than natural annual variations in distribution, such as responding to changes in the location of food sources. Ward and Pessah (1988) concluded that the available information from 1976 to 1985 and the historical whaling information do not support the suggestion of a trend for decreasing use of the industrial zone by bowheads as a result of oil and gas exploration activities.

If the drillships are attended by icebreakers, as typically is the case during the fall in the U.S. Beaufort Sea, the drillship noise frequently may be masked by icebreaker noise, which often is louder. No observations have been made of bowhead reactions to icebreakers breaking ice. Response distances would vary depending on icebreaker activities and sound-propagation conditions. Based on models, bowhead whales likely would respond to the sound of the attending icebreakers at distances of 2 to 25 km (1.24-15.53 mi) from the icebreakers (Miles, Malme, and Richardson, 1987). This study predicted that roughly half of the bowhead whales showed avoidance response to an icebreaker underway in open water at a range of 2 to 12 km (1.25-7.46 mi) when the S:N is 30 dB. The study predicted roughly half of the bowhead whales would show avoidance response to an icebreaker pushing ice at a range of 4.6 to 20 km (2.86-12.4 mi) when the S:N is 30 dB. It should also be noted that the calculated range of 20 km (12.4 mi) exceeds the maximum range at which the propagation model was believed to be reliable. That also is the case with many of the sound-propagation estimates presented in Appendix D of the study. (Page 317, Appendix D of that study shows the estimated range at which noise from an icebreaker pushing ice would be received at a 20-dB S:N ratio [using 250 Hz and East/West distance values] is 42 km [26 mi]. It should be noted this exceeds the maximum range at which the propagation model is believed to be reasonably reliable, which is 30 km [18.6 mi]. The value of the 42 km [26 mi] figure is not clear, considering that it falls outside the reliability range of the model. The estimated range at which noise from an icebreaker pushing ice would be received at a 30-dB S:N ratio [using 250 Hz and East/West distance values] is 18 km [11.2 mi], which is within the maximum range at which the propagation model is believed to be reasonably reliable. This distance, 18 km [11.2 mi], falls within the 4.6 to 20 km [2.86-12.4 mi] distance. The authors emphasize that the estimates for intermittent sources are only theoretical and should not be used to predict whale avoidance at specific locations, because the methods may or may not be valid. Also, the zone of responsiveness generally is given as a range rather than as a diameter, because sound generally does not travel equivalent distances in all directions. As stated earlier in the text, sound transmission is affected by a wide variety of things, including water depth, salinity, temperature, frequency composition of the sound, ice cover, bottom type, and bottom contour.) Some whales likely would react at greater ranges when the S:N is 20 dB. For example, this study estimated the zone of responsiveness for bowhead whales for intermittent icebreaker noise at a frequency of 250 Hz at the Erik location at a range of 19 km (11.8 mi) and 4.6 km (2.86 mi) (adjusted for duty cycle) in the East/West direction when the S:N is 20 dB and 30 dB, respectively.

Richardson et al. (1995b) found that bowheads migrating in the nearshore lead often tolerated exposure to projected icebreaker sounds at received levels up to 20 dB or more above the natural ambient noise levels at corresponding frequencies. The source level of an actual icebreaker is much higher than that of the projectors (projecting recorded sound) used in this study (median difference 34 dB over the frequency range 40-6300 Hz). Over the two-season period (1991 and 1994), when icebreaker playbacks were attempted, an estimated 93 bowheads (80 groups) were seen near the ice camp when the projectors were transmitting icebreaker sounds into the water, and approximately 158 bowheads (116 groups) were seen near there during quiet periods. Some bowheads diverted from their course when exposed to levels of projected icebreaker sound >20 dB above the natural ambient noise level in the one-third-octave band of the strongest icebreaker noise. However, not all bowheads diverted at that S:N, and a minority of whales apparently diverted at a lower S:N. The study concluded that exposure to a single playback of variable icebreaker sounds can cause statistically but probably not biologically significant effects on the movements and behavior of migrating bowheads visible in the open water of nearshore lead system during the spring migration east of Point Barrow. The study indicated the predicted response distances for bowheads around an actual icebreaker would be highly variable; but for typical traveling bowheads, detectable effects on movements and behavior were predicted to extend commonly out to radii of 10 to 30 km (6.2-18.6 mi) and sometimes to 50+ km (31.1 mi). The study also noted that effects of an actual icebreaker on migrating bowheads, especially mothers and calves, could be biologically significant. It should be noted that these predictions were based on reactions of whales to playbacks of icebreaker sounds in a lead system during the spring migration and are subject to a number of qualifications. (The predicted "typical" radius of responsiveness around an icebreaker, such as the *Robert Lemeur*, is quite variable, because propagation conditions and ambient noise vary with time and with location. In addition, icebreakers vary widely in engine power and thus noise output, with the *Robert Lemeur* being a relatively low-powered icebreaker. Furthermore, the reaction thresholds of individual whales vary by at least 10 dB around the "typical" threshold, with commensurate variability in predicted reaction radius.)

The authors' discussion of the limitations over the course of the study was presented earlier in this section. As stated previously, one of the main limitations of the study was the inability of a practical sound projector to reproduce the low-frequency components of recorded industrial sounds. Both the *Karluk* rig and the icebreaker *Robert Lemeur* emitted strong sounds down to ~10 to 20 Hz, and quite likely at even lower frequencies. It is not known whether the underrepresentation of low-frequency (<45 Hz) components during icebreaker playbacks had significant effects on the responses by bowheads.

While conducting aerial surveys over the Kuvlum drilling location, Brewer et al. (1993) noted that the closest observed position for a bowhead whale detected during the aerial surveys was approximately 23 km (14.3 mi) from the project icebreakers. The drilling rig was not operating on that day, but all three icebreakers had been actively managing ice periodically during the day. The study did not indicate what the whale's behavior was, but it did not appear to be avoiding the icebreaker. Three whales were sighted that day, and all three appeared to be moving to the northwest along the normal migration route at speeds of 2.4 to 3.4 km (1.5-2.1 mi).

There also has been speculation that extremely strong noise might cause temporary or permanent hearing impairment under some conditions. According to Richardson and Malme (1993), there is no evidence that noise from routine human activities (aside from explosions) would permanently cause negative effects to a marine mammal's ability to hear calls and other natural sounds. Given their mobility and avoidance reactions, it is unlikely that whales would remain close to a noise source for long. Also, baleen whales themselves often emit calls with source levels near 170 to 180 dB re 1 μPa, comparable to those from many industrial operations. It is unknown whether noise pulses from nonexplosive seismic sources, which can be much higher than 170 to 180 dB, are physically injurious at any distance. The avoidance reactions of bowheads to approaching seismic vessels normally would prevent exposure to potentially injurious noise pulses.

In many cases, drilling activities are likely to be in shallow, nearshore waters outside the main bowhead migration route. Many of these wells will be drilled from an ice island or gravel island or other bottom-founded structure and would not require the use of an icebreaker. Spring-migrating bowheads are not expected to be exposed to drilling noise from activities in the Sale 170 area.

In general summary, bowheads have been sighted within 0.2 to 5 km (0.12-3 mi) from drillships, although some bowheads probably change their migration speed and swimming direction to avoid close approach to noise-producing activities. Koski and Johnson (1987) observed that one whale appeared to adjust its course to maintain a distance of 23 to 27 km (14.3-16.8 mi) from the center of a drilling operation. The study detected no bowheads within 9.5 km (5.9 mi) of the drillship, and few were observed within 15 km (9.3 mi). Some bowheads may avoid drilling noise at 20 km (12.4 mi) or more. Inupiat whalers believe that noise from drilling activities displace whales farther offshore away from their traditional hunting areas.

Overall, no definitive conclusions can be drawn on the effect drilling noise may have on the bowhead whale-migration corridor. As stated above, a committee of the National Research Council commented that it is possible to argue at great length about the validity of individual studies, but the overriding issue is that there is widespread distrust of the results and dissatisfaction with the design of studies in arctic communities and others. The committee believes that further studies are unlikely to resolve the issues soon (NRC, 1994) and recommended that the issue be dealt with by other means, such as mitigation.

(e) Effects from Construction Activities: Pipeline-construction activities, including dredging and pipelaying, also could result in noise and disturbance to bowhead whales. Offshore pipeline-construction activities between production platforms and onshore facilities would be relatively close to shore and could take up to five seasons to complete. Pipeline installation in nearshore areas could be installed either during the open-water season or during the winter. In water depths >40 feet, installation activities are likely to take place during the relatively short open-water season. The offshore portion of the pipeline would range from 64 to 96.5 km (39.8-60 mi) in length. Construction activities could cause some whales to temporarily avoid the area of activity. Bottom-founded drilling units and/or gravel islands may cover small areas of benthic habitat, and drilling muds and cuttings may cover portions of the seafloor that support epibenthic invertebrates used for food by bowhead whales. However, the effects are expected to be negligible, because bowheads feed primarily on pelagic zooplankton, and the areas of sea bottom that are impacted would be inconsequential in relation to the available habitat.

(f) Effects from Oil-Spill Cleanup: In the event of an oil spill, it is likely that large numbers of personnel, vessels, and aircraft will be present to conduct cleanup operations in the Beaufort Sea. If spilled oil is present during the bowhead whale migration, it could result in disturbance and possible displacement of whales from their normal migration route. An increase in oil-spill-cleanup activities could occur from the higher resource estimate, if a spill occurred from the main trunk of the pipeline or from more than one location.

Potential effects of noise disturbance to bowhead whales as a result of vessel and aircraft traffic is expected to be similar to that discussed in more detail earlier in this section, with temporary disruption of activities and possible displacement. Disturbance effects on the bowhead whale are expected to persist for the duration of cleanup operations, if the operations are conducted during the whale-migration period.

(3) Potential Effects from an Oil Spill: The effects of an oil spill on bowhead whales are unknown. Several researchers (Geraci and St. Aubin, 1982; St. Aubin, Stinson, and Geraci, 1984) concluded that exposure to spilled oil is unlikely to have serious direct effects on baleen whales.

(a) General Effects: Assuming an oil spill occurred in bowhead whale habitat while bowheads were present, some whales could experience one or more of the following: skin contact, baleen fouling, respiratory distress caused by inhalation of hydrocarbon vapors (from a fresh spill), localized reduction in food resources, consumption of some contaminated prey items, and perhaps a temporary displacement from some feeding areas. The number of whales contacted would depend on the size, timing, and duration of the spill; the density of the whale population in the area of the spill; and the whales' ability or inclination to avoid contact with oil.

Bowhead whales have not been observed in the presence of an oil spill, so it is uncertain if they can detect an oil spill or would avoid surfacing in the oil. Several investigators have observed a variety of cetaceans in the presence of spilled oil and noted that cetaceans, including fin whales, humpback whales, gray whales, dolphins, and pilot whales, did not avoid slicks but swam through them, apparently showing no reaction to the oil. During one study, humpback and fin whales and a whale tentatively identified as a right whale were observed surfacing and even feeding in or near an oil slick off Cape Cod, Massachusetts (Geraci and St. Aubin, 1990). None of the observations provide a definitive picture of whether cetaceans are capable of detecting oil and avoiding it. Some researchers have concluded that the surface vision of baleen whales is so effective, that they rely upon visual clues for a variety of activities. Bowhead whales have been observed "playing" with floating logs and sheens of floating dye on the sea surface, suggesting that bowheads may be able to recognize oil floating on the sea surface (Bratton et al., 1993).

Additional studies on the potential effects of an oil spill on cetaceans were conducted after the EVOS. No effects on the humpback whale population from the EVOS were documented by Dahlheim and Loughlin (1990). Ziegesar, Miller, and Dahlheim (1994) found no indication of a change in abundance, calving rates, seasonal residency time of female-calf pairs, or mortality in humpback whales as a result of EVOS. Temporary displacement from some areas of Prince William Sound was observed. It was difficult to determine whether the EVOS had any measurable impact on the number of humpback whales occurring in Prince William Sound. Long-term physiological impacts to whales or cumulative impacts to the ecosystem affecting humpback prey would not have been detected during this study. Loughlin (1994) conducted necropsies on three gray whales, one minke whale, and three harbor porpoises (which are not baleen whales) but found no indication of the cause of death. The cause of death could not be directly linked to the EVOS. Although 26 gray whale carcasses were observed, the large number was attributed to the timing of the search effort coinciding with the northern migration of gray whales, augmented by increased survey effort in the study area associated with the oil spill.

In a study on nonbaleen whales and other cetaceans, Harvey and Dahlheim (1994) observed 80 Dall's porpoise, 18 killer whales, and 2 harbor porpoises in the presence of oil from the EVOS on the surface of the water. The authors observed groups of Dall's porpoises on 21 occasions in areas with light sheen, several occasions in areas with moderate to heavy surface oil, once in no oil, and once when the amount of oil was not recorded. Thirteen of the animals were close enough to determine whether oil was present on their skin. Twelve animals that were present in light sheen or moderate-heavy oil were confirmed not to have oil on their skin. One Dall's porpoise was observed that had oil on the dorsal half of its body. In addition, 18 killer whales and 2 harbor porpoises were observed in the presence of oil, but no oil was observed on their skin. The Dall's porpoise that had oil on the dorsal half of its body appeared stressed because of its labored breathing pattern. In no case did cetaceans alter their behaviors when in areas with oil. The authors concluded their observations were consistent with other reports of cetaceans behaving normally in the presence of oil. Dahlheim and Matkin (1993) conducted observations on killer whales associated with the EVOS. Prior to the EVOS, the AB pod had 36 whales. Following the EVOS, 14 killer whales were missing from the AB pod in Prince William Sound and are presumed to have died. The cause of death of the killer whales is uncertain. The authors concluded that some of the whales may have died of natural causes, and the remainder are dead from either a result of interactions with fisheries or the EVOS, or a combination of both. There is a spatial and temporal correlation between the loss of whales and the EVOS, but there is no clear cause-and-effect relationship.

1) Effects of Contact: If a bowhead came in contact with spilled oil, the skin would be the first organ to be exposed to the oil. Oil is unlikely to adhere to smooth areas of bowhead skin but might adhere to rough areas on the skin surface. Henk and Mullan (In press) studied epidermal lesions on bowheads and categorized the lesions into three broad classes: shallow lacerations, circular depressions, and epidermal sloughing. They concluded that all three classes of lesions are confined to the superficial epidermis and result in no inflammatory or other dermal response. The authors stated that whatever the etiological agent or the morphological form of the lesion, the general response to exposing the strateum spinosum appears to be production of a secondary cornified layer of cells proximal to the affected area. This keratinized layer is contiuous with the strateum corneum of the unaffected skin at the edges of the lesion thus effectively circumscribing the damaged spinosum. Ultimately the secondary keratinized layer moves to the surface as a new strateum corneum, healing the lesion without scarring. The authors suggest that the increased microrelief on an otherwise smooth skin surface may increase the potential for adherence of spilled petroleum. Haldiman et al. (1981) also described the skin and lesions on the skin of bowheads. The structure of the skin of bowheads is described in more detail in Haldiman et al. (1985). The maximum thickness of the epidermal layer was found to be as much as seven to eight times thicker than found on most whales. This study also included some very simple preliminary trials to determine possible interactions between bowhead skin and crude oil. Using preserved bowhead skin dipped into crude oil, the study found that little or no crude oil adhered to the skin with up to three immersions, as long as a water film was maintained on the skin surface. Once the oil made sufficient contact with the skin to adhere, it would adhere in small patches to the epidermal surface and to the vibrissae. The amount of oil adhering to the surrounding skin and epidermal depression appeared to be directly proportional to the number of exposures to oil and the degree of roughness of the skin surface.

As described above, during a study of the EVOS, Harvey and Dahlheim (1994) observed groups of Dall's porpoise on 21 occasions in areas with light sheen, several occasions in areas with moderate to heavy surface oil, once in no oil, and once when the amount of oil was not recorded. One Dall's porpoise was observed that had oil on the dorsal half of its body. In addition, 18 killer whales and 2 harbor porpoises were observed in the presence of oil, but no oil was observed on their skin. In the case of the Dall's porpoise with oil on its skin, it isn't known how long spilled oil will adhere to the skin of a free-ranging cetacean.

Albert (1981) suggests that oil would adhere to the rough surfaces of the skin (eroded areas on the skin surface, tactile hairs, and the depressions around the tactile hairs). Albert theorizes that information provided to the animal by the tactile hairs could be affected and the skin could be irritated, especially the eroded areas on the skin surface. Because the function of the hairs is unknown, it is difficult to assess the impact to the bowheado f their possible loss of function. Albert expresses concern that if the eroded skin is damaged more, it may provide a point of entry for pathogenic bacteria to enter into the bloodstream. Shotts et al. (1990) found a large number of species of bacteria and yeast, both from the normal skin and from lesions on bowheads. Enzymatic assays from isolates from normal and lesional skin demonstrated production of enzymes capable of causing necrosis. The presence of the enzymes suggests that the lesions are active sites of necrosis. The authors noted that 38 percent of the microorganisms in lesions contained enzymes necessary for hemolytic activity of blood cells compared to 28 percent of the microorganisms on normal skin. Many of these species were determined to be potential pathogens of mammalian hosts. Hansen (1985) speculates that crude oil may kill the bacteria in the lesions, and that much of the oil is likely to be washed off as the whale moves through the water.

Haldiman et al. (1981) suggested that the significance of the epidermal erosion in the lesions may be misinterpreted, because epidermal thickening also occurred at the rim of some lesions, resulting in no actual decrease in the distance between the epidermal surface within the lesion and the tips of the dermal papillae. As stated above, it isn't known how long spilled oil will adhere to the skin of a free-ranging cetacean. If bowheads vacated oiled areas, it is possible that most of the oil would wash off the skin and body surface within a short period of time. However, if bowheads remained in oiled areas, oil might adhere to the skin and other surface features (such as sensory hairs) for longer periods of time.

Histological data and ultrastructural studies from the work of Geraci and St. Aubin (1990) showed that long exposures to petroleum hydrocarbons produced only transient damage to cells of the epidermis. The authors began their experiments by applying a small sponge soaked in crude oil to discrete areas of skin of four species of toothed whales. After contact for up to 45 minutes was ineffective, they progressed to longer exposures, up to 75 minutes, with gasoline. The authors stated at this point it became clear that even unrealistically long contact times could not elicit the kind of severe reaction that typically occurs in other mammals. Subtle changes that did occur were evident only histologically and, in each case, healed within a week. The authors stated that the studies pointed to the effectiveness of cetacean epidermis as a barrier to the noxious substances found in petroleum. Whereas these substances normally damage the skin by permeating intercellular spaces and dissolving protective lipids, their penetration in cetacean skin was impeded by tight intercellular bridges, the vitality of the superficial cells, and the extraordinary thickness of the epidermis. The intercellular and intracellular lipids are protected well enough that after exposing skin from a white-sided dolphin to gasoline for 16 hours *in vitro*, the authors could not detect a change in lipid concentration. The authors also investigated how oil might affect healing of superficial wounds in the skin of a bottlenose dolphin. They found that following a cut, newly exposed epidermal cells degenerate to form a zone of dead tissues that shields the underlying cells from seawater during healing. During the study, the superficial wounds were massaged with crude oil or tar for 30 minutes. The substances had no effect on healing. Applied in the same manner, lead-free gasoline caused an exaggerated inflammatory response that subsided by 24 hours and was indistiguishable from control cuts. The authors concluded that the devitalized shield had protected underlying tissues from gasoline in the same way it repels osmotic attack by seawater. The authors further concluded that, in real life, contact with oil would be less harmful than they and others had proposed.

Bratton et al. (1993), in a synthesis of studies on the potential effects of contaminants on bowhead whales, stated that there is no published data to prove oil fouling of the skin of any free-living whales and concluded that bowhead whale encounters with fresh or weathered petroleum most likely present little toxicologic hazard to the integument. The report concluded that cetacean skin presents a formidable barrier to the toxic effects of petroleum. As discussed above, Harvey and Dahlheim (1994) observed 13 Dall's porpoises, 18 killer whales, and 2 harbor porpoises in the presence of oil during a study of the EVOS. One Dall's porpoise had oil on the dorsal half of its body. No oil was observed on the skin of the other cetaceans. The Dall's porpoise was reported to have a labored breathing pattern. No other information was provided regarding the effects to the Dall's porpoise.

2) Effects of Ingestion/Inhalation:

Bowheads would be most likely to contact spilled oil as they surfaced to breathe. It is unlikely that they would inhale oil into the blowhole while breathing, although bowheads surfacing in a spill of lightly weathered oil could inhale some hydrocarbon vapors that might result in pulmonary distress. Perhaps the most serious situation would occur if oil were spilled into a lead from which bowheads could not escape. In this situation, the inhalation of oil vapor might cause intoxication (Bratton et al., 1993). If this were to occur, Bratton et al. (1993) theorized that whales could experience irritation of the mucous membranes or respiratory tract and possibly absorb volatile hydrocarbons into the bloodstream as a result of inhalation of toxic vapors. The volatile hydrocarbons likely would be rapidly excreted. Vapor concentrations that could be harmful to whales would be expected to dissipate within several hours after the termination of a spill. Whales exposed to toxic vapors within a few hours after the spill could suffer pulmonary distress and possible mortality. Generally, only a few whales would be likely to occupy the affected lead at any given time.

Bowheads sometimes skim the water surface while feeding, filtering large volumes of water for extended periods, and consequently might ingest some spilled oil, if any were present. Albert (1981) suggested that tarballs or large "blobs" of oil could be inadvertently engulfed along with prey items, or that baleen "hairs" that have been swallowed become matted together into small "balls" due to the oil and potentially cause a mechanical blockage in the stomach at the connecting channel. The connecting channel is a very narrow tubular structure connecting the fundic and pyloric chambers of the stomach (Tarpley et al., 1987). Hansen (1985 and 1992) suggests that cetaceans can metabolize ingested oil due to the presence of cytochrome p-450 in their livers (1992) and that any oil adhering to baleen filaments causing clumping may be broken down by the digestive process (1985). There is no evidence from observational studies or stranding records to suggest whether or not cetaceans would feed around a fresh oil spill long enough to accumulate a critical dose of oil.

Another concern is that the baleen hairs might be fouled, resulting in a reduced filtration efficiency. Preliminary studies (Braithwaite, 1983, as cited in Bratton et al., 1993) used a simple system to demonstrate that there was a 5- to 10-percent decrease in filtration efficiency of bowhead baleen after fouling of the baleen, which lasted for up to 30 days. Studies conducted by Geraci and St. Aubin (1985) found that 70 percent of the oil adhering to baleen plates was removed within 30 minutes after fouling, and 95 percent of the oil was removed within 24 hours after exposure. The study could not detect any change in resistance to water flow through baleen after 24 hours. This study tested baleen from fin, sei, humpback, and gray whales, which have short, coarse baleen compared to bowhead whales, which have longer baleen with many hairlike filaments. Bowheads most likely would occupy oiled waters for only a short time, and zooplankton-filtration efficiency would return to normal in a matter of hours, as oil is flushed from the baleen. However, repeated baleen fouling over an extended period of time might result in reduced food intake and blubber deposition that, in turn, might adversely affect the health and survival of bowheads.

Further information on the effects of ingesting oil by other marine mammals, such as polar bears, may be found in Section IV.B.6.

3) **Indirect Effects:** The population of zooplankton, the major food source of bowhead whales, likely would not be affected permanently by an oil spill. Researchers (Richardson et al., 1987, as cited in Bratton et al., 1993) stated that it was unlikely that accidental oil spills permanently would affect zooplankton or their availability to bowheads in the area studied and postulated that if effects on zooplankton or their availability did occur, they would be most likely to occur in nearshore feeding areas. The amount of zooplankton lost in even a large oil spill would be negligible in comparison to the plankton resources available on the whales' summer-feeding grounds (Bratton et al., 1993). Bowheads might ingest some oil-contaminated prey items, but it is likely these organisms would comprise only a small portion of the bowheads' food intake. Some zooplankton consumed by bowheads actively consume oil particles but apparently can excrete hydrocarbons from their system relatively rapidly. Tissue studies analyzing the level of naphthalene in the liver and blubber of whales indicated low levels of naphthalene in baleen whales, suggesting that prey species have low concentrations in their tissues or that baleen whales may be capable of metabolizing and excreting petroleum hydrocarbons (Geraci and St. Aubin, 1990).

Information regarding the adverse effects on the bowhead whale from materials such as petroleum products, heavy metals, and other contaminants is generally lacking, and information about cetacean metabolism also is inadequate. Based on the limited data available, researchers (Bratton et al., 1993) concluded that potential contaminants such as petroleum products appear to pose no harm to bowheads or to humans who eat them, although much more work is required to understand the significance of residue levels to both whales and humans. Bowheads also may be temporarily displaced from an area due to an oil spill or cleanup operations.

(b) **Sale-Specific Effects:** Sale-specific effects are likely to be the same as described earlier under general effects. Assuming an oil spill occurred in bowhead whale habitat while bowheads were present, some whales could experience one or more of the following: skin contact, baleen fouling, respiratory distress caused by inhalation of hydrocarbon vapors (from a fresh spill), localized reduction in food resources, consumption of some contaminated prey items, and perhaps a temporary displacement from some feeding areas. The number of whales contacted would depend on the size, timing, and duration of the spill; the density of the whale population in the area of the spill; and the whales' ability or inclination to avoid contact with oil.

1) **Probability of Contact:** No oil spills are assumed to occur during exploration. During development/production activities, the OSRA model estimates a 46- to 70-percent chance of one or more spills ≥ 1,000 bbl occurring. In this analysis, it is estimated that if a spill occurs, the average spill from a pipeline or platform would be 7,000 bbl.

For combined probabilities, the OSRA model estimates a 3- to 15-percent chance of one or more spills ≥ 1,000 bbl occurring and contacting bowhead whale habitat, such as I/SS's 7 to 9, areas where bowheads may be present during the fall migration, within 30 days over the assumed production life of Alternative I. The OSRA model estimates a 1-percent chance of one or more spills ≥ 1,000 bbl occurring and contacting bowhead whale habitat, such as I/SS's 4, an area where bowheads may be present during the spring migration, within 180 days over the assumed production life of Alternative I.

For conditional probabilities, the OSRA model estimates a 5- to 66-percent chance of a spill ≥ 1,000 bbl contacting I/SS's 7 to 9 within 30 days, during the winter season, assuming a spill occurs at launch boxes (L1-L8) and a 5- to 16-percent chance, assuming a spill occurs at pipeline segments (P1-P7). The OSRA model estimates a 1-percent chance of a spill ≥ 1,000 bbl contacting I/SS's 3 or 4 (an area where bowheads may be present during the spring migration) within 180 days, during the winter season, assuming a spill occurs at launch boxes (L1-L8) and a 1-percent chance, assuming a spill occurs at pipeline segments (P1-P7). The greatest percent chance of contact occurs at I/SS 9, which has a 66-percent chance of contact from a spill occurring at L7 and a 16-percent chance of contact from a spill occurring at P4, respectively.

The OSRA model estimates a 5- to 82-percent chance of a spill ≥ 1,000 bbl contacting I/SS's 6 to 13 within 30 days during the summer season, assuming a spill occurs at L1 to L8, and a 5- to 62-percent chance, assuming a spill occurs at P1 to P7. The OSRA model estimates a 0-percent chance of a spill ≥ 1,000 bbl contacting I/SS's 3 or 4 within 180 days during the summer season. The greatest percent chance of contact occurs at I/SS's 8 and 9, which have an 82-percent and an 81-percent chance of contact from a spill occurring at L3 and at L7, respectively, and a 57-percent and a 62-percent chance of contact from a spill occurring at P2 and P3, respectively.

2) **Site-Specific Effects:** Should an oil spill occur, the probability of oil actually contacting whales would be considerably less than the probability of contact with bowhead habitat. If an uncontrolled, uncontained spill were to occur, bowheads could experience one or more of the following: skin contact with oil, baleen fouling, inhalation of hydrocarbon vapors, a localized reduction in food resources, the consumption of oil-contaminated prey items, and perhaps temporary displacement from some feeding areas. Some individuals may be killed or injured as a result of prolonged exposure to freshly spilled oil; however, the number of individuals so affected is expected to be small. Exposure of bowhead whales to spilled oil may result in lethal effects to a few individuals, with the population recovering to prespill levels within 1 to 3 years. Most individuals exposed to spilled oil are expected to experience temporary, nonlethal effects.

Effectiveness of Mitigating Measures: As stated previously, a committee of the National Research Council commented that it is possible to argue at great length about the validity of individual studies, but the overriding issue is that there is widespread distrust of the results and dissatisfaction with the design of studies in arctic communities and others. Despite the numerous studies, questions regarding the effects of oil and gas activities on bowhead whales are not resolved, and it is not clear whether any amount of research will resolve them (NRC, 1994). The committee believes that the best (and perhaps only) solution is for MMS, industry, and North Slope residents to attempt to reach agreement on the controversial matters and how they should be adjusted, remedied, or mitigated—as specific times and places that various activities occur—in lieu of or concurrent with additional studies.

Along those lines, the MMS has included, as part of Alternative I, Stipulation 5 (Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Subsistence Activities), which requires the lessee to consult with potentially affected subsistence communities to discuss siting, timing, and methods of proposed operations and safeguards or mitigating measures that could be implemented by the operator to prevent unreasonable conflicts. This stipulation originated as a result of negotiations among representatives from the MMS, NSB, AEWC, industry, and other Federal and State agencies for OCS Lease Sale 144. Since 1995, consultations between the AEWC and the lessee have resulted in conflict avoidance agreements that require operators to cease geophysical operations east of Cross Island after August 31 until subsistence whaling activities in the area have been completed. Measures such as these are intended to help ensure that disturbance to bowhead whales will be minimized.

The stipulation on Industry Site-Specific Bowhead Whale-Monitoring Program will determine when bowhead whales are present in the vicinity of leases during exploratory drilling operations and will study the effects of these activities on the behavior of the bowheads. If the information obtained from this or other monitoring programs indicates that there is a threat of serious, irreparable, or immediate harm to the species, the lessee will be required to suspend operations causing such threat, which should help to minimize the likelihood of disrupting whale feeding, migration, or socialization. Some endangered whales may interact with the activities associated with exploratory drilling, and some inadvertent conflicts or incidental "taking" situations may occur. These inadvertent conflicts with or incidental "taking" situations of some individual whales as a result of exploration-drilling activities would not constitute a threat of harm to the species. This stipulation, in conjunction with the ITL on Information on Endangered Whales and MMS Monitoring Program, addresses the NMFS' Conservation Recommendation 4 in the ARBO and will help protect endangered bowhead whales during their migration from significant adverse effects due to exploratory activities, such as a blockage or delay of the migration.

Two other ITL's apply for protection of the bowhead whale: Bird and Marine Mammal Protection, which advises lessees of requirements under the ESA and Marine Mammal Protection Act (MMPA) and provides guidelines regarding disturbance of marine mammals, and Sensitive Areas to be Considered in Oil-Spill-Contingency Plans, which identifies areas needing protection in the event of an oil spill. While the mitigating measures may result in a slight reduction in disturbance to individual or small numbers of bowhead whales, the overall effects on the bowhead whale population with these mitigating measures in place is likely to be about the same as if the measures were not in place.

Overall, the mitigating measures will provide additional protection to whales and to subsistence whaling but will not eliminate all potential effects. As stated above, the stipulation on Conflict Avoidance Mechanisms to protect Subsistence Whaling and Other Subsistence Activities requires the lessee to consult with potentially affected subsistence communities to discuss siting, timing, and methods of proposed operations and safeguards or mitigating measures that could be implemented by the operator to prevent unreasonable conflicts. The Industry Site-Specific Bowhead Whale-Monitoring Program should be effective in preventing a delay or blockage of the migration. Fewer whales may be affected by activities due to these measures or may be affected to a lesser extent. However, even with the mitigating measures in place, whales still are expected to experience temporary, nonlethal effects as a result of exposure to oil and gas activities, with potential for some mortality if whales are exposed to freshly spilled oil over a prolonged period.

Summary: The effects of discharges of drilling muds and cuttings and formation waters are expected to be negligible to bowhead whales, because many of the wells likely will be drilled in relatively nearshore waters outside of the main migration route. Observations from studies on the effects of seismic sounds on bowhead whales indicate that bowheads exhibit avoidance behavior when exposed to sounds from seismic activity at distances ranging from around 1.3 to 1.5 km (0.81 to 0.93 mi) (Ljungblad et al., 1985; Fraker et al., 1985) to 24 km (14.9 mi) (Koski and Johnson, 1987). Richardson and Malme (1993) stated that most bowheads usually show strong avoidance when an operating seismic vessel is within 6 to 8 km (3.8-5 mi), and there probably are some effects at greater distances. They also noted that the apparent avoidance response at 24 km (14.9 mi) is the longest-distance avoidance of a seismic vessel documented in the studies they reviewed. The bowheads' surface-respiration-dive characteristics appeared to recover to pre-exposure levels within 30 to 60 minutes following the cessation of the seismic activity. Inupiat subsistence whalers state that industrial noise, especially noise due to seismic exploration, has displaced the fall bowhead migration seaward and is thereby interfering with the subsistence hunt. Whaling captains from Barrow, Nuiqsut, and Kaktovik, at the Arctic Seismic Synthesis and Mitigating Measures Workshop on March 5-6, 1997, in Barrow, Alaska, stated in written testimony: ". . .Factual experience of subsistence whalers testify that pods of migrating bowhead whales will begin to divert from their migratory path at distances of 35 miles from an active seismic operation and are displaced from their normal migratory path by as much as 30 miles." The NRC (1994) concluded that further research may not resolve the issue. Bowheads appear not to be affected much by aircraft overflights at altitudes above 300 m (328 yd). Some Inupiat feel that aircraft could be disruptive to bowheads. Bowheads may exhibit avoidance behavior if approached by vessels at a distance of 1 to 4 km (0.62-2.5 mi). Thomas Brower, Sr. from Barrow, who began whaling in about 1916, commented on the use of motors on small boats for hunting whales during the 1960's and 1970's. He said "In the fall, we have to go as much as sixty-five miles out to sea to look for whales. I have adapted my boat's motor to have the absolute minimum amount of noise, but I still observe that the whales are panicked by the sound when I am as much as three miles away from them. When they hear the sound of the motor, the whales scatter in groups of eight to ten and they scatter in every direction" (Brower, 1980). Bowheads have been sighted within 0.2 to 5 km (0.12-3 mi) from drillships, although some bowheads probably change their migration speed and swimming direction to avoid close approach to noise-producing activities. Koski and Johnson (1987) observed that one whale appeared to adjust its course to maintain a distance of 23 to 27 km (14.3-16.8 mi) from the center of the drilling operation. The study detected no bowheads within 9.5 km (5.9 mi) of the drillship, and few were observed within 15 km (9.3 mi). Hall et al. (1994) indicate that bowheads may avoid drilling noise at 20 km (12.4 mi) or more. Inupiat whalers believe that noise from drilling activities displace whales farther offshore away from their traditional hunting areas. In general, based on studies to date, behavioral changes are temporary, lasting from minutes (in the case of vessels and aircraft) up to 30 to 60 minutes (in the case of seismic activity). It also should be noted that individuals that are engaged in feeding, socializing, breeding, etc., may react to a stimulus at a higher threshold than resting or milling animals. Despite the numerous studies, questions regarding the effects of oil and gas activities on bowhead whales have not been resolved, and it is not clear whether any amount of research will resolve them (NRC, 1994). Most studies were observational, and based on opportunistic whale sightings near industrial activities. No definitive conclusions may be drawn on the overall effects on the migration corridor.

Should an oil spill occur, the probability of oil actually contacting whales would be considerably less than the probability of contact with bowhead habitat. If an uncontrolled, uncontained spill were to occur, bowheads could experience one or more of the following: skin contact with oil, baleen fouling, inhalation of hydrocarbon vapors, a localized reduction in food resources, the consumption of oil-contaminated prey items, and perhaps temporary displacement from some feeding areas. Some individuals may be killed or injured as a result of prolonged exposure to freshly spilled oil; however, the number of individuals so affected is expected to be small. Exposure of bowhead whales to spilled oil may result in lethal effects to a few individuals, with the population recovering to prespill levels within 1 to 3 years. Most individuals exposed to spilled oil are expected to experience temporary, nonlethal effects.

Conclusion: Overall, bowhead whales exposed to discharges of drilling muds and cuttings, noise-producing activities, and oil spills most likely would experience temporary, nonlethal effects. It is expected that many of the wells likely would be drilled in relatively nearshore waters outside of the main migration route. Bowheads may exhibit temporary avoidance behavior in response to seismic surveys, vessel and aircraft activities, drilling, and construction during exploration and development and production. Avoidance behavior usually begins at distances ranging from 1 to 4 km (0.62-2.5 mi) from a vessel. Observations from studies on the effects of seismic sounds on bowhead whales indicate that bowheads show avoidance behavior to seismic sounds at distances ranging from around 1.3 to 1.5 km (0.81 to 0.93 mi) (Ljungblad et al., 1985; Fraker et al., 1985) to 24 km (14.9 mi) (Koski and Johnson, 1987). Richardson and Malme (1993) stated that most bowheads usually show strong avoidance when an operating seismic vessel is within 6 to 8 km (3.8-5 mi), and there probably are some effects at greater distances. They also noted that the apparent avoidance response at 24 km (14.9 mi) is the longest-distance avoidance of a seismic vessel documented in the studies they reviewed. Bowheads show avoidance behavior to drilling noise at distances ranging from 0.2 to 5 km (0.12-3.1 mi). Koski and Johnson (1987) observed that one whale appeared to adjust its course to maintain a distance of 23 to 27 km (14.3-16.8 mi) from the center of the drilling operation. The study detected no bowheads within 9.5 km (5.9 mi) of the drillship and few were observed within 15 km (9.3 mi). Hall et al. (1994) indicate that bowheads may avoid drilling noise at ≥20 km (≥12.4 mi). In general, bowheads do not appear to travel more than a few kilometers in response to a single disturbance incident. Behavioral changes may last up to 60 minutes after the disturbance has left the area or the whales have passed, but overall effect on the migration pattern has not been determined. Subtle shifts in direction could cause bowheads to be at greater distances offshore while they migrate westward. Inupiat subsistence whalers state that industrial noise, especially noise due to seismic exploration, has displaced the fall bowhead migration seaward and is thereby interfering with the subsistence hunt at Barrow and Nuiqsut. Whaling captains from Barrow, Nuiqsut, and Kaktovik, at the Arctic Seismic Synthesis and Mitigating Measures Workshop on March 5-6, 1997, in Barrow, Alaska, stated in written testimony: "Factual experience of subsistence whalers testify that pods of migrating bowhead whales will begin to divert from their migratory path at distances of 35 miles from an active seismic operation and are displaced from their normal migratory path by as much as 30 miles." Despite the numerous studies, questions regarding the effects of oil and gas activities on bowhead whales have not been resolved and it is not clear whether any amount of research will resolve them (NRC, 1994). Some bowhead whales could be exposed to spilled oil, resulting primarily in temporary, nonlethal effects. Some mortality might result if exposure to freshly spilled oil were prolonged; however, the population is expected to recover to prespill levels within 1 to 3 years.

b. Effects on the Spectacled Eider:

Postbreeding male spectacled eiders stage and migrate as dispersed flocks primarily in lagoon areas along the Beaufort Sea coast; females with young typically are found offshore as a result of migrating later when the ice usually is farther from the coast (Petersen, 1997, pers. comm.). Most Arctic Slope nesting also occurs along this coastline, particularly west from the Sagavanirktok River.

(1) Potential Effects of Discharges:

Discharges from drilling operations during exploration (2 rigs) and development/production (3-5 platforms) are discussed in Section IV.B.4.a.(1) in this document. Discharged materials typically disperse rapidly in the water column, and bottom deposition occurs near drill sites. Because postbreeding eiders occur in dispersed flocks, relatively few are expected to occur in or rely specifically on prey potentially buried in these local drill-site areas (<0.5% of benthic habitat available in the proposed sale area). Therefore, discharges are not expected to cause significant effects either through direct contact with birds or by affecting prey availability.

(2) Potential Effects of Aircraft/Vessel Disturbance:

Spectacled eiders staging or migrating in coastal or offshore waters are not expected to experience significant disruption of foraging from routine activities (primarily helicopter flights), because of the low probability that these areas occupied by scattered flocks during the relatively brief staging/migration periods (late May/early June, late June/early July, late August/September) would be overflown by support aircraft flying between rigs and onshore facilities at Kuparuk Field or Deadhorse (1-2 round-trip flights/day). However, flocks often are large, and a disturbance corridor within 1 to 2 km (0.62-1.2 mi) of established flight paths suggests any disturbance event is likely to involve substantial numbers of individuals. Such incidents, likely to occur at low frequency, are expected to cause intermittent displacement of eiders from the vicinity of 3 to 5 flight corridors (representing <2.5% of the proposed sale area) between platforms and shore base for the 7 years of exploration and development. This is not expected to increase mortality significantly, but a portion of the population may experience lowered fitness as a result of routine displacement from favored foraging sites and depletion of energy stores during the critical staging/migration period. The net result is expected to be somewhat lower survival and/or productivity, from which the population is not likely to recover while the current decline persists. Onshore, because nest sites are scattered at low density over much of the Arctic Slope, relatively few are expected to be overflown by helicopters from offshore units, and substantial disturbance of nesting or broodrearing eiders is not expected to occur.

(3) Potential Effects of Construction Disturbance: Offshore pipeline and platform construction that occurs during summer and fall is likely to displace flocks of foraging eiders from the local area (within about 1 km of pipeline route); however, such short-term and localized disturbances are not expected to cause significant population effects. Likewise, localized burial of potential prey and destruction of a few square kilometers of foraging habitat as a result of pipeline trenching is not expected to cause a significant decline in prey availability for eiders. Because few eiders would be expected to occur in these relatively small areas (represents <1% of habitat available in the proposed sale area), they are not expected to experience substantial adverse effects from routine construction activities.

Onshore, because nest sites are scattered at low density over much of the Arctic Slope, relatively few are expected to become unavailable through burial or location in areas of gravel extraction, and only small numbers of nesting eiders are likely to be displaced away from the vicinity of onshore pipeline corridors by construction activity (lasting about 2 years) and vehicle-traffic disturbance. Although burial would result in permanent removal of habitat, routine disturbance effects would persist over the life of the field (potentially up to 30 years), and they would be localized primarily within a few kilometers of the pipeline corridor. Positive effects may be realized from water impoundments and early-season food- plant growth in dust shadows along pipeline roads. Net habitat loss and disturbance effects on spectacled eider productivity are not expected to be substantial, but the population is not likely to recover such losses while the current decline persists.

(4) Potential Effects of Disturbance from Oil-Spill Cleanup: The presence of substantial numbers of workers, boats, and aircraft flights (depending on spill size) following a spill is expected to displace eiders foraging in offshore or nearshore habitats during open-water periods for one or two seasons. However, staging/migrating flocks are dispersed and thus would not necessarily occur in the vicinity of much of the cleanup activity, particularly that occurring on barrier islands. As a result, relatively few flocks are likely to be displaced from favored habitats and expend energy stores accumulating for migration. Survival and fitness of individuals may be affected to some extent, but this infrequent disturbance is not expected to result in significant population losses.

(5) Potential Effects of an Oil Spill: Exposure of spectacled eiders to oil is expected to result in the general effects noted in Section IV.B.5 (i.e., individuals are not expected to survive moderate to heavy contact). During summer/fall periods when staging/migrating eiders occupy marine habitats, a highly variable proportion of the Arctic Slope population could be vulnerable to an oil spill approaching the Beaufort coastline, primarily west of the Sagavanirktok River. Probability of contact is lowered by individuals being concentrated in relatively few scattered flocks, primarily offshore, during brief summer/fall intervals; however, because such flocks typically are quite large, any contact is expected to cause substantial losses. Flocks foraging inside the barrier islands (approximately 50% of the coastline has adjacent islands) are protected to some extent from oil-spill contact. During spring migration, most migrant spectacled eiders arrive at the nesting areas via overland routes; thus, few are expected to occupy leads offshore where they would be vulnerable to oil. Spectacled eiders essentially are absent from the area from late October to May.

The probability (expressed as a percent chance) of one or more ≥1,000-bbl spills occurring and contacting offshore areas (I/SS's 6-11, Fig. IV.A.2-2) occupied by eider flocks during staging and migration periods within 180 days ranges from 3 to 15 percent at the low end of the resource estimate and to 5 to 27 percent, if resource recovery was at the high end. Probability of contact with flocks using the area between shore and the barrier islands ranges from <0.5 to 4 percent (Simpson Lagoon to Jago Lagoon; LS's 33-38, Fig. IV.A.2-3), suggesting a relatively low level of contact risk. As a result of a relatively small temporal window during which staging and migrating flocks could be exposed to a spill, and the generally dispersed flock distribution, the Arctic Slope spectacled eider population is expected to experience low mortality from oil spills associated with Alternative I (<300 individuals); however, unless mortality is near the lower end of this range (e.g., <25), recovery from spill-related losses is not expected to occur while the current declining numbers of breeding individuals and low reproductive rate persists.

Effectiveness of Mitigating Measures: Awareness of potential disturbance effects through the stipulated Orientation Program is expected to result in fewer disturbances of spectacled eiders by personnel associated with this proposed project. The ITL on Bird and Marine Mammal Protection is expected to result in fewer disturbance incidents involving aircraft as a result of industry awareness of recommended approach distance (1 mi) and altitude (1,500 ft) from animal concentrations. The ITL on Spectacled Eider and Steller's Eider emphasizes the protected status of these species under the ESA. Because few adverse effects are expected to result from disturbance factors associated with Alternative I, these mitigating measures, with the exception of the buffer recommendations of the ITL on Bird and Marine Mammal Protection, are not expected to significantly reduce overall effects on the spectacled eider.

Summary: Spectacled eiders staging or migrating along the Beaufort Sea coast or nesting in coastal habitats are not expected to experience significant adverse effects from drilling discharges or potentially disturbing routine activities during exploration and development/production because of the apparently low probability that scattered nest sites or the routes traveled and area covered by scattered flocks during two relatively brief staging/migration intervals would be overflown by support aircraft flights between offshore units and onshore facilities. Disturbance of some individuals over the life of the project is expected to be unavoidable, and any disturbance could be considered a "take" under the ESA. Relatively low spectacled eider mortality is expected from an oil spill (<300 individuals); however, unless mortality is near the lower end of this range (e.g., ≤25), recovery from spill-related losses is not expected to occur if the current population decline persists.

Conclusion: Overall routine effects on the spectacled eider are expected to be minimal, affecting <2 percent of the population; however, recovery from any substantial mortality resulting from an oil spill is not expected to occur while the current uncertain population status persists.

c. **Effects on the Steller's Eider:** Postbreeding male Steller's eiders stage and migrate as dispersed flocks along the Beaufort Sea coast; females with young may be found farther offshore as a result of migrating later, when the ice usually is farther from the coast (Petersen, 1997, pers. comm.).

(1) **Potential Effects of Disturbance Factors:** Steller's eiders staging or migrating in coastal Beaufort Sea areas west of the proposed sale area are not expected to experience adverse effects from potentially disturbing routine activities (helicopter flights), because of the extremely low probability that the routes traveled and area covered by scattered coastal flocks of this small Alaskan breeding population during two relatively brief staging/migration intervals would be intersected by the flight paths of distant support aircraft (1-2 round-trip flights/day) between onshore facilities at Kuparuk Field or Deadhorse and rigs in the western sale area. It is likely that the limited reduction of available foraging habitat in the western sale area during the brief time males in late June and females with juveniles in late August occupy coastal waters, primarily in the Barrow area, would have an inconsequential effect on the small Alaskan breeding population. Also, it is unlikely that the primary Alaskan nesting area, located south and southeast of Barrow, would be overflown by helicopters from offshore units, so significant disturbance of nesting or broodrearing eiders is not expected to occur. Little significant disturbance resulting from cleanup activities following any oil spill is expected to occur, because staging/migrating flocks are likely to be quite distant from the primary activity within or near the proposed sale area.

(2) **Potential Effects of an Oil Spill:** Exposure of Steller's eiders to oil is expected to result in the general effects noted in Section IV.B.5 (i.e., not expected to survive moderate to heavy contact). A minor proportion of the Alaskan breeding population is expected to be vulnerable to an oil spill, because the staging/migrating individuals generally are scattered in relatively few flocks along the coast during two brief intervals, and the oil would be well weathered and dispersed after moving considerably west of the proposed sale area. Because most spring-migrant Steller's eiders arrive at the nesting areas via overland routes, few are expected to occupy leads offshore where they would be vulnerable to oil entering such habitat. Eiders are not present in the area from October to May. The combined probability (expressed as a percent chance) of one or more ≥1,000-bbl spills occurring and contacting areas occupied during migration periods within 180 days (Elson Lagoon, C2, Fig. IV.A.2-6; LS's 20-25, Fig. IV.A.2-3) is <0.5 percent. Thus, low Steller's eider mortality is expected from an oil spill (<100 individuals); however, unless mortality is near the lower end of this range (e.g., <25), recovery of the Alaska population from spill-related losses is not expected to occur if population status remains similar to that at present—declining numbers on the breeding grounds and relatively low reproductive rate.

Effectiveness of Mitigating Measures: Awareness of potential disturbance effects through the Orientation Program stipulation is expected to result in fewer disturbances of Steller's eiders by personnel associated with this proposed project. The ITL on Bird and Marine Mammal Protection is expected to result in fewer disturbance incidents involving aircraft as a result of industry awareness of recommended approach distance (1 mi) and altitude (1,500 ft) from animal concentrations. The ITL on Spectacled Eider and Steller's Eider emphasizes the protected status of these species under the ESA. Because few adverse effects are expected to result from disturbance factors associated with Alternative I, these mitigating measures are not expected to significantly reduce overall effects on the Steller's eider.

Summary: Because potentially disturbing routine activities (helicopter flights) associated with this proposed sale generally would be far removed from most of the Steller's eiders staging or migrating along the western Beaufort Sea coast or breeding in the primary nesting area south of Barrow, the population is not expected to experience any significant effects from such activities. No disturbance effects of the primary Alaskan breeding population are expected to occur under exploration-only assumptions. Any disturbance of individuals could be considered a "take" under the ESA. Low mortality would be expected from an oil spill (<100 individuals); however, unless mortality is quite low, recovery of the Alaska population from spill-related losses is not expected to occur if the population decline persists.

Conclusion: Overall routine effects on the Steller's eider are expected to be minimal, affecting <2 percent of the Alaska population; however, recovery from any substantial mortality resulting from an oil spill is not expected to occur the current uncertain population staus persists.

d. Effects on the Arctic Peregrine Falcon:

Nesting peregrines could, on rare occasions, be disturbed by aircraft overflights associated with the proposed sale activities that may occur inland from the coast. Nesting sites such as those on the Colville River, about 32 km (20 mi) inland, may be vulnerable to such occasional disturbance. Aircraft based in Deadhorse typically would not fly over this area. Thus, significant disturbance of peregrine falcons associated with the exploration phase is unlikely. Significant population-level disturbance effects associated with the development and production phase would be unlikely as well. It appears that the onshore gathering pipelines projected for the production phase will be routed coastward of all peregrine falcon-nesting sites and thus should not adversely affect the species. Gravel mining for any artificial islands associated with proposed Sale 170 also is unlikely to affect the peregrine, because extraction is expected to occur near the Beaufort Sea coast where peregrines are not known to nest.

Because relatively few peregrines forage in coastal areas during the summer nesting season, the probability that significant numbers would contact spilled oil or oiled prey when hunting, or be affected indirectly through reduction of prey populations (seabirds and shorebirds), is low. Probability of contact during the fall season in areas such as the Colville or Canning river deltas may be somewhat greater as birds disperse. The combined probability (expressed as a percent chance) of one or more ≥1,000-bbl spills occurring and contacting potential foraging areas within 180 days (LS's 20-45, Fig. IV.A.2-3) ranges from <0.5 to 4 percent. Because the actual risk (probability) of spill contact for peregrines in these areas probably is much less than suggested by these values, due to this species' transient occurrence in the areas likely to be contacted and the fact that they typically do not contact the water surface, it is very unlikely that peregrines would be significantly affected by oil spills. If oil spills affected prey populations, short-term, localized reductions in food availability for peregrines could occur.

Effectiveness of Mitigating Measures: Awareness of potential disturbance effects through the Orientation Program stipulation is expected to result in fewer disturbances of arctic peregrine falcons by personnel associated with this proposed project. The ITL on Bird and Marine Mammal Protection is expected to result in fewer disturbance incidents involving aircraft as a result of awareness of recommended approach distance and altitude from animal concentrations. Because few adverse effects are expected to result from disturbance factors associated with Alternative I, these mitigating measures are not expected to significantly reduce overall effects on the arctic peregrine falcon.

Summary: Because support aircraft are not likely to fly routes as far inland as peregrine falcons nest, this activity is not expected to be a source of significant disturbance, either during exploration/development/production phases. Pipeline development is likely to take place coastward of nesting areas and thus is not expected to affect peregrines. Gravel mining associated with Sale 170 is not expected to occur near peregrine nesting areas. Peregrines foraging in coastal areas could be affected by an oil spill through contact with oiled prey or shoreline, or by a reduction in available prey (aquatic birds). The low probability (≤5%) of shoreline contact by a spill, the transient occurrence of peregrines in coastal areas, and their general avoidance of water contact supports the expectation that they would not be affected significantly by an oil spill.

Conclusion: Neither support aircraft nor onshore construction activities far removed from arctic peregrine falcon nest sites are expected to be a source of significant disturbance. There is a very low probability that an oil spill would contact falcons while infrequently foraging in coastal areas. The overall effect on peregrine falcons from oil spills and disturbance is expected to be minimal, with <5 percent of the population exposed to potentially adverse factors; no mortality is expected to result from Alternative I.

5. Marine and Coastal Birds:

Several million migratory birds of about 75 species occur in or adjacent to the proposed Sale 170 area, occupying offshore and coastal marine, freshwater, and tundra habitats. Shorebird, waterfowl, and a few seabird species are among the most vulnerable to OCS development activities. Important coastal habitats are shown in Figure III.B.4. The primary adverse effects on marine and coastal birds from exploration and development/production activities in the proposed sale area would result from alteration of habitats, disturbance of birds during the breeding or migration periods, and oil pollution of the marine environment. Portions of the following discussion and analysis are summarized from the Beaufort Sea Planning Area Oil and Gas Lease Sale 144 Final EIS (USDOI, MMS, 1996a), which is incorporated by reference.

a. Potential Effects of Discharges:

Routine discharges from drilling operations during exploration (2 rigs) and development/production (3-5 platforms) are discussed in Section IV.B.4.a.(1) of this document.

Discharged materials typically disperse rapidly in the water column, and deposition occurs near drill sites. Because most postbreeding waterfowl occur in flocks that generally are dispersed widely, relatively few are expected to occur in or rely specifically on prey potentially buried in these local drill-site areas (<0.5% of benthic habitat available in the proposed sale area), and thus discharges are not expected to cause significant effects either through direct contact with birds or by affecting prey availability.

b. Potential Effects of Disturbance and Habitat Alteration: Although air traffic is the primary activity associated with exploration, development, and production that may disturb marine and coastal birds, vessel traffic, construction, and oil-spill-cleanup activities in nesting, foraging, staging, or molting areas and vehicle and human foot traffic near nesting birds may disturb birds at critical points in their annual cycle. The response of birds to disturbance depends on the species; the physiological and reproductive state; distance from the disturbance; type, intensity, and duration of the disturbance; and other factors.

(1) Potential Effects of Aircraft and Vessel Disturbance: Local population segments of species nesting on barrier islands, river deltas or coastal wetlands, or molting/staging/migrating in coastal or offshore areas are expected to experience brief, temporary disruption of these activities, primarily from helicopter flights. Routine flights following three to five relatively direct-flight corridors between rigs/platforms and onshore facilities at Kuparuk Field or Deadhorse (1-2 round-trip flights/day) for the 7 years of exploration and development are likely to intercept scattered flocks infrequently, causing intermittent displacement of birds from within 1 to 2 km (0.62-1.2 mi) of flight paths (represents <2.5% of the proposed sale area). Population segments nesting or routinely foraging along these corridors will experience more frequent disturbance that may result in routine displacement from foraging and/or nesting areas and, potentially, seasonal abandonment of these local areas. Nesting eider colonies on barrier islands are particularly susceptible. Larger numbers of birds (potentially thousands during staging/migration periods) could be disturbed, for example, in nearshore lagoons, if poor visibility conditions forced aircraft to follow a lengthy shoreline route on the return to the shore base. Studies by Gollup, Goldsberry, and Davis (1974) suggest that if aircraft-disturbance events are relatively infrequent and of short duration, long-term displacement or abandonment of molting and foraging areas by oldsquaw, for example, is unlikely.

None of these scenarios is expected to increase adult mortality significantly, but a portion of these populations may experience lowered fitness as a result of displacement from favored nesting and foraging sites and depletion of energy stores during the critical staging/migration period, thereby adversely affecting the ability of migratory birds to acquire the energy (fat-lipid reserves) necessary for successful migration. Productivity of most species may be affected adversely if displaced adults are no longer able to protect eggs or young from predator populations (e.g., foxes, gulls) that have increased as a result of decreased trapping pressure (foxes, as noted by Barrow elders in USDOI, FWS, 1996) or increased availability of human-generated food. Frequent boat-traffic disturbance of nesting ducks has resulted in a 200- to 300-percent increase in the gull-predation rate on duck eggs and young ducklings in nesting areas that occur within 200 m of gull colonies versus predation rates at undisturbed duck nesting areas (Ahlund and Gotmark, 1989). Birds nesting on barrier islands and river deltas are particularly susceptible to such predation. The net result of these various scenarios is expected to be somewhat lower survival and/or productivity; however, losses are not expected to be significant because of the relatively low probability that areas occupied by scattered flocks during the relatively brief staging/migration periods, or nest sites during the brief nesting season, would be overflown frequently by support aircraft flying between rigs and shore bases.

Relatively few nest sites of individual species are expected to be overflown by helicopters from offshore units, because most are scattered at low density on the arctic slope, and thus substantial disturbance of nesting or brood-rearing birds is not expected to occur.

(2) Potential Effects of Other Disturbance Factors and Habitat Alteration: Construction activities and air and vessel traffic associated with drilling rigs during exploration and platform installation during development temporarily could displace (≤1 season) birds using areas near such sites. This local disturbance of birds within about 1 km of construction activities would be short term. Offshore pipeline and platform construction that occurs during summer and fall is likely to displace flocks of foraging waterfowl from the local area (within about 1 km of pipeline route); however, such short-term (≤1 year) and localized disturbances are not expected to cause significant population effects. Likewise, localized burial of potential prey and destruction of a few square kilometers of foraging habitat as a result of pipeline trenching is not expected to cause a significant decline in prey availability. Because few birds would be expected to occur in these relatively small areas (represents <1% of potential foraging habitat available in the proposed sale area), they are not expected to experience substantial adverse effects from routine construction activities.

Onshore, because nest sites are scattered at low density on the Arctic Slope, relatively few are expected to become unavailable through burial or location in areas of gravel extraction, and only small numbers of nesting birds are likely to be displaced away from the vicinity of onshore pipeline corridors (few hundred meters) by construction activity (lasting about 2 years and vehicle traffic disturbance. Although burial would result in permanent removal of habitat, routine disturbance effects would persist only over the life of the field (potentially up to 30 years), and they would be localized primarily within 1 to 2 km of the pipeline corridor. Positive effects may be realized from water impoundments and early-season food-plant growth in dust shadows along pipeline roads, which would benefit waterfowl; however, availability of shorebird prey is likely to be adversely affected near pipeline roads, and some shorebird nesting would be displaced. Net habitat loss and disturbance effects on most species' productivity are not expected to be substantial but would persist over the life of the field in the local areas affected.

(3) Potential Effect of Oil-Spill Cleanup: Oil-spill-cleanup activities involving large numbers of workers, extensive vessel activity, and additional aircraft operating in coastal habitats with concentrations of nesting birds is expected to cause displacement of nesting, molting, and feeding birds in the oiled areas and contribute to reduced reproductive success. This effect is expected to persist during cleanup operations (1 or 2 seasons) and affect birds within about 1 km of the activity.

Disturbance from all sources is expected to result primarily in short-term displacements of birds from the local areas where disturbance events are occurring; disturbance of local nesting birds probably would have little effect on Arctic Slope bird populations as a whole. Little direct mortality is expected, but losses of eggs and young to predators when adults are displaced is likely to occur. Routinely disturbed adults may experience lowered fitness, with resulting declines in survival and productivity over the life of the field. The effects of any losses from discharges, all sources of disturbance, and habitat alteration, are expected to be minor at the population level and may not be detectable above the natural fluctuations of the population and survey methods/data available.

c. Potential Effects of an Oil Spill: Exposure of waterfowl, seabirds, and shorebirds to oil is expected to result in the general effects reviewed in Rice et al., 1996; Hansen (1981); King and Sanger (1979); Rosie, Barnes, and Frampton (1983); Stickel and Dieter (1979); and USDOI, MMS, (1996a), i.e., individuals are not expected to survive moderate to heavy contact. Oiling causes death from hypothermia, shock, and/or drowning. Oil ingestion through preening of oiled feathers significantly reduces reproduction in some species, causes various pathological conditions, and reduces growth in chicks of such parents. Oiling of eggs significantly reduces hatching success. Adverse effects of oil on contacted food resources during critical energy-requiring periods, for example seabird nestling feeding or waterfowl staging, may result in lowered fledging success or survival.

(1) Vulnerability to Oil Spills: During summer/fall periods when molting/staging/migrating waterfowl, seabirds and shorebirds occupy marine habitats, a highly variable proportion of their Arctic Slope populations could be vulnerable to an oil spill approaching the Beaufort Sea coastline. The probability of contact is lowered by species being concentrated in relatively few scattered flocks during brief summer/fall intervals; however, because such flocks may be quite large, any contact is expected to cause substantial losses. Flocks foraging inside the barrier islands (approximately 50% of the coastline has adjacent islands) are protected to some extent at least from short-term contact by a spill that occurs outside such an area. During spring migration, many migrant waterfowl arrive at the nesting areas via overland routes, thus few are expected to occupy leads offshore where they would be vulnerable to oil; however, king eiders do occupy spring leads in substantial numbers. Waterfowl, seabirds, and shorebirds are absent from the area essentially from late October to May.

(2) Potential Site-Specific Oil-Spill Effects: The probability (expressed as a percent chance) of one or more ≥1,000-bbl spills associated with Alternative I occurring and contacting offshore areas (I/SS's 4-11, Fig. IV.A.2-2) occupied by waterfowl flocks during staging and migration periods within 180 days ranges from 0.5 to 15 percent at the low end of the resource estimate to 1 to 27 percent if resource recovery was at the high end. Probability of contact with flocks using the area between shore and the barrier islands ranges from <0.5 to 4 percent and 1 to 8 percent (Simpson Lagoon to Jago Lagoon, Fig. IV.A.2-6; LS's 28-38, Fig. IV.A.2-3), both of which suggest a relatively low level of contact risk. Also, the relatively small temporal window during which molting, staging, and migrating flocks could be exposed to a spill, and the often dispersed flock distribution, suggest that Arctic Slope waterfowl, seabird, and shorebird populations are expected to experience relatively low mortality from oil spills. However, an oil spill contacting coastal, nearshore (<20-m water depth), or offshore habitats during the open-water period could expose substantial numbers of birds per square kilometer (birds/km^2) to contamination: Pitt Point-Cape Halkett, 145; Harrison Bay, 30; Simpson Lagoon, 70; Gwydyr Bay-Flaxman Island, 80; Camden Bay, Jago Lagoon-Hulahula River, and Beaufort Lagoon, 25 (Divoky, 1983). Because the assumed spill may spread over several hundred kilometers of coastline, a spill contaminating lagoon waters where large aggregations of several thousand oldsquaw or other species were rafting could cause mortality ranging from several hundred to several thousand individuals.

If a spill occurred during the winter season, it is assumed that at least part of the spill would not be effectively cleaned up prior to ice breakup and could contact one or more important habitat areas (Fig. III.B-4) after ice breakup.

Local reduction or contamination of food sources due to an oil spill also could temporarily reduce survival and reproductive rates of up to several thousand additional migratory birds for that season. Most migratory species use various Beaufort Sea coastal habitats, depending on food availability. However, the contamination of some local habitat areas is not likely to affect a large proportion of a species' regional population frequenting the Beaufort Sea coast. The death of several thousand oldsquaw, an abundant species, would not have a long-term effect on the regional population, because recruitment would replace such losses within one generation. Most species with low reproductive rates or population levels (e.g., black guillemot, loons) are not likely to suffer high mortality as a result of an oil spill, because they are not abundant in the sale area and do not occur in large feeding flocks, although any losses would be recovered slowly. The effects of oil spills on marine and coastal birds in the Sale 170 area are expected to include the loss of several thousand to perhaps 10,000 sea ducks (primarily oldsquaw) and some seabirds and shorebirds. The effects of any spill-related losses are expected to be minor at the population level and may not be detectable above the natural fluctuations of the population and survey methods/data available.

Effectiveness of Mitigating Measures: The Orientation Program (Stipulation 2) and Information on Bird and Marine Mammal Protection (ITL 5) are expected to reduce potential disturbance effects on marine and coastal birds. The Orientation Program is expected to inform oil-company workers and contractors of the sensitivity of nesting, molting, and staging birds to disturbance, especially from air traffic, and to make the workers (and aircraft pilots) aware of the ITL and the recommended measures to avoid disturbing barrier island nesting colonies and other known bird-concentration areas by approaching no closer than 1.6 km (1 mi) and 545 m (1,500-ft) overflight altitude, when weather conditions permit. Compliance is expected to prevent excessive disturbance of marine and coastal birds. However, some disturbance of individual nesting birds and feeding concentrations is expected to occur when weather conditions require aircraft to fly below or within recommended minimums.

Information on Sensitive Areas To Be Considered in the Oil-Spill Contingency Plans (ITL 12) and Information on River Deltas (ITL 6) may provide some protection for marine and coastal bird sensitive habitats that are listed in the ITL and/or have been identified by the FWS as special bird-nesting habitats (e.g., Colville and Canning river deltas). The lessees are informed that these areas should be protected in the event of an oil spill. However, it is unlikely that oil-spill-protection and -cleanup measures would prevent a large spill from contacting these marine and coastal bird habitats, if wind and ocean currents were driving the spill into these areas.

Stipulation 1 on Protection of Biological Resources primarily concerns protection of benthic habitat that may be buried by drill-platform installation. The amount of benthic habitat thus affected (<1% of that potentially available in proposed sale area) is not expected to be of consequence to marine and coastal bird populations; thus, this stipulation is not expected to provide significant protection to marine and coastal birds.

Foraging, staging, and migrating birds and their coastal habitats could benefit from demonstrated industry preparedness, capability, and responsibility to contain, clean up, and financially compensate for damages associated with any oil spill, as would be demonstrated by operating as indicated in Information on Oil-Spill-Cleanup Capability (ITL 13), Information on Oil-Spill-Response Preparedness (ITL 14), and Information on Certification of Oil Spill Financial Responsibility (ITL 15).

Summary: For Alternative I, adverse effects on marine and coastal birds primarily would come from (1) routine exploration, development, and production activities; (2) alteration of marine and terrestrial habitats; and/or (3) oil spills.

Disturbance from all sources, especially helicopter traffic, is expected to result primarily in short-term displacements of birds from the local areas where disturbance events are occurring; disturbance of local nesting birds probably would have little effect on arctic slope bird populations as a whole. Little direct mortality is expected, but losses of eggs and young to predators when adults are displaced is likely to occur. Routinely disturbed adults may experience lowered fitness with resulting declines in survival and productivity over the life of the field. Losses to bird populations adversely affected by discharges, all sources of disturbance, and habitat alteration may not be detectable above the natural fluctuations of the population and survey methods/data available .

Vulnerability of bird populations to an oil spill is highly variable as a result of their seasonally patchy distribution and the relatively small temporal window during which molting, staging, and migrating flocks could be exposed to a spill. The probability of a spill occurring and contacting lagoons or other coastal areas ranges from <0.5 to 8 percent, suggesting a relatively low risk of contact and relatively low mortality for waterfowl, seabird, and shorebird populations. However, although a spill may spread over several hundred kilometers of coastal, nearshore, or offshore habitat during the open-water period, exposing large seasonal aggregations of several thousand oldsquaw or other species to contamination and causing mortality ranging from several hundred to several thousand individuals, the death of several thousand oldsquaw would not have a long-term effect on such an abundant regional population, because recruitment likely would replace losses within one generation; less abundant species are expected to require longer recovery periods. With few exceptions, the contamination of local habitat areas is not likely to affect a large proportion of any species' regional population exhibiting a dispersed distribution. The effects of oil spills on marine and coastal birds in the proposed sale area are expected to include the loss of several thousand to perhaps 10,000 sea ducks (primarily oldsquaw) and some seabirds and shorebirds, and may not be detectable above the natural fluctuations of the and survey methods/data available .

Conclusion: The potential effect of disturbance and habitat alteration on marine and coastal birds would be short-term displacement of nesting, feeding, molting, and staging birds and a potential minor decline in fitness. Oil spills are expected to cause the loss of several thousand birds due to oil contamination. The overall effects of displacement and mortality are expected to be minor at the population level, and may not be detectable above the natural fluctuations of the and survey methods/data available.

6. Pinnipeds, Polar Bears, and Belukha Whales:

Six species of nonendangered marine mammal—ringed, spotted, and bearded seals; polar bears; walruses; and belukha whales—commonly occur year-round or seasonally in a portion of or throughout the Beaufort Sea Planning Area, and some individuals of these species are likely to be exposed to some OCS exploration and development and production activities as a result of Alternative I. Noise and disturbance, alteration of habitats, and oil pollution could adversely affect some portion of these marine mammal populations found in the proposed Sale 170 area. For the purpose of this analysis, generation is defined as the average time interval between the birth of the female parent and the birth of her offspring. The generation time for ringed seals is about 4 to 8 years and about 7 years for polar bears (Kelly, 1988; USDOI, FWS, 1995b).

a. Effects of Noise and Disturbance: Airborne or underwater noise associated with OCS activities is the main source of disturbance of pinnipeds, polar bears, and belukha whales. For a discussion of the nature of airborne and underwater noise effects on these species, see the Sale 124 FEIS (USDOI, MMS, 1990a). A discussion of site-specific noise and disturbance effects follows.

The primary sources of noise and disturbance of ringed, bearded, and spotted seals; polar bears; and belukha whales would come from the air and marine traffic associated with Alternative I and more specifically from the supply boats, icebreakers, and helicopters associated with the assumed one or two exploration-drilling rigs and three to five production platforms. Secondary disturbance sources would be low-frequency noises from drilling operations on the two exploration-drilling rigs and three to five production platforms (see Sec. IV.A.1 and Table IV.A.1-1). Aircraft traffic (about 1,440 helicopter round trips over a 7-year exploration period and 46-59 and 26-43 round-trip flights/month during development and production, respectively) centered out of Deadhorse-Prudhoe Bay, traveling to and from the two exploration platforms and the three to five production platforms, is assumed to be a source of primary disturbance to some bearded and ringed seals hauled out on the ice and polar bears traveling on the ice within the sale area (Oliktok Point east to Camden Bay). Some belukha whales might be diverted by helicopter noise and presence, if they occur on the ice up to 100 m away (Richardson et al., 1995). Such brief, occasional disturbances are not likely to have any serious consequences for these cetaceans (Richardson et al., 1991; 1995).

Some of the air traffic to and from the one to two exploration-drilling units and to and from the three to five production platforms (see Sec. IV.A.1 and Table IV.A.1-1) could disturb hauled-out seals and walruses, causing them to charge in panic into the water. Because of frequent low visibility due to fog, aircraft may not always be able to avoid disturbing seals hauled out on the ice. Aircraft disturbance of hauled out seals in the sale area could result in injury or death to some young seal pups. Although air-traffic disturbance would be very brief, the effect on individual seal pups could be severe, if the pups were injured or abandoned by their mothers. The number of seals affected is expected to be small due to the low number of disturbance incidents expected under the proposed activities during exploration only and under development. Aircraft disturbance of small groups of spotted and ringed seals hauled out along the coast or disturbance of bearded and ringed seals hauled out offshore near the one or two drill platforms is expected to result in the death, injury, or abandonment of no more than small numbers (<10) of seals. Increases in physiological stress of adult or juvenile seals caused by the disturbance might reduce the longevity of some seals, if disturbances were frequent. However, the number of disturbances from three to five round-trip helicopter flights/day is expected to be infrequent. During the belukha whale migration, some of the aircraft traffic over open-water ice leads temporarily may divert the migration movements of some belukha whales as the aircraft pass overhead or nearby, but these reactions are not expected to be biologically significant (Richardson et al., 1995).

Exploration drilling would take place from gravel islands within ≤20 m water depth from bottom-founded mobile and floating drilling units; depending on ice conditions, the floating units would be supported by one or more vessels with icebreaking capabilities. Native people of the North Slope are concerned that noise from drilling platforms could be heard from miles and miles away, and that this noise would drive ringed and bearded seals away from subsistence hunting areas (Philip Tikluk from the village of Kaktovik, as cited in Kruse et al., 1983). However, exploratory drilling during the winter season—when natural leads often are frozen over—would result in the formation of leads and cracks in the ice on the leeward sides of the drill rigs, and such local changes in the ice habitat would attract seals that, in turn, would attract polar bears to the drilling platforms (Stirling, 1988). Some polar bears could be unavoidably killed to protect oil workers, when the bears were attracted to the rigs due to food odors and curiosity. Under the MMPA, oil companies are required to have a permit to take or harass polar bears. Consultation between the companies and the FWS on this matter is expected to result in the use of nonlethal means in most cases to protect the rig workers from polar bear encounters. The number of bears lost as a result of such encounters is expected to be very low (such as 1 or 2 bears).

Boat traffic (between about 50-205 supply boat trips/year; see Sec. IV.A.1 and Table IV.A.1-1) or icebreakers could briefly (a few days) disturb some marine mammal concentrations within a lead system and may temporarily interrupt the movements of belukha whales and seals or temporarily displace some animals when the vessels pass through the area. However, there is no evidence to indicate that vessel traffic would block or significantly delay marine mammal migrations. In fact, severe ice conditions are likely to have a far greater influence on spring and fall migrations than vessel traffic associated with Alternative I. Such traffic is not likely to have more than a short-term (a few hours to a few days) effect on marine mammal migrations or distributions; but the displacement of pinnipeds, polar bears, and belukha whales could affect the availability of these animals to subsistence hunters for that season. Icebreaker activity also may physically alter some ice habitats and destroy some ringed seal lairs in pack-ice areas, perhaps crushing or displacing some ringed seal pups and perhaps displacing some denning polar bears.

b. Effects of Seismic Activities: It is assumed that geophysical surveys (about 27-71 km^2 during exploration and 276-460 km^2 during development) would be shot over 21 to 35 days, primarily during the open-water season, using about two vessels (see Sec. IV A.1 and Table IV.A.1-1). Geophysical site-clearance surveys for a block survey would occur during development in association with production-platform installation; and 92 km^2 of high-resolution seismic-survey lines are assumed to be run in association with the laying of about 64 to 97 km of offshore pipelines under Alternative I.

Ringed seals pupping in shorefast-ice habitats within about 150 m (490 ft) of the on-ice shot lines are expected to be disturbed by on-ice seismic exploration (Burns et al., 1983). However, the number of ringed seal pups that possibly could be lost as a result of this very low level of disturbance is likely to be fewer than a few hundred, considering the low density of breeding seals in the Beaufort Sea, and would represent no more than a short-term (<2 year) effect on the population. During development, an estimated 276 to 460 km^2 of open-water shallow-hazards survey lines at (3-5 platforms) survey sites (based on past seismic activity), using perhaps two seismic boats for 21 to 35 days, could disturb some pinnipeds, polar bears, and belukhas during the 3 to 4 weeks of survey activity.

Winter seismic activities may result in disturbance to polar bear maternity dens (Blix and Lentfer, 1991; Amstrup, 1993; USDOI, FWS, 1995b). Denning polar bears were reported to tolerate exceptional levels of seismic activity and ice-road traffic; the latter only 400 m from an occupied den (Amstrup, 1993). However, dens located in the paths of seismic surveys or other industrial activity may incur physical damage (USDOI, FWS, 1995b). The FWS recommends that operators obtain a Letter of Authorization for activities in polar bear habitats, especially during winter months (see ITL 10). This measure is expected to prevent significant disturbance of denning polar bears.

Similar to other boat traffic, open-water, active seismic activities are likely to result in startle responses by ringed, bearded, and spotted seals; polar bears; and belukha whales near the sound source. As with other vessel traffic, this disturbance response is likely to be brief; and the affected animals are likely to return to normal behavior patterns within a short period of time after a seismic vessel has left the area. Noise and disturbance from seismic boats and other vessels could be a problem if boat traffic moved near marine-mammal-haulout areas or interfered with seal movements. However, this effect is unlikely, given the expected amount of vessel traffic associated with Alternative I. If the presence of noise from industrial activity occurred very near coastal subsistence areas and reduced or delayed the use of these habitats by marine mammals, the availability of these subsistence resources to villagers could be adversely affected for that season (see Sec. IV.B.9, Subsistence-Harvest Patterns). Overall, noise and disturbance from air and marine traffic associated with exploration only and the development of Alternative I are expected to have short-term (a few minutes to a few hours) local effects on marine mammal populations.

c. Effects of Offshore Construction: Under the assumed development scenario, one to two exploration-drilling units per year and three to five oil-production platforms are assumed to be used in the sale area (see Sec. IV.A.1 and Table IV.A.1-1). Platform-site preparation and pipeline trenching along the assumed 64 to 97 km of offshore pipeline could affect marine mammals through noise and disturbances, through habitat alterations (a few km^2) of benthic habitat (representing <1 percent of the benthic habitat in the sale area affected by pipeline trenching), and through temporary changes in availability of food sources within this area. Some pinnipeds, polar bears, and belukha whales could be temporarily displaced by noise and disturbance from platform-installation and pipe laying activities and also from other support activities. Temporary displacement could occur within about 2 to 3 km of the following platform and pipeline-trenching locations: Camden Bay, offshore of Prudhoe Bay-Point MacIntyre, and offshore of Oliktok Point. Prey species could be temporarily disrupted or buried near the pipeline-trenching and platform-preparation sites (see Sec. IV.C.2). During construction, some marine mammals near platform-installation sites and along the total of 64 to 97 km of offshore pipelines could be temporarily displaced for approximately one season or less. In theory, marine mammals could continue to be disturbed, and habitat use could continue to be diverted a few kilometers away from the platforms over the life of the field. The installation of exploration and production platforms (and drill rigs) in ice habitats of seals and their breathing-hole ice habitat is a concern (Akootchook, 1986, pers. comm.). However, the amount of displacement and change in habitat use (within 2-3 km of the platforms) is likely to be very small in comparison with the natural variability in seasonal habitat use and natural variations in marine mammal distributions. Noise-disturbance and adverse-habitat effects associated with platform and offshore-pipeline installation are expected to be very local (within a few kilometers or less of the platforms) and not affect marine mammal populations.

d. Effects of Onshore Construction: Onshore landfall development for the pipeline to the existing pipeline facilities is assumed to take place at Point McIntyre-West Dock, Oliktok Point, and Flaxman Island (Fig. IV.A.1-1) with the construction of 32 to 161 km of elevated onshore pipelines to the existing pipeline facilities (see Sec. IV.A.1 and Table IV.A.1-1). During construction-development activities associated with Alternative I, a small number of seals and polar bears located within a few kilometers of the landfall sites could be disturbed and perhaps displaced. However, the number of animals disturbed and/or displaced would be few, and the amount of coastal habitat altered would be localized near the pipeline-landfall site. As a result of Alternative I, onshore-development effects on regional marine-mammal populations are likely to be short term (1 year or season) and local (1-3 km [0.62-1.9 mi] from activity), with any disturbance of seals and polar bears declining after construction activities are complete.

e. Effects of Oil Spills:

(1) General Effects of Oil Pollution: Thomas Brower, Sr. (as cited in U.S. Department of Defense [USDOD], U.S. Army Corps of Engineers [COE], In prep.) observed some of the effects of a 25,000-gallon oil spill at Elson Lagoon in 1944. He saw birds and seals that were blinded and suffocating from the oil in the water. It took about 4 years for the spill to disappear and, during this time, whales avoided passing near the lagoon during fall migration (Brower, as cited in USDOD, U.S. Army COE, In prep.). See OCS Reports, MMS 85-0031 and MMS 92-0012 (Hansen, 1985; 1992) and the Sale 144 FEIS (USDOI, MMS, 1996a) for detailed discussions of the various possible direct and indirect effects of oil and other chemical pollutants on marine mammals.

Direct contact with spilled oil may kill some marine mammals and have no apparent effect on others, depending on factors such as the species involved and the animal's age and physiological status. Some polar bears and newly born seal pups occurring in the sale area are likely to suffer direct mortality from oiling through loss of thermoinsulation, which could result in hypothermia. Adult ringed, spotted, and bearded seals and walruses are likely to suffer some temporary adverse effects, such as eye and skin irritation with possible infection. Such effects may increase physiological stress and perhaps contribute to the death of some individuals (Geraci and Smith, 1976; Geraci and St. Aubin, 1980; St Aubin, 1990). Deaths attributable to oil contamination are more likely to occur during periods of natural stress such as during molting or times of food scarcity and disease infestations. Oil ingestion by marine mammals through consumption of contaminated prey and by grooming or nursing could have pathological effects, depending on the amount ingested, species involved, and the animal's physiological state. Death would be likely to occur if a large amount of oil were ingested or if oil were aspirated into the lungs. Consumption of apparently large quantities of oil over a relatively short period of time (as in the Oritsland et al. experiment with polar bears) can result in high concentrations of hydrocarbons in the bloodstream. If these concentrations exceed the filtering ability of the kidneys (and liver) to remove toxins and the ability of the liver to detoxify hydrocarbons (Engelhardt, 1983), kidney failure may occur, with severe toxic reactions and an imbalance of body chemistry leading to the death of the animal (Oritsland et al., 1981). Chronic oil ingestion may cause degeneration of liver and kidney tissue in marine mammals that have thick fur (to which oil will adhere) and that exhibit intensive grooming behavior, such as sea otters and polar bears.

Seals, walruses, polar bears, and belukha whales are not likely to intentionally avoid oil spills, although they may limit or avoid further contact with oil if they experience discomfort or apprehension as a result of contact with an oil slick (Hansen, 1985; 1992). Under some circumstances, they may be attracted to the spill site if concentrations of food organisms are nearby, or they may have little choice but to move through the spill site during migration. Polar bears may be attracted to an oil-spill site due to their curiosity (Adams, 1986, pers. comm., as cited in USDOI, MMS, 1986b) and due to the presence of dead birds or other animals killed by the spill.

(2) **Effects of Disturbance From Oil-Spill Cleanup:** In the event of a large oil spill contacting and extensively oiling coastal habitats, the presence of several hundred humans, many boats, and several aircraft operating in the area involved in cleanup activities is expected to cause displacement of seals, polar bears, and other marine mammals in the oiled areas and to contribute to increased stress and reduced pup survival of ringed seals, if operations occur during the spring. This effect is expected to persist for perhaps 1 or 2 years and to affect seals, polar bears, and other marine mammals within about 1.6 km (1 mi) of the activity.

(3) **Site-Specific Effects of Oil Spills:** Unless otherwise specified, oil-spill contact and probabilities referred to in this section assume the occurrence of the proposed development to the extent estimated in Section II.B.2.a and the associated spill rates (Sec. IV.A.I). No oil spills ≥ 1,000 bbl are assumed to occur with exploration only. Most attention is devoted to potential spills ≥ 1,000 bbl that have a trajectory period of up to 180 days during the open-water period and up to 180 days after meltout during the spring. There is a 46- to 70-percent chance of one or more spills ≥ 1,000 bbl (7,000-bbl average) occurring as a result of Alternative I. The following analysis assumes that one 7,000 bbl-oil spill occurs some time over the life of Alternative I.

Marine mammals using the flaw zone and pack-ice edge offshore of Oliktok Point (I/SS 7) east to Camden Bay area (I/SS 9) are at a greater risk (>6% chance of spill occurrence and contact) of potential oil-spill contamination within 180 days from an oil spill than marine mammals distributed in other offshore habitats of the Beaufort Sea (Fig. IV.B.6-1, I/SS's 4-6 and 10-13). The probability of spill occurrence and contact to the coastline (land) ranges from 23 to 40 percent (Fig. IV.B.6-1). Coastline habitats adjacent to the sale area generally have the highest risks of spill occurrence and contact. Thus, polar bears and seals frequenting the shoreline adjacent to the sale have the highest risk of exposure to oil spills.

Winter spills that occur nearshore within the 20-m isobath fast-ice zone are likely to affect some pupping and breeding ringed seals. Spills that occur in October are not likely to be cleaned up effectively under freezeup

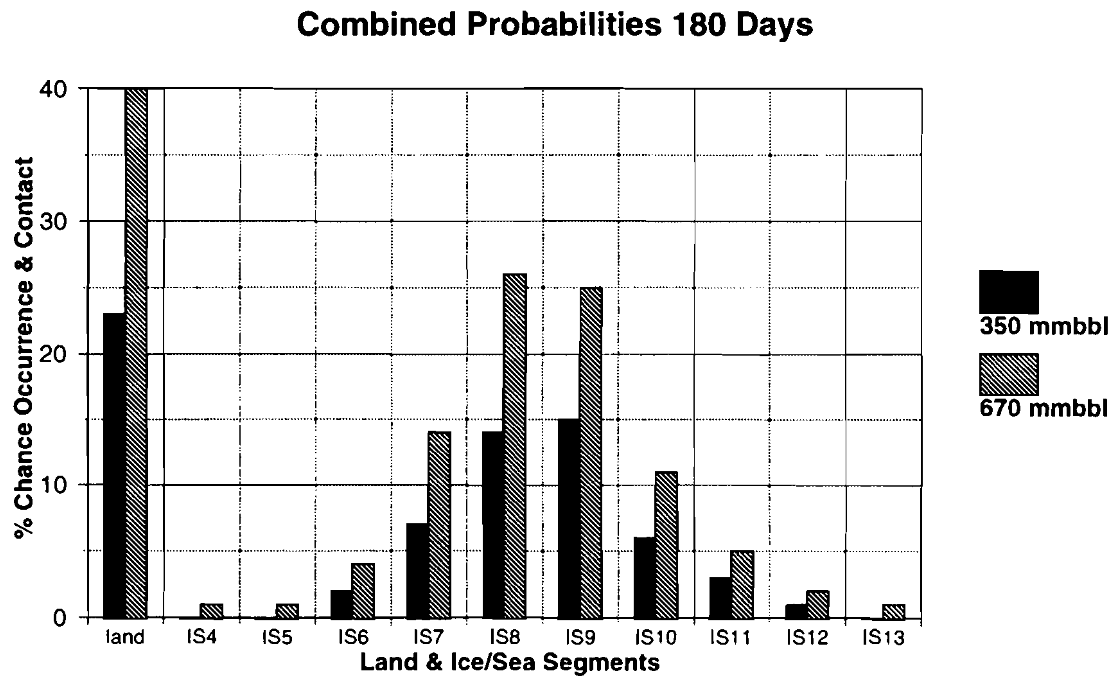

Figure IV.B.6-1 Combined Probabilities of One or More Spills ≥1,000 Barrels Occurring and Contacting Land (the shoreline) and Ice/Sea Segments (representing segments of the active ice flaw zone, see Fig. IV.A.2-2) Under the Resource Range of Alternative I Within 180 Days over the Assumed Production Life of Sale 170 (Source: Anderson et al., 1997, Table 10).

conditions and may contaminate fast-ice habitats of ringed seals. However, once freezeup occurs in the fast-ice zone, little spill movement or oil spreading would occur under fast ice. The number of ringed seal pups and adult seals contaminated is likely to be small (0.30-0.62 seals/km^2 in fast ice or perhaps 75-100 seals total loss out of a winter population of 40,000). If an oil spill (7,000 bbl) occurred during the open-water period or occurred during winter and contacted the offshore flaw zone, a numbers of ringed and bearded seals might be contaminated. Aggregations of hundreds of seals do occur in open water. Such an event could result in the contamination and loss of perhaps 75 to 100 seals.

The net westward movement of the spill and the chance of spill contact for the Northern Lead System [during] Spring (NLSS) during the spring, May through June (Anderson et al., 1997: Table 10, NLSS) indicate that the walrus-feeding habitat northwest and west of Point Barrow would be at a very low risk (<05-1%) of oil-spill occurrence and contact within 180 days. Oil contamination of walruses probably would not result in direct mortality of healthy individuals. However, contamination seriously could stress diseased or injured animals and stress young calves, causing some deaths. Perhaps a small number of calves (<100) and some adults could die from oil contamination, but such a loss is likely to be replaced within 1 year by natural recruitment in the population. Little or no significant contamination of benthic food organisms and bottom-feeding habitats of walruses and bearded seals is expected, because the fraction of the spill (such as 1-5%) is expected to be widely dispersed in the water column and to be weathered and degraded by bacteria prior to sinking to the bottom as scattered tarballs (see Sec. IV.A.3, Spilled Oil Fate and Behavior in Marine Waters). The amount of benthic prey killed or contaminated by scattered tarballs from the 7,000-bbl spill is likely to be a very small and represent an insignificant proportion of the prey and benthic habitat available in the eastern Chukchi Sea.

Polar bears would be most vulnerable to oil-spill contamination along the ice-flaw zone north of Oliktok Point east to Camden Bay (Fig. IV.B.6-1, I/SS's 7-9, respectively). However, the number of bears likely to be contaminated and ingest oil or indirectly affected by local reduction in seals as a result of the 7,000-bbl oil spill probably would be small considering the approximate density of one bear per 141 to 269 km^2 (54-103 mi^2) (Amstrup Stirling, and Lentfer, 1986) and the wide dispersion of the spill. In a severe situation where a concentration of perhaps 20 to 40 bears (such as at a whale carcass) out of a population of 1,300 to 2,500 were contaminated by an oil spill and all the bears died, this one-time loss is expected to be replaced by the Beaufort Sea population of polar bears within less than one generation (perhaps 3-5 years). Assuming an annual recruitment rate from the current growth rate of 2.4 percent would allow a potential biological removal rate or a yield of 48 bears per year and assuming equal sex ratio of removed bears and a subsistence harvest of 20 to 30 bears/year (USDOI, FWS, 1995). Assuming a Beaufort Sea polar bear population of 2,000 and a sex ratio of 2:1 male to female, the sustainable yearly harvest would be about 76 bears, which is considerably more than recent annual subsistence harvest of bears from this population under the North Slope Borough/Inuvailuit Game Committee Management Agreement on Polar Bears (Nageak, Brower, and Schliebe, 1991). Thus, the additional loss of 20 to 40 bears from the assumed 7,000-bbl spill (a total of 40-70 bears removed from the population from harvest and spill mortality for that one year or 8-22 bears over the 48 bears/yr yield) is expected to be recovered within less than one generation (3-5 years with an assumed polar bear generation time of at least 7-8 years), even if the sustainable yield is exceeded for 1 year. Some of the bears lost to the spill also are expected to be animals that would have been harvested that year. In fact, the harvest rate for the year of the spill probably would be <20 to 30 bears due to the reduced availability of bears to subsistence hunters as a result of the spill.

Belukha whales would be most vulnerable to oil contact during the spring migration off Point Barrow. Oil-slick contamination of the ice-lead system during spring migration (April-June) could directly expose several whales to some oil-spill contact. However, such contact is expected to be brief or intermittent and probably would not result in any deaths of healthy whales or have long-lasting sublethal effects after short exposure. The probability of oil-spill occurrence and contact to the lead system (Anderson et al., 1997; Table 10, NLSS) during the spring (May-June) period is very low(<0.05-1%). The likely physical reaction between oil, ice, water temperature, and wind off Point Barrow would appreciably reduce the chance of an oil slick persisting in the lead system (Sackinger, Weller, and Zimmerman, 1983). Therefore, belukhas of the western Beaufort population may have some contact with an oil spill (hydrocarbons in the water column or on the surface) that would temporarily contaminate the lead system off Point Barrow; however, few, if any, belukha whales are likely to be seriously affected, even in a severe situation, with no significant effect on the population.

One small oil spill ($\geq$1 bbl and <1,000 bbl) of about 9 bbl is estimated to occur during exploration, and 82 to 157 small oil spills <50 bbl and 3-7 spills $\geq$50 bbl but <1,000 bbl during production also are assumed to occur offshore under Alternative I (Table IV.A.2-4). These minor spills are expected to have an additive effect on seal, walrus, and polar bear losses, perhaps increasing losses by a few polar bears, seals, and walrus pups and increasing habitat contamination by perhaps about 1 to 2 percent.

Effectiveness of Mitigating Measures: The stipulation on the Orientation Program and the ITL on Information on Bird and Marine Mammal Protection are expected to reduce potential noise and disturbance effects of air and vessel traffic on pinnipeds, polar bears, and belukha whales. The Orientation Program is expected to inform oil-company workers and company contractors of the sensitivity of seals, polar bears, and belukha whales to noise and disturbance from air and vessel traffic and to make the workers (and aircraft pilots) aware of the ITL and the recommended measures to be taken to avoid disturbing seal haulout areas.

This analysis assumes that the oil industry and its contractors would comply with the ITL on Bird and Marine Mammal Protection and avoid flying within 1.6 km (1 mi) of seal and walrus haulout sites and other known marine mammal-concentration areas, when weather conditions permitted them to avoid these areas. This compliance is expected to prevent excessive or frequent disturbance of seals, polar bears, and belukha whales. However, some unavoidable disturbance of hauled out and feeding seals, belukha whales, and a few polar bears is expected to occur when (1) weather conditions prevent aircraft from flying at or above the recommended 545-m (1,500-ft) altitude or within $\geq$1.6 km (1 mi) from concentrations; (2) aircraft may fly low over concentrations of seals, polar bears, or belukha whales during takeoffs and landings; and (3) boats may disturb some seals, polar bears, or belukha whales near ice floes on in leads. These effects are expected to be short term and local and not to affect pinniped, polar bear, or belukha whale populations.

The ITL on Information on Sensitive Areas To Be Considered in the Oil-Spill Contingency Plans may provide some protection, at least in theory, for nonendangered marine mammal sensitive habitats that are listed in the ITL (such as the lead system off Point Barrow). The lessees are informed that these areas should be protected in the event of an oil spill. However, it is unlikely that oil-spill-protection and -cleanup measures would prevent a large spill from contacting these marine mammal habitats, if wind and ocean currents were driving the spill into these areas.

The stipulation on Protection of Biological Resources primarily concerns protection of benthic habitats that may be buried or covered by drill-platform installation. The amount of benthic habitats (probability <1 km^2 [0.62 mi^2]) is not expected to be of consequence to marine mammal populations; thus, this stipulation is not expected to provide much protection to pinnipeds, polar bears, and belukha whales. Other stipulations that are part of Alternative I and other proposed mitigating measures are not expected to provide any additional protection for nonendangered marine mammals or to reduce potential adverse effects.

If these mitigating measures are not part of Sale 170, the effects on pinnipeds, polar bears, and belukha whales are expected to be about the same as with the measures enforced. This is because the measures that provide protection for marine mammals, primarily the ITL on Bird and Marine Mammal Protection, are still likely to be complied with by the lessees because of the MMPA, which requires lessees to have a permit to conduct activities that may harass or take marine mammals in order to limit and avoid excessive harassment or taking of nonendangered marine mammals.

Summary: For Alternative I, noise and disturbance and habitat alterations from drill-platform installation, pipeline laying, and other construction and oil spills could have some adverse effects on pinnipeds, polar bears, and belukha whales found in the lease-sale area. Scientific and local Native knowledge of the behavior of nonendangered marine mammals and the nature of noise associated with offshore oil and gas activities suggest that intense noise causes startle, annoyance, and/or flight responses of pinnipeds, polar bears, and belukha whales. Helicopter trips and supply-boat traffic to and from the one or two exploration-drilling units and the three to five production platforms could disturb some hauled out ringed, bearded, and spotted seals, causing them to panic and charge into the water, resulting perhaps in the injury, death, or abandonment of small numbers of seal pups. Because nursing seals and pups are widely distributed along the ice front, aircraft moving to and from drill platforms are likely to temporarily disturb only a small portion of the seal populations. Thus, aircraft disturbance of seals and polar bears is likely to cause short-term displacement (a few minutes to less than a few days) of small numbers of these animals (less than a few hundred) within about 1 km of the air traffic route. Vessel traffic (16 trips/year) associated with the two exploration-drilling units and eight production units and seismic vessels operating during the open-water season temporarily could displace or interfere with marine-mammal migration and change local distribution for a few hours to a few days. Such short-duration and local displacement (within 1-3 km [0.62-1.9 mi] of the traffic) is expected to have a short-term (less than a few days') effect on the distribution of pinnipeds, polar bears, and belukha whales. The installation of three to five production platforms and the laying of 64 to 97 km of offshore pipelines within a few square kilometers of benthic habitat likely would have a short-term and local effect on these marine mammals.

There is a 46- 70-percent chance of one (7,000-bbl average) or more oil spills $\geq$1,000 bbl occurring during exploration and development. The analysis assumes that one 7,000-bbl oil spill occurs some time over the life of Alternative I. Oil spills pose the greatest risk of contact to all marine mammals in the Oliktok Point east to Camden Bay offshore areas (Fig. IV.B.6-1, I/SS's 7-9). Some aggregations of about 10 to perhaps a few hundred ringed, spotted, and bearded seals and fewer walruses occurring in these habitats could be contaminated and suffer lethal or sublethal effects. A small number of breeding ringed seals and their pups are likely to be contaminated by a winter oil spill, resulting perhaps in the death of some pups—probably no more than 100 because of the sparse distribution of pupping lairs. Polar bears also would be most vulnerable to oil spills in the ice-flaw zone; however, a small number of bears (20-40 bears) are likely to be affected because of their sparse distribution, with recovery taking place within less than one generation (or 3-5 years).

Walrus herds and their seasonal feeding habitat west and north of Point Barrow are at very low risk of oil-spill contact (<0.05%). If the 7,000-bbl spill contacts this area, direct effects of oil are likely to include the loss of some walrus calves and highly stressed adults. Such a loss is likely to be replaced by natural recruitment within <1 year. Little or no significant contamination of benthic-food sources of walruses and bearded seals is expected, because very little oil is likely to sink to the bottom except for scattered tarballs. This contamination is not expected to reduce the availability of benthic organisms.

Belukha whales are most vulnerable to oil-spill contact during spring migration off Point Barrow. Some belukhas could contact hydrocarbons in the water column or on the surface if an oil spill contaminated the lead system off Point Barrow during spring migration. However, few belukha whales are likely to be seriously affected by probable brief exposure to the 7,000-bbl spill (estimate of <10 whales), with population recovery expected to take place within 1 year.

Ringed seal pups and polar bears are the species most likely to suffer direct some mortality from the 7,000-bbl oil spill in the sale area. A small number of ringed seals—perhaps 75 to 100 pups and highly stressed adults (out of the winter population estimate of 40,000)—and a small number of polar bears (no more than perhaps 20-30 in a severe case out of a population of 1,300-2,500) could die if a spill occurred. This would represent no more than a short-term (<1-generation) effect on the Beaufort Sea populations, with losses within the populations replaced within about 1 year. The combined effect of noise and disturbance, habitat alterations, and oil spills is likely to be short-term, with populations recovering within less than one generation (or 3-5 years).

The effect of exploration only is expected to be less, with only brief disturbances of small numbers of seals, polar bears, and belukha whales from air and vessel traffic, with recovery from any disturbance event occurring within <1 day.

Conclusion: The effects from activities associated with Alternative I are estimated to include the loss (due to an oil spill, 46-70% chance) of small numbers of seals (for example, 75-100 seals out of a winter ringed seal population estimate of 40,000), walruses (<100 out of a population >200,000), polar bears (perhaps 20-40 out a population of 1,300-2,500), and belukha whales (<10 out of a population of >40,000), with populations recovering (recovery meaning the replacement of individuals killed as a consequence of Alternative I) within less than one generation (or 3-5 years).

7. Caribou:

Among the terrestrial-mammal populations that could be affected by Sale 170 are the caribou of the Central Arctic Herd (CAH) occurring along the coast adjacent to or near the sale area. Under Alternative I, the primary potential effects of OCS exploration and development activities on caribou would come from motor-vehicle traffic (disturbance) along pipeline-road corridors and near other onshore-support facilities (aircraft traffic is likely to have less of an effect, see Sec. IV.E.7). Secondary effects could come from potential oil spills contacting coastal areas used by caribou for insect relief and small areas of habitat alteration associated with onshore pipeline-road construction, including gravel mining for roads, for onshore facilities, and for possible artificial-island construction.

a. Effects of Disturbance:

(1) General Effects:

Caribou can be briefly disturbed by low-flying aircraft, fast-moving ground vehicles associated with an onshore pipelines, and the construction of other facilities (Calef, DeBock, and Lortie, 1976; Horejsi, 1981). The response of caribou to potential disturbance is highly variable—from no reaction to violent escape reactions—depending on their distance from human activity; speed of approaching disturbance source; frequency of disturbance; sex, age, and physiological condition of the animals; size of the caribou group; and season, terrain, and weather. Cow and calf groups appear to be the most sensitive to vehicle traffic, especially during the early summer months immediately after calving, while bulls appear to be least sensitive all year.

Tolerance to aircraft, ground-vehicle traffic, and other human activities has been reported in several studies of hoofed-mammal populations in North America including caribou (Davis, Valkenburg, and Reynolds, 1980; Valkenburg and Davis, 1985; Johnson and Todd, 1977). The variability and unpredictability of the arctic environment (snow conditions, late spring or early winter, etc.) dictate that caribou have the ability to adapt their behavior (such as change the time and route of migration) to some environmental changes. Consequently, repeated exposure to human activities such as oil exploration and development over several hundred square kilometers of summer range has led to some degree of tolerance by some caribou of the CAH. Some groups of caribou that overwinter in the vicinity of Prudhoe Bay and near Camp Lonely on the NPR-A and that have been continually exposed to disturbance stimuli, apparently have become accustomed to human activities. However, most of the North Slope caribou herds that overwinter south of the Brooks Range are less tolerant to human activities, to which they are seasonally or intermittently exposed, than some caribou that overwinter on the arctic coast.

Some displacement of the CAH from a portion of the calving range near the Prudhoe Bay and Milne Point facilities has occurred (Cameron, Whitten, and Smith, 1981, 1983; Cameron et al., 1992). This displacement of some caribou cows and calves has occurred within about 4 km (2.48 mi) of some oil facilities (Dau and Cameron, 1986a; 1986b; Nellemann and Cameron, 1996). The use of specific calving sites within the broad calving area varies from year to year; and the amount of displacement may be of secondary importance due to the low density of caribou on the calving range and the abundance of the CAH's calving habitat. However, recent information on the productivity of CAH caribou calving in the oilfields (west of the Sagavanirktok River) compared to CAH cows calving east of the oil fields (east of the Sagavanirktok River) suggests that displacement-disturbance of cow caribou on the oil fields may be affecting caribou productivity (Cameron, 1994). The avoidance of the Prudhoe Bay oilfield complex of roads and pipelines by cow caribou represents a functional loss of summer range habitat (Cameron et al., 1995).

(2) Sale-Specific Disturbance Effects Associated With Oil and Gas Exploration: Disturbance of caribou associated with exploration activities would come primarily from helicopter traffic (2-6 flights/day or 360 to 1,440 flights over the 8-year exploration period) to and from Deadhorse-Prudhoe Bay or to and from other onshore facilities and the one or two offshore-exploration platforms (see Sec. IV.A.1 and Table IV.A.1-1). Caribou have been shown to exhibit panic or violent flight reactions to aircraft flying at elevations of 60 m (162 ft) or less and exhibit strong escape responses (animals trotting or running from aircraft) to aircraft flying at 150 to 300 m (500-1,000 ft) (Calef, DeBock, and Lortie, 1976). These documented reactions of caribou were from aircraft that circled and repeatedly flew over caribou groups. Some of the aircraft traffic associated with exploration is likely to pass overhead of caribou once during any flight to or from the platforms; and the disturbance reactions of caribou are expected to be brief, lasting for a few minutes to no more than 1 hour and have no effect on caribou herd distribution and abundance.

(3) Effects of Exploration Habitat Alteration: No significant habitat alteration is expected to occur during exploration, because it is assumed that existing onshore-support facilities at Prudhoe Bay or other facilities will be used. The only habitat alteration that might occur would be gravel extraction from onshore-mining sites used in construction of an artificial gravel island drilling platform. Such gravel is likely to come from existing quarries and would represent a very small (a few acres or hectares) loss of tundra habitat.

b. Effects of Development:

(1) Effects of Aircraft Traffic: Some of the helicopter traffic associated with development (46-59 flights/month) and production (26-43 flights/month) is likely to pass overhead of caribou once during any flight to or from the platforms; and the disturbance reactions of caribou are expected to be brief, lasting for a few minutes to no more than 1 hour and have no effect on caribou herd distribution and abundance.

(2) General Disturbance Effects Associated With Pipelines: Some Natives of the North Slope believe that caribou migration movements have changed since the construction of the TAPS (Jonas Ningeok, as cited in Kruse et al., 1983). Recent studies (Roby, 1978; Cameron, Whitten, and Smith, 1981, 1983; Cameron et al., 1992; Pollard and Ballard, 1993) indicate significant seasonal avoidance of habitat near within 4 km (2.48 mi) some existing Prudhoe Bay area facilities by cows and calves during calving and early postcalving periods (May through June). Therefore, disturbance from vehicle traffic and human presence associated with present levels of oil development in the Prudhoe Bay area apparently has affected local distribution on a percentage (an estimated 25%) of the caribou's summer range. However, caribou abundance and overall distribution apparently have not been greatly affected—the CAH has greatly increased since oil development began, although this increase in caribou numbers is not to be inferred as caused by oil development, and the herd has recently declined. The CAH peaked at 23,000 in 1992, but declined to about 18,000 animals in 1994 with all of the decline occurring among caribou using the oilfields. The decline in abundance and productivity deficiencies of CAH cows (higher rate of reproductive pauses for cows ranging on the oilfields) appear to be directly linked to reduced body condition of females during the fall rather than to weather conditions, range quantity or quality, or different predation rates (FWS, 1997). Some Natives from Kaktovik have noticed that caribou overwintering on the North Slope have become scarce since development of the oil fields (Rexford, 1982, as cited in USDOI, MMS, 1982a).

Vehicle traffic (particularly high traffic levels such as 40-60 vehicles/hour) on a road adjacent to a pipeline would have the greatest manmade influence on behavior and movement while caribou are crossing the Prudhoe Bay and

Kuparuk oil fields and pipeline corridors (Murphy and Curatolo, 1984; Lawhead and Flint, 1993). A decline in the frequency at which caribou cross pipeline corridors is attributed to high traffic levels on the adjacent road and the frequency of severe disturbance reactions exhibited by caribou during crossing (Curatolo, 1984). Caribou generally hesitate before crossing under an elevated pipeline (there is no problem with buried pipelines) and may be delayed in crossing a pipeline and road for several minutes or hours during periods of heavy road traffic, but successful crossings do occur. Caribou have returned to areas of previous disturbance after construction was complete in other development areas (Hill, 1985; Northcott, 1984).

(3) General Effects of Habitat Alteration: The construction of pipelines and other onshore facilities on the North Slope necessitates the use of very large quantities (several million tons) of gravel. With the construction of roads and gravel pads for facility-building sites, small areas of tundra vegetation are excavated at the gravel-quarry sites. However, the several square kilometers of caribou tundra-grazing habitat destroyed by onshore development represents a very small percentage of the range habitat available to the caribou herd. The construction of roads and gravel pads also provides the caribou with additional insect-relief habitat on the roads and gravel pads, particularly when there is little or no road traffic present. However, displacement of calving caribou due to disturbance has resulted in a significant functional loss of habitat on the oilfields.

(4) Effects of Site-Specific Onshore Development: Assuming oil development takes place in the Beaufort Sea, the following potential oil-transportation (pipeline) projects and facility-construction projects could take place and affect the caribou herds. The following assumptions are made regarding Alternative I: (1) gas will be uneconomical to develop and produce for the foreseeable future, (2) the TAPS will have the capacity to handle production from the lease sale, and (3) three pipeline routes will be required to connect the TAPS or other existing pipeline facilities with the acreage offered (see Sec. IV.A.1). The route would include the following landfalls at the Point McIntyre, Oliktok Point, Endicott, and Flaxman Island areas.

(a) Oil Transportation East of Prudhoe Bay: Oil transportation from assumed platforms located in Camden Bay and connecting with the leases from Sales 124 and 144 in this area is assumed to be by offshore pipeline connecting to an onshore pipeline with a landfall at the Flaxman Island area (west of the ANWR boundary). Effects of oil development on the Porcupine Caribou Herd (PCH) probably are expected to be avoided, because no onshore system of roads, pipelines, pump stations, and other facilities would cross the calving or summer range of this herd. The onshore pipelines and road (32-161 km) from Point McIntyre (or Flaxman Island) to the TAPS would increase vehicle traffic by perhaps several hundred vehicles per day during construction, which could temporarily disturb some of the 18,100 caribou of the CAH within about 3 to 4 km of Point McIntyre and along the pipeline and road corridors to the TAPS, particularly during construction activities. Disturbance and habitat effects on the CAH are expected to be short term, because interference with caribou movements would be temporary (probably a few minutes to less than a few days); caribou eventually would cross the pipeline-road complex. However, CAH caribou calving in the area are expected to be displaced within 3 to 4 km of the pipeline road. Interference with CAH movements is expected to diminish after construction is complete, and vehicle-traffic levels are likely to decrease to <100 per day at the most. The abundance and overall productivity of the CAH is not likely to be affected by the construction and operation of oil-transportation facilities east of Prudhoe Bay that are assumed to be associated with Alternative I. Local distribution of caribou cows and calves within about 4 km (2.48 mi) of the pipeline-road could be affected during construction of the pipeline and road due to heavy traffic levels (such as >100 vehicles/day), and such an effect on local distribution and habitat use may be expected to persist beyond the construction period (2 years) and may persist over the life of the field. The pipeline landfalls at Endicott and the Flaxman Island areas are assumed to connect up with existing pipeline facilities in the Prudhoe Bay area. Effects of oil development on the PCH probably could be avoided if no onshore system of roads, pipelines, pump stations, and other facilities would cross the calving or summer range of this herd. However, decisions on whether there would be onshore or offshore pipelines east of the Canning River Delta on the ANWR would be influenced by any future decision of the U.S. Congress on possible exploration and development in the ANWR.

(b) Oil Transportation West of Prudhoe Bay: It is assumed that oil would be transported from offshore platforms located west of Prudhoe Bay, with the landfall located at Oliktok Point. Construction and support activities associated with this pipeline-landfall temporarily would disturb some caribou of the CAH, particularly when high levels (several hundred vehicles/day) of vehicle traffic are present during construction-gravel hauling. After construction is complete, disturbance levels would subside within 2 years or one generation (because of the great reduction in vehicle traffic to <100 vehicles/day at most for 4-5 hours). This level of effect is expected, because the animals eventually would cross the pipeline and road, and their numbers and the herd's distribution are not expected to be affected.

c. Effects of Oil Spills:

(1) General Effects: Caribou sometimes frequent barrier islands and shallow coastal waters during periods of heavy insect harassment and may possibly become oiled or ingest contaminated vegetation. During late winter-spring, caribou move out on to the ice and lick sea ice for the salt and thus may be exposed to oil if a spill contaminates the ice (Roosman Petook of Barrow, 1983). Caribou that become oiled are not likely to suffer the loss of thermoinsulation through fur contamination, although toxic hydrocarbons could be absorbed through the skin and also could be inhaled.

Oiled caribou hair would be shed during the summer before the caribou grow their winter fur. Toxicity studies of crude-oil ingestion in cattle (Rowe, Dollahite, and Camp, 1973) indicate that anorexia (significant weight loss) and aspiration pneumonia leading to death are possible adverse effects of oil ingestion in caribou. However, caribou frequent coastal areas to avoid insects and thus are not likely to be grazing on coastal or tidal plants that may become contaminated. In the event of an onshore oil spill that contaminated tundra habitat, caribou probably would not ingest oiled vegetation because they are selective grazers that are particular about the plants they consume. However, caribou that become oiled by contact with a spill in coastal waters could die from toxic-hydrocarbon inhalation and absorption through the skin.

(2) Site-Specific Effects of Oil Spills: Unless otherwise specified, oil-spill-contact probabilities referred to in this section assume the occurrence of exploration and development activities to the extent estimated for Alternative I in Section IV.A.1.a and associated spill rates (Sec. IV.A.2). Attention is devoted to an oil spill averaging 7,000 bbl and to spill contacts that occur within 180 days during the summer season. Coastlines that may be frequented by caribou in the Point Thomson-Bullen Point area (LS's 36-37) and Prudhoe Bay-Point McIntyre areas (LS's 34 and 35) have the highest (3-8%) chance of oil-spill occurrence and contact (Fig. IV.B.7-1).

If a spill (7,000 bbl) occurred during the open-water season or during the winter and melted out of the ice during the spring, some caribou of the CAH and the PCH that frequent coastal habitats from Harrison Bay (LS 28) east to Barter Island (LS 41) could be directly exposed to and contaminated by the spill along the beaches and in shallow waters during periods of insect-pest-escape activities (Fig. IV.B.7-1). However, even in a severe situation, a comparatively small number of CAH animals, perhaps 10 to 300 animals based numbers of CAH caribou recorded at coastal locations that appear to be in the water on some summer distribution surveys (Pollard and Ballard,1993)

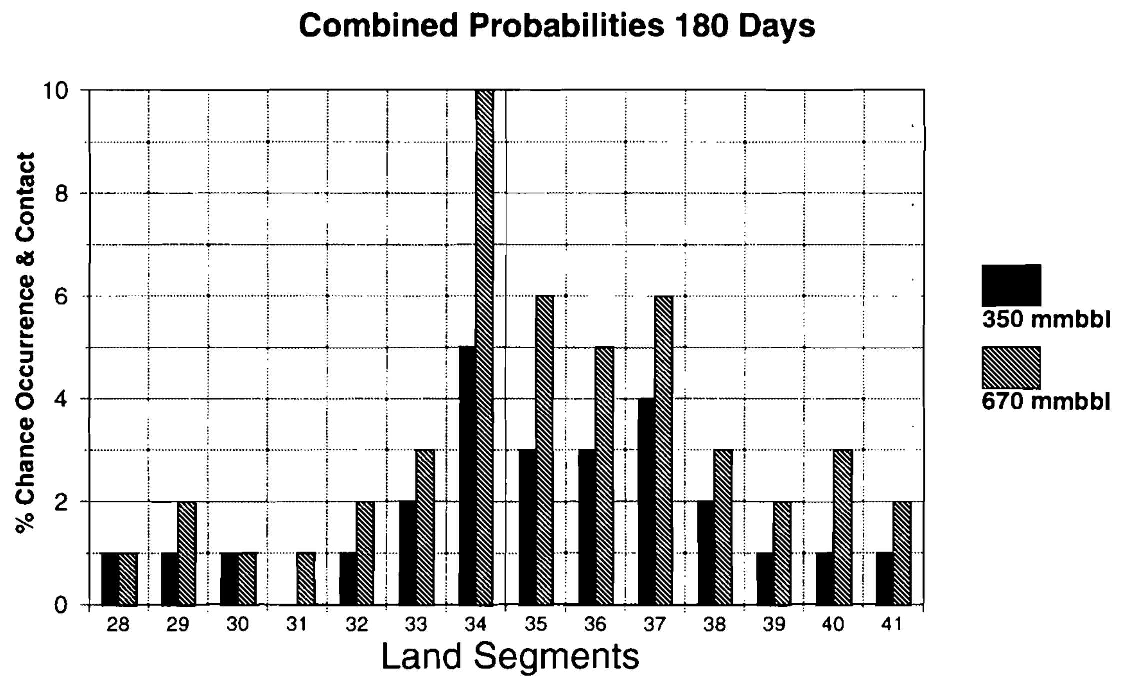

Figure IV.B.7-1 Combined Probabilities of One or More Spills ≥1,000 Barrels Occurring and Contacting Certain Land Segments (see Fig. IV.A.2-3) Under the Resource Range of Alternative I Within 180 Days Over the Assumed Production Life of Sale 170 (Source: Anderson et al., 1997).

and PCH caribou (no more than 1500 to 3,000 or 1 to 2% of the population (Whitten, 1997, pers. comm.) is likely to be directly exposed to the oil spill and may die as a result of toxic-hydrocarbon inhalation and absorption. This loss probably would be small for any of the caribou herds, with these losses replaced within about 1 year.

One small oil spill (≥1 bbl and <1,000 bbl) of about 9 bbl is estimated to occur during exploration, and 82 to 157 small oil spills <50 bbl and 3 to 7 spills ≥50 bbl but <1,000 bbl during production also are estimated to occur offshore under Alternative I (Table IV.A.2-4). These minor spills are expected to have an additive effect on caribou, perhaps increasing losses by a few animals and increasing coastal habitat contamination by perhaps about 1 to 2 percent.

(3) Effects of Disturbance from Oil-Spill Cleanup: In the event of a large oil spill contacting and extensively oiling coastal habitats with herds or bands of caribou during the insect season, the presence of several thousand humans, hundreds of boats, and several aircraft operating in the area involved in cleanup activities is expected to cause displacement of some caribou in the oiled areas and contribute temporarily to seasonal stress on some caribou. This effect is expected to occur during cleanup operations (perhaps 1 or 2 seasons) but is not expected to significantly affect the caribou herd movements or the foraging activities of the populations.

(4) Onshore Oil-Spill Effects: Under Alternative I, a total of about 452 to 866 small spills <50 bbl and 2 to 4 spills ≥50 bbl but <1,000 bbl of either crude oil or petroleum products also are estimated to occur onshore in association with pipeline facilities, including the TAPS. These minor spills are expected to have an additive effect on caribou, perhaps increasing contamination of terrestrial habitats along pipeline and road corridors by 1 to 2 percent. Some tundra vegetation in the pipeline corridor would become contaminated from these spills. However, caribou probably would not ingest oiled vegetation, because they are selective grazers and are particular about the plants they consume (Kuropat and Bryant, 1980). If a pipeline spill occurred, it is likely that control and cleanup operations (ground vehicles, air traffic, and personnel) at the spill site would frighten caribou away from the spill and prevent the possibility of caribou grazing on the oiled vegetation. Thus, onshore oil spills associated with Alternative I are not likely to directly affect caribou through ingestion of oiled vegetation.

Onshore oil spills on wet tundra kill the moss layers and aboveground parts of vascular plants, or they kill all macroflora at the spill sites (McKendrick and Mitchell, 1978). Thus, pipeline oil spills can destroy or alter the local grazing habitat along the pipeline corridor. Damage to oil-sensitive mosses may persist for several years, if the spill sites are not rehabilitated (e.g., by applying phosphorus fertilizers to spill sites) (McKendrick and Mitchell, 1978). For the most part, the effect of onshore oil spills would be very local and would contaminate tundra in the immediate vicinity of the pipeline; these spills would not be expected to significantly contaminate or alter caribou range within the pipeline corridors.

Effectiveness of Mitigating Measures: The ITL 1, Information on Bird and Mammal Protection, is expected to indirectly reduce noise and disturbance effects of air and vessel traffic on caribou occurring along the coast of the sale area. This measure recommends air- and vessel-traffic distances to avoid disturbance of marine and coastal birds and marine mammals that generally use many of the same coastal habitats as caribou and is expected to prevent frequent disturbance of caribou from air traffic along the coast of the sale area. However, air traffic is on occasion expected to disturb individual or bands of caribou. This effect is expected to be short term and local and is not expected to affect caribou populations.

Other stipulations that are part of Sale 170 are not expected to provide any additional protection for terrestrial mammals nor reduce potential adverse effects. If these measures are not part of Sale 170, the effects of noise and disturbance on caribou are expected to be about the same as with the measures in place, because the harassment of wildlife would be bad public relations for the oil industry; and lessees are likely to avoid such conflicts whenever possible.

Summary: The primary source of disturbance to caribou is vehicle traffic (perhaps as much as several hundred vehicles/day) that could be associated with onshore transportation of oil from offshore leases. A possible oil spill (7,000 bbl) could cause the loss of small numbers (perhaps 100) of caribou. The construction and presence of onshore pipelines and roads and the development of other facilities and associated motor-vehicle traffic are disturbance factors to caribou, particularly cow/calf groups of the CAH, on their summer range. The CAH-caribou surveys have shown some displacement of cow/calf groups from coastal habitats (an estimated 5% of their summer range) within 4 km (2.48 mi) of some Prudhoe Bay-area industrial facilities on the calving range of the CAH.

Disturbance of caribou along the pipelines and roads from Oliktok Point, Point McIntyre, Endicott, and Flaxman Island to the TAPS through existing facilities in the Prudhoe Bay and adjacent oilfields would be most intense during the construction period (perhaps 6 months), when motor-vehicle traffic is highest, but would subside after construction is complete. Caribou are likely to successfully cross the pipeline corridor within a short period of time (a few minutes to a few days) during breaks in the traffic flow, even during high traffic periods, with little or no restriction in movements, because caribou successfully cross other roads and the TAPS during spring and fall migrations (Cameron, Whitten, and Smith, 1986; Eide, Miller, and Chihuly, 1986); but, a local reduction in cow-calf distribution within about 4 km (2.48 mi) along the pipeline-road corridor from the Flaxman Island area to the Endicott pipeline or the pipeline-road corridor from Oliktok Point may be expected to persist for more than one generation (and perhaps over the life of the oilfields).

Because oil transportation for development of Federal offshore leases east of the Canning River is expected to be located offshore of the ANWR caribou of the PCH that calve on the ANWR are not expected to be affected by habitat alteration (pipelines and roads with traffic) associated with Alternative.

If a spill (7,000 bbl) occurred during the open-water season, some caribou of the CAH and PCH that frequent coastal habitats from Harrison Bay (LS 28) to Barter Island (LS 41) possibly could be directly exposed to and contaminated by the spill along the beaches and in shallow waters during periods of insect-pest-escape activities (Fig. IV.B.7-1). However, even in a severe situation, a comparatively small number of CAH animals (perhaps a few hundred) and PCH caribou (no more than a few thousand) is likely to be directly exposed to the oil spill and die as a result of toxic-hydrocarbon inhalation and absorption. This loss probably would be small for any of these caribou herds and would be replaced within about 1 year. For the most part, the effect of onshore oil spills would be very local and would contaminate tundra in the immediate vicinity of the pipeline; these spills would not be expected to significantly contaminate or alter caribou range within the pipeline corridors. Exploration only is expected to have very brief (few minutes to <1 hour) disturbance effects on caribou, with recovery occurring within ≤1 day for any disturbance event and have no effect on the population.

Conclusion: The effects of Alternative I on caribou are expected to include local displacement of cow-calf groups within about 4 km (2.48 mi) along the onshore pipeline roads, with this local effect persisting for more than one generation (and perhaps over the life of Alternative I). Brief disturbances (a few minutes to a few days) of large groups of caribou are expected to occur along the road and pipeline corridor during periods of high traffic over the life of the project, but these disturbances are not expected to affect caribou migrations and overall distribution. If an oil spill occurred under Alternative I, it is expected to result in the loss of no more than a small number of caribou (perhaps a few hundred to a few thousand), with recovery expected within about 1 year.

8. Economy of the North Slope Borough:

Increased revenues and employment are the most significant economic effects that would be generated Alternative I. Increased property-tax revenues and new employment would be created with the construction, operation, and servicing of facilities associated with OCS activities. These facilities are described in Table IV.A.1-1 and are summarized as follows. For exploration and development and production, 6 to 8 exploration and 6 to 8 delineation wells would be drilled; during the exploration phase between 1998 and 2006, 87 to 111 production and service wells would be drilled and three to five platforms and 64 to 96 km of offshore pipeline would be installed during the development and production phase between 2004 and 2010. The number of workers needed to operate the infrastructure is determined by the scale of the infrastructure and not the amount of oil produced. A wide range of production volume can be handled by a given level of infrastructure. Once the infrastructure is constructed, the number of workers needed to operate it does not depend on the amount of product flowing through it. Some temporary employment may be generated in the event of oil spills. Analysis of economic effects resulting from proposed Sale 170 is limited to effects on the NSB. Potential effects on other parts of the State or on the State as a whole are considered to be negligible.

a. North Slope Borough Revenues and Expenditures: Total property taxes in the NSB and NSB revenues are anticipated to decline without Sale 170. These revenues will be determined by several different factors; therefore, the revenue projections should be considered with the understanding that many uncertainties exist. Exploration, development, and production are projected to generate increases in property taxes above the levels without the sale starting in 1998 and averaging about 1 to 2 percent above the level without the sale each year through the production period. The two expenditure categories that affect employment—operations and the Capital Improvements Program (CIP)—are projected to decline without Sale 170. Of these two categories, it is assumed that only expenditures on operations would be affected by the proposed sale's effects on taxable property value. Those CIP expenditures that have generated many high-paying jobs for residents would not be changed by Sale 170.

b. Employment: The gains from Sale 170 in direct employment would include jobs in petroleum exploration and development and production and jobs in related activities (Table IV.B.8-1). For exploration, development, and production, direct employment is anticipated to peak in the range of 1,400 to 1,800 jobs during the development phase, decline to a level in the range of 800 to 1,200 in 2011 to 2020, and then decline further to the range of 500 to 1,200 by 2027. All these jobs would be filled by commuters who would be present at the existing enclave-support facilities in and near the Prudhoe Bay complex approximately half of the days in any year. Most workers would commute to permanent residences in the following

Table IV.B.8-1 Summary of Employment Forecasts, Alternative I

Year	OCS Employment in Enclave: Without OCS Activity	OCS Employment in Enclave: With OCS Activity 350 bbl	OCS Employment in Enclave: With OCS Activity 670 bbl	Resident Employment: Without OCS Activity	Resident Employment: *Increase* with OCS Activity 350 bbl	Resident Employment: *Increase* with OCS Activity 670 bbl
1998	0	0	0	1,910	0	0
1999	0	127	157	1,865	3	4
2000	0	280	310	1,825	11	17
2001	0	127	142	1,794	15	17
2002	0	315	330	1,767	14	15
2003	0	146	161	1,746	18	19
2004	0	1,165	1,180	1,730	32	33
2005	0	681	1,874	1,716	65	71
2006	0	1,350	1,462	1,701	63	100
2007	0	911	1,153	1,685	47	55
2008	0	1,411	1,709	1,662	31	38
2009	0	1,008	1,840	1,614	21	37
2010	0	881	1,378	1,565	17	27
2011	0	834	1,270	1,513	10	32
2012	0	848	1,284	1,470	24	38
2013	0	808	1,244	1,431	25	40
2014	0	808	1,244	1,393	27	41
2015	0	803	1,244	1,357	27	42
2016	0	803	1,284	1,350	27	42
2017	0	835	1,271	1,330	27	42
2018	0	818	1,254	1,310	27	42
2019	0	810	1,246	1,290	27	42
2020	0	802	1,238	1,290	27	42
2021	0	769	1,205	1,310	24	42
2022	0	834	1,270	1,330	27	42
2023	0	616	1,270	1,350	20	42
2024	0	625	1,279	1,370	20	42
2025	0	625	1,279	1,390	20	42
2026	0	625	1,279	1,410	20	42
2027	0	516	1,279	1,430	16	42

Sources: OCS employment, and resident employment 2016–2017, Manpower Model, MMS.
Resident employment 1998–2015, Rural Alaska Model for North Slope Borough.

three regions of Alaska: Southcentral; Fairbanks; and, to a much smaller extent, the North Slope. Some workers would commute from the enclaves to permanent residences outside of Alaska, especially during the exploration phase. Because economic effects in other parts of Alaska would be insignificant, only employment increases in the North Slope region are discussed.

Because of the development of facilities or the continued use of facilities onshore that are taxable by the NSB, the NSB will have additional revenues available that most likely will be used for its ongoing operations. This in turn results in NSB government jobs.

For exploration, development, and production, total resident employment is anticipated to increase in the range of 63 to 100 jobs in the peak of production and level off to 27 to 42 in the production phase after 2011 (Table IV.B.8-1). The peak increase during development is about 4- to 6-percent greater than resident employment without Sale 170 and about 2- to 3-percent greater during the production phase. The increase in employment opportunities partially may offset declines in other job opportunities and delay expected outmigration. Increases in resident population will correspond to the resident employment increase and are shown in Table IV.B.8-2.

The employment and population forecasts were calculated using the MMS Manpower Model and the Rural Alaska Model (RAM) for the North Slope Borough, created and updated by the Institute for Social and Economic Research (ISER) of the University of Alaska Anchorage (UAA) (Tables IV.B.8-1 and 8-2). Using the Exploration and Development Report for Sale 170, the number of wells, platforms, shore bases, and kilometers of pipeline are input to the Manpower Model. The Manpower Model predicts the number of direct oil-industry workers. These data are input to the RAM. Among other variables, the RAM predicts the resident workers and resident population. The terms "job" or "employee" are used in this section to mean one full-time-equivalent worker working for 1 year. A "resident worker" is defined as a resident of the NSB.