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# PLAN OF EXPLORATION PROPOSED EXPLORATORY DRILLING OPERATIONS ON THE GALAHAD PROSPECT OCS LEASE SALE 97 AREA, OFFSHORE ALASKA

Prepared by:

AMOCO PRODUCTION COMPANY

**JULY 1988** 

With the Assistance of:

HOOKS, McCLOSKEY & ASSOCIATES, INC.

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AUGUST 1988

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#### INTRODUCTION

This document has been prepared by Amoco Production Company (Amoco) to comply with Section 11(c)(1) of the Outer Continental Shelf Lands Act, as amended, which requires that a Plan of Exploration (POE) be submitted to and approved by the Minerals Management Service (MMS) prior to commencing exploration operations on leases which the Company acquired an interest in during Lease Sale No. 97. The contents of this POE are consistent with the provisions of 30 CFR Part 250.33 of the MMS regulations (i.e., the provisions which relate to the contents of a POE) and the "Guidelines for Preparing Outer Continental Shelf Environmental Reports" which were published in 1980 by the U.S. Department of the Interior.

This POE details the environmental setting and the potential environmental, economic and social impacts associated with a proposed exploratory drilling program in the eastern Alaska Beaufort Sea OCS area. In addition, this POE is designed to demonstrate to the MMS and the State of Alaska that the proposed exploratory drilling operations are consistent with the enforceable policies of the Alaska Coastal Management Program. Finally, this POE contains specific information on the steps Amoco has taken and the measures that Amoco has incorporated into the proposed exploration operations to satisfy the Stipulation and Information to Lessees portions of the Final Notice of Sale for Lease Sale No. 97 (herein referred to as Final Notice of Sale).

Information applying to the proposed exploratory operations has been furnished by Amoco. Information on the environmental setting has been obtained from documents which pertain to offshore oil and gas activities in the eastern Alaska Beaufort Sea OCS area. Copies of referenced materials are available, for the most part, at the MMS library in Anchorage or the library of Hooks, McCloskey & Associates,

Inc. in Radnor, Pennsylvania. In the event that any reviewing agency has difficulty in obtaining a copy of a particular reference, the party listed on the Title Page should be contacted.

All data which Amoco views as proprietary in nature have been placed in a separate volume. These data, which are provided for the exclusive use of the MMS, include: a current structure contour map; schematic cross-sections; and a preliminary drilling prognosis. Additional geophysical information will be provided to the MMS with the APD for each well.

If exploratory operations result in the discovery of a commercially developable accumulation of oil or gas, or both, then a plan for the development of the resource will be required. In this event, a Development and Production Plan will be prepared and submitted to the MMS (see 30 CFR § 250.34 of the MMS regulations).

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#### (I) TITLE PAGE

Plan of Exploration for Proposed Exploratory PROJECT NAME:

Drilling Operations on the Galahad Prospect in the eastern Alaska Beaufort Sea OCS Area.

Lease Sale No. 97 Area, Offshore Alaska AREA NAME:

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Amoco Production Company. OPERATOR:

Company, Shell CO-LESSEES: Amoco Production

Exploration and Production Inc., and Union Oil

Company of California

DATE: August 1988

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Aerial Surveys of Endangered Whales in the North-RELATED ENVIRONern Bering, Eastern Chukchi, and Alaskan Beaufort MENTAL DOCUMENTS: Seas, 1985, With a Seven Year Review, 1979-1985,

Ljungblad et al., 1986.

Aerial Surveys of Endangered Whales in the Northern Bering, Eastern Chukchi, and Alaskan Beaufort Seas, 1984, With a Six-year Review, 1979-1984, Ljungblad et al., 1985.

Aerial Surveys of Endangered Whales in the Northern Bering, Eastern Chukchi and Alaskan Beaufort Seas, 1983, With a Five-Year Review, 1979-1983. Ljungblad et al., 1984.

Aerial Surveys of Endangered Whales in the Beaufort, Chukchi and Northern Bering Seas, 1982, Ljungblad, 1983.

Aerial Surveys of Endangered Whales in the Beaufort, Chukchi, and Northern Bering Seas, Final Report, April-October, 1981, Ljungblad et al., 1982.

Aerial Surveys of Endangered Whales in the Beaufort Sea, Chukchi Sea and Northern Bering Sea, Final Report, Fall 1980, Ljungblad, 1981.

Aerial Surveys of Bowhead Whales, North Slope, Alaska, Ljungblad et al., 1980.

Alaska Mammals, Rearden, 1981.

Arctic National Wildlife Refuge, Alaska, Coastal Plain Resource Assessment, U.S. Fish and Wildlife Service, 1987.

Arctic Summary Report; Outer Continental Shelf Oil and Gas Activities in the Arctic and Their Onshore Impacts, Lynch et al., 1985.

Balaena mysticetus: Whales, Oil, and Whaling in the Arctic, Fraker, 1984.

Beaufort Sea Barrier Island-Lagoon Ecological Processes Studies, Craig and Haldorson, 1981.

Beaufort Sea Monitoring Program: Analyses of Trace Metals and Hydrocarbons for Outer Continental Shelf (OCS) Activities. Final Report. Boehm et al., 1987.

Beaufort Sea Monitoring Program: Analyses of Trace Metals and Hydrocarbons from Outer Continental Shelf (OCS) Activities, Boehm et al., 1985.

Beaufort Sea Sale 97 Final Environmental Impact Statement, MMS, 1987.

Beaufort Sea Sale 97 Draft Environmental Impact Statement, MMS, 1986.

Behavior, Disturbance Responses, and Distribution of Bowhead Whales, Balaena mysticetus in the Eastern Beaufort Sea, 1980-1984: A Summary, Richardson et al., 1985.

Behavior, Disturbance Responses and Distribution of Bowhead Whales (Balaena mysticetus) in the Eastern Beaufort Sea, 1982, LGL, 1983.

Biological Productivity of the Southern Beaufort Sea: Phytoplankton and Seaweed Studies, Hsiao, 1976.

Bowhead, Balaena mysticetus, Gusey, 1983.

Bowhead Whales in the Beaufort Sea: A Summary of Their Seasonal Distribution and Activities, and Potential Disturbance by Offshore Oil and Gas Exploration and Development, Fraker and Richardson, 1980.

Climatic Analysis of the Outer Continental Shelf Waters and Coastal Regions of Alaska. Vol. III: Chukchi-Beaufort Seas, Brower et al., 1977.

Comments on the World Stocks of Bowhead Whales and Estimating Total Population Abundance in the Western Arctic, Braham, 1982.

Cultural Resource Compendium, Dixon et al., 1986.

Distribution, Abundance, Behavior and Bioacoustics of Endangered Whales in the Alaskan Beaufort and Eastern Chukchi Seas, 1979-86, Ljungblad et al., 1987.

Draft Oil Spill Response in the Arctic. An Assessment of Containment, Recovery, and Disposal Techniques, Industry Task Group, 1983.

Drilling Discharges in the Marine Environment, NAS, 1983.

Final Environmental Impact Statement. Beaufort Sea Sale 97, MMS, 1987.

Final Subsistence Management and Use: Implementation of Title VIII of ANILCA, USFWS, 1985.

Geologic Framework, Hydrocarbon Potential, and Environmental Conditions for Exploration and Development of Proposed Oil and Gas Lease Sale 87 in the Beaufort and Northeast Chukchi Seas, Grantz et al., 1982.

Geologic Report for the Beaufort Sea Planning Area, Craig et al., 1985.

Identification, Documentation and Delineation of Coastal Migratory Bird Habitats in Alaska. I. Breeding Bird Use of Barrier Islands in the Northern Chukchi and Beaufort Seas, Divoky, 1978.

Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales, 1985-1986, Richardson, 1987.

Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales, 1985, Richardson, 1986.

Kaktovik Subsistence, Land Use Values Through Time in the Arctic National Wildlife Refuge Area, Jacobson and Wentworth, 1982.

Normal Behavior of Bowheads, Wursig et al., 1981.

North Slope Borough Coastal Management Program: Background Report, Maynard and Partch/Woodward-Clyde Consultants, 1983.

Population Biology of the Bowhead (<u>Balaena</u> mysticetus) and Beluga (<u>Delphinapterus</u> leucas) Whale in the Bering, Chukchi and Beaufort Seas, Braham and Krogman, 1977.

Possible Effects of Offshore Oil and Gas Development on Marine Mammals: Present Status and Research, Geraci and St. Aubin, 1979.

Prediction of Drilling Site-Specific Interaction of Industrial Acoustic Stimuli and Endangered Whales on the Alaskan Beaufort Sea, Miles et al., 1987.

Prediction of Drilling Site-Specific Interaction of Industrial Acoustic Stimuli and Endangered Whales: Beaufort Sea, Miles et al., 1986.

Proceedings of a Synthesis Meeting Beaufort Sea - Sale 71 Synthesis Report, Norton and Sackinger, 1981.

Recent Shore Ice Ride-up and Pile-up Observations, Part 1, Beaufort Coast, Alaska, Kovacs, 1982.

Response of Bowhead Whales to an Offshore Drilling Operation in the Alaskan Beaufort Sea, Autumn 1986, LGL, Ltd. and Greenridge Sciences Inc. 1987.

Revisions to the State Air Quality Control Plan, ADEC, 1980.

Subsistence Fisheries at Coastal Villages in the Alaskan Arctic, 1970-1986, Craig, 1987.

Subsistence Study of Alaska Eskimo Whaling Villages, ACI/Braund, 1984.

The Diapir Field Environment and Possible Consequences of Planned Offshore Oil and Gas Development. Proceedings of a Synthesis Meeting, Becker, 1987.

#### A. CO-LESSEES AND OPERATOR

Amoco Production Company (Amoco), Shell Western Exploration and Production Inc., and Union Oil Company of California are the colessees of and Amoco is operator for the leases covered by this plan.

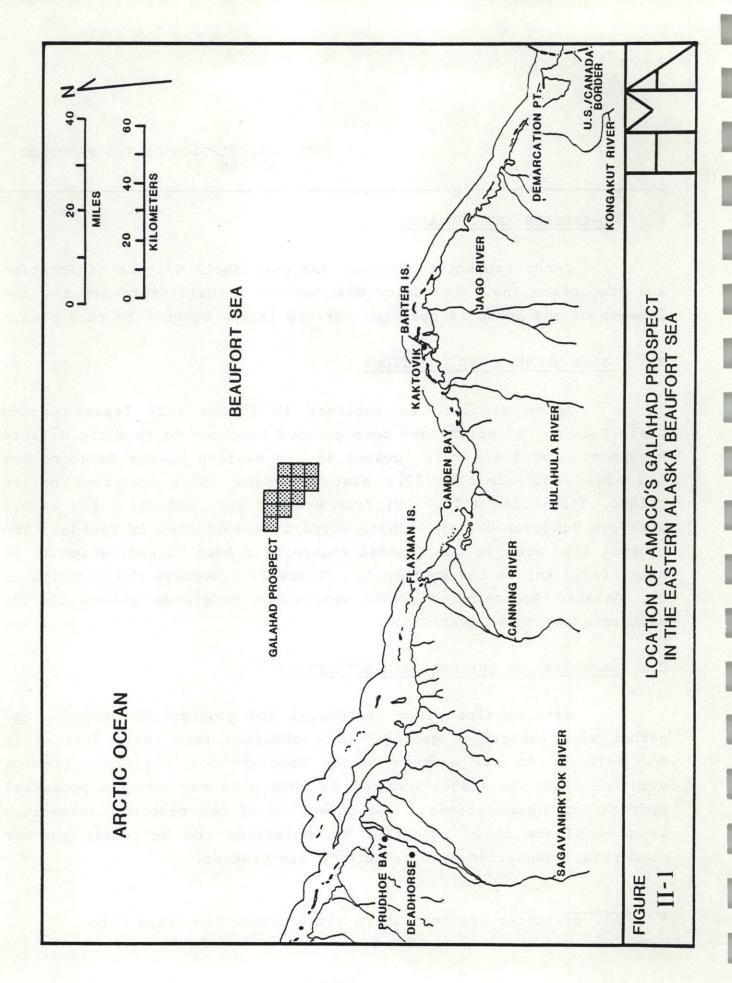
#### B. LEASE NUMBERS AND LOCATIONS

Amoco acquired an interest in twelve (12) leases during Lease Sale No. 97 which have been grouped together to form the Galahad Prospect. The leases are located in the eastern Alaska Beaufort Sea OCS Area, approximately 32.2 statute\* miles (51.8 km) from Barter Island, 74.4 miles (119.7 km) from Prudhoe Bay, and 283 miles (455.3 km) from Tuktoyaktuk, an onshore support base located in Canada. The closest land area to the Galahad Prospect is Arey Island, which is 30 miles (48.3 km) to the southeast. Figure II-1 depicts the location of the Galahad Prospect to major geographic reference points in the eastern Alaskan Beaufort Sea.

#### C. OBJECTIVE OF THE PROPOSED ACTIVITIES

Data obtained from geological and geophysical surveys, together with subsurface geologic data obtained from wells drilled in and adjacent to the eastern Alaska Beaufort Sea OCS Area, provide evidence that the leases covered by this plan may contain potential hydrocarbon accumulations. The objective of the proposed operations is to evaluate these potential accumulations and determine whether commercial quantities of hydrocarbons are present.

<sup>\*</sup> All distances are in statute miles unless otherwise noted.



# D. <u>DESCRIPTION AND LOCATION OF PROPOSED DRILLING UNITS AND ACTIVITIES</u>

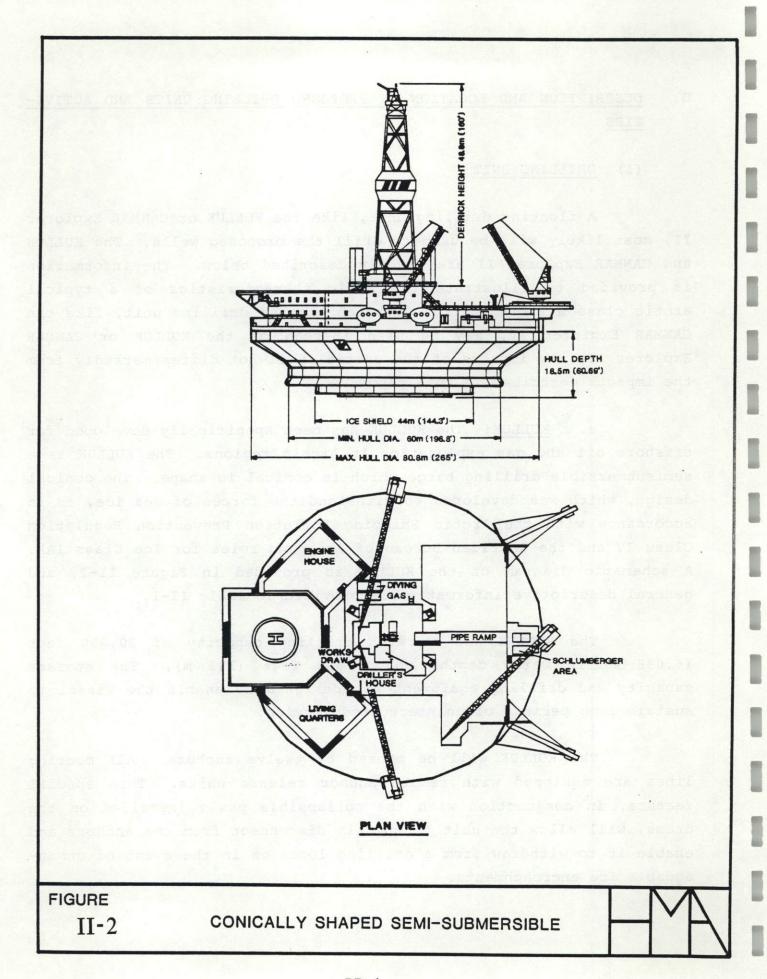
#### (1) DRILLING UNIT

A floating drilling unit, like the KULLUK or CANMAR Explorer II, most likely will be used to drill the proposed wells. The KULLUK and CANMAR Explorer II are briefly described below. The information is provided to illustrate the basic characteristics of a typical arctic class drilling unit. Although another drilling unit, like the CANMAR Explorer IV, may be used instead of the KULLUK or CANMAR Explorer II, the impacts of the unit(s) will not differ markedly from the impacts described in this report.

a. <u>KULLUK</u>: The KULLUK has been specifically developed for offshore oil and gas exploration in Arctic regions. The KULLUK is a semisubmersible drilling barge which is conical in shape. The conical design, which was developed to withstand the forces of sea ice, is in accordance with the Arctic Shipping Pollution Prevention Regulation Class IV and the American Bureau of Shipping rules for Ice Class 1AA. A schematic diagram of the KULLUK is provided in Figure II-2, and general descriptive information is provided in Table II-1.

The KULLUK has a rated drilling capacity of 20,000 feet (6,098 m) in water depths up to 600 feet (183 m). The storage capacity and drilling equipment are designed to enable the vessel to sustain long periods of uninterrupted service.

The KULLUK will be moored by twelve anchors. All mooring lines are equipped with remote anchor release units. This special feature, in conjunction with the collapsible pawls installed on the drums, will allow the unit to quickly disconnect from the anchors and enable it to withdraw from a drilling location in the event of unmanageable ice encroachments.



#### TABLE II-1

#### GENERAL DESCRIPTIVE INFORMATION ON THE KULLUK

#### ENVIRONMENTAL CAPABILITY

#### o Operating Condition Without Ice:

- Maximum horizontal displacement equal to 5 percent of water depth.
- One year return seas (9-foot significant wave height, 8 second peak period).
- 70 mph sustained wind.
- 1.6-foot/second current.
- Maximum line pull equal to 50 percent of breaking strength.

#### Operating Condition With Ice:

- Maximum horizontal displacement equal to 5 percent of water depth.
- One year return ice (4 feet thick, 110 psi flexural strength).
- Total system response to ice load of 800 tons.
- 88 mph sustained wind.
- 1.0-foot/second current.
- Maximum line pull equal to 50 percent of breaking strength.

#### o Survival Condition Without Ice:

- Marine riser disconnected.
- 100 year return storm (24-foot significant wave height, 12.5-second peak period).
- 175 mph sustained wind.
- 2.3-foot/second current.

#### TABLE II-1 (cont.)

#### o Survival Condition With Ice:

- The system is designed to release the anchors prior to the point at which the breaking strength of the system is reached.

#### DRILLING CAPABILITY

- o Water Depth Capability 600 feet maximum depth.
- o Well Depth Rating 20,000 feet.
- o Typical Drilling Equipment:
  - 160-foot derrick with 1,400,000 pounds capacity.
  - Mud Pumps Ideco Model T 1200 kw triplex (4 6E 752R DC motors).
  - Rotary 49.5 inches, 1,000 HP (Ideco Model LR-495).
  - Drawworks Ideco Model E-3000 (3 GE motors @ 940 kw each).
  - Accessory all additional drilling and pipe handling equipment to complement the above primary drilling equipment.

#### SUBSEA EQUIPMENT\*

- o BOP 18.75-inch, 10,000 or 15,000 psi.
- o Riser 21-inch and 30-inch with integral choke and kill line.
- o Accessory all additional required and state-of-the-art design control systems and accessory equipment to complement the above primary subsea equipment.

#### MOORING SYSTEM

- o Points 12 points wire line mooring system.
- o Anchors Bruce 16.5-ton anchors.
- o Anchor Wire Lines 3.5-inch, 3,760 feet long.

<sup>\*</sup> A spare well head assembly will be stored onboard the drilling unit for use in drilling a relief well during a blowout situation.

#### TABLE II-1 (cont.)

#### POWER PLANT

3 - 2190 kw @ 600 volts.

#### CRANES

- 3 Liebherr offshore pedestal cranes with maximum rated lift of 72 tons.
- 1 BOP handling hoist, rated lift 85 tons.
- 4 Derrick floor air hoists (3 tons).

#### HELIPORT

Capable of handling Sikorsky S-61, Super Puma, and all smaller helicopters - complete fuel system, aircraft fire-fighting system, and flight navigation system (DME type), SAWRS (Certified) weather station onboard to meet FAA rules for IFR aircraft operations.

#### SURVIVAL EQUIPMENT

- o Personnel Safety all USCG, SOLAS, ABS and OSHA required equipment.
- o Fire Safety all firefighting equipment and sensors as required by USCG.
- O H<sub>2</sub>S Safety equipment for detection and personnel safety as required by the H<sub>2</sub>S contingency plan.

#### STORAGE CAPACITIES

- o Drilling Water 4,225 barrels.
- o Potable Water 1,875 barrels (two on-board water makers rated at 358 barrels per day).
- O Diesel Fuel 10,000 barrels (approximately 55-100 days operating supply).
- o Liquid Drilling Mud Active = 908 barrels, Reserve = 1,144 barrels, Kill Mud = 450 barrels.
- o Bulk Cement 13,450 cubic feet.
  - o Bulk Barite 8,040 cubic feet.

b. <u>CANMAR Explorer II</u>: The CANMAR Explorer II also has been specifically developed for offshore oil and gas exploration in Arctic regions. The hull, built to ABS Ice Reinforced Type 1A Super Class 1AA specifications, is fully equipped for open water Arctic environmental conditions and is classified by both ABS and Lloyds registry. The vessel's outboard profile is shown in Figure II-3, and general descriptive information is provided in Table II-2.

The CANMAR Explorer II has a rated drilling capacity of 19,700 feet (6,000 m) in water depths up to 600 feet (180 m). The large storage capacity and drilling equipment are designed to enable the drillship to sustain long periods of uninterrupted service.

The CANMAR Explorer II will be moored by eight anchors. Like the KULLUK, the unit's mooring lines are equipped with remote anchor release units and collapsible pawls installed on the drums which will allow the unit to withdraw from a drilling location in the event of unmanageable ice encroachment.

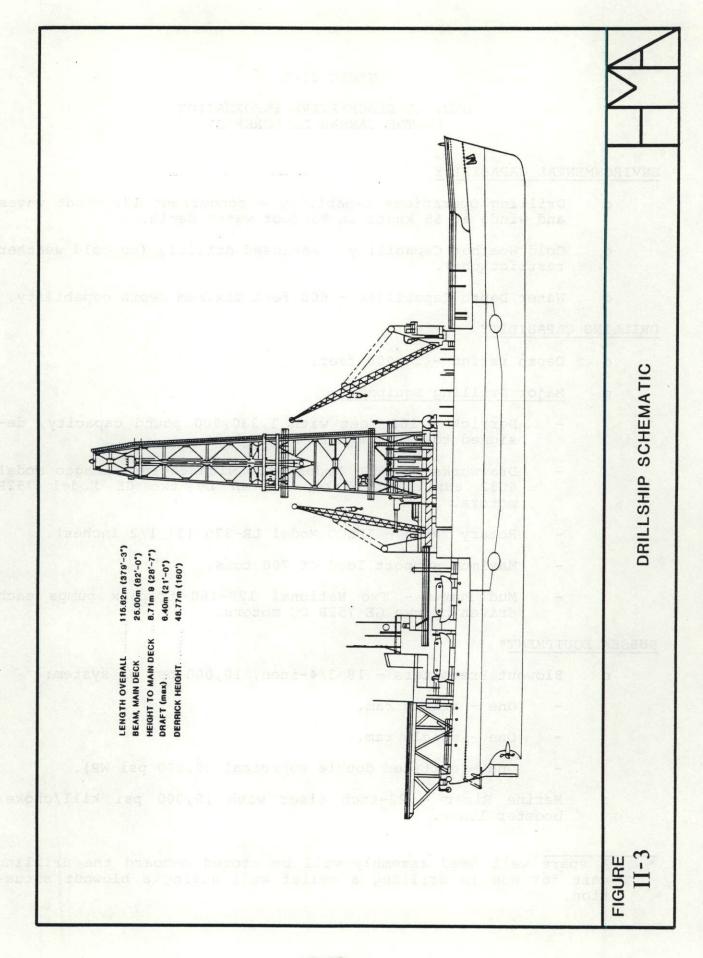
#### (2) WELL LOCATIONS

A total of fourteen proposed well locations are covered by this POE (see Figure II-4). Detailed information on the proposed well locations is provided in Table II-3.

#### E. APPROXIMATE TIMEFRAMES FOR CONDUCTING ACTIVITIES

The proposed exploratory drilling operations on the Galahad Prospect will be of temporary duration. The spud date for the first well may be as early as the "open water" period in 1988.\* The initial

<sup>\*</sup> The duration of the "open water" period is difficult to predict. In 1986, "break up" occurred on July 24 and "freeze up" occurred on October 8; in 1987, "break up" occurred on July 15 and "freeze up" occurred on October 16.



#### TABLE II-2

### GENERAL DESCRIPTIVE INFORMATION ON THE CANMAR EXPLORER II

#### ENVIRONMENTAL CAPABILITY

- o Drilling Operations Capability concurrent 17.5-foot waves and winds at 65 knots in 85-foot water depth.
- Cold Weather Capability enclosed drillrig (no cold weather restrictions).
- o Water Depth Capability 600 feet maximum depth capability.

#### DRILLING CAPABILITY

- o Depth rating 20,000 feet.
- o <u>Major Drilling Equipment</u>:
  - Derrick 160 feet with 1,330,000 pound capacity, designed to withstand 86 knot winds.
  - Drawworks IDECO Model 2100 with Baylor Elmagco Model 6032 auxiliary brake, driven by two GE Model 752R motors.
  - Rotary Table IDECO Model LR-375 (37 1/2 inches).
  - Maximum support load of 700 tons.
  - Mud Pumps Two National 12P-160 triplex pumps each driven by two GE 752R DC motors.

#### SUBSEA EQUIPMENT\*

- Blowout Preventers 18 3/4-inch, 10,000 psi WP system:
  - One triple ram.
  - One single ram.
  - One unitized double spherical (5,000 psi WP).
- o Marine Riser 22-inch riser with 10,000 psi kill/choke/ booster lines.

<sup>\*</sup> A spare well head assembly will be stored onboard the drilling unit for use in drilling a relief well during a blowout situation.

#### TABLE II-2 (cont.)

o All accessory and control equipment necessary to complement the primary subsea equipment represents state-of-the-art design.

#### MOORING SYSTEM

The CANMAR Explorer II utilizes an eight point system with acoustic quick release modules on all eight lines. Four Skagit model DMW-250 double drum winches with collapsible pawls and 2 3/4-inch wires. Eight Bruce 6.5-ton moorfast anchors are employed.

#### POWER PLANT

- o Main Engines Seven Caterpillar D-399Ta (1125 BHP each).
- O AC Generators Four GE 1162.5 KVA 600VAC three Tamper 1250 KVA 600 VAC.
- O DC Conversion Seven GE SCR's 1000 AMP @ 750VDC, two Marine & Industrial SCR's, 700 AMP @ 750 VDC.
- o Emergency Power One caterpillar D-343, 250 kw (360 BHP).

#### CRANES

- o One Liebherr Model BOS 35/360 (100-foot boom, 35-ton).
- o One Liebherr Model BOS 80/1800 (95-foot boom, 80-ton).
- o One Skagit (35 tons).

#### HELIPORT

Capable of handling Sikorsky S-61, Puma, and all smaller helicopters - complete fuel system, aircraft fire fighting system, and flight navigation system (DME type), SWRS (Certified) weather station onboard to meet FAA rules for IFR aircraft operations.

#### SURVIVAL EQUIPMENT

- o Personnel Safety all USCG, SOLAS, ABS, and OSHA required equipment.
- o Fire Safety All firefighting equipment and sensors as required by the USCG.
- o Evacuation covered power lift boats as required by the USCG.

#### TABLE II-2 (cont.)

o H<sub>2</sub>S Safety - Equipment for detection and personnel safety as required by the H<sub>2</sub>S contingency plan.

#### STORAGE CAPACITIES

- o Drilling Water 2,000 bbls.
- o Potable Water 16,800 gallons (onboard water maker capable of producing 9,600 gallons per day).
- o Diesel Fuel 294,000 gallons.
- o Helicopter Fuel 1,200 gallons.
- o Liquid Drilling Mud 3,800 bbls.
- o Bulk Cement 9,600 cubic feet.
- o Bulk Mud 9,600 cubic feet.
- o Sacked Material 313 tons.

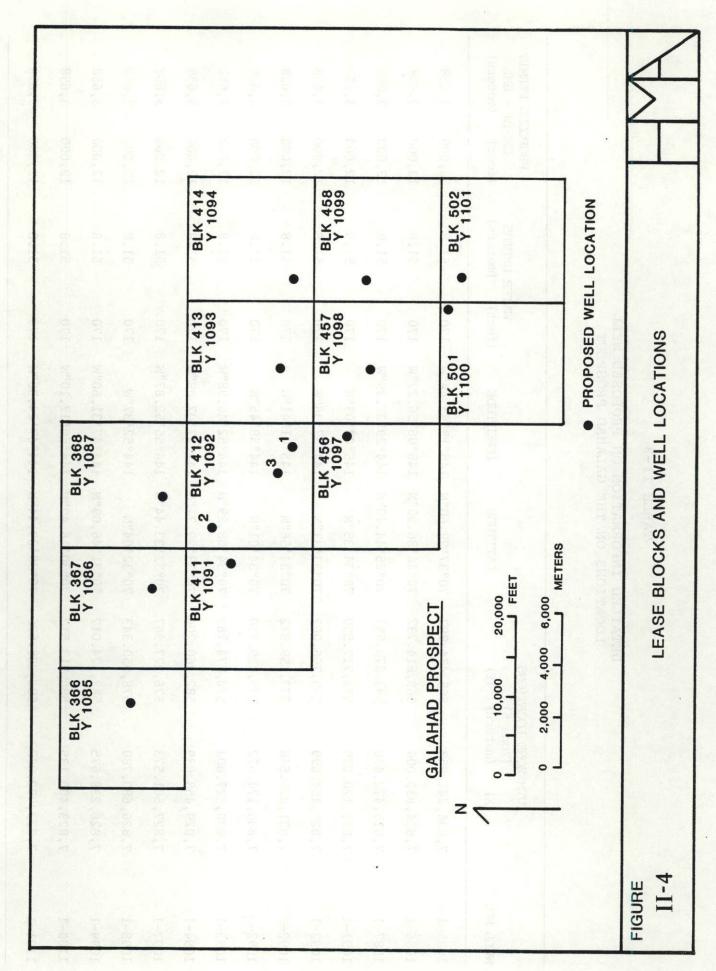


TABLE II-3

DETAILED INFORMATION ON PROPOSED WELL LOCATIONS ON THE GALAHAD PROSPECT

1085-1.	7,836,341.953		LATITUDE	LONGITUDE	(feet)	warek Derihs t) (meters)	DEPTH (feet)	H - BML (meters)
1086-1		565,474.992	70°37'29.60"N	145°13'53.44"W	170	51.8	12,000	3,658
	7,834,839.004	569,814.732	N"06.36'36.90"N	145°06'56.27"W	170	51.8	12,000	3,658
1087-1	7,815,472.436	593,679,651	70°25'44.40"N	144°29'37.39"W	170	51.8	12,000	3,658
1091-1	7,831,120.220	571,717.550	70°34'35"N	145°04'03"W	170	51.8	12,000	3,658
1092-1	7,829,454.699	575,766.062	70°33'37"N	144°57'36"W	170	51.8	12,000	3,658
1092-2	7,831,817.546	573,159.822	70°34'56"N	145°01'41"W	170	51.8	12,000	3,658
1092-3	7,830,174.072	575,029.710	70°34'01"N	144°58'45"W	170	51.8	12,000	3,658
1093-1	7,830,527.802	578,774.789	70°34'08.29"N	144°52'40.98"W	170	51.8	12,000	3,658
1094-1	7,829,458.039	582,260.206	70°33'29.77"N	144°47'07.08"W	170	51.8	12,000	3,658
1097-1	7,827,501.573	576,277.367	70°32'33.44"N	144°55'52.87"W	170	51.8	12,000	3,658
1098-1	7,826,680.780	578,950.343	70°32'04"N	144°52'37"W	170	51.8	12,000	3,658
1099-1	7,826,238.675	582,124.017	70°31'46.09"N	144°47'31.60"W	170	51.8	12,000	3,658
1100-1	7,823,400.135	580,513.517	70°30'16.40"N	144°50'17.10"W	170	51.8	12,000	3,658
1101-1	7,823,992.002	582,280.626	70°30'33.44"N	144°47'24.36"W	170	51.8	12,000	3,658

well to be drilled probably will be located on lease OCS-Y 1092. Final well selection, however, will be based on further analysis of available data and this decision will be reflected in the initial Application for Permit to Drill (APD). The location and sequence of subsequent wells will depend upon the results obtained from previous drilling operations.

The minimum level of activity envisioned on the leases covered by this report will be the drilling of one well per "open water" period. The maximum level of activity will be the drilling of two wells per "open water" period.

Operational flexibility is considered necessary to schedule drilling operations so that adjustments may be made as new data are obtained. Decisions on whether and when to drill subsequent wells will be made within a reasonable period of time following the evaluation of geologic data provided by the most recent well(s) drilled. These decisions also will be dependent upon weather conditions, sea ice concentrations, the availability of appropriate drilling equipment, the results of drilling and seismic control programs conducted on adjacent leases, and/or government-imposed seasonal drilling limitations.

Amoco believes that the weight of scientific evidence demonstrates that the proposed operations can be conducted through the "open water" period without adversely affecting endangered bowhead whales or interfering with subsistence whaling activities. The Company recognizes and will comply with the provisions of Stipulation No. 7 of the Final Notice of Sale which requires consultation with potentially affected subsistence whaling communities (i.e., Kaktovik and Nuiqsut) to assure that the proposed exploration operations are compatible with whaling activities and will not result in undue interference with the subsistence whale hunt. A discussion of consultation efforts to date is provided in Appendix A. In addition, Amoco has prepared a separate document, entitled "An Evaluation of the Potential Impacts of Exploratory Drilling and Scientific Research Operations on Subsistence Resources and Subsistence Use Activities in

the Beaufort Sea" which, among other things, details how the proposed operations have been scheduled and located to minimize potential conflicts with subsistence whaling activities.

Prior to the initiation of exploratory drilling operations from a floating drilling unit, the MMS may require or Amoco may decide that a "glory hole" be constructed at one or more of the proposed well locations to house and protect blowout prevention and other well head equipment in the event of unmanageable ice encroachments. If the MMS requires or Amoco decides that the construction of a glory hole is necessary, it will be drilled from the drilling unit with a conventional glory hole bit.

# F. DESCRIPTION OF SUPPORT CRAFT, PROPOSED TRAVEL MODES AND ROUTES, AND FREQUENCY OF USE FOR MOVING SUPPLIES AND PERSONNEL TO AND FROM OFFSHORE ACTIVITY SITES

As currently planned, helicopters will be used to move personnel and small supplies between Deadhorse and possibly Barter Island and the drilling unit. Personnel will be transported to Deadhorse on commercial, fixed-wing aircraft operating out of Anchorage. Helicopter routes from Deadhorse are planned generally to follow an existing aircraft corridor along the coast between Prudhoe Bay and the Camden Bay area and then proceed directly offshore to a drill site. Helicopters operating from Barter Island will travel directly offshore to a drill site.

Current plans call for one to three ice class support vessels to be dedicated to the project at all times. An additional ice class support vessel also may be dedicated to the project to transport supplies and equipment from an existing shorebase to the

drilling site. Marine support vessels will travel direct routes (ice conditions permitting) between Tuktoyaktuk, Canada and, possibly, Prudhoe Bay, and the drilling unit. If a foreign-flagged vessel is used to conduct resupply operations out of Prudhoe Bay, U.S. Customs must be advised before the vessel enters the 3-mile limit.

Consistent with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale, project-related aircraft and vessels will maintain at least a 1.0-mile (1.6-km) horizontal distance and project-related aircraft will maintain at least a 1,500-foot (457 m) vertical distance from observed wildlife or known wildlife concentration areas such as bird colonies or marine mammal concentrations, unless such an action would jeopardize human safety. Also, to reduce potential effects to endangered bowhead whales, project-related aircraft and vessel traffic will be minimized or rerouted when endangered bowhead whales are in the area of the proposed operations, unless such an action would jeopardize human safety.

The support craft are briefly described below. The information is provided to illustrate the basic characteristics of the proposed support craft operations. Although the support craft actually used may differ somewhat from the craft described in this plan, the impacts of the support craft used will not vary significantly from the impacts described in this plan.

#### (1) HELICOPTERS

Current plans call for the use of Bell 214 helicopters, operating out of Deadhorse and possibly Barter Island, to support the proposed operations. The helicopters will be equipped with IFR (Instrument Flight Rules) instruments to allow flight under poor visibility conditions. Two round trips to the drilling unit are expected to take place each day. Each roundtrip from Deadhorse will take approximately 1.5 hours, while those, if any, from Barter Island will take approximately 45 minutes.

#### (2) ICE CLASS SUPPORT VESSELS

Ice class support vessels are characterized as "large" or "medium" depending upon the size of the vessel. Up to three ice class support vessels will be required depending upon the amount of ice which must be managed. For purposes of this analysis, it is assumed that an additional ice class support vessel may make one round trip per well between Tuktoyaktuk, Canada or, possibly, Prudhoe Bay and the drilling unit. The round trip travel time, which will vary depending upon ice conditions, is expected to take approximately 62 hours for ice-free or near ice-free conditions.

#### G. PERSONNEL REQUIRED TO CONDUCT ACTIVITIES

#### (1) OFFSHORE

Approximately 100 people may be onboard the drilling unit at any given point in time. Personnel would include drilling and service personnel, galley cooks and help, and operations and maintenance personnel. Crews will work an even/even schedule. Except for the roustabouts and caterers, all personnel will be highly trained and experienced in oil and gas exploration operations. There will be approximately 8 to 20 people on each of the ice class support vessels.

#### (2) ONSHORE

It is estimated that one expediter, two materials handlers, two 2-man helicopter flight crews, and one 3-man helicopter maintenance crew will be based in Deadhorse and/or on Barter Island to support the proposed exploratory drilling operations.

# H. DESCRIPTION OF EQUIPMENT TO BE USED AND GENERAL LAYOUT; SAFETY SYSTEMS; MONITORING SYSTEMS; AND ONSHORE SUPPORT SYSTEMS

#### (1) EQUIPMENT AND GENERAL LAYOUT

A detailed description of the actual drilling unit to be used for each well will be provided in the APD that will be filed for

each well. Specifications for typical helicopters and ice class support vessels are provided in Tables II-4 (helicopter), II-5 (large ice class support vessel) and II-6 (medium ice class support vessel). Brochures describing typical vessels are provided in Appendix B of this plan.

#### (2) SAFETY SYSTEMS

Amoco will take a variety of actions to ensure worker safety, maintain the integrity of the drilling unit, and protect the environment during the conduct of the proposed operations. These actions include: an assessment of potential shallow drilling hazards; hydrogen sulfide contingency planning; plans for curtailing activities during adverse meteorological and oceanographic conditions; plans for drilling a relief well if a blowout occurs; and plans to cover the loss or disablement of the drilling unit or support craft. Also, the drilling unit will be equipped with blowout preventer equipment, adequate quantities of mud, firefighting, evacuation and lifesaving equipment, and vessel/meteorological monitoring equipment which meets the standards set by the MMS and the U.S. Coast Guard. Finally, regular equipment testing, performance monitoring, and personnel training programs will be employed to help minimize the potential for accidents.

a. <u>Drilling Hazards</u>: Consistent with § 250.33(b)(1)(ix) of the MMS regulations, the required analysis of subsurface geologic and manmade hazards that could have an adverse impact on the proposed exploratory drilling operations will be completed and submitted to the MMS with the APD for each proposed well. High resolution geophysical data (mini-sleeve), seismic Common Depth Point (CDP) and bright spot information, velocity data, and structural interpretations will be examined and all potential shallow drilling hazards will be assessed and the results incorporated into the detailed drilling programs.

TABLE II-4

SPECIFICATIONS FOR TYPICAL HELICOPTER (Bell 214)

Bell Model 21	4ST Super Transport - Twin Eng	ine - IFR	this plan.
Weights:	Basic Empty Weight: Useful Load: Maximum Gross Weight: Maximum External Load:	4,445 kgs 3,492 kgs 7,938 kgs 2,722 kgs	9,800 lbs 7,700 lbs 17,500 lbs 6,000 lbs
Fuel:	Normal Tankage:	1,647 l 1,270 kgs	435 gals 2,760 lbs
	Sponson Tanks:	924 1 493 kgs	244 gals 1,072 lbs
Engines:	Take-off Power: Maximum Continuous Power:		1,625 hp 1,258 hp
Performance: (standard atmosphere)	Fast Cruise (SL): Economical Cruise (SL): Rate of Climb (SL MAX GW): Service Ceiling (MAX GW):	256 km/hr 250 km/hr 564 m/mi 2,135 m	159 mph 155 mph 1,850 fpm 7,000 ft
	Hovering Ceiling - IGE (MAX GW): Hovering Ceiling -	3,170 m	10,400 ft
	OGE (MAX GW): Max Range (SL MAX GW)	2,896 m	9,500 ft
	(Normal Fuel): Max Endurance (SL)	678 km	421 mi
	(Normal Fuel): SFC (lb/hp):		3.1 hrs 0.36 lb/hp hr
	Max Range (SL MAX GW) W/Sponsons:	1,143 km	710 mi

#### TABLE II-5

## DESCRIPTION OF AND PERFORMANCE REQUIREMENTS FOR TYPICAL LARGE ICE CLASS SUPPORT VESSEL

M.V. Kalvik Ice-Breaking,	Anchor-Handling, Towing and	d Supply Vessel
Main Characteristics:	Lenth overall: Length B.P.: Beam overall: Depth: Draught loaded: Cargo deck: Displacement loaded: Lightship:	88 m 75 m 17.82 m 10 m 8.3 m 34 m x 13 m 6,820.95 tons 1,866.95 tons
Tonnage:	Gross registered tons: Net registered tons:	4,219.39 tons 1,970 tons
Class:	ASPPR Ice Class 4	
Capacities:	Fuel oil: Drilling water: Potable water: Deck cargo: Bulk material:	1,918.56 m <sup>3</sup> 1,432.38 m <sup>3</sup> 40 m <sup>3</sup> 800 tons 102 m <sup>3</sup>
Speed:	Cruise 13.28 kts	
Bollard Pull:	Over 220 long tons	

34 berths

7.8 m

One 40-person Watercraft life boat, Model

One rescue boat, Lucas Model 700 D

Accommodations:

Life Saving Equipment:

#### TABLE II-6

# DESCRIPTION OF AND PERFORMANCE REQUIREMENTS FOR TYPICAL MEDIUM ICE CLASS SUPPORT VESSEL

M.V. Ikaluk Ice-Breaking,	Anchor-Handling, Towing and	Supply Vessel
Main Characteristics:	Lenth overall: Length B.P.: Beam overall: Depth: Draught loaded: Cargo deck: Displacement loaded: Lightship:	78.95 m 70.0 m 17.22 m 9.707 m 7.532 m 12.7 m x 35.6 m 5,107.30 tons 1,898.50 tons
Tonnage:	Gross registered tons: Net registered tons:	3,255.80 tons 1,432.43 tons
Class:	ASPPR Ice Class 4	
Capacities:	Fuel oil: Drilling water: Potable water: Deck cargo: Bulk material:	1,596 m <sup>3</sup> 1,146 m <sup>3</sup> 152 m <sup>3</sup> 1,000 tons 142 m <sup>3</sup>
Speed:	Cruise 12 kts	
Bollard Pull:	50 long tons	
Accommodations:	34 berths	
Life Saving Equipment:	One 40-person Watercraft 7.8 m One rescue boat, Lucas Mo	

b. <u>Hydrogen Sulfide</u>: Even though Amoco does not believe hydrogen sulfide gas will be encountered during the drilling of the proposed wells, a Hydrogen Sulfide Contingency Plan will be submitted with the initial APD. A copy of the plan will be on file with the MMS and onboard the drilling unit.

Consistent with the provisions of § 250.67 of the MMS regulations, the drilling unit will be equipped with adequate  $\rm H_2S$  detectors, alarms, and protective equipment. A list of the  $\rm H_2S$  detection and protection equipment will be referenced in the  $\rm H_2S$  Contingency Plan.

c. <u>Curtailment of Critical Operations</u>: The following critical operations will be curtailed when the wind and waves either individually or in combination exceed the limits expressed below: drilling; coring; running and cementing casing or riser; cutting and recovering casing; logging or other wireline operations; and drill stem testing. As a general rule, no critical operation will commence when the significant wave height exceeds 9 feet and/or the wind velocity exceeds 70 mph.

In addition, no drilling operations will commence when any of the following conditions exist:

- o When there is an insufficient supply of mud onboard the drilling unit to control the well.
- o When there are not enough boats in the area to deploy oil spill response equipment.
- o When oil spill response equipment is not on location or is not in good working order.
- o When the manpower required to safely conduct drilling operations is not available.

- o When any critical machinery needed to assure a safe operations is not operative.
- o When directed to curtail operations by the MMS to avoid potential impacts to endangered bowhead whales migrating through the area.

The above list is only a guideline. Decisions concerning what actions to implement during a given emergency, no matter what the cause, must be based on the judgment of the Amoco On-Site Drilling Foreman and the Contract Tool Pusher.

d. Drilling a Relief Well: Although a general plan for drilling a relief well is presented below, it is not practical to present a detailed plan prior to an event due to the large number of incident-specific variables that must be taken into consideration in the design of relief well drilling and kill operations. Amoco drilling experts will be on location at all times and, if a blowout occurs, will comprise the Well Control Team. Based on their specific knowledge of the well, they will formulate a relief well plan. The Well Control Team can communicate directly with Amoco's drilling experts in other locations, if necessary.

If possible, the drilling unit will be used to drill a relief well. Both the KULLUK and CANMAR Explorer II are capable of winching off location, moving out of danger, and commencing a relief well. A complete spare wellhead assembly and sufficient casing, cement and mud will be available to facilitate such an operation.

In the event that the drilling unit cannot be used to drill a relief well, another unit will be mobilized to the blowout location as soon as possible. This capability will be provided by drilling units available for hire in the Beaufort Sea. Regardless of the unit used, the relief well will be directionally drilled to intercept the vicinity of the uncontrolled well. Specialized logging tools will be used to determine the proximity of the target wellbore. The uncontrolled flow will then be killed by sequential pumping of water, heavy drilling mud, and cement into the blowing well.

- e. Loss or Disablement of the Drilling Unit or Support
  Craft: If the drilling unit becomes partially or totally disabled
  while under contract to Amoco in Alaskan waters, the priorities for
  action will be:
  - o Personnel safety.
  - o Prevention of pollution.
  - o Minimization of damage to the drilling unit.
  - o Notification of the appropriate government agencies and Amoco Management.

All contingency plans will be developed with these priori-If the drilling unit is damaged to the point where it ties in mind. cannot be repaired on location, non-essential personnel will be evacuated and the unit will be towed to the nearest suitable harbor for repairs. Before moving off location, a well in progress will be secured or plugged. If necessary, a new unit will be brought in as soon as possible to continue drilling or to plug and abandon the well in progress. Re-entering a subsea well in this fashion is a routine procedure as long as the wellhead is not severely damaged during the removal of the first unit. If there is significant damage to the wellhead or shallow casing strings, a directional well would be drilled so that the original well bore can be re-entered and plugged. will be removed from the seafloor in accordance with U.S. Coast Guard and MMS regulations.

In the event that an ice class support vessel or helicopter is disabled, the same priorities for emergency response will be followed as for the drilling unit. While operating in the eastern Alaska Beaufort Sea OCS Area, there will be up to three ice class support vessels and one helicopter dedicated to Amoco's operations at all times. These vessels will assure that a strong back-up capability exists to provide assistance to a disabled support craft. Additional assistance for search and rescue operations will be available from one or more of the following sources: other operators working in the area; the Prudhoe Bay industrial enclave; the U.S. Coast Guard; and other military organizations. If any support craft is lost from service, a suitable replacement for the craft will be acquired before proceeding with any aspect of the proposed operations which depends for its safety on the support craft.

Blowout Prevention: Consistent with the provisions of § 250.56 of the MMS regulations, the drilling unit will be adequately equipped with the necessary diverter and blowout prevention equipment (BOPE) to maintain well control. Consistent with the provisions of § 250.57 of the MMS regulations, the diverter and BOPE will be installed and tested, and the results will be recorded on the driller's report. Regular inspection and maintenance will be performed on the equipment. Consistent with the provisions of § 250.58 of the MMS regulations, blowout prevention drills will be conducted as required by the MMS and recorded on the driller's report. Consistent with § 250.211 of the MMS regulations, drilling personnel will be trained and qualified in accordance with the provisions of the MMS OCS standard "Training and Qualifications of Personnel in Well-Control Equipment and Techniques for Drilling on Offshore Locations" (MMSS-OCS-T1) before initiating work on a well. A description of the diverter and BOPE to be installed will be provided in the APD.

Consistent with the provisions of § 250.54 and § 250.60 of the MMS regulations, drilling mud, casing, and cementing programs will be designed to insure that all the wells are drilled in a safe and workmanlike manner. These programs will be described in the APD for

each proposed well. Company representatives will provide onsite supervision of drilling operations on a 24-hour/day basis. Also, a member of the drilling crew or the tool pusher will continuously maintain rig floor surveillance, unless the well is secured by BOPE, bridge plugs, storm packer, or cement plugs.

- g. <u>Mud</u>: Quantities of basic mud materials maintained at the proposed drill sites will meet the minimum quantities required under § 250.60(d) of the MMS regulations. Amoco will comply with the notice and reporting provisions specified in the general NPDES permit for the Beaufort Sea.
- h. <u>Fire Fighting, Evacuation and Lifesaving</u>: The drilling unit will be equipped with a U.S. Coast Guard approved fire fighting system. Fire stations will be located at strategic points on the drilling unit and at the heliport. Frequent drills will be conducted to familiarize personnel with the location and use of the fire fighting equipment.

The drilling unit will be equipped with emergency evacuation and lifesaving equipment in accordance with U.S. Coast Guard regulations. U.S. Coast Guard-approved cold-water survival suits will be provided to all personnel onboard the drilling unit, and additional suits will be stored at critical work stations. These exposure suits are designed to provide protection against the effects of cold water and to provide flotation for many hours.

Rig survival equipment also will include two or more life-boats or capsules, and a sufficient number of inflatable life rafts to handle 200 percent of the vessel manning capacity. Lifeboats will be constructed of fiberglass reinforced plastic, will be fully enclosed, and will have self-contained fire protection water spray systems. The lifeboats will be equipped with approved deployment and retrieval systems and U.S. Coast Guard-approved radio locator beacons. The life rafts will be self-inflating and provided with hydrostatic release gear and a complete weather cover.

Abandon-ship drills will be conducted to familiarize personnel with the use of the survival equipment. The lifeboats, life rafts, and associated equipment, and launching procedures will be U.S. Coast Guard approved. (A) nearby ice class support vessel(s) will be available at all times to assist in evacuation efforts.

i. <u>Vessel/Environmental Monitoring</u>: A mud logging unit will continuously monitor the drilling mud for hydrocarbon gases. Hydrogen sulfide gas also will be monitored. The mud pit room will be equipped with hydrogen sulfide and methane gas monitors. The liquid level in the mud pits and the well flow rate also will be monitored.

Consistent with the provisions of § 250.51(c) of the MMS regulations, meteorological, oceanographic, and performance data will be collected during the conduct of the proposed operations. The data to be collected is outlined in Table II-7.

Meteorological data for the area indicate that moderate to heavy superstructure icing can occur during the months of September and October. The occurrence of icing conditions is dependent upon air temperature, surface water temperature, and wind speed. The drilling unit will be instrumented with meteorological and oceanographic monitoring systems that will accurately monitor wind speed, air temperature, and water temperature. Meteorological and oceanographic forecasts will be made on a routine basis. Conditions at the drill site will be monitored and recorded, and information disseminated to supervisory personnel on a routine basis. Also, routine reports will be disseminated to the support craft. By utilization of recorded data and forecasts, impending superstructure icing conditions can be predicted, and support craft can be advised to take protective actions.

The eastern Alaska Beaufort Sea OCS Area is subject to some degree of sea ice cover from late September through July. An ice observation and monitoring program will be implemented to forecast ice movements. In the event that encroaching ice threatens the drilling unit, the ice class support vessels will be used to break up the ice

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METEOROLOGICAL, OCEANOGRAPHIC AND PERFORMANCE DATA TO BE COLLECTED DURING EXPLORATORY DRILLING OPERATIONS

#### METEOROLOGICAL DATA

- o wind speed and direction (mph average, maximum)
- o barometric pressure (in Hg)
- o air temperature (°F)
  - dew point
  - relative humidity
- o precipitation (type, amount)
- o visibility, ceiling, cloud over and type
- o other weather conditions

# OCEANOGRAPHIC DATA

- o waves (significant, maximum, direction, period visual)
- o water temperature (°F)
  - o ice conditions (if any nature, thickness, coverage)
  - o sea spray (structural icing)

#### PERFORMANCE DATA

- o vessel motion (average)
  - heave (ft)
  - pitch (deg)
  - roll (deg)
  - offset (deg)
  - draft (ft)
  - heading (deg)
- o anchor tension (each anchor) (kips)

around the drilling unit. Large floes will be broken, forced, or pushed so that their drift trajectories will avoid impacting the drilling unit. In heavy ice, the support vessels will continuously move around the drilling unit to keep the ice broken up so as to minimize the ice forces upon the drilling unit. The conical design of the drilling unit will enhance this capability.

Amoco understands that, under the provisions of Section 14(i) of the Information to Lessees portion of the Final Notice of Sale, the RSFO will receive recommendations from the Beaufort Sea Biological Task Force concerning the implementation of Stipulation No. 3 of the Final Notice of Sale, and that, as a result of these recommendations, the Company may be required to conduct biological surveys to determine the extent and composition of biological populations or habitats which might require additional protective measures. Amoco will comply with the survey requirements specified by the RSFO.

Amoco also understands that, under Stipulation No. 4 of the Final Notice of Sale, the Company will be required to conduct or participate in an industry site-specific endangered bowhead whale monitoring program to determine when migrating whales are present in the area of the proposed operations, and to determine any effects that drilling activities have on the behavior of migrating whales. Amoco has submitted plans for a detailed monitoring program to the MMS under a separate cover.

Under the proposed monitoring program, the movements and behavior of endangered bowhead whales will be studied in response to repeated exposures to noise associated with offshore industrial activities. The overall objective of the research will be to determine whether bowhead whales will become accustomed to repeated encounters with the sounds of industrial activity.

Radio tags will be attached to six endangered bowhead whales while they are in the Canadian Beaufort Sea. Following implantation

of the tags, the endangered bowhead whales will be exposed to play-backs of drilling and ice breaking sounds. The sounds will be presented from a ship and the animal's behavior will be observed both from the ship and from an aircraft. Both the ship and aircraft will have automatic direction finding radio receivers which will not only allow the researchers to determine the locations of the whales but also will provide them with a record of whale reactions before, during, and after exposure. Comparable data also will be obtained from a number of endangered bowhead whales accompanying the radiotagged individuals.

In addition to observations made of endangered bowhead whales exposed to recordings of industrial noise, observations will be made of whales whose migration routes bring them close to sites of actual industrial activity (e.g., drilling operations on the Galahad Prospect). It is hoped that a comparison can be made between the same whales which had heard the recordings and those which had not heard the recordings as each is exposed to the actual sounds of industrial activity. This would enable the researchers to assess habituation of the animals.

According to previous studies (Richardson et al., 1985), endangered bowhead whales will show a behavioral reaction to drilling only when they are relatively close to a drilling site. However, the probability of bowhead whales' passing relatively close to an active drilling site is quite low. Two things will be done to acquire this data: passive hydrophone array listening will be conducted from a ship which will move to any active site the whales are approaching; and Amoco will continue drilling as long as possible during the migration period so that as much interaction data as possible can be acquired.

The probability also is low that the endangered bowhead whales which are tagged in the Canadian Beaufort Sea will pass near an operating industrial site. Therefore, up to six additional animals may have to be tagged which are headed toward, and are within a day's

travel from, an operating site. These animals will not be exposed to recordings. Instead, their behavior will be observed as they pass by an active site.

In addition to following some animals via the radio tags, any animals that are vocalizing will be located and tracked using a portable hydrophone array. Vocalizations will be tracked during playback and while in the vicinity of the actual site to determine if bowhead whales exhibit the typical response of ceasing vocalizations in the presence of a novel stimulus.

The endangered bowhead whales that will, in each case, be sought for tagging are those which are initially in different sized groups and those which appear to be in different social contexts. In particular, it is hoped that some individuals will be tagged from groups with female-young pairs. However, no female whales with calves will be tagged.

Tagging and subsequent observation by ship and aircraft will provide data on a number of parameters of bowhead whale behavior. In addition to observing the surfacing and diving patterns of the animals, data also will be obtained on the orientation of the animals, the mean distance to the nearest animal, and cumulative sighting distributions.

The research program will occur in the Alaska Beaufort Sea from the U.S./Canada border to Point Barrow. If permits can be obtained from Canada, some of the radio-tagging and playback experiments will be conducted in the Canadian Beaufort Sea. The playback experiments will use radio-tagged whales and their associates whenever the animals are within 62 miles of shore. The behavioral observations near active industrial sites will be concentrated within 31 miles of these sites.

In June 1988, the research program was expanded to include a site-specific, aerial monitoring program. The program design calls

for a broad scale survey of the "industrial" area and two adjacent central areas, and a fine scale survey centered on a drilling site.

Under the broad scale survey, each of the three areas to be surveyed will be divided into quarters and the search for whales will be begun in different quarters on different days on a rotation basis. Flight days also will be rotated among the three areas.

Under the finer scale survey, straight-line flight paths which are oriented as spokes with the drilling site as the center will be flown in order to maintain a sampling/unit effort statistic. Given the range of distances at which behavioral changes have been noted, the "spokes" will be divided into six distance intervals (i.e., 0 to 4 km, 4 to 8 km, 8 to 12 km, 12 to 16 km, 16 to 20 km, and 20 to 24 km). The "spokes" will be flown in an alternating pattern (e.g., west to east followed by north to south, followed by northwest to southeast, followed by southwest to northeast).

### (3) ONSHORE SUPPORT SYSTEMS

Amoco will maintain an onshore communications base at Prudhoe Bay which will operate 24 hours a day. Amoco will use existing onshore support facilities at Deadhorse/Prudhoe Bay, Tuktoyaktuk, Canada and, possibly, Barter Island. The Deadhorse/Prudhoe Bay industry enclave contains oil production facilities, operations facilities, support services, and living quarters for persons who work in the North Slope oil fields. The enclave is geographically isolated from other communities on the North Slope, and does not depend upon them for services (CSA, 1985). Oil and gas support activities in Tuktoyaktuk take place at facilities adjacent to, but separate from, the community (Dome Petroleum Ltd. et al., 1982).

Amoco may establish a small, temporary operations base at the airport on Barter Island. The operations base will include temporary facilities for communications equipment, storage of perishable supplies, and a landing area for helicopters. No new construction will take place on Barter Island.

# I. NEW OR UNUSUAL TECHNOLOGY

No new or unusual technology will be used during the proposed exploratory drilling operations.

# J. DISCUSSION OF OIL SPILL CONTINGENCY PLAN

It is Amoco's policy to protect the environment by employing the best control mechanisms, procedures, and processes which are technically sound and economically feasible. All proper and appropriate actions will be taken to avoid spillage, and to contain, cleanup, and dispose of oil and oily debris. State-of-the-art equipment will be used and all activities will be conducted in a carefully planned and orderly fashion so as to prevent the discharge of pollutants.

In compliance with § 250.33(a)(2) of the MMS regulations, the drilling unit will be equipped with curbs, gutters, drip pans, and drains which will be linked to a sump system. The sump will be used to collect only treated produced water, treated sand, liquids from drip pans and deck drains, and as a final trap for hydrocarbon liquids in the event of equipment upsets. The sump will automatically maintain the oil at a level sufficient to prevent the discharge of oil into OCS waters.

Prevention of oil spills will be maximized through compliance with MMS regulatory requirements relating to: well casing and cementing (i.e., § 250.54); blowout preventer systems and system components (i.e., § 250.56); mud program (i.e., § 250.60); supervision, surveillance, and training (i.e., § 250.63); liquid and solid waste disposal (i.e., § 250.40); inspections and reports (i.e., § 250.41); and personnel training and drills for pollution prevention (i.e., § 250.43). In addition, Amoco will comply with the provisions

of Section 14(c) of the Information to Lessees portion of the Final Notice of Sale which authorizes the RSFO to prohibit exploratory drilling and other downhole activities in broken ice conditions unless Amoco demonstrates to the RSFO the Company's ability to detect, contain, clean up, and dispose of spilled oil in such conditions.

Amoco's ability to respond rapidly and effectively to an oil spill incident is facilitated through planning and the conduct of training and drills. Consistent with the provisions of § 250.33(b)(2) of the MMS regulations and Stipulation No. 6 of the Final Notice of Sale, Amoco has submitted a comprehensive Oil Spill Contingency Plan for Exploratory Drilling Operations in the eastern Alaska Beaufort Sea OCS Area to the MMS under a separate cover. Among other things, Amoco's Oil Spill Contingency Plan describes the training and drills that have been and will be conducted to satisfy § 250.43 of the MMS regulations.

Consistent with § 250.42 of the MMS regulations, Amoco's Oil Spill Contingency Plan is designed to assist Company personnel and contractors in responding rapidly and effectively to an oil spill that may result from the proposed exploration operations. It contains a description of the techniques that will be used to control the source of a spill, contain, clean up, store and dispose of spilled oil, and protect sensitive habitats and biological resources. It lists the response equipment available onsite and from offsite sources, and demonstrates, among other things, the Company's ability to respond to an oil spill in broken ice conditions (i.e., consistent with the provisions of Section 14(c) of the Information to Lessees portion of the Final Notice of Sale).

In the event that an oil spill should occur, either during fuel transfer operations or from the well, and response operations will not endanger the lives of personnel, onsite containment and cleanup equipment will be deployed by an Immediate Response Team organized and trained to react immediately to an oil spill incident. This onsite equipment, which is designed to provide an immediate

response capability to contain and clean up a small spill and an initial response to a major spill, will be inspected regularly and maintained in a constant state of readiness. Results of the inspections will be recorded and maintained as required.

If an oil spill occurs which is beyond the means of onsite personnel and equipment, Amoco will mobilize its Major Spill Response Team and, most likely, will request assistance from Alaska Clean Seas (ACS), an oil spill cleanup organization whose Area of Interest includes the Alaska Beaufort Sea OCS area. A complete description of the equipment maintained by ACS and other cleanup organizations located in Alaska is provided in Amoco's Oil Spill Contingency Plan.

## K. WASTE MATERIALS

Discharges of wastes into the environment will fall into two categories: (1) gaseous pollutants; and (2) solid and liquid wastes.

# (1) GASEOUS POLLUTANTS

Air emissions resulting from the proposed drilling operations will include nitrogen oxides and small quantities of sulfur oxides, carbon monoxide, suspended particulates, and hydrocarbons. Information on the nature and quantity of these emissions and the characteristics and operating frequency of significant emission sources are summarized in Section IV.B.(2) and are described in detail in Appendix C of this plan.

The air pollutants generated as a result of the proposed operations are minor in nature and of short duration. Because the emissions produced by the drilling and testing of the proposed exploratory wells described in this report are less than the exemption amounts "E" established under § 250.45 of the MMS regulations, no

further analysis of their impact on onshore areas is required. The emissions generated by ice class support vessels and helicopters also are low and should have no adverse onshore impacts.

## (2) SOLID AND LIQUID WASTES

In compliance with the provisions of the Federal Water Pollution Control Act, as amended (33 USC 1251 et seq.), the U.S. Environmental Protection Agency (EPA) regulates and approves the discharge of liquid and solid wastes into OCS waters.

Estimates of the volumes of the discharges from the proposed activities are summarized in Table II-8. The estimates are based on a 70-day drilling program, which is the maximum amount of time envisioned to drill, test, and abandon the proposed wells. Use of this "high side" estimate allows for unexpected extensions of drilling time as a result of factors such as unpredicted decreases in drilling rate.

a. <u>Drilling Unit</u>: Liquid discharges from the drilling unit will result from the normal domestic activities onboard the unit, the cooling systems, deck drainage, and boiler blowdown. Discharges of solids or solid suspensions will be generated as part of the proposed drilling operations and will include drilling mud, cuttings, and cement.

Seawater discharges, resulting from desalinization unit wastes, fire control system test water, non-contact cooling water, and uncontaminated bilge water and ballast water, will discharge approximately 2,000,000 gallons per day. The remaining daily liquid discharges (i.e., deck drainage, sanitary wastes, domestic wastes, BOP

TABLE II-8
ESTIMATED SOLID AND LIQUID WASTE DISCHARGES (12,000-foot well)

DISCHARGE	ESTIMATED VOLUME
Drill mud (daily dump)	100,000 GPD
+ excess mud	42,000 gals, 4 times
Drill cuttings and wash water	4500/2,165,000 GPD
Deck drainage	25,000 GPD
Sanitary waste	5,000 GPD
Domestic waste	4,000 GPD
Desalinization unit	18,000 GPD
Blowout prevention (BOP) fluid	50 GPD
Boiler blowdown	200 GPD
Non-contact cooling water	1,950,000 GPD
Fire control system test water	10,000 gals, 1 time/mo.
Uncontaminated ballast water	30,000 GPD
Uncontaminated bilge water	2,000 GPD
Excess cement	7,500 gals, 4 times
Mud, cuttings, cement at ocean floor	175,000 gals
Well test fluids	200,000 gals, 2 times

fluid and boiler blowdown) will yield about 34,250 gallons per day. In addition, up to 200,000 gallons of formation and injected water will be discharged during each formation test.

In compliance with § 250.33(a)(2) of the MMS regulations, the drilling unit will be equipped with curbs, gutters, drip pans, and drains which will be limited to a sump system. The sump will be used to collect only treated produced water, treated sand, liquids from drip pans and deck drains, and as a final trap for hydrocarbon liquids in the event of equipment upsets. The sump will automatically maintain the oil at a level sufficient to prevent discharge of oil into OCS waters.

Domestic sewage will be treated prior to release. A marine sanitation device, which meets the requirements of the U.S. Coast Guard will be used, and the resulting effluent will be chlorinated to a level greater than or equal to 1 mg/l of total residual chlorine prior to discharge.

Contaminated deck drainage will be released only after desilting, gravity separation, and oil/water separation processing.

Mud discharges during a 70-day drilling operation will total approximately 1,378,000 gallons. Cuttings and washwater will be discharged commensurate with the drilling rate, and could amount to 2,169,500 gallons per day.

If a glory hole is constructed to protect the subsea well-head, each glory hole construction operation would result in the discharge of dredge spoils. These discharges would be made at the drill site.

Sea water will be the base of the mud used to spud each well and for drilling prior to the setting point of the first two casing strings. Freshwater/saltwater gel mud will be used for drilling the hole for surface casing. Below surface casing, a fresh water EPA Mud

No. 6 will be used. All components for these muds will be EPA-approved for discharge to the ocean. Specific mud programs will be provided with the APD for each well.

Except for the structural and conductor casing holes, all mud and cuttings will be discharged at the ocean surface at the drill site. Any oil contaminated mud will be transported to shore for storage and eventual disposal at a state-approved site.

Cuttings and seawater gel mud will be discharged at the ocean floor while drilling the structural hole, and mud and a small quantity of cement will be displaced at the ocean floor while running and cementing the structural and conductor casing.

The composition of the drilling mud used, and hence the composition of the mud discharged, will be determined by the conditions encountered as the well is drilled. The drilling mud used will only be discharged if such discharges are approved by the EPA.

Other solid wastes from the proposed operations will include scrap iron or metal, packing materials, and miscellaneous items like boxes and paper. These materials will be incinerated or taken to shore in containers and sold as junk (scrap iron or metal) or disposed of at an approved onshore disposal facility.

b. <u>Ice Class Support Vessels</u>: Discharges from the ice class support vessels will consist primarily of ballast water. Additional quantities of bilge water, domestic water, and sewage also will be discharged. The sewage will be treated prior to discharge to the ocean. Solid wastes, such as garbage and packing materials, also will be produced, and will be transported to shore for reclamation or disposal at a state or Canadian-approved facility. Since the ice class support vessels have not been contracted yet, the quantities of liquid discharges from these vessels will be provided at a later date.

- c. <u>Helicopters</u>: Liquid and solid wastes generated as a result of the proposed helicopter operations will be small in quantity and will consist almost exclusively of sanitary wastes. These are included in the quantities estimated for the service bases presented below.
- d. <u>Service Bases</u>: Wastes generated at the service bases will include wastewater and solid wastes such as packing materials and domestic refuse. The quantities of wastes produced will depend on a variety of factors including the level of drilling activity, the number of vessels and helicopters used and their travel frequency, and the number of onshore support personnel. For purposes of this report, it is estimated that 3,300 GPD of domestic wastewater and 1,000 GPD of sewage will be produced at each base. Wastewater will be disposed of through existing systems. Solid waste generation is highly variable, but all solid wastes generated will either be reclaimed or disposed of at a state or Canadian-approved disposal facility.

# L. MAPS AND DRAWINGS SHOWING DETAILS OF THE PROPOSED PROJECT LAYOUT

Schematic drawings of the KULLUK and CANMAR Explorer II are provided in Figures II-2 and II-3, respectively. The location of the leases is depicted in Figure II-1. See Part II.D.(2) of this Section for information on the proposed well locations.

# M. CERTIFICATION OF COASTAL ZONE CONSISTENCY

The proposed exploratory drilling operations comply with the State of Alaska's approved coastal management program and will be conducted in a manner consistent with the coastal program. Amoco's consistency evaluation is included as Appendix D of this plan.

# N. A DESCRIPTION OF MEASURES PROPOSED TO COMPLY WITH PERTINENT REGULATIONS

The proposed operations will satisfy all applicable MMS regulatory requirements and will be conducted in compliance with MMS

standards, criteria, guidelines, and requirements pertaining to well control, personnel training, monitoring, surveillance and reporting, well surveys and testing, and hydrogen sulfide detection and safety measures. The proposed activities will be carried out in a manner which will satisfy all requirements imposed by the Stipulations and Information to Lessees portions of the Final Notice of Sale for Lease Sale No. 97, including Stipulation No. 2 which requires the preparation of an Orientation Program to inform project-related personnel of specific types of environments, social and cultural concerns which relate to operations in the eastern Alaska Beaufort Sea.

# O. NEARBY PENDING ACTIONS

As of July 1988, the MMS has approved six Exploration Plans for leases acquired during Lease Sale Nos. 87 and 97. These plans have been submitted by Amoco (two plans), Exxon Company, U.S.A., Shell Western E&P Inc., Tenneco Oil Company, and Union Oil Company of California. These plans cover a number of leases in the vicinity of the leases covered by this report. Although unlikely, it is possible that exploratory drilling activities could be conducted by other lessees, on nearby leases, concurrently with those proposed in this POE.

# P. MEANS FOR TRANSPORTING OIL AND GAS TO SHORE

Not applicable to exploratory drilling programs.

# Q. EXISTING OR PLANNED MONITORING SYSTEMS

All the  $\mathrm{H}_2\mathrm{S}$ , mud, and environmental monitoring systems described in this POE or in an APD will be in operation as required during the proposed operations.

## R. OTHER ENVIRONMENTAL PROTECTION MEASURES

The discussions in this plan document the environmental protection measures which will be taken to insure that the proposed operations are conducted in a safe and workmanlike manner (i.e., consistent with § 250.20 of the MMS regulations).

Site-specific data obtained through sources such as shallow seismic work, coring, and/or diver observations will be reviewed prior to the submittal of APDs to evaluate whether or not special biological populations or habitats exist or are likely to occur in areas potentially affected by the proposed operations.

Amoco will comply with provisions of Stipulation No. 4 of the Final Notice of Sale which requires the conduct of an industry site-specific monitoring program to determine when migrating endangered bowhead whales are in the vicinity of the proposed operations and to determine any effects that drilling activities have on the behavior of migrating whales [see Part II.H.2(i) of this section].

Meteorological, oceanographic, and performance data will be collected and reported as required.

Finally, the Orientation Program required under Stipulation No. 2 of the Final Notice of Sale will be prepared and presented to all management, supervisory, and other personnel (lessees, lessees' agents, contractors, and subcontractors) involved in the proposed operations. The program will provide information on the physical, biological, and archaeological resources of the Beaufort Sea OCS area, and the history and present day lifestyles, values, and customs of the residents of communities that may be affected by oil and gas operations proposed for the sale area.

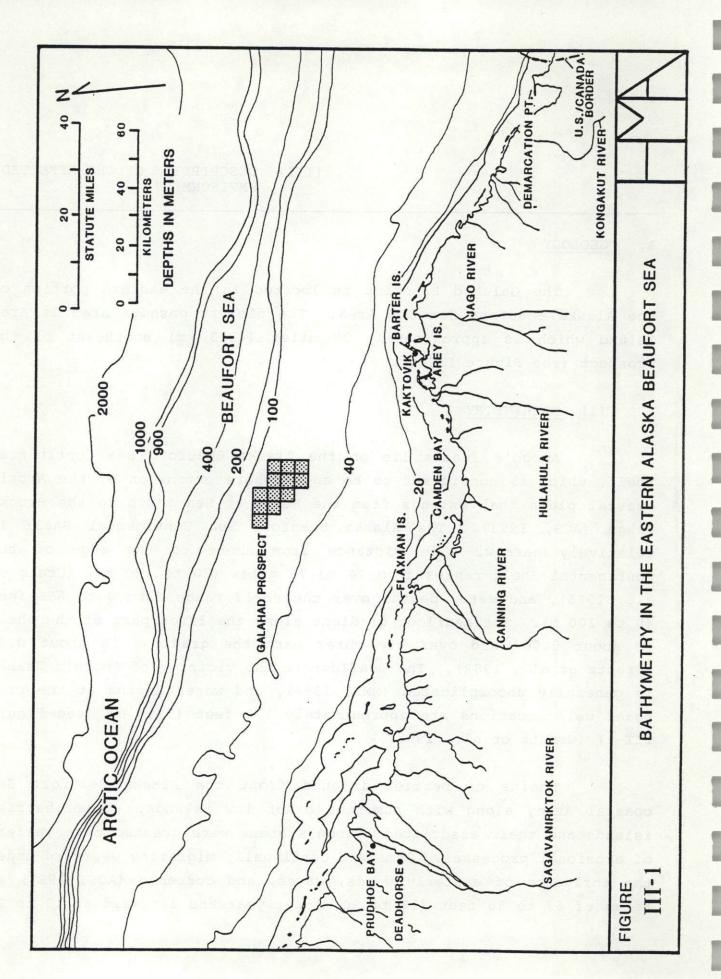
# A. GEOLOGY

The Galahad Prospect is located in the eastern portion of the Alaska Beaufort Sea OCS Area. The closest onshore area is Arey Island which is approximately 30 miles (48.3 km) southeast of the prospect (see Figure III-1).

## (1) BATHYMETRY

Amoco's leases lie on the Alaska Beaufort Sea Continental Shelf, which is considered to be an offshore extension of the Arctic coastal plain that extends from the Beaufort Sea south to the Brooks Range (ACS, 1983). The Alaska Beaufort Sea Continental Shelf is relatively narrow. The distance from shore to the edge of the Continental Shelf ranges from 44 to 75 miles (70 to 120 km) (Craig et al., 1985), and water depths over the shelf range from 0 to 656 feet (0 to 200 m). The seafloor gradient along the inner part of the shelf is about 0.06° and over the outer part the gradient is about 0.9° (Grantz et al., 1982). The seafloor in the vicinity of Amoco's leases is generally uncomplicated (MMS, 1984), and water depths at the proposed well locations are approximately 170 feet (51.8 m) (see Figure III-1) (Grantz et al., 1982).

Chains of barrier islands front the Alaska Beaufort Sea coastal area, along with numerous other low islands. These barrier islands and their associated lagoon systems were created by a variety of erosional processes. Some are continually migrating westward under the influence of easterly winds, waves, and currents (ACS, 1983) at rates of 62 to 98 feet (19 to 30 m) per year and landward at 10 to 23



feet (3 to 7 m) per year (MMS, 1987). Between the mainland coastline and the barrier islands, water depths generally range from 6 feet (2 m) to slightly more than 26 feet (8 m). Most of the passes between the islands have water depths which range from 20 feet to 26 feet (6 m to 8 m) (BLM, 1982).

The Continental Shelf gives way to the Continental Slope which marks the region where the steepest descent of the seafloor occurs (Lynch et al., 1985). The Alaska Beaufort Sea Continental Slope extends from the Continental Shelf break down to a depth of about 6,562 feet (2,000 m). East of 147°W longitude (i.e., in the eastern Alaska Beaufort Sea), both an inner and an outer shelf break have been identified. The inner shelf break occurs at the 197-foot (60-m) water depth and marks a sharp boundary between the flat-lying shelf and the so-called "Beaufort Ramp" (Grantz and Eittreim, 1979). The Beaufort Ramp is characterized by bedding-plane faults. The outer shelf break lies seaward of the Beaufort Ramp at depths of 1,969 to 2,625 feet (600 to 800 m). This break marks the top of a chaotic zone of large rotational slumps (Craig et al., 1985).

The Continental Slope has gradients that average about 4° to 12°; however, locally greater gradients, up to 16°, may occur (Grantz et al., 1981). The slope is characterized by many slumps, mudslides, and canyons. The canyons that cut into the slope may be slump scars or turbidity channels that contain bedded sediments and levees on the sides (MMS, 1984).

The Continental Slope gives way to the Continental Rise which is an area of coalescent sedimentary fans located between the Continental Slope and the Abyssal Plain (Birkeland and Larson, 1978). In the Alaska Beaufort Sea, the Continental Rise has been divided into two physiographic provinces—the Alaska Continental Rise and the Canada Continental Rise. The Alaska Continental Rise descends from a depth of about 6,562 feet (2,000 m) to the Canada Basin abyssal plain

at about 12,468 feet (3,800 m). The seafloor gradients range from  $0.9^{\circ}$  to  $2.2^{\circ}$  degrees. Bathymetric profiles show that channels and levees cross the rise (Grantz et al., 1982).

A part of the Canada Continental Rise is located in the northeast portion of the MMS Beaufort Sea Planning Area. The transition from the Continental Slope to the rise occurs in water depths between 4,593 and 5,906 feet (1,400 and 1,800 m). The upper surface of the Canada Continental Rise slopes gently toward the Abyssal Plain where there is a gradational boundary at a water depth of about 12,140 to 12,468 feet (3,700 to 3,800 m). The rise is underlain by a thick sedimentary fill derived from the Mackenzie River Valley and Arctic Islands. In the overlap area, sedimentation on the Canada Continental Rise has overwhelmed sedimentation on the Alaska Continental Rise (Grantz et al., 1981).

# (2) STRUCTURE AND STRATIGRAPHY

Structure: The MMS Beaufort Sea Planning Area has been divided into two main petroleum provinces. The Arctic Platform province is an older southern province containing strata deposited on a continental basement complex. The Brookian Basins province, which encompasses the Galahad Prospect, is a younger northern province containing strata deposited in deep basins on the continental margin. (Note: a third province, the Canada Basin, is located seaward of the present continental shelf). The dividing line between the two main petroleum provinces is called the Hinge Line. The Hinge Line lies offshore along a zone of down-to-the-north basement faults. the southern edge of a major rift zone that developed in Late Jurassic to Early Cretaceous time. In Camden Bay, the Hinge Line trends southeast and then swings eastward in a sigmoidal configuration, passing north of Barter Island before it turns southeast to trend parallel to the present Alaska coastline (Craig et al., 1985).

South of the Hinge Line, the basement surface forms the broad Arctic Platform that dips southward away from northern tectonic highlands that existed before continental rifting. The present structural relief of this continental basement complex is largely the result of coeval compression tectonics in the Brooks Range and rifting of the Arctic Platform since Late Jurassic or Early Cretaceous time (Craig et al., 1985).

Seaward of the Hinge Line, over 35,000 feet (10,668 m) of Cretaceous and Tertiary sediments have accumulated in a formation termed the Kaktovik Basin (Grantz et al., 1982; Craig et al., 1985). The Kaktovik Basin contains an extensive northwest to southeast trending growth fault system related to active basinal subsidence north of the Hinge Line (Craig et al., 1985).

The Kaktovik Basin and contiguous areas of the Arctic Platform to the south of the Hinge Line have been further subdivided into two sectors on the basis of fundamental differences in stratigraphic and structural histories. The western section is termed the Camden Sector, while the eastern section is termed the Demarcation Sector. The Galahad Prospect lies within the Camden Sector (Grantz et al., 1982; Craig et al., 1985).

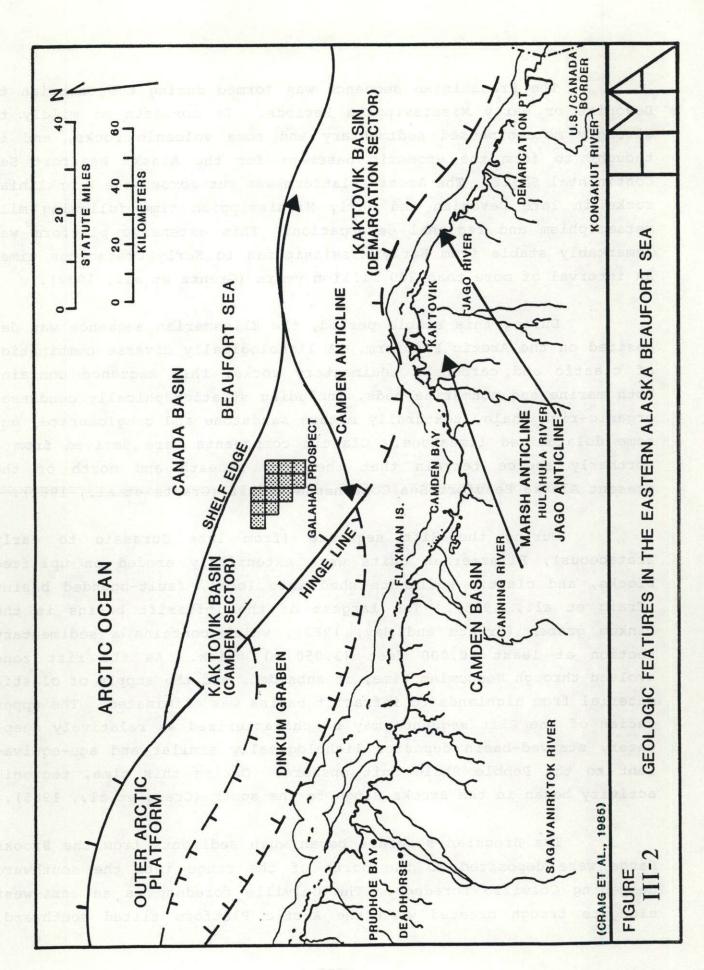
The principal structural feature of the Camden Sector is the Camden anticline. This immense fold can be traced for nearly 60 miles (96 km) along its northeast trending axis. The northeast to southwest trend of this anticline is structurally anomalous in that it is oblique to the regional northwest to southeast trending margin of the Kaktovik Basin. The fold is cut by numerous faults which, in some cases, extend to the seafloor. The majority of these faults are part of the Hinge Line fault system and trend northwest. There is also evidence to suggest that the Camden anticline is a very youthful structure (i.e., of late Tertiary or possibly Quatenary origin) (Craig et al., 1985). Modern, shallow-crustal seismic activity suggests that the fold is still growing (Biswas and Gedney, 1978).

While the Camden Sector is stratigraphically similar to the Camden Basin, which is located in the vicinity of the Canning River, the Demarcation Sector is believed to be more stratigraphically analogous to the geology found in the contiguous Canadian Beaufort Sea. The structure of the Demarcation Sector south of the Hinge Line is dominated by two major structures known as the Jago and Marsh anticlines. These structures, and a host of minor folds and faults, trend northeast, approximately parallel to the axis of the Camden anticline (Craig et al., 1985). They appear to be similar to the Camden anticline in age, in that they also seem to deform late Tertiary to Quaternary sediments (Grantz and Mull, 1978; Reiser et al., 1980). The Marsh and Jago anticlines appear to be truncated to the northeast approximately 10 miles (16 km) offshore, where they intersect with the Hinge Line fault system (Craig et al., 1985).

The structure of the Kaktovik Basin in the Demarcation Sector north of the Hinge Line is dominated by large diapiric shale ridges or anticlines and Tertiary sedimentary subbasins, formed concurrently with the diapirs. At least three episodes of diapiric movement have been recorded by seismic work over one of the diapiric structures. This includes one in which the core sediments of the fold were raised above wave base (i.e., the lowest level of wave transportation and erosion), and possibly above sea level (Grantz et al., 1982; Lynch et al., 1985).

Major geologic features of the eastern Alaska Beaufort Sea OCS planning area are depicted in Figure III-2.

b. <u>Stratigraphy</u>: The sedimentary strata of the Alaska Beaufort Sea Continental Shelf are conveniently grouped into four regionally extensive sequences of contrasting lithology, tectonic character, and hydrocarbon potential. Beginning with the oldest, they are the Franklinian, Ellesmerian, Rift, and the Brookian sequences (Craig et al., 1985).



The Franklinian sequence was formed during the Cambrian to Devonian or early Mississippian Periods. It consists of mildly to strongly metamorphosed sedimentary and some volcanic rocks, and is thought to form the economic basement for the Alaska Beaufort Sea Continental Shelf. The Arctic Platform was cut across the Franklinian rocks in late Devonian and early Mississippian time following mild metamorphism and regional deformation. This extensive platform was remarkably stable from Early Mississippian to Early Cretaceous time, an interval of more than 200 million years (Grantz et al., 1982).

During this stable period, the Ellesmerian sequence was deposited on the Arctic Platform. A lithologically diverse combination of clastic and carbonate sedimentary rocks, this sequence contains both marine and nonmarine beds, including stratigraphically condensed organic-rich shale, texturally mature sandstone and conglomerate, and some dolatomized limestone. Clastic components were derived from a northerly source terrain that then lay beneath and north of the present Alaska Beaufort Sea Continental Shelf (Grantz et al., 1982).

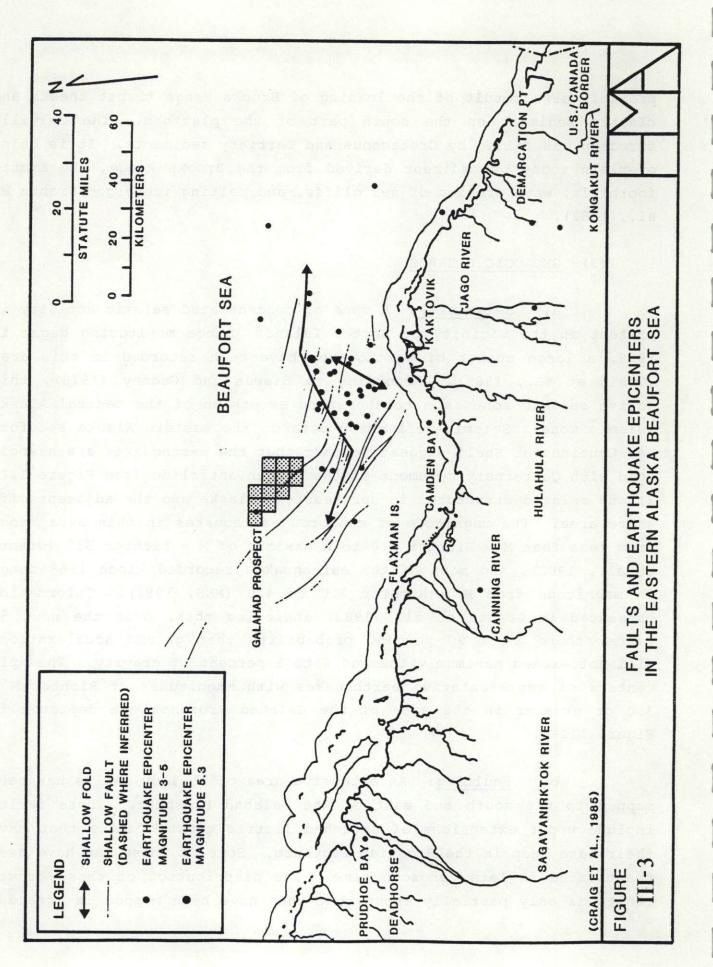
During the Rift sequence (from late Jurassic to early Cretaceous), Ellesmerian units were extensively eroded on uplifted blocks, and clastic sediments shed into local, fault-bounded basins (Craig et al., 1985). The largest of the infrarift basins is the Dinkum graben (Grantz and May, 1982), which contains a sedimentary section at least 10,000 feet (3,050 m) thick. As the rift zone evolved through Neocomian time, it subsided, and the supply of clastic material from highlands to infrarift basins was eliminated. The upper facies of the Rift sequence may be characterized as relatively deepwater, starved-basin deposits lithologically similar and age-equivalent to the Pebble Shale unit onshore. During this time, tectonic activity began in the Brooks Range to the south (Craig et al., 1985).

The Brookian sequence began when sediments from the Brooks Range were deposited to the north of the range into the southward deepening Colville foredeep. The Colville foredeep is an east-west elongate trough created when the Arctic Platform tilted southward,

probably as a result of the loading of Brooks Range thrust sheets and clastic sediment on the south part of the platform. The Colville foredeep was filled by Cretaceous and Tertiary sediments. It is being overlain today by sediment derived from the Brooks Range, the Arctic foothills, wave erosion of sea cliffs, and melting icebergs (Grantz et al., 1982).

## (3) GEOLOGIC HAZARDS

- Seismicity: A zone of concentrated seismic activity is present in the vicinity of Barter Island. Since monitoring began in 1978, a large number of earthquakes have been recorded in this area (Craig et al., 1985). According to Biswas and Gedney (1978), this active seismic zone is a northeastern extension of the central Alaska seismic zone. Seismic-reflection data on the eastern Alaska Beaufort Sea Continental Shelf suggest further that the earthquakes are associated with Quaternary movement of the Camden anticline (see Figure III-2) and related structures in northeastern Alaska and the adjacent offshore area. The magnitude of measured earthquakes in this area range from less than M = Richter 1.0 to a maximum of M = Richter 5.3 (Grantz et al., 1982), and most of the earthquakes recorded since 1968 range in magnitude from M = Richter 3.0 to 4.0 (MMS, 1987). Information presented in Grantz et al. (1982) indicates that, over the next 50 years, there is a 90 percent probability that ground accelerations will not exceed maximum values of 4 to 5 percent of gravity. centers of representative earthquakes with magnitudes of Richter M = 3.0 or greater in the area of the Galahad Prospect are depicted in Figure III-3.
- b. <u>Faulting</u>: An extensive area of shallow faults has been mapped to the south and east of the Galahad Prospect. These faults include upper extensions of detached listric growth faults that have their base deep in the Brookian sequence. Some of these may have been reactivated in late Cenozoic time. The distribution of these growth faults is only partially known, but they have been mapped in greatest



detail where the Hinge Line approaches the Beaufort Sea coastline (Craig et al., 1985). In the Camden Bay area, near-surface faults have several tens of meters of Quaternary offset (Grantz et al., 1983). Seismic activity is clustered around the Camden anticline. Tertiary and Quaternary units dip away from and are truncated at the top of this fold, indicating that it has been growing in recent geologic time. In contrast to the northeast-southwest trend of the Camden anticline, the faults in Camden Bay trend northwest-southeast, parallel to the Hinge Line. As they approach and intersect the axis of the Camden anticline they offset progressively younger units. This relationship suggests that these faults are older Hinge Line-related structures that were reactivated in late Tertiary and Quaternary time by the uplift of the Camden anticline (Craig et al., 1985). faults are depicted in Figure III-3. Active near-surface faults may be more numerous than indicated in the Camden Bay area, due to the tendency of ice-gouging to smooth scarps on the seafloor (Craig et al., 1985).

- c. <u>Volcanic Activity</u>: There is no evidence of active volcanism in or adjacent to the Alaska Beaufort Sea OCS area (Grantz et al., 1982).
- d. <u>Seafloor Instability</u>: Three types of seafloor instability have been observed in the vicinity of the Galahad Prospect--submarine landslides, sediment transport, and permafrost. Although gas-charged sediments occur in the eastern Alaska Beaufort Sea OCS area, this type of seafloor instability is found at depths greater than those encountered on the Galahad Prospect [note: gas-charged sediments are not believed to occur inside the 197-foot (60-m) isobath] (MMS, 1984; Grantz et al., 1982; Craig et al., 1985).

Submarine Landslides: Most of the Alaska Beaufort Sea Continental Shelf seaward of the 164- to 197-foot (50- to 60-m) isobaths and the upper part of the consolidated sediments appear to be unstable and show a variety of features associated with the downslope movement of large, tabular sediment blocks (Grantz et al., 1982; Craig et al.,

1985). Since the slip planes along which the blocks move seaward slope only 0.5° to 1.5°, these deposits are believed to include sediments of very low shear strength. The size of the sediment blocks varies, but masses up to 24 miles (38 km) long and 66 to 755 feet (20 to 230 m) thick have been observed. North of Camden Bay, near the 197-foot (60-m) isobath, the landward margin of the slide area is marked by scarps (i.e., steep slopes which form as the sediment masses slide downslope) (Grantz et al., 1981). Estimates of the horizontal movement at the head of well-developed slides range from 0.1 to 1.4 miles (0.2 to 2.3 km). Locally, up to three generations of slide masses have been superimposed on one another, and reactivation of sliding along older slip planes apparently is common (Grantz et al., 1982).

In the eastern part of the Alaska Beaufort Sea, the surface relief features that indicate slumping, sliding, and faulting may be relict and produced by processes which are not active today (Reimnitz et al., 1982). Sediment samples, some containing gravel-size particles, and seismic records may indicate areas of nondeposition along the central and outer part of the Continental Shelf. If fine-grained sediments are not accumulating along the outer part of the present day Continental Shelf, the surface features related to mass movement of sediments, or mudslides, may have been produced in the past (MMS, 1984). However, sediments involved in sliding have not been directly dated (Craig et al., 1985).

Sediment Transport and Erosion: There is evidence that, at times, the forces of ocean currents are sufficiently strong to rework coarse sediments (Barnes et al., 1981). On the inner part of the Continental Shelf, this evidence includes: surface sand waves or linear-shaped sand bars overlying jagged relief; overconsolidated silty clays that outcrop in the troughs of the sand waves; and a lack of ice gouge marks on the crests of sand waves in areas where ice grounding generally occurs (MMS, 1984).

Strudel scouring occurs on and near the river deltas during spring from the flooding of rivers. The flood water overflows the nearshore sea ice and passes, often violently, through cracks creating scour depressions in seafloor sediments. These depressions are commonly 49 to 82 feet (15 to 25 m) in diameter and as deep as 13 feet (4 m) (Reimnitz and Barnes, 1974).

Ice moving in response to wind, current, and pack ice pressures often plows through and disrupts the Continental Shelf sediments, forming seabed gouges which are found from the nearshore area out to a water depth of about 197 feet (60 m). In the Alaska Beaufort Sea, most studies (Barnes and Reimnitz, 1974; Reimnitz and Barnes, 1974; Reimnitz et al., 1978; Rearic et al., 1981) indicate that gouges are generally oriented parallel to shore, although on the inner shelf where shoals and other bottom features deflect the ice, orientations can vary considerably (Craig et al., 1985). Gouges commonly range from 1.6 to 3.3 feet (0.5 to 1.0 m) deep. However, gouges up to 20 feet (6 m) deep have been measured on the outer shelf. When first formed, the gouges may be considerably deeper. High gouge densities are common within the stamukhi zone and along the steep seaward flanks of topographic highs. Inshore of the stamukhi zone, seasonal gouges may be abundant, but generally are smoothed over during summer by wave and current activity (Barnes and Reimnitz, 1979).

Erosion of the coastal areas adjacent to the eastern Alaska Beaufort Sea OCS area is affected by: thermokarst collapse (i.e., the collapse or loss of volume due to melting out of ground water in excess of normal porosity), and thermal erosion (i.e., lateral erosion resulting from melting out of ground and interstitial ice accompanied by lateral current transport of resulting fine material) (Hopkins and Hartz, 1978). The rates of coastal retreat vary from year to year and depend upon the timing of the sea ice breakup, variations in the size of the open-water areas (i.e., exposure to the sea), the timing of late summer and autumn storms, the composition of the coastal bluffs, and the morphology of the adjacent seafloor (MMS, 1984).

Permafrost: Relict permafrost underlies the present day Alaska Beaufort Sea Continental Shelf shoreward of the 295-foot (90-m) isobath and probably is widespread in the upper 1,640 feet (500 m). The permafrost formed during periods of major glaciation when the sea level was lowered and a large part of the present Continental Shelf was exposed to subfreezing temperatures for long periods of time (MMS, 1984).

The distribution of relict permafrost on the outer Continental Shelf is unknown. Studies are underway to seismically assess the depth and thickness of relict permafrost layers over the entire area. Fully ice-bonded permafrost may or may not be encountered at depth offshore (Grantz et al., 1982).

## (4) MINERAL DEPOSITS

a. <u>Petroleum</u>: In 1987, the MMS estimated that the tracts offered during Lease Sale No. 97 may contain recoverable reserves ranging from 0.11 to 1.66 billion barrels of oil. The mean estimate was 0.65 billion barrels of oil. In 1986, the MMS estimated that the conditional mean economically recoverable resource estimates for blocks leased as a result of Lease Sales BF, 71, and 87 was 600 million barrels of oil (MMS, 1987).

In 1984, the MMS estimated that the mean estimate for gas resources was 7.75 trillion cubic feet. However, gas resources have not been deemed economical to produce (Cooke, 1985).

b. <u>Non-Petroleum</u>: Gravel and coarse sand are one of the Arctic's most valuable resources because these scarce aggregates are required to construct roads, airstrips, work pads, foundations, causeways and, in the event of offshore drilling, artificial soil islands. Quantitative and qualitative data on North Slope and Alaska Beaufort Sea gravel and sand resources are limited. Most of the major rivers and streams contain sand and gravel. In addition, coastal gravel and sand resources are available in beaches and spits east of the Colville

River and on barrier islands. Significant gravel deposits occur in a series of coalesced alluvial fans along the flanks of the Brooks Range east of the Canning River (Dames and Moore, 1978a).

Few data are available on offshore seafloor and subsurface gravel and sand deposits. Data on these resources have generally been collected incidentally as part of investigations on such issues as coastal processes, subsea permafrost, and sediment transport rather than as specific resource evaluations (Dames and Moore, 1978a).

## (5) FRESHWATER AQUIFERS

No fresh water aquifers are known to exist beneath Amoco's leases. During drilling activities, all horizons which contain fresh water will be fully protected by casing and cement designed in accordance with the provisions of § 250.54 of the MMS regulations.

# B. METEOROLOGY

### (1) GENERAL WEATHER PATTERNS

The eastern Alaska Beaufort Sea OCS area is located in the arctic climatic zone, which extends south to the Brooks Range (BLM, 1979). Climatic conditions in this area are influenced by the alternating long periods of daylight and darkness, the presence of snow and ice, a distinctive temperature inversion, and the presence of a cold, upper atmospheric high pressure system which encircles the entire arctic region (ACS, 1983).

a. <u>Temperature</u>: During most of the year, the Arctic is covered by a shallow layer of stable cold air which is effectively isolated from the atmosphere above. As a result, ground-level air temperatures, which are largely determined by the temperature of the earth's surface, remain relatively cold (Becker, 1987).

Barter Island (i.e., the station closest to the Galahad Prospect). Based on these data, mean monthly air temperatures in the eastern Alaska Beaufort Sea OCS area are above freezing from June through August, and the warmest and coldest mean monthly temperatures occur in July and August [39°F (4°C)] and February [-20°F (-29°C)], respectively. Table III-1 also contains information on maximum and minimum air temperatures. The figures presented represent those air temperatures which occur 99 percent of the time (i.e., 1 percent of the recorded air temperatures could be greater or less than the given values) (Brower et al., 1977). The highest air temperature recorded at Barter Island for the period 1948-1977 was 78.1°F (25.6°C) and the lowest air temperature was -59.1°F (-50.6°C) (NOAA, 1977).

b. <u>Cloud Cover and Visibility</u>: During summer, moisture from the relatively warm, open coastal waters and relatively low wind speeds aid in the formation of low cloud cover. Fog tends to increase toward the end of summer as onshore areas begin to cool more rapidly than offshore areas (LGL, 1983).

During summer, fog, which is generally associated with winds from the southwest or north, is present in the eastern Alaska Beaufort Sea OCS Area approximately 10 to 30 percent of the time. Fog generally tends to be less prevalent during the afternoon and early evening hours when solar radiation tends to burn off the fog (ACS, 1983).

Visibility of 2 nautical miles (4 km) or less in the vicinity of the Galahad Prospect occurs 15 to 25 percent of the time during most of the year. On the other hand, visibility of 5 nautical miles (9 km) or greater occurs more than 65 percent of the time throughout the year. The best sustained visibility occurs from February through April (see Table III-1) (Brower et al., 1977).

CLIMATIC INFORMATION FOR THE EASTERN BEAUFORT SEA OCS

	-			(BRO	(BROWER ET AL., 1977)	ET AL., 1977)			מבנו ממס עוודע			
ece w cits a cits s ofwere codes	THENNER	THANHAIL	Birm	MAN	76%	NAN ANN	The	1snons	HIRMII 41	43BO13C	HANING.	4 HANNO
AIR TEMPERATURE F(C)	0.6	7.1	81						à		n	00
MEAN EXTREMES	-15(-26)	-15(-26)  -20(-29)	-18(-28)	0(-18)	21(-6)	34(1)	39(4)	39(4)	32(0)	16(-9)	-15(-28)	0(-18)
НІВН	28(-2) -44(-42)	18(-8) -48(-44)	21(-6)	32(0) -26(-32)	39(4)	50(10)	61(16)	54(12)	46(8)	36(2)	28(-2)	25(-4)
WIND SPEED (KNOTS) AND DIRECTION	13.0 W-E	13.0 W-E 12.1 W-E 11	11.8 W-E	10.3 E-W	10.6 E-W	9.8 E-NE	9.2 E-NE	10.0 E-W	11.4 E-W		13.9 F-W	10 3 W-E
% FREQUENCY PRECIPITATION	50	20	18	20	29	18	. 21	21	28	37	31	2.3 W E
% FREQUENCY FOG	10	<10	<10	\$10	>20	25	25	30	25	9	4	
VISIBILITY	ios	77 E		B.C						2	2	
% ≥ 5nm % < 2nm	70 20	75 20	75	75	70 20	75	75	65-70	0 0 0	70	65	75
									2	777	02	2

WIND SPEEDS ARE SCALAR WIND SPEED WIND DIRECTIONS LISTED IN THEIR ORDER OF FREQUENCY c. <u>Wind Speed and Direction</u>: Two atmospheric "effects" are responsible for the generation of coastal winds: the mountain barrier effect and the sea breeze effect. The mountain barrier effect is induced during winter when cold wind piles up against the Brooks Range, producing westerly winds along the coast (Kozo, 1981). The sea breeze effect is generated in summer by the land-sea thermal contrast (Kozo, 1979) which leads to an increased persistence of onshore winds (LGL, 1983).

Along the coast of the eastern Alaska Beaufort Sea, prevailing winds originate either from an east to northeast direction or from a west to northwest direction (ACS, 1983; Brower et al., 1977). At Barter Island, the annual wind direction is easterly, except from December through March, when the prevailing direction is westerly. Mean scaler wind speeds at Barter Island range from 9.2 knots (17.0 km/hr) in July to 13.2 knots (24.4 km/hr) in November (see Table III-1) (Brower et al., 1977).

d. Storms: Storms which affect the eastern Alaska Beaufort Sea OCS Area most frequently originate along the Aleutian chain, pass through the Bering Sea, and enter the Beaufort Sea through the Bering Strait. However, the area occasionally is affected by storms which move eastward from Siberia (Searby and Hunter, 1971). Storm tracks generally lie north of the Alaska Beaufort Sea coastline, and storms usually progress toward the east (NOAA, 1978). Storm movement is rapid, so storm conditions at a given location are relatively short-lived (BLM, 1979).

Oceanweather, Inc. (1978) identified 50 severe storms for the August through October period from 1949 to 1976. The storms were characterized by strong and persistent surface winds from either the west (240°-300°) (i.e., storms associated with a low pressure system traversing north of the Beaufort Sea) or east (60°-120°) (i.e., storms associated with a low pressure system traversing south of the Beaufort Sea). Easterly and westerly storm types occurred with about equal frequency and were associated with well-defined synoptic scale weather

systems. Storms of the easterly type did not favor any particular region in the southern Beaufort Sea, but those of the westerly type intensified as they moved eastward, resulting in high winds in the eastern areas. Winds in both types of storms were stronger in the southern than in the northern Beaufort Sea.

e. <u>Precipitation</u>: Average annual precipitation in the Alaska Beaufort Sea ranges from 5 inches (13 cm) in the west to 7 inches (18 cm) in the east (ACS, 1983). The frequency of precipitation during each month ranges from 15 percent in July to 37 percent in October (see Table III-1) (Brower et al., 1977). Precipitation occurs mostly in the form of summer rain (MMS, 1987).

# (2) AIR QUALITY

The air quality impact analysis, performed in accordance with § 250.46 of the MMS regulations, is summarized in Section IV.B.(2) and is attached as Appendix C of this plan.

a. Onshore Air Quality: The Air Quality Control Plan for Alaska (January, 1980) divides the state into four Air Quality Control Regions (AQCRs). The land areas adjacent to the Alaska Beaufort Sea are located within the Northern Alaska Intrastate AQCR. The Northern Alaska AQCR is an extremely large area covering approximately 320,000 square miles (828,800 sq km) (ADEC, 1980).

All regions in Alaska have been evaluated by the state as to their compliance with the National Ambient Air Quality Standards (NAAQS) as prescribed by the EPA. In Alaska, non-attainment areas are those in which the NAAQS are exceeded, while attainment areas are those in which ambient air quality is better than the national standards. The State has designated the Northern Alaska Intrastate AQCR as an attainment area (ADEC, 1980).

The only major source of industrial emissions existing in arctic Alaska is the Prudhoe Bay/Kuparuk complex, 76 miles (122.3 km) west-southwest of the Galahad Prospect. Even in the vicinity of this complex, the NAAQS consistently are met. In summer and fall, pollutant levels in the Alaska Beaufort Sea are extremely low (MMS, 1984). In winter and spring, pollutants from industrial Europe and Asia are transported into the area (Rahn, 1982); however, air quality still far exceeds the NAAQS (MMS, 1984).

Under the provisions of the Prevention of Significant Deterioration requirements of the Clean Air Act, as amended, an area classification system has been established and increments and ceilings have been prescribed to insure that emissions of sulfur dioxide (SO<sub>2</sub>) and total suspended particulates (TSP) do not cause "significant" air In Class I areas, only small incremental inquality degradation. creases (10 percent of the national air quality standards) allowed. In Class II areas, moderate increases (25 percent of the national standard) are permitted. In Class III areas, new sources are allowed to use up to 50 percent of the national air quality standards. No incremental increase limitations have been set for the other criteria pollutants (carbon monoxide, nitrogen dioxide, and ozone) (ADEC, 1980). There are four Class I areas in Alaska, and the closest of these to the Galahad Prospect in the Alaska Beaufort Sea is the Denali National Park and Preserve, which is more than 625 miles (1,006 km) to the south. The remainder of the "attainment" areas in Alaska, including the coastal areas adjacent to Amoco's leases, are Class II.

b. Offshore Air Quality: Any emissions produced by the proposed operations are expected to affect only ocean areas. No information is currently available on the quality of ambient air in the immediate vicinity of the Galahad Prospect. However, because of the absence of any major pollution sources operating in the area, ambient air quality is presumed to be well within all applicable air quality standards.

### C. PHYSICAL OCEANOGRAPHY

### (1) TEMPERATURE AND SALINITY

Two oceanic regimes occur in the eastern Alaska Beaufort Sea OCS Area: the ice-covered regime and the open-water regime. The ice-covered regime lasts roughly from late September or early October until late June, and the open water regime occurs during the remainder of the year. Major differences in temperature and salinity levels exist between these regimes (Woodward-Clyde, 1981).

a. <u>Temperature</u>: Temperatures in the eastern Alaska Beaufort Sea OCS Area vary with season, depth, and distance from shore. Temperatures are subject to a variety of influences, including: ice and ice melt, river runoff, surface winds, solar heating, and currents (CSA, 1981).

The surface temperature of nearshore waters during summer (August) typically reaches 45°F (7°C), but can remain as low as 32°F (0°C) or can reach as high as 54°F (12°C) in areas influenced by river water outflows. Farther offshore near the barrier islands, water temperatures typically range from 36°F (2°C) to 41°F (5°C) during summer. Waters less than 6 feet (2 m) deep tend to be vertically isothermal during summer. Waters greater than 6 feet (2 m) deep exhibit a vertical temperature gradient with colder bottom water and a bottom to surface temperature differential of from 37°F to 46°F (3°C to 8°C) (USACOE, 1980).

In winter, water temperatures in the eastern Alaska Beaufort Sea OCS Area average 30°F to 28°F (-1°C to -2°C) (AINA, 1974). For the most part, the variation in under-ice temperatures in the area is less than 1.8°F (1.0°C), but pockets of high saline water may have temperatures as low as 10°F (-12°C). Winter water temperatures in the eastern Alaska Beaufort Sea OCS Area are believed to be relatively uniform regardless of depth (CSA, 1981).

Salinity: In summer, salinities in the eastern Alaska Beaufort Sea OCS Area are influenced primarily by river runoff and sea ice and can vary considerably over a short period of time. River runoff is responsible for keeping salinity levels in the coastal area relatively low. Farther offshore, the interaction between freshwater discharges and landward-moving bottom water results in a well-mixed water mass with a salinity level of less than 25 ppt (BLM, 1979). deed, localized areas of fresh water may even occur. Freshwater river discharges also contribute to low salinity levels (26 to 29 ppt) in surface waters on the middle and outer Continental Shelf areas (USACOE, 1980). At summer's end, salinities increase and stabilize as river runoff decreases and ice formation progresses. Salinities generally rise to 31 ppt or higher everywhere on the Continental Shelf during winter. Some pockets of seawater trapped under the ice can have salinities as high as 183 ppt (USACOE, 1980). These high salinities result from brine drainage from the forming ice (CSA, 1981).

#### (2) CURRENTS

Inshore of the 164-foot (50-m) isobath, winds are the principal driving force to open water surface circulation, particularly in shallow lagoons and embayments between the coastline and barrier islands. Longshore currents, which are influenced by the location of · pack ice, the presence of barrier islands, and the lack of topographic relief, essentially parallel the coast and generally flow in a westerly direction (ACS, 1983). However, in the eastern Alaska Beaufort Sea, the distribution of winds is more bimodal. At Barter Island, the average winds are from the east-northeast to east 35 percent of the time, and from the west-southwest to west 25 percent of the time (Searby and Hunter, 1971). Winds are predominantly from the west during winter, and from the east during the open water period. fore, currents in the eastern Alaska Beaufort Sea exhibit a mean eastward flow in winter and a mean westward flow in summer (Brower et al., This was found to be the typical pattern for 8 out of 10 studies of summer current patterns (Kozo, 1983).

Surface currents range in velocity from 0.5 to 1.0 feet/sec (15.2 to 30.5 cm/sec) during summer; however, currents may exceed 6.6 feet/sec (201.2 cm/sec) during storm events (ACS, 1983). Winter currents generally flow westward and may range from 0.2 to 0.5 feet/sec (6.1 to 15.2 cm/sec) in shallow water [i.e., less than 7 feet (2 m) deep], to 0.07 feet/sec (2.1 cm/sec) in deeper water (Norton and Sackinger, 1981).

Beyond the 164-foot (50-m) isobath, surface circulation patterns are controlled by the Beaufort Current. This current typically extends from near the surface to the bottom between the 164-and 8,202-foot (50- and 2,500-m) isobaths, a horizontal distance of 37.3 to 43.5 miles (60 to 70 km) through the Alaska Beaufort Sea at velocities on the order of 0.5 to 0.8 feet/sec (15.2 to 24.4 cm/sec) to the east (Aagaard, 1983; Thomas, 1983). Beyond the 656-foot (200-m) isobath, circulation is controlled by the clockwise Beaufort Sea gyre which moves from Canada to the west at velocities reaching 0.2 to 0.4 feet/sec (6.1 to 12.2 cm/sec) (Aagaard, 1979).

### (3) TIDES

2. <u>Tides</u>: The astronomically induced tides in the Alaska Beaufort Sea are much smaller than weather-induced tides (i.e., storm surge). Tides appear to approach the area from the north, with a slight increase in height from west to east along the coast (MMS, 1987). At Point Barrow, mean and diurnal tidal fluctuations are 0.5 feet (15.2 cm) and 0.6 feet (18.3 cm), respectively. Tide gauges at Oliktok Point, Prudhoe Bay, Tigvariak Island, and Flaxman Island all report mean and diurnal tidal fluctuations of 0.6 feet (18.3 cm) and 0.8 feet (24.4 cm), respectively (ACS, 1983).

In the Alaska Beaufort Sea, storm surges are the most important sea level variation. Storm surges are a result of meteorological conditions (i.e., wind, pressure gradients, temperature) interacting with the physical elements of the water's surface (i.e.,

open water, fetch, density gradients, bathymetry, shoreline topography) creating wave, current, and water mass accumulations that can change sea level conditions by up to 10 feet (3 m). Storm surges most frequently occur in summer and fall when eastward moving storms cross the face of the Alaska Beaufort Sea coastline, and long stretches of open water are present (Exxon, 1979; MMS, 1987). A vertical rise in the water's surface will occur on those beach fronts impinged by the wave train, and a negative vertical change in the water's surface will occur on the lee side of large embayments and extended promontories. Negative surges (i.e., levels falling below mean sea level) occur primarily during December and January, and range to -5.2 feet (-1.6 m) (Norton and Sackinger, 1981). Extensive fracturing of shorefast ice is possible during such surge events (ACS, 1983).

Most historical records of severe storms are based upon either short-term sea level records or secondary observations. Observations of strandlines along the entire Alaska Beaufort Sea coastline tend to confirm extreme tidal surges of 3 to 10 feet (1 to 3 m) (Wiseman et al., 1973; Norton and Sackinger, 1981; Reimnitz and Maurer, 1979). A surge of 10 feet (3 m) at Barrow resulted during an October 3, 1963 storm when average winds of 42 knots (78 km/hr) and gusts to 65 knots (120 km/hr) were registered (Ostrom and Britch, 1981). As with all observed storm surges, beach and cliff erosion was most extreme on those beach faces exposed perpendicularly to the wave direction. The surge at Barter Island associated with this storm was recorded at 4.9 feet (1.5 m). Hindcasting for conditions at Prudhoe Bay suggest that the storm surge was 5.6 feet (1.7 m) with a maximum wave height at 16.4 feet (5.0 m) (Exxon, 1979).

A second storm of comparable intensity occurred September 14, 1970. Although winds were stronger, averaging 52 knots (96 km/hr), the storm surge may not have been as severe. However, wave height and wave periods were greater, resulting in inundation of low-lying tundra plain and delta areas as far as 3 miles (5 km) inland. A driftwood strandline remains to this day along the Alaska Beaufort Sea coastline as much as 11.2 feet (3.4 m) above normal sea level.

Barrier islands were entirely awash during the storm. By examination of stranded debris, Reimnitz and Maurer (1978) suggest the severity of the 1970 storm has not been equaled since at least 1889.

#### (4) SEA STATE

When winds blow over open water, the surface is stressed. Waves form at the air/sea interface and grow in size and strength as wind energy is transferred to the sea surface. The rate of wave growth and potential energy is determined by the length of wind fetch, wind speed, and wind duration. The height and length characteristics of the resulting waves depend upon the recent wave and water current history of the sea surface, and the local bathymetry (ACS, 1983).

The entire coastline of the Alaska Beaufort Sea is a low-wave energy environment. Waves generally approach the area from the northeast and east, and are limited to the open water season. The ice pack limits fetch even during this season. Because of the pack ice, significant wave heights are reduced by a factor of four from what would otherwise be expected in summer (MMS, 1984).

More than 50 percent of the time, nearshore waters in the eastern Alaska Beaufort Sea tend to be calm, with no significant surface wave phenomenon or direction. Long period ocean ground swells are the only discernible sea motion. During the remaining summer measurements, more than half of the recorded waves are less than 1.0-foot (0.3-m) in height. Along the entire coast, it is generally observed that 90 percent of expected wave heights will be 3 feet (1 m) or less. During storm-associated events, sea conditions and wave energies may be much higher and can significantly accelerate erosion of shorelines (ACS, 1983). However, wave heights greater than 18 feet (5.5 m) were not recorded in 2,570 observations by Brower et al. (1977).

#### (5) SEA ICE

Sea ice conditions in the eastern Alaska Beaufort Sea OCS Area can be characterized according to the following periods: break-up, open water, and freeze-up. These periods are described below; approximate timeframes for their occurrence are given in Table III-2.

a. <u>Breakup</u>: During May and June, increasing air temperatures and sunlight cause the usual 5.0 to 6.0 feet (1.5 to 2.0 m) of solid, landfast ice in the eastern Alaska Beaufort Sea to decay. As the ice decays, the number of brine channels increase and the strength of the ice decreases. Surface melting and freshwater inundation at the mouths of rivers add to the deterioration of the ice and make it increasingly susceptible to deformation, cracking, and movement. The increased absorption of short-wave radiation in water, as compared to snow or ice, causes accelerated melting in puddled areas. The ice thickness beneath these melt pools decreases more rapidly than the surrounding ice, in some cases causing strudel holes through the ice (Industry Task Group, 1983).

During the early stages of the breakup period, the sea surface generally is still covered with ice. If the sea remains relatively calm, thereby avoiding a massive physical breakup of the ice sheet, the surface may deteriorate to a very high percentage of water, ranging from inches to feet deep, over a relatively continuous layer of solid ice (Industry Task Group, 1983).

As the breakup period progresses, the ice will deteriorate until it is sufficiently rotten to break up under the influence of winds and currents. The ice cover will begin to shift, crack, and deteriorate into a field of ice cakes and brash ice [less than 65 feet (20 m) in diameter], combined with small to medium floes [65 to 1,600 feet (20 to 488 m)], big floes [greater than 1,600 feet (488 m)], and giant floes which can exceed 6 miles (10 km) in diameter. Giant floes will normally break up rapidly depending upon sea state conditions (Industry Task Group, 1983).

### TABLE III-2

# AVERAGE SEASONAL REGIMES IN ALASKAN SHOREFAST ICE1 (Barry, 1979)

ICE PHASE	CENTRAL ALASKA BEAUFORT SEA COAST <sup>2</sup>
New Ice Forms	3 October
First Continuous Fast Ice	Mid-October
Extension/Modification of Fast Ice	November to January/February
Stable Ice Sheet Inside 49-foot (15-m) Isobath	January/February to April/May
Rivers Flood the Fast Ice	25 May
First Melt Pools	10 June
First Openings and Movement	30 June
Nearshore Area Largely Free of Fast Ice	1 August

These dates are based on available LANDSAT imagery for 1973-77. Locally, the ice may not achieve any prolonged stability. Given data ± 7 to 10 days. 2

The ice cover typically will require only a couple of weeks to pass through the 7 oktas (87.5 percent) and 6 oktas (75 percent) coverage states. During this stage of breakup, many of the ice floes are still relatively large (i.e., medium to big) and the floes and ice cakes are generally touching each other (Industry Task Group, 1983).

During the final stage of the breakup period, which may last for only one to two weeks, ice floe sizes continue to decrease and the distance between floes increases. Rarely do floes exceed 1,600 feet (488 m) in size once the ice concentrations reach 3 oktas (37.5 percent) or less (Industry Task Group, 1983).

It should be noted that during breakup, ice concentrations frequently are heavier seaward of the barrier islands. At the same time, there are often open water areas nearshore and in the lee of the barrier islands (Industry Task Group, 1983).

b. Open Water: Once the average ice concentration reaches 2 oktas (25 percent) or less, the open water period commences. During this period, the waters of the eastern Alaska Beaufort Sea remain relatively free of ice except when northerly winds push pack ice into the area (Industry Task Group, 1983).

Studies from 1972 to 1980 in the Alaska Beaufort Sea show that after the first openings and ice movement in late June and early July, two things occur: first, the areas of open water with few ice floes expand along the coast and away from the shore; and second, there is a seaward migration of pack ice. By the middle of July, much of the lagoonal and open fast ice inside the 33-foot (10-m) isobath has melted, and there has been some movement of the ice. The concentration of ice floes generally increases seaward and, as the pack ice retreats, the width of the bands that define percentage of sea ice cover also increases (Stringer, 1978; 1982).

c. <u>Freeze-up</u>: By October, decreasing daylight and falling air temperatures generally signal the formation of ice in the nearshore and inshore/backwater areas (Industry Task Group, 1983).

The growth of sea ice begins at the surface with the formation of small ice crystals that are generally referred to as frazil. The initial frazil ice concentrations form a layer 0.4 to 4.0 inches (1.0 to 10.0 cm) thick under calm wind and wave conditions. Wind-driven frazil ice accumulations, however, may reach a thickness of 3 feet (1 m). When a continuous ice skim has formed across the sea surface, the downward growth of the ice sheet begins and there is an increase in the size and a change in the orientation of the ice crystals. This portion of the ice sheet is called the transition zone and it is usually about 2 to 4 inches (5 to 10 cm) thick (Weeks and Ackley, 1982).

The physical properties of sea ice are affected by its crystal structure and orientation, grain size, salinity/porosity, temperature, and strain rate (i.e., the rate at which the ice is deformed). On the basis of the dynamic behavior and the location of structural types, the sea ice regime in the eastern Alaska Beaufort Sea can be divided into the landfast ice zone, the stamukhi (or shear) zone, and the pack ice zone. The location of the zones varies spatially and temporally and is strongly influenced by bathymetry and the location of offshore islands and shoals (MMS, 1984).

The <u>landfast ice zone</u> extends from the shore out to the zone of grounded ridges which first form in about 26 to 49 feet (8 to 15 m) of water, but by late winter may extend beyond the 66-foot (20-m) isobath (Barry et al., 1979).

During the early part of freeze-up (i.e., October and November), the ice is thin, susceptible to displacement by only modest wind and water stresses, and easily deformed. Displacements of the ice sheets may be up to several kilometers per day. Deformations take the form of pileups and rideups on the coastal and island beaches and

rubble fields and small ridges offshore (MMS, 1987). Extensive deformation within the landfast ice zone generally decreases as the winter progresses. As the ice in the landfast zone thickens and strengthens, it becomes more resistant to deformation (Kovacs and Mellor, 1974).

By late winter, first-year sea ice in the Beaufort Sea land-fast ice zone is generally about 7 feet (2 m) thick, relatively stable, and undeformed. Out to a depth of about 7 feet (2 m), it is frozen to the bottom, forming the bottomfast ice subzone. The remaining ice in the landfast zone is floating, forming the floating fast ice zone (MMS, 1984). Movement of floating fast ice can occur on a large scale. The degree of movement appears to depend upon the effectivenes of the grounded ridges, which define the offshore boundary of the zone, in anchoring the ice sheet (MMS, 1984; Shapiro, 1981).

The onshore movement of sea ice in the landfast ice zone is a relatively common event (Weeks, 1981) that generates pile-ups and ride-ups along the coast and on barrier islands. These nearshore and onshore pile-ups frequently extend up to 66 feet (20 m) inland from the shoreline over both gently and sloping terrain and up onto steep coastal bluffs (Kovacs, 1982). The height of pile-ups along the eastern Alaska Beaufort Sea coastline is commonly less than 39 feet (12 m) (NRC, 1982) but may reach 82 feet (25 m) (Weeks, 1981). Shore ice ride-ups are a destructive phenomenon that push up and aside beach and tundra material and damage unprotected coastal facilities (Kovacs, 1982). Pile-ups and ride-ups may occur at any time of the year, but they are most frequent in fall and spring (MMS, 1984).

Seaward of the landfast ice zone is the <u>stamukhi</u>, <u>or shear</u>, <u>zone</u>. The boundary between these two zones occurs somewhere in the vicinity of the 66-foot (20-m) isobath from February 1 to June 15 (Weeks, 1987), but it is gradational and varies geographically, seasonally, and yearly. The stamukhi zone is a region of dynamic interaction between the relatively stable ice of the landfast ice zone and the mobile ice of the pack ice zone that results in the formation

of ridges and leads. In the eastern Alaska Beaufort Sea area, the region of most intense ridging occurs in waters that are 49 to 148 feet (15 to 45 m) deep (MMS, 1987; Barnes et al., 1983).

One of the characteristics of the stamukhi zone is that some portions of the ice are grounded on the seafloor. In fall when the winds begin to move the pack ice toward the coast, the multi-year floes impinge upon the first-year ice along the outer part of the landfast zone. This thinner, seasonal ice is broken and pushed into ridges. The pack ice continues to move until it is halted by the first-year ice or until the deep draft masses, such as multi-year ridges or ice island fragments, become firmly grounded. Grounded ice features become strong points which help to anchor the ice by obstructing movement (MMS, 1984).

The outer edge of the stamukhi zone appears to advance seaward during the ice season. The first-year and thinner multi-year ice on the seaward side of the grounded ice is broken and pushed into ridges. This action, plus the encroachment and potential grounding of deeper draft multi-year ridges and ice island fragments, extends seaward the width of the stamukhi zone (MMS, 1984).

Shoreward of the 197-foot (60-m) isobath, long linear depressions have been cut into the sediments of the Alaska Beaufort Sea Continental Shelf by the plowing action of drifting ridges and ice island fragments. The dominant orientation of these ice gouges in waters 33 to 164 feet (10 to 50 m) deep is within 20° of being parallel to the coast. In waters shallower than 33 feet (10 m) and deeper than 164 feet (50 m), individual gouge orientations may deviate from being parallel to the coast by as much as 50°. The highest density of gouges is found in the stamukhi zone in waters 66 to 131 feet (20 to 40 m) deep (Barnes et al., 1983). Dense gouging also occurs on the seaward side of shoals and bathymetric highs. Gouge density decreases shoreward and seaward of the stamukhi zone (MMS, 1984; MMS, 1987).

The pack ice zone lies seaward of the stamukhi zone and includes the following morphologically different sea ice types: first-year ice; multi-year floes, ridges, and floebergs; and ice islands. First-year ice forms in the fractures, leads, and polynyas (i.e., large areas of open water) within the pack ice zone, and can vary in thickness from an inch (2.5 cm) to over 3 feet (1 m). Multi-year ice is simply defined as ice that has survived one or more melt seasons. Ice islands are tabular icebergs that have calved (i.e., broken away) from a relict ice shelf on Ellesmere Island (MMS, 1984).

During winter, movement in the pack ice zone generally is small and tends to occur in discrete events associated with strong winds of several days duration (MMS, 1987). Wind-driven pack ice moves at a rate of about 2.5 percent of the wind velocity (i.e., estimated in summer pack ice conditions) (Pritchard and Stringer, 1981). The long-term direction of pack ice movement is from east to west in response to the Beaufort Sea gyre; however, there may be short-term perturbations from the general trend due to the passage of low and high pressure weather systems across the arctic. The velocity of pack ice movement has been variously reported as having a daily drift rate ranging from 0.9 to 4.6 miles (1.4 to 7.4 km) per day, with extreme events up to 20 miles (32 km) per day (MMS, 1984; MMS, 1987).

#### (6) STRUCTURAL ICING

The formation of ice on superstructures is a complex process that depends on sea conditions, atmospheric conditions, and ship size and behavior. Although ice can be caused by freezing rain and fog, freezing sea spray is the most common and dangerous form of icing. It can occur when the air temperature falls below the freezing temperature of sea water [usually about -2°C (28°F)] and when sea surface temperatures are -18°C (0°F), wind-induced spray may freeze before striking the ship and not adhere. The lower the temperature and the stronger the wind, the more rapidly ice accumulates. Freezing spray may deposit thick layers of ice in rigging or on deck areas, rapidly

increasing the vessel's weight, hampering steerability, and slowing ship speed. In extreme cases the excessive weight can lead to sinking (Brower et al., 1977).

In the Alaska Beaufort Sea, superstructure icing from spray usually is not a problem due to the presence of nearby ice cover limiting the fetch of wind over open water (NPC, 1981).

## (7) WATER QUALITY

Water quality of the eastern Alaska Beaufort Sea OCS Area is nearly pristine. Pollutants are introduced into the marine environment through many pathways, including river runoff, coastal erosion, natural hydrocarbon seeps, atmospheric deposition, and industrial and other human activities. The rivers which flow into the Alaska Beaufort Sea remain relatively unpolluted (MMS, 1984). A baseline monitoring program originated by the MMS in 1984 has not found any evidence of chemical contamination of sediments or benthic fauna (Boehm et al., 1985).

Satellite imagery and suspended particulate matter data suggest that, in general, turbidity is confined to depths within the 16-foot (5-m) isobath and does not extend seaward of the barrier islands. Water samples obtained in August 1978 from the Continental Shelf between Harrison Bay and the Canning River and seaward of the 66-foot (20-m) isobath had suspended sediment concentrations that ranged from 0.3 to 2.1 parts per million. The water samples for these measurements were taken at the surface and at various depths; at one of the stations a sample was in water which was 295 feet (90 m) deep (Naidu, 1979; MMS, 1984).

In mid-June through early July, the shallow inshore waters generally carry more suspended material because or river runoff causing very high turbidity adjacent to the river mouths (MMS, 1984).

Dissolved oxygen levels in the eastern Alaska Beaufort Sea OCS Area are usually high, about 8 milliliters of oxygen per liter (Hufford, 1974). During winter, respiration of oxygen continues, but atmospheric exchange and photosynthetic production of oxygen cease. Some oxygen is forced into underlying water by thickening of the ice. Areas with unrestricted circulation seldom drop below 6 milliliters of oxygen per liter. In areas of reduced circulation or high respiration, further depletion occurs. Schell (1975) found only 2 milliliters of oxygen per liter underneath the ice in the vicinity of the Colville River delta. Such areas sometimes turn anoxic before spring breakup.

Trace-metal concentrations in the eastern Alaska Beaufort Sea OCS Area are low and show no indication of pollution (see Table III-3). Existing water concentrations are one-to-three orders of magnitude lower than those required by federal salt water quality criteria.

A number of trace-metal concentration studies have been performed on coastal sediments. The most recent study (Boehm et al., 1987) reported trace metal concentrations and compared them to the results of studies by Naidu et al., 1982, Campbell and Loring, 1980, and Bowen, 1979. Table III-4 presents these results.

The three-year Boehm et al. (1987) study further noted that trace-metals in Beaufort Sea sediments show a wide range of concentrations. Levels of trace-metals are generally higher in fine-grained offshore sediments than they are in nearshore, shallow water, sandy sediments. Regional trends in the concentrations of barium and chromium in sediments appeared to be the result of local riverine inputs rather than shoreline erosion of peat deposits.

TABLE III-3

TRACE METAL CONCENTRATIONS IN THE BEAUFORT SEA (MMS, 1987; EPA, 1986; Boehm et al., 1985; Naidu, 1982; Nortec, 1981b; Naidu et al., 1980; Thomas, 1978; Naidu, 1974; Burrell et al., 1970; and Chester, 1965)

	Chromium	Mercury	SEDIN	SEDIMENTS (parts per million) Lead Zinc Cadmium Bari	ts per mil Cadmium	llion) Barium	Copper	Nickel	Vanadium
Nearshore, Lagoons, and Bays	52	0.02	ω	62	0.1	405	19	33	79
Shelf	85	0.07	3	86	0.2	1	57	47	140
Slope and Abyssal	66	1	1	8 2	!	1	59	99	192
Average World Coastal Ocean	100	1 0	20	5 to 200	0.2 to 3.0	750	48	5.5	130
0 1 1 3 a & & (C)	Chromium	SUSI	SUSPENDED Iry Lead	SEDIMENTS Zinc	(parts pe Cadmium	SEDIMENTS (parts per million) Zinc Cadmium Barium	Copper	Nickel	Vanadium
Lasor	21	1	1	ω	1	+	25	10	. 2
	to 140			to 232			to 83	100	307

TABLE III-3 (cont.)

	Chromium	Mercury	WATER Lead	(parts Zinc	WATER (parts per billion) ad Zinc Cadmium Ba	ion) Barium	Copper	Nickel	Vanadium
Total	0.10	1	!	0.4	1	1	0.4	1	10 <b>1</b>
	to 2.10			to 3.7	THE STREET		to 2.1		
Dissolved	0.02	0.010	0.02	0.2	0.02		0.3	1	1
	to 0.3	0.027	to 1.70	10 to	to 0.11		to 1.8		
EPA Dissolved Saltwater Criteria	20.00	0.025	2.60	86.0	9.30	None	2.9	7.1	None

TABLE III-4

RANGE OF TOTAL METAL CONCENTRATIONS IN ARCTIC COASTAL SEDIMENTS COMPARED TO AVERAGE CONTINENTAL CRUST (MMS, 1987) to the same as a second desired and

METALS <sup>1</sup>	BOEHM ET AL., 1987 <sup>2</sup>	NAIDU ET AL., 1982 (ug/g)	CAMPBELL AND LORING, 1980	BOWEN, 1979
Barium	185-745	A sylandber der 1-60- Tisag soll	of the Beautous bas to the choice	500
Cadmium	0.04-0.31	_	-	0.11
Chromium	17-91	82-97	16-139	100
Copper	4.9-37	0-61	4-42	50
Lead	3.9-20	-	4-42	14
Vanadium	33-153	25-275	47-156	. 160
Zinc	19-116	38-130	17-83	75

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early Detober to early December Wictio citics, least cisco,

tall, but tall fishing accounts for the greates

bry weight.
3-year means. and east channel of the Colville River adjacent to Mad

Background hydrocarbon concentrations also are low. They are on the order of 1 part per billion or less and appear to be biogenic. Both aliphatic and aromatic hydrocarbons occur in sediments of the eastern Alaska Beaufort Sea. The aliphatic hydrocarbons range between 13 to 41 parts per million and are mostly of recent biological origin. The aromatic hydrocarbons range between 8 and 16 parts per million and appear to be derived from nonindustrial, abiotic source materials (MMS, 1984). Although both peat and river sediments contribute to the hydrocarbon character of marine sediments, hydrocarbon composition of the Beaufort Sea sediments is more similar to the river sediments than to the shoreline peat deposits (Boehm et al., 1987).

### D. OTHER USES OF THE AREA

#### (1) COMMERCIAL FISHING

The only continuous commercial fishing operation in the Alaska Beaufort Sea is operated by a single family. the Helmerick's commercial fishery, there is fishing in both summer and fall, but fall fishing accounts for the greatest effort and yield. Fall fishing is done with gill nets set under the ice in the Kupigruak and east channel of the Colville River adjacent to Anachilik Island [approximately 115.4 miles (185.7 km) west of the Galahad Prospect] from early October to early December. Arctic cisco, least cisco, broad whitefish, and humpback whitefish are the primary fish species Arctic cisco is the most important commercial species: 20,000 to 70,000 of these have been caught annually since 1976 (Craig and Haldorson, 1981).

Table III-5 shows average annual catch statistics for each of the primary species from 1964 to 1984. It is estimated that about 9 percent of the Arctic ciscoes and 5 percent of the least ciscoes are commercially exploited each year (MMS, 1984; MMS, 1987; ADF&G, 1984).

TABLE III-5

AVERAGE ANNUAL CATCH STATISTICS
(1964-1984) FOR THE COLVILLE DELTA FISHERY
(MMS, 1984; MMS, 1987; ADF&G, 1984)

to the Marks of or	VII Budas Lada i	Echal Lador	momal unique (1h-)
SPECIES	NUMBER	PERCENT	TOTAL WEIGHT (1bs)
Arctic Cisco	30,615	55	30,615
Least Cisco	21,602	39	19,441
Broad Whitefish	2,183	Liberton 4	11,133
Humpback Whitefish	1,351	boto lea-muelo	to ide-free contas.

#### (2) SHIPPING

There are no deepwater ports along the Alaska Beaufort Sea coastline. Generally, ships must anchor from approximately 0.5 to 1.1 miles (0.8 to 1.8 km) offshore and cargo must be lightered ashore. Barges operated by Pacific Alaska Lines deliver approximately 2,000 tons (1,500 metric tons) of freight annually to the North Slope. Arctic Lighterage and Bowhead Transport provide supplemental barge service to North Slope communities out of Kotzebue. Cape Lisburne and the various Distant Early Warning System (DEW-line) sites on the North Slope are presently served by a contract carrier of the U.S. Air Force (Alaska Puget United Transportation Company). Deliveries are limited to ice-free months. Barges transport most heavy and bulk cargo associated with petroleum-related activities in the Borough (Maynard-Partch/Woodward Clyde Consultants, 1983). Prudhoe Bay has three barge docks -- one at the east dock and two at the west dock. The east dock can accommodate vessel drafts of 4 feet (1 m), and the west docks can accommodate vessel drafts of 6 to 10 feet (2 to 3 m). The end of the west dock has been expanded to accommodate deeper draft barges as part of the Prudhoe Bay Unit Waterflood Project (MMS, 1984).

Barge traffic in support of continued development on the North Slope of Alaska has ranged from a low of 2 barges in 1979 to a high of 26 in 1983 and 1986. Typically, 10 to 15 barges per year have been in the sealift (MMS, 1987).

Peak years of goods movement by the marine mode have been 1970 (187,000 tons), 1975 (153,000 tons), and 1983 (estimated to be 126,100 tons). These years correspond with the Prudhoe Bay Unit construction, Trans-Alaska Pipeline System (TAPS) construction, and the Prudhoe Bay Unit Waterflood Project, respectively. In comparison, 1981 sealift traffic to Prudhoe Bay was estimated to be 70,000 tons (MMS, 1984). The barge fleet goes no further east than ARCO's docks in Prudhoe Bay (CSA, 1981).

### (3) MILITARY USE

Two military-related activities have taken place in the vicinity of the Alaska Beaufort Sea. These are oil and gas exploration in the National Petroleum Reserve-Alaska (NPR-A) by the U.S. Navy and construction and maintenance of the Oliktok DEW station by the U.S. Air Force (LGL, 1983).

NPR-A (formerly Naval Petroleum Reserve 4) is no longer under Navy jurisdiction. Even when it was, there was no military activity in the usual sense. The Barter Island and Oliktok DEW stations are radar surveillance bases located well away from the proposed operations (LGL, 1983). Consequently, there is no potential for interference from military operations in the vicinity of the Galahad Prospect.

### (4) RECREATION

The recreational qualities offered by the eastern Alaska Beaufort Sea area include the seasonal changeability of the natural land/seascape, the solitude, the challenge of the environment, the special nature of the area, and the area's visual qualities. Native communities of Barrow, Nuigsut, and Kaktovik, and the adjacent land and ocean areas are visited most frequently by tourists because of their intrinsic cultural and recreational qualities and because they are accessible by air. Approximately 5,000 people come to Barrow each year and make excursions into remote areas. Excursions from Barrow and entry points at Nuigsut and Kaktovik involve: backpacking, cross-country skiing, float trips, observing wildlife, and other recreational activities. In addition, wilderness areas are used for the qualities they possess, including: remoteness, exceptional wildlife species, exceptional terrain, and other wilderness qualities that are not found in more populated areas. Near the Galahad Prospect, the Arctic National Wildlife Refuge is an area where a variety of controlled recreational interests, including wildlife observation, can be pursued (ADNR, 1976; 1983; MMS, 1987).

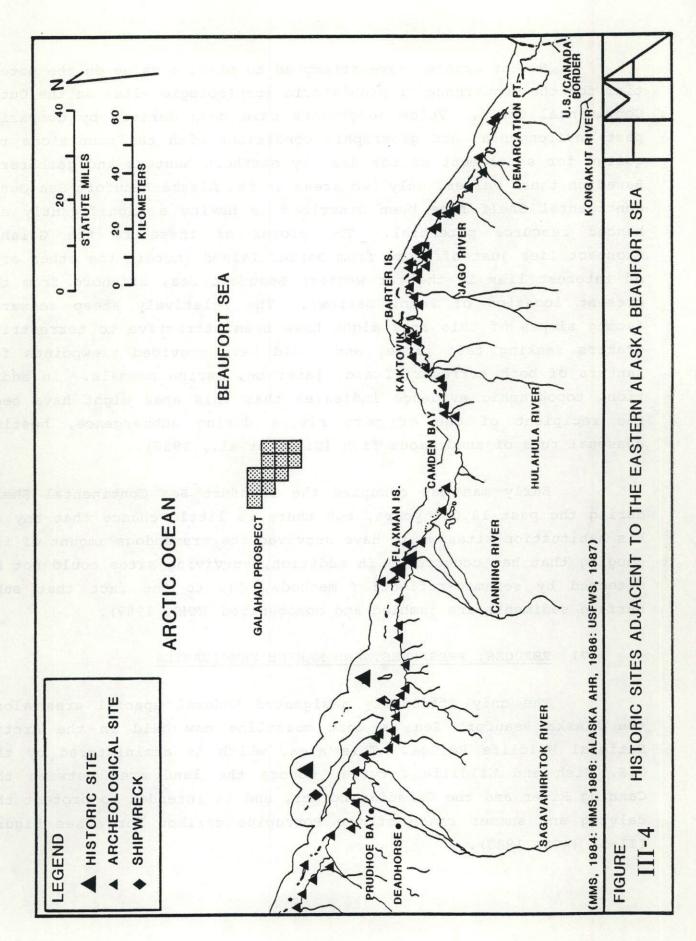
An Alaska Travelers Survey and Visitor Industry Analysis reported that of all surveyed visitors to Alaska, about 2 percent visited the Barrow and adjacent surrounding area. Therefore, of the approximate 645,960 visitors to Alaska from October 1982 to September 1983, a substantial number visited the area at least once (i.e., approximately 3,900). The report states that an average of 500 people in the Barrow-North Slope area were employed as a result of these visitors and that the visitors brought in about \$19.5 million in total wages to the area. According to recent figures, the trend from 1983 to the present has been toward \$25 million in tourist trade for the area (ADNR, 1983; MMS, 1987).

#### (5) MARICULTURE

No mariculture activities occur on or in the vicinity of the Galahad Prospect.

### (6) CULTURAL RESOURCES

A number of historic and archaeological sites have been identified in the vicinity of the Alaska Beaufort Sea; however, the significance of many of these sites has not been established. known sites whose significance has been assessed, two are registered National Historic Sites and three have been approved but are not yet entered in the National Register. The former are the Ernest de Koven Leffingwell's camp on Flaxman Island and the archaeological site at Birnirk near Barrow. The latter three are at Cross Island, Tigvariak Island, and Flaxman Island-Brownlow Point (ACS, 1983). In addition, there was a recent discovery of an Eskimo family preserved for about two or three centuries in their house on the eroding edge of the Beaufort Sea near Barrow (MMS, 1987). These historic sites (i.e., with the exception of Birnirk and the most recent discovery), potential natural landmarks, and known archaeological sites are identified in Figure III-4.

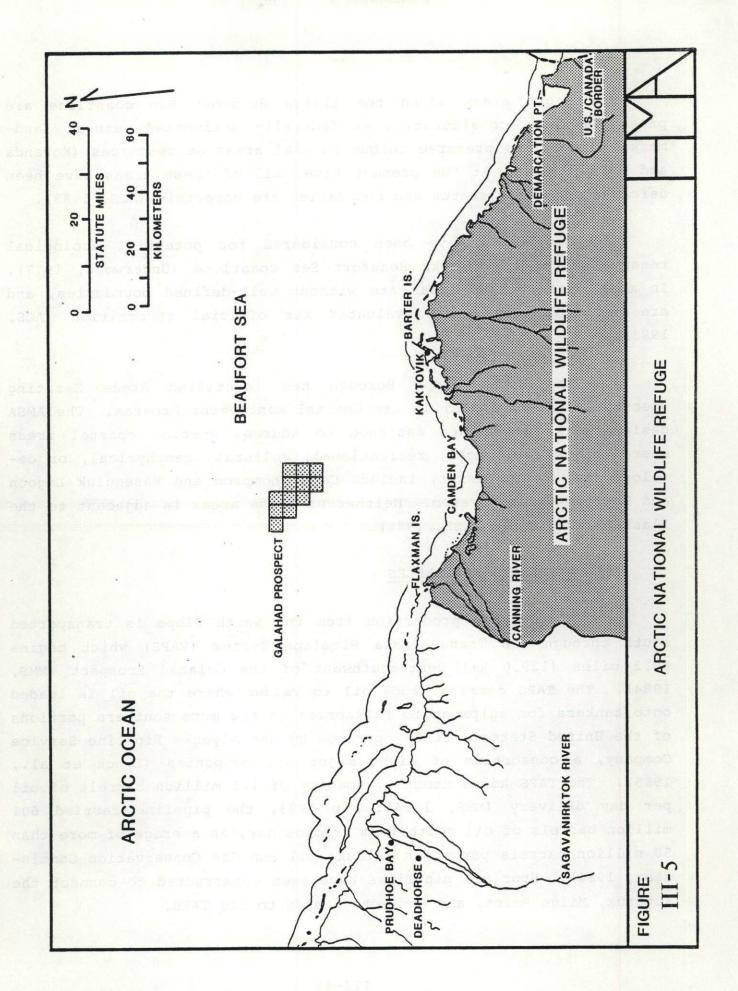


Recent studies have attempted to place a value on the potential for the occurrence of prehistoric archaeologic sites on the Outer Continental Shelf. Value judgements have been derived by comparing past environmental and geographic conditions with the conditions required for settlement of the area by northern hunters and gatherers. Based on these values, only two areas on the Alaska Beaufort Sea Outer Continental Shelf have been described as having a significantly enhanced resource potential. The closer of these to the Galahad Prospect lies just offshore from Barter Island (note: the other area of interest lies in the far western Beaufort Sea, offshore from the present location of Point Barrow). The relatively steep seawardfacing slopes of this area might have been attractive to terrestrial grazers seeking fall range, and would have provided viewpoints for hunters of both terrestrial and, later on, marine mammals. In addition, topographic evidence indicates that this area might have been the recipient of one or more rivers during submergence, hosting seasonal runs of anadromous fish (Dixon et al., 1986).

Early man has occupied the Beaufort Sea Continental Shelf during the past 18,000 years, but there is little chance that any of his habituation sites would have survived the tremendous amount of ice gouging that has occurred. In addition, surviving sites could not be detected by seismic-reflection methods, due to the fact that subsurface sediments are jumbled and homogenized (MMS, 1987).

# (7) REFUGES, PRESERVES, AND MARINE SANCTUARIES

The only officially designated Federal special area along the Alaska Beaufort Sea is that coastline now held in the Arctic National Wildlife Refuge. This area, which is administered by the U.S. Fish and Wildlife Service, covers the land area between the Canning River and the Canadian border, and is intended to protect the calving and summer range of the Porcupine caribou herd (see Figure III-5) (ACS, 1983).



Eight areas along the Alaska Beaufort Sea coastline are presently under consideration as federally designated natural landmarks intended to preserve unique natural areas or resources (Koranda and Evan, 1975). At the present time, all of these areas have been deferred and their status and boundaries are uncertain (ACS, 1983).

Ten areas have been considered for potential ecological reserves along the Alaska Beaufort Sea coastline (Underwood, 1977). In most cases, these areas are without well-defined boundaries, and are not presently being evaluated for official recognition (ACS, 1983).

The North Slope Borough has identified Areas Meriting Special Attention (AMSA) in its Coastal Management Program. The AMSA designations, which are designed to address special coastal areas where unique ecological, recreational, cultural, geophysical, or developmental values exist, include Cape Thompson and Kaseguluk Lagoon and Barrier Island System. Neither of these areas is adjacent to the Alaska Beaufort Sea (NSB, 1986).

### (8) PIPELINES AND CABLES

Hydrocarbon production from the North Slope is transported south through the Trans-Alaska Pipeline System (TAPS) which begins 80.2 miles (129.0 km) west-southwest of the Galahad Prospect (MMS, 1984). The TAPS carries crude oil to Valdez where the oil is loaded onto tankers for shipment to refineries in the more southern portions of the United States. It is operated by the Alyeska Pipeline Service Company, a consortium of eight major oil companies (Lynch et al., 1985). The TAPS has a nominal capacity of 1.5 million barrels of oil per day delivery (MMS, 1984). In 1983, the pipeline carried 601 million barrels of oil south from Prudhoe Bay, an average of more than 50 million barrels per month (Alaska Oil and Gas Conservation Commission, 1984). Spur oil pipelines have been constructed to connect the Kuparuk, Milne Point, and Endicott fields to the TAPS.

There are no pipelines or cables on or in the vicinity of the Galahad Prospect.

## (9) OTHER MINERAL RESOURCES

Gravel and sand resources are discussed in Part A.4.b. of this section.

#### (10) OCEAN DUMPING

There are no known military or domestic dumps or dumping activities taking place on or in the vicinity of the Galahad Prospect.

### (11) SUBSISTENCE USE

The Alaska Boards of Fisheries and Game has designated six fish and game resource management regions in Alaska to more easily monitor the great diversity in the nature and extent of subsistence uses across the state. The Galahad Prospect is within the Arctic Region. In addition, activities on the prospect may affect resources utilized in the other regions (USFWS, 1985). This section will summarize the activities which may be affected by the proposed exploration operations.

The Arctic Region is the site of eight traditional Inupiat villages. Three of these villages are situated along the Alaska Beaufort Sea coastline, within the North Slope Subregion. The closest of the villages to the Galahad Prospect is Kaktovik which is about 34.6 miles (55.6 km) east-southeast of the prospect.

a. <u>Kaktovik</u>: The village of Kaktovik began as a trading center for the nomadic Inupiat. Its establishment as a permanent community dates back to 1923. Kaktovik was incorporated as a fourth class city in 1971 and was reclassified as a second-class city in 1972 (BLM, 1979).

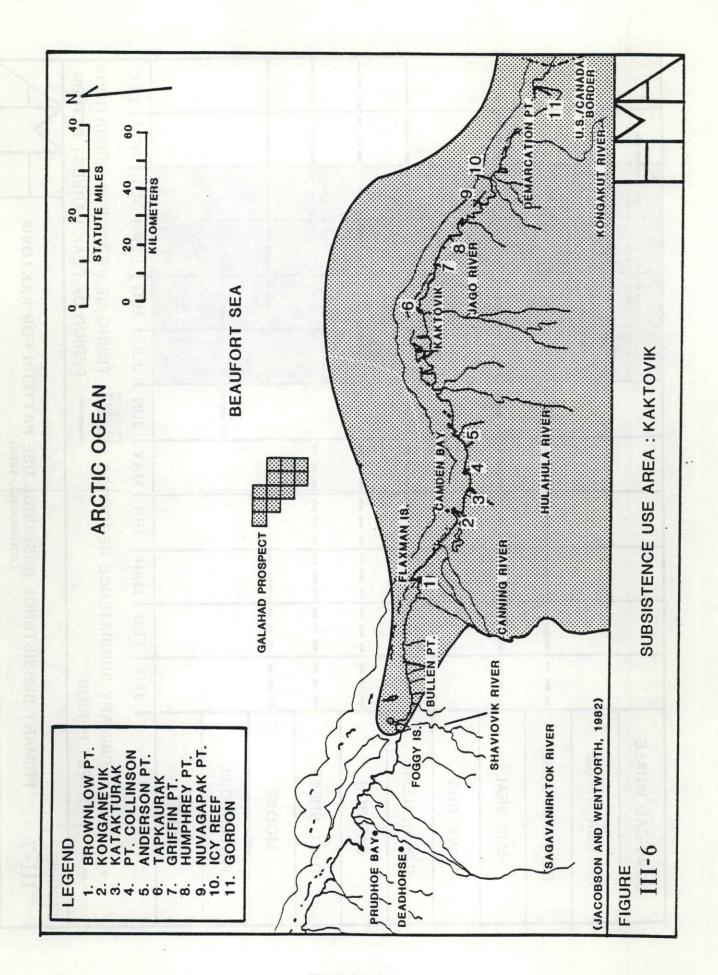
Kaktovik's present subsistence use area encompasses the northern part of the Arctic National Wildlife Refuge south to the headwaters of the Hulahula River in the Brooks Range (Jacobson and Wentworth, 1982). Kaktovik residents also utilize the coastal area west of the refuge to Flaxman Island and Bullen Point and occasionally to the Shaviovik River and Foggy Island (see Figure III-6).

Although subsistence activities go on throughout the year (see Figure III-7), subsistence travel can be broken down into two periods: the ice-free period and the ice period. During the ice-free period (i.e., early July through September), travel is done primarily by outboard-powered boat, and activities generally are confined to coastal areas from Foggy Island to Demarcation Bay. Boats also are taken a few miles up the main channel of the Canning River to a point where shallow water prevents further passage (Jacobson and Wentworth, 1982).

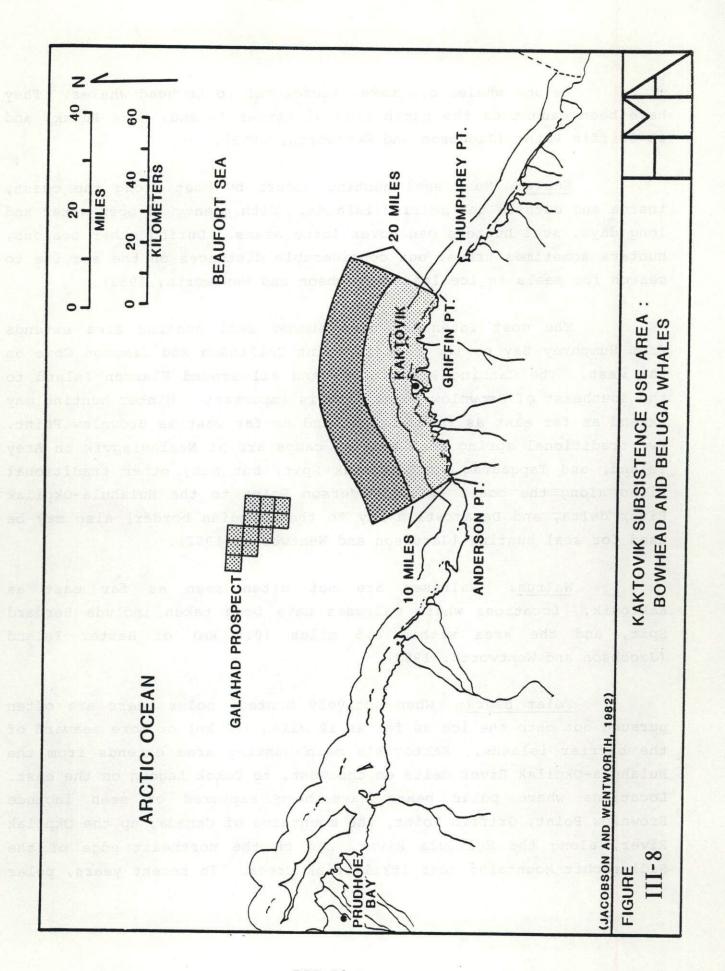
Ice and snow greatly expands the range of land used for subsistence. After freeze-up, from October through May, snow cover permits travel across the open tundra of the coastal plain and access to camps along the Sadlerochit and Hulahula River drainages (Jacobson and Wentworth, 1982).

Whales: Kaktovik's bowhead whaling season occurs during the westward migration of bowhead whales from Canada to the Bering Sea. Hunting activities generally occur within 10 miles (16 km) of the coastline, but sometimes happen as much as 20 miles (32 km) offshore (see Figure III-8) (Jacobson and Wentworth, 1982).

Crews normally go as far west as Anderson Point in Camden Bay and as far east as Griffin Point to look for whales. They may occasionally go as far east as Humphrey Point, but they try to stay closer to shore when they go this far. A consideration when whaling is not to go too far from Barter Island since a harvested whale must be towed back home (Jacobson and Wentworth, 1982).



											APR MAY JUN JUL AUG SEP OCT NOV DEC	DURCE TIMING OF PROPOSED OPERATIONS PERIOD OF PEAK HARVEST RETURN	RCE USE PATTERN FOR KAKTOVIK
BOWHEAD WHALE	BELUGA WHALE	BEARDED SEAL	HAIR SEAL	WALRUS	POLAR BEAR	CARIBOU	DALL SHEEP	MOOSE	WATERFOWL	FISH*	JAN FEB MAR AP	*. NOT A PRIMARY SUBSISTENCE RESOURCE HARVEST PERIOD	FIGURE III-7 PRIMARY SUBSISTENCE RESOURCE



Beluga whales are taken incidental to bowhead whales. They have been caught on the north side of Barter Island, near Pukak, and at Griffin Point (Jacobson and Wentworth, 1982).

Seals: Most seal hunting occurs by boat along the coast, inside and outside the barrier islands. With plenty of open water and long days, seal hunters can cover large areas. During other seasons, hunters sometimes travel out considerable distances on the sea ice to search for seals in ice leads (Jacobson and Wentworth, 1982).

The most intensely used summer seal hunting area extends from Humphrey Bay on the east to Point Collinson and Simpson Cove on the west. The Canning River delta and all around Flaxman Island to the southeast of Brownlow Point also is important. Winter hunting may extend as far east as Pokok Lagoon and as far west as Brownlow Point. Two traditional spring seal hunting camps are at Naalagiagvik on Arey Island, and Tapqauraq on Tapkaurak Spit, but many other traditional sites along the coast [e.g., Anderson Point to the Hulahula-Okpilak River delta, and Demarcation Bay to the Canadian border] also may be used for seal hunting (Jacobson and Wentworth, 1982).

Walrus: Walruses are not often seen as far east as Kaktovik. Locations where walruses have been taken include Bernard Spit, and the area within 0.5 miles (0.8 km) of Barter Island (Jacobson and Wentworth, 1982).

Polar Bears: When actively hunted, polar bears are often pursued out onto the ice as far as 10 miles (16 km) or more seaward of the barrier islands. Kaktovik's main hunting area extends from the Hulahula-Okpilak River delta on the west, to Pokok Lagoon on the east. Locations where polar bears have been captured or seen include Brownlow Point, Griffin Point, the mountains of Canada, up the Okpilak River, along the Hulahula River, and on the northeast edge of the Sadlerochit Mountains near Itkilyariak Creek. In recent years, polar

bears almost always have been taken in the vicinity of the village, occasionally within a few feet of a person's house (Jacobson and Wentworth, 1982).

Caribou: It has been estimated that Kaktovik's caribou hunting range covers approximately 7,600 square miles (19,684 sq km), and that the most intensely used areas cover approximately 2,900 square miles (7,511 sq km). The size of the most intensely used areas varies with caribou distribution and availability (Pederson and Coffing, 1985).

Caribou are hunted in coastal areas during summer. The area directly south of Barter Island and eastward to the Jago River delta is used intensely. The mainland southwest of Barter Island along Arey Lagoon also is quite important. Farther to the east, the coastal area from Tapkaurak Spit to Humphrey Bay is heavily used for caribou hunt-Within this area, Griffin Point is probably the most popular Tapkaurak Spit and Pukak also are popular places to camp. Present caribou hunting extends beyond Pukak to the Kogotpak River mouth and Nuvagapak Lagoon. People also may hunt caribou Demarcation Bay if very few caribou have been seen closer to Barter Island, or if they are on their way to or from visiting relatives in West of Barter Island, Anderson Point and Sanniqsaaluk are used as bases for caribou hunting. Although the entire coast is used, the area from Nataroarok Creek to the eastern shore of Camden Bay appears to be very important. Point Collinson in Camden Bay is another well used caribou hunting location (Jacobson and Wentworth, 1982).

In August, scattered groups of caribou often appear near the coast in the areas of Konganevik Point and the Canning River delta. These caribou probably belong to the Central Arctic herd. This has been a particularly important hunting area over the past few years, when relatively few caribou have been available. Almost everyone in Kaktovik hunts at Konganevik Point. Several people also hunt from Konganevik Point to the delta of the Canning River's main channel, up

the channel as far as it is navigable, and from this area up to Brownlow Point. While most of this hunting is in August, people hunt at Konganevik Point throughout the year, particularly in fall and winter (Jacobson and Wentworth, 1982).

Caribou tend to congregate on the sandbars and delta of the Canning River and nearby sandspits to avoid soggy tundra and mosquitoes. According to Kaktovik hunters, caribou often are present on Flaxman Island during spring and summer. Caribou are sometimes hunted there, as well as along the coast from Brownlow Point to beyond the Staines River and around Bullen Point. People have emphasized the importance of the whole delta area as caribou habitat (Jacobson and Wentworth, 1982).

In a study of the caribou harvest for the 1983-84 season, 78 percent of the harvest (i.e., 80 animals) took place at 9 sites near the coast. The harvest consisted of 2 males caught near Tiqutaaq on the Canning River Delta, 25 males and 15 females caught near Konganevik Point; 1 male and 4 females harvested near Point Collinson; 1 male harvested at a site just west of the Sadlerochit River mouth; 10 females harvested at 2 locations around Arey Lagoon; 5 males harvested near the Jago River mouth; 2 females harvested near Tapkauraq; and 15 males harvested near Griffin Point (Coffing and Pedersen, 1985).

Inland caribou hunting begins in late October, following the end of the subsistence whaling season. At this time, enough snow has accumulated to make the inland caribou hunting areas accessible by snowmachines. A few people may get an early start by taking their snowmachines over to the mainland in a boat, but most wait until the Kaktovik Lagoon is frozen before heading for the mountains. Most winter caribou hunting occurs along river valleys in the mountains. Occasionally, caribou are hunted on the coastal plain, especially at favored locations like Konganevik Point (Jacobson and Wentworth, 1982).

The Hulahula River's Second Fish Hole is one of the most intensely used areas for winter caribou hunting. Hunters radiate out from this winter camp in every direction, looking for animals. Many people hunt the Hulahula River drainage area between Second and First Fish Hole, and from Second Fish Hole upriver to Kolotuk Creek. The area between this stretch of the Hulahula River and the Sadlerochit River drainage also is intensively hunted. People normally hunt as far south as Katak and Karen Creeks, the Kekiktuk River, and along the north side of Lake Schrader, as far west as the upper Sadlerochit River the Fire Creek drainage, and as far north as the southern slopes of the Sadlerochit Mountains. They often camp along the Sadlerochit River, and hunt across the foothill country to the Hulahula River (Jacobson and Wentworth, 1982).

The Okpilak River drainage is another winter caribou hunting area, especially from as far south as the Hulahula River's First Fish Hole inland to Okpilak Lake. People hunt the Okpirourak Creek drainage, as well. They may travel from Barter Island and follow the Okpilak River or they may travel to the Okpilak River from Second Fish Hole, travelling in a northeasterly direction. The foothill area from Second Fish Hole to Kingak Hill near the Hulahula River, and across to the Okpilak River and Okpirourak Creek drainages is another important winter caribou hunting area (Jacobson and Wentworth, 1982).

Some winter caribou hunting is done on the Jago River drainage, as far inland as Marie Mountain. East of the Jago River, two important winter caribou hunting areas are the uplands between the Jago and John Rivers and south to Niguanak Ridge. Another widely noted winter caribou hunting area is Konganevik Point. People have emphasized that the area immediately west of the Staines River, from the coast to about 30 miles inland, is especially important winter caribou habitat (Jacobson and Wentworth, 1982).

In spring, caribou hunting continues in the Hulahula, Sadlerochit, Okpilak, and Jago River winter use areas. More hunting goes on across the coastal plain and in the foothills and mountain

valleys due to increased daylight and slightly warmer air temperatures. Hunting activities covering the most territory occur during this time of year. Occasional trips are made up the Okerokavik River and to the foothill country of the Aichilik River (Jacobson and Wentworth, 1982).

In late winter or early spring, people occasionally travel to the Canning River in the vicinity of Ignek Valley and Shublik Island to hunt caribou as far upriver as the Marsh Fork. They may travel via the north side of the Sadlerochit Mountains, or up the Sadlerochit River to Fire Creek and over to Ignek Valley. Formerly, they travelled to this area by dogteam up the Canning River from Flaxman Island or other coastal locations (Jacobson and Wentworth, 1982).

The 1983-84 caribou harvest study reported 22 percent of the harvest (i.e., 22 animals) occurring at 6 inland sites. Four of the sites were located relatively close to one another near the foothills region of the Hulahula River and Sadlerochit Springs area. The harvest in these sites consisted of 6 males caught in the area where the Kekiktuk River meets the Sadlerochit River; 2 caribou (sex unknown) harvested near Sadlerockit Springs; 4 males harvested at the head of Arctic Creek; and 4 females harvested at Second Fish Hole. The most easterly harvest site was located on the Aichilik River, where 5 females were harvested. The most westerly harvest location was situated on the Shaviovik River, over 100 miles (161 km) west of Kaktovik, where 1 female was harvested. Though this last area was to the west of the most intensely used areas, residents of Kaktovik have a Native Allotment near this site and have frequented the area over several years (Coffing and Pedersen, 1985).

<u>Dall Sheep</u>: The upper Hulahula River is by far the most intensely used hunting area for Dall sheep. Hunting activities occur from the entrance to the mountains near Second Fish Hole all the way up to the headwaters of the Hulahula River in an area called Kanich. The hunting area includes most of the tributary creeks. People also

hunt sheep in the Sadlerochit mountains beginning a few miles south of Sadlerochit Springs, along the Sadlerochit River in the Franklin Mountains, adjacent to the creeks along the eastern side of the Shublik Mountains and third Range, and near the Whistler Creek area at Neruokpuk Lakes. During recent years there has been increased hunting in the upper Okpilak, Jago, and Aichilik River drainages. Hunting on the Okpilak River begins at about Okpilak Lake, and on the Jago River drainage near Marie Mountain. At the Aichilik River, people begin hunting near First Fish Hole (Jacobson and Wentworth, 1982).

Moose: Moose are often taken in the Sadlerochit Valley, and in the foothills along Old Man Creek and the Okpilak and Okpirourak Rivers. They are more commonly seen along the Sadlerochit River, even at its mouth, than along the Hulahula River. Moose also are hunted along the Kekiktuk River and on the Sadlerochit side of Kikiktat Mountain. Moose often congregate in the Ignek, Ikiakpaurak and Ikiakpuk Valleys, and along the Canning River, between these valleys. Kaktovik hunters have seen several moose together there, at one time. People sometimes make hunting trips to this area in spring. They also take moose occasionally on the other side of the Canning River along the Kavik River and in the foothills near its headwaters (Jacobson and Wentworth, 1982).

Bears: According to Kaktovik hunters, the Sadlerochit River drainage has many grizzly bears. Bears have been taken near the Neruokpuk Lakes, in the hills near the Kekiktuk River, and in the Kongakut River valley. Also, "nuisance" bears have been shot in summer camps at Manning Point, at Second Fish Hole on the Hulahula River, and at a Canning River delta camp (Jacobson and Wentworth, 1982).

<u>Furbearers</u>: Small furbearers are hunted in the mountains and along the coast. The Arctic fox is trapped mainly along the coast and on the coastal plain. In recent years, most people have set their traps on Barter Island, the barrier islands, lagoon ice, and in the

coastal area between the Sadlerochit River and Griffin Point. Traplines are usually within 10 to 15 miles (16 to 24 km) of the coast, but Arctic fox sometimes are taken further inland. They have been taken at the Hulahula River's First Fish Hole and in the Sadlerochit Valley. Arctic fox have been seen as far inland as the headwaters of the Hulahula River (Jacobson and Wentworth, 1982).

Red and cross foxes are trapped mainly in the mountains, though occasionally they are caught on the coastal plain. Traps are set along the Hulahula River drainage from Kingak Hill in the foothills to Kanich in the headwaters. Old Man Creek drainage and the entire lowland area between the Hulahula and Sadlerochit Rivers, including the area around Neruokpuk Lakes, is good for fox trapping (Jacobson and Wentworth, 1982).

Most wolves and wolverines are trapped or shot in the foothills of the Brooks Range. The Hulahula, Sadlerochit and Okpilak River areas are most commonly hunted. The Canning River area is hunted less, but is regarded as a good area for wolves. A particularly favorable area for finding wolves in winter is between the Hulahula and Sadlerochit River drainages, and from Sadlerochit Springs on the north to Kikiktat Mountain and the Neruokpuk Lakes on the south. This terrain is characterized by gentle slopes and open country where one can see long distances, yet it is protected from the strong winds of the coastal plain by the Sadlerochit Mountains. Wolves and wolverines are often first seen low in drainage areas where willows occur, since this is where their prey is found. Wolves also are encountered in the upper Hulahula River area during fall when people enter the mountains to hunt sheep. Occasionally, wolves are trapped along the coast (Jacobson and Wentworth, 1982).

Hunting for Arctic ground squirrel may take place anywhere, but usually is done along the banks and sandy mounds of the major rivers, especially the Jago, Okpilak, Hulahula and Sadlerochit Rivers. Hunting often is best in the river deltas and in the lower reaches of the rivers, within 5 to 15 miles (8 to 24 km) of the coast. Two of

the most intensely used areas are the Jago and Hulahula-Okpilak River deltas, from the coast to several miles upstream. People also hunt the entire drainages of the Jago and the Okpilak Rivers, up to their sources (Jacobson and Wentworth, 1982).

The Sadlerochit River for several miles around Sadlerochit Springs is another area where many people hunt ground squirrels. Nearly the entire Sadlerochit River drainage is hunted, up to and including the Kekiktuk River tributary over to Neruokpuk Lakes, but the Sadlerochit Springs area up to 10 miles (16 km) north of the springs seems to be most heavily hunted. People also hunt ground squirrels along the Hulahula River from the coast up to Second Fish Hole where the mountains begin, and along the Old Man and Old Woman Creek tributaries near Second Fish Hole. Hunting is especially intense in the vicinities of First and Second Fish Hole (Jacobson and Wentworth, 1982).

The banks and lowland areas around the Neruokpuk Lakes are good places for ground squirrel hunting, as are the lowlands between Neruokpuk Lakes and the upper Sadlerochit River south of Okiotak Peak. East of the Jago River, people may hunt squirrels in fairly large areas covering most of the Niguanak and Sikrelurak River drainages, including the Niguanak Hills. Occasionally, they may hunt them along the Aichilik and Egaksrak Rivers. Formerly, they hunted them on the Kongakut River, especially in the area where the river makes the big bend as it emerges from the mountains (Jacobson and Wentworth, 1982).

West of the Sadlerochit River, some squirrel hunting is done near the mouths of Marsh and Carter Creeks, from Camden Bay to 4 or 5 miles (6 to 8 km) inland. On the Canning River, squirrels may be hunted in conjunction with spring fishing trips, up near the warm springs close to Ignek and Nanook Creeks and several miles further inland. In summer, they may be hunted in the large mound areas of the Canning River delta, near the main channel (Jacobson and Wentworth, 1982).

Birds: Waterfowl and coastal birds are a subsistence resource that has been growing in importance since the mid-1960's. The most important of these birds at Kaktovik are black brants, oldsquaws, eiders, snow geese, Canada geese, and pintail ducks, although other birds, such as loons, may be occasionally harvested. Waterfowl hunting occurs mostly in spring, from May through early July. However, less intensive harvesting continues throughout summer and into September. During spring, birds are hunted by groups that camp along the ocean's coast; spits and points of land often provide the best hunting locations. In summer and early fall, bird hunting occurs as an adjunct to other subsistence activities, such as checking nets (MMS, 1987).

One very popular place to hunt waterfowl in spring is Point Collinson. The campsite is just at the base of the spit, west of Marsh Creek and on the shores of Simpson Cove. People hunt in a wide area around the spit and coastline. Sometimes, families camp at Anderson Point on the eastern shore of Camden Bay, and hunt waterfowl in nearby coastal areas. On the opposite, western side of Camden Bay, Konganevik Point and the small bay directly to the south are known as good hunting sites for brant (Jacobson and Wentworth, 1982).

Griffin Point, located 25 miles (40 km) east of Barter Island, is another popular waterfowl hunting camp where several families go each year. While camping there, they hunt Oruktalik Lagoon up to Tapkaurak Point and all around the narrow spit and coastline from Griffin Point to Pokok Lagoon (Jacobson and Wentworth, 1982).

Close to Barter Island, the most commonly used hunting site during recent years has been the south end of Manning Point spit, about 4 miles (6 km) from Kaktovik. If birds pass further out from the mainland, Naalagiagvik on Arey Island is a popular camping spot. The lakes southwest of Barter Island also are hunted, and sometimes

waterfowl hunting camps are set up along the banks of the Okpilak and Hulahula Rivers just south of the delta (Jacobson and Wentworth, 1982).

Stays at camps close to Barter Island tend to be of shorter duration, with more frequent travel to and from Kaktovik. Some people make day trips to the western or southern sides of Barter Island or to Bernard Spit when ducks and geese are present, and may go as far as the lakes south of the Jago River delta. Later in summer, after the sea ice goes out, waterfowl may be hunted by boat in Arey, Kaktovik, and Jago Lagoons (Jacobson and Wentworth, 1982).

Although the sites and areas just detailed are those most commonly used for waterfowl hunting, people may hunt ducks and geese along the entire coastline from Flaxman Island to Demarcation Bay. Travel to the more distant areas usually is done by boat in July after the ice goes out, and often is done in combination with fishing or caribou hunting. Flaxman Island is occasionally hunted and is remembered for brant and eider by those who used to live there. fall, geese usually are hunted in the lake system south of Tamayariak River. During summer, some people hunt waterfowl Humphrey Bay and Angun Lagoon and on the seaward side of these spits. Good waterfowl hunting areas occur at Beaufort Lagoon from Angun Point to Nuvagapak Lagoon, and Siku Lagoon from Siku Entrance to the eastern mouth of the Kongakut River. Ducks and geese are taken in Demarcation Bay and outside Demarcation spit to the Canadian border, as well (Jacobson and Wentworth, 1982).

Ptarmigan are hunted throughout Kaktovik's subsistence use area. Although ptarmigan may be hunted year-round, most are taken in spring when many villagers travel inland to the mountains. At this time, ptarmigan are abundant in the foothills and mountain valleys along the rivers and streams where willow grow. Concentrations of several hundred (sometimes thousands) of ptarmigan are not uncommon. The majority of birds occurring in these areas are willow ptarmigan. The last trips to the mountains during spring often are made to get

Arctic ground squirrels and ptarmigan. During spring and summer, many ptarmigan also may be taken along the coast. Most of these birds are rock ptarmigan (Jacobson and Wentworth, 1982).

A favorite area for ptarmigan hunting is the Sadlerochit River from about 5 miles (8 km) north of Sadlerochit Spring to Fire Creek. Tributaries of the Sadlerochit River, such as Last Creek and Arctic Creek, are heavily hunted, as is the Kekiktuk River and its tributaries including Karen Creek. The Canning River is hunted less commonly but is well known as an excellent area for ptarmigan, especially upriver from Ignek Creek (Jacobson and Wentworth, 1982).

Summer subsistence fishing occurs on the barrier islands, in nearshore waters, and in coastal areas. People usually set gill nets, although rods and reels sometimes are used near Kaktovik and at the fish camps. People presently fish as far west as Foggy Island and as far east as Demarcation Bay. They set up fish camps at places such as Koganak Inaat, Brownlow Point, Collinson Point, and Griffin Point. During summer, fishing activity is concentrated off the coast and around the spits of Barter Island, all around Bernard Spit and Arey Island, and in Oruktalik Lagoon off Griffin This area is very good for Arctic char and Arctic cisco. popular summer fishing camp is Griffin Point, where people dry large quantities of fish for winter use. They fish on Tapkaurak Island, in Oruktalik and Pokok Lagoons, and on either side of the long and narrow barrier islands which form Angun Lagoon (Jacobson and Wentworth, 1982).

West of Barter Island, Point Collinson in Camden Bay and the eastern part of Camden Bay near Anderson Point are other summer fishing places for Arctic char and Arctic cisco. The little river between Point Collinson and Anderson Point, called Carter Creek, is known for its Arctic cisco and Arctic char (NSB, 1980).

The Canning River drainage is known for its variety of fish, being the only river in the Arctic National Wildlife Refuge where people from Kaktovik find broad whitefish. The place most often used is the main channel of the Canning River from near the mouth to about 10 to 15 miles (16 to 24 km) upriver. This stretch of river is especially noted for its grayling in early fall, and broad whitefish in summer. The latter also are caught in the largest lake south of the main channel (i.e., between the main channel and the Tamayariak River), in the Tamayariak River, and the system of small lakes to the south. People catch Arctic cisco in this area, as well (Jacobson and Wentworth, 1982).

Brownlow Point at the northern tip of the Canning River delta is another important fishing area. Nets are set in the ocean north-northwest of the point, and in the lagoon inside the spit, just to the east of the point. Arctic cisco is the main species taken, Arctic flounder and sculpin occasionally are followed by char. caught, as well. Summer fishing for char also occurs along the coast southeast of Brownlow Point, as far as the main mouth of the Canning Summer fishing for char and Arctic cisco takes place in several places off Flaxman Island. People have noted the inland sides of both the eastern and western ends of the island, especially the area west of the Panningona cabin and Leffingwell historic site as good fishing areas. Moving further west, Kaktovik residents sometimes fish for char and Arctic cisco in the vicinity of Point Hopson, Point Gordon, and Bullen Point. The large triangular shaped bay between Point Gordon and Bullen Point, and the river emptying into it, are known for good summer fishing. Some families may travel to the Shaviovik River delta and as far as Foggy Island for summer fishing, camping at traditional sites such as Koganak Inaat and Ekoolook Inaat. At the Shaviovik River delta they fish for char, Arctic cisco, and least cisco (Jacobson and Wentworth, 1982).

In 1985, average sizes of fish caught during summer were 19 inches (48.2 cm) for Arctic char and 15 inches (38.7 cm) for Arctic cisco (Cannon and Hachmeister, 1986). Tagging studies have shown that

the char caught at Kaktovik came from streams between the Sagavanirktok and Firth Rivers, and that Arctic cisco are caught while they are migrating to or from the Mackenzie River (Craig, 1987).

After freeze-up and all through the snow season, people travel inland up the Hulahula and other rivers, where they fish through holes in the ice. They camp near the deep pools and open water springs where the fish overwinter. In springtime, they fish through the ice of the Neruokpuk and Okpilak Lakes in the Brooks Range. Presently, winter fishing may take place as far west as the Canning River and as far east as the Kongakut River. The Hulahula River is by far the most important winter fishing river to Kaktovik residents. After freeze-up, people travel to First and Second Fish Holes where they set up camp. Almost everybody in the village fishes at one or both of these locations during the year. When travel conditions permit, most people also go up to Katak or Third Fish Hole, beyond Kolotuk Creek. They catch Arctic char and some grayling at First and Second Fish Holes, and char at Katak. The area around First Fish Hole is particularly good for char in fall, from about 5 miles (8 km) north of the camp to 2 miles (3 km) south. At Second Fish Hole, overflows often make for good fishing (Jacobson and Wentworth, 1982).

The Sadlerochit and Okpilak Rivers are much less important for snow season fishing than the Hulahula River, but they both contain grayling. One fishing place for grayling is the area downriver from Sadlerochit Springs, where the water stays open much of the year. Grayling also are caught in Okpilak Lake and the other lakes to the north. Neruokpuk Lakes is where people go if they want to catch lake trout (Jacobson and Wentworth, 1982).

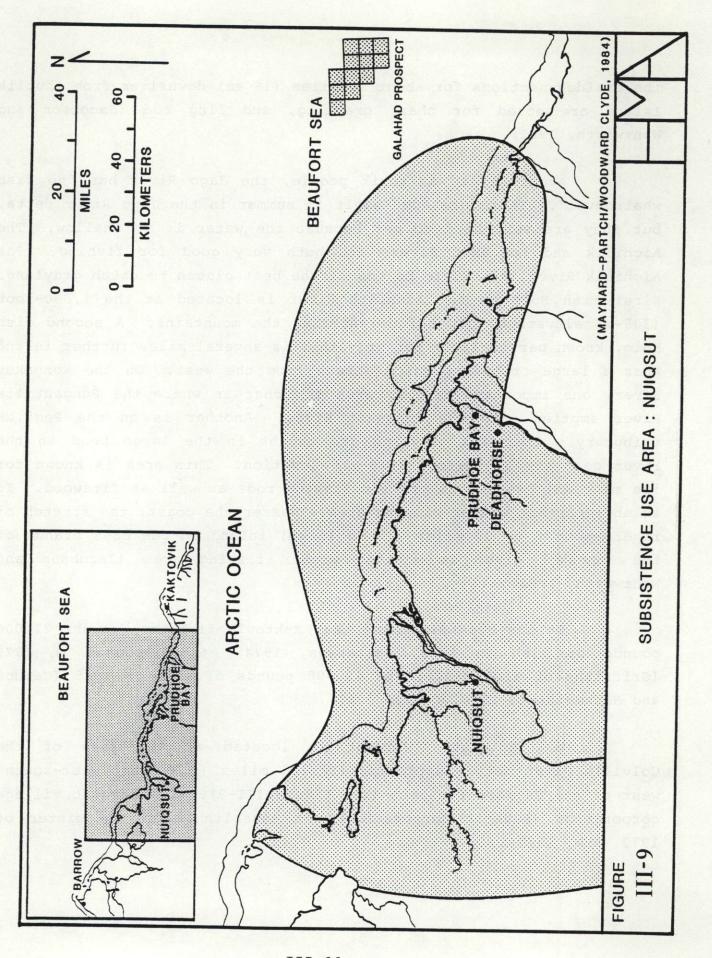
The Canning River drainage provides winter as well as summer fishing, inland from the delta. Important areas occur along the braided sections of the river and at the warm springs near Ignek and Nanook Creeks. There are many fish holes in the braided sections south of the Staines River's confluence with the Canning River. Also,

the braided sections for about 10 miles (16 km) downriver from Shublik Island are noted for char, grayling, and ling cod (Jacobson and Wentworth, 1982).

According to Kaktovik people, the Jago River has "no fish whatsoever". There are some smelt in summer in the Jago River delta, but they are very hard to get because the water is so shallow. Aichilik and Kongakut Rivers are both very good for fishing. Aichilik River is said to be one of the best places to catch grayling. First Fish Hole on the Aichilik River is located at the 1,000-foot (305-m) elevation just before entering the mountains. A second fish hole, known particularly for grayling, is several miles further inland near a large tributary which enters from the west. On the Kongakut River, one important fishing area for char is where the Pungautilik River empties into the Kongakut River. Another is on the Pagilak tributary. Char and grayling are caught in the large bend in the river near the 2,000-foot (610-m) elevation. This area is known for its many willows, which provide fishing rods as well as firewood. is an important winter camping area. Nearer the coast, the stretch of river about 6 to 10 miles (10 to 16 km) inland on the east branch of the Kongakut River is another winter fishing area (Jacobson and Wentworth, 1982).

It has been estimated that Kaktovik fishermen caught 21,000 pounds of fish in 1973 (Patterson, 1974); 6,500 pounds in 1975 (Griffiths et al., 1977); and 12,700 pounds of fish in 1985 (Cannon and Hachmeister, 1986; Craig, 1987).

b. <u>Nuiqsut</u>: Nuiqsut is located at the base of the Colville River delta, approximately 135 miles (217.2 km) west-southwest of the Galahad Prospect (see Figure III-9). The Nuiqsut village corporation (Kuukpik Corporation) was established in the winter of 1972 (BLM, 1979).



III-66

Nuiqsut's location on the Colville River delta gives the residents an opportunity to utilize marine mammal resources from the Beaufort Sea, as well as terrestrial mammal and fish resources from the inland and riverine environments of the tributaries of the lower Colville River and delta area (MMS, 1984).

Nuiqsut residents prefer to travel to the west and north of the village to hunt. They consider the quality of game to the east to be low due to oil development activities; however, hunters have been observed to have success in the east. People hunt south of the village but do not talk about hunting there as much as they do about hunting to the west. There may be a disparity between the verbal description of and the actual areas used for hunting (MMS, 1984).

The general area of subsistence use activities for Nuiqsut extends from the village east to the Sagavanirktok River, south to the middle Colville River, west to Teshekpuk Lake, and along the coast from Pitt Point to the mouth of the Canning River (see Figure III-9). Hunters also join Barrow residents for marine mammal hunting and occasionally go to Kaktovik and Wainwright (Maynard-Partch/Woodward-Clyde, 1984).

The annual subsistence use cycle for hunters in Nuiqsut (see Figure III-10) demonstrates the importance of caribou as the single most available food source (Libbey et al., 1979). They are within range of the village throughout the year, and are the only subsistence resource taken year-round (MMS, 1984).

Nuiqsut residents also rely for subsistence on moose and fish as well as endangered bowhead whales. As in other villages, polar bear and Arctic fox are secondary subsistence species but are still important for the furs they provide for clothing (ACI/Braund, 1984).

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BOWHEAD WHALE	BELUGA WHALE*	BEARDED SEAL (LISTED WITH HAIR SEALS)	HAIR SEAL	WALRUS*	POLAR BEAR*	CARIBOU	DALL SHEEP*	MOOSE	WATERFOWL	FISH	P. 10	* NOT A PRIMARY 8	FIGURE III-10 PRIMARY

Caribou: In Nuiqsut, caribou are the most heavily harvested subsistence resource (Hoffman et al., 1978; Underwood et al., 1982; Brown, 1979; Nelson, 1979; Pederson, 1979). Approximately 400 caribou are taken per year (ACI/Braund, 1984). Caribou are hunted before the snow melts in conjunction with snowmobile trips to see relatives and friends in Kaktovik, Barrow, or at even more distant locations. The most important location for caribou hunting is Fish Creek, on the Colville River, though caribou are often found over a much larger area (MMS, 1984). However, predicting where concentrations of caribou will be is not always possible, since migration patterns vary from year to year (Pederson, 1979; Nielson, 1977).

Whales: Nuiqsut has been whaling as an independent community since 1973. It has been estimated that an average of 5,886 pounds of whale meat is harvested per year.

No spring whaling is done near Nuiqsut; however, spring whaling on the coast does draw some Nuiqsut residents to Barrow to participate as crew members or whaling captains. Fall whaling does occur from Nuiqsut, along the coast as far east as the Canning River (Maynard-Partch/Woodward-Clyde, 1984). Flaxman Island is the most heavily used site for whaling (MMS, 1984).

Fish and Other Resources: Aside from caribou and whales, Nuiqsut harvests a considerable amount of fish, though statistics as to poundage are not available (ACI/Braund, 1984). They also are known to take moose, beluga whale, and spotted seal (Hoffman et al., 1977), though no estimates or harvest statistics are available (ACI/Braund, 1984).

Fishing, both with nets and hook and line, takes place in all of the lower Colville River tributaries (MMS, 1984). Permanent fish camp locations on these inland rivers have been documented from the early twentieth century to the contemporary period (Brown, 1979). Ice fishing occurs in and around the village area. Jigging for grayling and burbot is a common activity for the women and children.

Whitefish are taken in nets in the Colville River when the water clears after the breakup period. Further up the Colville River, fishing is done at Fish Creek. Char and salmon also are caught as they run upriver. Fishing for cisco and whitefish occurs in coastal areas, the Colville River, and Fish Creek (Maynard-Partch/Woodward-Clyde, 1984).

Seals, ducks, and sometimes polar bears are taken while whaling. Other independent marine mammal hunting includes seal hunting near the Colville River delta and on the sea ice after open leads appear (Maynard-Partch/Woodward-Clyde, 1984).

Small furbearers are hunted in the foothills of the Brooks Range and on the coastal plain. Children set traps for ground squirrels. Waterfowl and moose also are hunted for subsistence. Waterfowl appear in the area of Fish Creek while Nuiqsut residents are fishing, and are taken until fall. Moose have recently moved into the Nuiqsut subsistence use area and are becoming an important resource, especially during times of restricted hunting of caribou. They are taken along the middle Colville River. Moose also congregate near Umiat during winter, but snowmachine travel is difficult at that time (Maynard-Partch/Woodward-Clyde, 1984).

c. <u>Barrow</u>: Barrow is located at the western edge of the Alaska Beaufort Sea. The City of Barrow was incorporated June 8, 1959, and became a first-class city on April 30, 1974 (BLM, 1979). Bowhead whale, ugruk (bearded seal), caribou, ducks, geese, and freshwater and ocean fish are primary resources and the focus of subsistence efforts in Barrow (ACI/Braund, 1984). Barrow has the longest tradition of whaling. Between 15 and 40 crews participate in the spring hunt, when skin boats are used. Barrow crews use aluminum boats and motors during fall whaling, but ice conditions close to Barrow and the skinboat traditions of the past are two factors which have so far discouraged Barrow whalers from accepting these newer boats for spring whaling (MMS, 1984).

d. Relative Importance of Resources: Alaska Consultants Inc./Braund (1984) has conducted extensive surveys in the North Slope villages. Table III-6 summarizes some of the results of this work. According to the surveys, caribou is the most important resource in terms of time and effort spent hunting, quantity of meat hunted, and quantity eaten. However, bowhead whale is the favorite meat of the majority of respondents (although in Nuiqsut and Kaktovik caribou is the favorite). The endangered bowhead whale also is the most important subsistence resource in terms of sharing and community cooperation, which are the foundations of the sociocultural system (ACI/Braund, 1984).

Because of its importance in the community structure, whaling is considered the single most valued activity in the North Slope Subregion's subsistence economy. Whaling traditions include kinship-based crews, shoreline preparation for and distribution of the hunt, total community participation and sharing, and often, the use of skin boats. In spite of rising cash incomes, these traditions remain as central values and activities for all the Inupiat in these villages, but especially for those who actively whale (ACI/Braund, 1984).

The villages of Wainwright, Nuiqsut, and Kaktovik regularly share bowhead whale meat with residents of Barrow (ACI/Braund, 1984). Arctic Slope area residents also share whale meat with relatives in Fairbanks, Anchorage, Juneau, and other communities. The sharing of bowhead whale meat is a common part of such occasions as Thanksgiving, Christmas, Nulukataq (blanket toss), other whaling feasts, birthdays, carnivals, and other holidays. All these occasions strengthen family and village ties and the sense of a common Eskimo heritage, culture, and way of life. As such they provide strength, purpose, and unity in the face of rapid change (MMS, 1984).

Outside of the Arctic Region, there is some subsistence use of wildlife which spend part of their life cycle in the North Slope Subregion. The species include: the beluga whale, the sea lion, ducks, and other types of waterfowl. Trading also occurs between

TABLE III-6

1981 SURVEY OF SUBSISTENCE USE PATTERNS OF BEAUFORT SEA REGION WHALING VILLAGES (ACI/Braund, 1984)

		Barrow	(5)		Nuigsut			Kaktovik	
	% of Meat Hunted	% of Meat % of Meat % of Meat Hunted Harvested Eaten	% of Meat Eaten	% of Meat Hunted	% of Meat Harvested	% of Meat Eaten	% of Meat Hunted	% of Meat % of Meat Harvested Eaten	% of Meat Eaten
Caribou	33.8	64.2	71.4	76.7	75.9	93.4	50.0	30.8	44.0
Walrus	5.6	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bowhead Whale	26.8	10.4	8.6	0.0	0.0	0.0	15.4	34.6	40.0
Fish	24.0	14.9	0.0	16.7	20.7	0.0	19.2	23.1	8.0
Seal	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.2	1.5	1.4	0.0	3.4	0.0	0.0	0.0	0.0
Same Birds	1.4	3.0	17.2	3,3	0.0	3,3	7.7	11.5	4.0
Other	2.8	1.5	1.4	3.3	0.0	3.3	7.7	0.0	4.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(Number of Respondents)	(71)	(29)	(10)	(30)	(29)	(30)	(26)	(26)	(25)

coastal and inland communities for some of these species. However, reliance on these marine species for subsistence purposes is not as heavy in these areas as it is in the North Slope Subregion, or the Arctic Region in general (USFWS, 1985).

## E. FLORA AND FAUNA

# (1) PELAGIC ENVIRONMENT

a. Phytoplankton: Ninety-four species and eighteen additional taxonomic categories (i.e., unidentified species and groups of species) of phytoplankton have been identified in the Beaufort Sea (MMS, 1987). The abundance and composition of phytoplankton communities in the eastern Alaska Beaufort Sea OCS Area are influenced, both seasonally and spatially, by the physical environmental extremes found in the area. For example, nearshore areas in summer generally contain rich phytoplankton communities due to a high nutrient load. However, in nearshore areas near the mouths of major rivers, attenuation of light resulting from heavy sedimentation may limit phytoplankton production. Further offshore, phytoplankton populations are limited by the continuous or intermittent ice cover that inhibits light penetration and by water column stratification which may inhibit upwelling of nutrients into the photic zone (MMS, 1984).

In general, nearshore communities are dominated by both pennate and centric diatoms, and flagellates (Bursa, 1963; Horner, 1969; Horner, 1972). Diatoms appear to favor nearshore areas, probably due to the lower light intensities and higher nutrient concentrations found in the nearshore areas (MMS, 1984). Flagellates appear to be more abundant in offshore areas, probably due to their tolerance to higher light intensities and lower nutrient levels (Hsiao, 1976).

Abundance of phytoplankton appears to be greatest in near-shore waters with decreasing numbers moving further offshore. Observations of vertical distribution of phytoplankton vary; however, most reports show that phytoplankton abundance is greatest in water

depths of less than 16 feet (5 m) (Alexander, 1974). Conversely, Horner et al. (1974) found phytoplankton abundance near Prudhoe Bay to be greater below 16 feet (5 m) than at shallower depths.

Annual primary production in the Alaska Beaufort Sea is considered low. By comparison, annual production in the Beaufort Sea has been estimated to range from 5 to 40 grams of carbon per square meter per year ( $gC/m^2/yr$ ) in nearshore areas (Carey, 1978a; Schell et al., 1982); whereas production in the Bering Sea is estimated at 121  $gC/m^2/yr$  (McRoy and Goering, 1974).

The annual cycle begins in fall as the ice forms. Pennate diatoms and microflagellates present in the water column in low numbers are incorporated into the ice. The microflagellates are probably not photosynthetic. The diatoms remain viable during the dark winter months, although if conditions allow, a modest ice algae bloom can occur in fall. Cores obtained in November 1980 off Narwhal Island, which is located 53.2 miles (85.6 km) west-southwest of the Galahad Prospect, demonstrated that the cell densities and species of the fall bloom were similar to those found in the same area in spring 1980 (Norton and Sackinger, 1981). It is not known if the fall bloom is a regular occurrence in the Alaska Beaufort Sea, since it has not been reported previously in other fall studies in similar climates (Hsiao, 1980).

Fewer phytoplankton cells are present in the water column in winter. The benthic microalgae have not been studied in winter (Norton and Sackinger, 1981).

By March, light returns with the lengthening days. Phytoplankton in the ice begin to photosynthesize and divide in response to a minimum threshold of light. Near Narwhal Island, an early peak occurred in late April-early May in 1980, with a later maximum peak at the end of May. Brine drains and algal cells in the brine pockets are carried downward through the ice. A yellow-brown layer of ice algae, mostly pennate diatoms, is present on the underside of the ice by

early April. Few cells are present in the water column, and chlorophyll  $\underline{a}$  levels are low. On the other hand, chlorophyll  $\underline{a}$  levels in the sediments are relatively high (Norton and Sackinger, 1981).

Maximum <sup>14</sup>C uptake and chlorophyll <u>a</u> levels in the ice occur in late May (Norton and Sackinger, 1981). The epontic algae, although not very productive, are probably important because of their proximity to the ice leads along which animals migrate into the Alaska Beaufort Sea, and because of their very early productivity (BLM, 1979). Primary production in the water column and sediments remains low because the ice algae and entrained sediment in nearshore ice effectively block the light reaching these habitats (Norton and Sackinger, 1981).

By early June, the soft bottom layer of ice containing diatoms is loosely associated with the ice and is rapidly eroded by water currents beneath the ice. The ice algae probably accelerate this process by selective absorption of radiation. The importance of the ice algal community is that it is the principal source of primary production in the early spring and is thus the only available source of food for those animals that can utilize it (Norton and Sackinger, 1981).

The spring phytoplankton bloom probably occurs sometime in June, but because of the difficulty of sampling in June efforts to document this bloom have not been fruitful to date. Sampling transects out to 35 miles (56 km) north of Prudhoe Bay in mid-June 1980 failed to detect water with high chlorophyll concentrations, although nitrogenous nutrient concentrations were less than 20 percent of April concentrations in the same area. This indicates that uptake may have occurred in the previous weeks, and the cells may have descended to below the maximum depth sampled [i.e., 49 feet (15 m)] (Norton and Sackinger, 1981). However, despite intense sampling, there are no data to indicate the occurrence of a spring phtoplankton bloom in the offshore area of the Beaufort Sea (Horner, 1984).

In summer (late July and August), two phytoplankton communities may be present in the nearshore area in Stefansson Sound [49.2 miles (79.6 km) west-southwest of the Galahad Prospect], with flagellates dominating in surface water where carbon uptake is low and centric diatoms dominating in deeper water where higher primary productivity occurs (Horner et al., 1974).

b. Zooplankton: Over 100 species of zooplankton have been identified for the Alaska Beaufort and northeastern Chukchi Seas. These species can be divided into four groups: species that occur throughout the Arctic Basin; species that are swept into the Beaufort Sea to various extents from the Bering and Chukchi Seas; species characteristic of nearshore, less saline environments; and species that are larval forms of animals that live in the benthos (i.e., meroplankton) (MMS, 1987).

Many of these species of zooplankton graze directly on phytoplankton, and are therefore responsible for much of the secondary production. Copepods are the most important components of the zooplankton, both numerically and in terms of biomass. All copepodid stages and adults are present (MMS, 1984; Norton and Sackinger, 1981). A study performed in the offshore area near Prudhoe Bay showed that the most important genus is <u>Calanus</u>, which comprises 45 to 54 percent of the zooplankton biomass in the upper 4,922 feet (1,500 m) of the Arctic Ocean. Other copepods found in the area include <u>Pseudocalanus minutus</u>, <u>Acartia longiremus</u>, <u>Oithoma spp.</u>, <u>Oncaea spp.</u>, and several Pacific Ocean expatriates (AINA, 1974).

During recent studies, in the eastern Alaskan Beaufort Sea, copepods were found to dominant the zooplankton in both biomass (78% of wet weight) and in numbers (87% of individual). The average zooplankton biomass was found to be higher in nearshore and in inner continental shelf waters, than in the Outer Continental Shelf (seaward of the 164-foot (50-meter) contour). In addition, zooplankton biomass

was quite low in surface waters and highest within or just below the pycnocline (layer of greatest seawater density change) (Richardson, 1986; Richardson, 1987; Griffiths et al., 1987).

Distribution of zooplankton in the eastern Alaska Beaufort Sea is described as patchy, with patches extending up to several 1,000 feet in length and only 16 to 33 feet (5 to 10 meters) in depth. In the vicinity of Kaktovik, patches were found to be more abundant and have a higher biomass in the nearshore and inner shelf areas than in outer shelf waters (Richardson, 1986; Richardson, 1987; Griffiths et al., 1987).

Other groups that may occasionally contribute significantly to the zooplankton population in the area include hydromedusans (Botrynema and Sminthea), decapods (Hymenodora), chaetognaths (Eukrohnia), amphipods (Parathemisto and Cyclocaris), larvaceans, and radiolarians. Radiolarians occasionally exceed the copepods in numbers. The hydromedusae are the second most diverse group. In addition, the zooplankton characteristically contain larval barnacles, gastropods, lamellibranchs, and fish. The larval barnacles are a major summer constituent of the zooplankton in terms of numbers and biomass (AINA, 1974).

The standing crop of zooplankton in the eastern Alaska Beaufort Sea is small compared to communities in the western Alaska Beaufort and Chukchi Seas, primarily because of low primary productivity by phytoplankton and the relative absence of meroplankton. The highest standing crop of zooplankton occurs about one or two weeks after the summer phytoplankton bloom. The greatest numbers of nauplii (from copepods) occur during October and November. Zooplankton may over-winter in the area by becoming dormant, using detritus as food, or by storing fat (AINA, 1974).

c. Finfish: Fish resources found in the eastern Alaska Beaufort Sea OCS Area during at least some portion of their life cycle fall into three basic categories: freshwater species, that make relatively short excursions seaward from coastal rivers; anadromous species, that spawn in fresh water and migrate seaward as juveniles and adults; and marine species, that complete their entire life cycle in the marine environment. These fish inhabit three aquatic zones: the nearshore zone [i.e., less than 7 feet (2 m) of water and within enclosed or protected coastal waters]; the inshore zone [7 to 66 feet (2 to 20 m) of water]; and the offshore zone [greater than 66 feet (20 m) of water] (Weller et al., 1978). The distribution and abundance of fish species in these aquatic zones is highly dependent on several factors, including: freshwater input from major coastal rivers, local wind patterns, and ice formations (MMS, 1984; MMS, 1987).

While sixty-two (62) species of fish have been collected along the Alaska Beaufort Sea coast (MMS, 1987), five (5) species account for over 90 percent of the numbers present in most areas surveyed (OCSEAP, 1978). These include Arctic char (Salvelinus alpinus), Arctic cisco (Coregonus autumnalis), and least cisco (Coregonus sardinella), which are anadromous species, and Arctic cod (Boreogadus saida) and fourhorn sculpin (Myoxocephalus quadricornis) which are marine species. In addition to these species, boreal smelt (Osmerus eperlanus), a spring spawning anadromous species, is present during winter (ACS, 1983).

Freshwater fish which occur in coastal waters of the Alaska Beaufort Sea are found almost exclusively in association with fresh or brackish waters off of major river deltas. Their presence in the marine environment is generally sporadic and brief, with peaks during and immediately following breakup. Freshwater species which have been observed in these areas include Arctic grayling (Thymallus arcticus), round whitefish (Prosopium cylindraceum), and burbot (Lota lota) (MMS, 1987).

Anadromous fish in the Alaska Beaufort Sea appear to be concentrated along and immediately adjacent to the mainland shoreline and along the edges and lee sides of the barrier islands. Anadromous species most commonly found in the region include Arctic char (Salvelinus alpinus), Arctic cisco (Coregonus autumnalis), least cisco (Coregonus sardinella), Bering cisco (Coregonus laurettae), rainbow smelt (Osmerus mordax), humpback whitefish (Coregonus clupeaformis), and broad whitefish (Coregonus nasus). Anadromous fish generally spawn in fall, with the exception of boreal smelt which spawns in spring or early summer. Spawning occurs in river deltas as well as further upstream in the Sagavanirktok, Canning, Hulahula, Aichilik, Kongagkut, and Colville Rivers (MMS, 1984). During winter, the nearshore areas also are used for feeding. Anadromous fish obtain much of their annual food during the open water period in the nearshore environment (Craig and McCart, 1976). They are highly mobile, and tend to use a large portion of the coastline, rather than remaining in one area during the open water period (Craig and Haldorson, 1980). However, they seem to prefer the warmer, less saline waters around river deltas rather than the cooler, more saline waters offshore or removed from drainages (Craig, 1984; Craig and Haldorson, 1981; Moulton et al., 1980; Griffiths and Gallaway, 1982; Critchlow, 1983; Dew, 1983; Griffiths et al., 1983; Woodward-Clyde Consultants, 1983; Moulton and Fawcett, 1984; and Moulton et al., 1985).

Forty-three (43) marine species have been identified in the Alaska Beaufort Sea, with the most important species (i.e., in terms of abundance) being the Arctic cod (Boreogadus saida), saffron cod (Eleginus gracilis), fourhorn sculpin (Myoxocephalus quadricornis), twohorn sculpin (Icelus bicornis), Canadian eelpout (Lycodes sp.), capelin (Mallotus villosus), and Arctic flounder (Liopsetta glacialis) (Craig, 1984). The Arctic cod is particularly important in the Arctic Ocean because of its abundance, widespread distribution, and importance to the diets of other Arctic species. Marine fish species spawn primarily during winter in shallow nearshore areas and in offshore waters (MMS, 1984; MMS, 1987).

### (2) BENTHIC ENVIRONMENT

a. <u>Infauna</u>: The eastern Alaska Beaufort Sea OCS Area can be divided into the following zones on the basis of the invertebrate fauna: nearshore, inshore or coastal, shelf, and slope (Broad et al., 1981).

The <u>nearshore zone</u> extends from the shoreline seaward to a water depth of about 7 feet (2 m). Surface sediments consist of sand, silt, and gravel and may contain large amounts of peat. Salinities are low, and water adjacent to the seafloor is usually warmer than bottom water further offshore. The principal infaunal organisms are chironomid (midge) larvae, which may be important to introducing terrestrial carbon in the marine system, and enchytraeid (oligochaete) worms. Throughout the system, biomass is low, lacking in diversity, and dependent on annual, or more frequent, colonization by available species. The nearshore zone is generally frozen by the annual shorefast ice (Broad et al., 1981; MMS, 1987).

The inshore or coastal zone has been defined as extending from the 7- to 66-foot (2- to 20-m) isobath throughout most of the eastern Alaska Beaufort Sea. Surface sediments in this zone primarily consist of silt; however, sand is present in areas adjacent to river deltas. Peat is a minor component of the bottom deposits. The salinity of the bottom water is high (i.e., 24 to 32 ppm, with most concentrations near the higher value), and the temperature is low [i.e., 30 to 39°F (-1 to +4°C), with most of the readings near the lower value] (Broad et al., 1981). Biomass and diversity generally increase with depth in the inshore zone out to approximately 49 feet (15 m) where intensive ice-gouging occurs which greatly disturbs the sediments in which infaunal organisms exist, thereby minimizing their abundance (MMS, 1984; MMS, 1987). The principal infaunal organisms are polychaete worms, amphipods, isopods (including the burrowing Saduria sabini), bivalve molluscs, and the priapulid Halicryptus spinulosus (Broad et al., 1981).

The <u>shelf zone</u> extends from a water depth of about 49 feet (15 m) to approximately 328 feet (100 m). The surface sediments in this zone are variable and may include clays and gravel. The bottom salinity usually exceeds 30 ppm, and the water is cold. The biomass is highly variable, indicating patchy distribution. The principal infaunal organisms are polychaetes, bivalves, brittle stars, sea cucumbers, and crustaceans (Broad et al., 1981).

Below the 328-foot (100-m) water depth, the bottom community belongs to the <u>slope zone</u>. There are no recent data from this area (Broad et al., 1981).

b. <u>Epibenthos</u>: Benthic epifauna are those organisms living on the surface of the seafloor, even though some species demonstrate burrowing tendencies for brief periods. This category is further separated into sessile or mobile forms. Sessile epifauna, which are uncommon in the Alaska Beaufort Sea, usually are found attached to hard substrates such as rocks, cobble, or wood, and even to kelp fronds. Sessile types include barnacles, hydroids, anemones, bryozoans, and mussels (MMS, 1984).

Mobile epifauna in the Alaska Beaufort Sea are dominated by the crustaceans (amphipods, mysids, isopods, cumaceans, euphausiids, and decapods), although echinoderms (starfish) and gastropods (snails) also are prominent. Members of this group form a substantial portion of the diets of vertebrate consumers (i.e., fish, birds, and marine mammals) (MMS, 1984; MMS, 1987).

The most abundant of the motile epibenthic crustaceans in the inshore zone are Mysis littoralis and Mysis relicta; amphipods including Pontoporeia affinis (also in the infauna), Apherusa glacialis, Gammarus setosus, and Onisimus glacialis; and the isopods Saduria entomon and Saduria sabini. Several recent studies have examined the patterns of distribution and abundance of these epibenthic organisms, primarily as they relate to fish movements and feeding behavior. In

general, the two major mysid species have somewhat different distributions, with Mysis littoralis apparently showing a lesser tolerance of low salinity water. Amphipods were exceptionally abundant on the inside of barrier islands. Hypersaline waters also apparently affected distribution, leading to reduced biomass of mysides and amphipods in offshore or central areas of Prudhoe Bay during late summer (Broad et al., 1981; Craig and Griffiths, 1981; Envirosphere, 1985; Moulton et al., 1985).

Offshore epifauna have been sampled on several cruises, the most extensive being Frost and Lowry (1983). Their trawls were made in the northeastern Chukchi and western Beaufort Seas at depths of 131 to 1,312 feet (40 to 400 m). However, samples were taken east of 150° west longitude, which would be the closest to the Galahad Prospect. This sample revealed a community characterized by the scallop (Delectopecten groenlandicus) and the crinoid (Heliometra glacialis). Sea cucumbers (Psolus sp.), sea urchins (Strongylocentrotus droebachiensis), several species of brittle stars (not Ophiura sarsi), and the shrimp (Sabinea septemcarinata) were usually among the most abundant species. Most trawls in which this species assemblage occurred was in rocky (i.e., cobble) areas (MMS, 1987).

Boulder patch areas consist of boulders from 32 to 39 inches (80 to 100 cm) in diameter and cobbles. There are boulder patch areas near Karluk, Flaxman, and Narwhal Islands, which are located greater than 31 miles (49.9 km) from the Galahad Prospect (BLM, 1979).

Boulder patches offer unique habitat to a variety of organisms, including kelp plants which are dominant. The largest kelp community thus far described occurs in Stefansson Sound, approximately 49.2 miles (79.2 km) west-southwest of the Galahad Prospect. Areas containing kelp are characterized by: an abundant and diverse flora and fauna; a high utilization of the rocky substrate and competition between species for space; a kelp overstory of high biomass consisting of Laminaria spp.; an algal understory of several red algal species and attached invertebrate species; and an apparently productive kelp

community with an unknown export of organic matter to the marine ecosystem (Dunton and Schonberg, 1979; Dunton et al., 1982; and Dunton, 1984).

Sea coastal area consists of flat gravel beaches that are up to 108 feet (33 m) wide. However, little if any permanent or resident biota exist on the beaches because of ice scour and freezing conditions (BLM, 1979). In general, inshore areas exposed to ice gouging support benthic organisms adapted to this seasonal destruction. These are opportunistic species with reproductive cycles not closely associated with other biological cycles. Their reproductive capacity is influenced by physical disturbances (Carey, 1978b). The principal infaunal organisms are chironomid (midge) larvae, which may be important in introducing terrestrial carbon in the marine system, and enchytraeid (oligochaete) worms. Motile epibenthic animals of the nearshore area include the isopod Saduria entomon and the amphipods Gammarus setosus and Onisimus litoralis (Broad et al., 1981).

## (3) BREEDING HABITATS AND MIGRATION ROUTES

Mammals and birds utilizing the coastal waters of the Alaska Beaufort Sea exhibit a high degree of mobility (i.e., all are, to some extent, migratory) and utilize a wide variety of food sources (ACS, 1983). Generally, living resources move into the area for the short summer season and move out before freeze-up. In spring, most mammals are found along the transition zone between the landfast and pack ice zones (NPC, 1981).

Four (4) distinct types of mammals inhabit or utilize the marine environment within or in the vicinity of the Galahad Prospect: cetaceans, pinnipeds (i.e., seals, sea lions, and walruses), polar bears, and terrestrial species, such as the Arctic fox. In addition, many species of seabirds, waterfowl, and shorebirds are found in the area (MMS, 1984).

a. <u>Cetaceans</u>: Five species of whales have been reported in the Alaska Beaufort Sea: the endangered bowhead whale (<u>Balaena mysticetus</u>), the endangered gray whale (<u>Eschrichtius robustus</u>), the beluga or white whale (<u>Delphinapterus leucas</u>), the narwhal (<u>Monodon monocerus</u>), and the killer whale (<u>Orcinus orca</u>). The Alaska Beaufort Sea is part of the normal range for the endangered bowhead whale and the beluga whale, and it is considered to be on the extreme edge of the endangered gray whale's summer range. Killer whales and narwhals can be considered "extralimital" or "accidental" inhabitants of the Alaska Beaufort Sea (ACS, 1983; MMS, 1987). In addition, two other species, which were listed as endangered in the Federal Register (Vol. 48, No. 145, 1983), may occur in the eastern Alaska Beaufort Sea OCS Area. They are the endangered fin whale (<u>Balaenoptera physalus</u>) and the endangered humpback whale (<u>Megaptera novaeangliae</u>).

Information on the endangered bowhead and gray whales is provided in the discussion of "Endangered or Threatened Species" which appears in Part (5) of this Subsection. Table III-7 contains information on the habitats, migration patterns, and population of the non-endangered whale species which may be found in the Alaska Beaufort Sea.

b. <u>Pinnipeds</u>: Pinnipeds that have been reported in the Alaska Beaufort Sea include: the harbor seal (<u>Phoca vitulina</u>), the spotted seal (<u>Phoca largha</u>), the harp seal (<u>Phoca groenlandica</u>), the hooded seal (<u>Cystophoca cristata</u>), the ringed seal (<u>Phoca hispida</u>), the bearded seal (<u>Erignathus barbatus</u>), the northern fur seal (<u>Callorhinus ursinus</u>), the northern sea lion (<u>Eumetopias jubata</u>), and the Pacific walrus (<u>Odobenus rosmarus</u>). However, only the ringed seal, bearded seal, and spotted seal can be said to be regular occupants of the eastern Alaska Beaufort Sea OCS Area (ACS, 1983; MMS, 1984; MMS, 1987).

The distribution and seasonal occurrence of these pinniped species is strongly influenced by the presence of sea ice (Burns et al., 1981). The stable sheet of landfast ice is of major importance

#### TABLE III-7

NONENDANGERED CETACEANS WHICH OCCUR IN THE EASTERN ALASKA BEAUFORT SEA OCS AREA (NPC, 1981; BLM, 1982; ACS, 1983; Lowry and Frost, 1981; MMS, 1984; MMS, 1987)

SPECIES: Beluga Whale (Delphinapterus leucas)

Normal Range:

Arctic and subarctic waters of North America and Eurasia.

Seasonal Occurrence in Region:

Present in Alaska Beaufort Sea from late April through September, however, most apparently spend summer (July and August) in Canadian waters in the vicinity of the Mackenzie River Delta. Both spring and a majority of fall migration occurs well offshore. An estimated 3,000 to 4,000 summer in the northwestern Beaufort and Chukchi Seas.

Population:

11,500 whales migrate to the eastern Beaufort Sea; at least 30,000 individuals in North America.

Migration:

Migrate north and east from Bering Sea during April or May following leads in ice; move west through the region in September or October.

SPECIES: Narwhal (Monodon monoceros)

Normal Range:

High Arctic, mainly in deep water, and north polar seas. Exist in considerable numbers on both sides of Greenland and in the Canadian archipelago east of Boothia Peninsula.

Seasonal Occurrence in Region:

Very rare. There are a few records of sightings from Point Hope on the Chukchi Sea north and eastward to the Canadian border, primarily of solitary stranded or shot specimens.

Population:

20,000 to 30,000 in northern population (as of 1978).

Migration:

Annual, with movement of the ice. They travel south as far as the coast of Labrador in fall, when ice forms; north to ice pack in spring.

#### TABLE III-7 (cont.)

SPECIES: Killer Whale (Orcinus orca)

Normal Range:

All oceans; coastal waters and cooler regions preferred. Widely distributed in the eastern North Pacific, from the Chukchi Sea south to the equator.

Seasonal Occurrence in Region:

May be found near pack ice in the Beaufort Sea.

Population:

N/A.

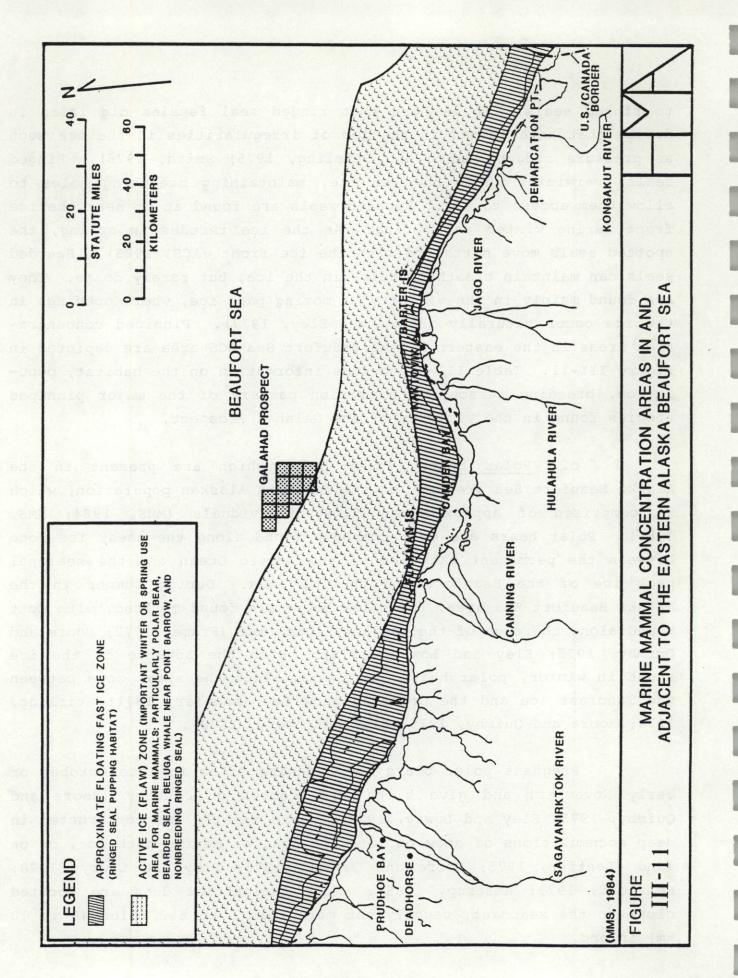
Migration:

Some herds appear to move toward the equator during winter and toward polar regions during summer, but definitive migratory patterns are unknown. Some herds are endemic to specific regions all year long.

to ringed seals. It is here that ringed seal females dig lairs in drifts that have formed in the lee of irregularities in the ice such as pressure ridges (Smith and Stirling, 1975; Smith, 1976). Ringed seals overwinter under the sea ice, maintaining breathing holes to allow them access to air. Spotted seals are found at or near the ice front during winter and spring. As the ice recedes in spring, the spotted seals move northward with the ice front (ACS, 1983). Bearded seals can maintain breathing holes in the ice, but rarely do so. They are found mainly in the vicinity of moving pack ice, where openings in the ice occur naturally (Burns and Eley, 1977). Pinniped concentration areas in the eastern Alaska Beaufort Sea OCS area are depicted in Figure III-11. Table III-8 provides information on the habitat, population, breeding season and migration pattern of the major pinniped species found in the vicinity of the Galahad Prospect.

c. Polar Bear: Polar bears which are present in the Alaska Beaufort Sea are part of the northern Alaskan population, which is comprised of approximately 2,000 individuals (MMS, 1984; MMS, 1987). Polar bears are most commonly found along the shear ice zone between the permanent pack ice of the Arctic Ocean and the seasonal pack ice of the Beaufort and Chukchi Seas. During summer in the Alaska Beaufort Sea area, few polar bears are found on land, with most found along the edge of the permanent pack ice (Frame, 1972; Moore and Quimby, 1975; Eley and Lowry, 1978). With the advance of the ice sheet in winter, polar bears are common along the shear zone between the landfast ice and the drifting pack ice (Lentfer, 1971; Stirling, 1974; Moore and Quimby, 1975; Eley and Lowry, 1978).

Pregnant polar bears seek denning sites in late October or early November, and give birth in December or January (Moore and Quimby, 1975; Eley and Lowry, 1978). Dens usually are constructed in deep accumulations of snow on landfast ice, on moving pack ice, or on land (Lentfer, 1975; Moore and Quimby, 1975; Eley and Lowry, 1978; Benfield, 1979; Amstrup, 1985). Most terrestrial dens are located close to the seacoast, usually not more than 5 to 6.2 miles (8 to 10 km) inland.



#### TABLE III-8

MAJOR PINNIPED SPECIES IN THE EASTERN

ALASKA BEAUFORT SEA OCS AREA

(NPC, 1981; BLM, 1982; ACS, 1983; Burns and Frost, 1979;

Lowry and Frost, 1981; MMS, 1984; MMS, 1987)

SPECIES: Ringed Seal (Phoca hispida)

Habitat:

Close to shore in the landfast ice and transition zone from April to breakup. Overwinters under sea ice. Concentrations occur from Harrison Bay to Flaxman Island in summer.

Seasonal Occurrence in Region:

Most widely distributed seal species in the arctic; present year-round.

Population:

Most abundant seal in Arctic. 80,000 in summer; 40,000 in winter.

Breeding Season:

Late March and April. Pupping occurs in lairs dug into the lee side of irregularities in the ice, such as pressure ridges.

Nursing Period:

4 to 6 weeks.

Migration:

Migration routes are not well delineated. Many move offshore with the receding ice, returning in late summer and fall to nearshore areas.

SPECIES: Bearded Seal (Erignathus barbatus)

Habitat:

On moving pack ice where movements in the ice cover occur naturally. Water depths less than 655 ft (200 m) deep. Summer concentrations along ice remnants between Harrison Bay and Flaxman Island.

Seasonal Occurrence in Region:

Although some are present year-round, most appear to migrate out of the area during the solid ice period. Densities are greatest during summer and lowest during winter.

#### TABLE III-8 (cont.)

SPECIES: Bearded Seal (Erignathus barbatus) (cont.)

Population:

Approximately 300,000 to 450,000 in Bering/Chuckchi Sea area. The Beaufort Sea supports low numbers in comparison, but some seals are present year-round.

Breeding Season:

May and June.

Pupping Season:

Late March through May (primarily in the Bering and Chukchi Seas, but sometimes in the Beaufort Sea).

Nursing Period:

12 to 18 days.

Migration:

Some present in Beaufort Sea year-round; however, most migrate out of the area during winter.

SPECIES: Spotted Seal (Phoca largha)

Habitat:

At or near the ice front during winter and spring, and coastal areas in summer; haulouts occur on beaches, barrier islands, and remote sandbars in river deltas.

Seasonal Occurrence in Region:

Present in summer and fall; however, few sightings occur east of the Colville River Delta.

Population:

Relatively low numbers (about 1,000) occur in Alaska Beaufort Sea.

Breeding Season:

April and May (not in Beaufort Sea).

Pupping Season:

Late March and early April.

Nursing Period:

4 weeks.

#### TABLE III-8 (cont.)

SPECIES: Spotted Seal (Phoca largha) (cont.)

Migration:

During winter and spring found at or near the ice front located in the Bering Sea. As the ice front recedes in spring the spotted seal moves northward entering the Alaska Beaufort Sea in July.

SPECIES: Pacific Walrus (Odobenus rosmarus)

Habitat:

For most of the year, walruses live on the pack ice, but in late summer many congregate on land. Recent aerial surveys have found several tens of thousands of walruses associated with the edge of the pack ice in the northeastern Chukchi Sea in early September. Only a few are known to enter the western Alaska Beaufort Sea during summer. Groups of animals and orphan calves occasionally have been seen in the Prudhoe Bay area and even more occasionally as far east as Barter Island.

Population:

170,000 to 250,000.

Breeding Season:

December to April.

Pupping Season:

Mid-April to mid-June.

Nursing Period:

At least 18 months.

Migration:

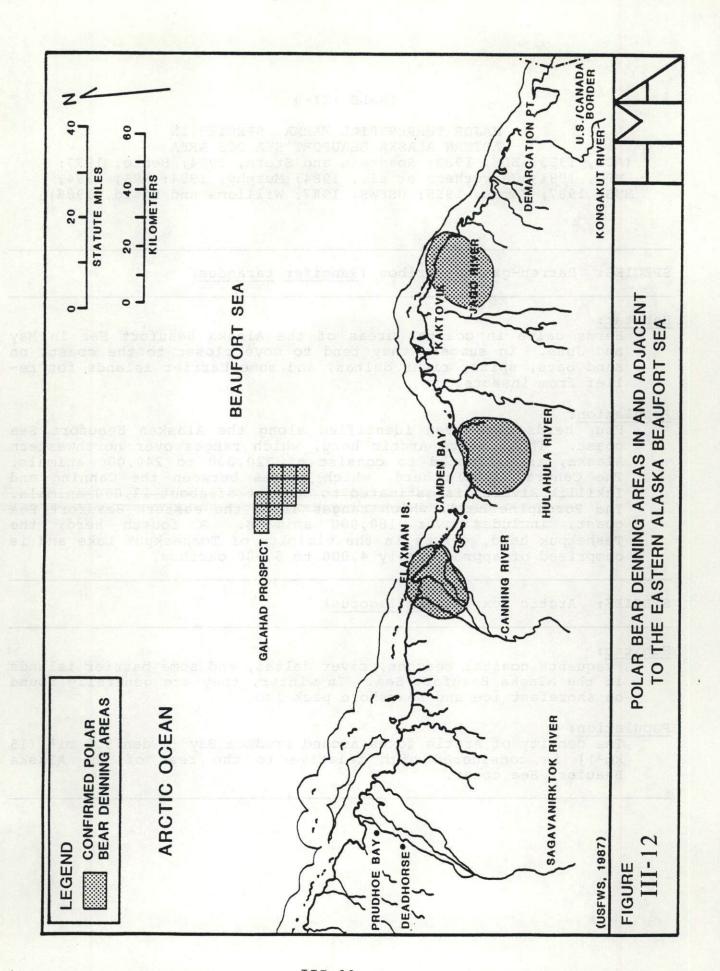
North/south movements determined by movement of pack ice.

Insufficient data exists to accurately quantify polar bear denning activities along the eastern Alaska Beaufort Sea coastline. However, three different parts of the MMS Beaufort Sea Planning Area have been generally delineated as confirmed denning areas (i.e., areas in which polar bear dens and denning activity have been observed during more than one winter) (Amstrup, 1985; MMS, 1987). These areas are identified in Figure III-12.

Cubs and their mothers usually remain in the dens until late March or April when they emerge and move out onto the sea ice to hunt (Lentfer, 1976). Males and non-breeding females rarely construct dens but remain active year-round, ranging widely over coastal areas and the adjacent sea ice (ACS, 1983).

d. Terrestrial Mammals: Eighteen species of terrestrial mammals have been reported as inhabiting the arctic coastal plain. The most abundant large mammals include: caribou (Rangifer tarandus), Arctic fox (Alopex lagopus), and the muskox (Ovibos moschatus). Grizzly bears (Ursus arctos) and wolves (Canis lupus) also are present. Except for the Arctic fox, which moves onto the sea ice during winter, these species are most conspicuous near the eastern Beaufort Sea OCS area during summer. During winter, most species move towards the treeline or denning sites (ACS, 1983). Table III-9 summarizes the habitats and current populations and Figure III-13 depicts the major areas of occurrence of the terrestrial mammals commonly found in the vicinity of the eastern Alaska Beaufort Sea.

Among the terrestrial mammals that occur along the coast of the Alaska Beaufort Sea, the caribou is the species most likely to be affected by oil and gas operations (MMS, 1984). Two major herds, the Porcupine and the Western Arctic, and two minor herds, the Central Arctic and the Teshekpuk Lake, utilize areas adjacent to the Alaska Beaufort Sea for at least a part of each year (ACS, 1983). The Porcupine caribou herd range is located adjacent to the Galahad Prospect.



#### TABLE III-9

## MAJOR TERRESTRIAL MAMMAL SPECIES IN EASTERN ALASKA BEAUFORT SEA OCS AREA

(ACS, 1983; BLM, 1982; Roseneau and Stern, 1974; Bente, 1977; NPC, 1981; Carruthers et al., 1984; Murphy, 1984; MMS, 1987; James, 1985; USFWS, 1987; Williams and Heard, 1986)

SPECIES: Barren-ground Caribou (Rangifer tarandus)

#### Habitat:

Herds calve in coastal areas of the Alaska Beaufort Sea in May and June. In summer, they tend to move closer to the coast, on sand bars, spits, river deltas, and some barrier islands for relief from insects.

Population:

Four herds have been identified along the Alaskan Beaufort Sea coast. The Western Arctic herd, which ranges over northwestern Alaska, is estimated to consist of 220,000 to 240,000 animals. The Central Arctic herd, which ranges between the Canning and Itkillik Rivers, is estimated to consist of about 13,000 animals. The Porcupine herd, which ranges along the eastern Beaufort Sea coast, includes over 180,000 animals. A fourth herd, the Teshekpuk herd, calves in the vicinity of Tesheskpuk Lake and is comprised of approximately 4,000 to 5,000 caribou.

SPECIES: Arctic Fox (Alopex lagopus)

#### Habitat:

Frequents coastal beaches, river deltas, and some barrier islands in the Alaska Beaufort Sea. In winter, they are generally found on shorefast ice and nearshore pack ice.

Population:

The density of Arctic foxes around Prudhoe Bay [1 den/5.8 mi² (15 km²)] is considered high relative to the rest of the Alaska Beaufort Sea coast.

#### TABLE III-9 (cont.)

SPECIES: Muskox (Ovibos moschatus)

Habitat:

Before indiscriminate hunting reduced their numbers, they were abundant along coasts of northern and eastern Greenland, on the tundra of northern Canada, and on arctic islands. In Alaska, following reintroduction, they now are found on Nunivak Island, Nelson Island, Seward Peninsula, and the arctic slope, the Canning River, the area between the Salderochit and Hulahula Rivers, and along the coast near the Jago, Egaksrak and Aichilik Rivers.

Population:

Approximately 1,000 are found in Alaska, counting all wild herds and the captive animals at Unalakleet.

SPECIES: Grizzly Bear (Ursus arctos)

Habitat:

Prefer open tundra and grasslands. Grasslands seem to be a particularly critical habitat during spring. Also found on tide flats of coastal bays, or on stream deltas, where there are grass, sedge, and horsetail flats.

Population:

There may be between 5,000 and 10,000 grizzly bears in Alaska.

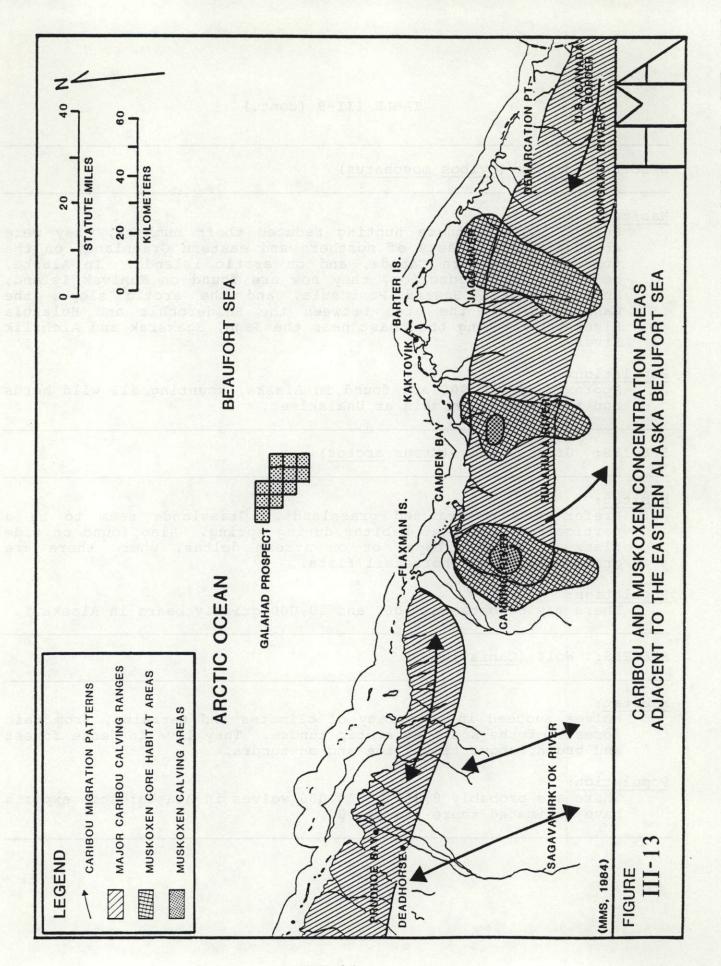
SPECIES: Wolf (Canis lupus)

Habitat:

Wolves succeed in a variety of climates and terrains, from rain forests of the south to arctic tundra. They live in dense forest and brush, above timberline and on tundra.

Population:

There are probably 8,000 to 10,000 wolves in Alaska; some experts have estimated there are 15,000.



The Porcupine caribou herd, estimated to be approximately 180,000 animals (USFWS, 1987), ranges from the Canning River eastward into Canada, and south to the Brooks Range (Carruthers et al., 1984).

By mid- to late May, Porcupine caribou have reached their calving grounds and summer range (Roseneau and Curatolo, 1978). Most calving takes place between May 30 and June 15 (ACS, 1983) on the coastal plain from the Canning River in Alaska to the Babbage River in Canada south to the northern foothills of the Brooks Range. Major concentrations of calving cows occur within this range between the Canning and Sadlerochit Rivers on the west and east, respectively, and between Camden Bay on the north and the Sadlerochit Mountains on the south (MMS, 1987).

Following the calving period, caribou movements generally converge in an area immediately south and west of Demarcation Bay prior to the dispersal of animals onto the summer range (LeResche and Linderman, 1975). During summer, caribou use various coastal habitats, such as sandbars, spits, river deltas, and some barrier islands, for relief from insect pests (MMS, 1987).

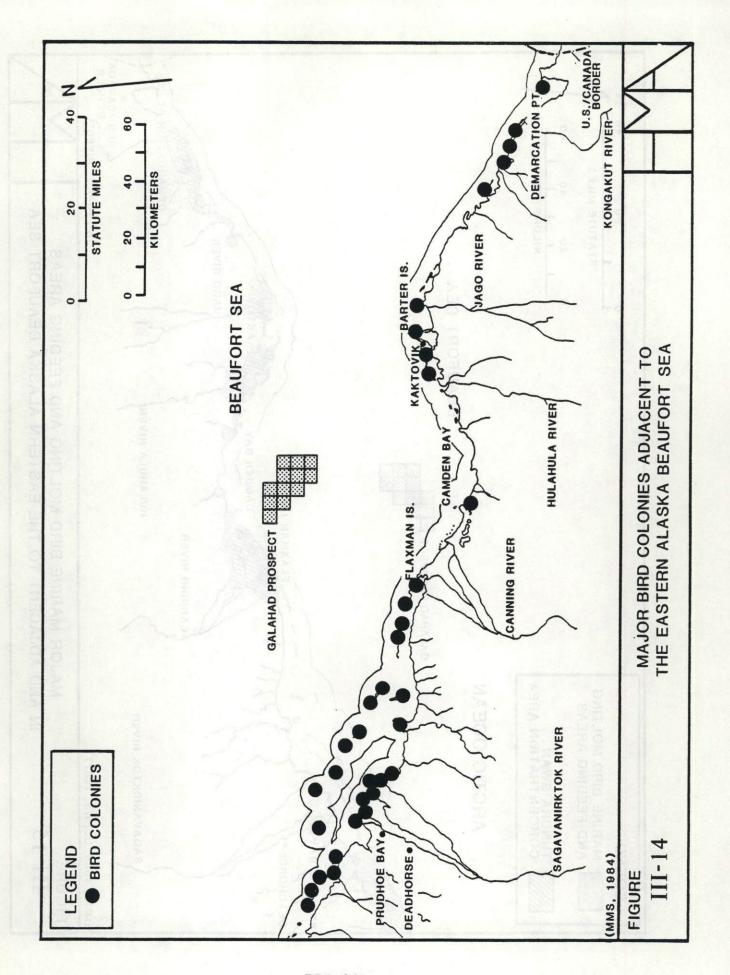
Fall migration begins in early September with most animals moving southward along the Old Crow and Richardson migration corridors (Hemming, 1971; Calef, 1974; Roseneau and Curatolo, 1978). Substantial numbers of caribou usually can be found in the vicinity of the Porcupine River by mid- to late September (Calef, 1974).

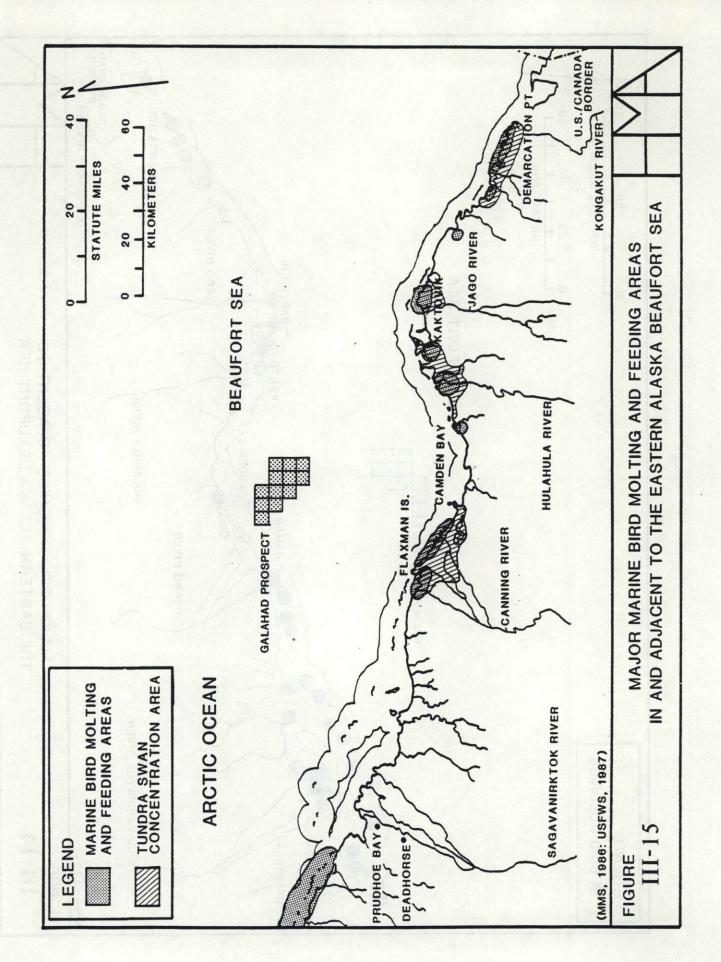
e. Marine and Coastal Birds: Several million birds, consisting of about 150 species of seabirds, waterfowl, shorebirds, and raptors (including the "threatened" Arctic peregrine falcon) occur on the Arctic coastal plain (Schamel, 1978; MMS, 1987). The great majority of birds in the area are migratory (BLM, 1979), with only six species present in the area from September to May. These overwintering species are the rock ptarmigan (Lagopus mutus), willow ptarmigan

(<u>Lagopus</u>), snowy owl (<u>Nyctea scandiaca</u>), common raven (<u>Corvus corax</u>), gyrfalcon (<u>Falco rusticolus</u>), and black guillemot (<u>Cepphus grylle</u>) (BLM, 1979).

The spring migration period marks the beginning of a major influx of marine birds into the eastern Alaska Beaufort Sea OCS Area. In general, spring migration occurs in a broad front eastward from Barrow over the Arctic coastal plain and the southern Beaufort Sea (Richardson and Johnson, 1981). Shortly after spring migration, most marine bird populations disperse to nesting grounds. During the breeding or nesting period, waterbirds can be found on both the mainland tundra or on the barrier islands. On the mainland, river deltas, lakes and marshes are considered vital for breeding activities (ACS, 1983). According to Divoky (1978), the barrier and deltaic islands are considered critical or unique sites, particularly when they house large populations of a single species. Timing of the break up of ice surrounding a barrier island is critical for determining the island's importance as a nesting site for marine birds (MMS, 1987). In the Alaska Beaufort Sea, the barrier islands from Oliktok Point to Flaxman Island are the most intensely used by breeding birds and of these, islands near river mouths receive the heaviest use (ACS, Figure III-14 depicts the major nesting colonies utilized by marine birds in the eastern Alaska Beaufort Sea OCS Area.

In addition to nesting areas, the nearshore and coastal areas of the Beaufort Sea provide important feeding areas to marine birds. From May through mid-June, the most important areas in the eastern Alaska Beaufort Sea region for marine-associated birds are patches of open water which occur in areas where the water is less than 82 feet (25 m) deep. These areas provide feeding and resting areas for the spring migrants (Barry et al., 1981). Figure III-15 depicts the location of major feeding and molting areas utilized by marine birds in the eastern Alaska Beaufort Sea OCS Area.





During mid- to late July, large numbers of marine birds, including oldsquaw (Clangula hyemalis), phalarope (Phalaropus spp.), and other shorebirds, congregate in coastal lagoons to feed and molt (Divoky, 1983). In general, habitat usage by most molting birds is restricted primarily to lagoons and the south or lee side of the barrier islands. Scoters are near the coast at this time, eiders are probably out at sea, and some scaup may molt in Harrison Bay (ACS, 1983). Use of these lagoons and other coastal habitats peaks in August to late September (Divoky, 1983; MMS, 1987).

The fall migration occurs after copious food consumption and molting. Unlike spring, fall migration is a more protracted event. The chief direction of flights are west and southwest. Among the water birds, swans, geese, and scoters are not especially noticeable along the coast because they tend to fly toward the interior of Alaska. Eiders also are inconspicuous and it is believed that their flights utilize offshore as well as coastal routes westward to Point Barrow. Oldsquaw have been detected by radar distributed over the North Slope, the coastline, and southern Beaufort Sea in wide bands during autumn. Some may wait as late as October before they depart (ACS, 1983).

The most abundant marine bird species in the eastern Alaska Beaufort Sea OCS Area include oldsquaws (Clangula hyemalis), red phalaropes (Phalaropus fulicarius), glaucous gulls (Larus hyperboreus), and common eiders (Somateria mollissima) (ACS, 1983: MMS, 1987). Information on the life history and habitats of these species is presented in Table III-10. Other common waterfowl and shorebird species are listed in Table III-11.

## (4) LIVE BOTTOM AREAS, FISH BANKS

There are no known live bottom areas or fish banks on or in the vicinity of the Galahad Prospect.

#### TABLE III-10

NESTING, RESIDENCY, AND BREEDING INFORMATION ON MARINE AND COASTAL BIRDS IN THE EASTERN ALASKA BEAUFORT SEA OCS AREA (Armstrong et al., 1980; BLM, 1982; Sowls et al., 1978)

SPECIES: Red Phalarope (Phalaropus fulicarius)

Nesting Habitat:

Nests on ground in tundra.

Residency in Region:

Spring, summer, and fall.

Breeding:

Breeds on wet tundra near ponds and lakes.

SPECIES: Oldsquaw (Clangula hyemalis)

Nesting Habitat:

Nests on the ground, often under low shrubs.

Residency in Region:

Spring, summer, and fall.

Breeding:

Breeds on tundra near lakes and ponds and along the coast.

SPECIES: Glaucous Gull (Larus hyperboreus)

Nesting Habitat:

Nests in colonies on cliff ledges and on the ground in slightly elevated portions of the tundra, or on islands in close association with other species.

Residency in Region:

Spring, summer, and fall.

Breeding:

Breeds on cliffs.

#### TABLE III-10 (cont.)

SPECIES: Common Eider (Somateria mollissima)

Nesting Habitat:

Nests on the ground, often near driftwood and other debris.

Residency in Region:

Spring, summer, and fall.

Breeding:

Low-lying rocky marine shores with numerous islands.

#### TABLE III-11

### OTHER WATERFOWL AND SHOREBIRD SPECIES COMMON TO THE EASTERN ALASKA BEAUFORT SEA OCS AREA (MMS, 1984)

#### COMMON NAME

#### SCIENTIFIC NAME

King eider

Spectacled eider

Arctic tern

Arctic loon

Red-throated loon

Yellow-billed loon

Pintail

White-fronted goose

Black brandt

Canada goose

Lesser snow goose

Whistling swan

Pectoral sandpiper

Dunlin

Northern phalarope

Semipalmated sandpiper

Parasitic jaeger

Pomarine jaeger

Longtailed jaeger

Sabine's gull

Ross' gull

Ivory gull

Black guillemot

Blacklegged kittiwake

Somateria spectabilis

Somateria fischeri

Sterna paradisaea

Gavia arctica

Gavia stellata

Gavia adamsii

Anas acuta

Anser albifrons

Branta bernicla nigricans

Branta canadensis

Anser c. caerulescens

Olor columbianus

Calidris melanotos

Calidris alpina

Phalaropus lobatus

Calidris pusilla

Stercorarius parasiticus

Stercorarius pomarinus

Stercorarius longicaudus

Xema sabini

Rhodostethia rosea

Pagophila eburnea

Cepphus grylle

Rissa tridactyla

## (5) ENDANGERED OR THREATENED SPECIES

Listed endangered or threatened species which may occur in the eastern Alaska Beaufort Sea OCS Area as reported in the Federal Register (Vol. 48, No. 145, 1983) are:

Bowhead whale (<u>Balaena mysticetus</u>)
Gray whale (<u>Eschrichtius robustus</u>)
Fin whale (<u>Balaenoptera physalus</u>)
Humpback whale (<u>Megaptera novaeangliae</u>)
Arctic peregrine falcon (<u>Falco pererginus tundrius</u>)

The endangered bowhead whale, because of its importance as a subsistence resource, is discussed below. Information on the other endangered or threatened species is summarized in Table III-12. The endangered fin and humpback whales are considered extremely rare in the Alaska Beaufort Sea and are not discussed.

The endangered bowhead whale is a large baleen whale that can reach 66 feet (20 m) in length. Originally, endangered bowhead whales were abundant in all arctic waters; however, extensive whaling, which ended in the early part of the 20th century, greatly reduced all stocks of this species (ACS, 1983). According to surveys performed by the International Whaling Commission, the western Arctic endangered bowhead whale stock is estimated to contain 7,200 individuals (MMS, 1988). The whale's population, however, has not yet approached what was believed to be its former size, despite nearly 70 years of protection from commercial whaling (Fraker, 1984).

Although endangered bowhead whales are generally considered to be "skimmers" (i.e., they feed on plankton by swimming at or near the surface of the ocean with their mouths open), it appears that they also feed in the water column and at or near the bottom. Copepods (Calanus hyperborus) and euphausiids (Thysanoessa raschii) have commonly been found in their stomachs (Wursig et al., 1981; Richardson, 1986; Richardson, 1987).

#### TABLE III-12

ENDANGERED OR THREATENED SPECIES WHICH OCCUR IN VICINITY OF THE EASTERN ALASKA BEAUFORT SEA OCS AREA (MMS, 1984; Gusey, 1983; Braham, 1982; Rearden, 1981; Morris, 1981; Lewbel, 1983; Richardson et al., 1985; Ljungblad et al., 1986; MMS, 1987)

SPECIES: Gray Whale (Eschrichtius robustus)

Normal Range:

Baja California to Alaska Beaufort Sea.

Seasonal Occurrence in Region:

Sightings reported at Beechey Point, north of the Shaviovik River, at Flaxman Island, Foggy Island, Cross Island, and Barter Island.

Population:

Eastern Pacific population is estimated at about 17,577 (± 2,364).

Migration:

Most winter along the west coast of Baja, California and travel for 4 months to the Chukchi, Bering, and western Beaufort Seas, where they summer. Recently, gray whales have been sighted in the eastern Beaufort Sea. Fall migration through the Bering Strait and northern Bering Sea occurs primarily in September through October, following approximately the same route as spring (i.e. paralleling shore, mostly taking the direct route when crossing indentations of the coastline). They may move up to 124 miles (200 km) offshore.

SPECIES: Peregrine Falcon (Falco peregrinus tundrius) "threatened"

Normal Range:

In western Alaska, nesting sites are located close to seabird or waterfowl concentrations.

Seasonal Occurrence in Region:

There are no known active nesting sites along the Alaska Beaufort Sea coastline. Nest sites or possible nesting sites closest to the coast include those of the Colville River at Ocean Point (25 miles inland), at Franklin Bluff on the Sagavanirktok River (25 miles inland), and at Red Hill on the Canning River (40 miles inland). Coastal sighting are most common from mid-August to mid-September east of the Colville River.

## TABLE III-12 (cont.)

SPECIES: Peregrine Falcon (Falco peregrinus tundrius) "threatened" (cont.)

Population:

Unknown.

Migration:

Usually are present in Alaska from mid-April to mid-September. Nesting sites are occupied from May to August in northern Alaska.

Endangered bowhead whales migrate each spring (i.e., from April to mid-June) from winter grounds in the Bering Sea to summer feeding grounds in the Canadian Beaufort Sea (Ljungblad, 1981; Ljungblad et al., 1980, 1982, 1983, 1984). The northward migration begins during breakup with most whales entering the Chukchi Sea by early April (Ljungblad et al., 1983). Once in the Chukchi Sea, most whales follow leads in the flaw zone from outer Kotzebue Sound to Barrow. After reaching Barrow, the whales move offshore in a northeasterly direction. During this part of the migration, whales can be found hundreds of miles offshore, migrating through leads and from opening to opening in the pack ice (Fraker, 1984). The majority of whales enter the Canadian Beaufort Sea by mid-June (Fraker Richardson, 1980; Braham and Krogman, 1977; Braham et al., 1979). During seven years of aerial surveys of the spring migration, few migrating endangered bowheads were sighted in the vicinity of the Galahad Prospect (Ljungblad et al., 1986; Ljungblad et al., 1987).

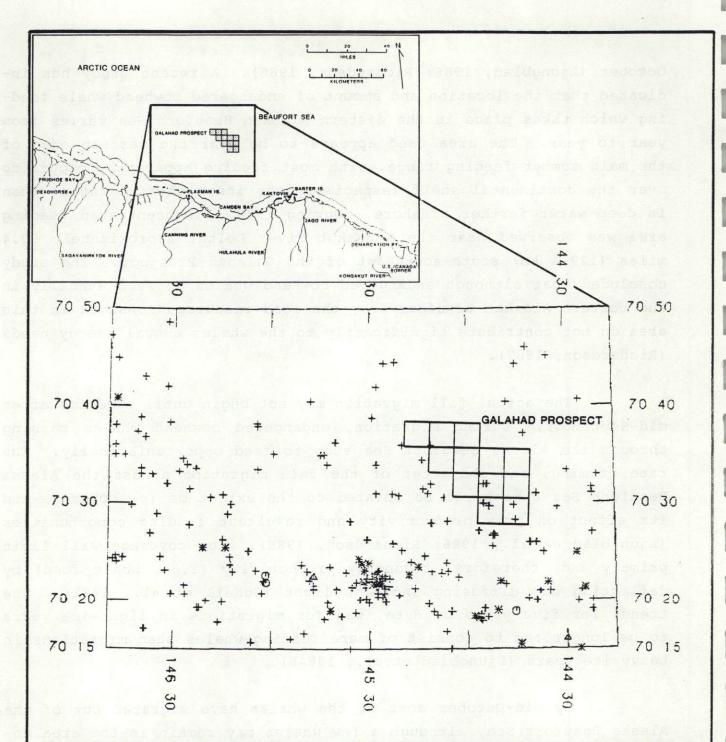
The bulk of the population (Fraker and Richardson, 1980) spends summer feeding in the Canadian Beaufort Sea, except for a small number of whales which may feed in an area east of Barter Island during late summer (Richardson, 1986; Richardson, 1987). In most years, a portion of the endangered bowhead whale population moves into the eastern Alaska Beaufort Sea during late August or early September and some remain in the area until October (Fraker, 1984; Richardson, 1986; Richardson, 1987).

Endangered bowhead whales usually begin moving westward into the Alaska Beaufort Sea in the latter half of August or first half of September (Ljungblad, 1981; Ljungblad et al., 1982, 1983; 1987). The arrival of these first whales is part of a gradual westward spread of the summer range and is distinct from the more rapid and direct movements associated with migration. In addition, there may be considerable movement of whales back and forth between the Canada and Alaska Beaufort Seas prior to the onset of the migration. Endangered bowhead whales seen in the Alaska Beaufort Sea in August have been generally farther offshore and in deeper water than those seen in September and

October (Ljungblad, 1986; Richardson, 1986). A recent study has indicated that the location and amount of endangered bowhead whale feeding which takes place in the eastern Alaskan Beaufort Sea varies from year to year. The area used appears to be near the western edge of the main summer feeding range, with most feeding apparently occurring over the continental shelf (especially the inner shelf), rather than in deep water farther offshore. During 1986, a concentrated feeding area was observed near the Kongakut River Delta, approximately 80.4 miles (129.4 km) south-southeast of the Galahad Prospect. The study concluded that although endangered bowhead whales do feed annually in the eastern Alaskan Beaufort Sea, the food resources consumed in this area do not contribute significantly to the whales annual energy needs (Richardson, 1987).

The actual fall migration may not begin until sometime after mid-September. During migration, endangered bowhead whales passing through the Alaska Beaufort Sea stop to feed opportunistically. The rate, timing, and character of the fall migration across the Alaska Beaufort Sea appears to be related to the extent of ice coverage and its effect on prey productivity and resultant feeding opportunities (Ljungblad et al., 1986; Richardson, 1986). Ice coverage will limit primary and, therefore, secondary productivity (i.e., whale food) by deflecting and diffusing incident light (Schell et al., 1982). The trend, for five years of data, was for migrations in light-ice years to be longer and to consist of more feeding whales than migrations in heavy ice years (Ljungblad et al., 1984b).

By mid-October most of the whales have migrated out of the Alaska Beaufort Sea, although a few whales may remain in the area until early November (Fraker, 1984). During the most recent survey of the fall migration (1986), it began on September 7 and lasted until October 17, and the highest concentration of endangered bowhead whales in the Alaska Beaufort Sea was 0.0027 whales/mi² (0.00703 whales/km²) in October (Ljungblad et al., 1987). Figure III-16 depicts the location of endangered bowhead whale sightings in the vicinity of the



THE LOCATION OF AERIAL SIGHTINGS OF BOWHEAD WHALES NEAR CAMDEN BAY IN THE BEAUFORT SEA. THE IGHTINGS WERE MADE FROM 1979 THROUGH 1987 BY THE MINERALS MANAGEMENT SERVICE, NAVAL OCEAN SYSTEMS CENTER AND LGL ECOLOGICAL RESEARCH ASSOCIATES. THE SYMBOLS DISTINGUISH SIGHTINGS OF FEEDING WHALES (\*) AND NON-FEEDING WHALES (+). THE LOCATIONS ARE SHOWN ALSO OF DRILLSITES (0) AND BOWHEAD WHALE SUBSISTENCE HARVESTS (TRIANGLE). ONE MINUTE OF LATITUDE EQUALS 1.0 NAUTICAL MILES, 1.2 STATUTE MILES, OR 1.8 KILOMETERS.

(MMS, 1988)

FIGURE III-16

LOCATION OF BOWHEAD WHALE SIGHTINGS (1979-1987) IN THE VICINITY OF THE GALAHAD PROSPECT Galahad Prospect as reported from 1979 through 1987 fall migration period in the eastern Alaska Beaufort Sea (Ljungblad et al., 1986; LGL, 1987; MMS, 1988).

Based upon an analysis of annual endangered bowhead whale sightings during the fall migration period (September to October), it appears the migration route is centered roughly along the continental shelf break. For the years 1979 through 1982 and 1984 through 1986, the observed annual medium water depth of whale sightings has been located between 82 feet (25 m) and 125 feet (38 m) in depth. During 1983 the medium depth was 476 feet (145 m). The reason for this offshore shift is unclear (Ljungblad et al., 1987).

## F. SOCIO-ECONOMICS

## (1) RELATED EMPLOYMENT AND UNEMPLOYMENT

Existing airport facilities in Deadhorse and, possibly, on Barter Island will be used for helicopter operations. In addition, harbor facilities in Tuktoyaktuk, Canada and, possibly, Prudhoe Bay will be used for ice classed support vessel operations.

Deadhorse is part of the Prudhoe Bay facilities complex, which was developed and continues to serve the needs of the oil and gas industry on the North Slope and in the Alaska Beaufort Sea. Today, the complex has grown to encompass an area of approximately 200 square miles (518 sq km) (Lynch et al., 1985).

The Prudhoe Bay facilities complex is an industrial enclave and individuals working in the complex have minimal contact with the local population. Most of the jobs in the complex are filled by non-residents who come to the region simply to work. The non-resident pattern of employment is associated with the technical nature of most of the jobs which precludes the use of unskilled or semi-skilled area

residents. Therefore, jobs available to North Slope residents from the Prudhoe Bay Unit, as well as other such units, have been limited (BLM, 1981).

A 1982 census of oil-related work sites in the North Slope Borough indicated that approximately 6,300 people were employed in the Prudhoe Bay-Kuparuk oil field complex, making this the largest North Slope employment center. However, a recent study (ACI, 1984) projected that 1985 oil field employment would be closer to 3,000. While 77.3 percent of the employees claimed Alaska as their state of residence, only 3.7 percent did not list a usual place of residence or listed the North Slope Borough (NSB) as their usual place of residence (Alaska Department of Labor, 1982).

The presence of resource development enclaves, however, has affected North Slope employment indirectly through the growth of the local government. The formation of the NSB in 1972 provided jobs in local government and enabled residents to collect a property tax on the Prudhoe Bay facilities. The Borough has used the tax resources not only to provide services and public facilities, but also to provide jobs (BLM, 1981).

Approximately 96 percent of Native employment in 1985 was related to NSB funds. Sixty-five percent of this employment was either through NSB operations or Capital Improvement Program (CIP). Residents seem to prefer the employment created by the NSB to jobs potentially available in the industrial enclaves at Prudhoe Bay (MMS, 1987).

## (2) LOCATION AND SIZE OF RELATED POPULATION AND INDUSTRY CENTERS

The Barrow-North Slope Census Division includes the entire northern coast of Alaska and encompasses 88,281 square miles (228,648 sq km) of territory (Alaska Department of Community and Regional

Affairs, 1977). The census division is very sparsely populated, with a 1985 projected total of about 8,300 permanent residents (State of Alaska, 1986; MMS, 1987), 64 percent of whom are Eskimo.

## (3) EXISTING COMMUNITY SERVICES

The North Slope Borough, a home-rule borough government headquartered in Barrow, provides most government and related services for the traditional Inupiat communities in the North Slope region. These services include such diverse and important functions as public safety, public utilities, fire protection, and most public health services. In recent years, the North Slope Borough's CIP in particular has prompted important changes on the North Slope. Funded by tax revenues from North Slope oil development and by federal and state matching funds and grants-in-aid, the CIP aims at upgrading housing, schools, public facilities and utilities, roads, and airports (MMS, 1984; MMS, 1987).

In addition to various goods and services available in individual communities, all Federal and State offshore oil and gas activities in the Alaskan Arctic are supported by the Prudhoe Bay facilities complex. The complex contains many support facilities in addition to various types of oil and gas processing equipment. A central power station located in the complex provides electricity to all field facilities. The station can generate 160 megawatts, which is enough electricity to power a city with a population of approximately 80,000 (Lynch et al., 1985). Other facilities include all required health, safety, and housing services (CSA, 1985).

#### (4) PUBLIC OPINION

Issues of major concern expressed by local residents in comments on the draft Environmental Impact Statement for Lease Sale No. 97 include (MMS, 1987):

- o The potential impacts of activities on subsistence harvest, habitat areas, and lifestyles.
- o The potential effects of activities on coastal areas, and on bird and marine mammal migration routes.
- o The accuracy of the analysis of oil spill prediction, and of the reported effects of oil spills on birds, fish, and marine mammals, particularly the bowhead whale.
- o The adequacy of environmental data used as the basis for impact analyses.
- o The ability of oil spill containment and cleanup equipment to operate in sea ice conditions, and the ability of this equipment to respond rapidly to a spill.
- o The ability of industry to design structures capable of withstanding the climatic conditions which exist in the area.
- o The accuracy of resource estimates.
- o Inupiat rights to certain areas proposed for sale in the lease offering.
- o Involvement of residents of North Slope villages in the mitigation process.

Public hearings were held in Barrow, Nuiqsut, Kaktovik, Anchorage, and Wainwright in December 1986 to discuss public opinions and to present views on the Draft Environmental Impact Statement. The issues raised are addressed in the Final Environmental Impact Statement for the Beaufort Sea Sale 97 Offering (MMS, 1987).

## (5) EXISTING TRANSPORTATION SYSTEMS AND FACILITIES

The NSB is linked to interior Alaska by the Dalton Highway, popularly called the Haul Road. Use of the Haul Road north of Dietrich Camp, which is located south of Deadhorse, is restricted to commercial carriers (MMS, 1984).

Annual average daily vehicle traffic on the Haul Road has been declining since the Trans-Alaska Pipeline System (TAPS) was completed in 1977. Vehicle capacity on the Haul Road had been estimated at 175 to 550 passenger car units in both directions (Berger and Associates, 1980), however, more recent levels have been at or below 100 (MMS, 1984).

Nearly every community and Distant Early Warning System (DEW-line) site on the North Slope has an internal, rudimentary road system linking the village or site with an airport, marine lightering site, or both. The Prudhoe Bay Unit, on the other hand, has an extensive, high quality gravel road system linking it to the Deadhorse Airport and various drill pads, storage, and dump sites. The road system connects with the Haul Road and has been extended west to serve the Kuparuk River field development (MMS, 1984).

Many activities associated with oil and gas activities use temporary ice roads. Winter operations on these roads are usually restricted to the period from November 1 through April 15 (MMS, 1984).

At this time, the Alaska Beaufort Sea coast has no deepwater ports. Ships must anchor offshore from approximately 0.5 to 1.1 miles (0.8 to 1.8 km). Cargo is then lightered ashore. Companies in the area which provide this service include Pacific Alaska Lines (a division of Crowley Maritime), Arctic Lighterage and Bowhead Transport, and the Alaska Puget United Transportation Company (MMS, 1984).

Barges transport most heavy and bulky cargo associated with petroleum-related activities in the North Slope Borough (Maynard-Partch/Woodward-Clyde Consultants, 1983). Prudhoe Bay has three barge docks. The east dock can accommodate vessel drafts of 4 feet (1 m), and the two west docks can accommodate vessel drafts of 6 and 10 feet (2 and 3 m). The end of the west dock has been expanded to accommodate deeper draft barges as part of the Prudhoe Bay Unit Waterflood Project (MMS, 1984).

Air transportation is the primary means of travel into the North Slope Borough (MMS, 1984). The Deadhorse Airport, which contains a 6,500-foot (1,981-m) paved airstrip, is located in the southeastern portion of the Prudhoe Bay Unit. The airport is operated by the State of Alaska and is equipped with the latest navigational aides, which allow for year-round operation of the airport (Lynch et al., 1985).

The airport on Barter Island is located on the north side of the island. The airport is connected by road to Kaktovik, which is approximately 0.5 miles (.8 km) to the south. The airport is owned by the U.S. Air Force and is equipped with a 5,000-foot, gravel runway.

## (6) SUPPLIES

All of the equipment and supplies needed to carry out the proposed operations will be purchased from outside the North Slope area and transported to the area by vessel or aircraft.

## A. GEOLOGIC HAZARDS

The following potential geologic hazards have been identified in the vicinity of the Galahad Prospect: seismicity, sediment transport, and permafrost. General information on potential geologic hazards is presented in Section III.A.(3) of this plan.

### (1) SEISMICITY

The magnitudes of measured earthquakes near Barter Island range from less than M = Richter 1.0 to a maximum of M = Richter 5.3. This seismic activity is associated with faults and faulting in the Camden Bay area which generally are to the south and east of the Galahad Prospect. The hazards generally associated with seismicity (i.e., ground acceleration, fault rupture, and seismically-induced ground failure) should not affect the proposed operations because of: the temporary nature of the proposed operations; the observed lack of major earthquakes (i.e., M = Richter 6.0 or greater) in the area; the relatively flat nature of the seafloor which minimizes the potential for ground failure; and Amoco's compliance with § 250.51 of the MMS regulations which requires the selection of a drilling unit which is designed to withstand the maximum environmental conditions, including seismic motion, anticipated to be encountered at the drilling sites.

## (2) SEDIMENT TRANSPORT

Sediment transport is considered to be an insignificant hazard to the proposed operations. Sediment instability and mass movement of seafloor sediments generally are related to relatively high seafloor gradients, low sediment strength in fine-grained

sediments, sediment loading from waves during the passage of storms, and ground motion during an earthquake. Hazards associated with mass movement are more likely to be found in the Camden Bay area during an earthquake, and in the deeper parts of the Lease Sale No. 97 area, particularly in the vicinity of the Continental Shelf break. Measures to guard against the effects of seismic activity have been discussed. With regard to water depth, the Galahad Prospect is situated on the Continental Shelf and the seafloor in the area of the leases is relatively flat in comparison to the steeper slopes found on the shelf break. In addition, the potential effects of sediment transport in the area of a well head, glory hole, or the anchor emplacements will be taken into consideration, as appropriate, in the design of the proposed drilling program.

Seafloor erosion from strudel scouring occurs during spring in the vicinity of river deltas. Generally, this phenomenon is confined to nearshore waters and should not affect the proposed operations.

The Galahad Prospect is located within the zone of grounded ice ridges and intense ice gouging. If required to do so by the MMS, measures will be instituted to protect operations (i.e., through the construction of a glory hole at one or more of the proposed well locations and through the management of ice with ice class support vessels) from the effects of ice incursions. Moreover, ice conditions will be monitored continuously to assess their potential impact on the safety of personnel and the integrity of the drilling unit.

#### (3) PERMAFROST

Relict permafrost may underly the Galahad Prospect. If thawing of the permafrost occurs around well casing during operations, then differential subsidence could occur, provided that the conditions of temperature, geotechnical properties, and ice content of the permafrost are appropriate. Potential permafrost hazards will be addressed when planning the specific drilling and casing programs for each well.

Current drilling and design technology can adequately compensate for permafrost conditions (MMS, 1984). Consistent with § 250.54 of the MMS regulations, sufficient cement, of a type especially suited to permafrost zones, will be used to fill the annular space between casing and permafrost to protect from thaw subsidence and freeze back effect.

Summary: Amoco believes that the proposed well locations can be drilled so that well bores will penetrate desired geologic targets and, to the maximum extent feasible, not intersect potential hazards. Consistent with the provisions of § 250.33 of the MMS regulations, a shallow hazards survey will be conducted in accordance with the specifications of the RSFO to determine the presence or absence of shallow geologic hazards. The results of the survey will be analyzed in the development of a well-specific drilling program and, upon request of the RSFO, will be submitted to the MMS with the APD for each well. Moreover, drilling, mud, casing, and cementing programs will be designed and carried out in accordance with the applicable MMS requirements.

Anchors used to moor the drilling unit will have a minor, short-term impact on the geologic environment. The anchors themselves and the anchor cables will "scar" the bottom in the immediate area of placement, and a small depression circled by a low relief mound will be created by anchor removal. These impacts should be short-lived due to the constant reworking of bottom sediments in the vicinity of the Galahad Prospect.

Impacts on the geologic environment that are expected to occur as a result of the proposed drilling operations include: the short-term, minor alteration of bottom topography; the localized redistribution of surface sediments; the localized alteration of the bedrock in the vicinity of the wellbore; and an insignificant removal of hydrocarbon resources if hydrocarbons should be encountered and production tested. Although unavoidable, the impacts associated with the proposed operations on the geologic environment are expected to be

minor and short-term. The wells will be plugged and abandoned at the completion of operations in accordance with § 250.110 of the MMS regulations.

## B. METEOROLOGY

## (1) WEATHER

Weather is a significant consideration in the design and conduct of operations in the arctic. For this reason, Amoco will select a drilling unit which is specifically designed to protect manpower and machinery from severe air temperatures and to withstand extreme wind loads. As a result, no significant impact on the proposed operations should result from the normal weather patterns experienced in the vicinity of the Galahad Prospect.

Severe weather associated with storms moving through the Alaska Beaufort Sea could cause temporary delays in certain operations. For example, if high winds associated with a severe weather event are adjudged to jeopardize personnel safety, exploratory drilling and/or research/monitoring operations will be suspended temporarily until safe operating conditions are restored. However, available technology and navigation systems have resulted in the design of drilling units and operational procedures which enable them to withstand severe weather events in the arctic.

Reduced visibility could cause temporary delays for the ice class support vessels and research vessel, and reduced visibility and ceilings could cause temporary delays for the helicopters and research/monitoring aircraft. Project-related vessels will have radar and project-related aircraft will be IFR equipped to minimize delays attributable to reduced visibility.

Visibility also can be a crucial factor in tracking the movement of an oil spill; however, tracking devices (e.g. the Orion tracking buoy system) are available from Alaska Clean Seas that can aid in tracking a slick during periods of reduced visibility. Foggy

conditions could reduce the short-term effectiveness of oil spill containment and cleanup efforts. Given the low probability of an oil spill, however, this is not considered to be a major factor militating against the proposed drilling activities.

## (2) AIR QUALITY

No significant impacts on onshore air quality are anticipated from the proposed exploratory drilling operations which will occur more than 30 miles (48.3 km) from the closest onshore area. The most likely operating scenario calls for the drilling program to be initiated by using one drilling unit to drill one well, probably on lease OCS-Y 1092, as early as the "open water" period in 1988. If initial exploratory drilling operations are successful, drilling operations may be conducted at one or more of the other four locations as early as the "open water" periods in 1989.

The principal sources of gaseous emissions from the proposed drilling activities will be the large diesel engines on the drilling unit. Small amounts of pollutants also may be produced if natural gas is flared during the testing phase.

Projected air emissions vary depending upon whether flaring takes place during production testing activities. "Worst case" projected emissions would include emissions from flaring. "Worst case" projected emissions (tons/well) for a 70-day, 12,000-foot well are as follows: NO = 43.37; SO = 2.50; TSP = 2.78; THC = 1.57; and CO = 6.55. The projected emissions for each pollutant are well below the emission exemption amount level established under § 250.45 of the MMS regulations. A more detailed description of the nature and quantity of the projected emissions and an explanation of how they were calculated appears in Appendix C of this plan.

Estimated total emissions (tons/well) from associated support activities (i.e., helicopters, ice class support vessels, and service bases) for  $\mathrm{NO}_{\mathrm{X}}$ ,  $\mathrm{SO}_{\mathrm{X}}$ ,  $\mathrm{TSP}$ , VOC, and CO also are presented in Appendix C of this plan. Although emissions from the ice class

support vessel are projected to exceed those from the drilling unit, they will mostly occur in the vicinity of the drilling unit and will not significantly affect any onshore area.

Although highly unlikely, the proposed operations could overlap with drilling activities by other companies in the vicinity of the Galahad Prospect. Theoretically, emissions from (an)other drilling unit(s) operating both simultaneously and closer to shore could mix with those from the Galahad Prospect and cause an exceedance of the exemption level for nitrous-oxide emissions. If such an impact was demonstrated through the conduct of a MMS required cumulative impact air quality analysis [see § 250.45(j)], emission levels could be reduced by: utilizing available pollution control technologies or operating procedures; agreements which would limit the conduct of simultaneous drilling operations; or moving (a) well location(s) further offshore and reaching desired geologic targets with (a) directional well(s) (MMS, 1987). Amoco has no plans to conduct simultaneous operations within, and is unaware of plans by any other Company to conduct simultaneous drilling operations inshore of, the Galahad Prospect.

In the unlikely event that a major oil spill occurs during the conduct of the proposed operations, Amoco's response may include in situ burning of oil. It should be noted that a decision to conduct in situ burning operations would be made only after a careful consideration, by Amoco and the appropriate governmental agencies, of all options and a determination that the benefits of conducting such operations outweigh the potential adverse impacts of such a decision.

In analyzing the <u>in situ</u> disposal technique, the North Slope Borough has expressed concern that the resulting smoke and residues could be harmful to the residents of coastal communities and/or subsistence resources (NSB, 1984). In January and March 1985, <u>in situ</u> oil burning tests were conducted at the U.S. Environmental Protection Agency's Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) facility in New Jersey. During these tests, air samples were taken for analyses of particles and chemical composition of the

smoke plume (Smith and Diaz, 1985). To the best of Amoco's knowledge, the results of the analyses have not been published to date. It is believed, however, that any contamination would be dispersed by wind and would therefore be reduced rapidly as the pollutants moved away from the burn site. In addition, while incremental degradations of air quality could occur, the air quality standards at any specific onshore location would be very unlikely to be exceeded (MMS, 1987).

Air pollution also would be created in the unlikely event of an oil or gas blowout, particularly if the blowout is accidentally or intentionally ignited. If the blowout involves gas, a portion of the gaseous hydrocarbons would be classified as volatile organic compounds (Stephens et al., 1977). Regardless of the air pollutants produced, it is unlikely that the concentrations of pollutants would exceed the air quality standards by the time they reach an onshore area (MMS, 1987).

## C. PHYSICAL OCEANOGRAPHY

# (1) EFFECT OF SEA ICE, SPRAY ICE, CURRENTS, AND WAVES ON THE PROPOSED ACTIVITIES

Sea Ice: Although the proposed operations are scheduled to take place during an "open water" period, sea ice may be present or move into the area during the conduct of operations. Consistent with § 250.51 of the MMS regulations, the drilling unit proposed drilling activities will perform the selected to specifically designed to withstand the forces of sea ice. To further mitigate problems associated with ice, Amoco will monitor ice movements during the conduct of operations and maintain ice class support vessels near the drilling unit to manage ice. If moving ice threatens drilling activities, the well will be shut in until safe operating If necessary, anchor mooring lines will be conditions are restored. disconnected using remote anchor release units to allow the drilling unit to withdraw temporarily from the drilling location.

Sea ice could impact the effectiveness of oil spill response equipment, and the safety of the personnel using it. However, such conditions also may increase recovery effectiveness by restricting the spread of spilled oil. A complete discussion of oil spill response equipment and capability is contained in Amoco's Oil Spill Contingency Plan for Exploratory Drilling Operations in the eastern Alaska Beaufort Sea OCS Area.

- b. <u>Superstructure Icing</u>: During fall storms, superstructure icing may be a factor which could temporarily affect the conduct of certain activities on the drilling unit and project-related vessels. During severe superstructure icing conditions, operations may have to be temporarily curtailed until the ice is removed and/or the contributing environmental conditions subside.
- c. <u>Currents</u>: The approximate mean speed of surface currents in the sale area is less than 1.0-foot/sec (30.5-cm/sec). Arctic class drilling units, like the KULLUK and CANMAR Explorer II, are designed to withstand maximum currents greater than those which exist in the sale area; thus surface currents should not be a limiting factor for the proposed operations.
- d. <u>Waves</u>: Wave heights in Alaska Beaufort Sea are less than 3 feet (1 m) 90 percent of the time. Arctic class drilling units, like the KULLUK and the CANMAR Explorer II, are designed to withstand a 100-year storm for the Beaufort Sea with a 24-foot significant wave height and a 12.5 second peak period; thus waves should not be a limiting factor for the proposed operations.

# (2) EFFECTS OF OPERATIONS ON WATER QUALITY

The adverse impact of the proposed operations on water quality will be minor and short-term in nature. The liquid and solid wastes generated from drilling at each proposed site are described in detail in Section II.K. of this plan. In summary, the major wastes discharged at the drillsite will be:

ESTIMATED Q	UANTITY
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Drilling Mud
Drill Cuttings and Wash
Water
Deck Drainage
Sanitary Wastes
Domestic Wastes
Desalinization Unit Wastes
BOP Fluid
Boiler Blowdown
Fire Control System Test
Water
Non-Contact Cooling Water
Ballast Water
Bilge Water
Test Fluids

WASTES

2,169,500 gallons per day
25,000 gallons per day
5,000 gallons per day
4,000 gallons per day
18,000 gallons per day
50 gallons per day
200 gallons per day
10,000 gallons per month

1,378,000 gallons per well

1,950,000 gallons per day 30,000 gallons per day 2,000 gallons per day 400,000 gallons per well

All liquid wastes will be discharged in accordance with the effluent limitations and monitoring requirements established by the EPA and set forth in the general NPDES permit for the Beaufort Sea, which prohibits the discharge of visible oil and floating solids.

The water column in the vicinity of the proposed operations will experience short-term degradation as a result of the discharge of drilling mud and drill cuttings. These discharges are composed mostly of water. The solids contained in these discharges will cause intermittent turbidity but settle rapidly. Studies of the dispersion and dilution of drilling mud discharged from offshore exploratory drilling units reveal that solids normally reach very low or background levels within about 3,280 ft (1,000 m) of the discharge pipe (Ayers, 1981). In addition, these quantities projected to be discharged are small compared to the natural sediment load of the Beaufort Sea (MMS, 1987).

Trace concentrations of heavy metals are sometimes associated with drilling mud and may be introduced into the water column as a result of mud discharges. These metals generally are present in very low concentrations in a highly insoluble and nonbioavailable

form (Cooper Consultants, Inc. and Envirosphere Company, 1987). Studies have shown that metal concentrations rapidly reach background levels within a short [3,280 ft (1,000 m)] distance of the discharge point (Ayers, 1981). A more detailed discussion of the impact of drilling mud and drill cuttings on marine flora and fauna appears in Part IV.E. of this section.

Prior to release, all sanitary water will be treated with chlorine maintained at a level greater than or equal to 1.0 ml/l, and thus will have a minimum impact on water quality. Domestic waste water from the kitchen, showers, and washing machines will not permanently alter water quality because it consists of natural or biodegradable substances.

Deck drainage and wash down water normally contain no toxic substances. If contaminated by hydrocarbons, they will be treated in the oil/water separator to insure that no visible sheen will occur when they are discharged into the ocean.

Ocean water used for engine cooling will not be contaminated by foreign materials. The temperature of discharged cooling waters will be below the range and volume thought harmful to marine biota.

Most formation waters are residuals from ancient seas and have a composition very similar to present day seawater. Should they be encountered during testing and contain visible oil, they will be handled in accordance with the provisions of the general NPDES permit.

Although highly unlikely, the proposed operations could overlap with drilling activities by other companies in the vicinity of the Galahad Prospect. Assuming that nearby, simultaneous operations occurred, the potential cumulative impact on the marine environment is judged to be negligible because: it is unlikely that simultaneous operations would occur at sites that are close together [i.e., less than 3 miles (5 km)]; wastes at each drill site would be deposited near the disposal site or spread, in low concentrations, over the

surrounding area; any envisioned quantity of discharges in the vicinity of the Galahad Prospect would be small in comparison to the natural sediment load found in the Beaufort Sea; the impact to any seafloor area affected by discharges would be short-lived because they would occur in a highly erosional environment; and Amoco assumes that all discharges would be subject to and would be made in a manner consistent with the general NPDES permit for the Beaufort Sea.

In summary, the impact on water quality of discharges of waste and liquid effluents from the proposed operations will be minor and short-term in nature.

## D. OTHER USES OF THE AREA

#### (1) SHIPPING ACTIVITIES

The proposed operations will have little if any impact on shipping activities. The very slight risk of a collision with vessels operating in the vicinity of the drilling unit or between project and non-project related vessels will be mitigated by Amoco's compliance with all U.S. Coast Guard safety, navigation, and notice requirements. These requirements also would apply to any other simultaneous drilling operations conducted in the vicinity of the Galahad Prospect, thus reducing the potential for a cumulative impact to be associated with the proposed operations.

#### (2) COMMERCIAL FISHING

The only continuous commercial fishing operation in the Alaska Beaufort Sea area is located in the vicinity of Colville River delta which is approximately 115.4 miles (185.7 km) west of the Galahad Prospect. The proposed exploratory drilling operations, or those of any other company conducted simultaneously with the proposed operations, will be so far away from the commercial fishery that they

will have no effect on commercial fishing operations. Moreover, no project-related aircraft or vessel will pass over or near the commercial fishery.

#### (3) MILITARY USE

There are no known active military operations taking place on or in the vicinity of the Galahad Prospect, nor are there any known active military operations taking place in any area that will be affected by project-related aircraft or vessels.

#### (4) EXISTING PIPELINES AND CABLES

There are no pipelines or cables on or in the vicinity of the Galahad Prospect.

# (5) MINERAL RESOURCE DEVELOPMENT OTHER THAN OIL AND GAS

There are no current plans to explore for any mineral resources, other than oil and gas, on the Galahad Prospect. The proposed operations will not interfere with future foreseeable mineral resource development activities in the area.

#### (6) CULTURAL RESOURCES

No known cultural resource areas exist on or in the vicinity of the Galahad Prospect. If a cultural resource, such as a shipwreck of historic significance, is discovered during site clearance activities or the drilling program, Amoco will notify the MMS and take immediate steps to protect the resource in compliance with Stipulation No. 1 of the Final Notice of Sale.

# (7) MARICULTURE ACTIVITIES

No mariculture activities take place on or in the vicinity of the Galahad Prospect.

# (8) OCEAN DUMPING

No ocean dumping activities take place on or in the vicinity of the Galahad Prospect.

# (9) RECREATION AND TOURISM

No recreation sites exist on or in the vicinity of the Galahad Prospect. Moreover, tourism is a negligible consideration in the eastern Alaska Beaufort Sea OCS Area. Thus, the overall effect of the proposed operations on recreation and tourism will be negligible (MMS, 1987).

# (10) SUBSISTENCE

The subsistence use areas which are closest to the Galahad Prospect are the ones utilized by the residents of Kaktovik, which is 34.6 miles (55.7 km) southeast of the Galahad Prospect (see Figure III-6), and Nuiqsut, which is 135 miles (217.2 km) west-southwest of the Galahad Prospect (see Figure III-6). Subsistence hunting and fishing activities from these villages occur year-round and utilize a wide variety of resources. A discussion of the primary subsistence activities occurring in the vicinity of the Galahad Prospect is provided in Section III.D.(10) of this plan.

The proposed well locations are situated in the eastern Alaska Beaufort Sea OCS area, outside the barrier islands and well away from the Kaktovik and Nuiqsut subsistence use areas. Onshore support operations will originate from existing facilities at Deadhorse and/or Barter Island (helicopters) and Tuktoyaktuk, Canada and/or Prudhoe Bay (ice class support vessels). Support craft, including the aircraft and vessel involved in the research/monitoring program, may pass through and over the Kaktovik and/or Nuiqsut subsistence use areas. If they do, they will follow routes and procedures which minimize interference with subsistence resources and uses, as recommended in Section 14(f) of the Information to Lessees portion

of the Final Notice of Sale. Specifically, project-related aircraft and vessels will maintain at least a 1.0-mile (1.6 km) horizontal distance and project-related aircraft will maintain at least a 1,500-foot (457-m) vertical distance from observed wildlife and known wildlife concentration areas, such as bird colonies or marine mammal concentrations, unless such actions would jeopardize human safety. Also, to reduce potential effects to endangered bowhead whales, project-related aircraft and vessel traffic will be minimized or rerouted to avoid disturbances to whales. For these reasons, the proposed activities should have no significant affect on terrestrial mammals (e.g., caribou, dall sheep, moose, and various furbearers), and birds and fish taken immediately along the coastline and further inland.

The marine mammals potentially affected by the proposed activities are endangered bowhead whales, beluga whales, seals (especially ringed and bearded), polar bears, and walrus. In addition, marine birds and fish can be found in the vicinity of the proposed activities.

Subsistence whaling activities occur in fall from Kaktovik and Nuiqsut. Kaktovik crews operate in an area bordered by Aanalaaq in Camden Bay on the west and Griffin Point on the east. Generally, Kaktovik crews remain within 10 miles (16 km) of shore; however, at the beginning of the hunting season, crews may travel as much as 20 miles (32 km) offshore (Jacobson and Wentworth, 1982). Crews from Nuiqsut travel as far east as the Canning River (Maynard-Partch/Wood-ward-Clyde, 1984), which is located 115.4 miles (185.7 km) west of the Galahad Prospect.

Beluga whales are taken incidental to the taking of endangered bowhead whales. From Kaktovik, beluga whales generally have been caught on the north side of Barter Island, near Pukak, and at Ugsruqtalik (Jacobson and Wentworth, 1982).

The importance of seals as a subsistence resource is believed to have diminished since the introduction of snowmobiles (Jacobson and Wentworth, 1982); however, sealing continues to occur from Kaktovik and Nuiqsut. Most seal hunting occurs along the coast-line and around the barrier islands. For Kaktovik, the most intensely used summer seal hunting area extends from Humphrey Bay on the east to Simpson Cove on the west. The Canning River delta and Flaxman Island also are important (Jacobson and Wentworth, 1982). From Nuiqsut, seals usually are taken during whaling and seal hunting may occur as far east as the Canning River delta (Maynard-Partch/Woodward-Clyde, 1984).

When actively hunted from Kaktovik, polar bears often are pursued out onto the ice beyond the barrier islands. However, Kaktovik's main hunting area is along the coastline between the Hulahula/Okpilak River delta and Pokok Lagoon, out to 10 miles (16 km) offshore. In recent years, polar bears almost always have been taken in the immediate vicinity of Kaktovik (Jacobson and Wentworth, 1982). From Nuiqsut polar bears usually are taken during whaling and polar bear hunting may occur as far east as the Canning River delta (Maynard-Partch/Woodward-Clyde, 1984).

Walrus are not often seen as far east as Kaktovik. Locations where walrus have been taken include Bernard Spit, and near Barter Island (Jacobson and Wentworth, 1982). There are no reports of walrus being harvested by Nuiqsut.

There is no evidence that either fish or birds are taken for subsistence purposes beyond the barrier islands. However, species which are important to subsistence users (e.g., Arctic cod and waterfowl such as brants, geese and eiders) may frequent, albeit in low numbers, waters in the vicinity of the Galahad Prospect.

From the preceeding discussion, it is clear that species utilized for subsistence purposes are not known to be concentrated in the vicinity of the Galahad Prospect or any other area that will be traversed by project-related aircraft and vessels. Instead, the species are spread over a wide area which may encompass areas where

the proposed operations will take place. Moreover, subsistence use activities are not known to occur in the vicinity of the Galahad Prospect.

To determine whether the proposed operations will result in a significant restriction of subsistence activities, the following factors have been considered:

- a. Will the proposed operations reduce the populations of harvestable resources?
- b. Will the proposed operations reduce the availability of resources by the alteration of their normal distribution patterns?
- c. Will the proposed operations limit access to subsistence resources.
- a. Potential to Reduce Populations of Harvestable Resources: Information on the distribution of harvestable resources is provided in Sections III.D.(1) and III.E.(3) of this plan. Information on the potential impacts of routine operations and the research/monitoring program on harvestable resources is provided in Parts IV.E.(1) and E.(2) of this section, and information on the potential impacts of a major oil spill on harvestable resources is provided in Part IV.E.(3) of this section. In general, the impacts are judged to be minor, short term, and localized in nature, and to be mitigated to the maximum extent practicable.

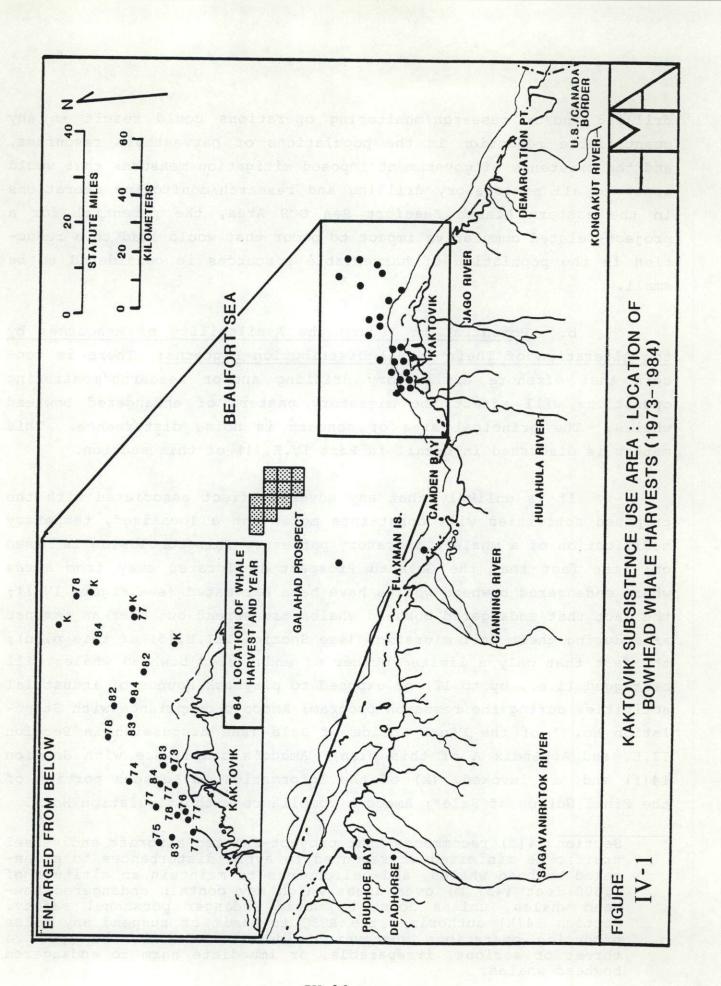
Although highly unlikely, the proposed operations could overlap with exploratory drilling and research/monitoring operations by other companies in the vicinity of the Galahad Prospect. Given the small geographic area occupied by exploratory drilling units and support vessels and aircraft, the localized nature of impacts, including those associated with airborne and underwater noise (see Part IV.E.(1) of this section), the limited circumstances under which exploratory

drilling and/or research/monitoring operations could result in any quantifiable reduction in the populations of harvestable resources, and the existence of government imposed mitigation measures that would apply to all exploratory drilling and research/monitoring operations in the eastern Alaska Beaufort Sea OCS Area, the potential for a project-related cumulative impact to occur that would lead to a reduction in the population of harvestable resources is considered to be small.

b. Potential to Reduce the Availability of Resources by the Alteration of Their Normal Distribution Patterns: There is concern that offshore exploratory drilling and/or research/monitoring operations will affect the migratory pattern of endangered bowhead whales. The principal area of concern is noise disturbance. This matter is discussed in detail in Part IV.E.(1) of this section.

It is unlikely that any adverse effect associated with the proposed activities will constitute more than a localized, temporary modification of a whale's migratory pattern. This conclusion is based on: the fact that the Galahad Prospect is located away from areas where endangered bowhead whales have been harvested (see Figure IV-1); the fact that endangered bowhead whales are spread out over an immense area during their fall migration (see Section III.E.(5) of this plan); the fact that only a limited number of endangered bowhead whales will be tagged (i.e., up to 12) or exposed to playback sounds of industrial activities during the research program; Amoco's compliance with Stipulation No. 7 of the Final Notice of Sale (see discussion in Section II.E. and Appendix A of this plan); Amoco's compliance with Section 14(f) and, if invoked, (k) of the Information to Lessees portion of the Final Notice of Sale\*; Amoco's compliance with Stipulation No. 2

<sup>\*</sup> Section 14(f) recommends that project-related aircraft and vessel traffic be minimized or rerouted to avoid disturbances to endangered bowhead whales, and helicopters to maintain an altitude of 1,500 feet (457 m) over areas which may contain endangered bowhead whales, unless doing so would endanger personnel safety. Section 14(k) authorizes the RSFO to limit or suspend any noise producing operations whenever he determines that they pose a threat or serious, irreparable, or immediate harm to endangered bowhead whales.



of the Final Notice of Sale\*; and Amoco's application of guidelines established by the MMS\*\* which are designed to assure protection of endangered bowhead whales. Even if localized, temporary effects occur, Amoco does not believe they will constitute a "significant" restriction on seasonal subsistence whaling activities. The same basic conclusion on subsistence uses also can be drawn for seals, polar bears, walrus, fish, and bird resources that may utilize waters in the vicinity of the Galahad Prospect or waters passed over or traversed by project-related aircraft and vessels.

c. <u>Limitation of Access to Subsistence Resources</u>: Subsistence use activities targeted on marine resources (e.g., endangered bowhead whaling) occur over a wide area. On the other hand, the proposed activities will occur in small, specific areas for a short period of time. Given the large area available to subsistence users and the small area affected by the proposed activities, it is unlikely that Amoco's operations will limit access to subsistence resources. In addition, Amoco's Galahad Prospect is located 30 miles (48.3 km) north of the closest onshore area used for subsistence purposes and approximately 12.2 miles (19.6 km) outside of the closest area where subsistence whaling activities (i.e., those originating in Kaktovik) take place (see Figure III-8).

Project-related vessel traffic could produce user conflicts, particularly if it occurs in the immediate vicinity of whaling activities during a year in which heavy ice conditions severely limit the length of the whaling season. To reduce potential project-related

<sup>\*</sup> Requires all personnel directly involved in the proposed operations to attend an Orientation Program which is designed to ensure, among other things, that they understand the importance of avoidance and nonharassment of endangered bowhead whales.

<sup>\*\*</sup> Project-related vessels will be operated at a speed that will make collisions with endangered bowhead whales unlikely; if visibility decreases to less than 3 miles (5 km), vessel speeds will be reduced. Project-related vessels will maintain a minimum approach distance of 1 mile (1.6 km) from endangered bowhead whales.

vessel conflicts with whaling crews, Amoco will work for the reestablishment of the Oil/Whalers Cooperative Agreement which, in 1986 and 1987, resulted in the establishment of a radio network to facilitate communications between project-related vessels and whaling boats. Under such an agreement, each project-related vessel and whaling boats would have a radio that would be tied into a shorebased clearinghouse by a special frequency. The purpose of the radio network would be to allow for the regular compilation and rapid dissemination of information on project-related vessel and whaling boat locations, the activities they are engaged in, and their movements.

d. <u>Summary of Potential Impacts and Mitigation Measures:</u>
For this portion of the analysis, Amoco has distinguished between potential impacts from routine operations and an oil spill.

Routine Operations: Routine operations should not result in a reduction in the population of harvestable resources, a reduction in the availability of harvestable resources, or a limitation on the access of subsistence users to harvestable resources. The proposed drill sites and areas that will be passed over or traversed by project-related aircraft and vessels do not correspond to areas where harvestable resources concentrate and they are generally outside the areas where subsistence use activities traditionally take place. Also, available evidence suggests that the drilling unit itself, project-related noise, and permitted discharges should have no significant effect on either the harvestable resources or subsistence activities. Any affects experienced are expected to be localized and temporary in nature.

To mitigate potential impacts during the conduct of the proposed operations, project-related vessels and aircraft will follow routes, in conformance with the recommendations in Section (f) of the Information to Lessees portion of the Final Notice of Sale, and project-related aircraft will operate at altitudes which are specifically designed to minimize the potential adverse impacts of the proposed operations on, among other things, harvestable resources and

subsistence use activities. Moreover, potential impacts on subsistence use activities and resources will be further mitigated by the conduct of the Orientation Program mandated by Stipulation No. 2 of the Final Notice of Sale. Through this program, Amoco and contract personnel will be informed of the nature and timing of subsistence use activities, the type and distribution of subsistence resources, the potential impacts of the proposed operations on subsistence use activities and resources, and the means of avoiding or mitigating potential conflicts.

During the endangered bowhead whale fall migration period, there will be minimal project-related vessel traffic in the immediate vicinity of the drill sites and along the route of what is most likely to be a limited number of migrating whales. If endangered bowhead whales are encountered by a project-related support vessel, Amoco will comply with the MMS operating guidelines.\* Also, Amoco will: work for the re-establishment of the Oil/Whalers Cooperative Agreement which, in 1986 and 1987, resulted in the establishment of a radio network that facilitated communications between vessels engaged in oil and gas operations and whaling boats; comply with all U.S. Coast Guard notice requirements which are designed to alert vessels, including those engaged in subsistence use activities, of the presence and operating frequency of project-related vessels; and, if invoked, comply with the operating procedures dictated by the RSFO under Section

reducing vessel speed within 300 yards (275 m) of the animal(s);

steering around the animal(s), if possible; 0

tion; and

0

If (a) project-related vessel(s) inadvertently approaches within 1 mile (1.6 km) of (an) endangered bowhead whale(s), the vessel operator(s) will take every precaution to avoid harrassment of the animal(s) by:

operating the vessel(s) in such a way as to avoid separating 0 members of a group of animals from other members of the operating the vessel(s) to avoid multiple changes in direc-

checking the waters immediately adjacent to the vessel(s) to ensure that no animal(s) will be injured when the propellers are engaged.

14(k) of the Information to Lessees portion of the Final Notice of Sale which empowers the RSFO to limit or suspend any noise-producing operations whenever he determines that they pose a threat of serious, irreparable, or immediate harm to endangered bowhead whales.

Onshore support facilities that will be used in Deadhorse, Tuktoyaktuk, Canada and, possibly, at Prudhoe Bay or on Barter Island are already in place and are being or have been utilized by the oil and gas industry without a significant adverse affect on either harvestable resources or subsistence use activities.

Although highly unlikely, the proposed operations could overlap with drilling and research/monitoring operations by other companies in the vicinity of the Galahad Prospect. Information on the potential cumulative impacts of simultaneous operations on the populations of harvestable resources is provided in Parts IV.E.(1), (2), and (3) of this section. Although the potential for impacts may increase in proportion to an increase in the scale of offshore oil and gas operations, the impacts are still judged to be minor in nature and, Amoco assumes, would be mitigated to the maximum extent practicable.

Oil Spill: It is unlikely that a major oil spill will occur during the proposed operations (see Part IV.G.(1) of this section). If a major spill does occur, response equipment located on the drilling unit and available through Alaska Clean Seas and other response organizations in and, if necessary, outside Alaska will be activated to minimize the area and subsistence resources affected by the spill.

Spilled oil would have an adverse affect on harvestable resources which come into contact with the oil. The potential impacts are discussed in detail in Part IV.E(3) of this section. However, the number of animals affected is expected to be small because of their wide distribution [see Section III.E.(1), (3), and (5) of this plan] and the ability of most species to avoid an affected area [see Part IV.(E)(3) of this section]. Subsistence activities also would have to be curtailed in the affected area; however, subsistence use activities

directed at any one harvestable resource also occur over a large area [see Section III.D.(11) of this plan] thus reducing the likelihood that the temporary closure of an area would preclude community access to one or more harvestable resources.

#### (11) NATIVE CLAIM ALLOTMENTS

There are no native claim allotments in the proposed project area.

#### E. FLORA AND FAUNA

Drilling, testing, and abandonment operations on the Galahad Prospect and project-related research/monitoring operations will be conducted in a way that minimizes impacts on the flora and fauna in any affected area.

#### (1) IMPACTS ON FLORA AND FAUNA FROM ROUTINE (NON-ACCIDENT) EX-PLORATION ACTIVITIES

The potential, project-related impacts on the major groups of flora and fauna of day-to-day, routine operations are discussed below. A summary of these potential impacts is provided in Table IV-1.

a. <u>Phytoplankton</u>: Local, temporarily increased levels of turbidity caused by the discharge of dredge material (i.e., from glory hole construction operations) and the discharge of drilling mud, drill cuttings, wash water, deck drainage, sewage waste, and excess cement could decrease phytoplankton photosynthesis by temporarily obstructing light penetration in the plume area. The decreased photosynthesis effect could cause minor, short-term impacts on the phytoplankton populations that pass through a plume extending 656 feet (200 meters) from the discharge point (Ecomar, 1978). However, Hester (1981) indicates that the effect of such a plume on solar energy available for photosynthesis is not significant compared to changes in water

# TABLE IV-1

# SUMMARY OF POTENTIAL IMPACTS ON FLORA AND FAUNA FROM ROUTINE OPERATIONS

FLORA OR FAUNA TYPE	POSSIBLE IMPACT	REASON WHY IMPACT IS MINIMAL
Phytoplankton	Decrease in photosynthesis caused by increased turbidity due to the discharge of dredge materials (i.e., if glory holes are constructed), drilling muds, and drill cuttings.	Occurs in limited area, normally no more than 3,280 feet (1,000 m) from discharge point.
	Toxic effect of drilling muds.	Toxicity levels of drill- ing muds are reduced to acceptably low levels when discharged in accor- dance with the general NPDES permit.
Zooplankton	Smothering or decrease in filter feeding efficiency caused by increased turbidity.	Occurs only in the immed- iate vicinity of dis- charge point and for short time.
	Toxic effect of drilling muds.	Toxicity levels of drill- ing muds are reduced to acceptably low levels when discharged in accor- dance with the general NPDES permit.
	Entrainment and death in cooling systems of drill-ing units.	Entrainment will cause negligible impact on zoo-plankton populations because of temporary nature of activities.
Benthic (Bot- tom-Dwelling) Animals	Smothering or burial by dredge materials (i.e., if glory holes are constructed), settled muds and cuttings, and anchor implacements.	Affects only a small area usually within few hundred meters of a drilling site. The changes will be temporary and highly localized. Some local species populations may

FLORA OR FAUNA TYPE	POSSIBLE IMPACT	REASON WHY IMPACT IS MINIMAL		
	o Ways: deoressed primarys po directed action for subjection by the production by and Suckers, 1984). Extense	be displaced because of localized changes in physical properties of the sediment.		
Mekton (swim- None ning or mobile nimals)		Smothering and clogging unlikely because animals can move away from disturbances.		
	chilim of the historic pola- for enstanded solids and too very clickely that partoplen high concentrations necessar s in the cischarge are bound	Toxicity levels of drill- ing muds are reduced to acceptably low levels when discharged in accor- dance with the general NPDES permit.		
Pelagic Birds	Collisions with structures; disturbance due to human presence and	Proposed operations will occur away from staging, nesting, and molting areas.		
		Collisions are unlikely and would affect an insignificant number of birds.		
		Project-related aircraft and vessels will comply with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale.		
Marine Mammals (pinnipeds and cetaceans)	Disturbances due to human presence and noise.	Proposed operations will occur away from hauling out and breeding areas.		
		with the recommendations in Sections 14(f) and (k) of the Information to		

transparency due to coastal runoff, primary productivity, and typical cloud cover. The effect of these discharges on the productivity of the regional phytoplankton population will be negligible.

The trace metals in drilling mud discharges could affect phytoplankton in one of two ways: decreased primary production and/or increased mortality due to direct acute or sublethal toxic effects of trace metals; or stimulation of primary production by trace nutrients in the discharges (Jones and Stokes, 1984). Extensive research has demonstrated that generic drilling muds approved for use under the general NPDES permit will have adverse impacts on marine organisms only at very high concentrations, and that such concentrations only occur in the immediate vicinity of the discharge point (Ayers, 1981). The short residence time for suspended solids and toxic materials in the water column makes it very unlikely that phytoplankton will be exposed long enough to the high concentrations necessary to show toxic effects. Also, most metals in the discharge are bound to particulates and are, therefore, unavailable for uptake by the organisms (Jones and Stokes, 1984). Any adverse effects on the phytoplankton will be concentrated to a small area around the drilling unit and will have a temporary and insignificant impact on regional phytoplankton populations.

Although highly unlikely, the proposed operations could overlap with drilling and research/monitoring operations by other companies in the vicinity of the Galahad Prospect. Assuming that nearby, simultaneous operations occurred, the potential cumulative impact on the regional phytoplankton population is judged to be negligible because: the phytoplankton population levels in the vicinity of the Galahad Prospect at the time of the proposed operations are projected to be low; it is unlikely that simultaneous operations would occur at sites that are close together [i.e., less than 3 miles (5 km)]; wastes at each drill site would enter the water column near the disposal sites or spread, in low concentrations, over a small area in comparison to that occupied by phytoplankton; any envisioned quantity of discharges in the vicinity of the Galahad Prospect would be small

in comparison to the natural sediment load found in Beaufort Sea; Amoco assumes that all discharges would be subject to and would be made in a manner consistent with the general NPDES permit for the Beaufort Sea; and there is no evidence that vessel and aircraft operations will have any adverse impact on phytoplankton.

b. Zooplankton: Increased turbidity caused by the introduction of discharged materials to the marine environment has been found to have a smothering effect on some passive and slow-moving zooplankton species. Temporary clogging of the filter feeding mechanisms of some zooplankton could occur, resulting in decreased filtering and feeding efficiency. However, this effect lasts only a few minutes for a given water parcel passing by the discharge point and will have a minor, short-term effect on the regional zooplankton population. For example, Benech et al. (1980) noted that there was no discernable impact on a sessile marine community 33 feet (10 m) downstream of a mud discharge source.

Zooplankton populations have been found to experience effects from trace metal concentrations in drilling mud discharges. These effects include: decreased growth, altered behavior, and/or increased mortality due to the direct acute or chronic effects of toxic materials in drilling muds; or indirect enhancement or inhibition of populations resulting from impacts on phytoplankton. However, no significant impacts are expected from the proposed operations for the same reasons outlined in the discussion of phytoplankton impacts (Jones and Stokes, 1984).

Entrainment mortality of planktonic organisms due to thermal shock in the cooling system of a drilling unit could occur. However, due to the temporary nature of the drilling operations, the small volume of water pumped, and the high regional abundance of organisms, the effect on the regional zooplankton population will be negligible.

Although highly unlikely, the proposed operations could overlap with drilling and research/monitoring operations by other

companies in the vicinity of the Galahad Prospect. Assuming that nearby, simultaneous operations occurred, the potential cumulative impact on regional zooplankton populations is judged to be negligible because: the zooplankton population levels in the vicinity of the Galahad Prospect at the time of the proposed operations are projected to be low; it is unlikely that simultaneous operations would occur at sites that are close together [i.e., less than 3 miles (5 km)]; wastes at each drill site would enter the water column near the disposal site(s) or spread, in low concentrations, over a small area in comparison to that occupied by zooplankton; any envisioned quantity of discharges in the vicinity of the Galahad Prospect would be small in comparison to the natural sediment load found in Beaufort Sea; Amoco assumes that all discharges would be subject to and would be made in a manner consistent with the general NPDES permit for the Beaufort Sea; and there is no evidence that vessel and aircraft operations will have any adverse impact on zooplankton.

c. <u>Benthos</u>: Short-term, highly localized effects to the benthic environment will be limited to temporary seabed accumulations of settled solids from discharged drilling mud, drill cuttings and, possibly, sediments excavated in the construction of (a) glory hole(s).

The majority of heavy cuttings together with some entrained drilling muds will settle to the bottom and could result in the smothering and burial of some benthic species inhabiting the ocean bottom within 328 feet (100 m) of the drilling unit (Menzies et al., 1980). Localized depression of faunal communities due to smothering effects will be most likely in areas where deposition of cuttings on the benthos exceeds 0.4 inch (1 cm) and persists for more than a few days (Jones and Stokes, 1984). In addition, the sediment composition of the bottom may be altered and impacts to benthic communities can occur from 492 feet (150 m) to 2,624 feet (800 m) of the drilling unit (Menzies et al., 1980). Evidence indicates that smothering effects are limited to small areas where current energy is sufficiently low to allow solids to settle rapidly, and are not detectable in high-energy

locations where solids are rapidly dispersed. Smothering either does not occur or the effects are limited to the bottom within a few hundred meters of the drilling site (Hester, 1981). Recovery within the smothered area would begin within days and the bottom would be repopulated within a short period of time.

In the event that a glory hole is constructed to house and protect blowout prevention and other well head equipment from ice incursions, construction operations will have an adverse impact on benthic organisms associated with the affected seafloor area. Organisms will be disrupted, smothered and/or crushed. The impact of these activities to the benthic environment will be minor from a regional perspective. Moreover, recolonization of the affected area will likely begin within days and the bottom will be repopulated within a short period of time following removal of the drilling unit from the site.

Accumulation of settled solids will result from the discharge of sediments excavated during the construction of a glory hole. Sediment released during glory hole construction will cover benthic organisms resulting in mortality or reduced reproductive success caused by smothering, inability to feed, or other mechanisms. This effect will be limited to the area immediately around the drill site. Based on the results presented for shallow water by NORTEC (1981a), seafloor accumulations of discharged solids will be indiscernible following project completion. The time required for replacement of benthic infaunal organisms lost as a result of accumulations of settled solids could vary from a few weeks (worms) to a few years (bivalves). However, the relative area affected is so small that such losses will be insignificant to regional populations.

The anchors used to moor the drilling unit and the anchor chains will adversely affect the bottom community within the immediate area of anchor placement. This effect will be temporary since the bottom community will rapidly repopulate the area once the anchors and anchor chains are removed.

In summary, most of the impact on the benthos will be through localized burial effects and displacement of some infaunal and epifaunal organisms that exhibit strong preferences for sediment particle size, microrelief, or availability of fouling organisms from the drilling unit. The changes will be temporary and highly localized.

Although highly unlikely, the proposed operations could overlap with drilling and research/monitoring operations by other companies in the vicinity of the Galahad Prospect. Assuming that nearby, simultaneous operations occurred, the potential cumulative impact on the regional population of benthic organisms is judged to be negligible because: the Galahad Prospect is located in a highly erosional environment where benthic populations are low; it is unlikely that simultaneous operations would occur at sites that are close together [i.e., less than 3 miles (5 km)]; wastes at each drill site would be deposited near the disposal site(s) or spread, in low concentrations, over the surrounding area(s) thus affecting a small seafloor area; any envisioned quantity of discharges in the vicinity of the Galahad Prospect would be small in comparison to the natural sediment load found in the Beaufort Sea; Amoco assumes that all discharges would be subject to and would be made in a manner consistent with the general NPDES permit for the Beaufort Sea; and there is no evidence that vessel and aircraft operations will have any adverse impact on benthic organisms.

d. Nekton: Since EPA-approved generic drilling muds have a very low toxicity and are rapidly dispersed, nekton are not expected to be adversely affected by the discharged materials (Neff, 1981). Also, most metals in the discharges are bound to particulates and are, therefore, unavailable for uptake by the organisms (Jones and Stokes, 1984). Even in the most sensitive species, studies show that deleterious sublethal responses are observed only following protracted exposure to whole suspended mud concentrations in the range of 100 ppm (Neff, 1981). Such exposures from the proposed drilling activities are unlikely to occur for periods exceeding a few minutes. Thus the

impact of the discharge plume on these marine organisms will be highly localized and minimal. Also, the limited effects which the discharges will have on benthic communities, phytoplankton, and zooplankton suggest the food supply reduction for the fish will be inconsequential (Jones and Stokes, 1984).

Fish and most motile pelagic species should be able to avoid discharge plumes and areas of high turbidity resulting from the proposed exploratory drilling operations (Cooper Consultants, Inc. and Envirosphere Company, 1987). Although some studies indicate that fish may be attracted to a discharge plume, it is likely that the stress brought on by their encounter with particulates in the main body of the plume would restrict fish to the plume edges (Jones and Stokes, 1984). Moreover, following cessation of the discharges, fish are likely return to the discharge area (Cooper Consultants, Inc. and Envirosphere Company, 1987).

Fish eggs could be adversely affected by drilling discharges. Discharged drilling fluids smother the eggs of cottids (Arctic cod) and other demersal fish (Jones and Stokes, 1984). However, the potential size of the affected area is relatively small (Cooper Consultants, Inc. and Envirosphere Company, 1987).

Although highly unlikely, the proposed operations could overlap with drilling and research/monitoring operations by other companies in the vicinity of the Galahad Prospect. Assuming that nearby, simultaneous operations occurred, the potential cumulative impact on regional fish populations is judged to be negligible because: fish concentrations in the Beaufort Sea are low; it is unlikely that simultaneous operations would occur at sites that are close together [i.e., less than 3 miles (5 km)]; wastes at each drill site would be introduced to the marine environment near the disposal site(s) or spread, in low concentrations, over the surrounding area(s) thus affecting a small ocean area; any envisioned quantity of discharges in the vicinity of the Galahad Prospect would be small in comparison to the natural sediment load found in the Beaufort Sea; Amoco assumes

that all discharges would be subject to and would be made in a manner consistent with the general NPDES permit for the Beaufort Sea; and there is no evidence that vessel and aircraft operations will have any adverse impact on fish.

e. <u>Birds</u>: Routine operations should have little, if any, impact on birds in the eastern Alaska Beaufort Sea. Areas of concern relate to disturbance effects associated with human presence, the disposal of wastes, airborne and underwater noise, and artificial illumination.

Human Presence: The primary concern is that humans and/or project-related facilities (i.e., the drilling unit and/or support craft) will encroach upon sensitive habitat areas for birds, particularly the threatened peregrine falcon. This potential impact is mitigated by the following facts: peregrine falcons do not occupy the coastal area which will be affected by the proposed operations; Amoco will use existing facilities, which are located away from sensitive habitat areas for birds, for onshore supply bases; Amoco will comply with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale by requiring project-related aircraft and vessels to maintain at least a 1-mile (1.6 km) horizontal distance and project-related aircraft to maintain at least a 1,500-foot (457-m) vertical distance from known bird staging, nesting and molting areas; and the proposed well locations are located away from bird concentration areas.

Disposal of Wastes: Routine discharges from the drilling unit, ice class support vessels, the research vessel, and at the shorebase(s) will be approved by the EPA and will be made in accordance with the provisions of the general NPDES permit for the Beaufort Sea, and should have no direct impact on bird resources. The potential impacts of these discharges on bird food resources are discussed in Part IV.E.(2) of this section. The stated impacts are temporary, highly localized, and generally minor in nature, and should have little, if any, affect on birds.

Airborne and Underwater Noise: Reactions to airborne noise vary with species, stage of annual life cycle, previous exposure to aircraft or other sources of noise, and the vertical and horizontal distance of the noise source from the affected birds. Potential impacts include: loss of habitat; increased energy expenditure which could lead to decreased productivity and increased mortality of adults and young; behavioral reactions that may increase mortality rates for young birds from chilling, predation, or injury; abandonment of nests; and a delay in the onset of nesting (Lewbel, 1983; Sterling and Dzuben, 1967; Ward and Sharp, 1974; Owens, 1977; Cooch, 1958).

Potential impacts associated with <u>airborne noise</u> will be mitigated by the fact that the shorebases, proposed well locations, and areas that will be passed over or traversed by project-related aircraft and vessels are situated away from sensitive habitat areas and, as a result, the number of birds that potentially could be affected is small in comparison to regional populations. Potential impacts will be mitigated further by Amoco's compliance with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale which, among other things, recommends that aircraft maintain a minimum altitude of 1,500 feet (457 m), unless doing so would jeopardize the safety of personnel.

Underwater noise should have no direct affect on birds and a minimal impact on bird food resources. The ecological significance of industrial sound perception by fish is not clear since variable responses and habituation to underwater sound have been observed in a number of instances (Olsen, 1976; Byers and Kashino, 1980; Chapman and Hawkins, 1969). It is likely that fish will hear noise from drilling operations, ice class support vessels, the research vessel, and other industrial sources over a distance of more than several miles. Some fish may avoid the immediate area of chronic, intermittent, high amplitude sound; however, this is unlikely to adversely affect regional populations. In addition, it appears probable that many species will become habituated to stationary and relatively continuous noise

sources (Dome Petroleum Ltd. et al., 1982). As a result, the degree of regional impact of <u>underwater noise</u> on fish in the eastern Alaska Beaufort Sea is expected to be negligible.

Artificial Illumination: In late summer and autumn (i.e., when large numbers of birds are present and the hours of darkness are on the increase), some birds may be attracted to and possibly collide with a drilling unit as a result of their attraction to artificial lighting on a drilling unit or, during the testing phase, a gas flare. Threatened peregrine falcons do not frequent coastal and offshore areas. Moreover, the number of non-endangered bird species that can be reasonably expected to be affected is small and, as a result, the potential impact is considered to be negligible.

Cumulative Impact: Although highly unlikely, the proposed operations could overlap with drilling and research/monitoring operations by other companies in the vicinity of the Galahad Prospect. The potential cumulative impact of simultaneous operations on birds is judged to be negligible because: threatened peregrine falcons do not occupy coastal and offshore habitats; non-endangered bird species concentrations in offshore areas are low; Amoco assumes that all operations would be subject to mitigation measures similar to the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale, and as a result, that all aircraft and vessels would maintain at least a 1-mile (1.6-km) horizontal distance and all aircraft would maintain at least a 1,500-foot (457-m) vertical distance from known bird staging, nesting and molting areas; and Amoco assumes that all operations would be subject to and be required to follow the provisions of the general NPDES permit for the Beaufort Sea.

f. Marine Mammals: The impacts of routine operations on marine mammals should be minimal. The marine mammals of primary concern are beluga and endangered bowhead whales and ringed seals. Beluga and endangered bowhead whales may be present in the vicinity of the proposed operations from late August through October. Ringed

seals are present in nearshore waters throughout the year. Although the whale species reach their peak in the project area and along the routes of project-related aircraft and vessels during fall, animal densities at a particular location (e.g., a drill site) will be low.

The areas of concern for marine mammals are similar to those for birds.

Human Presence: Migration is a critical lifestage activity for beluga and endangered bowhead whales, and this activity takes place in a habitat which will be occupied by the drilling unit, ice class support vessels and the research vessel, and flown over by project-related aircraft. The area potentially affected by the proposed operations is extremely small in comparison to the area used by migrating whales. Moreover, any deviation in migratory patterns caused by the presence of project-related facilities appear to be temporary in nature and should cause no long term changes to annual migratory patterns (Ljungblad et al., 1987).

Studies conducted in both the Canadian and Alaskan Beaufort Sea indicate that endangered bowhead whale behavior can be affected markedly but temporarily by the close approach of vessels or aircraft (LGL and Greeneridge Science Inc., 1987; Richardson et al., 1985). During these studies, reactions were less obvious in cases where industrial activities continued for hours or days, such as distant seismic exploration, drilling, and dredging operations. This suggests that transient operations are more disturbing than ongoing operations. One reason for this may be that endangered bowhead whales will exhibit a startle reaction to the sudden onset of an activity, but then habituate to the associated sounds if the activity continues. It also is possible that endangered bowhead whales may vary in their level of sensitivity to industrial noise, and that animals seen near such activities are the less sensitive individuals (Richardson et al., 1985).

Reactions of endangered bowhead whales to disturbance by a vessel or aircraft have included brief, incidental interruptions of feeding, movement or orientation away from the approaching vessel, and disruptions of social groupings. It is more difficult to determine reactions to ongoing operations; however, studies have shown that the duration of surfacings and dives, and the number of blows per surfacing tend to be reduced in the presence of such operations (Richardson et al., 1985; Richardson, 1986; LGL and Greeneridge Science Inc., 1987). In addition, noise disturbances could mask an endangered bowhead whale's call thus reducing the range at which the calls are detectable to other whales (Richardson et al., 1985).

The analysis of endangered bowhead whale distribution in and around the area of offshore exploration operations in the Canadian Beaufort Sea over a period of several years appears to document a trend toward their reduced utilization of the main industrial area. However, endangered bowhead whale distribution also varied outside the main industrial area, suggesting that other factors, such as food availability, may be involved in the changing distribution pattern (Richardson et al., 1985; Richardson, 1986; Richardson, 1987).

Recent studies conducted in the Alaskan Beaufort Sea have attempted to determine the response of migrating endangered bowhead whales to ongoing exploratory drilling operations (LGL and Greeneridge Science Inc., 1987; Ljungblad et al., 1987). These studies concentrated on activities conducted at the Hammerhead and Corona Prospects, which are located 21.8 miles (35 km) and 9 miles (14.4 km), respectively, from the Galahad Prospect. These studies indicate that, although endangered bowhead whales were observed relatively near ongoing drilling activities [note: six (6) whales were sighted within 8 miles (13 km) and 118 whales were sighted within 31 miles (50 km) of the Hammerhead Prospect], the overall distribution pattern of, and distance from the activities maintained by, the migrating whales suggest that avoidance behavior may have been occurring (Ljungblad et

al., 1987). At the same time, the studies found that the observed whales exhibited no, or at most subtle, behaviorial responses (LGL and Greeneridge Science Inc., 1987).

The above mentioned studies included additional analyses to determine whether the drilling activities acted as a "barrier" to the westward migration. These analyses indicate that whales passed both north and south of the drilling site on the Hammerhead Prospect, and that the diversion of the migration was temporary and caused no significant delay in the fall 1986 migration (LGL and Greeneridge Science Inc., 1987; Ljungblad et al., 1987). It should also be noted that the drilling activities had no apparent adverse impact on subsistence whaling activities. In fact, the hunt in 1986 was one of the most successful in recent years (i.e., three (3) whales were taken by Kaktovik whalers, and one (1) whale was harvested by Nuiqsut whalers) (LGL and Greeneridge Science Inc., 1987).

Potential project-related impacts to subsistence resources will be minimized by Amoco's compliance with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale which suggest that:

- o Project-related aircraft and vessels maintain at least a 1-mile (1.6 km) horizontal distance from observed wildlife or known wildlife concentration areas.
- o Project-related aircraft and vessel operations be minimized or rerouted to avoid disturbances to endangered bowhead whales.
- o Project-related aircraft maintain an altitude of 1,500 feet (457 km) when in transit over areas that may contain endangered bowhead whales, unless doing so would jeopardize human safety.

During the endangered bowhead whale fall migration period, there will be minimal project-related vessel traffic in the immediate vicinity of the drill sites and along the route of a small number of migrating whales. If whales are encountered by a project-related vessel, the following MMS mandated guidelines will be observed:

- The vessel will operate at a speed that will make collisions with endangered bowhead whales unlikely; if visibility decreases to less than 3 miles (5 km), vessel speed will be reduced.
- The vessel will maintain a minimum approach distance of 1 mile (1.6 km) from endangered bowhead whales.
- o If the vessel inadvertently approaches within 1 mile (1.6 km) of (an) endangered bowhead whale(s), the vessel operator will take every precaution to avoid harrassment of the animal(s) by:
  - reducing vessel speed within 300 yards (275 m) of the animal(s);
  - steering around the animal(s), if possible;
  - operating the vessel in such a way as to avoid separating members of a group of animals from other members of the group;
  - operating the vessel to avoid multiple changes in direction; and
  - checking the waters immediately adjacent to the vessel to ensure that no animal(s) will be injured when the propellers are engaged.

Disposal of Wastes: Routine discharges from the drilling unit and project-related vessels will be approved by the EPA and will be made in accordance with the provisions of the general NPDES permit for the Beaufort Sea, and should have no direct impact on marine mammals. The potential impact of these discharges on marine mammal food resources are discussed in Part IV.E.(2) of this section. The stated impacts are temporary, highly localized, and generally minor in nature, and should have little, if any, effect on marine mammals.

Airborne and Underwater Noise: Factors affecting the degree of impact of airborne noise on marine mammals include: the species; life cycle stage; altitude of source; frequency of overflights; flight paths; type of aircraft; and time of year. Ringed and bearded seals are particularly susceptible to airborne noise when they are hauled out on ice during the molting period (i.e., March to June). disturbance is pronounced, seals may dive into the water. response could lead to thermoregulatory distress and/or the abandon-Smith, ment of pups (McLaren, 1958; 1973; Finley, disturbance of hauled-out seals occurs frequently during molting, successful regrowth of skin and hair cells may be retarded, thus increasing physiological stress on seals during a normally stressful Increases in physiological stress may decrease fertility and longevity of affected seals (MMS, 1987). The proposed operations will not occur during the molting period.

Polar bears also react to <u>airborne noise</u> disturbances. They have been known to retreat from low flying aircraft and occasionally to react aggressively toward the source of noise. Female polar bears can be especially sensitive to noise and human presence during maternity denning; however, denning activities probably will not commence during the conduct of the proposed operations. Even if they do, preliminary results of noise measurements taken within a simulated polar bear den suggest that external noise is only detectable by denning bears if the source is very near the den (MMS, 1987).

Overt reactions of whales to <u>airborne noise</u> include hasty dives and, on rare occasions, moving away from the source of the noise (Fraker and Richardson, 1980).

Concerns over the potential impacts of <u>underwater noise</u> generated by offshore oil and gas operations on marine mammals have been raised due to the fact that many marine mammals appear to be highly dependent on the underwater acoustic environment for communications, location of food, spatial orientation, avoidance of predators,

and other activities (Cowles et al., 1981). The principal, project-related sources of <u>underwater noise</u> will be the ice class support vessels, and noise generated by drilling operations and project-related aircraft.

Underwater noise created by comparable sources has been found to be transmitted rapidly and effectively through water; however, many factors will influence the range to which the noise can be detected. These sound modifying factors include: ambient noise levels; spreading, channelization, absorption and scattering losses; and the initial strength and frequency of the sound. Ambient noise levels, in turn, are influenced by wind speed, non-project-related shipping noise, and ice movements. The spreading, channelization, absorption and scattering loss of sound is controlled by environmental conditions including water depth, temperature, salinity, presence or absence of ice, and bottom sediments (Acoustical Society of America, 1981; Fraker et al., 1981; Richardson et al., 1983; Turl, 1980).

In general, most of the industrial operations that have been examined in the Beaufort Sea produce considerable <u>underwater noise</u>, mainly at low frequency levels. In shallow waters, where most industry activities occur, many of the recorded industrial noises increased the level of continuous noise by 25 decibels (db) or more at 0.6 miles (1 km) and by 10 db at 6.2 miles (10 km) relative to the ambient noise levels. In addition, <u>underwater noise</u> associated with vessel traffic has been detected up to 6.2 miles (10 km) away from the source and noise from seismic operations has been detected up to 31 miles (50 km) away from the source (Richardson et al., 1985; Richardson et al., 1983; Miles et al., 1987).

A recent study (Miles et al., 1987) conducted in the Alaskan Beaufort Sea has taken the recorded <u>underwater noise</u> levels of various industrial activities associated with oil and gas exploration and attempted to predict the impact of <u>underwater noise</u> on endangered gray and bowhead whales. The basic purpose of the study was to estimate: the distance between a sound source and the area around an industrial

site where the industrial noise level equalled or exceeded the ambient noise level (i.e., the zone of audibility); and the area around an industrial site within which a significant fraction of the whales are expected to exhibit overt avoidance response to noise at that site (i.e., the zone of responsiveness). The study included the Corona Prospect, which is 9 miles (14.4 km) south-southeast of the Galahad Prospect, and concluded that the zone of audibility for a dredge, tug, icebreaker or drillship operating at the Corona Prospect would be 31 miles (50 km) to the east, west and north, and that the zone of responsiveness would be:

in migrating beluga	20 dB S:N*	30 dB S:N*	110 dB
Two Tugs (Bollard)	14.3-21.1 miles	4.3-7.4 miles	5.6-8.7 miles
Drillship	3.1-5.0 miles	0.6 miles	1.9-5.0 miles
Tug Underway	8.1-17.4 miles	1.9-5.0 miles	2.5-6.8 miles
Icebreaker Underway	4.3-15.5 miles	1.2-5.0 miles	2.5-12.4 miles

Little information is presently available on the impacts of underwater noise on pinnipeds; however, current information indicates that pinnipeds demonstrate considerable tolerance to underwater noise and other stimuli from passing vessels (Richardson et al., 1983). In addition, there are a number of reports of pinniped species hauling out on oil and gas structures while drilling and/or production activities are underway. In regards to seismic activities (note: the proposed operations do not include seismic operations), there is evidence that ringed seals have abandoned areas in the Beaufort Sea where onice seismic activities have occurred during winter. This effect, however, was very localized (Burns et al., 1981a). Studies designed to determine the extent of ringed seal reactions to seismic exploration indicated that some localized displacement of ringed seals did occur in the immediate vicinity of the seismic lines, but that overall displacement was insignificant in the nearshore Beaufort Sea area (Burns et al., 1981b).

<sup>\*</sup> Signal-to-noise ratio.

Far more research on the effects of underwater noise on cetaceans has been conducted due to concerns associated with the beluga and endangered bowhead whales and oil and gas operations in both the Alaska and Canadian Beaufort Seas. Previous research on beluga whales has shown that the direction of travel of beluga whales in a feeding mode was not greatly affected by drilling noise (Stewart et al., 1983). In addition, beluga whales have been reported to approach within 33 feet (10 m) of oil production platforms in Cook Inlet; however, sudden changes in noise elicited temporary avoidance reactions (McCarty, 1981). Finally, sudden start-ups and variable noise levels associated with the ramming and backing of icebreakers has been noted to cause marked avoidance behavior in migrating beluga whales that were 22 to 31 miles (35 to 50 km) from the source (Finley et al., 1984). This avoidance response occurred in beluga whales that were waiting for winter ice to break up in an area of low industrial activity. Another study reported beluga whales within .06 miles (0.1 km) of an icebreaker (Kanik et al., 1980).

During studies by Richardson et al. (1985), Ljungblad et al. (1987), and LGL and Greeneridge Science Inc. (1987), endangered bowhead whale reactions to underwater noise from various oil and gas operations were observed. From these studies, it appears that endangered bowhead whale behavior was affected markedly, but temporarily, by the close approach [0.6 to 2.5 miles (1 to 4 km)] of a vessel. The initial reaction often was an attempt to outrun the vessel. a vessel was within a few hundred feet, whales either turned and swam away from the vessel, or dove. While endangered bowhead whales were avoiding vessels, surfacings were usually short and there were unusually few respirations per surfacing. Groups of whales scattered. Fleeing generally ceased a few minutes after the vessel passed, but scattering persisted longer. Reactions were far less obvious in the case of industrial activities that continued for hours or days, such as distant seismic exploration, drilling, and dredging operations. some cases, summering endangered bowhead whales have been observed less than 3 miles (5 km) from operating drillships and dredges in Canada. On the other hand, a recent study of migrating whales found that the closest recorded sighting to an ongoing drilling operation was 6 miles (9.5 km).

The study conducted by LGL and Greeneridge Science Inc. (1987) concluded that migrating endangered bowhead whales appeared to avoid offshore drilling operations. At the same time, the study found that migrating whales exhibited no, or at most subtle, behavioral response to the operations (see Table IV-2).

Endangered bowhead whale behavior in the presence of noise pulses from seismic vessels 3.7 to 61.4 miles (6 to 99 km) away also has been observed (note: the proposed operations do not include the conduct of seismic operations). Endangered bowhead whale behavior on these occasions was not dramatically different from behavior in the absence of industrial activities, despite the fact the noise levels were sometimes very high (Richardson et al., 1985).

In examining the effects of seismic activities, Ljungblad et al. (1985) concluded that there are no discernable behavioral changes in endangered bowhead whales during exposure to seismic sound at ranges of greater than 6.2 miles (10 km), but that there were pronounced changes in behavior occurring once an active seismic vessel approached to within 3.1 miles (5 km) of the whales. Avoidance responses to full-scale seismic operations included orientation away from the approaching vessel, "flight", and some significant short-term changes in surfacing, respiration, and diving patterns. The influence of seismic sounds on endangered bowhead whale behavior was determined to be short-term due to a return to pre-seismic surfacing, respiration, and diving characteristics in 30 to 60 minutes following exposure.

During a recent study (LGL and Greeneridge Science Inc., 1987) a group of endangered bowhead whales was observed moving rapidly away from an operating seismic vessel which was approaching the whales from about 14.3 miles (23 km) away (see Table IV-2). The apparent

TABLE IV-2

SUMMARY OF IMPORTANT INFORMATION ABOUT BOWHEAD OBSERVATION SESSIONS, AUTUMN 1986 (LGL and Greeneridge Science Inc., 1987)

	Sessi	Session No.							
Date	Behav.	Photo	No. Bowheads	General	Responses of Whales	Potential/Probable Disturbance Source	Background3	Maximum3	Seismic
ear Alask	Near Alaska-Tukon Border	order	10			e a c			
4 Sep	4	1	,	Feeding	None	0.5	•	92-97	. 1
5 Sep	2	2	7-8	Feeding	Strong	Supplier VI, 1 km N	•	123	•
8 Sep	3	3	11-12	Feeding	None		1034	•	•
Corona Study Area	dy Area								
9 Sep	4	4	9-11	Moving SE	None-Subtle	Robert Lemeur, 20 km, SSE	26-96	901	119
10 Sep	5	5, 6	2-3	Moving SE	Strong	Supplier III, 15-36 km, SSU-NE	109-110	118-121	125-126
11 Sep A	•	1	6-11	Feeding and moving E	None	Seismic ship, 17 km SW, not operating, and same saismic ship, 20 km SW, operating	2 7A 20	1205	126
11 Sep B				Moving S	Strong	Supplier III, 3-5 km WSW-ENE	-0	•	
17 Sep	7, 8	• i st		Feeding	None	Robert Lemeur, 13 km NNE, calibrating moored array	98-105	112-115	
axmerbea	Hammerhead Study Area								
19 Sep	•	•	m i.e	Migrating UNW	Subrle	Aircraft @ 305 m ASL; Robert Lemeur, 26 km SE; Explorer II, 23 km SE	109-112	117-1119	
26 Sep	0	• 1	7	Higrating W	Subtle	Supplier VII, 27 km SSW; Setsuic ship; 28 km WNW, not operating	101-104	paer paer	•
28 Sep	11	10	12-15	Oriented W	Insufficent	Explorer II, 17 km NV	No so	No sonobuoy	
				near coast	evidence				
1 0ct	•	11, 12	30-32	Migrating NW moving SE	None-Mild	Expiorer II, 11 km NV	No e	No sonobuoy	9.
2 Oct		13	20-30	Migracing NW	None	Explorer II, 33-42 km V; seismic_ship, 30-35 km NV, intermittently operating	No so	No sonobuoy	•
3 Oct	12	. 41	15-20	Moving NNV	Strong	Seismic ship, 23 km SSE operating	111-1113	121-123	117-1377
6 Oct	£1 .	15	tos co ent	Migrating NW	ніна	Explorer II, 24 km SW supply ship 21 km SSW	104-114	117-120	124

Name of vessel, distance from whales, bearing from whales to source. Recorded at our sonobuoy except for 8 Sep and 11 Sep.

Band width is 20-1000 Hz.

Background level on 8 Sep recorded via sonobuoy dropped by HMS crew near Demarcation Bay ( $\underline{cf}$ . Richardson et al. 1987). Seismic pulses present but not measured. After the moored array situated 15 km E of Corona site on 11 Sep (Greene 1987, this volume). Hinimal levels since sonobuoys overloaded.

response of the whales represents the greatest distance at which a strong response to seismic operations has been observed. It should be noted, once again, that the proposed operations do not include the conduct of seismic operations.

In summary, the disturbance studies show that endangered bowhead whale behavior can be affected markedly, but temporarily, by transient industrial operations, especially the close approach of surface and seismic vessels. Reactions are less obvious in the cases of industrial activities that continue for hours or days, such as distant seismic exploration, drilling, and dredging operations (Richardson et al., 1985; Ljungblad et al., 1985). Some incidental avoidance behavior may occur as westward migrating whales approach an active drilling site. However, any deviation in a migration route will be temporary and is not expected to cause a significant delay in overall fall migration (LGL and Greeneridge Science Inc., 1987; Ljungblad et al., 1987).

The potential impact of <u>airborne</u> and <u>underwater noise</u> will be mitigated by Amoco's compliance with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale which suggest that:

- o Project-related aircraft and vessels maintain at least a 1-mile (1.6 km) horizontal distance from observed marine mammal concentration areas.
- o Project-related aircraft and vessel operations be minimized or rerouted to avoid disturbances to endangered bowhead whales.
- o Project-related aircraft maintain an altitude of 1,500 feet (457 m) when in transit over areas that may contain endangered bowhead whales unless doing so would jeopardize personnel safety.

During the endangered bowhead whale fall migration period, there will be minimal project-related vessel traffic in the immediate vicinity of the drill sites and along the route of a small number of migrating whales. If endangered bowhead whales are encountered by a project-related vessel, the following MMS-mandated guidelines will be observed:

- The vessel will operate at a speed that will make collisions with endangered bowhead whales unlikely; if visibility decreases to less than 3 miles (5 km), vessel speed will be reduced.
- o The vessel will maintain a minimum approach distance of 1 mile (1.6 km) from endangered bowhead whales.
- o If the vessel inadvertently approaches within 1 mile (1.6 km) of (an) endangered bowhead whale(s), the vessel operator will take every precaution to avoid harrassment of the animal(s) by:
  - reducing vessel speed within 300 yards (275 m) of the animal(s);
  - steering around the animal(s), if possible;
  - operating the vessel in such a way as to avoid separating members of a group of animals from other members of the group;
  - operating the vessel to avoid multiple changes in direction; and
  - checking the waters immediately adjacent to the vessel to ensure that no animal(s) will be injured when the propellers are engaged.

The potential impacts of noise disturbance on endangered bowhead whales may be further mitigated if the RSFO elects to exercise his authority under Section 14(k) of the Information to Lessees portion of the Final Notice of Sale. Section 14(k) empowers the RSFO to limit or suspend any noise-producing operations on a lease whenever he determines that they pose a threat of serious, irreparable, or immediate harm to endangered bowhead whales.

Artificial Illumination: There is the possibility that artificial lighting may attract polar bears to the drilling unit or an onshore support base. If a polar bear acts aggressively toward personnel, it might have to be destroyed. Polar bears are unlikely to be present in the vicinity of the proposed operations. Even if they were and came into contact with the proposed operations, the impact of any foreseeable loss of animals on the regional population of polar bears will be negligible.

Cumulative Impact: Although highly unlikely, the proposed operations could overlap with drilling and research/monitoring operations by other companies in the vicinity of the Galahad Prospect. The potential cumulative impact of simultaneous operations on marine mammals is judged to be negligible because: although present, whales and seals are widely dispersed thus reducing the potential for any cumulative impact to have more than a negligible impact on regional whale and seal populations; Amoco assumes that all operations would be subject to mitigation measures similar to Sections 14(f) and (k) of the Information to Lessees portion of the Final Notice of Sale and the MMS-mandated guidelines which are designed to minimize the potential impact of vessels on endangered bowhead whales; and Amoco assumes that all operations would be subject to and follow the provisions of the general NPDES permit for the Beaufort Sea.

## (2) CONCERNS ABOUT THE AFFECT OF DRILLING FLUID DISCHARGES ON ALL MAJOR MARINE FLORA AND FAUNA GROUPS

Discharges from a drilling unit are allowed if they are approved by the EPA and are made in compliance with the provisions of the general NPDES permit for the Beaufort Sea. Many studies have been conducted to determine whether routine, permitted discharges into the ocean have an adverse impact on marine flora and fauna. The three principal areas of concern are that: a) dispersion may not be rapid enough to accommodate the discharges; b) some discharges (i.e., drilling mud and produced water) may be acutely toxic or produce deleterious sublethal responses in sensitive marine species; and c) heavy metals present in some discharges (i.e., drilling mud and produced

water) may be accumulated by marine organisms to concentrations that may be harmful to the organisms themselves or to consumers, including man, of fish products.

Dispersion of Discharges: Several studies have been done to examine drilling mud plume dynamics and the water-column fate of drilling mud discharges (Ray and Shinn, 1975; Zingula, 1975; Ecomar, 1978 and 1983; Environmental Devices Corporation, 1976; Dames and Moore, 1978b; Ayers et al., 1980a and b; Ray and Meek, 1980; Trefry et al., 1981; Trocine and Trefry, 1983; NORTEC, 1981a and c; NAS, 1983). The dilution of the discharge plume is dependent upon the type and characteristics of the mud used, the effluent discharge rate, water depth, surface and subsurface currents, and oceanographic characteristics. Ayers et al. (1980a) found that over 90 percent of discharged drilling-fluid solids settled directly to the bottom. Ayers et al. (1980b) estimated that the amount of material remaining in the upper plume of a discharge is 5 to 7 percent of the total discharge. In deeper water [greater than 262 feet (80 m)], the lower plume will reach neutral buoyancy before encountering the bottom. In the studies cited above, components of the drilling fluids investigated had either settled to the bottom or diffused by a factor of 106 to less than 1 mg/l within 328 to 656 feet (100 to 200 m) less than 1 hour after discharge. A concentration of 30 to 50 mg/l of mud solids was reached within a few minutes after discharge (NAS, 1983).

The results of the "Mud Dispersion Study Norton Sound Cost Well No. 2" (Ecomar, 1983) indicate that the majority of discharged mud solids settled to the ocean floor within 305 feet (93 m) of the discharge source. Concentrations of suspended solids and metals in the surface plume continued to fall rapidly but at a slower rate as the plume moved further away. Concentration decreases of three to four orders of magnitude occurred at distances of 2,132 to 2,263 ft (650 to 690 m) from the discharge source. Except for light transmission, hydrographic variables were unaffected by the discharge plume.

Ecomar (1983) concluded that, except near the source, drilling mud discharges have a negligible effect on water quality during high rate, high volume discharges in shallow marine areas.

Although highly unlikely, the proposed operations could overlap with drilling activities by other companies in the vicinity of the Galahad Prospect. Assuming that nearby, simultaneous operations occurred, the potential cumulative impact to the marine environment is judged to be negligible because: it is unlikely that operations would occur simultaneously at sites that are close together [i.e., less than 3 miles (5 km)]; wastes at each drill site would be deposited near the disposal site or spread, in low concentrations, over the surrounding area; any envisioned quantity of discharges in the vicinity of the Galahad Prospect would be small in comparison to the natural sediment load found in the Beaufort Sea; and the impact to any seafloor area affected by discharges would be short-lived because resuspension of sediments may occur during open water season at the water depths encountered in the area of the Galahad Prospect.

b. Toxicity of Discharges: To date, the toxicity of more than 70 water-based drilling muds has been evaluated with 62 species of marine animals from the Atlantic and Pacific Oceans, the Gulf of Mexico, and waters offshore Alaska (Carls and Rice, 1980; Conklin et al., in press; ERCO, Inc., 1980; Gerber et al., 1980, 1981; Gilbert, 1981; Houghton et al., 1980; Marine Bioassay Labs, 1982; McLeay, 1976; Neff, 1981; Neff et al., 1981; Tornberg et al., 1980). The bioassay organisms represented five major marine animal phyla, including Chordata (12 species of fish), Arthropoda (30 species of crustaceans), Mollusca (12 species of molluscs), Annelida (6 species of polychaetes), and Echinodermata (one species of sea urchin). Larvae and other early life stages were included (NAS, 1983).

More than 96 percent of the whole drilling fluids tested in short-term experiments (from 44 to 144 hours) had LC 50 values greater than 1,000 ppm and are classified as "slightly toxic" or "practically

non-toxic". More than 98 percent of the tests that have used the suspended particulate phase of drilling fluids found their LC 50 values greater than 10,000 ppm (in the range of "practically non-toxic"). This distribution of toxicities indicates that most water-based drilling fluids are relatively non-toxic (NAS, 1983).

A number of investigations of the chronic and sublethal responses of marine animals to drilling fluids have been conducted with 35 species of marine animals, including 10 species of coral, 5 species of molluscs, 15 species of crustaceans, 1 species of polychaete worm, 2 species of echinoderms, and 2 species of teleost fish (NAS, 1983). Sublethal responses include: alterations in burrowing behavior and chemosensory responses in lobsters (Derby and Atema, 1981); alterations in patterns of embryological or larval development or behavior in several species of shrimp, crab, lobsters, sand dollars and fish (Crawford and Gates, 1981; Gerber et al., 1981; Neff, 1981; Sharp et al., 1982); decreased food assimilation and growth efficiency in opossum shrimp (Carr et al., 1980); decreased shell growth and condition in corals, scallops, oysters, and mussels (Gerber et al., 1980, 1981; Neff, 1981; Rubinstein et al., 1980); alternations in rates of filtration, respiration, and nitrogen excretion in corals and mussels (Gerber et al., 1980); changes in tissue enzyme activity in crustaceans (Gerber et al., 1980, 1981); gill histopathological lesions in shrimp and salmon fry (Houghton et al., 1980); and polyp retraction, mucus hypersecreation, ability to clean surfaces, photosynthesis, extrusion of 200 anthellae, and survival in corals (Thompson and Bright, 1980; Hudson and Robbin, 1980). These studies show that even in the most sensitive species, significant deleterious sublethal responses occur only at drilling mud concentrations nearly as high as those that are acutely toxic, and that damage is probably caused by intolerance to the high concentrations (100 to 1) of suspended particulates (NAS, 1983).

The field studies published to date on the effects of drilling mud discharges on demersal, benthic, and sessile marine communities around offshore exploratory drilling units tend to corroborate conclusions derived from laboratory studies that the ecosystem effects of drilling mud discharged to the ocean are minimal, and when detected, are of short duration and restricted to the benthos (Zingula, 1975; Gettleson, 1978; Lees and Houghton, 1980; Houghton et al., 1980; Menzies et al., 1980; Mauer et al., 1981; and Benech et al., 1980).

Heavy Metals Accumulation: The metals most commonly found in drilling fluids are barium, chromium, lead, and zinc. of the other metals detected in drilling fluids (i.e., mercury, nickel, arsenic, cadmium, and copper) are present primarily as trace impurities (Boehm et al., 1985). Brannon and Rao (1979), Carr et al. (1982), Espy, Huston & Associates (1981), Gerber et al. (1981), Liss et al. (1980), McCulloch et al. (1980), Page et al. (1980), and Rubinstein et al. (1980) have performed laboratory investigations on the bioaccumulation of some of these metals in drilling mud and drill-These studies, which used a wide variety of ing mud ingredients. species of marine animals, show that some metals are bioavailable to marine animals. Statistically significant bioaccumulation of chromium and barium may occur, despite the very low solubility of barium sulfate in seawater. Organically-bound and particle-absorbed heavy metals usually are much less bioavailable than the metal ions in solu-The available evidence indicates that little likelihood exists that heavy metals from realistic levels of used drilling mud would be accumulated in the edible portions of shell and finfish to concentrations that would pose a health hazard to human consumers of such fish products (NAS, 1983).

Crippen and Hood (1980) evaluated increased metal concentrations in surficial sediments and benthic fauna resulting from drilling fluid disposal from an exploratory well in the Beaufort Sea. Elevated levels of mercury, lead, zinc, cadmium, arsenic, and chromium were recorded within 148 feet (45 m) of the discharge point. Density and biomass of benthic organisms were lower in the affected area. No correlation, however, was found between metal concentrations in sediments and infaunal organisms.

Although the Crippen and Hood analysis suggests that mercury may be bioaccumulated in infaunal organisms in an affected area, field and laboratory studies in the Beaufort Sea completed by NORTEC (1981a) recorded no changes in the abundance of benthic organisms related to discharges of drilling fluids. In addition, no metals were found to accumulate in the tissues of invertebrates or fish. Drilling effluents were determined to be present only in discharge areas for short period of time.

In summary, the available data generally suggest that discharges of drilling fluids result in relatively minor effects on benthic and other invertebrate organisms present in the immediate area of deposition. Other organisms that are more mobile and wide-ranging are probably not adversely affected by drilling effluents to a measurable extent.

#### (3) IMPACTS OF A MAJOR OIL SPILL ON FLORA AND FAUNA

The statistical probability of a major oil spill occurring during the proposed exploratory operations is extremely small (see Part IV.G(1) of this section). In the unlikely event that a major spill did occur, however, it could have a serious impact on marine flora and fauna (BLM, 1979). The effects would be physiological and/or chemical. Physiological effects could include contamination of protective layers of fur or feathers, loss of bouyancy, and loss of locomotive capabilities. Chemical effects may consist of direct lethal toxicity or sublethal irritation, as well as the temporary alteration of the chemical makeup of the ecosystem. There are both controllable and uncontrollable variables that influence the impact of oil, including: oil type and dosage, season of occurrence, animal behavior, oceanographic and meteorological conditions, and the cleanup methods employed.

a. <u>Cetaceans</u>: Possible effects of oil on cetaceans include: fouling of the baleen plates in baleen whales (e.g., endangered bowhead and gray whales); possible disruption of respiratory

functions; ingestion of oil with unknown effects on the physiology of the individual; reduction of the food supply through contamination of the habitat; and irritation of the skin and eyes (NMFS, 1980). In addition, endangered bowhead whales might avoid oil contaminated water, which could delay migration long enough for them to become trapped in the ice (Fraker et al., 1978).

Experiments have demonstrated that heavy weathered oil can clog baleen and impair feeding, at least temporarily. The inside edge of baleen plates have a hair-like fringe where oil could accumulate (Fraker, 1984). Endangered bowhead whale baleen has been used to evaluate the effects of varying degrees of oil fouling. To simulate light fouling, crude oil was painted on the baleen, and to simulate a heavier level of fouling, crude oil was poured into water in which the baleen was submerged, and then the water level was quickly decreased. The results indicated a reduction in filtering efficiency in all cases, but only when the baleen was exposed to the heavier fouling was the change in filtering capacity statistically different (Braithwaite, 1980). Another experiment was conducted to show the effects of oil contamination on baleen from endangered fin and gray whales by measuring changes in the flow of water through sections of oiled baleen. Light and medium weight oils were found to cause transient changes in water flow; however, water flow patterns returned to normal within forty seconds. Repeated oiling did not result in any additive effect. Bunker C, a heavy fuel oil, was found to restrict water flow patterns for up to fifteen minutes. Under continuous flushing at a natural rate for fifteen to twenty hours, light oils were no longer detectable on the baleen, but some oil of heavier types remained (Geraci and St. Aubin, 1981, 1982).

If baleen plates were to remain fouled for a number of hours, food organisms might be contaminated and serve as a vehicle for entry of oil. Moreover, oil coating of plates may cause plankton to adhere, further reducing the flow of water and delaying recovery. As yet, there has been no recorded sightings of a whale with its baleen fouled by oil (Geraci and St. Aubin, 1985).

The effects of oil on baleen also has been studied with regard to its impact on the structural properties and composition of isolated baleen plates. Baleen plates from endangered fin, right, and gray whales were soaked in gasoline, crude oil or tar for periods exceeding those which might be expected under natural conditions (St. Aubin et al., 1984). It was discovered that exposure to petroleum resulted in the loss of lipids, leaching of trace elements, and changes in the keratin structure. Tensile properties also were affected after 21 days in tar. The plates became stiffer and more force was required to part the matrix. Under less rigorous and more realistic conditions, exposure to oil is not likely to damage or weaken baleen plates (Geraci and St. Aubin, 1985).

The possibility of the cetacean's blowhole becoming clogged with oil has been discounted. The musculature is adapted to exclude water and would exclude oil equally well (Geraci and St. Aubin, 1980). However, inhalation of highly concentrated petroleum vapors could lead to inflammation of the respiratory tract which could prove fatal. This could occur if the animals were unable to leave the area of a spill, or were made more vulnerable by other physical problems. Also, the effect of such exposure would probably depend on the health of the animal. Thus, cetaceans that are already stressed in those areas affected by inhalation of vapors, such as by lung and liver parasites or adrenal disorders (Geraci and St. Aubin, 1979) might be particularly vulnerable to low levels of hydrocarbon vapors (Geraci and St. Aubin, 1985). On the other hand, animals that are away from the affected area or that are exposed to oils that have weathered at least two to four hours would not be expected to suffer any consequences from inhalation, regardless of their condition (Geraci and St. Aubin, 1982).

Very little information is available concerning the internal effects of oil on cetaceans. It is possible that whales exposed to an oil spill might ingest some oil directly or might feed on contaminated prey. One conceivable effect would be the aspiration of regurgitated

oil into the lungs. Cetaceans are uniquely protected from this potential complication because their respiratory system is not connected directly to the alimentary canal. Moreover, because whales normally consume very small amounts of seawater, it is unlikely that a whale would ingest enough oil for the oil to be toxic (Fraker, 1984).

It would be possible for toothed whales to ingest oil along with contaminated prey. However, observations of captive animals suggest that they are not likely to scavenge food that is tainted. Baleen whales (e.g., endangered bowhead and gray whales) feeding in the area of a spill are more likely to ingest oil-coated or oil-contaminated food, particularly zooplankton which actively consume oil particles. It is unlikely, however, that whales would feed around a spill long enough to accumulate quantities of oil which could be fatal (Geraci and St. Aubin, 1985). Even though whales have been observed feeding in oiled waters (Goodale et al., 1979), there have been no reports linking oil ingestion with mortality (Geraci and St. Aubin, 1985).

Another problem could be the ingestion of small amounts of oil over a long term, either directly or in food. Small ingested amounts could be detoxified by enzymes in the liver tissue, if the system works the same way in cetaceans as it does in other mammals. It is unlikely that any cetacean would ingest enough spilled oil to cause death (Geraci and St. Aubin, 1982). Experiments on bottlenose dolphins show no clinical signs of organ damage or intoxication due to long-term ingestion (Caldwell and Caldwell, 1982).

There has been speculation that the "hairs" that are shed from the inside edge of the baleen might combine with any oil that is ingested to form a "hair ball" that could obstruct the alimentary canal in endangered bowhead whales. In these whales, there is a narrow portion which measures about 1.5 inches in diameter and 12 inches in length which connects two chambers of the stomach. An obstruction of this connection would be serious for the whales involved. It is impossible to arrive at an unequivocal conclusion about this

concern. There are no relevant data on which to base a conclusion, in large part because there has never been a documented case of death or injury to any kind of whale resulting from contact or ingestion of oil. For now, this possible effect should be viewed as a concern to be considered, but not as a demonstrated consequence (Fraker, 1984).

Endangered bowhead and gray whales feed on zooplankton and benthic species. Toothed whales and some baleen whales feed on pelagic fish. Recent studies (Richardson, 1986 and 1987) on the importance of the eastern Alaskan Beaufort Sea to endangered bowhead whales have concluded that although oil could cause adverse impacts to exposed zooplankton, it is unlikely that such exposures would cause a significant or long lasting affect on zooplankton in the eastern Alaskan Beaufort Sea, or on the availability of zooplankton to endangered bowhead whales. Benthic feeding species, most notably the endangered gray whale, are more likely to be affected, but no specific data concerning potential indirect effects exist (Richardson et al., 1983).

External irritation is another possible effect of oil contamination. Because the outer layer of a whale's skin is composed primarily of living cells that may have physiological functions beyond that of providing a protective barrier, oil coming in contact with the skin may cause serious morphological, physiological, or biochemical effects on cetacean skin (Geraci and St. Aubin, 1980).

Histological and ultrastructural studies have shown that petroleum hydrocarbons can produce mild and transient damage to cells of the epidermis of smooth-skinned cetaceans, primarily in the external and intermediate layers. The germinal layer and dermis seem to be unaffected by exposures of less than 75 minutes to lead-free gasoline. However, such effects on the skin are likely to be short-term or transient, with recovery occurring within a few days (Geraci and St. Aubin, 1982).

The skin of whales is often damaged by parasites (Pike, 1951; Humes, 1964; Perrin, 1969), micro-organisms (Migaki et al., 1971; Geraci et al., 1979), and predators (Ridgway and Dailey, 1972), as well as aggressive social encounters. In some, such as endangered right whales, the skin is roughened by the presence of callosities. However, findings on a study of damaged skin on dolphins suggest that breaks in the continuity of the epidermis do not necessarily magnify the reaction of skin to petroleum products, as has been suggested. Biochemical processes in cetacean epidermal cells have been examined for evidence of functional damage due to oil. Exposure to oil resulted in a depression of phosopholipid synthesis. However, creatine kinase, oxygen consumption, and vitamin E concentrations in oil-exposed skin showed no consistent pattern of change (Geraci and St. Aubin, 1982).

If an oiled whale remained within an oiled area because of ice conditions, oil might adhere to the skin and other surface features (e.g., tactile hairs) for an extended period of time (Hansen, 1985). It remains to be seen whether such exposure would affect the biochemistry and architecture of cells, and the functional integrity of the skin (Geraci and St. Aubin, 1985).

All marine mammals would undoubtedly experience irritation and inflammation of eyes and sensitive mucous membranes following contact with oil (Geraci and St. Aubin, 1985). However, hydrocarbons dissolved in the water column are not likely to have any long-term effects on a whale's eyes, even at high concentrations, because of the very brief exposure period and the dissipation of hydrocarbon fractions (Hansen, 1985). It has been suggested that oil droplets could become entrapped within the large conjunctival sac surrounding an endangered bowhead whale's eye (Albert, 1981). However, based on the few examinations and disections of endangered bowhead whales, there are no reported observations of foreign bodies found in the conjunctiva. It is likely that oil droplets would be washed away from the eye before becoming trapped in the conjunctival sac (Hansen, 1985).

There has been some speculation concerning a whale's ability to avoid oil on the water's surface. Experiments with captive dolphins suggest that cetaceans could visually detect oil with an optical density greater than 0.2 to 0.34, and with experience, could reliably detect substances with an optical density of 0.05 or less, corresponding to a 0.04-inch film of dark crude oil. Using echolocation alone, a dolphin was able to detect thick (0.5-inch or greater) patches of heavy oil, particularly if the substance contained air bubbles, such as one might expect if oil had been churned by wind or waves. Studies have shown that dolphins will avoid what they can detect, indicating a generalized toothed whale behavior pattern. At sea, this response might be modified by social interactions, feeding, agonistic behavior, migration, or human activity (Geraci and St. Aubin, 1986; Geraci and St. Aubin, 1985; Geraci et al., 1983; Smith et al., 1983).

The reaction of baleen whales, like the endangered bowhead whale, are as much a subject of concern as are the toothed whales. However, studies from one group cannot be generalized to the other because of differences in their sensory capabilities. Observations of migrating endangered gray whales in an area of the Santa Barbara Channel, offshore California, which is affected by natural oil seeps, reveal that whales will swim through oil at a modified swimming speed, but without a consistent pattern. Aerial observers occasionally noted a radical change in direction when some whales approached oil, but this "reaction" was not accompanied by any alteration in their respiratory patterns or swimming speeds and, in fact, may not have been in response to the oil. Changes in respiratory behavior were noted when whales were in oil-contaminated areas. In oiled waters, they spent less time at the surface and breathed at a faster rate. If this reaction is interpreted as an avoidance response, it suggests that gray whales can detect oil. Whales showing no response either could not detect the amount or type of oil present or were indifferent to it. Ultimately, the ability of a marine mammal to avoid oil rests on its dependence on the area and avenues of escape (Geraci and St. Aubin, 1985; Kent et al., 1983).

b. <u>Pinnipeds</u>: Seals which occur in the Alaska Beaufort Sea OCS area and are used for subsistence purposes include the ringed, bearded, spotted, and ribbon seals. The walrus also is found in the area, and occasionally is harvested (MMS, 1984).

Juvenile and adult members of all of the aforementioned pinnipeds rely on thick, subcutaneous fat layers for insulation and are not likely to suffer significant heat loss from even extensive oil contamination. However, the newborn pups of the seal species possess a long-haired pelt, called lanugo, which functions as the main barrier to heat loss until a thick fat layer develops as the pup matures. If the lanugo is oiled, pups are likely to lose thermal insulation from oil contact and could die from exposure (Hansen, 1985).

Laboratory experiments have demonstrated that oil/eye contact causes severe eye irritation in ringed seals after 24 hours of exposure and can result in permanent damage if exposure is prolonged (Geraci and Smith, 1976). However, ringed seals and other marine mammals encountering an oil spill in the natural environment may be able to prevent prolonged exposure by leaving the contaminated area. Oil irritation of a pinniped's epidermis is likely to be most severe during the molting season, when the outer keratin-cell layer is shed and epidermal cells are growing. Eye and skin irritations may increase physiological stress and contribute to the death of weakened and severely contaminated individuals (Geraci and St. Aubin, 1980). In case histories, the few recorded marine mammal deaths attributed to oil spills occurred during winter (Duval et al., 1981), a season of increased natural stress (Hansen, 1981).

Oil contact may interfere with the olfactory senses, and hydrocarbons in the water column or in sediments may affect possible chemoreception in pinnipeds. Oiling of pinniped fur can mask olfactory recognition of young pups by nursing females. The sense of smell is reported to be important in harbor seal mother/pup bonds (Renouf et al., 1983) and probably is important in other seals as well (Hansen, 1985).

Oil ingestion through consumption of contaminated prey and through grooming or nursing can have pathological effects, depending on the amount ingested, the species, and the physiological state of the animal. Although the literature indicates that ringed seals, and probably other pinnipeds, rapidly absorb oil in body fluids and tissues (Geraci and St. Aubin, 1980), ingestion of 75 milliliters (ml) of oil over a short period of time apparently results in no acute organ damage (Geraci and Smith, 1976). With longer periods of ingestion, however, accumulation in body tissues can increase (Hansen, 1985).

It is unclear whether petroleum ingestion has more toxic effects on some species than on others. The level of effects is likely to be a function of the quantity and toxicity of ingested oil and of whether the ingested oil is regurgitated and aspirated into the lungs. If aspiration occurs, small doses of a few milliliters generally are acutely fatal, while relatively large quantities of oil may be tolerated if the oil is rapidly excreted from the gastrointestinal tract (Geraci and St. Aubin, 1982). Consumption over a long period of time can prove fatal if concentrations of hydrocarbons in the blood-stream exceed the filtering abilities of the kidneys and liver (Oritsland et al., 1981).

Effects of inhalation of vapors are similar to those noted previously for cetaceans. In a field immersion study of ringed seals, some of the hydrocarbons taken up were probably volatiles absorbed through the respiratory tract. Despite this, internal effects were minor (Geraci and Smith, 1976; Engelhardt et al., 1977; Engelhardt, 1978).

Mechanical damage to seals from oil probably depends on the amount and type of oil present. Experimental oilings of ringed seals with Norman Wells crude, which is relatively light and of low viscosity, showed no mechanical damage (Geraci and Smith, 1976). In contrast, gray seal pups on an oil-contaminated beach became so encased in weathered, tarry oil that their molting pelage was held in place

until the oil-fur layer had abraded. Two other pups drowned when they were washed off the beach by waves and were so encased in oil that they could not swim (Davis and Anderson, 1976). However, other studies have shown that after oiled hair seals leave the area of the spills, they gradually lose the oil (LeBoeuf, 1971).

It is not known whether pinnipeds detect small amounts of oil in the water. There is little evidence that they avoid the oil. Pinnipeds are most likely to become externally contaminated when they haul out of the water due to the tendency of oil to collect on or near the shoreline (Geraci and St. Aubin, 1980; Smiley, 1982; Richardson et al., 1983).

Long-term effects of oiling of seals and walruses are difficult to study and little specific information is available. The same is true for indirect effects. Oil can affect benthic organisms (Cross et al., 1983) and can remain in sediments for prolonged periods (Sanders et al., 1980). If indirect food chain effects occur, they are most likely in benthic-feeding species such as bearded seals and walruses (Burns and Frost, 1979; Geraci and St. Aubin, 1980; Cowles et al., 1981). If stress is a major factor in determining susceptibility to oiling, then members of populations whose sizes are near the carrying capacity of their environment may be especially susceptible to oil (Richardson et al., 1983).

c. <u>Polar Bears</u>: No field studies of oil effects on polar bear have been done, but laboratory studies of effects on three live bears and on thermal conductance of pelts show that polar bears can be harmed or killed when their fur is heavily oiled (Oritsland et al., 1981). Polar bears could be oiled if they were to swim across contaminated cracks and leads, or by contact with oil that has migrated upward through the ice (Lewis, 1978). Bears might also ingest oil by grooming oiled fur or by eating oiled prey (i.e., mainly ringed and bearded seals) (Richardson et al., 1983; Engelhardt, 1985).

bear, although subcutaneous fat also is significant (Irving, 1972; Frisch et al., 1974). Polar bear fur is a more effective insulator in air than in water, where it is completely wetted, but even in water it is of significant value because it maintains a layer of stagnant water about 0.4 inches (10 mm) thick adjacent to the skin (Frisch et al., 1974). Laboratory tests on the effects of oil contamination on thermoregulation in polar bears show findings which are consistent with the results from other groups of mammals that depend on fur for insulation. Oiling would probably cause significant thermoregulatory problems for free-ranging polar bears (Richardson et al., 1983). External oiling also apparently causes marked epidermal responses and an acute inflammatory condition in the nasal passages, probably because of the local irritant action of the crude oil (Oritsland et al., 1981).

Oil ingestion can have serious acute effects on polar bears. Oritsland et al. (1981) reported the deaths of two captive polar bears due to renal failure and dysfunction in the production of red-blood cells after the bears were heavily coated with crude oil that was subsequently ingested in large amounts while grooming. Results of an oil immersion experiment demonstrated that serious internal effects may not become obvious for several weeks (Engelhardt, 1981). Thus, the direct effects of heavy oiling on polar bears may not be obvious in a spill situation unless contaminated bears are observed for a substantial period of time (Richardson et al., 1983). In addition, oil residues were detected in the tissues of the exposed polar bears almost four weeks after their initial exposure to oil. brain, and bone marrow contained the highest concentration of oil residues. However, unlike other species, such as the ringed seals, no oil residues were detected in the polar bears fatty tissues. lack of oil residues in the polar bears fatty tissues was believed to be caused by the lack of feeding by the polar bears and the subsequent utilization of stored body fat (Engelhardt, 1985).

Polar bears that are not directly contaminated by oil may ingest oil when eating oil-contaminated ringed and bearded seals (i.e., their main prey). If there are serious declines in seal numbers as a result of a spill, bear distribution and numbers would be expected to change (Stirling et al., 1977). As top carnivores, polar bears also might be especially likely to acquire high levels of hydrocarbon in their tissue if bioaccumulation occurs. However, there is no information about bioaccumulation of hydrocarbons in the food chains leading to polar bears (Richardson et al., 1983).

d. <u>Seabirds</u>: Direct contact with oil can affect seabirds in three different ways: thermal effects due to external oiling of plumage; toxic effects of ingested oil as adults; and effects on eggs, chicks and reproductive success.

The primary external effect of oil on birds is loss of waterproofing. If oiling is severe, bouyancy is lost as well. Oil destroys the arrangement of feathers which is responsible for water repellency (Fabricius, 1959). Once this occurs, water can penetrate through the dense layers of feathers to the skin causing a loss of body heat. At the same time, oiled birds will reduce or stop feeding activities (Hartung, 1964). When this occurs, the bird must metabolize stored sugars, fat, and eventually skeletal muscle proteins to maintain body heat. Death in many oiled birds is due as much to exposure and depletion of these energy reserves as it is to the toxic effects of ingested oil (Schultz et al., 1983).

The internal effects of oil, swallowed when the bird preens in an attempt to remove the oil from its feathers, are varied. Liver, kidney, and pancreatic functions can be disturbed. Pneumonia may develop when oil passes into the trachea and bronchi. Bleeding from inflamed intestinal walls can produce anemia (Hartung, 1964). Finally, dehydration can occur when ingested oil inhibits the mechanism for salt excretion that enables seabirds to obtain fresh water from salt water (Holmes and Cronshaw, 1975).

Studies have shown that ingested oil may alter egg yolk structure, reduce egg laying rate, and reduce egg hatchability (Grau et al., 1977; Hartung, 1965). Oil applied to the exterior of eggs also reduces hatching success (Hartung, 1965; Albers and Szaro, 1978; King and Lefever, 1979; Patten and Patten, 1977; Coon et al., 1979; McGill and Richmond, 1979).

The effects of a major oil spill in the Alaska Beaufort Sea OCS area on birds would vary with the season; volume, nature, and duration of the spill; species and numbers of birds occurring in the areas affected; and many other variables. Spills that occur during winter would have no immediate effect on birds. However, oil that remains in the ice after cleanup efforts may directly affect birds during the following spring breakup period or indirectly affect them through changes or reductions in food source availability (MMS, 1984).

oil spills that may occur or meltout during spring breakup or during the open-water period are very likely to have an effect on birds. Species most likely to suffer direct mortality would be sea ducks, specifically oldsquaw and eiders. Depending on the timing and areas contacted by the spill, other birds such as phalaropes, loons, brants, and other waterfowl also may be directly contaminated by oil that contacts leads in the ice during spring or contacts coastal marshes or lagoons during the summer-fall feeding periods. Birds that are likely to avoid direct mortality from an oil spill, such as gulls and terns, and other birds that may survive partial oiling, could incur various pathological effects from oil ingestion and reduced productivity from egg or chick mortality or displacement from local habitats (MMS, 1984).

Indirect effects of oil pollution on birds would be those primarily associated with changes in availability or suitability of various food sources. The arctic marine ecosystem consists of a relatively simple food web with top-level consumers such as marine and coastal birds and marine mammals feeding on relatively few abundant invertebrate species and arctic cod. During heavy ice years, primary

productivity is comparatively low and food could be a limiting factor in the Beaufort Sea (Frost and Lowry, 1981). Low productivity, as well as reduced availability of food sources during years of late ice breakup, are apparent factors in extensive natural mortalities of marine and coastal birds reported during severe ice years (Barry, 1968). If a major oil spill were to occur during the summer through fall period of a heavy ice year, local mortality of plankton and epibenthic invertebrates in the spill area could substantially reduce limited food sources for that season. During years of high natural mortality due to food shortages, further reduction in available food due to an oil spill could substantially increase bird mortality for that year and retard natural recovery of the population. During more productive, moderate ice years a local reduction in available food sources is unlikely to affect a significant number of birds because several alternative locations of food would probably be available (MMS, 1984).

Long-term and chronic effects on birds of oil pollution from OCS activities could cause some population reductions depending on the species involved, the level of development, and the enforcement of existing mitigating measures. Long-term, gradual reduction in available food sources on at least a local level is a possibility leading to displacement or reduction in bird populations. Adverse alterations of nesting habitats is another possibility (MMS, 1984).

e. <u>Terrestrial Mammals</u>: The potential effects of oil on terrestrial mammals is dependent on the species, the timing and duration of the spill, and the type and quantity of oil spilled. Species which inhabit or frequent coastal areas may become oiled or may ingest contaminated prey and/or vegetation; however, this is highly unlikely because of the low conditional probability of a landfall as a result of a spill originating on one of Amoco's leases, and because of the mobile nature of terrestrial mammals.

Caribou and Arctic fox are the most important terrestrial species that utilize the Alaska Beaufort Sea coastal area. Caribou sometimes frequent barrier islands and shallow coastal waters during periods of heavy insect harassment. Thus, caribou may come in contact with oil along a contaminated coastline. The number of caribou that are likely to be affected would be small in comparison with the number of caribou that range along the Alaska Beaufort Sea coastline (MMS, 1984).

If a spill occurs during the open water season, caribou frequenting coastal habitats such as in the Cape Halkett or Jones Islands area could possibly be directly exposed to oil along the beaches and in shallow waters during periods of insect-pest escape activities. It also is possible that caribou could ingest oiled vegetation (MMS, 1984). Toxicity studies of crude oil ingestion in cattle indicate that anorexia, significant weight loss, and aspiration pneumonia leading to death are possible adverse effects of oil ingestion in caribou. The effects could increase mortality rates of any caribou that interact with oil pollution (Rowe et al., 1973).

Arctic foxes also could be affected by a major oil spill. This species could be impacted through the ingestion of oil-contaminated prey (Dome Petroleum et al., 1982). Chief prey items which could become contaminated include voles, the eggs and young of cliff-nesting bird species, and adult birds (DeGange and Sowls, 1978).

f. <u>Fish</u>: Fish of the arctic region differ from their counterparts in subarctic and temperate regions in that they have lower species diversities and reduced numbers. Additionally, arctic fish have developed life history, behavioral, physiological, and population characteristics that enable them to exist under harsh and fluctuating environmental conditions of both daily and seasonal occurrence. Occasionally, such conditions cause high mortalities, especially to the more sensitive life stages (eggs or juveniles). Because

of this, these fish populations seem well adapted to withstand at least short-term fluctuations in the environment, whether natural or man-induced (MMS, 1984).

The interaction of oil and fish could produce a variety of lethal and sublethal responses. Such responses include actual mortality if lethal concentrations are encountered, or damage to fish (i.e., to gills, skin, eyes, etc.) which could increase susceptibility to disease and possibly death. Sublethal effects include an assortment of physiological and behavioral responses which could alter the ability of the fish to resist disease, find food, or avoid predation (Rice, 1981; Starr et al., 1981; Hamilton et al., 1979; Malins, 1977).

Sublethal chronic effects may occur if fish are exposed to low-level concentrations over a long period of time. Such effects may involve declines in growth and reproductive rates, which could affect populations of fish over a long period of time. These sublethal effects are the most poorly understood, and would be difficult if not impossible to detect in the natural environment. Other effects could involve a loss or decline in fish prey organisms or tainting of commercial or subsistence species (MMS, 1984).

In general, it is the nearshore zone that contains the highest densities and species diversity of fish in the Alaska Beaufort Sea, at least during the open-water season. However, the nearshore area is used mainly as a migration corridor and feeding area. It is not a significant spawning or larval-rearing area for anadromous fish or a significant spawning area for most marine species.

Anadromous and marine fish are broadly distributed in the nearshore area during the open water season. Patchy occurrences of some marine types such as arctic cod are typical. Therefore, an oil spill contacting this area would only affect a small portion of a regional population and would avoid most of the sensitive life stages. For most species this contact would be brief because of their highly mobile behavior (MMS, 1984). Studies on salmonids (Weber et al.,

1981; Maynard and Weber, 1981) suggest that anadromous species may be able to detect acute lethal concentrations of oil in the water column and avoid contaminated areas (MMS, 1984). Even after contamination, they are often able to quickly purge oil from their systems after a return to uncontaminated waters (Brocksen and Bailey, 1973; Neff et al., 1976; McKeown, 1981).

The absence of acute lethal concentrations in the water column is another factor that minimizes effects on fish. Most acute toxicity values [96-hour lethal concentration for 50 percent of test organisms (LC<sub>50</sub>)] for fish are generally on the order of 1 to 10 parts per million (ppm). However, the concentrations observed under past crude oil spills and those calculated by modeling are less than the acute values for fish (Kineman et al., 1980). The effect on most nearshore species from oil contacting nearshore areas (other than critical habitats such as deltas) during the open water season would be minor. These effects may only last during the season of the spill, or may persist at some level for years if nearshore sediments are heavily contaminated (MMS, 1984).

To affect anadromous species a large spill would have to contact the nearshore in a relatively unweathered state, during conditions that would promote sinking or mixing of oil into the bottom sediments, such as high turbidity or surf. Residual effects of oil could inhibit colonization of important epibenthic food organisms (i.e., mysids and amphipods) in the contaminated area causing anadromous fish to feed less or swim longer distances to feed. This increased use of energy could reduce the amount of food reserves the fish need later for spawning or over-wintering. The increased energy demand could subsequently decrease reproductive and survival capacities and lead to long-term declines in regional populations (MMS, 1984).

A large oil spill contacting (a) river delta(s) used by fish as (a) spawning and/or overwintering area(s), as (a) habitat(s) for larvae and juvenile fish, and as (a) corridor(s) for migrating fish

could also effect (a) regional fish population(s). For example, large portions of the regional populations of arctic and least cisco and other whitefish species could overwinter in major river deltas. If oil contacted (a) river delta(s), it could result in lethal and sublethal effects on (a) fish population(s) occupying the affected delta(s). Such effects could include mortalities, particularly for newly hatched larvae, fry and smolts which are highly susceptible to hydrocarbons, a decline in fish prey organisms, tainting of fish used for commercial or subsistence purposes, and a variety of sublethal physiological and/or behavioral dysfunctions. In shallower under-ice habitats, an increase in the biochemical oxygen demand (BOD) from oil contamination could produce additional stress (MMS, 1984).

A large oil spill contacting (a) river delta(s) coincidentally with spawning migrations could induce avoidance responses which could, in turn, adversely affect reproductive success. However, this is not likely to occur and, if it did, such effects would probably be short-lived and affect only a portion of a spawning population. Concentrations that have produced effects on salmon generally fell within the range of acute toxicity values (1 to 3 ppm) (Weber et al., 1981). Such concentrations, however, are not expected. Further, spawners of arctic char populations do not appear to make seaward migrations during the year they spawn (Craig and McCart, 1976) and arctic cisco are suspected to spawn only in the Mackenzie River system (Gallaway, 1982).

Fourhorn sculpin are less mobile than the other species and hence more susceptible to either lethal or sublethal oiling. This species may even be eliminated from an area if nearshore subtidal areas are contaminated, either through avoidance, loss of prey, or other sublethal responses (MMS, 1984).

Capelin spawning areas along beaches adjacent to the Alaska Beaufort Sea OCS area could be contaminated and result in lethal or sublethal effects on all life stages. Oil persists in these areas for years which could imply a long-term effect on this species (MMS, 1984).

Even though interactions between other marine fish species and oil could occur, fish densities are generally very low and species are widely distributed. Most marine species are either pelagic or demersal. In these greater water depths, the probability that these species would be in contact with oil is further reduced. Since most marine fish species spawn during winter under the ice, eggs would not be greatly exposed to oil contamination. Oil spills which persist into winter would be confined to relatively small areas under the ice. If the ice is still growing, ice could form beneath the oil and encapsulate it, thus removing the possibility for later contact by marine fish. Some eggs, especially buoyant eggs from species such as arctic cod, could be affected; however, the number would be relatively small (MMS, 1984).

Phytoplankton community responses Plankton: range from stimulated growth to marked reductions in primary productivity and associated changes in species composition. soluble components of crude oils and refined products appear to be responsible for the most toxic effects, with refined oils providing the greatest amount of soluble components and hence and greatest toxicity. These effects vary with concentration of oil, season, and with community composition. Stimulatory effects (i.e., increase in cell numbers) have been observed in low concentrations, [i.e., less than 50 parts per billion (ppb)] while higher concentrations (i.e., 50 to 300 ppb) have caused inhibitory effects (i.e., a decline in cell numbers). Spills occurring during periods of greater light intensity (i.e., spring and summer) would have greater effects than those occurring in fall, because toxicity of oil to phytoplankton seems to increase with temperature and light intensity. Flagellates appear to be more resistant to petroleum hydrocarbons than centric or pennate diatoms. This suggests that nearshore Alaska Beaufort Sea communities may be more likely to respond with a reduction in growth and primary production due to the dominance of these diatoms (MMS, 1984).

Effects on zooplankton also would vary and may range from complete lethality to no effect. Water soluble fractions of oil have resulted in paralysis of copepods in concentrations of between 0.2 and 0.5 ppm while dispersed oil concentrations of 0.05 to 100 ppm produced lethal results in copepod larvae and adults. Other short-term (44 to 96 hour) acute toxicity tests produced LC<sub>50</sub> values within this range for other zooplankton larvae and adults (ESL, 1982). A recent study conducted in the Alaskan Beaufort Sea concluded that it is unlikely that an oil spill would cause a significant or lasting effect on zooplankton. If significant effects were to occur, they would most likely occur in nearshore areas (Richardson, 1987).

Effects of oil spills on epontic (under-ice) communities have not been documented; however, they would probably be similar to those for the planktonic communities. Oil spilled on top of the sea ice would probably be contained in a relatively small area. Such a spill would reduce the amount of light penetrating the ice, thereby lowering productivity of epontic diatoms. Oil spilled below the sea ice would pool beneath the ice smothering and killing the epontic organisms. However, the areal extent of these effects would be small. Oil spilled under the ice would probably become encapsulated in the ice and remain until spring. Therefore, effects on epontic communities would not last longer than a winter season (MMS, 1984).

h. <u>Benthos</u>: Benthic life would be affected by a major oil spill only under conditions that would allow oil to reach the sea bottom. These conditions include high winds and waves creating a mixing condition, high concentrations of suspended sediments in the water column, and oil contacting and becoming stranded in the intertidal zone. The probability of these conditions occurring and driving oil into the sediments is greatest in the shallower, nearshore environment than the deeper offshore areas (MMS, 1984).

Oil contacting a nearshore area during the open water season would have the greatest effect on the epibenthic crustaceans that invade the nearshore waters during this period. Effects on infaunal organisms would be of lesser importance because of their low abundance and diversity, and reduced ecological significance in this region (MMS, 1984).

Effects on epibenthic crustaceans would range from direct mortality to sublethal effects that include a variety of physiological and behavioral dysfunctions (Rice et al., 1980). Common sublethal effects include altered respiration, assimilation and excretion rates, uptake of aromatic hydrocarbons, decreased activity and locomotion, decreased frequency of molting, disruption of osmoregulation, reduced rates of development and brood size, narcosis, decreased borrowing activity, decreased chemoreception during feeding and reproduction, avoidance responses, reduced feeding rates, and reduced reproductive success (ESL, 1982). Responses dealing with avoidance, growth, feeding, and reproductive processes would be of greatest concern because of their potential for producing localized population declines. Effects on the nearshore infaunal worms (annelids) and mollusks (clams and snails) also could produce acute lethal responses and chronic sublethal responses. Some organisms such as certain species of infaunal polychaetes may be more tolerant of oil and therefore may thrive in oil-contaminated sediments (MMS, 1984).

Amphipods are very sensitive to oil pollution and have disappeared from areas as a result of spills and chronic pollution (Elmgren et al., 1980; d'Ozouville et al., 1979; Cabioch et al., 1981). Amphipods may be important in the diets of other invertebrates, as well as fish. However, a number of epibenthic invertebrates, as well as some fishes, serve as prey to fishes abundant in the nearshore zone so the local demise of some prey due to a spill should not affect fish populations significantly (MMS, 1987).

Although the impacts of a major oil spill could be substantial, the statistical likelihood of such an occurrence is very low

[see Part IV.G.(1) of this section]. The threat of environmental damage from a major oil spill will be minimized by Amoco's adherence to the drilling mud, casing, cementing and testing requirements contained in the applicable MMS regulations, the installation and frequent testing of blowout preventer equipment in conformance with industry standards and the requirements of § 250.56 and 250.57 of the MMS regulations, and Amoco's continuing commitment to safe and workmanlike operating practices and procedures. In the unlikely event that a major spill occurs, the drilling unit will be equipped with state-of-the-art containment and cleanup equipment and, if necessary, offsite equipment can be obtained from Alaska Clean Seas. In conformance with Stipulation No. 6 and Section 14(c) of the Information to Lessees portion of the Final Notice of Sale, Amoco has submitted an Oil Spill Contingency Plan which demonstrates, among other things, that Amoco is prepared to respond to an oil spill in broken ice conditions. Finally, Amoco believes that the weight of scientific evidence demonstrates that continuous, year round operations can be conducted safely and without substantial risk to the long term survival of endangered bowhead whales.

### F. ONSHORE IMPACTS

### (1) SOCIO-ECONOMIC

The proposed operations will have virtually no impact on onshore socio-economic conditions. Although some supplies and equipment may be purchased locally, these purchases will be made from vendors within industry enclaves which cater to the needs of offshore and onshore oil and gas operations.

a. <u>Effect on Local Employment</u>: The activities described in this plan may provide limited new employment opportunities to residents of the North Slope Borough. If so, the economic impact will be short term and beneficial.

- b. Effect Upon Local Population Centers and Industry: There will be no appreciable effect on the population of or existing industry in the North Slope Borough.
- c. <u>Increased Demand on Community Services</u>: Material necessary for the proposed operations will be shipped to Deadhorse, Tuktoyaktuk and, possibly, Prudhoe Bay and Barter Island from outside the North Slope area. Community services, such as water supply, materials handling, and transportation will be provided by existing infrastructures within established industry enclaves or at the Barter Island airport. No competition for goods and services will occur with the North Slope Borough during the course of the proposed operations.
- d. <u>Public Opinion Concerning the Proposed Activities:</u>
  Native perceptions of the threats of offshore oil development primarily focus on subsistence issues. Perceived subsistence impacts can be divided into the following categories: direct damage to subsistence resources and/or their habitats; disruptions in the migratory patterns of subsistence species; disruption of access to subsistence use areas; harm to cultural resource landmarks; and loss of Native food sources (MMS, 1984).

All of the impacts on subsistence use activities compound and are additive to the biological impacts on subsistence species. Harm to any one of the subsistence species or subsistence use activities is not expected to have greater than a highly localized, short term impact on subsistence use activities. Concurrent impacts to several species and/or to several activities could have a major impact on subsistence resources and/or subsistence use activities. This occurrence, however, is considered unlikely (MMS, 1984).

e. <u>Effect of Increased Boat Traffic</u>: The frequency of vessel traffic into and out of the port facilities at Tuktoyaktuk, Canada and, possibly, Prudhoe Bay may increase slightly as a result of

the proposed operations. However, the expected impact will be negligible. Existing port facilities are adequate to accommodate the planned operations.

- f. <u>Increased Competition for Scarce Coastal Resources:</u>
  The capacity of existing harbor facilities at Tuktoyaktuk, Canada and Prudhoe Bay is sufficient to support the limited use envisioned during the proposed operations. Other aspects of the transportation system, including air service from Deadhorse and, possibly, Barter Island, though limited, is highly flexible and particularly suited to meeting fluctuations in demand.
- g. <u>Effects on Subsistence Activities</u>: Information on the potential impacts to subsistence use activities is provided in Part IV.D.(10) of this section.

#### (2) DEMAND FOR GOODS AND SERVICES

- a. <u>Equipment and Supplies</u>: All of the equipment and supplies needed to carry out the proposed operations will be purchased from outside the North Slope Borough area and transported to the area by vessel or aircraft.
- b. <u>Water:</u> The drilling unit will have the capability to distill water to meet all crew and drilling requirements for fresh water.
- c. Aggregate Energy: Electricity for the drilling and support units will be produced through the use of onboard generators. Electricity for the service bases at Deadhorse, Tuktoyaktuk and, possibly, Barter Island will be supplied through existing generating facilities.

d. Other Resources: Due to limited supplies of commodities for sale in the North Slope Borough area, the majority of supplies for this project will be brought into the area by Amoco. Additional resources can be obtained from the Prudhoe Bay and Tuktoyaktuk facilities complex, which cater to the needs of the oil and gas industry.

#### (3) ENVIRONMENTAL IMPACTS

- a. Onshore Construction Activities: No onshore facility construction will be needed to support the proposed operations.
- b. Other Impacts Not Previously Discussed: The leases covered by this report are situated 30 miles (48.3 km) or more from the closest onshore area and will be used individually only for a short period of time. Moreover, they are situated in a remote, virtually uninhabited area. The adverse aesthetic impact of the proposed operations, therefore, a considered to be insignificant.

#### G. ACCIDENTS

#### (1) POTENTIAL IMPACTS OF MAJOR ACCIDENT

The potential for a major oil spill continues to be one of the major concerns expressed over oil and gas exploration activities offshore Alaska. Based on historical data, however, the probability that a major oil spill will occur during the conduct of the proposed operations is extremely remote. Indeed, there has never been a major oil spill anywhere in U.S. waters as a result of exploratory drilling operations.

A major oil spill from an exploratory well most likely would occur as the result of the sudden loss of well control and the uncontrolled escape of hydrocarbons (i.e., a "blowout"). Data on the incidence of blowouts from offshore exploratory wells is available for the United States OCS for the period 1971 through 1985.

In 1980, the U.S. Geological Survey published a report entitled "Outer Continental Shelf Oil and Gas Blowouts" which provides statistics for blowouts from exploratory wells in the Gulf of Mexico for the period 1971 through 1978. According to these data, 17 blowouts occurred during the drilling of 2,250 exploratory wells (Danenberger, 1980).

In 1983, the MMS published a report entitled "Outer Continental Shelf Oil and Gas Blowouts, 1979-1982". This document provides blowout data for 1,580 exploratory wells drilled on the United States OCS from 1979 through 1982. According to the MMS data, 8 blowouts occurred during this period (MMS, 1983).

In 1985, the MMS published a report entitled "Federal Offshore Statistics: 1985". This document provides information on the number of blowouts (i.e., 8) which occurred during the drilling of exploratory wells for the years 1983-85.

Finally, Amoco acquired data on the number of exploratory wells drilled on the United States OCS for the years 1983 through 1985 (i.e., the last year for which blowout data are available) by contacting the MMS. During these three years, 1,507 exploratory wells were drilled (Adams, 1986).

When the available data on blowouts from exploratory wells on the United States OCS are combined, a total of 33 blowouts occurred during the drilling of 5,337 wells (Danenberger, 1980; MMS, 1983; Adams, 1986; MMS, 1988).

Using the combined United States OCS data, the estimated blowout rate is P = 0.62 percent chance per well with an upper 95 percent confidence bound of 0.80 percent. Thus, there is a 95 percent degree of confidence in the statement that the unknown probability of a blowout is below 0.80 percent.

The risk of a blowout during exploratory drilling operations resulting in a major oil spill is extremely low. Indeed, since the inception of exploratory drilling operations on the United States OCS up to January 1, 1988, there has <u>never</u> been a major oil spill from a blowout during the drilling of 7,951 exploratory wells (Adams, 1986; MMS, 1988).

Given the data of zero out of 7,951 trials, the maximum likelihood estimator of "P" (i.e., the probability of a major oil spill occurring as a result of a blowout) is P=0. The upper 95 percent confidence bound on a major oil spill occurring as a result of a blowout from an exploratory well is  $P \leq .0004$ . It should be emphasized that this is an upper bound (i.e., as more experience is accumulated, the number will decrease).

A description of possible impacts of oil spills on each major group of marine flora and fauna is provided in Part IV.E. (3) of The studies done to date indicate that a major spill could severely impact plankton, finfish, larvae, pelagic and benthic crustaceans, gastropods, bivalves, benthic invertebrates, marine mammals, and birds in the immediate vicinity of the spill. If the oil reached the intertidal zone, a spill could also have adverse effects The severity of these effects would depend upon in that area. temporal variations in the abundance of marine organisms, seasonal cycles of reproductive phases, the degree of oil weathering, type, rate and volume of oil, upon the weather and oceanographic conditions at the time of the spill, and upon the effectiveness of oil spill containment and cleanup equipment. These parameters would determine how much oil is dispersed into the water column, the degree of settling, weathering and scattering before impacting a shoreline, and the final amount, concentration, and composition of the hydrocarbons at the time of impact.

A major oil spill could have a short-term adverse effect on air quality, due to the sudden escape of uncontrolled hydrocarbon vapors into the atmosphere, and on water quality. The water quality impact has been analyzed extensively during the past decade. These analyses have concluded that the water quality in the immediate vicinity of the slick would be degraded, but that the degradation would decrease rapidly following control of the source (BLM, 1981).

# (2) IMPACTS FROM HYDROCARBON DISCHARGE RESULTING FROM ROUTINE OPERATIONS

Every effort will be made to avoid small hydrocarbon discharges into ocean waters. Accidental discharges could occur during operations through the release of diesel fuel during fueling operations. The quantities of oil associated with such spills would be quite small and would be contained and cleaned up by equipment maintained onboard the drilling unit. It is highly unlikely that a spill of this nature would have a significant effect on air or water quality, or marine biota.

(V) ALTERNATIVES TO THE PROPOSED ACTION

No discussion is required for exploratory operations.

(VI) UNAVOIDABLE ADVERSE ENVIRON-MENTAL EFFECTS

Very few unavoidable impacts are expected as a result of the proposed exploratory drilling operations. The most significant unavoidable environmental effects which may occur are:

1. The short-term disturbance of bottom sediments from glory hole construction operations, wellhead equipment, settled mud and drill cuttings, and anchors.

Project-related drilling facilities and equipment will be removed as soon as the drilling operations are completed, and the seafloor is expected to return to normal within a short period of time. Most of the solid materials released to the water column will sink rapidly to the bottom and the remaining, lighter fractions will disperse over a relatively small area prior to settling. Once settled, materials will be reworked by currents and ice.

2. The crushing, smothering or displacement of benthic organisms over the area affected by construction of a glory hole, permitted discharges, etc.

The proposed drilling operations are temporary in nature and will occur in separate locations. Once operations have ceased in any one area, benthic organisms are expected to repopulate the affected area.

3. An adverse localized impact on plankton and other filterfeeders due to the increased turbidity associated with project-related discharges.

This effect will be temporary and very localized. A return to background turbidity levels should occur within 3,280 feet (1,000 m) of the drillsite.

A localized and short-term impact on water quality due to the discharge of drilling mud, cuttings, and produced water.

The overall impact on water quality is expected to be temporary and highly localized. All discharges will be made in accordance with the general NPDES permit for the Beaufort Sea.

5. A minor, localized, short-term impact on offshore air quality.

The air emissions impact analysis performed as required by the MMS regulations indicates that the air emissions will not have a significant impact on any onshore area.

## (VII) REFERENCES

- Aagaard, K. 1979. Current Measurements in Possible Dispersal Regions of the Beaufort Sea. <u>In</u>: Environmental Assessment of the Alaskan Continental Shelf, Annual Report of the Principal Investigators, Research Unit 91 U.S. Department of Commerce. National Oceanic and Atmospheric Administration, OCSEAP.
- Aagaard, K. 1983. The Beaufort Current. <u>In:</u> The Alaskan Beaufort Sea Ecosystems and Environment. Edited by Schell, D., Barnes, P., and Reimnitz, E. Acadamic Press. New York, NY.
- Acoustical Society of America. 1981. San Diego Workshop on the Interaction Between Man-made Noise and Vibration and Arctic Marine Wildlife. A Report and Recommendation.
- Adams, M. 1986. Personal Communication, April 4, 1986. Minerals Management Service, Pacific OCS Region.
- Alaska Clean Seas (ACS). 1983. Alaskan Beaufort Sea Coastal Region, Vols. I and II. Alaska Clean Seas Contingency Planning Manual Supplement. Anchorage, AK.
- Alaska Consultants, Inc., and Stephen Braund and Associates (ACI/Braund). 1984. Subsistence Study of Alaska Eskimo Whaling Villages. Prepared for U.S. Department of Interior.
- Alaska Department of Community and Regional Affairs. 1977. Organized Boroughs and Cities (map).
- Alaska Department of Environmental Conservation (ADEC). 1980. Revisions to the State Air Quality Control Plan.
- Alaska Department of Fish and Game (ADF&G). 1984. Annual Management Report, 1984, Yukon Area, Div. of Commercial Fisheries.
- Alaska Department of Labor. 1982. Population Estimates by Census Division.
- Alaska Department of Natural Resources (ADNR). 1983. Notice: State of Alaska Competitive Oil and Gas Lease Sale 39. Beaufort Sea. Anchorage, AK.
- Alaska Department of Natural Resources (ADNR). 1976. Division of Parks. Joint Federal-State Land Use Planning Commission.
- Alaska Oil and Gas Conservation Commission. 1984. 1983 Statistical Report.

- Albers, P. H. and Szaro, R. C. 1978. Effects of No. 2 Fuel Oil on Common Eider Eggs. Marine Pollution Bulletin, 9.
- Albert, T. F. 1981. Some Thoughts Regarding the Possible Effects of Oil Contamination on Bowhead Whales, <u>Balaena mysticetus</u>. <u>In:</u> Tissue Structural Studies and Other Investigations on the Biology of Endangered Whales in the Beaufort Sea, Vol. 1. Edited by Albert, T. F. Final Report for the period April 1, 1981 June 30, 1981. Prepared for U.S. Department of the Interior, Bureau of Land Management, Alaska OCS Office, Anchorage, AK.
- Alexander, V. 1974. Primary Productivity Regimes of the Nearshore Beaufort Sea, with Reference to Potential Roles of Ice Biota.

  In: The Coast and Shelf of the Beaufort Sea. Edited by Reed, J. C. and Slater, J. E. Arlington, VA: Arctic Institute of North America.
- Amstrup, S. C. 1985. Research on Polar Bears in Alaska, 1983-1985. Report presented at International Union for Conservation of Nature and Natural Resources, Polar Bear Specialist Group, Ninth Meeting, Edmonton, Alberta, Canada, 1985.
- Arctic Institute of North America (AINA). 1974. The Alaskan Arctic Coast. A Background Study of Available Knowledge. USACOE Contract No. DACW85-74-C-0029.
- Armstrong, Robert H. and the Editors of Alaska Magazine. 1980. A Guide to the Birds of Alaska. Alaska Northwest Publishing Company. Anchorage, AK.
- Ayers, R. C. Jr., Meek, R. P., Sauer, T. C. Jr., and Stuebner, D. O. 1980a. An Environmental Study to Assess the Effect of Drilling Fluids on Water Quality Parameters During High Rate, High Volume Discharges to the Ocean. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Ayers, R. C., Jr., Sauer, T. C., Meek, R. P., and Bowens, G. 1980b.
  An Environmental Study to Assess the Impact of Drilling Discharges in the Mid-Atlantic. I. Quantity and Fate of Discharges. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Ayers, R. C., Jr. 1981. The Fate and Effects of Offshore Drilling Discharges. Presented to Second Meeting of the United Nations Environmental Consultive Committee on the Petroleum Industry. June 2-4, 1981. Paris, France.
- Barnes, P. W., Rearic, D. M., and Reimnitz, E. 1983. Ice Gouging Characteristics and Processes. Annual Reports of the Principal Investigators for the Year Ending March 1983, RU 205, Geological Processes and Hazards of the Beaufort and Chukchi Sea Shelf and Coastal Regions. USDOC, NOAA, OCSEAP.

- Barnes, P. W. and Reimnitz, E. 1974. Sedimentary Processes on Arctic Shelves Off Northern Coast of Alaska. <u>In</u>: The Coast and Shelf of the Beaufort Sea. Edited by Reed, <u>J</u>. C. and Slater, J. E. Proceedings of the Arctic Institute of North America Symposium on Beaufort Sea Coast and Shelf Research: Arlington, Virginia, Arctic Institute of North America.
- Barnes, P. W. and Reimnitz, E. 1979. Ice Gouge Obliteration and Sediment Redistribution Event--1977-1978, Beaufort Sea, Alaska: U.S. Geological Survey Open-File Report 79-848.
- Barnes, P. W., Reimnitz, E., and Naidu, A. S. 1981. Sediments. Chapter 3. In: Proceedings of a Synthesis Meeting: Beaufort Sea-Sale 71-Synthesis Report. Chena Hot Springs, Alaska, April 21-23, 1981. Edited by Norton, D. W. and Sackinger, W. M. Juneau, AK: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program.
- Barry, R. C. 1979. Study of Climatic Effects on Fast Ice Extent and Its Seasonal Decay Along the Beaufort-Chukchi Coasts. In: Environmental Assessment of the Alaskan Continental Shelf, Final Reports of the Principal Investigators, Research Unit No. 244. Boulder, CO: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program.
- Barry, T. W. 1968. Observations on Natural Mortality and Native Use of Eiders Along the Beaufort Sea Coast. Canadian Field-Naturalist, 82.
- Barry, T. W., Barry, S. J., and Jacobsen, B. 1981. Sea-Bird Surveys in the Beaufort Sea, Amundsen Gulf, Prince of Wales Strait and Melville Sound 1980 Season. Prepared for Dome Petroleum Ltd., and Esso Resources Canada Ltd., Calgary, and Canadian Wildlife Service, Edmonton.
- Becker, P. R., ed. 1987. The Diapir Field Environment and Possible Consequences of Planned Offshore Oil and Gas Development. Proceedings of a Synthesis Meeting, January 25-28, 1983, Chena Hot Springs, Alaska. Prepared by NOAA/Ocean Assessments Division, OCSEAP, Anchorage.
- Benech, S., Bowker, R., and Pimental, B. 1980. Chronic Effects of Drilling Fluids Exposure to Fouling Community Composition on a Semi-submersible Exploratory Drilling Vessel. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.

- Benfield, D. 1979. A Survey of Polar Bear Denning on NPR-A, 1977.

  In: Vol. 1. Studies of Selected Wildlife and Fish and Their Use of Habitats on and Adjacent to the National Petroleum Reserve in Alaska 1977-1978. Land Use Study, Work Group 3, Field Study 3. U.S. Dept. Interior. NPR-A 105(c).
- Bente, P. J. 1977. Distribution and Numbers of Muskox in Northeastern Alaska, 1974-1977. <u>In:</u> Unpubl. Rep. by Renewable Resources Consulting Services Ltd. for Alaskan Arctic Gas Study Co.
- Birkeland, P. W. and Larson, E. F. 1978. Putnam's Geology. Third Edition. Oxford University Press, New York, NY.
- Biswas, N. N., and Gedney, L. 1978. Seismotectonic Studies of Northeast and Western Alaska: University of Alaska Geophysical Institute.
- Boehm, P., Steinhauer, M., Crecelius, E., Neff, J., and Tuckfield, C. 1987. Final Report on Beaufort Sea Monitoring Program: Analysis of Trace Metals and Hydrocarbons from Outer Continental Shelf (OCS) Activities. Prepared by Battelle Ocean Sciences, Duxbury, MA. Prepared for Minerals Management Service, Alaska OCS Region, Anchorage, AK. Contract No. 14-12-001-30163.
- Boehm, P. D., Crecelius, E., Steinhauer, W., Steinhauer, M., Rust, S., and Neff, J. 1985. Final Annual Report on Beaufort Sea Monitoring Program; Analysis of Trace Metals and Hydrocarbons from Outer Continental Shelf (OCS) Activities Year 1 Results. Batelle New England Marine Research Laboratory, Duxbury, MA.
- Bowen, H. J. M. 1979. Environmental Chemistry of the Elements. Academic Press, London.
- Braham, H. W. 1982. Comments on the World Stocks of Bowhead Whales and Estimating Total Population Abundance in the Western Arctic. IWC SC/34/PS13.
- Braham, H. W. and Krogman, B. D. 1977. Population Biology of the Bowhead (Balaena mysticetus) and Beluga (Delphinapterus leucas) Whale in the Bering, Chukchi and Beaufort Seas. Northwest and Alaska Fisheries Center Processed Report, National Marine Fisheries Service, Seattle, Washington.
- Braham, H., Krogman, B., Leatherwood, S., Marquette, W., Rugh, D., Tillman, M., Johnson, J., and Carroll, G. 1979. Preliminary Report of the 1978 Spring Bowhead Whale Research Program Results. Rep. Int. Whal. Comm.

- Braithwaite, L. F. 1980. The Effects of Oil on the Feeding Mechanism of the Bowhead Whale. <u>In</u>: Draft Proceedings of the Interagency Meeting to Review, Coordinate, and Plan Bowhead Whale Research, Other Cetacean Research, and Related Research Bearing Upon the Conservation and Protection of Endangered Marine Species in Alaska and Elsewhere. Bureau of Land Management, Washington, D. C.
- Brannon, A. C. and Rao, K. R. 1979. Barium, Strontium and Calcium Levels in the Exoskeleton, Hepatopancreas and Abdominal Muscle of the Grass Shrimp Paleomonetes pugio: Relation to Molting and Exposure to Barite. In: Comp. Biochem. Physiol., 63A.
- Broad, A. C., Griffiths, W., and Carey, A. C., Jr. 1981. Inverte-brates. In: Proceedings of a Synthesis Meeting: Beaufort Sea-Sale 71-Synthesis Report. Chena Hot Springs, Alaska, April 21-23, 1981. Edited by Norton, D. W. and Sackinger, W. M. Juneau, AK: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program.
- Brocksen, R. W. and Bailey, H. T. 1973. Respiratory Response of Juvenile Chinook Salmon and Striped Bass Exposed to Benzene, a Water-Soluble Component of Crude Oil. In: Proceedings of 1973 Joint Conference on Prevention and Control of Oil Spills, American Petroleum Institute, Washington, D.C.
- Brower, W. A., Searby, H. W., and Wise, J. L. 1977. Climatic Atlas of the Outer Continental Shelf Waters and Coastal Regions of Alaska. Vol. III: Chukchi-Beaufort Sea. National Oceanic and Atmospheric Administration. OCSEAP. Asheville, NC.
- Brown, W. E. 1979. Nuiqsut Heritage: A Cultural Plan. Arctic Environmental Information and Data Center, Anchorage, AK.
- Bureau of Land Management (BLM). 1982. Final Environmental Impact Statement Proposed Outer Continental Shelf Oil and Gas Lease Sale No. 71 Diapir Field. BLM-YK-ES-81-010-1792.
- Bureau of Land Management (BLM). 1981. Final Environmental Impact Statement, Proposed 1982 Outer Continental Shelf Oil and Gas Lease Sale Offshore Southern California, OCS Sale No. 68. Volumes 1 and 2.
- Bureau of Land Management (BLM). 1979. Beaufort Sea Final Environmental Impact Statement. Anchorage, AK.
- Burns, J. J. and Eley, T. 1977. "The Natural History and Ecology of the Bearded Seal (Erignathus barbatus) and the Ringed Seal (Phoca hispida)." Principal Investigators Annual Reports, Vol. 1, Research Unit 230. Boulder, CO: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program.

- Burns, J. J. and Frost K. J. 1979. The Natural History and Ecology of the Bearded Seal <u>Erignathus</u> <u>barbatus</u>. Final Rep., Contract No. 02-5-002-53. BLM/NOAA, OCSEAP. Boulder, CO.
- Burns, J. J., Kelly, B. P., and Frost, K. J. 1981a. Studies of Ringed Seals in the Beaufort Sea During Winter. In: Environmental Assessment of the Alaskan Continental Shelf, Executive Summary. Biological Studies, Research Unit 237. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program.
- Burns, J. J., Kelly, B. P., and Frost, K. J. 1981b. Executive Summary: Studies of Ringed Seals in the Beaufort Sea During Winter. Unpublished Report for Alaska Department of Fish and Game.
- Burrell, D. C., Kinney, P. J., Hadley, R. S., and Arhelger, M. E. 1970. Beaufort Sea Environmental Data: USCGC Northwind, 1968; USCGC Staten Island, 1968 and 1969. University of Alaska Institute of Marine Science, College, AK. Report R70-20.
- Bursa, A. S. 1963. "Phytoplankton in the Coastal Waters of the Arctic Ocean Near Point Barrow, Alaska." Arctic, 16.
- Byers, S. C. and Kashino, R. K. 1980. Survey of Fish Populations in Kugmallit Bay and Tuktoyaktuk Harbor. Prepared for Dome Petroleum Ltd. Calgory, Alberta, Canada.
- Cabioch, L., Dauvin, J. C., Gentil, F., Retiere, C., and Rivain, V. 1981. Perturbations Induites dan la Composition et le Fonctionnement des Peuplements Benthiques Sublittoraux, sous l'effet des Hydrocarbures de l'Amoco Cadiz. In: Amoco Cadiz, Fates and Effects of the Oil Spill. CNEXO, Paris.
- Caldwell, M. C. and Caldwell, D. K. 1982. A Study of the Effects of Oil Ingestion on a Bottlenose Dolphin, <u>Tursiops truncatus</u>. <u>In</u>: Study of the Effects of Oil on Cetaceans. Geraci, J. R. and St. Aubin, D. J. Final Report, Prepared for U.S. Dept. of the Interior, Bureau of Land Management, Washington, D.C. Contract #AA551-CT9-29.
- Calef, G. W. 1978. Population Status of Caribou in the Northwest Territories. Pages 9-16. <u>In</u>: Parameters of Caribou Population Ecology in Alaska. Proceedings of a Symposium. Edited by Klein, D. R. Biol. Pap. Univ. of Alaska. Special Report No. 3.
- Campbell, J. A. and Loring, D. H. 1980. Baseline Levels of Heavy Metals in the Waters and Sediments of Baffin Bay. Marine Pollution Bulletin, V. 11.
- Cannon, T. and Hachmeister, L., eds. 1986. Endicott Environmental Monitoring Program. Vol. I. Prepared by Envirosphere Co. Prepared for U.S. Army Corps of Engineers, Alaska District, and Sohio Alaska Petroleum Co.

- Carey, A. G. (ed). 1978a. Marine Biota (Plankton/Benthos/Fish). In:
  Environmental Assessment of the Alaskan Continental Shelf,
  Interim Synthesis: Beaufort/Chukchi. Boulder, CO: U.S. Dept.
  of Commerce, National Oceanic and Atmospheric Administration,
  Outer Continental Shelf Environmental Assessment Program.
- Carey, A. G., Jr. 1978b. The Distribution, Abundance, Diversity and Productivity of the Western Beaufort Sea Benthos. <u>In:</u> Environ. Assess. Alaskan Cont. Shelf, Annu. Rep. Prin. Invest., Vol. 4. BLM/NOAA, OCSEAP, Boulder, CO.
- Carls, M. G. and Rice, S. D. 1980. Toxicity of Oil Well Drilling Muds to Alaskan Larval Shrimp and Crabs. Research Unit 72. Final Rept. Proj. No. R7120822. OCSEAP.
- Carr, R. S., McCulloch, W. L., Neff, J. M. 1982. Bioavailability of Chromium From a Used Chrome-Lignosulfonate Drilling Mud to Five Species of Marine Invertebrates. <u>In</u>: Marine Environ. Res., <u>6</u>.
- Carr, R. S., Raitsema, R. A., and Neff, J. M. 1980. Influence of a Used Chrome-lignosulfonate Drilling Mud on the Survival, Respiration, Growth, and Feeding Activity of the Opposum Shrimp Mysidopsis almyra. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Carruthers, D. R., Jakimchuk, R. D., and Ferguson, S. H. 1984. The Relationship Between the Central Arctic Caribou Herd and the Trans-Alaska Pipeline. Prepared for Alyeska Pipeline Service Company, Anchorage, AK, by Renewable Resources Consulting Services, Ltd.
- Chapman, C. J. and Hawkins, A. D. 1969. The Importance of Sound in Fish Behavior in Relation to Capture by Trawls. FAO Fisheries Report No. 62, 3.
- Chester, R. 1965. Elemental Geochemistry of Marine Sediments. In: Chemical Oceanography, Vol. 2. Edited by Riley, J. P. and Skirrow, G. Academic Press, New York, NY.
- Coffing, M. and Pedersen, S. 1985. Caribou Hunting: Land Use Dimensions, Harvest Level, and Selected Aspects of the Hunt During Regulatory Year 1983-84 in Kaktovik, Alaska. Technical Paper No. 120. Alaska Department of Fish and Game, Division of Subsistence, Fairbanks, Alaska.
- Conklin, P. J., Drysdale, D., Doughties, D. G., Rao, K. R., Kakareka, J. P., Gilbert, T. R., and Shokes, R. F. In press. Comparative Toxicity of Drilling Fluids: Role of Chromium and Petroleum Hydrocarbons. Mar. Environ. Res.
- Continental Shelf Associates, Inc. (CSA). 1985. Environmental Report (Plan of Exploration) Beaufort Sea, Diapir Field OCS Sale 87 Area. Prepared for Exxon Company, U.S.A., Houston, TX.

- Continental Shelf Associates, Inc. (CSA). 1981. Environmental Report, Beaufort Sea (Beechey Point). Prepared for Exxon Company, U.S.A., Houston, TX.
- Cooch, F. G. 1958. The Breeding Biology and Management of the Blue Goose (Chen caerulescens). PhD. Diss., Cornell University, Ithaca, New York.
- Cooke, L. W. 1985. Estimates of Undiscovered Economically Recoverable Oil and Gas Resources for the Outer Continental Shelf as of July, 1984. U.S. Department of the Interior. Minerals Management Service, Offshore Resource Evaluation Division. MMS 85-0012.
- Coon, C., Albers, P. H., and Szaro, R. C. 1979. Number 2 Fuel Oil Decreases Embryonic Survival of Great Black-backed Gulls. Bull. Envir. Contam. Toxicol., 21.
- Cooper Consultants, Inc. and Envirosphere Company. 1986. Fate and Effects of Exploratory Phase Oil and Gas Drilling Discharges in the Beaufort Sea Planning Area, Lease Sale 97. Prepared for U.S. Environmental Protection Agency. Appendix L. In: Draft Environmental Impact Statement, Proposed Beaufort Sea Lease Sale 97. Prepared by Minerals Management Service, Alaska OCS Region.
- Cowles, C. J., Hansen, D. J., and Hubbard, J. D. 1981. Types of Potential Effects of Offshore Oil and Gas Development on Marine Mammals and Endangered Species of the Northern Bering Sea and Arctic Ocean. Technical Paper No. 9. U.S. Department of Interior, Bureau of Land Management, Alaska Outer Continental Shelf Office.
- Craig, J. D., Sherwood, K. W., and Johnson, P. P. 1985. Geologic Report for the Beaufort Sea Planning Area, Alaska: Regional Geology, Petroleum Geology, Environmental Geology. U.S. Department of the Interior. Minerals Management Service. MMS 85-0111.
- Craig, P. C. 1987. Alaska OCS Socio-economic Studies Program, Subsistence Fisheries at Coastal Villages in the Alaskan Arctic, 1970-1986. Prepared by LGL Ecological Research Associates, Inc. Prepared for Minerals Management Service, Alaska OCS Region, Leasing and Environment Office.
- Craig, P. C. 1984. Fish Use of Coastal Waters of the Alaskan Beaufort Sea. A Review Transactions of the American Fisheries Society 113:265-282.
- Craig, P. C. and Griffiths, W. B. 1981. Passage of Large Fish Around a Causeway in Prudhoe Bay, Alaska. Arctic, 34(4).

- Craig, P. C. and Haldorson, L. 1981. <u>In:</u> Beaufort Sea Barrier Island-Lagoon Ecological Processes Studies. Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, Vol. 7, Biological Studies, Research Unit 467. Boulder CO: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program.
- Craig, P. C. and Haldorson, L. 1980. Beaufort Sea Barrier Island-Lagoon Ecological Process Studies: Final Report, Simpson Lagoon. Part 4. Fish. <u>In</u>: Environ. Assess. Alaskan Cont. Shelf, Annu. Rep. Prin. Invest. Vol. 7 and 8. BLM/NOAA, OCSEAP, Boulder, CO.
- Craig, P. C. and McCart, P. 1976. Fish Use of Nearshore Coastal Waters in the Western Arctic: Emphasis on Anadromous Species.

  In: Assessment of the Arctic Marine Environment. Fairbanks, AK:
  University of Alaska, Institute of Marine Science.
- Crawford, R. B. and Gates, J. D. 1981. Effects of Drilling Fluid on the Development of a Teleost and an Echinoderm. Bull. Environ. Contam. Toxicol., 26.
- Crippen, R. W. and Hood, S. L. 1980. Metal Levels in Sediment and Benthos Resulting from a Drilling Fluid Discharge into the Beaufort Sea. <u>In</u>: Proc. Symposium Research on Environmental Fate and Effects of Drilling Fluids and Cuttings, January 21-24, 1980. Lake Buena Vista, FL.
- Cross, W. E., Thomson, D. H., and Maltby, A. 1983. Effects of Oil and Dispersed Oil on Nearshore Macrobenthos at Cape Hatt, Northern Baffin Island, III. Results of 1980, 1981 and 1982 Pre- and Post-Spill Studies. Unpublished Report Prepared by LGL Limited, Toronto. Prepared for Envir. Prot. Serv., Edmonton.
- Dames & Moore. 1978a. Beaufort Sea Region Natural, Physical and Biotic Baseline.
- Dames & Moore. 1978b. Drilling Fluid Dispersion and Biological Effects Study for the Lower Cook Inlet C.O.S.T. Well. Report prepared for Atlantic Richfield Company.
- Danenberger, W. 1980. Outer Continental Shelf Oil and Gas Blowouts. U.S. Geological Survey Open File Report 80-101.
- Davis, J. E. and Anderson, S. S. 1976. Effects of Oil Pollution on Breeding Gray Seals. Marine Pollution Bulletin, 7(6).
- DeGange, A. R. and Sowls, A. L. 1978. A Faunal Reconnaissance of the Bering Sea National Wildlife Refuge. 26 June, 27 July, 1977. Unpublished Field Report #77-039. U.S. Fish and Wildlife Service. Office of Biological Studies. Coastal Ecosystems Team. Anchorage, AK.

- Derby, C. D. and Atema, J. 1981. Influence of Drilling Muds on the Primary Chemosensory Neurons in Walking Legs of the Lobster, Homarum americanus. Can. J. Fish. Aquat. Sci., 18:268-274.
- Divoky, G. J. 1978. Identification, Documentation and Delineation of Coastal Migratory Bird Habitats in Alaska. I. Breeding Bird Use of Barrier Islands in the Northern Chukchi and Beaufort Seas.

  In: Environ. Assess. Alaskan Cont. Shelf, Annu. Rep. Prin.

  Invest., Vol. 1, March 1978. BLM/NOAA, OCSEAP, Boulder, CO.
- Dixon, E., Sharma, G., and Stoker, S. 1986. Alaska Outer Continental Shelf Cultural Resource Compendium, Technical Report 119. Prepared for Minerals Management Service, Alaska OCS Region, Alaska OCS Social and Economic Studies Program, Anchorage, AK. MMS 86-0018.
- Dome Petroleum Limited, Esso Resources Canada Limited, and Gulf Canada Resources, Inc. 1982. Environmental Impact Statement for Hydrocarbon Development in the Beaufort Sea Mackenzie Delta Region.
- d'Ozouville, L., Hayes, M. O., Gundlach, E. R., Sexton, W. J., and Michel, J. 1979. Occurrence of Oil in Offshore Bottom Sediments at the <u>Amoco Cadiz</u> Oil Spill Site. <u>In</u>: Proceedings of the 1979 Oil Spill Conference. American Petroleum Institute Publication No. 4308.
- Dunton, K. H. 1984. An Annual Carbon Budget for an Arctic Kelp Community. In: The Alaskan Beaufort Sea Ecosystems and Environments. Edited by Barnes, P. W., Schell, D. M. and Reimnitz, E. Academic Press Inc., NY.
- Dunton, K. H., Reimnitz, E. and Schonberg, S. V. 1982. An Arctic Kelp Community in the Alaskan Beaufort Sea. Arctic 35(4).
- Dunton, K. H. and Schonberg, S. V. 1979. An Arctic Kelp Community in Stefansson Sound, Alaska: A Survey of the Flora and Fauna. In: Environmental Assessment of the Alaskan Continental Shelf. Annual Report. Nat. Oceanic Atmos. Admin., Boulder CO.
- Duval, W. S., Martin, L. C., and Fink, R. P. 1981. A Prospectus on the Biological Effects of Oil Spills in Marine Environments. Prepared by E.S.L., Environmental Sciences Limited, Vancouver, B. C., for Dome Petroleum Limited, Calgary, Alberta, Canada.
- Ecomar, Inc. 1978. Tanner Bank Mud and Cuttings Study. Conducted for Shell Oil Company.
- Ecomar Marine Consulting. 1983. Mud Dispersion Study Norton C.O.S.T. Well No. 2. Conducted for ARCO Alaska, Inc.
- Eley, T. and Lowry, L. 1978. Marine Mammals. In: Environmental Assessment of the Alaskan Continental Shelf, Interim Synthesis: Beaufort/Chukchi. National Oceanic and Atmospheric Administration. OCSEAP. Boulder, CO.

- elmgren, R., Hansson, S., Larsson, U., and Sundelin, B. 1980. Impact of Oil on Deep Soft Bottoms. In: The Tsesis Oil Spill. Edited by Kineusan, J. J., Elmgren, R., and Hansson, S. Washington, D.C.: USDOC, NOAA.
- Engelhardt, F. R. 1985. Effects of Petroleum on Marine Mammals. In:
  Petroleum Effects in the Arctic Environment. Edited by
  Engelhardt, F. R. Elisvier Applied Science Publishers, Inc. New
  York.
- Engelhardt, F. R. 1981. Oil Pollution in Polar Bears: Exposure and Clinical Effects. <u>In</u>: Proc. Fourth Arctic Marine Oil Spill Program Technical Seminar. June 16-18, 1981. Env. Canada, Edmonton, Alberta.
- Engelhardt, F. R. 1978. Petroleum Hydrocarbons in Arctic Ringed Seals, Phoca hispida, Following Experimental Oil Exposure. Proc. Conf. on Assessment of Ecological Impacts of Oil Spills, Keystone, Colorado, American Institute of Biological Sciences.
- Engelhardt, F. R., Geraci, J. R., and Smith, T. G. 1977. Uptake and Clearance of Petroleum Hydrocarbons in the Ringed Seal, Phoca hispida. J. Fisheries Research Board of Canada, 34(8).
- Environmental Devices Corporation. 1976. Special Water Monitoring Study. C.O.S.T. Atlantic G-1 Well 14, July 1976. Prepared for Ocean Production Company.
- Environmental Protection Agency (EPA). 1986. Quality Criteria for Water. Washington, D.C. Report No. EPA 440/5-86-001.
- Environmental Sciences Ltd. (ESL). 1982. Biological Impacts of Three Oil Spill Scenarios in the Beaufort Sea. Prepared for Dome Petroleum, Ltd., Calgary, Alberta, Canada.
- Envirosphere Co. 1985. Prudhoe Bay Waterflood Project, Preliminary Draft, Synthesis Report. Prepared for the Department of the Army, U.S. Army COE, Alaska District, Anchorage, AK.
- ERCO, Inc. 1980. Results of Joint Bioassay Monitoring Program.
  Houston, Texas. Final Report to the Offshore Operators Committee
  Under Direction of Exxon Production Research Co.
- Espy, Huston and Associates. 1981. Bioassay and Depuration Studies on Two Types of Barite. Document No. 81123. Report to Magcobar Group, Dresser Industries, Inc. Houston, TX.
- Exxon Company, U.S.A. 1979. Technical Seminar on Alaskan Beaufort Sea Gravel Island Design. Presented in Anchorage, AK. October 15, 1979.
- Fabricius, E. 1959. What Makes Plumage Waterproof? Tenth Annual Report of the Wildfowl Trust.

- Finley, K. J. 1979. Haul-out Behavior and Densities of Ringed Seals (Phoca hispida) in the Barrow Strait Area. N.W.T. Can. J. Zool, 57.
- Finley, K. J., Miller, G. W., Davis, R. A., and Greene, C. R. 1984.

  Responses of Narwhals (Monodon monoceros) and Belugas
  (Deliphinapterus leucas) to Ice-breaking Ships in Lancaster Sound
   1983. Rep. by LGL Ltd., King City, Ontario, for Canada
  Department of Indian Affairs and Northern Development, Ottawa.
- Fraker, M. A. 1984. <u>Balaena mysticetus</u>: Whales, Oil, and Whaling in the Arctic. Published by Sohio Alaska Petroleum Company and BP Alaska Exploration, Inc., Anchorage, AK.
- Fraker, M. A. et al. 1981. Disturbance Responses of Bowheads and Characteristics of Waterborne Noise. <u>In</u>: Behavior, Disturbance Responses and Feeding of Bowhead Whales in the Beaufort Sea. Edited by Richardson, W. J. Prepared for U.S. Department of the Interior, Bureau of Land Management.
- Fraker, M. A. and Richardson, W. J. 1980. Bowhead Whales in the Beaufort Sea: A Summary of Their Seasonal Distribution and Activities, and Potential Disturbance by Offshore Oil and Gas Exploration and Development. Prepared for U.S. Dept. of the Interior, Bureau of Land Management, by LGL Limited, Ecological Research Associates, Inc., Bryan, TX.
- Fraker, M. A., Sergeant, D., and Hoek, W. 1978. Bowhead and White Whales in the Southern Beaufort Sea. Beaufort Sea Project, Department of Fisheries and the Environment, Sidney, B.C.
- Frame, G. W. 1972. Occurrence of Polar Bears in the Chukchi and Beaufort Seas, Summer 1969. J. Mammal, <u>53</u>.
- Frisch, J., Oritsland, N. A., and Krog, J. 1974. Insulation of Furs in Water. Comp. Biochem. Physiol., <u>47A</u>.
- Frost, K. J. and Lowry, L. F. 1981. Feeding and Trophic Relationship of Bowhead Whales and Other Vertebrate Consumers in the Beaufort Sea. Contract 80-ABC-00160. Final Report Submitted to the USDOC, NOAA, NMFS, NMML, Seattle, WA.
- Gallaway, B. J. 1982. An Assessment of the Beaufort Sea Stock of Arctic Cisco (Coregonus autumnalis) Based Upon the Deriso Model Applied to the Catch and Effort Data From the Helmerick's Commercial Fishery. Prepared by LGL Limited, Ecological Research Associates, Bryan, TX.
- Geraci, J. R. and Smith, T. G. 1976. Direct and Indirect Effects of Oil on Ringed Seals (Phoca hispida) of the Beaufort Sea. J. Fish. Res. Board Can. 33, 1976-1984.

- Geraci, J. R. and St. Aubin, D. J. 1986. An Assessment of the Effects of Oil on Bowhead Whales, <u>Balaena</u> <u>mysticetus</u>. Prepared for Amoco Production Company.
- Geraci, J. R. and St. Aubin, D. J. 1985. Effects of Offshore Oil and Gas Development on Marine Mammals and Turtles. In: The Long-Term Effects of Offshore Oil and Gas Development: An Assessment and a Research Strategy. Boesch, D. F. and Robalais, N. N. (eds.). A Report to NOAA, National Marine Pollution Program Office for the Interagency Committee on Ocean Pollution, Research, Development and Monitoring. Prepared by Louisiana Universities Marine Consortium.
- Geraci, J. R. and St. Aubin, D. J. 1982. Study of the Effects of Oil on Cetaceans. University of Guelph. Final Report. Bureau of Land Management. Washington, D.C.
- Geraci, J. R. and St. Aubin, D. J. 1981. Study of the Effects of Oil on Marine Mammals. Fourth Interim Report. Unpublished Report Prepared by University of Guelph. Prepared for U.S. Bureau of Land Management, Washington, D.C. Contract AA551-CT9-29.
- Geraci, J. R. and St. Aubin, D. J. 1980. Offshore Petroleum Resources Development and Marine Mammals: A Review and Research Recommendations. Marine Fisheries Review, 42.
- Geraci, J. R. and St. Aubin, D. J. 1979. Possible Effects of Offshore Oil and Gas Development on Marine Mammals: Present Status and Research. Manuscript submitted to the Marine Mammals Commission.
- Geraci, J. R., St. Aubin, D. J., and Reisman, R. J. 1983. Bottlenose Dolphins, <u>Tursiops</u> <u>truncatus</u>, Can Detect Oil. Can. J. Fish. Aquat. Sci., 40.
- Gerber, R. P., Gilfillan, E. S., Hotham, J. R., Galletto, L. J., and Hanson, S. A. 1981. Further Studies on the Short and Long Term Effect of Used Drilling Fluids on Marine Organisms. Unpublished Final Report (Year II) to the American Petroleum Institute.
- Gerber, R. P., Gilfillan, E. S., Page, B. T., Page, D. S., and Hotham, J. B. 1980. Short and Long Term Effects of Used Drilling Fluids on Marine Organisms. In: Proceedings of a Symposium on Research and Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Gettleson, D. A. 1978. Ecological Impact of Exploratory Drilling: a Case Study. <u>In</u>: Energy/Environment '78. Soc. of Petroleum Industry Biologists Symposium, August, 22-24, 1978. Los Angeles, CA.

- Gilbert, T. R. 1981. A Study of the Impact of Discharged Drilling Fluids on the Georges Bank Environment. New England Aquarium. H. E. Edgerton Research Laboratory. Progress Report No. 2 to U.S. EPA, Gulf Breeze, FL.
- Goodale, D. R., Hyman, M. A., and Winn, H. E. 1979. Cetacean Responses in Association With the Regal Sword Oil Spill. In: Cetacean and Turtle Assessment Program, University of Rhode Island. Annual Report for 1979. U.S. Dept. of the Interior, Washington, D.C.
- Grantz, A., and May, S. D. 1982. Rifting History and Structural Development of the Continental Margin North of Alaska. In: Studies in Continental Margin Geology. Edited by Watkins, J. S. and Drake, C. L. AAPG Memoir.
- Grantz, A., Dinter, D. A., and Biswas, N. N. 1983. Map, Cross Sections, and Chart Showing Late Quaternary Faults, Folds, and Earthquake Epicenters on the Alaskan Beaufort Shelf. U.S. Geological Survey Miscellaneous Investigations Series, Map I-1182-C.
- Grantz, A., Dinter, D. A., Hill, E. R., May, S. D., McMullin, R. H., Phillips, R. L., and Reimnitz, E. 1982. Geologic Framework, Hydrocarbon Potential, and Environmental Conditions for Exploration and Development of Proposed Oil and Gas Lease Sale 87 in the Beaufort and Northeast Chukchi Seas. Prepared for U.S. Geological Survey.
- Grantz, A., Eittreim, S., and Whitney, P. T. 1981. Geology and Physiography of the Continental Margin North of Alaska and Implications for Origin of the Canada Basin. In: The Ocean Basins and Margins. Edited by Nairn, A. E. M., Churkin, M., Jr., and Stehli, F. G. New York, Plenum Publishing Corporation, 5.
- Grantz, A., and Eittreim, S. 1979. Geology and Physiography of the Continental Margin North of Alaska and Implications for the Origin of the Canada Basin. U.S. Geological Survey Open-File Report 79-288.
- Grantz, A. and Mull, C. G. 1978. Preliminary Analysis of the Petroleum Potential of the Arctic National Wildlife Range, Alaska. U.S. Geological Survey Open-File Report 78-489.
- Grau, C. R., Roudybush, T., Dobbs, J., and Wathen, J. 1977. Altered Yolk Structure and Reduced Hatchability of Eggs From Birds Fed Single Doses of Petroleum Oils. Science, 195.
- Griffiths, W. B., Thomson, D. H., and Johnson, G. E. 1987. Zooplankton and Hydroacoustics. In: Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales, 1985-86. Edited by Richardson, W. J. Prepared by LGL Ecological Research Associates, Inc., Bryan, TX. Prepared for U.S. Minerals Management Service, Reston, VA. Contract No. 14-12-0001-30233.

- Griffiths, W. B., DenBeste, J. K., and Craig, P. C. 1977. Domestic and Sport Fisheries in the Vicinity of Barter Island. Appendix 1. In: Fisheries Investigation in a Coastal Region of the Beaufort Sea (Kaktovik Lagoon, Alaska). Arctic Gas Biol. Serv. V. 40.
- Griffiths, W. B., Fechhelm, R. G., Schmidt, D. R., and Gallaway, B. J. 1983. Environmental Summer Studies (1982) for the Endicott Development, Fish Ecology, Vol. 3. Edited by Gallaway, B. J. and Britch, R. P. Prepared by LGL Alaska Research Associates, Inc., and Northern Technical Services for Sohio Alaska Petroleum Co., Anchorage, AK.
- Gusey, W. F. 1983. Bowhead, <u>Balaena</u> <u>mysticetus</u>. Prepared for Shell Oil Company, Houston, TX.
- Hamilton, C. I., Starr, S. J., and Trasky, L. L. 1979. Recommendations for Minimizing the Impacts of Hydrocarbon Development on the Fish, Wildlife, and Aquatic Plant Resources of Lower Cook Inlet, Vols. I and II. Prepared by Alaska Department of Fish and Game. Prepared for National Oceanic and Atmospheric Administration. Anchorage, AK.
- Hansen, D. J. 1985. The Potential Effects of Oil Spills and Other Chemical Pollutants on Marine Mammals Occurring in Alaskan Waters. MMS, Alaska OCS Region, Anchorage, AK. OCS Report MMS 85-0031.
- Hansen, D. J. 1981. The Relative Sensitivity of Seabird Populations in Alaska to Oil Pollution. Technical Paper No. 3. U.S. Department of the Interior, Bureau of Land Management, Alaska OCS Office, Anchorage, AK.
- Hartung, R. 1965. Some Effects of Oiling on Reproduction in Ducks. Journal of Wildlife Management, 29.
- Hartung, R. 1964. Some Effects of Oil on Waterfowl. Doctoral Dissertation, University of Michigan.
- Hemming, J. E. 1971. The Distribution and Movement Patterns of Caribou in Alaska. Game Tech. Bull. No. 1. Alaska Dept. Fish and Game.
- Hester, Frank. 1981. Testimony, EPA Evidentiary Hearing on Lease Sale 48 NPDES Permits.
- Hoffman, D. G., Libbey, D., and Spearman, G. 1978. Nuiqsut: A Study of Land Use Values Through Time. CPSR OCCAS Paper No. 12. Univ. of Alaska, Fairbanks.
- Holmes, W. N. and Cronshaw, J. 1975. Final Progress Report on Studies Completed During 1972 and 1975 on the Effects of Petroleum on Marine Birds. Submitted to the American Petroleum Institute, Washington, D.C.

- Hopkins, D. M. and Hartz, R. W. 1978. Shoreline History of Chukchi and Beaufort Seas as an Aid to Predicting Offshore Permafrost Conditions. In: Environmental Assessment of the Alaskan Continental Shelf: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Boulder, CO, Annual Reports, 12.
- Horner, R. A. 1984. Phytoplankton Abundance, Chlorophyll a, and Primary Productivity in the Western Beaufort Sea. In: The Alaskan Beaufort Sea Ecosystems and Environments. Edited by Barnes, P. W., Schell, D. M., and Reimnitz, E. Academic Press, Inc. New York, NY.
- Horner, R. A. 1972. Ecological Studies on Arctic Sea Ice Organisms. University of Alaska, Institute of Marine Science. Report No. 72-17.
- Horner, R. A. 1969. Phytoplankton Studies in the Coastal Waters near Barrow, Alaska. PhD. Thesis. University of Washington, Seattle, WA.
- Horner, R. A., Coyle, K. O., and Redburn, D. R. 1974. Ecology of the Plankton of Prudhoe Bay, Alaska. Fairbanks, AK: University of Alaska, Institute of Marine Science. Report No. 74-2.
- Houghton, J. P., Beyer, D. L., and Thielk, E. D. 1980. Effects of Oil Well Drilling Fluids on Several Important Alaskan Marine Organisms. In: Proceedings of a Symposium on Research and Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Hsiao, S. I. C. 1980. Quantitative Composition, Distribution, Community Structure and Standing Stock of Sea Ice Microalgae in the Canadian Arctic. Arctic, 33.
- Hsiao, S. I. C. 1976. Biological Productivity of the Southern Beaufort Sea: Phytoplankton and Seaweed Studies. Dept. of Environment, Beaufort Sea Project Tech. Report 12-C, Victoria, British Columbia.
- Hudson, J. H. and Robbin, D. M. 1980. Effects of Drilling Mud on the Growth Rate of the Reef-Building Coral, Montastrea annularis.

  In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. January 21-24, 1980. Lake Buena Vista, FL.
- Hufford, G. L. 1974. Dissolved Oxygen and Nutrients Along the North Alaskan Shelf. The Coast and Shelf of the Beaufort Sea. In: Proceedings of a Symposium on Beaufort Sea Coast and Shelf Research. Edited by Reed, J. C. and Slater, J. E. Arlington, VA: Arctic Institute of North America.
- Humes, A. G. 1964. <u>Harpaticus pulex</u>, a New Species of Copepod From the Skin of a Porpoise and a Manatee in Florida. Bull. Mar. Sci. Gulf Carib., <u>14</u>.

- Industry Task Group. 1983. Draft Oil Spill Response in the Arctic. An Assessment of Containment, Recovery and Disposal Techniques. Amoco Production Company, Exxon Company, U.S.A., Shell Oil Company, Sohio Alaska Petroleum Company.
- Irving, L. 1972. Arctic Life of Birds and Mammals Including Man. Zoophysiology and Ecology, Vol. 2. Springer, New York.
- Jacobson, M. J. and Wentworth, C. 1982. Kaktovik Subsistence, Land Use Values through Time in the Arctic National Wildlife Refuge Area. U.S. Department of the Interior, U.S. Fish and Wildlife Service.
- James, D. D. 1985. Current Status of Alaska's Western Arctic Caribou Herd. Presented at the Fourth International Reindeer/ Caribou Symposium, Whitehorse, Yukon Territory, Canada, August 1985.
- Jones and Stokes Associates, Inc. and Tetra Tech. 1984. Final Ocean Discharge Criteria Evaluation. Diapir Field OCS Lease Sale 87 and State Lease Sales 39, 43, and 43a. Prepared for the U.S. Environmental Protection Agency, Region 10.
- Kanik, B., Winsby, M. and Tanasichuk, R. 1980. Observations of Marine Mammal and Seabird Interaction with Icebreaking Activities in the High Arctic July 2-12, 1980. Hatfield Consultants Limited, West Vancouver, B.C.
- Kent, D. B., Leatherwood, S., and Yohe, L. 1983. Responses of Migrating Grey Whales, <u>Eschrichtius robustus</u>, to Oil on the Sea Surface. Hubbs-Sea World Research Institute, San Diego, CA.
- Kineman, J. J., Elmgren, R., and Hansson, S. (eds.). 1980. The Tsesis Oil Spill. U.S. Dept. of Commerce, NOAA, Office of Marine Pollution Assessment, Boulder, CO.
- King, K. A. and Lefever, C. A. 1979. Effects of Oil Transferred from Incubating Gulls to their Eggs. Marine Pollution Bulletin, 10.
- Koranda, J. J. and Evan, C. D. 1975. A Discussion of Sites Recommended as Potential Natural Landmarks in the Arctic Lowland Natural Region, Northern Alaska. Unpubl. Rep. by Tundra Biome Center, Univ. of Alaska, Fairbanks for Natl. Park Serv.
- Kovacs, A. 1982. Recent Shore Ice Ride-up and Pile-up Observations, Part 1, Beaufort Coast, Alaska. Draft Report. Research Unit 88. Outer Continental Shelf Environmental Assessment Program.
- Kovacs, A. and Mellor, M. 1974. Sea Ice Morphology and Ice as a Geologic Agent in the Southern Beaufort Sea. <u>In</u>: The Coast and Shelf of the Beaufort Sea. Edited by Reed, J. C. and Slater, J. E. Arlington, VA: Arctic Institute of North America.

- Kozo, T. L. 1983. Mesoscale Meteorology. <u>In</u>: Environmental Characterization and Biological Use of Lagoons in the Eastern Beaufort Sea. Edited by Truett, J. C. U.S. Department of Commerce and U.S. Department of Interior, OCSEAP Final Report 24.
- Kozo, T. L. 1981. Winds. <u>In</u>: Beaufort Sea-Sale 71-Synthesis Report. Edited by Norton, <u>D</u>. W. and Sackinger, W. M. NOAA/OCSEAP, BLM. Juneau, AK.
- Kozo, T. L. 1979. Meteorology of the Alaskan Arctic Coast. Environmental Assessment of the Alaskan Continental Shelf. NOAA/OCSEAP Ann. Rep. 8.
- LeBoeuf, B. J. 1971. Oil Contamination and Elephant Seal Mortality: A Negative Finding. <u>In</u>: Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill 1969-1970, Vol. I, Biology and Bacteriology. Edited by Straughan, D.
- Lees, D. C. and Houghton, J. P. 1980. Effects of Drilling Fluids on Benthic Communities at the Lower Cook Inlet C.O.S.T. Well. In: Proceedings of a Symposium on Research and Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Lentfer, J. W. 1971. The Effects of Ocean Currents and Ice Movement on Polar Bear Activity. Final Rep., Alaska Dept. Fish and Game, Fed. Aid. in Wildl. Restoration. Projects W-17-2 and W-17-3, Job 5.2R.
- LeResche, R. E. and Linderman, S. A. 1975. Caribou Trail Systems in Northeastern Alaska. Arctic, 28.
- Lewbel, G. S. (ed) 1983. Bering Sea Biology: An Evaluation of the Environmental Data Base Related to Bering Sea Oil and Gas Exploration and Development. Prepared by LGL Alaska Research Associates, Inc. Prepared for Sohio Petroleum Company. Anchorage, AK.
- Lewis, E. L. 1978. Oil in Sea Ice. <u>In</u>: Science in Alaska, 1976. Proceedings 27th Alaska Science Conference, Fairbanks, August 4 7, 1976, Vol. 2. Am. Assoc. Adv. Sci., Fairbanks, AK.
- LGL Ecological Research Associates, Inc. 1987. Importance of Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales, 1985-86. Volumes I and II. OCS Study MMS 87 (Draft). MMS, Reston, VA.
- LGL Ecological Research Associates, Inc. 1983. Behavior, Disturbance Responses and Distribution of Bowhead Whales (Balaena mysticetus) in the Eastern Beaufort Sea, 1982.
- LGL Limited and Greeneridge Sciences, Inc. 1987. Response of Bowhead Whale to an Offshore Drilling Operation in the Alaskan Beaufort Sea, Autumn 1986. Prepared for Shell Western Exploration and Production Inc.

- Libbey, D., Spearman, G., and Hoffman, D. 1979. Nuiqsut Synopsis.

  In: Native Livelihood and Dependence: A Study of Land Use
  Values Through Time. North Slope Borough Contract Staff. U.S.
  Department of the Interior, National Petroleum Reserve in Alaska
  105(c) Land Use Study. National Petroleum Reserve in Alaska Work
  Group 1 Study 1. Anchorage, AK.
- Liss, R. G., Knox, F., Wayne, D., and Gilbert, T. R. 1980. Availability of Trace Elements in Drilling Fluids to the Marine Environment. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Ljungblad, D. K. 1981. Aerial Surveys of Endangered Whales in the Beaufort Sea, Chukchi Sea and Northern Bering Sea. Final Rep. Fall 1980. Naval Ocean Systems Center Tech. Doc. 449. San Diego, CA.
- Ljungblad, D. K., Moore, S. E., Clarke, J. T., and Bennett, J. C. 1987. Distribution, Abundance, Behavior, and Bioacoustics of Endangered Whales in the Alaskan Beaufort and Eastern Chukchi Seas, 1979-86. Prepared for Minerals Management Service, Alaska OCS Region. Report No. MMS 87-0039.
- Ljungblad, D. K., Moore, S. E., Clarke, J. T., and Bennett, J. C. 1986. Aerial Surveys of Endangered Whales in the Northern Bering, Eastern Chukchi, and Alaskan Beaufort Seas, 1985: With a Seven Year Review, 1979-1985. Prepared for Minerals Management Service, Alaska OCS Region. Report No. MMS 86-0002.
- Ljungblad, D. K., Moore, S. E., Clarke, J. T., and VanSchoik, D. R., and Bennett, J. C. 1985. Aerial Surveys of Endangered Whales in the Northern Bering, Eastern Chukchi, and Alaskan Beaufort Seas, 1984: With a Six Year Review, 1979-1984. Prepared for the Minerals Management Service, Alaska OCS Region. Technical Report 1046.
- Ljungblad, D. K., Moore, S. E., VanSchoik, D. R. 1984. Aerial Surveys of Endangered Whales in the Northern Bering, Eastern Chukchi and Alaskan Beaufort Seas, 1983: With a Five Year Review, 1979-1983. NOSC Tech. Rep. 955, Naval Ocean Systems Center, San Diego, CA.
- Ljungblad, D. K., Moore, S. E., and Van Schoik, D. R. 1983. Aerial Surveys of Endangered Whales in the Beaufort, Eastern Chukchi, and Northern Bering Seas, 1982.
- Ljungblad, D. K., Moore, S. E., VanSchoik, D. R., and Winchell, C. S. 1982. Aerial Surveys of Endangered Whales in the Beaufort, Chukchi and Northern Bering Seas. Final Rep. April-Oct. 1981. Naval Ocean Systems Center Tech. Doc. 486. San Diego, CA.

- Ljungblad, D. K., Platter-Reiger, and Shipp, F. S., Jr. 1980. Aerial Surveys of Bowhead Whales, North Slope, Alaska. U.S. Naval Ocean Systems Center Technical Document 314. San Diego, CA.
- Lowry, L. F. and Frost, K. J. 1981. Marine Mammals. <u>In</u>: Ecological Characterization of the Sale 71 Environment. Beaufort Sea (Sale 71) Synthesis Report. Edited by Johnson, S. R. Outer Cont. Shelf Envir. Assess. Program, BLM/NOAA (OMPA). Juneau, AK.
- Lynch, C., Slitor, D. L., and Rudolph, R. W. 1985. Arctic Summary Report; Outer Continental Shelf Oil and Gas Activities in the Arctic and their Onshore Impacts. Prepared by Rogers, Golden and Halpern, Inc. Prepared for the Minerals Management Service, Contract No. 14-12-0001-30042.
- Malins, D. C. (ed). 1977. Effects of Petroleum on Arctic and Subarctic Marine Environments and Organisms. Vols. I and II. Nature and Fate of Petroleum, Academic Press, Inc., New York, NY.
- Marine Bioassay Labs. 1982. Drilling Fluids Bioassays. Texaco Habitat Platform Well A-1 Pitas Point Lease Sale Unit: Acanthomysis sculpta and Macoma nasuta. Report Submitted to Texaco, Inc.
- Martin, F. B. 1986. The Probability of a Major Oil Spill Resulting from a Beaufort Sea OCS Exploratory Well Blowout. Prepared for ECON, Inc., Ecological Consulting Service Division, Helena, MT.
- Mauer, D., Leathem, W., and Menzie, C. 1981. The Impact of Drilling Fluid and Well Cuttings on Polychaete Feeding Guilds from the U.S. Northeastern Continental Shelf. Mar. Pollut. Bull., 12.
- Maynard and Partch/Woodward-Clyde Consultants. 1984. North Slope Borough Coastal Management Program Background Report. Prepared for Alaska Coastal Management Program.
- Maynard and Partch/Woodward-Clyde Consultants. 1983. North Slope Borough Coastal Management Program: Background Report. Review Draft. Barrow: North Slope Borough.
- Maynard, D. J. and Weber, D. D. 1981. Avoidance Reactions of Juvenile Coho Salmon. Canadian Journal of Fisheries and Aquatic Sciences, 38(7).
- McCarty, S. 1981. Survey of Effects of Outer Continental Shelf Platforms on Cetacean Behavior. Appendix C. Vol. II. <u>In</u>: Gales, R. S. Effects of Noise on Offshore Oil and Gas Operations on Marine Mammals. An Introductory Assessment. NOSC Tech. Rep. 844.

- McCulloch, W. L., Neff, J. M., and Carr, R. S. 1980. Bioavailability of Heavy Metals from Used Offshore Drilling Muds to the Clam Rungia cuneata and the Oyster Crassostrea gigas. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings, January 21-24, 1980. Lake Buena Vista, FL.
- McGill, P. A. and Richmond, M. E. 1979. Hatching Success of Great Black-backed Gull Eggs Treated with Oil. Bird-banding, 50.
- McKeown, B. A. 1981. Long-Term Sublethal and Short-Term High Dose Effects of Physically and Chemically Dispersed Oil on Accumulation and Clearance from Various Tissues of Juvenile Coho Salmon, Oncorhynchus kisutch. Marine Environmental Research, 5.
- McLaren, I. A. 1958. The Biology of the Ringed Seal (Phoca hispida) in the Eastern Canadian Arctic. Fish. Res. Board Can. Bull., 118.
- McLeay, D. J. 1976. Marine Toxicity Studies on Drilling Fluid Wastes. Vol. 10. Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian Arctic, Yellowknife, N.W.T., Canada.
- McRoy, C. P. and Goering, J. J. 1974. The Influence of Sea Ice on the Primary Productivity of the Bering Sea. <u>In</u>: Oceanography of the Bering Sea. Edited by Wood, D. W. and Kelly, E. J. Fairbanks, AK: University of Alaska, Institute of Marine Science. Occasional Publication No. 2.
- Menzies, C. A., Mauer, D., and Leathem, W. A. 1980. An Environmental Monitoring Study to Assess the Impact of Drilling Discharges in the Mid-Atlantic. IV. The Effects of Drilling Discharges on the Benthic Community. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Migaki, G., Valerio, M. G., Irvine, B., and Garner, F. M. 1971. Lobo's Disease in an Atlantic Bottlenosed Dolphin. J. Amer. Vet. Med. Assoc., 159.
- Miles, P. R., Malme, C. I. and Richardson, W. J. 1987. Production of Drilling Site-Specific Interaction of Industrial Acoustic Stimuli and Endangered Whales in the Alaskan Beaufort Sea. Prepared for the Minerals Management Service, Alaska OCS Office. Prepared by BBN Laboratories, Inc. and LGL Ltd. OCS Study MMS 87-0084.
- Minerals Management Service (MMS). 1988. Personal Communications.
- Minerals Management Service (MMS). 1987. Final Environmental Impact Statement. Beaufort Sea Sale 97 (January, 1988). U.S. Department of the Interior. MMS 87-0069.

- Minerals Management Service (MMS). 1984. Final Environmental Impact Statement. Proposed Diapir Field Lease Offering (June, 1984). U.S. Department of the Interior.
- Minerals Management Service (MMS). 1983. Outer Continental Shelf Oil and Gas Blowouts, 1979-1982. U.S. Geological Survey Open File Report 83-562.
- Moore, G. D. and Quimby, R. 1975. Environmental Considerations for the Polar Bear (<u>Ursus maritimus</u>, Phipps) of the Beaufort Sea. Arctic Gas Biol. Rep. Ser. 32(2).
- Morris, B. E. 1981. An Assessment of Living Marine Resources of the Central Bering Sea and Potential Resource Use Conflicts Between Commercial Fisheries and Petroleum Development in the Navarin Basin, Proposed Sale No. 83. Prepared for U.S. Department of Commerce, NOAA and National Marine Fisheries Service. NOAA Technical Memorandum NMFS F/AKR-2.
- Moulton, L. L., Tarbox, K., and Thorne, R. 1980. Beaufort Sea Fishery Investigations, Summer 1979. <u>In:</u> Environmental Studies of the Beaufort Sea, Summer 1979. Prepared for the Prudhoe Bay Unit by Woodward-Clyde Consultants.
- Moulton, L. and Fawcett, M. 1984. Oliktok Point Fish Studies-1983.
  Report by Woodward-Clyde Consultants for Kuparuk River Unit, ARCO Alaska, Inc., Anchorage, AK.
- Moulton, L. L., Fawcett, M. H., and Carpenter, T. A. 1985. Lisburne Development Environmental Studies: 1984. Fish, Final Report, Chapter 5, Vol. 4. Prepared for ARCO Alaska, Inc., Anchorage, AK, by Woodward-Clyde Consultants (Entrix Inc.).
- Murphy, G. M. 1984. Caribou Use of Ramps for Crossing Pipe/Road Complexes, Kuparuk Oilfield, Alaska, 1984. Fairbanks, AK: Prepared by Alaska Biological Research for ARCO Alaska, Inc.
- Naidu, A. S. 1982. Aspects of Size Distributions, Clay Mineralogy and Geochemistry of Sediments of the Beaufort Sea and Adjacent Deltas, North Arctic Alaska. In: Environmental Assessment of the Alaskan Continental Shelf. Final Report of the Principal Investigators, Research Unit 529, U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program. Fairbanks, AK: University of Alaska.
- Naidu, A. S. 1979. Sources, Transport Pathways, Depositional Sites and Dynamics of Sediments in the Lagoon and Shallow Marine Region, Northern Arctic Alaska. In: Environmental Assessment of the Alaskan Continental Shelf. Annual Reports of the Principal Investigators for the Year Ending March 1979, Vol. 8. Boulder CO: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program.

- Naidu, A. S. 1974. Sedimentation in the Beaufort Sea: A Synthesis.

  In: Marine Geology and Oceanography of the Arctic Seas. Edited
  by Herman, Y. New York, NY: Springer-Verlag.
- Naidu, A. S., Larsen, L. H., Mowalt, T. C., Sweeney, M. D., and Weiss, H. V. 1982. Aspects of Size Distributions, Clay Minerology and Geochemistry of Sediments of the Beaufort Sea and Adjacent Deltas, North Arctic Alaska. Final Report.
- Naidu, A. S., Larsen, L. H., Sweeney, M. D., and Weiss, H. V. 1980. Sources, Transport, Pathways, Depositional Sites and Dynamics of Sediments in the Lagoon and Adjacent Shallow Marine Region, Northern Arctic Alaksa. In: Environmental Assessment of the Alaskan Continental SHelf, Annual Reports of Principal Investigators for the Year Ending March 1986. Vol. III, Transport Data Management. Boulder, CO. Prepared by U.S. Department of Commerce, NOAA, OCSEAP and U.S. Department of Interior, Bureau of Land Management.
- National Academy of Science (NAS). 1983. Drilling Discharges in the Marine Environment. National Academy Press: Washington, D.C.
- National Marine Fisheries Service (NMFS). 1980. Biological Opinion on the Impact of Oil and Gas Operations on the Bowhead Whales. Endangered Species Act, Section 7.
- National Oceanic and Atmospheric Administration (NOAA). 1978. Interim Synthesis Report: Beaufort/Chukchi. Boulder, CO: Outer Continental Shelf Environmental Assessment Program.
- National Oceanic and Atmospheric Administration (NOAA). 1977. Local Climatological Data, Barter Island, Alaska. U.S. Department of Commerce, Asheville, NC.
- National Petroleum Council (NPC). 1981. Physical Environment of Alaska, Working Paper #21, Production Task Group Papers of the National Petroleum Council's Committee on the Arctic Oil and Gas Resources.
- National Research Council (NRC). 1982. Understanding the Arctic Sea Floor for Engineering Purposes. Marine Board, Commission on Engineering and Technical Systems. Washington, D.C.: National Research Council.
- Neff, J. M. 1981. Rebuttal Testimony on the Toxicity and Biological Effects of Used Offshore Drilling Fluids on Marine Animals.
- Neff, J. M., Carr, R. S., and McCulloch, W. L. 1981. Acute Toxicity of a Used Chrome Lignosulfonate Drilling Mud to Several Species of Marine Invertebrate. Mar. Environ. Res., 4.

- Neff, J. M., Anderson, J. W., Cox, B. A., Loughlin, R. B., Rossi, S. S., and Tatem, H. E. 1976. Effects of Petroleum on Survival, Respiration, and Growth of Marine Animals. In: Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment. Proceedings of a Symposium, American University, Washington, D.C. A.I.B.S., Washington, D.C.
- Nelson, R. K. 1979. The Environmental Setting. <u>In</u>: Native Livelihood and Dependence: A Study of Land Use Values Through Time. U.S. Dept. of the Interior, National Petroleum Reserve in Alaska 105(c) Land Use Study, Anchorage. National Petroleum Reserve in Alaska Work Group 1 Field Study 1.
- Nielson, J. M. 1977. Beaufort Sea Study--Historic and Subsistence Site Inventory: A Preliminary Cultural Resource Assessment. North Slope Borough, Barrow.
- Northern Technical Services (NORTEC). 1981a. Beaufort Sea Drilling Effluent Disposal Study. Report Prepared for the Reindeer Island Stratigraphic Test Well Participants Under the Direction of Sohio Alaska Petroleum Company, Anchorage.
- Northern Technical Services (NORTEC). 1981b. Progress Report for Above-Ice Disposal Tests, Sag Delta 7 and 8 and Challenge Island Wells, Beaufort Sea, Alaska. Prepared for Sohio Alaska Petroleum Company. Anchorage, AK: Northern Technical Services.
- Northern Technical Services (NORTEC). 1981c. Environmental Assessment of Proposed Dredging Operations: Beaufort Sea, Alaska. Report Prepared for Polar Constructors, Inc., Seattle, WA.
- North Slope Borough (NSB). 1980. Qiniqtuagaksrat Utuqqanaat Inuuniagninisiqun. The Traditional Land Use Inventory for the Mid-Beaufort Sea. Vol. I. Commission on History and Culture.
- North Slope Borough (NSB). 1986. North Slope Borough Coastal Management Program.
- North Slope Borough (NSB). 1984. What's New in Arctic Oil Spill Response Technology A Summary of Recent R&D.
- Norton, D. W. and Sackinger, W. M. (eds). 1981. Proceedings of a Synthesis Meeting Beaufort Sea Sale 71 Synthesis Report. OCSEAP: U.S. Department of Commerce: U.S. Department of the Interior.
- Oceanweather, Inc. 1978. Surface Winds in the Beaufort Sea for Selected Periods Between December 1976 and May 1977. In: Beaufort Sea Ice Movement Study, Three Year Summary, Volume III. Oceanographic Services, Inc. Informal Report 78-3.

- Olsen, K. 1976. Evidence for Localization of Sound by Fishing Schools. In: Sound Reception in Fish. Proceedings of a Symposium Held in Honour of Professor Dr. Sven Dijkgraaf, Otrecht, The Netherlands. Elsevier Scientific Publishing Company. Amsterdam, Oxford, NY.
- Oritsland, N. A., Engelhardt, F. R., Juck, F. A., Hurst, R. J., and Watts, P. D. 1981. Effects of Crude Oil on Polar Bears. Northern Affairs Program Environmental Study No. 24, Department of Indian and Northern Affairs, Canada.
- Ostrom, J. and Britch, R. 1981. Arctic Environment: Meteorology and Physical Oceanography. Prepared by Northern Technical Services, Inc. Fairbanks, AK.
- Owens, N. W. 1977. Responses of Wintering Brant Geese to Human Disturbance. Wildfowl, 28.
- Page, D. S., Page, B. T., Hotham, J. R., Gilfillan, E. S., and Gerber, R. P. 1980. Bioavailability of Toxic Constituents of Used Drilling Muds. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Patten, S. M. and Patten, L. R. 1977. Effects of Petroleum Exposure on Hatching Success and Incubation Behavior of Glaucous-winged Gulls (Larus glaucescens) in the Northeast Gulf of Alaska. In: Environmental Assessment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators Vol. III: National Oceanic and Atmospheric Administration Environmental Research Laboratory, Boulder, CO.
- Patterson, A. 1974. Subsistence Harvests in Five Native Regions. Joint Federal-State Land Use Planning Commission for Alaska. Anchorage, AK.
- Pederson, S. and Coffing, M. 1985. Caribou Hunting: Land Use Dimensions and Recent Harvest Patterns in Kaktovik, Northeast Alaska. Alaska Department of Fish and Game, Division of Subsistence, Fairbanks, AK. Technical Paper No. 92.
- Pederson, S. 1979. Barrow-Atqasuk Synopsis. <u>In</u>: Native Livelihood and Dependence: A Study of Land Use Values Through Time. U.S. Department of the Interior, National Petroleum Reserve in Alaska 105(c) Land Use Study. Anchorage, AK.
- Perrin, W. F. 1969. The Barnacle, <u>Conchoderma</u> <u>auritum</u> on a Porpoise <u>Stenella graffmani</u>. J. Mammal, <u>50</u>.
- Pike, G. C. 1951. Lamprey Marks on Whales. J. Fish Res. Bd. Can.,  $\underline{8}$ .

- Pritchard, R. S. and Stringer, W. J. 1981. Ice Characteristics and Sea Ice Motions. In: Proceedings of a Synthesis Meeting: Beaufort Sea-Sale 71-Synthesis Report. Chena Hot Springs, Alaska, April 21-23, 1981. Edited by Norton, D. W. and Sackinger, W. M. Juneau, AK: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program.
- Rahn, K. A. 1982. On the Causes, Characteristics and Potential Environmental Effects of Aerosol in the Arctic Atmospheric. In:
  The Arctic Ocean: The Hydrographic Environment and the Fate of Pollutants. Edited by Rey, L. New York, NY: John Wiley and Sons.
- Ray, J. P. and Meek, R. P. 1980. Water Column Characterization of Drilling Fluids Dispersion from an Offshore Exploratory Well on Tanner Bank. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. January 21-24, 1975. Lake Buena Vista, FL.
- Ray, J. P. and Shinn, E. A. 1975. Environmental Effects of Drilling Muds and Cuttings. Presented in the Conference Proceedings of the Environmental Aspects of Chemical Use in Well-Drilling Operations, Sponsored by the U.S. Environmental Protection Agency. May 21-23, 1975. Houston, TX.
- Rearden, J. (ed.). 1981. Alaska Mammals. Alaska Geographic, 8(2).
- Rearic, D. M., Barnes, P. W., and Reimnitz, E. 1981. Ice Gouge Data, Beaufort Sea, Alaska, 1972-1980: U.S. Geological Survey Open-File Report 81-950.
- Reimnitz, E. and Barnes, P. W. 1974. Sea Ice as a Geologic Agent on the Beaufort Sea Shelf of Alaska. <u>In</u>: The Coast and Shelf of the Beaufort Sea. Edited by Reed, J. C. and Sater, J. E. Proceedings of the Arctic Institute of North America Symposium on Beaufort Sea Coast and Shelf Research: Arlington, Virginia, Arctic Institute of North America.
- Reimnitz, E. and Maurer, D. K. 1979. Effects of Storm Surges on the Beaufort Sea Coast, Northern Alaska. Arctic, 32(4).
- Reimnitz, E. and Maurer, D. M. 1978. Storm Surges on the Beaufort Sea Shelf. USGS Open File Rep. 78-593. Anchorage, AK.
- Reimnitz, E., Toimil, L. J., and Barnes, P. W., 1978. Arctic Continental Shelf Morphology Related to Sea-ice Zonation, Beaufort Sea, Alaska: Marine Geology, 28.
- Reiser, H. N., Brosge, W. P., Dutro, J. T., Jr., and Detterman, R. L. 1980. Geologic Map of the Demarcation Point Quadrangle, Alaska. U.S. Geological Survey Miscellaneous Investigations Series, Map I-1133.

- Renouf, D., Lawson, J., and Gaborko, L. 1983. Attachment Between Harbor Seal (Phoca vitulina) Mothers and Pups. Journal of Zoology (London), 199.
- Rice, S. D. 1981. Review: Effects of Oil on Fish. National Academy of Sciences, Workshop on Petroleum in the Environment, November, 1981.
- Rice, S. D., Korn, S. and Kariner, J. F. 1980. Lethal and Sublethal Effects on Selected Alaskan Marine Species After Acute and Long-Term Exposure to Oil and Oil Components. Annual Report, Research Unit 72. U.S. Department of Commerce, NOAA, OCSEAP, Boulder, CO.
- Richardson, W. J. (Ed.) 1987. Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales. 1985-86. Prepared for the Minerals Management Service, Prepared by LGL Research Associates, Inc. OCS Study MMS 87-0037.
- Richardson, W. J. 1986. Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales. Prepared for the Minerals Management Service. Prepared by LGL Ecological Research Associates, Inc. Report No. MMS 86-0026.
- Richardson, J. and Johnson, S. 1981. Waterbird Migration Near the Yukon and Alaskan Coast of the Beaufort Sea. Arctic, 34(2).
- Richardson, W. J., Greene, C. R., Hickle, J. P., and Davis, R. A. 1983. Effects of Offshore Petroleum Operations on Cold Water Marine Mammals. A Literature Review. Prepared by LGL Limited, Toronto, Ontario, Canada. Prepared for the American Petroleum Institute, Environmental Affairs Department, Washington, D.C.
- Richardson, W. J., Greene, C. R., and Wursig, B. 1985. Behavior, Disturbance Responses, and Distribution of Bowhead Whales <u>Balaena mysticetus</u> in the Eastern Beaufort Sea, 1980-84: A Summary. Prepared by LGL Ltd. Prepared for U.S. Minerals Management Service, Contract No. 14-12-0001-29051.
- Ridgway, S. H. and Dailey, M. D. 1972. Cerebral and Cerebellar Involvement of Trematode Parasites in Dolphins and Their Possible Role in Stranding. J. Wild. Dis., 8.
- Roseneau, D. G. and Stern, P. M. 1974. Distribution and Movements of the Porcupine Caribou Herd in Northeastern Alaska, 1972. In:
  Arctic Gas Biol. Rep. Series 7.
- Rowe, L., Dollahite, J., and Camp, B. 1973. Toxicity of Two Crude Oils and of Kerosine to Cattle. Journal of American Veterinary Medicine Associates, 16.

- Rubinstein, N. I., Rigby, R., and D'Asaro, C. N. 1980. Acute and Sublethal Effects of Whole Used Drilling Fluids on Representative Estuarine Organisms. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Sanders, H. L., Grassle, J. F., Hampson, G. R., Morse, L. S., Garner-Price, S., and Jones, C. C. 1980. Anatomy of an Oil Spill: Long-Term Effects from the Grounding of the Barge Florida off West Falmouth, Mass. J. Mar. Res., 38.
- Schamel, D. 1978. Birds. <u>In</u>: Environmental Assessment of the Alaskan Continental Shelf, Interim Synthesis: Beaufort/Chukchi. National Oceanic and Atmospheric Administration, OCSEAP. Boulder, CO.
- Schell, D. M., Ziemann, P. J., Parrish, D. M., Dunton, K. H., and Brown, E. J. 1982. Foodweb and Nutrient Dynamics in Nearshore Alaska Beaufort Sea Waters. In: Outer Continental Shelf Environmental Assessment Program, 25.
- Schell, D. M., Ziemann, P. J., Parrish, D. M., Dunton, K. H., and Brown, E. J. 1982. Foodweb and Nutrient Dynamics in Nearshore Alaska Beaufort Sea Waters. Cumulative Summary Report. Prepared for NOAA, OCSEAP.
- Schell, D. M. 1975. Seasonal Variation in the Nutrient Chemistry and Conservative Constituents in Coastal Alaskan Beaufort Sea Waters.

  In: Environmental Studies of an Arctic Estuarine System. Edited by Alexander, V. et al. DPA-660/3-75-026. Environmental Protection Agency.
- Schultz, D. P., Johnson, W. W., and Berkner, A. B. 1983. A Unique Oiled Bird Rehabilitation Operation Myrtle Beach, South Carolina, February, 1981. <u>In</u>: Proceedings 1983 Oil Spill Conference (Prevention, Behavior, Control, Cleanup). February 28 March 3, 1983, San Antonio, TX. American Petroleum Institute. Pub. No. 4356.
- Searby, H. W. and Hunter, M. 1971. Climate of the North Slope of Alaska. NOAA Tech. Mem. NWS AR-4, Anchorage.
- Shapiro, J. H., ed. 1981. Environmental Hazards. In: Environmental Assessment of the Alaskan Continental Shelf. Beaufort Sea Synthesis-Sale 71. Edited by Norton D. W., and Sackinger, W. M. Fairbanks and Juneau, AK: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program.
- Sharp, J. R., Carr, R. S., and Neff, J. M. 1982. Influence of Used Chrome Lignosulfonate Drilling Mud on the Early Life History of the Mummichog <u>Fundulus</u> <u>heteroclitus</u>. <u>In</u>: Proceedings of an Ocean Dumping Symposium. Plenum Press, New York.

- Smiley, B. D. 1982. The Effects of Oil on Marine Mammals. <u>In:</u> Oil and Dispersants in Canadian Seas--Research Appraisal and Recommendations. Edited by Sprague, J. B., Vandermeulen, J. H., and Wells, P. G. Environment Canada, EPS3-EC-82-2.
- Smith, N. K. and Diaz, A. 1985. In-place Burning of Crude Oil in Broken Ice: 1985 Testing at OHMSETT.
- Smith, T. G. 1976. Predation of Ringed Seal Pups (Phoca hispida) by the Arctic Fox (Alopex lagopus) Canadian Journal of Zoology, 54.
- Smith, T. G. 1973. Population Dynamics of the Ringed Seal in the Canadian Eastern Arctic. Fish. Res. Board Can. Bull., 181.
- Smith, T. G., Geraci, J. R., and St. Aubin, D. J. 1983. The Reaction of Bottlenose Dolphins, <u>Tursiops</u> truncatus, to a Controlled Oil Spill. Can. J. Fish. Aquat. Sci., <u>40</u>.
- Smith, T. G. and Stirling, J. 1975. The Breeding Habitat of the Ringed Seal (Phoca hispida). The Birth Lair and Associated Structures. Canadian Journal of Zoology, 53.
- Sowls, A. L., Hatch, S. A., and Lensink, C. J. 1978. Catalog of Alaskan Seabird Colonies. Prepared by U.S. Fish and Wildlife Service. FWS/OBS-78/78.
- Starr, S. J., Kuwada, M. N., and Trasky, L. L. 1981. Recommendations for Minimizing the Impacts of Hydrocarbon Development on the Fish, Wildlife, and Aquatic Plant Resources of the Northern Bering Sea and Norton Sound. Alaska Department of Fish and Game, Habitat Division, Anchorage, AK.
- State of Alaska, Alaska Heritage Resource File and Computer Inventory (Alaska, AHR). 1986. Comments on Pre-regulatory Review of Exxon's Sale 87 Exploration Plan and Environmental Report. May 1986.
- St. Aubin, D. J., Stinson, R. H., and Geraci, J. R. 1984. Aspects of the Structure and Composition of Baleen, and Some Effects of Exposure to Petroleum Hydrocarbons. Can. J. Zool., 62.
- Stephens, R. H., Braxton, C., and Stephens, M. M. 1977. Atmospheric Emissions from Offshore Oil and Gas Development and Production. EPA-450/3-77-026. U.S. Environmental Protection Agency, Office of Air and Waste Management and Office of Air Quality Planning and Standards. Research Triangle Park, NC.
- Sterling, T. and Dzubin, A. 1967. Canada Goose Molt Migrations to the Northwest Territories. Trans, N. Am. Wildl. Nat. Res. Conf., 32.

- Stewart, B., Aubrey, F., and Evans, W. 1983. Beluga Whale (Deliphinapterus leucas) Responses to Industrial Noise. In: Final Report to: National Oceanic and Atmospheric Administration, P.O. Box 1808, Juneau, AK 99802. Technical Report, 83-161.
- Stirling, I. 1974. Polar Bear Research in the Beaufort Sea. <u>In:</u>
  The Coast and Shelf of the Beaufort Sea. Edited by Reed, J. C. and Slater, J. E. Arctic Institute of North America.
- Stirling, I., Schweinsburg, R. E., Calvert, W., and Kiliaan, H. P. L. 1977. Population Ecology of the Polar Bear Along the Proposed Arctic Islands Gas Pipeline Route. ESCOM Rep. AI-15, Can. Dept. Environment.
- Stringer, W. J. 1982. Ice Concentration in the Eastern Beaufort Sea. Prepared for the National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program. Contract No. 81-RAC00147. Fairbanks, AK: University of Alaska, Geophysical Institute.
- Stringer, W. J. 1978. Morphology of Beaufort, Chukchi and Bering Seas Nearshore Ice Conditions by Means of Satellite and Aerial Remote Sensing. Geophys. Inst., Univ. Alaska, Vol. I and Vol. II.
- Thomas, D. J. 1978. Copper, Zinc, Cadmium, Lead, Chromium, Mercury and Iron in Sediment, Seawater and Zoobenthos at Selected Dome Drill Sites in the Beaufort Sea, Summer 1977. Prepared for Dome Petroleum, Ltd. by Seakem Oceanography, Ltd. Sidney, D.C.
- Thomas, D. R. 1983. Potential Oiled Ice Trajectories in the Beaufort Sea. Report No. 252. Kent, WA: Flow Industries, Inc., Research and Technology Division.
- Thompson, J. H. and Bright, T. J. 1980. Effects of an Offshore Drilling Mud on Selected Corals. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. January 21-24, 1980. Lake Buena Vista, FL.
- Tornberg, L. D., Thielk, E. D., Nakatoni, R. E., Miller, R. C., and Hillman, S. O. 1980. Toxicity of Drilling Fluids to Marine Organisms in the Beaufort Sea, Alaska. In: Proceedings of a Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. Washington, D.C.: Courtesy Associates.
- Trefry, J. H., Trocine, R. P., and Meyer, D. B. 1981. Tracing the Fate of Petroleum Drilling Fluids in the Northwest Gulf of Mexico. <u>In</u>: Oceans '81 Marine Technology Society. Washington, D.C.
- Trocine, R. P. and Trefry, J. H. 1983. Particulate Metal Tracers of Petroleum Drilling Fluid Dispersion in the Marine Environment. Environmental Science Technology, 17(9).

- Turl, C. W. 1980. Literature Review of I. Underwater Noise from Offshore Oil Operations and II. Underwater Hearing and Sound Production of Marine Mammals. Interim Report for the Study on the Effects of Sound on Marine Mammals. U.S. Department of the Interior, Bureau of Land Management.
- Underwood, L. S., Brown, W. E., and LaBelle, J. 1982. Socioeconomic Profile: National Petroleum Reserve in Alaska. U.S. Department of the Interior, National Petroleum Reserve in Alaska 105(c) Land Use Study, Anchorage. National Petroleum Reserve in Alaska Task Force Study Report 3.
- Underwood, L. S. 1977. A Proposal for an Ecological Reserve System for Alaska. Unpubl. Rep. by Arctic Environ. Information and Data Center, Univ. of Alaska, for Joint Federal State Land Use Planning Commission.
- United States Fish and Wildlife Service (USFWS). 1987. Arctic National Wildlife Refuge, Alaska, Coastal Plain Resource Assessment. Report and Recommendation to the Congress of the United States and Final Legislative Environmental Impact Statement. Prepared in Cooperation with the U.S. Geological Survey and the Bureau of Land Management.
- United States Fish and Wildlife Service (USFWS). 1985. Final Subsistence Management and Use: Implementation of Title VIII of ANILCA.
- U.S. Army Corps of Engineers (USACOE). 1980. Waterflood Project.
- Walker, J. 1987. Personal Communication. Minerals Management Service, Alaska OCS Region.
- Ward, J. and Sharp, P. L. 1974. Effects of Aircraft Disturbance on Molting Seaducks at Herschel Island, Yukon Territory, August 8, 1973. In: Studies on Terrestrial Bird Populations, Molting Sea Ducks and Bird Productivity in the Western Arctic, 1973. Edited by Gunn, W. W. H., Richardson, W. J., Schweinsburg, R. E. and Wright, T. D. Arctic Gas Biol. Rep. Series Vol. 29, by LGL Ltd., Edmonton, Alberta.
- Weber, D. D., Maynard, D. J., Gronlund, W. D., and Konchin, V. 1981.
  Avoidance Reactions of Migrating Adult Salmon to Petroleum Hydrocarbons. Canadian Journal of Fisheries and Aquatic Sciences,
  38.
- Weeks, W. F. 1987. Sea Ice Hazards. In: The Diapir Field Environment and Possible Consequences of Planned Offshore Oil and Gas Development. Proceedings of a Synthesis Meeting, January 25-28, 1983, Chena Hot Springs, Alaska. Edited by Becker, P. R. Prepared by NOAA/Ocean Assessments Division, OCSEAP, Anchorage, AK.

- Weeks, W. F. 1981. "Statistical Aspects." Chapter 3. <u>In: Proceedings of a Synthesis Meeting: Beaufort Sea-Sale 71-Synthesis Report.</u> Chena Hot Springs, Alaska, April 21-23, 1981. Edited by Norton, D. W. and Sackinger, W. M. Juneau, AK: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program.
- Weeks, W. F. and Ackley, S. F. 1982. The Growth, Structure and Properties of Sea Ice. Monograph 82-1. Hanover, NH: U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory.
- Weller, G., Norton, D., and Johnson, T. (eds.). 1978. Interim Synthesis: Beaufort/Chukchi. <u>In</u>: Envir. Assess. Alaskan Cont. Shelf, BLM/NOAA, OCSEAP. Boulder, CO.
- Williams, T. M. and Heard, D. C. 1986. World Status of Wild Rangifer tarandus Populations. Rangifer, Special Issue No. 1.
- Wiseman, W. J., Jr., Coleman, J. M., Gregory, A., Hsu, S. A., Short, A. D., Suhayda, J. N., Walters, C. D., Jr., and Wright, L. D. 1973. Alaskan Arctic Coastal Processes and Morphology. Rep. No. 149. Cstl. Studies Inst. Louisiana State Univ., Baton Rouge, LA.
- Woodward-Clyde Consultants. 1983. Lisburne Development Area: 1983 Environmental Studies-Final Report. Prepared by Woodward-Clyde Consultants for ARCO Alaska, Inc., Anchorage, AK.
- Woodward-Clyde Consultants. 1981. Environmental Report for Exploration in the Beaufort Sea Federal/State Lease Sale Area-Seal Prospect. Prepared for Shell Oil Company, Houston, TX.
- Wursig, B., Clark, G. W., Dorsey, E. M., Fraker, M. A., and Payne, R. S. 1981. Normal Behavior of Bowheads. <u>In</u>: Behavior, Disturbance Responses and Feeding of Bowhead Whales in the Beaufort Sea. Edited by Richardson, W. J. Unpub. Rpt. from LGL Ecological Research Assoc., Inc. Bryan, TX for BLM.
- Zingula, R. P. 1975. Effects of Drilling Operations in the Marine Environment. <u>In</u>: Environmental Aspects of Chemical Use in Well Drilling Operations. EPA-560/1-75-004. U.S. Environmental Protection Agency.

## APPENDIX A

SUMMARY OF CONSULTATIONS HELD WITH SUBSISTENCE WHALING COMMUNITIES, THE ALASKA ESKIMO WHALING COMMISSION, AND OTHERS

### APPENDIX A

SUMMARY OF CONSULTATIONS HELD WITH SUBSISTENCE WHALING COMMUNITIES, THE ALASKA ESKIMO WHALING COMMISSION, AND OTHERS

Since 1986, Amoco Production Company and other oil and gas companies with holdings in the eastern Alaska Beaufort Sea OCS Area have engaged in regular consultations with subsistence whaling communities (i.e., Kaktovik, Nuiqsut, and Barrow) and the Alaska Eskimo Whaling Commission concerning proposed exploratory drilling operations (e.g., see Table A-1 for a list of individuals that attended a March 1986 meeting of the Oil/Whalers 1986 Working Group). These consultations have included discussions concerning potential conflicts with the siting, timing, and methods of the proposed operations.

In 1986, these consultations led to the adoption of an Oil/Whalers Cooperative Agreement which, among other things, established a network to facilitate communications between vessels engaged in exploration operations and boats engaged in subsistence whaling activities. Under the network, radios on the industry vessels and whaling boats were tied, by a special frequency, into a shorebased clearinghouse. Eskimos, fluent in Inupiat, were stationed on the industry vessels and at the clearinghouse to ensure the rapid dissemination of information on vessel locations and activities. The operation of the network was guided by a manual which detailed operating procedures, reporting requirements, and dispute resolution procedures. The Oil/Whalers Cooperative Agreement was re-established in 1987, and Amoco is working on the establishment of a similar arrangement for 1988.

Since 1986, the consultation process engaged in by Amoco also has focused on the Scientific Research/Monitoring Program that Amoco plans to conduct in concert with the proposed exploratory drilling operations on the Galahad Prospect. Over the past three years, Amoco has had both formal and informal discussions with the residents

of Kaktovik, Nuiqsut and Barrow, the Alaska Eskimo Whaling Commission, individual whalers, and the representatives of federal, state, and North Slope Borough agencies.

Amoco has used the ongoing consultation process to identify potential conflicts with subsistence use activities, and to devise an exploration program on the Galahad Prospect which will avoid or minimize these conflicts to the maximum extent possible. This plan documents this approach.

On July 21-22, 1988, a team of Amoco representatives travelled to Kaktovik and Barrow to brief local leaders, whalers, and residents about the scope and nature of the operations planned in 1988 at the Galahad and Belcher Prospects. The Amoco group included members of Amoco's environmental, permitting, exploration and drilling groups. The group also included a representative from Beaudril Ltd., the probable drilling contractor, Alaska Telecom and legal counsel.

The first meeting was held in Kaktovik, Alaska on July 21, 1988. The Amoco group made a presentation at the regularly scheduled session of the Kaktovik Village Council. In attendance at the meeting were the Council, the village mayor, a representative of the North Slope Borough, the local commissioners of the Alaska Eskimo Whaling Commission (AEWC), other local whaling captains and crew members, and members of the Kaktovik general public (note: a list of the attendees at the Kaktovik and Barrow Meetings is provided in Table A-2). The Amoco presentation covered the following general topics: the location, nature, and scope of the operations planned for the Galahad and Belcher Prospects; the type of drilling equipment and procedures to be used; support vessel arrangements; associated research projects; and the status of Amoco's permitting efforts.

Amoco entertained questions and comments from the audience relating to all aspects of these operations, and expressly solicited the statement of any concerns that might exist relating to its plans to conduct exploratory drilling operations at the Galahad Prospect. A number of attendees expressed a desire that no oil exploration operations of any type be conducted in the eastern Alaska Beaufort Sea during the fall bowhead whale hunting season. The Amoco representatives explained why that was not possible given the narrow parameters for conducting exploration activities in that part of the world. In the absence of a commitment to suspend all operations for the duration of the hunt, Amoco was then asked if it would apply the Oil/Whalers Cooperative Agreement, currently being negotiated for 1988, to the Galahad Prospect as well as the Belcher Prospect. Amoco agreed that an Oil/Whalers Cooperative Agreement should also apply to the Galahad Prospect. This commitment was of particular importance to the whalers and AEWC representatives in attendance.

Many other questions and comments were brought up during the session. Amoco responded to inquiries about the general location of the drilling and support operations for operations on the Galahad Prospect, and no particular objections were raised to those locations. In response to other questions, Amoco provided detailed information pertaining to ice avoidance and management techniques, the design and operations of the KULLUK, the length of the drilling season, anticipated start-up dates, the KULLUK's emergency capabilities, its history of operations in the Canadian Beaufort Sea, and the use of drilling muds. Many of the questions and concerns dealt with ice class support vessel operations and whether they would be coordinated so as to avoid interference with subsistence whaling activities. Amoco explained that the KULLUK is able to carry a larger amount of on-board supplies than a traditional drillship, and that, as a result, fewer resupply trips are anticipated than those which occurred during the drilling conducted at the Corona Prospect in 1986. Amoco further explained that all of the ice class support vessels would be part of an Oil/Whalers Cooperative Agreement, which would require that each vessel have an Inupiat communicator on-board and trained to employ a special radio communications system which would be designed to allow industry vessels to avoid any interference with subsistence whaling activities. also explained that the 1988 Oil/Whalers It was

Cooperative Agreement would include new communications and reporting procedures intended to improve what has already been generally recognized as a successful program. The AEWC and whalers in attendance expressed their satisfaction with these arrangements.

Another concern related to the basing of helicopters and helicopter overflights. Amoco explained that it did not intend to conduct major helicopter staging operations out of Kaktovik and that all of its flights would observe the minimum height restrictions set forth in this POE. Amoco further committed to avoid routing substantial helicopter activities over areas of active whaling operations, as permitted by weather and operational conditions.

Other questions dealt with the water depth at the proposed well locations and whether permafrost existed on the seabed floor. These questions were answered by Amoco's geologist. Amoco was asked whether the type of drilling operations contemplated for the Galahad Prospect were similar in nature to those already approved at the Belcher Prospect, and Amoco answered that they were. Finally, Amoco was also asked several questions about the type of whale research and monitoring project it planned to employ at the Galahad Prospect. Amoco explained that it intended to use the same research program which has already been approved for use at the Belcher Prospect, and that the research program has received its final permitting authorization from the National Marine Fisheries Service.

The following day, Amoco made a similar presentation to a group gathered in Barrow. This meeting, held in the North Slope Borough council chambers, was attended by numerous officials of the Borough planning, legal, environmental and permitting departments, representatives of the leadership of the AEWC (which maintains its offices in Barrow), local whalers, members of the local public and the local news media. After the main presentation, Amoco again took questions from the audience and attempted to address all of the concerns expressed. The greatest number of questions dealt with the reactions that Amoco had received from the people in Kaktovik the

previous day. To a large extent, the people in attendance in Barrow deferred to Kaktovik on all subsistence related issues since Kaktovik is the community which is closest in proximity to the anticipated operations at the Belcher and Galahad Prospects. No particular concerns were expressed relating to the proposed well locations on the Galahad Prospect; to the contrary, the attendees seemed generally pleased that it was farther north of the Corona site drilled in 1986. The audience was also informed that operations on the Galahad Prospect would be incorporated into a Oil/Whalers Cooperative Agreement which is currently being negotiated for the 1988 season.

Other topics discussed included inquiries about the class of ice-breaking vessels which would support the KULLUK, relief well scenarios, emergency abandonment procedures, ice warning systems, precautions against human error, and rig staffing. Again, the audience seemed generally satisfied with Amoco's responses and raised no particular objections. Representatives of the Borough planning department were pleased to find out that the KULLUK has two complete BOP systems on-board, unlike a conventional drillship. Inquiries were also raised about the monitoring program to be used at the Galahad Prospect.

Other members of the audience inquired about the start-up date for operations at either the Belcher or Galahad Prospects. Amoco explained that it was impossible to specify an exact start-up date because it is not known when the KULLUK will complete its current operations in the Canadian Beaufort Sea; however, it is anticipated that operations will commence sometime during the period of August 15 to September 15. The planning department asked about the threshold depths for the two prospects and were told that for the Belcher Prospect threshold had been set at 5,200 feet while no determination had yet been made for the Galahad Prospect. Other discussion topics included anticipated vessel traffic and scheduling; the Barrow audience was informed that there should be less supply vessel traffic associated with drilling in 1988 than had been the case in 1986 when Corona was drilled from a CANMAR drillship. Finally, several

questions were raised regarding local hire opportunities, and Amoco responded that it would be hiring an as yet undetermined number of local residents.

After the formal public meeting, Amoco conducted two separate meetings with the AEWC and representatives of the North Slope Borough. At the meeting with the AEWC, Amoco went over the latest draft of a 1988 Oil/Whalers Cooperative Agreement with the whaling representatives. The 1988 agreement would be virtually identical to that which has been successfully employed in the Beaufort during both 1986 and 1987. The only significant modification would be the inclusion of some additional communications procedures which worked particularly well in practice in the Nuiqsut area during 1987. During the 1988 negotiations, the AEWC had specifically requested that these procedures be formally incorporated into the agreement.

Barrow, there appear to be no obstacles to signing an Oil/Whalers Cooperative Agreement for 1988. The formal signing ceremony has been tentatively scheduled for August 8, 1988 in Anchorage. During the interim period, both the AEWC and Amoco are compiling the final contact and participant information necessary to implement the agreement, as well as overhauling and performing general maintenance on the radio and communications equipment.

The final meeting in Barrow was with several representatives of the North Slope Borough. The main topic of discussion was the research program to be used at the Galahad and Belcher Prospects. In the past the Borough has expressed its concerns about some aspects of the project, while stating its general support of the program's basic concept and objectives. At this meeting the Borough acknowledged that the program would in fact be proceeding in 1988, and asked that after the first year of research operations that the results be closely examined to see if the research methods and procedures required revision or could be improved upon based upon the 1988 experience.

Amoco assured that such a process would take place and that all of the results of the study would be made publicly available in the manner required by the State of Alaska consistency certification.

After departing Barrow, Amoco met briefly in Fairbanks with representatives of the State of Alaska Division of Governmental Coordination, Department of Natural Resources and Department of Fish and Game. Amoco informed these agencies of its intention to commence permitting the Galahad Prospect in the very near future, explained the reasons for wanting the ability to perform operations at the Galahad Prospect in 1988 and provided general descriptions of the location of the prospect and the type of operations anticipated. While none of these agencies was in a position to make any commitments about consistency certification at this initial briefing, no particular objections or concerns were stated.

On Thursday, August 19, 1988, representatives of Amoco held a public meeting at the Nuiqsut Fire Hall to discuss proposed Galahad operations. Approximately 25 people attended. Representatives of the Nuiqsut Whaling Captains' Association, the North Slope Borough, KBRW in Barrow and members of the general public were present.

A number of issues were discussed. Questions were asked about noise from helicopter travel. It was explained that Amoco would comply with all applicable guidelines for aircraft operation, which, among other things, call for a minimum 1,500-foot altitude in certain areas. It was also explained that the helicopters Amoco will use will be quieter than similar two-bladed (rotored?). When the helicopters operate instrument flight rating, which is expected to be frequently, the minimum altitude will be 2,000 feet. Amoco also indicated its supply and personnel flights will avoid the Nuiqsut area and would, to the extent possible, fly along the coast until the shortest possible over water flight to the drilling rig.

Amoco was also asked about a specific start date for its Galahad drilling. It was explained that because of operational uncertainties (i.e., speed at which the Belcher well can be drilled, ice, and weather conditions, etc.) Amoco cannot provide an exact start date. Amoco was also asked about supply boat traffic and it was explained that Amoco had selected the Kulluk in part because of the Kulluk's greater storage capacity which reduced the need for supply boat travel. Amoco was also asked about what would occur if the drill ship was being towed from Canada through the eastern Beaufort during the whale migration. It was explained that it was almost certain that the drill ship would be in American waters well before the migration begins. Questions concerning supply vessel routings were also addressed.

Other concerns were discussed which related primarily to the Belcher Prospect or to the Sandpiper Island operations. Amoco described in that context the whale research program that it has proposed for this drilling season.

### TABLE A-1

# ATTENDANCE LIST OIL/WHALERS 1986 WORKING GROUP MARCH 13-14, 1986 MEETING KUPARUK INDUSTRIAL CENTER

# NORTH SLOPE BOROUGH

Mr. Warren Matumeak
Deputy Director, Permitting
Planning Department
P.O. Box 69
Barrow, AK 99723
(907) 852-2611

Mr. Benjamin P. Nageak
Subsistence Research Specialist
Dept. of Wildlife Management
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Mr. Thomas F. Albert
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(907) 852-7242 (H)

# ALASKA ESKIMO WHALING COMMISSION

Mr. Arnold Brower, Jr. Chairman, AEWC P.O. Box 69 Barrow, AK 99723 (907) 852-2611

Mr. Thomas Napageak Commission for Nuiqsut General Delivery Nuiqsut, AK 99723 (907) 480-6328 Mr. Nolan Soloman & Spouse Commissioner for Kaktovik P.O. Box 84 Kaktovik, AK 99747 (907) 640-6613

# BARROW WHALING CAPTAINS ASSOCIATION

Mr. Arnold Brower, Sr. Whaling Captain P.O. Box 351 Barrow, AK 99723 (907) 852-7362

Mr. Alfred Leavitt
Whaling Captain
P.O. Box 446
Barrow, AK 99723
(907) 852-3706

### TABLE A-1 (cont.)

# NUIQSUT WHALING CAPTAINS ASSOCIATION

Mr. Sam M. Taalak Whaling Captain General Delivery Nuiqsut, AK 99723 (907) 480-6811

Mr. Glenn Taalak Crew Member General Delivery Nuiqsut, AK 99723 (907) 480-6811

Mr. Edward Kukapigak & Spouse Whaling Captain General Delivery Nuiqsut, AK 99723 Mr. Norman Lampe Whaling Co-Captain General Delivery Nuiqsut, AK 99723 (907) 480-6212

Mr. Arnold A. Kittick & Spouse Whaling Captain General Delivery Nuiqsut, AK 99723 (907) 480-6811

Mr. Patsy Tukle Whaling Captain General Delivery Nuiqsut, AK 99723 (907) 480-6520

(Note: The following whaling captain from Nuiqsut arrived late on March 14)

Mr. Billy Oyagak Whaling Captain General Delivery Nuiqsut, AK 99723 (907) 480-6729

# KAKTOVIK WHALING CAPTAINS ASSOCIATION

Mr. Joseph Kaleak & Spouse
Whaling Captain and Alternate
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Mr. Herman Aishanna & Spouse Whaling Captain P.O. Box 58 Kaktovik, AK 99747 (907) 640-6326

Mr. Daniel Akootchook & Spouse Whaling Captain General Delivery Kaktovik, AK 99747 (907) 640-6215

Mr. Archie K. Brower & Spouse Whaling Captain P.O. Box 109 Kaktovik, AK 99747 (907) 640-6211

Mr. Isaac Akootchook Whaling Captain General Delivery Kaktovik, AK 99747 (907) 640-6612

Mr. Alfred Linn & Spouse Whaling Captain General Delivery Kaktovik, AK 99747 (907) 640-6214

# TABLE A-1 (cont.)

Mr. Tom Agiak
Whaling Captain
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### OIL COMPANIES

Mr. Gerry A. Graham Unocal P.O. Box 190247 Anchorage, AK 99519 (907) 276-7600

Ms. E. H. (Pete) Nelson Texaco Inc. 550 W. 7th Avenue, Suite 1320 Anchorage, AK 99510 (907) 278-9611

Ms. Cheryl Winkler Amoco Production Co. 425 G Street Anchorage, AK 99510 (907) 263-2209 Mr. Jimmy Soplu & Spouse Whaling Captain P.O. Box 4 Kaktovik, AK 99747 (907) 640-7127

> Mr. L. E. Bratos Western Geophysical P.O. Box 2469 8300 Westpark Houston, TX 77252 (713) 952-4475

Mark Savit, Esq. (for Western Geophysical) Cotten, Day & Doyle 1899 L Street, N.W. Washington, D.C. 22036 (202) 659-9505

Ms. Diedre J. J. Bush Standard Alaska Production Co. P.O. Box 196612 Anchorage, AK 99519 (907) 561-5111

Mr. Larry Dinneen Amerada Hess Corp. 550 W. 7th Avenue, Suite 1150 Anchorage, AK 99501 (907) 274-4512

Mr. Pete Woodson Shell Western E&P Inc. 601 W. 5th Avenue, Suite 810 Anchorage, AK 99501 (907) 263-9625

### TABLE A-1 (cont.)

Tim McKeever, Esq. (for Amoco) Faulkner, Banfield, Doogan & Holmes 2550 Denali Street Anchorage, AK 99503 (907) 274-0666

John Clough, Esq. (for Amoco)
Faulkner, Banfield, Doogan & Holmes
800 W. 10th Avenue, Suite 300
Juneau, AK 99802
(907) 586-2210

Mr. W. I. (Tex) Norcross Shell Western E&P Inc. 200 N. Dairy Ashford, Rm 1-256 Houston, TX 77079 (713) 870-4521

Mr. Billy R. Vehnekamp Shell Western E&P Inc. 601 W. 5th Avenue, Suite 810 Anchorage, AK 99501 (907) 263-9642

# DRILLING CONTRACTORS

Mr. Lorne Hammer Canadian Marine Drilling Ltd. P.O. Box 200 Calgary, Alberta, Canada T2P 2H8 (403) 231-1991 Mr. Dave Yesland
Shell Western E&P Inc.
601 W. 5th Avenue, Suite 810
Anchorage, AK 99501
(907) 263-9617

Mr. Jim Anderson Shell Western E&P Inc. 200 N. Dairy Ashford, Rm 1-156 Houston, TX 77079 (713) 870-4080

Mr. Ed Hubbard, Jr.
Shell Western E&P Inc.
200 N. Dairy Ashford, Rm 1-228
Houston, TX 77079
(713) 870-4502

# TABLE A-2

# ATTENDEES AT KAKTOVIK, BARROW AND FAIRBANKS MEETINGS

Loren Ahlers, Mayor of Kaktovik Kaktovik Village Council Nolan Solomon, AEWC Commissioner for Kaktovik Joseph Kaleak, AEWC Deputy Commissioner for Kaktovik Arthur Brower Susie Akootchook Isaac Akootchook Lon Wolasek Al Linn, Jr. Phillip Tukak Bobby McCumber Other unidentified Kaktovik whalers and villagers Warren Matumeak, NSB Planning Elfrieda Edgington, AEWC - Barrow Dave Germann, NSB Permitting Sarah Newman, NSB Permitting Selena Brotherton Geoff Carroll, NSB Wildlife Management Henry Huntington, NSB Wildlife Management David Smith, NSB Planning Margaret Ferguson, AEWC - Barrow Kenneth Toovak, Sr., NSB Charles Brower, NSB Wildlife Management Benjamin P. Nageak, NSB Wildlife Management Tom Lohman, NSB Legal Carmella Carroll, KBRW Marie Adams, NSB Mayor's Office Dr. Tom Albert, NSB Wildlife Management Other unidentified Barrow whalers and villagers Elizabeth Benson, Alaska Division of Governmental Coordination Al Ott, Alaska Department of Fish and Game Bill Van Dyke, Alaska Department of Natural Resources Cheryl Winkler, Amoco (Environmental Coordinator) Dave Smith, Amoco (Drilling) Charlie Bartberger, Amoco (Geology) Bill Halvosson, Amoco (Drilling) Frank Mitton, Beaudril Limited Tim McKeever, Faulkner, Banfield, Doogan & Holmes John Clough, Faulkner, Banfield, Doogan & Holmes Lloyd Morris, Alaska Telecom

# APPENDIX B

BROCHURES ON SELECTED ICE CLASS SUPPORT VESSELS



# 

# Icebreaker/Anchor Handling Tug Supply Vessel

Contact Self-right	A PARTY OF THE PARTY OF THE PARTY.
	डार्कताचा अध्यक्ष्यस्थ
Builder  Commissioned  Managing Company	Saint John Shipbuilding and Drydock Saint John, N.B

Calgary, Alberta Canada, T2P 2H8 Official Number 392930 Radio Call Sign VC9921 Port of Registry Vancouver, B.C. Classification Lloyds +100 A1 Arctic Class 4 ASPPR Arctic Flag Canadian

# वाराच्युवाग्रह

Lèngth O.A. 297.6 ft. (90.72 m) Breadth: Moulded 56.6 ft. (17.25 m) 32.8 ft. (10.0 m) Depth: Moulded Draft: Summer Load 27.4 ft. (8.35 m) Gross Tonnage 3,641.6 T Net Tonnage 1,240.6 T Accommodation 18 crew STATE AND STATE 16 supernumeraries

Same of the Main Propulsion

BHP

Thrusters

Single screw installation 2 Sulzer 12ZV40/48 diesel engines to direct reduction gears driving LIPS C.P. propeller in fixed nozzle - 1 rudder 16,800

2 LIPS C.P. propellor CT12 electric driven tunnel type thrusters - one forward and one aft.

Auxiliary Machinery

Speed (cruising) Fuel Consumption

CATILevoy Somer 300 kW diesel generators 15 knots (max. 17.25 kts.) 220 bbls. (35 m3/day) at cruising speed

Bollard Pull 196 ton Tow Winch 1 - triple drum waterfall type anchor handling tow winch, 2 - 150 ton capacity towing drums with 1,968 ft. (600 m) of 23/4 inches 33 (63 mm) dia. wire 12 ton tugger winches 15 ton capstans

- deck crane 20 ton at 10.5 ft. (3.2 m) 8 ton at 55 ft. (16.8 m) Stern Roller 14.6 ft. long by 6 ft. dia. (4.45 m long by 1.83 m dia.)

2 storage reels

# To I.M.O. and M.O.T. Standards

manoeuvering control stations Winch control station c/w video monitoring Sperry gyro pilot
Rae & Sons magnetic compass

Anschutz standard 12 gyro compasses c/w 3 bearing repeaters and 2 steering repeaters Sperry Selescan 1024 radar

Sperry 1270 radar

Sperry 16" Selescan slave radar

Marconi CH150 multi-channel SSB transceiver Motorola 40S synthesized SSB radio telephone

2 Raytheon Ray 55 multi-channel VHF radios and 2 Ray 55 slaves

1 President C.B. radio 1 WCS 300 air to ground VHF radio Narco Com 120 TSO air to ground VHF radio Simrad RW105 watch receiver

Kelvin Hughes type MS45F echo sounder Kelvin Hughes type MS48 echo sounder

Marconi Loadstar IIID automatic radio direction

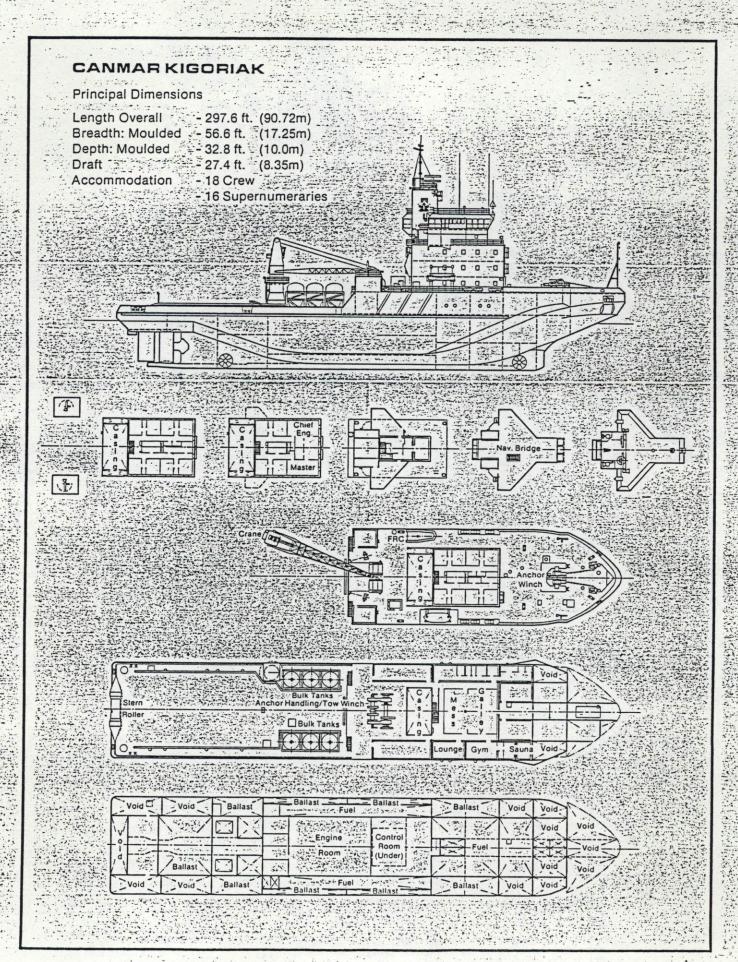
Magnavox MX1107 dual channel satellite navigator

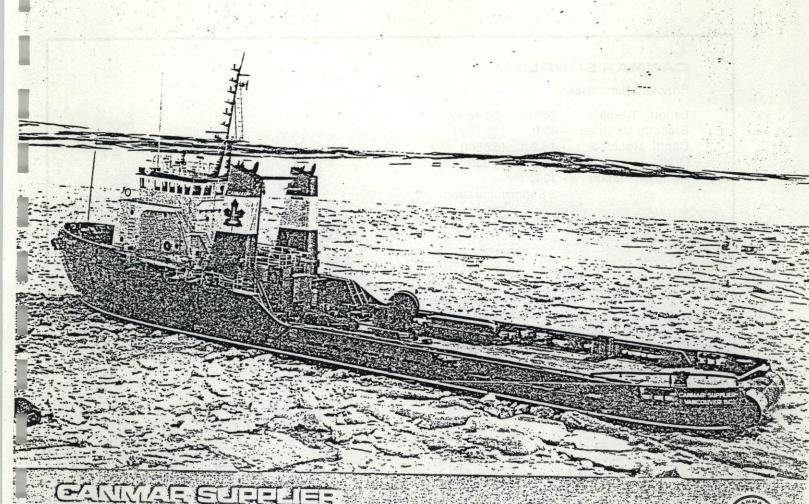
Decca DL91 Mk2 Loran C receiver Facsimile receiver Facsimile receiver
Mobile PBX telephone with fax. transcer

Xenon searchlights

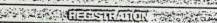
Deadweight at Max. Draft 1,890 Clear Deck Space (2 Areas) Length 88.6 ft. (27 m) and 42.6 ft. (13 m) Breadth 42.6 ft. (13 m) and 23 ft. (7 m Total Area 4,756 ft.2 (442 m²) Max. Deck Cargo 590 T Bulk (Barite/Cement) Pressure. Tanks Capacity/each 1,200 ft3 (34.3 m3) Potable Water 201 bbls. (32 m<sup>3</sup>) Drill Water 8,820 bbls. (1 400 m3) Fuel (total carrying capacity) 8,190 bbls. (1 302 m<sup>3</sup>) Refrigerated Storage Deep Freeze 3,355 ft.3 (95 m3) Cooler 3,355 ft.3 (95 m3)

- Meets MARPOL requirements
- Equipped with high speed rescue craft 360° visibility wheelhouse
- Icebreaking hull wash system
- Bow reamers
- Double skin hull Special ice-breaking low friction hull coating





# Icebreaking Anchor Handling, Tug Supply Vessel



Allied Shipbuilders Ltd Vancouver, B.C. Commissioned 1975 20 - V.M. Managing Company Canadian Marine Drilling Ltd.

P.O. Box 200 Calgary, Alberta Canada, T2P 2H8 Official Number 370255 CZ6459 Radio Call Sign Port of Registry Vancouver, B.C. Classification Lloyds +100 A1

Arctic Class 2 ASPPR Arctic Class Flag Canadian

# BUILDING STORE STORE

Length O.A. 205 ft. (62.48 m)
Breadth: Moulded .45 ft. (13.72 m)
Depth: Moulded .18.2 ft. (5.56 m)
Draft: Summer Load .14.2 ft. (4.33 m)
Gross Tonnage .1,188 T Length O.A. Net Tonnage 384 T Accommodation 13 crew
3 supernumeraries

### भागानियां माला के विकास

Main Propulsion Twin screw installation, 2 Nohab Polar F216V-D825 diesel engines clutched to reduction gears driving Ka Me Wa C.P. propellers in fixed nozzles - 4 rudders

7,040 Thrusters 1 - 350 BHP tunnel type bow thruster

Auxiliary Machinery \$2 CAT D343 200 kW diesel generators CAT D343 (bow thruster) Speed (cruising) 12 knots (max. 14 knots) Fuel Consumption 100 bbls. (16 m3/day) at cruising speed

# STAN STANDARDS

Bollard Pull

Tow Winch Hydraulic double drum waterfall type anchor handling tow winch - 136 ton capacity Towing drum with 3,000 ft. (914 m) of 21/4 inches (57 mm) dia. wire 4 - 5 ton tugger winches 2 - 6.8 ton capstans - 3 ton SWL service boom 1 storage reel Stern Roller 12.5 ft. long by 6 ft. dia. (3.81 m long by 1.83 m

# WAVIGATION & COMMUNICATIO 包含用的工具化 经营

dia.)

To I.M.O. and M.O.T. Standards manoeuvering control stations Sperry auto pilot Sestral magnetic compass Sperry Mk.37 gyro compass Sperry Selescan 1024 radar Sperry 1270 radar Marconi CH150 multi-channel SSB transceiver

Motorola Triton 40S synthesized SSB transceiver Honeywell distress generator Raytheon Ray 55 multi-channel VHF radios Simrad Model 11566 echo sounder Simrad Taiyo TDL-1100 radio direction finder Magnavox MX4102 satellite navigator C.B. radio Johnson A.M. air to ground radio Omega receiver 33 Facsimile receiver

# Searchlights

Realistic air scanner

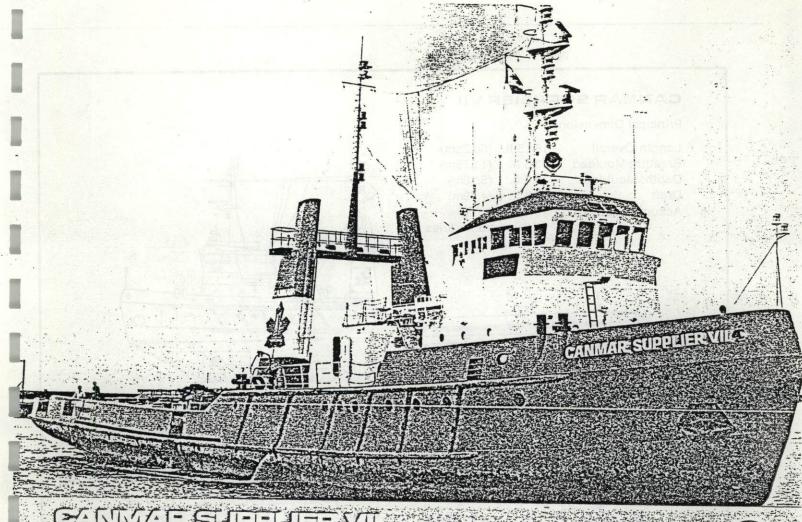
Deadweight 3 at Max. Draft Clear Deck Space Length 98.4 ft. (30 m)
Length 98.4 ft. (30 m)
Breadth 3,616 ft.² (336 m²)
Lax. Deck Cargo 7.700 T Max. Deck Cargo Bulk (Barite/Cement) Pressure Tanks Capacity/each 1,200 ft3 (34.3 m3) Potable Water 1,358 bbls. (216 m<sup>3</sup>) 3,478 bbls. (553 m<sup>3</sup>) Drill Water Fuel/Fuel Cargo 2,765 bbls. (440 m3) Refrigerated Storage
Deep Freeze 317 ft.³ (9 m³)
Cooler 317 ft.³ (9 m³)

# STUTE TO SERVICE

- Meets MARPOL requirements
- Equipped with high speed rescue craft 360° visibility from bridge Totally enclosed winch house

- Double skin hull
- Special ice-breaking low friction hull coating

# CANMAR SUPPLIER Principal Dimensions Length Overall - 205 ft. (62.48m) Breadth: Moulded - 45 ft. (13.72m) Depth: Moulded :- 18.2 ft. (5.56m) Draft - 14.2 ft. (4.33m) - 13 Crew - 3 Supern Accommodation 3 Supernumeraries Gear



# Anchor Handling, Towing Supply Vessel

CHARLEST TOTAL BETWEEN Builder Cochrane and Sons Ltd. Selby, Yorkshire, England Commissioned 1971 Managing Company Canadian Marine Drilling Ltd. P.O. Box 200

Calgary, Alberta Canada, T2P 2H8 Official Number 343013 Radio Call Sign CZ7758 Port of Registry Vancouver, B.C. Classification Lloyds +100 A1 Fice Class 1

ASPPR Arctic Class Type A Canadian

Length O.A. Breadth: Moulded 38.5 ft. (11.75 m) 16.7 ft. (5.10 m) 15.4 ft. (4.69 m) Depth: Moulded Draft: Summer Load Gross Tonnage 700 T Net Tonnage 293 T Accommodation 13 crew SA TOMAT 5 supernumeraries

# THE PROPERTY OF THE PARTY OF TH

Main Propulsion Twin screw installation. 2 KHD Deutz Model 12M SBV628 turbo charged diesel engines clutched to reduction gears, driving open C.P. propellers - twin rudders 5,200

**Auxiliary Machinery** 

Speed (cruising) Fuel Consumption cruising speed

350 BHP tunnel type bow thruster 2 CAT D346 350 kW diesel generators 31 CAT D3306 125 kW diesel generator 10.5 knots (max. 15 kts.) 72 bbls. (11.5 m³/day) at

Bollard Pull Tow Winch hydraulic double drum waterfall type anchor handling/towing winch - 136 ton capacity towing drum with 2,500 ft. (762 m) of 21/s inches (55 m) dia. wire - work drum capacity 900 ft. (274 m) of 21/2 inches (63 mm) dia. wire Deck Machinery 1 . 5 ton tugger winch 为"人" 2 - 7 ton capstans Stern Roller

9.5 ft. long by 5 ft. dia.

(2.9 m long by 1.52 m

To I.M.O. and M.O.T. Standards

manoeuvering control stations Sperry SRP 680 auto pilot Decca magnetic compass

Sperry Mk.37 gyro compass c/w 2 repeaters Decca RM916C radars

Marconi CH150 multi-channel SSB transceivers Motorola Triton 40S synthesized SSB transceiver Raytheon Ray 55 multi-channel VHF radios

Simrad ED1101 echo sounder Simrad Taiyo TDL-1100 radio direction finder Facsimile receiver

Marconi SM100 auto alarm generato Johnson A.M. air to ground radio C.B. radio

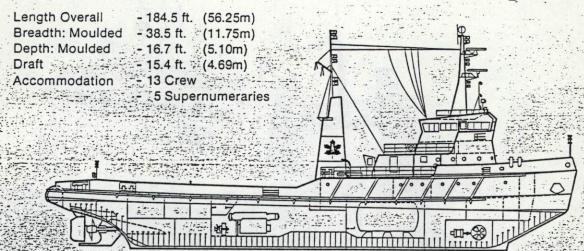
Searchlights

Deadweight at Max. Draft 706 T Clear Deck Space Length 82 ft. (25 m) Breadth 28.2 ft. (8.6 m) Total Area 2313.8 ft.2 (215 m2) Max. Deck Cargo 350 T Bulk (Barite/Cement) Pressure Tanks 1,230 ft.3 (34.8 m3) Capacity/each Potable Water 420.2 bbls. (66.8 m<sup>3</sup>) 2,340 bbls. (372 m<sup>3</sup>) Drill Water Fuel/Fuel Cargo 2,805 bbls. (446 m3) Refrigerated Storage 288 ft.3 (8.16 m³) .359 ft.3 (10.17 m³) Deep Freeze

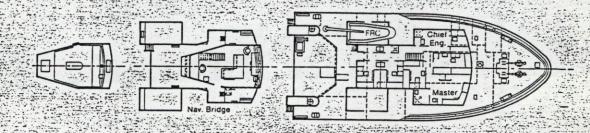
- Meets MARPOL requirements
- Moonpool 3.5 ft. (1.07 m) dia.
   Equipped with high speed rescue craft

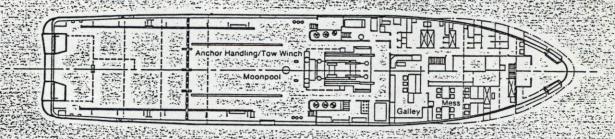
# CANMAR SUPPLIER VII

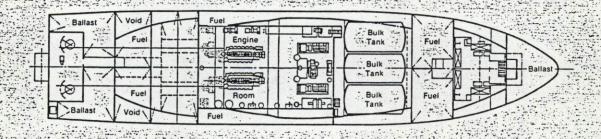
# Principal Dimensions



13.5



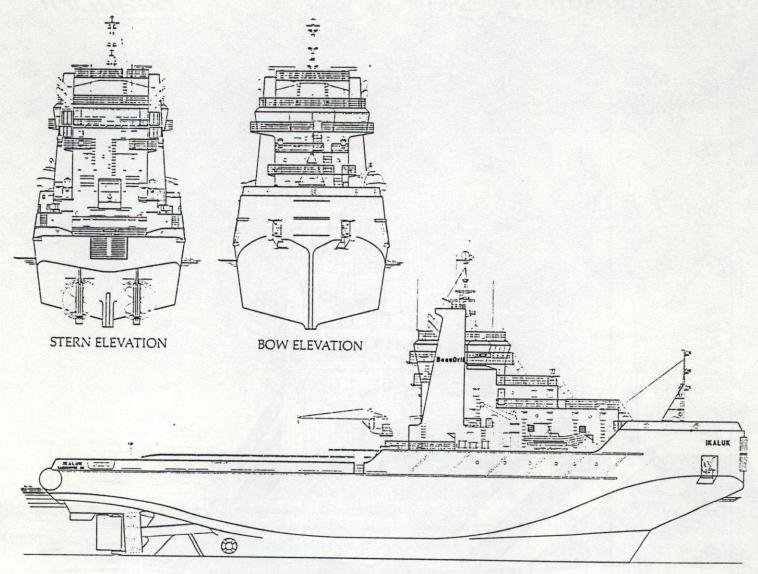




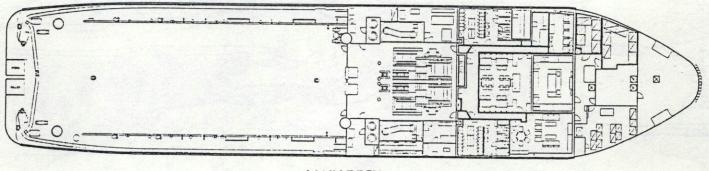
# M.V. "Ikaluk" Ice-breaking, anchor-handling, towing and supply vessel







GENERAL ARRANGEMENT



MAIN DECK



# Ship's Particulars

# General Information

Designed By: Robert Allan Ltd.

Built By: Nippon Kokan KK (NKK)

Tsurumi, Japan

Keel Laid: September 20, 1982

Hull Number: SNO 1007

Launched: November 15, 1982

Delivered: April 15, 1983

Owners: BeauDril Limited

Official Number: 802786
Call Sign: CZ 9982
Flag: Canadian

Port of Registry: Vancouver. B.C.

Type: Ice-breaker, Anchor-handling,

Supply, Tug

Class: ASPPR Ice Class 4

Lloyds Class: 100A1 "Ice-Breaker" "Offshore

Supply" Ice Class 1A Super

Voyage Class: Home Trade 1

Berths Total: 34 Crew: 19

Dimensions

 Length O.A.:
 78.95m

 Length B.P.:
 70.0m

 Breadth Extreme:
 17.22m

 Depth Moulded:
 9.707m

 Draft:
 7.532m

**Tonnage** 

Gross Tonnage: 3255.80
Net Tonnage: 1432.43
Deadweight Summer: 1898.50
Displacement: 5107.30

Deck (Loading Capacities)

Deck Cargo Area: 12.7m x 35.6m

Deck Cargo

Capacity: 1 000 tonnes

Bulk Barite/Cement

Capacity:  $4 \times 35.5 = 142 \text{m}^3$ 

 Fuel Oil:
 1 596m³

 Drill Water:
 1 146m³

 Fresh Water:
 152

Engine

Main Engine: Wartsila VASA 8R32 x 4 DIESEL

RPM: 750

BHP:  $3725 \times 4 = 14.900$ 

Thrusters FWD: Omnithruster/Airbubbling

System 1200 HP

Thrusters AFT: Kamewa 800 HP

Fresh Water

Maker Capacity: 10 tonnes/day

Propellers: 2 LIPS, CPP with Nozzle 4 blades

Bollard Pull: 150 tonnes

Service Speed

(two engines): 12 knots Speed (four engines): 14.7 knots

Fuel Consumption

Open Water: 20m³

Fuel Consumption

Heavy Ice: 58m<sup>3</sup>

Deck Machinery

Tugger Winches: 2 x 12-tonne pull
Capstans: 2 x 10-tonne pull

Towing & Work 2 Double-Drum Towing/Anchor-

Winches: Handling Winches

Deck Cranes: 2 x 5-ton SWL Hydralift

Life-saving Units

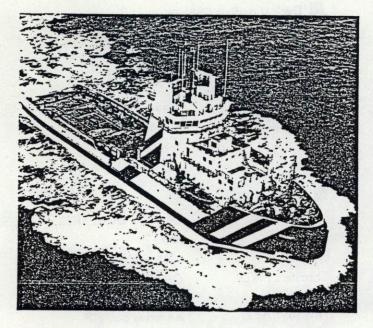
Life Boat: 40-person Watercraft

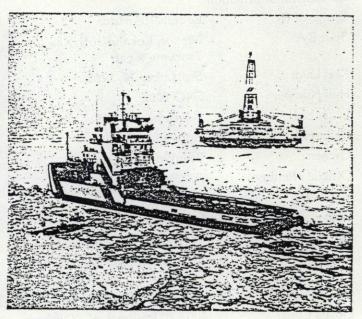
Model 7.8m

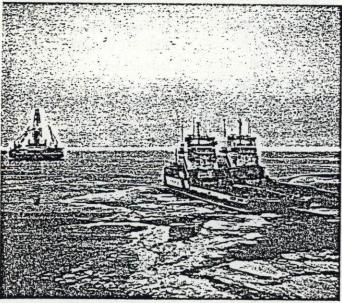
Rescue Boat: Lucas Model 700D

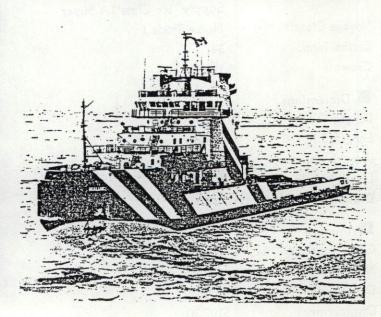
# M.V. "Ikaluk"

Ice-breaking, anchor-handling, towing and supply vessel









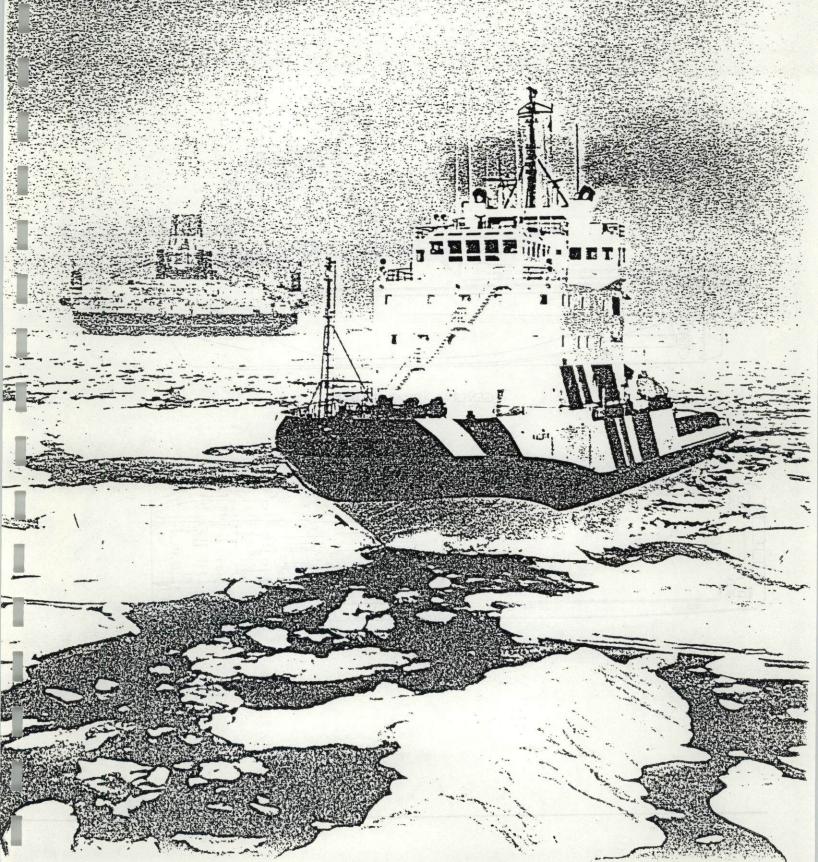
BeauDril Limited, 401 - 9th Avenue S.W., Box 2574, Calgary, Alberta, Canada T2P 3S7 403-233-5485, Telex: 038-21335 BeauDril

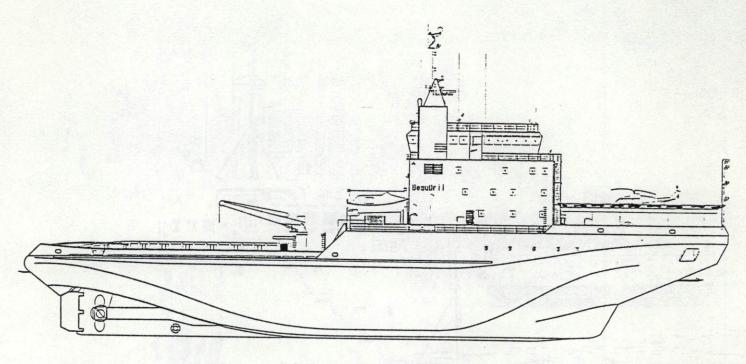
"Excellence, by any measure"

# M.V. "Kalvik"

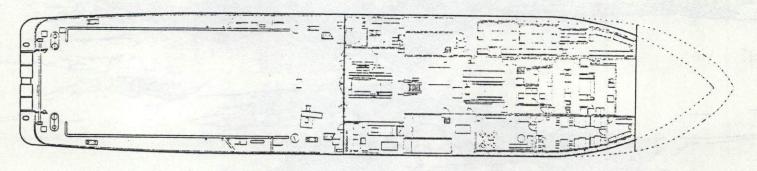
Ice-breaking, anchor-handling, towing and supply vessel







GENERAL ARRANGEMENT



MAIN DECK



# Ship's Particulars

# General Information

Designed By:

German and Milne Inc.

Built By:

Burrard Yarrows Corporation

(Victoria) Division

Keel Laid:

June 21, 1982 (Esquimalt, B.C.)

Hull Number:

5-54

Launched: Delivered:

April 2, 1983 July 22, 1983

Owners:

BeauDril Limited

Official Number:

803564

Call Sign:

VY 9403

Flag:

Canadian

Port of Registry:

Vancouver, B.C.

Type:

Ice-breaker, Anchor-handling,

Supply, Tug

Class:

ASPPR Ice Class 4

Lloyds Class:

100A1 Ice-Breaker, Tug

Voyage Class:

Home Trade 1

Berths Total: Crew:

34 19

Helideck:

Can handle up to Bell 214 ST

(with skids)

Dimensions

Length O.A.:

88m

Length B.P.:

75m

Breadth Extreme:

17.82m

Depth Moulded:

To Main Deck-10m

Draft Extreme:

8.3m

Tonnage

Gross Tonnage:

4219.39

Net Tonnage:

1970

Deadweight

Winter Draft:

1866.95

Displacement

Winter Draft:

6820.95

Deck (Loading Capacities)

Deck Measurements:

34m x 13m

Deck Cargo Capacity:

800 tonnes

Bulk Barite/Cement

Capacity:

 $34m^3 \times 3 = 102m^3$ 

Fuel Oil:

1 918.56m<sup>3</sup>

Drill Water:

1 432.38m<sup>3</sup>

Fresh Water:

40

**Engine** 

Main Engine:

(4) Stork Werkspoor Diesel

RPM:

600

BHP:

23.200

Thrusters FWD:

Wartsila Air Bubbler System

Thrusters AFT:

Kamewa CPP

Fresh Water Maker

Capacity:

10 tonnes/day

Propellers:

2 LIPS, N.V. C.P. 4 blades

Bollard Pull:

Over 220 tonnes

Service Speed

(two engines):

Speed (four engines):

15.57 knots

13.28 knots

Fuel Consumption

Open Water:

Fuel Consumption

Heavy Ice:

90m3

30m3

Deck Machinery

Tugger Winches:

2 x 15-tonne pull

Capstans:

2 x 10-tonne pull

Towing & Work

2 Double-Drum Towing/Anchor-

Winches:

Deck Cranes:

Handling Winches-

Van Der Gleseen

2 x 5-ton SWL Hagglund Wartsila

Life-saving Units

Life Boat:

40-person Watercraft

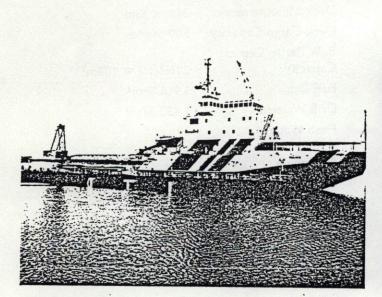
Model 7.8m

Rescue Boat:

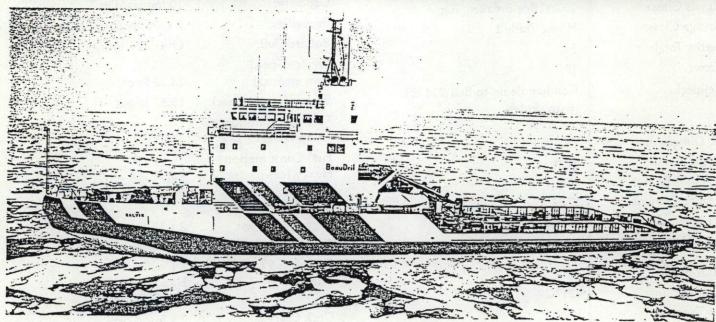
Lucas Model 700D

# M.V. "Kalvik"

# Ice-breaking, anchor-handling, towing and supply vessel







BeauDril Limited, 401 - 9th Avenue S.W., Box 2574, Calgary, Alberta, Canada T2P 3S7 403-233-5485, Telex: 038-21335 BeauDril

"Excellence, by any measure"

# APPENDIX C

ANALYSIS OF IMPACT OF AIR EMISSIONS FROM THE PROPOSED OPERATIONS ON ONSHORE AIR QUALITY

### APPENDIX C

# ANALYSIS OF IMPACT OF AIR EMISSIONS FROM THE PROPOSED OPERATIONS ON ONSHORE AIR QUALITY

# (1) INTRODUCTION

Section 5(a)(8) of the Outer Continental Shelf Lands Act Amendments of 1978 requires the Secretary of the Department of the Interior (DOI) to prescribe regulations with provisions "for compliance with the national ambient air quality standards pursuant to the Clean Air Act (42 U.S.C. 7401 et. seq.) to the extent that activities authorized under the Act significantly affect the air quality of any State." The Minerals Management Service (MMS) is responsible for administering the DOI's air quality regulations, and has published regulations which establish a three step process is created to determine whether emissions from OCS facilities have the potential to have or are having a significant affect on the ambient air quality of any onshore area (see 30 CFR Part 250.45). In Step 1, an exemption formula is used to "screen out" those facilities which, because of their low emissions levels and distance from shore, are unlikely to significantly affect any onshore area. Under Step 2, significance levels are established to determine whether emissions not exempted under Step 1 significantly affect any onshore area. Finally, under Step 3, controls are specified for those facilities that have the potential to affect or are significantly affecting any onshore area.

Exploration activities of the type described in this Plan of Exploration fall within the definition of "temporary facilities" (see § 250.44 of the MMS regulations). Therefore an identification of the air emissions from the proposed exploration operations and an analysis of the impacts of these emissions on onshore air quality is necessary as part of this submission.

# (2) DESCRIPTION OF GASEOUS EMISSIONS

The major sources of gaseous emissions from the proposed operations which must be considered under the MMS regulations are the large diesel engines which will be used as "prime movers" to generate electricity on the drilling unit. This electricity drives the locomotive, positioning, pumping, compressing, and drilling equipment on the unit. Small amounts of emissions also may occur as a result of flaring if testing occurs. Emissions also will be produced by the operation of ice class support vessels and helicopters.

Information about the nature and quantity of emissions from each of these activities is presented in this analysis. However, in calculating the onshore impacts of air emissions under the MMS regulations, only the emissions generated from the equipment on the drilling unit are to be considered. Therefore, the following discussion is divided into two sections:

- To fulfill the requirements of the MMS regulations, a description of the nature and quantity of emissions produced as a direct result of drilling operations and the onshore impacts of these emissions is provided in Subsection a. below.
- o To provide additional baseline data on projected emissions, a description of the nature and quantity of other emissions generated by support operations is provided in Subsection b. below.
  - a. Emissions Produced as a Direct Result of Actual Drilling Operations: The MMS regulations require that each major source of emissions from a facility, the amount of the emissions by air pollutant expressed in tons per year, and the frequency and duration of emissions be described, and an explanation be provided that presents the basis for all calculations.

The air emission calculations provided in this analysis are based on use of the KULLUK drilling unit. Air emissions from another drilling unit, like the CANMAR Explorer II or IV, that may be used in lieu of or in addition to the KULLUK most likely would be comparable in nature and quantity to those presented in this analysis.

The projected emissions have been calculated on the basis of estimated electromotive requirements [horsepower hours (hp-hr)] during each of ten representative phases of exploratory drilling activities. Data compiled by Radian Corporation\* concerning the electromotive requirements and number of days required for completion of 5,000-, 10,000-, and 15,000-foot generic wells were used as the basis for estimating electromotive requirements for the 12,000-foot wells described in Section II of this plan. These Radian data are presented in Tables C-1 and C-2.

The projected air emissions were calculated in the following manner:

- 1. The proposed well depth (12,000 feet) was provided by Amoco.
- 2. The number of days to complete each of the ten representative phases of drilling activities were provided by Amoco.
- 3. Using information from 1 and 2, electromotive requirements were calculated using the approach described in Table C-3. The results of these calculations are presented in Table C-4.

<sup>\*</sup> Radian Corporation, Final Report For Task 1, Drilling Units Contracted or Available for Use Off the California Coast and Task 2
Assessment of Baseline NO Emissions, Prepared for Industry/Government Task Force, July, 1982.

4. The following emission factors were used in conjunction with the estimated electromotive requirements to calculate the projected emissions for the KULLUK diesel engines:

NOx	15.740 g	/hp-hr	from	Radian	Study**
SOx	0.903 g	/hp-hr	from	Radian	Study**
TSP	1.000 g	/hp-hr			Table 3.3.3-1
THC*	0.500 g	/hp-hr	from	Radian	Study**
CO	2.330 g	/hp-hr	from	Radian	Study**

The projected emission are presented in Table C-5.

5. The projected emissions were compared to the emission exemption amount "E" prescribed in the MMS regulations ["E" = 33.3 D for TSP,  $SO_X$ ,  $NO_X$ , and THC (VOC) and E = 3,400 ( $D^{2/3}$ ) for CO, where D = distance of the proposed surface location from the nearest onshore area, and "E" is expressed in tons per year], and the results are presented in Table C-6. An example of how these projected emissions were calculated using the estimated electromotive requirements and the emission factors appears in Table C-7.

Very insignificant amounts of pollutants may be produced if natural gas is flared during the testing phase. The emissions associated with such flaring, or whether any flaring will be necessary at all, is dependent upon identification and testing of hydrocarbon zones as they might occur in each well. An estimate of air emissions that might result from flaring is presented in Table C-8. In Table C-9, the projected air emissions from drilling and flaring operations are combined to present a "worst case" condition.

\*\* See Table 5-1. Exhaust Emissions Data at Standard and Four Degrees Retarded Injection Timing (EMD Drilling Rig Engines), page 5-4.

<sup>\*</sup> Total hydrocarbon (THC) contains a reactive or "volatile" component (VOC) as well as a non-reactive component. Generally, about 88 percent of the total hydrocarbon emission consists of VOC. Because the percent VOC can vary, these hydrocarbon emission projections are for total hydrocarbons. This conservative approach results in a slight but insignificant overestimate of the VOC.

- b. Emissions Generated by Support Operations: The MMS regulations require that this plan include a description of the nature and quantity of emissions from onshore activities directly associated with the proposed OCS facility. Emissions in this category include those generated by ice class support vessels and helicopters moving to, among and from points of operations (i.e., the drilling rig, Tuktoyaktuk, Canada, Barter Island, and Deadhorse).
- 1. <u>Ice Class Support Vessels</u>: Up to three ice class support vessels may be used to tow the drilling unit on and off location and for ice-management, anchor-handling, supply and standby duties. Two of the vessels probably will be 14,900 hp vessels which are primarily designed for supply, anchor-handling and towing functions, with a secondary function of ice management. The remaining vessel probably will be a 24,000 hp icebreaker designed primarily for ice management, long distance towing, and anchor handling duties. The projected emissions for the three vessels are based on a maximum utilization scenario where the larger and smaller vessels are underway using fuel 50 percent of the time at rates of 646 and 517 gal/hr for ice management, and 50 percent of the time for open water duties at rates of 388 and 310 gal/hr, respectively. Emissions for the two classes of vessels are presented in Table C-10.
- 2. <u>Helicopter</u>: A Bell 214 helicopter probably will be used and will make approximately 140 roundtrips from Deadhorse and/or Barter Island, Alaska to each drilling site. The projected emissions for this activity are presented in Table C-11.

# (3) CONCLUSION

The air pollutants generated as a result of the proposed exploration operations will be minor in nature and of short duration. Because the emissions produced by the drilling and testing of the exploratory wells described in this plan are less than the exemption

amounts "E" established by the MMS, no further analysis of impacts of the proposed operations on onshore areas is required under the existing MMS regulations.

projected suit riche for the three ventels are taked on a maximum



TABLE C-1

ELECTROMOTIVE REQUIREMENTS (11P · 11R) FOR COMPLETION OF

5,000, 10,000 AND 15,000 FOOT GENERIC WELLS
(AVERAGE, MEDIAN, MINIMUM, AND MAXIMUM VALUES ARE PRESENTED)

				REPRESENTATIVE DRILLING PHASES	IVE DRILLI	IG PIIASES					SUN FOR
	MOVEMENT	SITE PREPARATION	DRILLINGA	TRIPPINGA	SETTING	CASING	ABANDON	10661116	DRILLSTEM TESTING	STANDBY	TEN DRILLING PHASES
AVERAGE	5	0 0		5 1		6 6 6 6	2 10	0 0	0.08	0.00	
5,000 FOOT WELL	92,898	78,739	556,840	166,120	166,364	63,310	68,441	83,897	634,672	169,819	2,081,130
10,000 FOOT WELL	92,898	78,739	1,113,680	332,240	166,364	63,310	68,441	83,897	634,672	169,849	2,804,090
15,000 FOOT WELL	95,898	78,739	1,670,520	498,360	166,364	63,310	68,441	83,897	634,672	169,849	3,527,050
MEDIAN		- 12	i.	100	*	5 2	0.1				
5,000 FOOT WELL	84,600	67,680	463,500	184,500	193,375	80,500	30,06	59,200	320,663	21,000	1,505,114
10,000 FOOT WELL	84,600	67,680	927,000	369,000	193,375	80,500	30,096	59,200	320,663	21,000	-2,153,114
15,000 FOOT WELL	84,600	67,680	1,390,500	553,500	193,375	80,500	30,096	59,200	320,663	21,000	2,801,114
HINIMIN				0 8	ar da				1 3	IP.	
5,000 FOOT WELL	16,415	0	268,000	38,500	35,520	9,648	12,960	000.9	129,600	270	MAB
10,000 FOOT WELL	16,415	0.	536,000	77,000	35,520	9,648	12,960	000'9	129,600	270	
15,000 FOOT WELL	.16,415	0	804,000	115,500	35,520	9,648	12,960	000*9	129,600	270	
MAXIMIM	NATIONAL PROPERTY.	3175 TH									
5,000 FOOT WELL	197,400	216,672	1,028,960	327,500	435,744	185,500	225,750	246,384	1,805,600	930,600	NAB
10,000 FOOT WELL	197,400	216,672	2,057,920	000°559	435,744	185,500	225,750	246,384	1,805,600	930,600	
15,000 FOOT WELL	197,400	216,672	3,086,880	982,500	435,744	185,500	225.750	246. 384	1.805.600	930.600	

Aprilling and tripping were the two phases whose electromotive requirements were determined to be significantly correlated with well depth. Due to this correlation, the values that are reported for these phases have been calculated based on electromotive requirements for completion of 1000 feet of well.

Hin and applicable. Summing the extreme values reported as minimum and maximum electromotive requirements would result in values that are either too high or too loo to be representative of data actually obtained in this study.



TABLE C-2

5,000, 10,000 AND 15,000 FOOT GENERIC WELLS
(AVERAGES, MEDIANS, MINIMUM, AND MAXIMUM VALUES ARE PRESENTED)

				REPRESENTATIVE DRILLING PHASES	IVE DRILLII	NG PILASES					SUM FOR
	HOVEHENT	SITE PREPARATION	DRILLINGA	TRIPPINGA	SETTING	CAS ING RECOVERY	ABANDON WELL	1.0661116	DRILLSTEM	STANDBY	TEN DRILLING
AVERAGE						Block C		-			
5,000 FOOT WELL	2	1.6	13.0	4.0	5.6	2.0	2.3	73	25.2	7.9	6
16,000 FOOT WELL	::	1.6	26.0	8.0	5.6	2.0	2.3	4.7	25.2	7.2	84.0
ואיממס נימו אברר	:	9.1	39.0	12.0	9.6	2.0	2.3	4.7	25.2	7.2	101.0
HEDIAN				0001 888						,	
5,000 FOOT WELL	1.5	1.5	12.6	8.4	91	0.0		Top: 000	100 mm		
10,000 FOOT WELL	1.5	1.5	25.0	5.6	9 7	0.0	0.5	;	6.22	5.5	58.4
15,000 FOOT WELL	1.5	1.5	37.5	14.3	9.4	0.6	0.2	3	22.9	5.5	75.6
	863	221.08		:	2:	.0.3	0.7		52.9	2.5	92.9
HINIMUM			0.00		A DATE OF THE PARTY OF THE PART		100 m				
5,000 FOOT WELL	0.3	0.0	10.5	31							
10,000 FOOT WELL	0.3	0.0	21.0	0:	0.0	0.0	0	0.2	10.0	0.05	NA
15,000 FOOT WELL	0.3	0.0	31.5	4.5	2.0	0.8	0.0	2.0.2	0.01	0.05	
MAXIHUM							and the second			70.0	
						SATASTA STATES					THE TANK
S,000 FUUT WELL	2.0	4.0	16.5	6.5	12.0	4.4	5.4	11.2	40.7	16.3	844
10,000 F00T WELL	2.0	4.0	33.0	13.0	12.0	4.4	5.4	11.2	40.7	36.3	£
13,000 F00T WELL	2.0	4.0	49.5	19.5	12.0	4.4	5.4	11 2	. 0	2000	

Aprilling and tripping were the two phases whose time requirements were determined to be significantly correlated with well depth. Due to this correlation, the values that are reported for these phases have been calculated based on time requirements for completion of 1000 feet of well.

<sup>B</sup>NA " Not applicable. Summing the extreme values reported as minimum and maximum time requirements would result in values that are either too high or too low to be representative of data actually obtained in this study.

#### SAMPLE CALCULATIONS

Method of calculating hp hrs needed for each drilling phase for a 12,000-foot well and a 70-day drilling and testing period using the results of Radian Study.

#### Example No. 1

Movement to Site

Time for 15,000-foot well (from Radian): 1.4 days
Hp hrs for 15,000-foot well (from Radian): 92,898 hp hr
Time for movement for 12,000-foot well (Amoco): 0.5 days

Using ratio and proportion, the electromotive requiement in hp hrs for movement to site is:

92,898 hp hr 1.4 days

as

x hp hr 0.5 days

x = 33,178 hp hr

#### Example No. 2

Drilling

(Drilling time is proportional to well depth)

Hp hr for 15,000-foot well (from Radian): 1,670,520 hp hr
Drilling time for 15,000-foot well (from Radian): 39 days
Drilling time for 12,000-foot well (from Amoco): 30 days

To determine the electromotive requirement for a 12,000-foot well requiring 30 days to drill, using ration and proportion:

 $\frac{1,670,520 \text{ hp hr}}{39 \text{ days}} = \frac{x}{30 \text{ days}}$ 

x = 1,285,015 hp hr

TABLE C-4

NUMBER OF DAYS AND ELECTROMOTIVE REQUIREMENTS

NEEDED FOR COMPLETION OF PROPOSED

12,000-FOOT WELLS

Activity	Days <sup>1</sup>	Electromotive Requirements (hp hr)
Movement	0.5	33,178
Site Preparation	2.0	98,424
Drilling	30.0	1,285,015
Tripping	8.0	332,240
Set Cement & Casing	6.0	178,247
Cut & Recover Casing	0.0	0
Cement & Abandon Hole	2.0	59,514
Logging/Eq. Testing	4.0	71,402
Drill Stem Testing	15.0	377,781
Standby/Fishing	2.5	58,975
Total	70.0	2,494,776

TABLE C-5

PROJECTED EMISSIONS FOR EACH OF THE TEN REPRESENTATIVE DRILLING PHASES DURING 70-DAY DRILLING, TESTING, AND ABANDONMENT PERIOD FOR A TYPICAL 12,000-FOOT WELL 70-DAY DRILLING, TESTING, AND ABANDONMENT PERIOD FOR A K

REPRESENTATIVE			POLLU	POLLUTANT (TONS/WELL)	WELL)	10	
PHASE	HP-hr	NOX	SO <sub>x</sub>	TSP	THC	X dg	00
Movement	33,178	0.58	0.03	0.04	0.02		0.08
Site Preparation	98,424	1.71	0.10	0.11	0.05		0.25
Drilling	1,285,015	22,30	1.28	1.42	0.71		3.30
Tripping	332,240	5.76	0.33	0.37	0.18		0.85
Set Cement and Casing	178,247	3.09	0.18	0.20	0.10		0.46
Cut and Recover Casing	0	00.0	00.00	00.0	00.00		00.00
Cement and Abandon Hole	59,514	1.03	90.0	0.07	0.03		0.15
Logging/Equipment Testing	71,402	1.24	0.07	0.08	0.04		0.18
Drill Stem Testing	377,781	6.55	0.38	0.42	0.21		0.97
Standby/Fishing	58,955	1.02	90.0	90.0	0.03		0.15
TOTAL	2,494,776	43.28	2.49	2.77	1.37		6.39

TABLE C-6

COMPARISON OF PROJECTED EMISSIONS TO MMS EMISSION EXEMPTION AMOUNTS "E" FOR PROPOSED WELLS ON AMOCO'S GALAHAD PROSPECT

		POLI	LUTANTS (TO	NS/WELL)	
SOURCE	NOx	sox	TSP	THC	СО
Projected Emissions	43.28	2.49	2.77	1.37	6.39
MMS Emission Exemption Amounts					N PY
OCS-Y 1085-1	1,178.82	1,178.82	1,178.82	1,178.82	36,660.58
OCS-Y 1086-1	1,205.46	1,205.46	1,205.46	1,205.46	37,210.88
OCS-Y 1087-1	1,232.10	1,232.10	1,232.10	1,232.10	37,757.13
OCS-Y 1091-1	1,138.86	1,138.86	1,138.86	1,138.86	35,827.30
OCS-Y 1092-1	1,158.84	1,158.84	1,158.84	1,158.84	36,245.14
OCS-Y 1092-2	1,165.50	1,165.50	1,165.50	1,165.50	36,383.89
OCS-Y 1092-3	1,158.84	1,158.84	1,158.84	1,158.84	36,245.14
OCS-Y 1093-1	1,212.12	1,212.12	1,212.12	1,212.12	37,347.81
OCS-Y 1094-1	1,225.44	1,225.44	1,225.44	1,225.44	37,620.94
OCS-Y 1097-1	1,125.54	1,125.54	1,125.54	1,125.54	35,547.39
OCS-Y 1098-1	1,152.18	1,152.18	1,152.18	1,152.18	36,106.13
OCS-Y 1099-1	1,165.50	1,165.50	1,165.50	1,165.50	36,383.89
OCS-Y 1100-1	1,152.18	1,152.18	1,152.18	1,152.18	36,106.13
OCS-Y 1101-1	1,105.56	1,105.56	1,105.56	1,105.56	35,125.43

#### SAMPLE CALCULATIONS

Calculation of projected emissions using electromotive requirements (hp hr) and emission factors (g/hp hr):

Power Emission Conversion Factors Emissions Requirement x Factor x  $\frac{1b}{(453.6 \text{ g})}$  x  $\frac{ton}{(2000 \text{ lb})}$  =  $\frac{(tons/y)}{(tons/y)}$ 

#### Example

Calculation of total NO  $_{\rm X}$  emissions during the drilling of a 12,000-foot well:

hp hr = 1,285,015 Emissions Factor = 15.74 g/hp hr

 $\frac{1,285,015 \text{ hp hr}}{\text{well}} \times \frac{15.74 \text{ g NO}_{x}}{\text{hp hr}} \times \frac{1b}{453.6 \text{ g}} \times \frac{\text{ton}}{2000 \text{ lb}} = \frac{22.30 \text{ tons}}{\text{well}}$ 

Assumes that Undelly S Luntuat of cate of eas will be 110 ppm (the aptual B; S content of days after aptual B; S content of days at grant 11 after the exploratory well in day (led and also gas out perced).

#### FLARING CALCULATIONS

During drillstem testing, it is anticipated that approximately 1,500 MCF of natural gas will be flared off during five hours for each well.

Source of emission factors: National Airoil Burner Company, Philadelphia, Pennsylvania

1,050 BTU\* 1,500 MCF SCF = 1,575 MMBTU/well X CO: 1,575 MMBTU 0.2 lb co well MMBTU 0.16 tons/well X VOC: 1,575 MMBTU 0.25 lb VOC well MMBTU 0.20 tons/well 0.12 lb NO<sub>x</sub> 1,575 MMBTU well MMBTU X 0.09 tons/well 0.0177 lb SO SOx: 1,575 MMBTU well MMBTU 0.01 tons/well X 1,575 MMBTU 0.015 lb TSP TSP: well MMBTU 0.01 tons/well

<sup>\*</sup> Typical BTU content of pipeline quality gas.

<sup>\*\*</sup> Assumes that the H<sub>2</sub>S content of natural gas will be 110 ppm (the actual H<sub>2</sub>S content of natural gas will not be known until after the exploratory well is drilled and the gas can be tested).

"WORST CASE" CONDITION COMPARISON OF PROJECTED EMISSIONS TO DOI EMISSION EXEMPTION AMOUNT

EMISSIONS TO DOI EMISSION EXEMPTION AMOUNT
"E" FOR PROPOSED WELLS ON AMOCO'S GALAHAD PROSPECT

						Distance		n Amounts ns/year
	Pollu	itant E	missic	ns (T/	Well)	to Shore	NO ,SO	
WELL	NOx	SOx	TSP	THC	CO	(miles)	TSP, THĈ	
NUMBER	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OCS-Y 1085-1	1	36.2	31. U		27.78	02.5 77.64		Total
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	35.4	1,178.82	36,660.58
OCS-Y 1086-1								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	36.2	1,205.46	37,210.88
OCS-Y 1087-1								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	37.0	1,232.10	37,757.13
OCS-Y 1091-1								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	34.2	1,138.86	35,827.30
OCS-Y 1092-1								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	34.8	1,158.84	36,245.14
OCS-Y 1092-2								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	35.0	1,165.50	36,383.89
OCS-Y 1092-3								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	34.8	1,158.84	36,245.14

Compare Columns (1), (2), (3) and (4) with the exemption amount in Column (7). Compare Column (5) with exemption amount in Column (8).

TABLE C-9 (cont.)

						Distance		on Amounts ons/year
	The second secon			ons (T/	Well)	to Shore	NO, SO	
WELL NUMBER	NOx (1)	SOx (2)	TSP (3)	THC (4)	CO (5)	(miles) (6)	TSP,THČ	(8)
OSC-Y 1093-1	(8c)		60	O DED	927	101 101		SESSIM
Prime Movers	43.28	2.49	2.77	1.37	6.39		phone.	
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	36.4	1,212.12	37,347.81
OCS-Y 1094-1								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	36.8	1,225.44	37,620.94
OCS-Y 1097-1								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	33.8	1,125.54	35,547.39
OCS-Y 1098-1								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	34.2	1,152.18	36,106.13
OCS-Y 1099-1								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	35.0	1,165.50	36,383.89
OCS-Y 1100-1								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	34.6	1,152.18	36,106.13
OCS-Y 1101-1								
Prime Movers	43.28	2.49	2.77	1.37	6.39			
Flaring	0.09	0.01	0.01	0.20	0.16			
Total	43.37	2.50	2.78	1.57	6.55	33.2	1,105.56	35,125.43
	.5.57	50	2.70	1.31	0.55	33.2	1,103.30	33,123.43

Compare Columns (1), (2), (3) and (4) with the exemption amount in Column (7). Compare Column (5) with exemption amount in Column (8).

TABLE C-10

PROJECTED EMISSIONS FOR SUPPORT OPERATIONS ASSOCIATED WITH PROPOSED DRILLING ACTIVITIES ON AMOCO'S GALAHAD PROSPECT

ran	NOX	×	ß	SOx	H	TSP	L	THC	00	
SOURCE	lb/day	T/well	1b/day	T/well	lb/day	T/well	lb/day	T/well	lb/day T/well lb/day T/well lb/day T/well lb/day T/well	T/well
Large Ice Class Support Vessel (12,408 gals/day)	3,350.2 117.3	117.3	335.0	0 11.7	310.2	10.9	310.2 10.9 620.4 21.7	21.7	1,364.9 47.8	47.8
Small Ice Class Support Vessel(2) (9,924 gals/day)	2,679.5	93.8	267.9	9.4	248.1	8.7	496.2 17.4	17.4	1,091.6 38.2	38.2
TOTAL		211.1		21.1		19.6		39.1		86.0
			6				500	200	MOTOR	MO+OM-

vessel activities Emissions Factors from AP-42, TABLE 3.2.3-1 "Average Emissions Factors for Commercial Motor-Calculations based on ice class support ships by Waterway Classification". Calculations as described in Section (2) (b) of this appendix.

TABLE C-11

# PROJECTED EMISSIONS FROM THE HELICOPTERS USED TO SUPPORT PROPOSED DRILLING ACTIVITIES ON AMOCO'S GALAHAD PROSPECT

Pollutant	Emission Factor <sup>1</sup> (lb/LTO/engine)	Projected Emissions <sup>2</sup> (lb/two engines)	tons/well
NOx	0.57	160	0.08
sox	0.18	50	0.02
TSP	0.25	70	0.03
THC	0.52	146	0.07
СО	5.70	1,596	0.80

From AP-42, Table 3.2.1-3; Emission Factors per Aircraft Landing-Take Off Cycle (LTO).

Based on 280 LTO's of a Bell 214 making 140 roundtrips per well; no flying mode emission factors available.

# APPENDIX D

COASTAL ZONE MANAGEMENT CONSISTENCY
CERTIFICATION ASSESSMENT AND FINDINGS DOCUMENT

#### APPENDIX D

# COASTAL ZONE MANAGEMENT CONSISTENCY CERTIFICATION ASSESSMENT AND FINDINGS DOCUMENT

#### PART 1

"RELEVANT ELEMENTS"\* OF THE ALASKA COASTAL MANAGEMENT PROGRAM, (ACMP)
AS AMENDED BY THE NORTH SLOPE BOROUGH COASTAL MANAGEMENT PROGRAM
(NSBCMP)

#### 6 AAC 80.040. COASTAL DEVELOPMENT (ACMP)

- (a) In planning for and approving development in coastal areas, districts and state agencies shall give, in the following order, priority to:
- (1) water-dependent uses and activities;
- (2) water-related uses and activities; and
- (3) uses and activities which are neither water-dependent nor water-related for which there is no feasible and prudent inland alternative to meet the public need for the use or activity.
- (b) The placement of structures and the discharge of dredged or fill material into coastal waters must, at a minimum, comply with the standards contained in Parts 320-323, Title 33. Code of Federal Regulations (Vol. 42 of the Federal Register, pp. 37133-47 (July 19, 1977).

# 6 AAC 80.050. GEOPHYSICAL HAZARD (ACMP)

- (a) Districts and state agencies shall identify known geophysical hazard areas and areas of high development potential in which there is a substantial possibility that geophysical hazards may occur.
- (b) Development in areas identified under (a) of this section may not be approved by the appropriate state or local authority until siting, design, and construction measures for minimizing property damage and protecting against loss of life have been provided.
- \* The "relevant elements" of the Alaska Coastal Management Program, as amended by the North Slope Borough Coastal Management Program which relate to subsistence are not covered in this Findings and Assessment Document. Instead, they are covered in a separate document, entitled "An Evaluation of the Potential Impacts of Exploratory Drilling and Scientific Research Operations on Subsistence Resources and Subsistence Use Activities in the Beaufort Sea."

# 2.4.4(b) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Offshore structures must be able to withstand geophysical hazards and forces which may occur while at the drill site. Design criteria must be based on actual measurements or conservative estimates of geophysical forces. In addition, structures must have monitoring programs and safety systems capable of securing wells in case unexpected geophysical hazards or forces are encountered.

# 2.4.6(c) MINIMIZATION OF NEGATIVE IMPACTS (NSBCMP)

Development is required to maintain the natural permafrost insulation quality of existing soils and vegetation.

# 6 AAC 80.070. ENERGY FACILITIES (ACMP)

- (a) Sites suitable for the development of major energy facilities must be identified by the state in cooperation with districts.
- (b) The siting and approval of major energy facilities by districts and state agencies must be based, to the extent feasible and prudent, on the following standards:
- (1) site facilities so as to minimize adverse environmental and social effects while satisfying industrial requirements;
- (2) site facilities so as to be compatible with existing and subsequent adjacent uses and projected community needs;
- (3) consolidate facilities;
- (4) cooperate with landowners, developers, and federal agencies in the development of facilities;
- (6) select sites with sufficient acreage to allow for reasonable expansion of facilities;
- (7) site facilities where existing infrastructure, including roads, docks, and airstrips, is capable of satisfying industrial requirements;
- (8) select harbors and shipping routes with least exposure to reefs, shoals, drift ice, and other obstructions;
- (9) encourage the use of vessel traffic control and collision avoidance systems;
- (10) select sites where development will require minimal site clearing, dredging and construction in productive habitats;

- (11) site facilities so as to minimize the probability, along shipping routes, of spills or other forms of contamination which would affect fishing grounds, spawning grounds, and other biologically productive or vulnerable habitats including marine mammal rookeries and hauling out grounds and waterfowl nesting areas;
- (12) site facilities so that design and construction of those facilities and support infrastructures in coastal areas of Alaska will allow for the free passage and movement of fish and wildlife with due consideration for historic migratory patterns and so that areas of particular scenic, recreational, environmental, or cultural value will be protected;
- (13) site facilities in areas of least biological productivity, diversity, and vulnerability and where effluents and spills can be controlled or contained;
- (14) site facilities where winds and air currents disperse airborne emissions which cannot be captured before escape into the atmosphere;
- (15) select sites in areas which are designated for industrial purposes and where industrial traffic is minimized through population centers; and
- (16) select sites where vessel movements will not result in over-crowded harbors or interfere with fishing operations and equipment.
- (c) Districts shall consider that the uses authorized by the issuance of state and federal leases for mineral and petroleum resource extraction are uses of state concern.

# 2.4.4(d) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Industrial and commercial development must be served by solid waste disposal facilities which meet state and federal regulations.

#### 2.4.4(e) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Development not on a central sewage system is required to impound and process effluent to state and federal quality standards.

#### 2.4.4(f) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Plans for offshore drilling activities are required to include a relief well drilling plan and an emergency countermeasure plan. The relief well drilling plan must identify suitable alternative drilling rigs and their location; identify alternative relief well drilling sites; identify support equipment and supplies including muds, casings, and gravel supplies which could be used in an emergency; and specify the estimated time required to commence drilling and complete a relief well. The emergency countermeasures plan must identify the

steps which will be taken to protect human life and minimize environmental damage in the event of 1) loss of a drilling rig; 2) ice override; or 3) loss or disablement of support craft or other transportation systems.

#### 2.4.4(g) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Offshore drilling operations and offshore petroleum storage and transportation facilities are required to have an oilspill control and clean-up plan. The plan must contain a risk analysis indicating where oilspills are likely to flow under various sets of local meteorological or oceanographic conditions. Impact areas must be identified and strategies fully developed to protect environmentally sensitive areas; the spill control and clean-up equipment which is available to the operator and the response time required to deploy this equipment under the various scenarios must be contained in the risk analysis.

<u>Intent</u>: Policies 2.4.4(f) and 2.4.4(g) are not intended to establish new regulations for offshore facilities. They restate and highlight requirements of existing regulations. Industry will not be required to go to considerable additional effort as a result of these policies.

#### 2.4.5.2(b) BEST EFFORT POLICIES (NSBCMP)

Development is required to be located, designed, and maintained in a manner that prevents significant adverse impacts on fish and wildlife and their habitat, including water circulation and drainage patterns and coastal processes.

# 2.4.5.2(c) BEST EFFORT POLICIES (NSBCMP)

Resource extraction support facilities, including administration offices, operations, residence, and other uses not absolutely required in the field, must be located in a designated service base which is sited, designed, constructed, and maintained to be as compact as possible and to share facilities to the maximum extent possible.

# 2.4.6(c) MINIMIZATION OF NEGATIVE IMPACTS (NSBCMP)

Airports and helicopter pads are required to be sited, designed, constructed, and operated in a manner that minimizes their impact upon wildlife.

# 6 AAC 80.130. HABITATS (ACMP)

- (a) Habitats in the coastal area which are subject to the Alaska coastal management program include:
- (1) offshore areas:
- (2) estuaries;
- (3) wetlands and tideflats;
- (4) rocky islands and seacliffs;
- (5) barrier islands and lagoons;
- (6) exposed high energy coasts;

- (7) rivers, streams, and lakes; and
- (8) important upland habitat.
- (b) The habitats contained in (a) of this section must be managed so as to maintain or enhance the biological, physical, and chemical characteristics of the habitat which contribute to its capacity to support living resources.
- (c) In addition to the standard contained in (b) of this section, the following standards apply to the management of the following habitats:
- (1) offshore areas must be managed as a fisheries conservation zone so as to maintain or enhance the state's sport, commercial, and subsistence fishery;
- (2) estuaries must be managed so as to assure adequate water flow, natural circulation patterns, nutrients, and oxygen levels, and avoid the discharge of toxic wastes, silt, and destruction of productive habitat;
- (3) wetlands and tideflats must be managed so as to assure adequate water flow, nutrients, and oxygen levels and avoid adverse effects on natural drainage patterns, the destruction of important habitat; and the discharge of toxic substances;
- (4) rocky islands and seacliffs must be managed so as to avoid the harassment of wildlife, destruction of important habitat, and the introduction of competing or destructive species and predators;
- (5) barrier islands and lagoons must be managed so as to maintain adequate flows of sediments, detritus, and water, avoid the alteration or redirection of wave energy which would lead to the filling in of lagoons or the erosion of barrier islands, and discourage activities which would decrease the use of barrier islands by coastal species, including polar bears and nesting birds;
- (6) high energy coasts must be managed by assuring the adequate mix and transport of sediments and nutrients and avoiding redirection of transport processes and wave energy; and
- (7) rivers, streams, and lakes must be managed to protect natural vegetation, water quality, important fish or wildlife habitat and natural water flow.
- (d) Uses and activities in the coastal area which will not conform to the standards contained in (b) and (c) of this section may be allowed by the district or appropriate state agency if the following are established:
- (1) there is a significant public need for the proposed use or activity;

- (2) there is no feasible prudent alternative to meet the public need for the proposed use or activity which would conform to the standards contained in (b) and (c) of this section; and
- (3) all feasible and prudent steps to maximize conformance with the standards contained in (b) and (c) of this section will be taken.
- (e) In applying this section, districts and state agencies may use appropriate expertise, including regional programs referred to in sec. 30(b) of this chapter.

# 2.4.5.2(g) BEST EFFORT POLICIES (NSBCMP)

Development within the Alaska Coastal Management Program-defined coastal habitats must be conducted in accordance with ACMP Standard 6 AAC 80.130(b), (c), and (d), and applicable policies of the North Slope Borough Coastal Management Program. These habitats including the following:

- offshore areas;
- 2. estuaries;
- wetlands and tideflats;
- rocky islands and seacliffs;
- barrier islands and lagoons;
- exposed high-energy coasts;
- 7. rivers, streams and lakes; and
- important upland habitat.

# 6 AAC 80.140. AIR, LAND, AND WATER QUALITY (ACMP)

Notwithstanding any other provision of this chapter, the statutes pertaining to and the regulations and procedures of the Alaska Department of Environmental Conservation with respect to the protection of air, land, and water quality are incorporated into the Alaska coastal management program and, as administered by that agency, constitute the components of the coastal management program with respect to those purposes.

# 2.4.3(i) STANDARDS FOR DEVELOPMENT (NSBCMP)

Development shall comply with state or federal land, air and water quality standards or regulations.

# 2.4.4(c) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Development resulting in water or airborne emissions must comply with all state and federal regulations.

# 6 AAC 80.150. HISTORIC, PREHISTORIC, AND ARCHAEOLOGICAL RESOURCES (ACMP)

Districts and appropriate state agencies shall identify areas of the coast which are important to the study, understanding, or illustration of national, state, or local history or prehistory.

#### 2.4.3(f) STANDARDS FOR DEVELOPMENT (NSBCMP)

Development which is likely to disturb cultural or historic sites listed on the National Register of Historic Places; sites eligible for inclusion in the National Register; or sites identified as important to the study, understanding, or illustration of national, state, or local history or prehistory shall 1) be required to avoid the sites; or 2) be required to consult with appropriate local, state and federal agencies and survey and excavate the site prior to disturbance. (Descriptions of sites identified to date are contained in Appendix C of the North Slope Borough Coastal Management Program Background Report and referenced on Map 2 of the Resource Atlas).

#### 2.4.3(g) STANDARDS FOR DEVELOPMENT (NSBCMP)

Development shall not significantly interfere with traditional activities at cultural or historic sites identified in the coastal management program.

#### 2.4.3(h) STANDARDS FOR DEVELOPMENT (NSBCMP)

Development shall not cause surface disturbance of newly discovered historic or cultural sites prior to archaeological investigation.

# 2.4.5.2(h) BEST EFFORT POLICIES (NSBCMP)

Development is required to be located, designed, and maintained in a manner that does not interfere with the use of a site that is important for significant cultural uses or essential for transportation to subsistence use areas.

#### PART 2

#### ASSESSMENT AND FINDING DOCUMENT

Amoco Production Company's (Amoco) proposed exploratory drilling operations comply with and will be conducted in a manner consistent with the "relevant elements" of the Alaska Coastal Management Program (ACMP), as amended by the North Slope Borough Coastal Management Program (NSBCMP). The "relevant elements", which provide a basis for determining the consistency of the proposed operations, are detailed in Section 1 of this Findings and Assessment Document. The findings and assessments made are presented in Part 2 of this document.

#### 6 AAC 80.040. COASTAL DEVELOPMENT (ACMP)

- (a) In planning for and approving development in coastal areas, districts and state agencies shall give, in the following order, priority to:
- (1) water-dependent uses and activities;
- (2) water-related uses and activities; and
- (3) uses and activities which are neither water-dependent nor water-related for which there is no feasible and prudent inland alternative to meet the public need for the use or activity.
- (b) The placement of structures and the discharge of dredged or fill material into coastal waters must, at a minimum, comply with the standards contained in Parts 320-323, Title 33. Code of Federal Regulations (Vol. 42 of the Federal Register, pp. 37133-47 (July 19, 1977).

#### A. ASSESSMENT

#### (1) BACKGROUND INFORMATION

- (a) <u>Lease and Well Locations</u>: Amoco acquired an interest in twelve (12) leases during federal Lease Sale No. 97 which have been grouped together to form the Galahad Prospect. The leases are located on the Outer Continental Shelf (OCS) in the eastern Alaska Beaufort Sea. Amoco proposes to drill, test, and abandon up to fourteen (14) exploratory wells to fully evaluate the hydrocarbon potential of the Galahad Prospect.
- (b) <u>Project-related Facilities</u>: A floating drilling unit will be used to drill the wells. Current plans call for one to three ice class supply vessels to be dedicated to and to remain in the immediate vicinity of the drilling unit at all times. Finally, helicopters will be used to transport personnel and small supplies from an existing shorebases to the drilling unit.

A glory hole may be constructed at one or more of the proposed well sites. If it is determined that a glory hole is needed, it would be drilled from the drilling unit with a conventional glory hole bit.

#### (2) ASSESSMENT OF POTENTIAL IMPACTS

The proposed exploratory drilling operations will be conducted in offshore waters. The offshore location of the proposed drill sites is dictated by the location of the leases which have been grouped together to form the Galahad Prospect, and the Company's assessment of the optimum locations, from a geological and environmental perspective, for exploring the hydrocarbon potential of the Galahad Prospect.

By their nature, the proposed exploratory drilling operations are a water-dependent activity which, under 6 AAC 80.040, should be accorded priority in "...planning for and approving development in coastal areas." However, because Amoco plans to temporarily use existing shorebases, no project-related development in coastal areas will occur as a result of the proposed operations.

The proposed exploratory drilling operations are covered by Section 810 of the Rivers and Harbors Act of 1899 which requires a permit for "structures or work" in or affecting the navigable waters of the United States. The U.S. Army Corps of Engineers (COE) has issued a Nationwide Permit (Nationwide Permit No. 8) which covers all exploration operations on the OCS. Amoco will comply fully with all of the applicable conditions and management practices defined in the permit which are designed to ensure protection of water quality and living marine resources.

Discharges from the proposed operations will be made in offshore waters, well away from coastal waters. Consistent with the COE Nationwide Permit, these discharges will not destroy a threatened or endangered species or destroy or adversely modify the critical habitat of such a species. Moreover, the discharges will be free of toxic pollutants in toxic amounts. Finally, Amoco will apply "best management" practices set out in 33 CFR § 330.6 of the COE regulations.

#### B. FINDINGS

The proposed exploratory drilling operations are consistent with the enumerated standards because:

- o The proposed exploratory drilling operations are a water-dependent activity which should be accorded priority in planning for and approving development in coastal areas; however, because Amoco plans to use existing shorebases, no project-related development in coastal areas will occur as a result of the proposed operations.
- o Amoco will comply fully with the provisions of the U.S. Army Corps of Engineers Nationwide Permit.

# 6 AAC 80.050. GEOPHYSICAL HAZARD (ACMP)

- (a) Districts and state agencies shall identify known geophysical hazard areas and areas of high development potential in which there is a substantial possibility that geophysical hazards may occur.
- (b) Development in areas identified under (a) of this section may not be approved by the appropriate state or local authority until siting, design, and construction measures for minimizing property damage and protecting against loss of life have been provided.

# 2.4.4(b) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Offshore structures must be able to withstand geophysical hazards and forces which may occur while at the drill site. Design criteria must be based on actual measurements or conservative estimates of geophysical forces. In addition, structures must have monitoring programs and safety systems capable of securing wells in case unexpected geophysical hazards or forces are encountered.

# 2.4.6(c) MINIMIZATION OF NEGATIVE IMPACTS (NSBCMP)

Development is required to maintain the natural permafrost insulation quality of existing soils and vegetation.

#### A. ASSESSMENT

#### (1) BACKGROUND INFORMATION

The following anomalies have been identified as potential "geophysical" hazards in the Lease Sale No. 97 area: seismicity; shallow gas; sediment transport; ice gouging; permafrost; and sea ice.

The magnitudes of measured earthquakes Seismicity: near Barter Island range from less than M = Richter 1.0 to a maximum of M = Richter 5.3. This seismic activity is associated with faults and faulting in the Camden Bay area which are generally south and to the east of the Galahad Prospect. The hazards generally associated with seismicity (i.e., ground acceleration, fault rupture, and seismically-induced ground failure) should not affect the proposed operations because of: the temporary nature of the proposed operations; the observed lack of major earthquakes (i.e., M = Richter 6.0 or greater) in the area; the relatively flat nature of the seafloor which minimizes the potential for ground failure; Amoco's compliance with § 250.51 of the MMS regulations which requires the selection of a drilling unit which is designed to withstand the maximum environmental conditions, including seismic motion, anticipated to be encountered at drilling sites; Amoco's compliance with the following MMS regulatory requirements which are designed, among other things, to ensure that the drilling unit is able to withstand geophysical hazards and forces which may occur while at a drill site-- \$ 250.50 (Control of Wells), § 250.51(a) (Fitness of Drilling Unit), § 250.54 (Well Casing (Blowout Preventer Systems and and Cementing), § 250.56 Components), § 250.59 (Diverter Systems), and § 250.60 (Mud Program); and Amoco's compliance with the following MMS regulatory requirements which are designed, among other things, to ensure that monitoring programs and safety systems capable of securing wells in case unexpected geophysical hazards or forces are encountered exist and are applied to the proposed operations -- § 250.51(e) (Tests, Surveys, and Samples), § 250.54 (Well Casing and Cementing), § 250.55 (Pressure Testing of Casing), § 250.56 (Blowout Preventer Systems and System Components), § 250.57 (Blowout Preventer Systems Tests, Actuations, Inspection, and Maintenance), § 250.58 (Well-Control Drills), § 250.59 (Diverter Systems), § 250.60 (Mud Program), § 250.61 (Security of Wells), and § 250.63 (Supervision, Surveillance, and Training).

- (b) Shallow Gas: Current drilling technology, practices, and procedures are adequate to control changes in downhole pressures associated with shallow gas potentially encountered during the proposed drilling activities. Gas, if encountered, will be controlled with drilling mud or, if appropriate, released and flared at a controlled rate. Gas hydrates are not expected to be encountered because necessary subsurface pressure and temperature conditions for hydrate formation are not known to exist shoreward of the 197-foot isobath (note: the Galahad Prospect is shoreward of the 197-foot isobath).
- (c) Sediment Transport: Sediment transport is considered to be an insignificant hazard to the proposed operations. Sediment instability and mass movement of seafloor sediments generally are related to relatively high seafloor gradients, low sediment strength in fine-grained sediments, sediment loading from waves during the passage of storms, and ground motion during an earthquake. associated with mass movement are more likely to be found in the Camden Bay area during an earthquake, and in the deeper parts of the Lease Sale No. area, particularly in the vicinity of 97 Continental Shelf break. Measures to guard against the effects of seismic activity have been discussed. With regard to water depth, the Galahad Prospect is situated on the Continental Shelf and the seafloor in the area of the leases is relatively flat in comparison to the steeper slopes found on the shelf break. In addition, consistent with provisions of § 250.54 (Well Casing and Cementing) of the MMS regulations, the potential effects of sediment transport in the area of a well head will be taken into consideration, as appropriate, in the design of the proposed drilling program.

- (d) <u>Ice Gouging</u>: Amoco's leases are located within the zone of grounded ice ridges and intense ice gouging. If required to do so by the MMS, measures will be instituted to protect well head and drilling unit operations (i.e., through the construction of a glory hole at one or more of the proposed well locations and through the management of ice with ice class support vessels) from the effects of ice incursions. Moreover, consistent with § 250.51(c) (Oceanographic, Meteorological, and Drilling Unit Performance Data) of the MMS regulations, ice conditions will be monitored continuously to assess their potential impact on the safety of personnel and the integrity of the drilling unit.
- (e) Permafrost: Relict permafrost may underly the Galahad Prospect. If thawing of the permafrost occurs around well casing during operations, then differential subsidence could occur, provided that the conditions of temperature, geotechnical properties, and ice content of the permafrost are appropriate. Current drilling and design technology can adequately compensate for permafrost conditions; consistent with § 250.54 (Well Casing and Cementing) of the MMS regulations, sufficient cement, of a type especially suited to permafrost zones, will be used to fill the annular space between casing and permafrost to protect from thaw subsidence and the freeze back effect. Also, this will protect the natural insulation quality of any permafrost encountered during the proposed drilling operations.
- operations are scheduled to take place during an "open water" period, sea ice may be present or move into the area during the conduct of operations. Consistent with § 250.51(a) (Fitness of Drilling Unit) of the MMS regulations, the drilling unit selected to perform the proposed drilling activities will be specifically designed to withstand the forces of sea ice. To further mitigate problems associated with sea ice encroachments, Amoco will monitor ice movements during the conduct of the proposed operations and maintain ice class support vessels near the drilling unit to manage ice. If moving ice threatens

drilling activities, a well can be shut in until safe operating conditions are restored. If necessary, anchor mooring lines can be disconnected using remote anchor release units to allow the drilling unit to withdraw temporarily from the drilling location.

Sea ice could impact the effectiveness of oil spill response equipment, and the safety of the personnel using it. However, such conditions also may increase recovery effectiveness by restricting the spread of spilled oil.

#### (2) ASSESSMENT OF POTENTIAL IMPACTS

The proposed well locations have been selected so that well bores will penetrate desired geologic targets and, to the maximum extent feasible, not intersect any potential hazard. Consistent with the provisions of § 250.33 of the MMS regulations, a shallow hazard survey will be conducted in accordance with the specifications of the MMS to determine the presence or absence of shallow geologic hazards, and a survey report will be submitted to the MMS with the Application for a Permit to Drill (APD) for each proposed well. The results of the survey will be analyzed in the development of the proposed drilling programs. Moreover, drilling, mud, casing, and cementing programs will be designed and carried out in accordance with applicable MMS requirements.

#### B. FINDINGS

The proposed exploratory operations are consistent with the enumerated standards because:

o Potential shallow geophysical hazards will be identified and taken into consideration in the development of the proposed drilling program for each well.

- o The absence of major earthquakes, the relatively flat nature of the seafloor in the vicinity of the proposed well locations, and the use of a floating drilling unit reduce the likelihood of an earthquake and related ground shaking or failure affecting the proposed drilling operations.
- o The proposed drilling operations will be conducted during the open water period reducing the possibility of ice gouging affecting drilling operations. Moreover, if a well is temporarily plugged, the top elevation of the wellhead will be well below the anticipated ice gouge depth.
- o Amoco will comply fully with all applicable MMS regulations which are designed, among other things, to ensure that: (1) the drilling unit is able to withstand geophysical hazards and forces which may occur while at a drill site; and (2) monitoring programs and safety systems capable of securing wells in case unexpected geophysical hazards or forces are encountered exist and are applied to the proposed operations.
  - o The insulative quality of any permafrost zone encountered during drilling operations will be protected by specialized cement which will be used to fill the annular space between casing and permafrost.

# 6 AAC 80.070. ENERGY FACILITIES (ACMP)

- (a) Sites suitable for the development of major energy facilities must be identified by the state in cooperation with districts.
- (b) The siting and approval of major energy facilities by districts and state agencies must be based, to the extent feasible and prudent, on the following standards:

- (1) site facilities so as to minimize adverse environmental and social effects while satisfying industrial requirements;
- (2) site facilities so as to be compatible with existing and subsequent adjacent uses and projected community needs;
- (3) consolidate facilities;
- (4) consider the current use of facilities for public or economic reasons;
- (5) cooperate with landowners, developers, and federal agencies in the development of facilities;
- (6) select sites with sufficient acreage to allow for reasonable expansion of facilities;
- (7) site facilities where existing infrastructure, including roads, docks, and airstrips, is capable of satisfying industrial requirements;
- (8) select harbors and shipping routes with least exposure to reefs, shoals, drift ice, and other obstructions;
- (9) encourage the use of vessel traffic control and collision avoidance systems;
- (10) select sites where development will require minimal site clearing, dredging and construction in productive habitats;
- (11) site facilities so as to minimize the probability, along shipping routes, of spills or other forms of contamination which would affect fishing grounds, spawning grounds, and other biologically productive or vulnerable habitats including marine mammal rookeries and hauling out grounds and waterfowl nesting areas;
- (12) site facilities so that design and construction of those facilities and support infrastructures in coastal areas of Alaska will allow for the free passage and movement of fish and wildlife with due consideration for historic migratory patterns and so that areas of particular scenic, recreational, environmental, or cultural value will be protected;
- (13) site facilities in areas of least biological productivity, diversity, and vulnerability and where effluents and spills can be controlled or contained;
- (14) site facilities where winds and air currents disperse airborne emissions which cannot be captured before escape into the atmosphere;
- (15) select sites in areas which are designated for industrial purposes and where industrial traffic is minimized through population centers; and

- (16) select sites where vessel movements will not result in over-crowded harbors or interfere with fishing operations and equipment.
- (c) Districts shall consider that the uses authorized by the issuance of state and federal leases for mineral and petroleum resource extraction are uses of state concern.

#### 2.4.4(d) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Industrial and commercial development must be served by solid waste disposal facilities which meet state and federal regulations.

#### 2.4.4(e) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Development not on a central sewage system is required to impound and process effluent to state and federal quality standards.

#### 2.4.4(f) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Plans for offshore drilling activities are required to include a relief well drilling plan and an emergency countermeasure plan. The relief well drilling plan must identify suitable alternative drilling rigs and their location; identify alternative relief well drilling sites; identify support equipment and supplies including muds, casings, and gravel supplies which could be used in an emergency; and specify the estimated time required to commence drilling and complete a relief well. The emergency countermeasures plan must identify the steps which will be taken to protect human life and minimize environmental damage in the event of 1) loss of a drilling rig; 2) ice override; or 3) loss or disablement of support craft or other transportation systems.

# 2.4.4(g) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Offshore drilling operations and offshore petroleum storage and transportation facilities are required to have an oilspill control and clean-up plan. The plan must contain a risk analysis indicating where oilspills are likely to flow under various sets of local meteorological or oceanographic conditions. Impact areas must be identified and strategies fully developed to protect environmentally sensitive areas; the spill control and clean-up equipment which is available to the operator and the response time required to deploy this equipment under the various scenarios must be contained in the risk analysis.

<u>Intent</u>: Policies 2.4.4(f) and 2.4.4(g) are not intended to establish new regulations for offshore facilities. They restate and highlight requirements of existing regulations. Industry will not be required to go to considerable additional effort as a result of these policies.

# 2.4.5.2(b) BEST EFFORT POLICIES (NSBCMP)

Development is required to be located, designed, and maintained in a manner that prevents significant adverse impacts on fish and wildlife and their habitat, including water circulation and drainage patterns and coastal processes.

# 2.4.5.2(c) BEST EFFORT POLICIES (NSBCMP)

Resource extraction support facilities, including administration offices, operations, residence, and other uses not absolutely required in the field, must be located in a designated service base which is sited, designed, constructed, and maintained to be as compact as possible and to share facilities to the maximum extent possible.

# 2.4.6(c) MINIMIZATION OF NEGATIVE IMPACTS (NSBCMP)

Airports and helicopter pads are required to be sited, designed, constructed, and operated in a manner that minimizes their impact upon wildlife.

#### A. ASSESSMENT

#### (1) BACKGROUND INFORMATION

Amoco acquired an interest in twelve (12) leases during federal Lease Sale No. 97 which have been grouped together to form the Galahad Prospect. Drilling operations will take place on up to fourteen (14) proposed well locations to fully evaluate the hydrocarbon potential of the Galahad Prospect.

Proposed exploratory drilling operations will be conducted from a floating drilling unit, and will be supported by ice class support vessels and helicopters. The helicopters and vessels will operate from existing shorebases. If glory hole construction operations are conducted, they will be drilled from the drilling unit with a conventional glory hole bit.

The proposed exploratory drilling operations will be temporary in nature. Drilling activities at the first well location are scheduled to occur as early as the "open water" period in 1988. It is estimated that it will take up to 70 days to drill, test, and

abandon each well. Schedules for drilling operations at the remaining well locations have not been finalized; however, the length of drilling operations (i.e., the time to drill, test, and abandon the well) will be similar to the initial well.

#### (2) ASSESSMENT OF IMPACTS

For the puspose of assessing impacts, the criteria contained in 6 AAC 80.070 and the relevant provisions of the NSBCMP [i.e., 2.4.4(d), 2.4.4(e), 2.4.4(f), 2.4.4(g), 2.4.5.2(b), 2.4.5.2(c), and 2.4.6(c)] are considered under the following categories: environmental and social effects; site suitability; facilities consolidation; cooperation with agencies; vessel traffic safety; protection of wildlife and sensitive habitats; prevention of oil spills; plans for a relief well; plans for loss or disablement of the drilling unit or support craft; plans for unmanageable ice encroachments; air pollution; solid and liquid wastes; and interference with shipping and commercial fishing operations.

(a) Environmental and Social Effects: This document is part of a detailed Plan of Exploration (POE) for the proposed exploratory drilling operations. The plan contains information on the proposed activities, a description of the environmental setting in which the proposed activities will be conducted, and an assessment of the impacts of the proposed activities on the environment. The potential environmental impacts are adjudged to be temporary and minor in nature.

In addition, the POE is accompanied by Amoco an exhaustive analysis\* of the potential social (i.e., on subsistence use activities) impacts of the proposed exploratory drilling operations. The potential social impacts were found to negligible.

<sup>\*</sup> The analysis is entitled "An Evaluation of the Potential Impacts of Exploratory Drilling and Scientific Research Operations on Subsistence Resources and Subsistence Use Activities in the Beaufort Sea."

(b) <u>Site Suitability</u>: With the exception of subsistence use activities directed at beluga and endangered bowhead whales, the proposed exploratory drilling operations will be conducted in offshore areas located outside the Kaktovik and Nuiqsut subsistence use areas and well away from the barrier islands, nearshore waters, and coastal areas where subsistence use activities tend to concentrate from July to November.

Whaling crews from Kaktovik and Nuiqsut pursue endangered bowhead whales from August to the middle of November, with a peak in activities during late September. From Kaktovik, whaling activities generally occur within 10 miles of the coastline, but sometimes occur as much as 20 miles offshore. Crews normally go as far west as Anderson Point in Camden Bay and as far east as Griffin Point to look for whales. Occasionally, however, they may go as far east as Humphrey Point. From Nuiqsut, whaling crews may travel as far east as the Canning River.

Beluga whales are taken incidental to endangered bowhead whales. From Kaktovik, they have been caught on the north side of Barter Island, near Pukak, and at Griffin Point.

The area utilized for subsistence whaling is very large in comparison to the small ocean area that will be temporarily occupied by project-related facilities (i.e., a few acres). Moreover, to the extent that information on endangered bowhead whale strikes can be used to determine where whaling activities are concentrated, the Galahad Prospect is situated well outside such an area.

Based upon the large area utilized by whaling crews in relationship to the small area occupied by Amoco's proposed operations, and given the fact that reported whale strikes indicate that no endangered bowhead whales have been harvested in the area of Amoco's proposed operations, the potential impact on subsistence use activities will be negligible.

Amoco's primary shorebase in Alaska will be the Prudhoe Bay facilities complex, which includes an airport facility at Deadhorse. The complex, which encompasses an area of approximately 200 square miles, is an industrial enclave. It contains oil production facilities, operations facilities, support services, and living quarters for persons who work in the North Slope oil fields. The enclave is geographically isolated from other communities on the North Slope. complex currently has an infrastructure sufficient to support the proposed operations. Project-related aircraft operating out of Deadhorse generally will follow an existing aircraft corridor along the coast between Prudhoe Bay and the Camden Bay area and then proceed directly offshore to a drill site. Consistent with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale, project-related aircraft will maintain at least a 1-mile horizontal distance and at least a 1,500-foot vertical distance from observed wildlife or known wildlife concentration areas, such as bird colonies or marine mammal concentrations, unless such actions jeopardize human safety. Also, to reduce potential effects to endangered bowhead whales, project-related aircraft traffic will be minimized or rerouted when endangered bowhead whales are in the area of the proposed operations, unless such an action would jeopardize human safety.

(c) Facilities Consolidation: Amoco is proposing to evaluate the hydrocarbon potential of the twelve (12) leases in the eastern Alaska Beaufort Sea OCS Area by drilling up to fourteen (14) wells. Although the proposed approach does not constitute a consolidation of facilities, it does represent an effort to minimize the number of wells needed to evaluate the hydrocarbon potential of leases exhibiting similar geologic characteristics. Moreover, Amoco currently plans to eliminate the need for a shorebase to support the marine aspects of the proposed exploratory drilling operations. Instead, the materials and supplies needed will be stockpiled on the drilling unit and ice class support vessels, thus reducing the need for ice class support vessels to transit between the drilling unit and an existing shorebase

for materials and supplies. Finally, Amoco plans to use (an) existing shorebase(s) for helicopter operations, thereby "consolidating" these activities with those currently underway on the North Slope.

- (d) <u>Cooperation With Agencies</u>: The proposed exploratory drilling operations will satisfy all applicable laws and MMS regulations and will be conducted in compliance with MMS standards, criteria, guidelines, and requirements pertaining to well control, personnel training, monitoring, surveillance and reporting, well surveys and testing, and hydrogen sulfide detection and safety measures. The proposed activities also will satisfy all requirements imposed by the Stipulations and Information to Lessees appearing in the Final Notice of Sale for Lease Sale No. 97. Finally, Amoco will comply with the safety, pollution prevention, and notification requirements of the U.S. Coast Guard, the solid and liquid waste discharge requirements of the U.S. Environmental Protection Agency, and the reporting and operating requirements of the U.S. Army Corps of Engineers.
- traffic associated with the proposed exploratory drilling operations. During drilling activities, the drilling unit will not move, and the ice class support vessels will remain in the immediate vicinity of the drill site. Necessary precautions will be taken to ensure that project-related vessels do not constitute a navigation hazard. Project-related vessels will be equipped with navigation, lighting, and safety equipment which complies with all U.S. Coast Guard requirements. Prior to the initiation of drilling activities, the U.S. Coast Guard will issue a Notice to Mariners informing vessel captains in the area of the exact location of the drilling unit in the Beaufort Sea.

A primary area of concern relates to a potential conflict between project-related vessels and boats engaged in subsistence whaling operations. To mitigate this potential conflict, Amoco will work for the reestablishment of the Oil/Whalers Cooperative Agreement which would result in all project-related vessels and whaling boats being tied by radio into a shorebased clearinghouse that would relay information on project-related vessel positions to whaling boats, and vice versa. With this system, each project-related vessel will have the capability to contact whaling boats directly via the radio network.

(f) Protection of Wildlife and Sensitive Habitats: Sensitive wildlife and habitat areas generally are situated well away from the offshore areas that will be occupied and/or utilized by project-related facilities (see discussion under standard 6 AAC 80.130). The proposed exploratory drilling operations, however, will occur in areas utilized by marine mammals, birds, and fish. For example, endangered bowhead whales will migrate through the eastern Alaska Beaufort Sea from September until November. The potential for the proposed operations to have a significant impact on endangered bowhead whales or any other marine resource is low because of the broad distribution of marine resources and the comparatively small ocean area that will be occupied and affected by project-related facilities.

Potential project-related impacts will be reduced further by Amoco's compliance with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale for Lease Sale which suggest that:

- o Vessels and aircraft maintain at least a 1-mile horizontal distance from observed wildlife or known wildlife concentration areas.
- o That vessel and aircraft traffic be minimized or rerouted to avoid disturbances to endangered bowhead whales.
- o Aircraft maintain a 1,500-foot altitude when in transit over areas where endangered bowhead whales are present.

During the endangered bowhead whale fall migration period, there will be minimal project-related vessel traffic between the drilling unit and an existing shorebase. If whales are encountered by a project-related support vessel, the following MMS-mandated guidelines will be observed:

- The vessel will operate at a speed that will make collisions with endangered bowhead whales unlikely; if visibility decreases to less than 3 miles, vessel speed will be reduced.
- o The vessel will maintain a minimum approach distance of 1 mile from endangered bowhead whales.
- o If the vessel inadvertently approaches within 1 mile of (an) endangered bowhead whale(s), the vessel operator will take every precaution to avoid harrassment of the animal(s) by:
  - reducing vessel speed within 300 yards of the animal(s);
  - steering around the animal(s), if possible;
  - operating the vessel in such a way as to avoid separating members of a group of animals from other members of the group;
  - operating the vessel to avoid multiple changes in direction; and
  - checking the waters immediately adjacent to the vessel to ensure that no animal(s) will be injured when the propellers are engaged.
- (g) Prevention of Oil Spills: It is Amoco's policy to protect the environment by employing the best control mechanisms, procedures, and processes which are technically sound and economically feasible. All proper and appropriate actions will be taken to avoid spillage, and to contain, cleanup, and dispose of oil and oily debris. State-of-the-art equipment will be used and all activities will be conducted in a carefully planned and orderly fashion so as to prevent the discharge of pollutants.

prevention of oil spills will be maximized through compliance with MMS regulatory requirements relating to: well casing and cementing (§ 250.54); blowout preventer systems and system components (§ 250.56); mud program (§ 250.60); supervision, surveillance, and training (§ 250.63); liquid and solid waste disposal (§ 250.40); inspections and reports (§ 250.41); and personnel training and drills for pollution prevention (§ 250.43). In addition, Amoco will comply with the provisions of Section 14(c) of the Information to Lessees portion of the Final Notice of Sale which authorizes the RSFO to prohibit exploratory drilling and other downhole activities in broken ice conditions unless Amoco demonstrates to the RSFO the Company's ability to detect, contain, clean up, and dispose of spilled oil in such conditions.

The risk of a blowout during exploratory drilling operations resulting in a major oil spill is extremely low. Indeed, since the inception of exploratory drilling operations on the United States OCS up to January 1, 1988, there was not a single major oil spill from a blowout during the drilling of 7,951 exploratory wells. To prevent a blowout, the drilling unit will be adequately equipped with the necessary diverter and blowout prevention equipment (BOPE) to maintain well control (i.e., consistent with the provisions of § 250.56 of the MMS regulations). Consistent with the provisions of of the MMS regulations: (1) the diverter and BOPE will be installed and tested, and the results will be recorded on the driller's report, regular inspection and maintenance will be performed on the equipment (§ 250.57); (2) blowout prevention drills will be conducted as required by the MMS and recorded on the driller's report (§ 250.58); (3) drilling personnel will be trained and qualified in accordance with the provisions of the MMS OCS standard "Training and Qualifications of Personnel in Well-Control Equipment and Techniques for Drilling on Offshore Locations" (MMSS-OCS-T1) before initiating work on a well (§ 250.63); and (4) drilling mud, casing, and cementing programs will be designed to insure that all the wells are drilled in a safe and workmanlike manner (§ 250.54 and 250.60). These programs will be described in the APD for each proposed well. Also, company representatives will provide onsite supervision of drilling operations on a 24-hour/day basis, and the drilling crew or the tool pusher will continuously maintain rig floor surveillance, unless the well is secured by BOPE, bridge plugs, storm packer, or cement plugs.

Amoco's ability to respond rapidly and effectively to an oil spill incident will be facilitated through planning and the conduct of training and drills. Consistent with the provisions of § 250.33(b)(2) of the MMS regulations and Stipulation No. 6 of the Final Notice of Sale, Amoco has submitted a comprehensive Oil Spill Contingency Plan for Exploratory Drilling Operations in the eastern Alaska Beaufort Sea OCS Area to the MMS under a separate cover. Among other things, Amoco's Oil Spill Contingency Plan describes the training and drills that have been and will be conducted to satisfy § 250.43 of the MMS regulations.

Consistent with § 250.42 of the MMS regulations, Amoco's Oil Spill Contingency Plan is designed to assist Company personnel and contractors in responding rapidly and effectively to an oil spill that may result from the proposed exploration operations. It contains a description of the techniques that will be used to control the source of a spill, contain, clean up, store and dispose of spilled oil, and protect sensitive habitats and biological resources. It lists the response equipment available onsite and from offsite sources, and demonstrates, among other things, the Company's ability to respond to an oil spill in broken ice conditions (i.e., consistent with the provisions of Section 14(c) of the Information to Lessees portion of the Final Notice of Sale).

In the event that an oil spill should occur, either during fuel transfer operations or from the well, and response operations will not endanger the lives of personnel, onsite containment and cleanup equipment will be deployed by an Immediate Response Team organized and trained to react immediately to an oil spill incident. This onsite equipment, which is designed to provide an immediate response capability to contain and clean up a small spill and an

initial response to a major spill, will be inspected regularly and maintained in a constant state of readiness. Results of the inspections will be recorded and maintained as required.

If an oil spill occurs which is beyond the means of onsite personnel and equipment, Amoco will mobilize its Major Spill Response Team and, most likely, will request assistance from Alaska Clean Seas (ACS), an oil spill cleanup organization whose Area of Interest includes the Alaska Beaufort Sea OCS area. A complete description of the equipment maintained by ACS and other cleanup organizations located in Alaska is provided in Amoco's Oil Spill Contingency Plan.

(h) <u>Drilling a Relief Well</u>: Although a general plan for drilling a relief well is presented below, it is not practical to present a detailed plan prior to an event due to the large number of incident-specific variables that must be taken into consideration in the design of relief well drilling and kill operations. Amoco drilling experts will be on location at all times and, if a blowout occurs, will comprise the Well Control Team. Based on their specific knowledge of the well, they will formulate a relief well plan. The Well Control Team can communicate directly with Amoco's drilling experts in other locations, if necessary.

If possible, the drilling unit will be used to drill a relief well. The drilling unit will be capable of winching off location, moving out of danger, and commencing a relief well. A complete spare wellhead assembly and sufficient casing, cement and mud will be available to facilitate such an operation.

In the event that the drilling unit cannot be used to drill a relief well, another unit will be mobilized to the blowout location as soon as possible. This capability will be provided by drilling units available for hire in the Beaufort Sea.

Regardless of the unit used, the relief well will be directionally drilled to intercept the vicinity of the uncontrolled well. Specialized logging tools will be used to determine the proximity of the target wellbore. The uncontrolled flow will then be killed by sequential pumping of water, heavy drilling mud, and cement into the blowing well.

- (i) Loss or Disablement of the Drilling Unit or Support Craft: If the drilling unit becomes partially or totally disabled while under contract to Amoco in Alaskan waters, the priorities for action will be:
  - o Personnel safety.
  - o Prevention of pollution.
  - o Minimization of damage to the drilling unit.
  - O Notification of the appropriate government agencies and Amoco Management.

All contingency plans will be developed with these priorities in mind.

If the drilling unit is damaged to the point where it cannot be repaired on location, non-essential personnel will be evacuated. The drilling unit will be equipped with emergency evacuation and life-saving equipment in accordance with U.S. Coast Guard regulations. U.S. Coast Guard-approved cold-water survival suits will be provided to all personnel onboard the drilling unit, and additional suits will be stored at critical work stations. These exposure suits are designed to provide protection against the effects of cold water and to provide flotation for many hours. Rig survival equipment also will include two or more lifeboats or capsules, and a sufficient number of inflatable life rafts to handle 200 percent of the vessel manning capacity. Lifeboats will be constructed of fiberglass reinforced

plastic, will be fully enclosed, and will have self-contained fire protection water spray systems. The lifeboats will be equipped with approved deployment and retrieval systems and U.S. Coast Guard-approved radio locator beacons. The life rafts will be self-inflating and provided with hydrostatic release gear and a complete weather cover. Finally, abandon-ship drills will be conducted to familiarize personnel with the use of the survival equipment. The lifeboats, life rafts, and associated equipment, and launching procedures will be U.S. Coast Guard approved. (A) nearby ice class support vessel(s) will be available at all times to assist in evacuation efforts.

A disabled drilling unit will be towed to the nearest suitable harbor for repairs. Before moving off location, a well in progress will be secured or plugged. If necessary, a new unit will be brought in as soon as possible to continue drilling or to plug and abandon a well in progress. Re-entering a subsea well in this fashion is a routine procedure as long as the wellhead is not severely damaged during the removal of the disabled drilling unit. If there is significant damage to the wellhead or shallow casing strings, a directional well would be drilled so that the original well bore can be re-entered and plugged. Debris will be removed from the seafloor in accordance with U.S. Coast Guard and MMS regulations.

In the event that an ice class support vessel or helicopter is disabled, the same priorities for emergency response will be followed as for the drilling unit. While operating in the eastern Alaska Beaufort Sea OCS Area, there will be up to three ice class support vessels and one helicopter dedicated to Amoco's operations at all times. These vessels will assure that a strong back-up capability exists to provide assistance to a disabled support craft. Additional assistance for search and rescue operations will be available from one or more of the following sources: other operators working in the area; the Prudhoe Bay industrial enclave; the U.S. Coast Guard; and other military organizations. If any support craft is lost from

service, a suitable replacement for the craft will be acquired before proceeding with any aspect of the proposed operations which depends for its safety on the support craft.

- (j) Ice Encroachments: The eastern Alaska Beaufort Sea OCS Area is subject to some degree of sea ice cover from late September through July. An ice observation and monitoring program will be implemented to forecast ice movements. In the event that encroaching ice threatens the drilling unit, the ice class support vessels will be used to break up the ice around the drilling unit. Large floes will be broken, forced, or pushed so that their drift trajectories will avoid impacting the drilling unit. In heavy ice, the support vessels will continuously move around the drilling unit to keep the ice broken up so as to minimize the ice forces upon the drilling unit. conical design of the drilling unit will enhance this capability. addition, the drilling unit will be moored by anchors which will be equipped with remote anchor release units. This special feature, in conjunction with the collapsible pawls installed on the drums, will allow the unit to quickly disconnect from the anchors and enable it to withdraw from a drilling location in the event of unmanageable ice encroachments.
- (k) Air Pollution: See the discussion under 6 AAC 80.140 (ACMP).
- (1) Solid and Liquid Wastes: See the discussion under 6 AAC 80.140 (ACMP).
- (m) Interference With Shipping and Commercial Fishing Operations: There are no deepwater ports along the Alaska Beaufort Sea coastline. Generally, ships must anchor from approximately 0.5 to 1.1 miles offshore and cargo must be lightered ashore. Barges operated by Pacific Alaska Lines deliver approximately 2,000 tons of freight annually to the North Slope. Arctic Lighterage and Bowhead Transport provide supplemental barge service to North Slope communities out of Kotzebue. Cape Lisburne and the various Distant Early

Warning System (DEW-line) sites on the North Slope are presently served by a contract carrier of the U.S. Air Force (Alaska Puget United Transportation Company). Deliveries are limited to ice-free months. Barges transport most heavy and bulk cargo associated with petroleum-related activities in the Borough. Prudhoe Bay has three barge docks-one at the east dock and two at the west dock. The east dock can accommodate vessel drafts of 4 feet, and the west docks can accommodate vessel drafts of 6 to 10 feet. The end of west dock has been expanded to accommodate deeper draft barges as part of the Prudhoe Bay Unit Water-Flood Project.

Barge traffic in support of continued development on the North Slope of Alaska has ranged from a low of 2 barges in 1979 to a high of 26 in 1983 and 1986. Typically, 10 to 15 barges per year have been in the sealift.

Peak years of goods movement by the marine mode have been 1970 (187,000 tons), 1975 (153,000 tons), and 1983 (estimated to be 126,100 tons). These years correspond with the Prudhoe Bay Unit construction, Trans-Alaska Pipeline System (TAPS) construction, and the Prudhoe Bay Unit Waterflood Project, respectively. In comparison, 1981 sealift traffic to Prudhoe Bay was estimated to be 70,000 tons. The barge fleet goes no further east than ARCO's docks in Prudhoe Bay.

The proposed operations will have little if any impact on the aforementioned shipping activities. The very slight risk of a collision with vessels transiting the sale area will be mitigated by compliance with all U.S. Coast Guard safety, navigation, and notice requirements.

The only continuous commercial fishing operation in the Alaska Beaufort Sea is operated by a single family. In the Helmerick's commercial fishery, there is fishing in both summer and fall, but fall fishing accounts for the greatest effort and yield. Fall fishing is done with gill nets set under the ice in the Kupigruak

and east channel of the Colville River adjacent to Anachilik Island from early October to early December. Arctic cisco, least cisco, broad whitefish, and humpback whitefish are the primary fish species caught. Arctic cisco is the most important commercial species: 20,000 to 70,000 of these have been caught annually since 1976. The proposed operations will have no impact on commercial fishing operations.

## C. FINDINGS

The proposed operations are consistent with the enumerated standards because:

- o They will be conducted from facilities that will temporarily occupy a small ocean area.
- Amoco has prepared detailed analyses of the potential environmental and social impacts of the proposed operations and has determined that potential environmental impacts will be temporary and minor in nature and potential social impacts will be negligible.
- o With the exception of subsistence whaling activities, the proposed exploratory drilling operations will be conducted in offshore areas located well away from the barrier islands, nearshore waters, and coastal areas where subsistence use activities tend to concentrate from July to November.
- o The area utilized for subsistence whaling is very large in comparison to the small ocean area that will be temporarily occupied by project-related facilities. Moreover, to the extent that information on endangered bowhead whale strikes can be used to determine where whaling activities are concentrated, the proposed well locations are outside such an area.

- o Existing shorebases will be used to support the proposed operations. The shorebases will:
  - Satisfy all of Amoco's requirements without contributing to an adverse impact on the environment.
  - Be compatible with existing and subsequent adjacent uses.
- Not require the construction or expansion of fa-
  - Be in areas which have been designated for in-
- o Facilities will be consolidated to the maximum extent possible (i.e., the selection of fourteen well locations sites to evaluate the hydrocarbon potential of twelve leases; supporting the proposed exploratory drilling operations by stockpiling materials and supplies on the drilling unit and ice class support vessels; and using (an) existing shorebase(s) for helicopter support operations).
  - o Amoco will comply fully with the requirements of the MMS, U.S. Coast Guard, U.S. Environmental Protection Agency, and U.S. Army Corps of Engineers.
  - o Project-related vessels will be equipped with navigation, lighting, and safety equipment which complies with all U.S. Coast Guard requirements.
  - o The U.S. Coast Guard will issue a Notice to Mariners informing vessel captains of the exact location of the drilling unit.

- O Amoco will work for the re-establishment of the Oil/Whalers Cooperative Agreement which would facilitate communications between project-rlated vessels and whaling boats.
- Sensitive wildlife and habitat areas generally are situated well away from the offshore areas that will be occupied and/or utilized by project-related facilities.
- The potential for the proposed operations to have a significant impact on endangered bowhead whales or any other marine resource is low because of the broad distribution of marine resources and the comparatively small ocean area that will be occupied by project-related facilities.
- Potential project-related impacts on sensitive habitat areas will be minimized by Amoco's compliance with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale for Lease Sale No. 97 which suggest that:
  - Vessels and aircraft maintain at least a 1-mile horizontal distance from observed wildlife or known wildlife concentration areas.
  - Vessel and aircraft traffic be minimized or rerouted to avoid disturbances to endangered bowhead whales.
  - Aircraft maintain a 1,500-foot altitude when in transit over areas where endangered bowhead whales are present.

- o If endangered bowhead whales are encountered by a project-related support vessel, the following MMS-man-dated guidelines will be observed:
  - The vessel will be operated at a speed that will make collisions with endangered bowhead whales unlikely; if visibility decreases to less than 3 miles, vessel speed will be reduced.
  - The vessel will maintain a minimum approach distance of 1 mile from endangered bowhead whales.
- - reducing vessel speed within 300 yards of the animal(s);
  - steering around the animal(s), if possible;
  - operating the vessel in such a way as to avoid separating members of a group of animals from other members of the group;
  - operating the vessel to avoid multiple changes in direction; and
  - checking the waters immediately adjacent to the vessel to ensure that no animal(s) will be injured when the propellers are engaged.
  - Oil spill frequency rates have declined steadily since the institution of more stringent safety standards in the early 1970's.
  - o Oil spill statistics confirm that most of the oil spills that do occur on the Outer Continental Shelf (OCS) are very minor in nature.
  - o According to the MMS, no oil spill of one barrel or more has occurred as a result of a blowout from an OCS exploratory well in the United States since 1971.

- o According to a risk assessment prepared by Amoco, the estimated blowout rate for an exploratory well on the United States OCS is  $\hat{P} = 0.62$  percent chance per well with an upper 95 percent confidence bound of 0.80 percent.
- o According to a risk assessment prepared by Amoco, the upper 95 percent confidence bound on a major oil spill occurring as the result of a blowout from an exploratory well is P≤.0004.
- o All proper and appropriate actions will be taken to avoid spillage of oil, and to contain, cleanup, and dispose of oil and oily debris.
- o State-of-the-art response equipment will be used and all activities will be conducted in a carefully planned and orderly fashion so as to prevent the discharge of oil.
- o Amoco will comply with all MMS regulatory requirements applicable to the prevention of and response to oil spills.
- Amoco has filed a comprehensive Oil Spill Contingency Plan which contains a description of the containment and cleanup equipment available onsite and from offsite sources, and demonstrates, among other things, the Company's ability to respond to an oil spill in broken ice conditions.
- o Amoco has developed a plan to drill a relief well if a blowout occurs during the proposed exploratory drilling operations.

- o Amoco has developed a plan to deal with the loss or disablement of the drilling unit or a support craft during the conduct of the proposed operations.
- o Amoco has developed a plan to deal with ice encroachments during the conduct of the proposed operations.
- o Air emissions from the proposed operations will not have a significant affect on any onshore area.
  - o Solid and liquid wastes will be disposed of in a manner consistent with federal and state laws and regulations and the provisions of the general NPDES permit for the Beaufort Sea.
  - o The proposed operations will have little, if any, impact on shipping; all U.S. Coast Guard safety, navigation, and notice requirements will be compiled with fully.
  - o The proposed operations will have no impact upon commercial fishing operations.

## 6 AAC 80.130. HABITATS (ACMP)

- (a) Habitats in the coastal area which are subject to the Alaska coastal management program include:
- (1) offshore areas; answer again again again again and the companie (7)
- (2) estuaries;
- (3) wetlands and tideflats;
- (4) rocky islands and seacliffs;
- (5) barrier islands and lagoons;
- (6) exposed high energy coasts;
- (7) rivers, streams, and lakes; and

- (8) important upland habitat.
- (b) The habitats contained in (a) of this section must be managed so as to maintain or enhance the biological, physical, and chemical characteristics of the habitat which contribute to its capacity to support living resources.
- (c) In addition to the standard contained in (b) of this section, the following standards apply to the management of the following habitats:
- (1) offshore areas must be managed as a fisheries conservation zone so as to maintain or enhance the state's sport, commercial, and subsistence fishery;
- (2) estuaries must be managed so as to assure adequate water flow, natural circulation patterns, nutrients, and oxygen levels, and avoid the discharge of toxic wastes, silt, and destruction of productive habitat;
- (3) wetlands and tideflats must be managed so as to assure adequate water flow, nutrients, and oxygen levels and avoid adverse effects on natural drainage patterns, the destruction of important habitat; and the discharge of toxic substances;
- (4) rocky islands and seacliffs must be managed so as to avoid the harassment of wildlife, destruction of important habitat, and the introduction of competing or destructive species and predators;
- (5) barrier islands and lagoons must be managed so as to maintain adequate flows of sediments, detritus, and water, avoid the alteration or redirection of wave energy which would lead to the filling in of lagoons or the erosion of barrier islands, and discourage activities which would decrease the use of barrier islands by coastal species, including polar bears and nesting birds;
- (6) high energy coasts must be managed by assuring the adequate mix and transport of sediments and nutrients and avoiding redirection of transport processes and wave energy; and
- (7) rivers, streams, and lakes must be managed to protect natural vegetation, water quality, important fish or wildlife habitat and natural water flow.
- (d) Uses and activities in the coastal area which will not conform to the standards contained in (b) and (c) of this section may be allowed by the district or appropriate state agency if the following are established:
- (1) there is a significant public need for the proposed use or activity;

- (2) there is no feasible prudent alternative to meet the public need for the proposed use or activity which would conform to the standards contained in (b) and (c) of this section; and
- (3) all feasible and prudent steps to maximize conformance with the standards contained in (b) and (c) of this section will be taken.
- (e) In applying this section, districts and state agencies may use appropriate expertise, including regional programs referred to in sec. 30(b) of this chapter.

## 2.4.5.2(g) BEST EFFORT POLICIES (NSBCMP)

Development within the Alaska Coastal Management Program-defined coastal habitats must be conducted in accordance with ACMP Standard 6 AAC 80.130(b), (c), and (d), and applicable policies of the North Slope Borough Coastal Management Program. These habitats including the following:

- 1. offshore areas;
- estuaries;
- wetlands and tideflats;
- rocky islands and seacliffs;
- barrier islands and lagoons;
- 6. exposed high-energy coasts;
- 7. rivers, streams and lakes; and
- 8. important upland habitat.

#### A. ASSESSMENT

#### (1) BACKGROUND INFORMATION

The proposed exploratory drilling operations will be conducted in offshore areas. The Galahad Prospect is located 34.6 statute miles from Kaktovik.

The closest estuary to the Galahad Prospect is the Hulahula River, which is located 31.2 miles to the southeast.

Wetlands and tideflats are ubiquitous along the coastline of the Alaska Beaufort Sea. The closest major wetland and tidal flats to the Galahad Prospect are associated with the Hulahula River. The closest scarps ("seacliffs") to the Belcher Prospect are located west of the Hulahula River, about 31.8 miles to the southeast. The closest barrier island to the Galahad Prospect is Arey Island, which is 30 miles to the southeast. The closest lagoon to the Galahad Prospect is Arey Lagoon, which is 30.2 miles to the southeast. High energy coasts also occur at Arey Island. The closest major river to the Galahad Prospect is the Hulahula River.

## (2) ASSESSMENT OF POTENTIAL IMPACTS

For the purpose of assessing impacts, the criteria contained in 6 AAC 80.130 (ACMP) and 2.4.5.2(g) (NSMCMP) are considered under the following categories: routine operations; and oil spill.

(a) <u>Routine Operations</u>: Although the proposed operations will be conducted from vessels operating in a sensitive habitat area for migrating whales, the area potentially affected by project-related vessels will be extremely small in comparison to the large ocean area used by migrating beluga and endangered bowhead whales.

Potential project-related impacts on whales will be minimized by Amoco's compliance with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale for Lease Sale No. 97 which suggest that:

- o Vessels and aircraft maintain at least a 1-mile horizontal distance from observed wildlife or known wildlife concentration areas.
- o Vessel and aircraft traffic be minimized or rerouted to avoid disturbances to endangered bowhead whales.
- o Aircraft maintain a 1,500-foot altitude when in transit over areas where endangered bowhead whales are present.

If project-related vessels encounter migrating endangered bowhead whales, they will observe the following MMS-mandated guidelines:

- The vessel will be operated at a speed that will make collisions with endangered bowhead whales unlikely; if visibility decreases to less than 3 miles, vessel speed will be reduced.
- o The vessel will maintain a minimum approach distance of 1 mile from endangered bowhead whales.
- o If the vessel inadvertently approaches within 1 mile of (an) endangered bowhead whale(s), the vessel operator will take every precaution to avoid harrassment of the animal(s) by:
  - reducing vessel speed within 300 yards of the animal(s);
  - steering around the animal(s), if possible;
  - operating the vessel in such a way as to avoid separating members of a group of animals from other members of the group;
  - operating the vessel to avoid multiple changes in direction; and
  - checking the waters immediately adjacent to the vessel to ensure that no animal(s) will be injured when the propellers are engaged.

Project-related vessels will be situated in areas which are well offshore, beyond the barrier islands, nearshore waters and coastal areas where most sensitive habitat areas are situated. Moreover, project-related support operations will be conducted from existing facilities which also are situated away from sensitive habitat areas, and from which existing traffic operates without any documented impact on sensitive habitat areas.

No sport fishing takes place on or in the vicinity of the leases. The closest commercial fishing operation to the Galahad Prospect is situated in the Colville River delta, approximately 115 miles

to the west. Subsistence fishing generally takes place from fishing camps situated on the barrier islands and along coastal areas from July until November. The proposed exploratory drilling operations will occur well away from these areas.

The proposed operations will have no impact on water flow, natural circulation patterns, nutrients, and oxygen levels in any estuaries, wetlands, and tideflats. Natural drainage patterns in wetlands and tideflats will be unaffected by the proposed operations. No competitive or destructive species will be introduced to offshore waters, barrier islands, nearshore waters, and coastal areas as a result of the proposed operations. The well locations on the Galahad Prospect are situated well away from the barrier islands and, as a result, the proposed activities will have no impact on the flow of sediments, detritus and water, wave energy, or the use of the barrier islands by polar bears or nesting birds. High energy coasts, rivers, streams, and lakes will be unaffected by the proposed operations.

No toxic pollutants will be introduced into a sensitive habitat area. On June 7, 1984, the EPA issued a general NPDES permit for the Beaufort Sea. This permit establishes effluent limitations, standards, monitoring criteria, and other conditions for discharges from exploratory drilling units which are designed, among other things, to minimize the impact of these discharges on sensitive habitat areas. Discharges from the proposed operations must be approved by the EPA and will be handled in a manner consistent with the provisions of the general NPDES permit.

(b) Oil Spill: A major oil spill could have a significant adverse impact on sensitive habitat areas which come into direct contact with oil. However, it is extremely unlikely that a major oil spill will occur during the proposed exploratory drilling operations. Moreover, in the unlikely event that a major oil spill does occur, the spilled oil should have a limited impact on sensitive habitat areas other than the offshore waters utilized by bowhead and beluga whales.

Risk: A major oil spill from an exploratory well most likely would occur as the result of the sudden loss of well control and the uncontrolled escape of hydrocarbons (i.e., a "blowout"). Data on the incidence of blowouts from offshore exploratory wells is available for the United States OCS for the period 1971 through 1985.

In 1980, the U.S. Geological Survey published a report entitled "Outer Continental Shelf Oil and Gas Blowouts" which provides statistics for blowouts from exploratory wells in the Gulf of Mexico for the period 1971 through 1978. According to these data, 17 blowouts occurred during the drilling of 2,250 exploratory wells.

In 1983, the MMS published a report entitled "Outer Continental Shelf Oil and Gas Blowouts, 1979-1982." This document provides blowout data for 1,580 exploratory wells drilled on the United States OCS from 1979 through 1982. According to the MMS data, 8 blowouts occurred during this period.

In 1985, the MMS published a report entitled "Federal Offshore Statistics: 1985". This document provides information on the number of blowouts (i.e., 8) which occurred during the drilling of exploratory wells for the years 1983-85.

Finally, Amoco acquired data on the number of exploratory wells drilled on the United States OCS for the years 1983 through 1985 (i.e., the last year for which blowout data are available) by contacting the MMS. During these three years, 1,507 exploratory wells were drilled.

When the available data on blowouts from exploratory wells on the United States OCS are combined, a total of 33 blowouts occurred during the drilling of 5,337 wells.

Using the combined United States OCS data, the estimated blowout rate is P=0.62 percent chance per well with an upper 95 percent confidence bound of 0.80 percent. Thus, there is a 95 percent degree of confidence in the statement that the unknown probability of a blowout is below 0.80 percent.

The risk of a blowout during exploratory drilling operations resulting in a major oil spill is extremely low. Indeed, since the inception of exploratory drilling operations on the United States OCS up to January 1, 1988, there has never been a major oil spill from a blowout during the drilling of 7,951 exploratory wells.

Given the data of zero out of 7,951 trials, the maximum likelihood estimator of "P" (i.e., the probability of a major oil spill occurring as a result of a blowout) is P = 0. The upper 95 percent confidence bound on a major oil spill occurring as a result of a blowout from an exploratory well is  $P \le .0004$ . It should be emphasized that this is an upper bound (i.e., as more experience is accumulated, the number will decrease).

Probability of Contact With Spilled Oil: In its oil spill risk analysis prepared prior to Lease Sale No. 97, the MMS used a model to determine the conditional probability that a major oil spill originating from MMS-designated launch points would contact MMS-defined land segments within 3, 10, and 30 days. The MMS-designated launch points closest to the Galahad Prospect are 10, 11, 12, and 13.

The results of the MMS analysis are presented in Table D-1. Based on the MMS analysis, a major oil spill originating at the closest launch points has less than a 0.5 percent conditional probability of contacting all land segments between Demarcation Point and Point Barrow, except 33 (i.e., the Simpson Lagoon Area), 34 (i.e., the Return Islands Area), 35 (i.e., the Prudhoe Bay Area), 37 (i.e., the Bullen Point Area), and 38 (i.e., the Canning River Area). For these segments, the conditional probabilities range from a 1 to 8 percent

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CONDITIONAL PROBABILITIES (EXPRESSED AS PERCENT CHANCE)
THAT AN OIL SPILL STARTING AT LAUNCH POINTS WILL CONTACT
A CERTAIN LAND SEGMENT WITHIN 3, 10, OR 30 DAYS OF A
SUMMER SPILL OR MELTOUT OF AN OVERWINTERING SPILL
(MMS, 1987)

	10			LAUNCH POINTS 11 12						13		
LAND SEGMENTS	3 5 Q 3 T	DAYS 10	30	3	DAYS 10	30	3	DAYS 10	30	3	DAYS 10	30
20	n	1	2	n	n	n	n	n	n	n n	n	r
21	n	1	1	n	n	n	n	n	n	n	n n	n
22	n	1	1	n	n	n	n	n	n	n	n	n
23	9011	0001	1	n	n	n	n	n	n	n	n	n
24	n	n	1	n	n	n	n	n	n	n	n	n
25	n	n	n	n	n	n	n	n	n	n	n	n
26	n	n	1	n	n	n	n	n	n	n	n	n
27	n	1	2	n	n	n	n	n	n	n	n	n
28	n	2	4	n	n	n	n	n	3	n	1	1
29	n	2	3	n	n	n	n	n	n	n	1	1
30	n	5391	2	n	n	n	n	n	n	n	1	1
31	n	n	n	n	n	n	n	n	n	n	n	n
32	n	n	1	n	n	n	n	n	n	n	n	n
33	a1/1	1	1011	n	n	n	n	n	n	n	n	n
34	8	11	11	n	n	n	3	4	4	1	2	3
35	1	4	4	n·	n	n	n	2	2	n	2	3
36	n	1	1	n	n	n	n	1	1	n	2	3
37	n	2	2	n	n	n	n	1	2	1	2	2
38	n	n	n	n	n	n	2	7	7	6	9	9
39	n	n	n	n	n	n	n	1	1	n	1	1
40	n	n	n	n	n	n	n	n	n	n	1	1

n = less than 0.5 percent chance.

chance. Within 10 days, the conditional probabilities of contact remain low for all land segments; the highest conditional probability (i.e., 11 percent chance) was recorded for land segment 34 which encompasses the Return Islands Area. Within 30 days, the conditional probabilities of contact still remain low for all land segments. The highest conditional probability (i.e., 9 percent chance) of contact within 30 days was recorded for land segment 38 which encompasses the Canning River Area.

Higher probabilities of contact can be anticipated for offshore areas; however, the size of the area potentially affected by a major oil spill would be dependent upon the amount of oil spilled, the duration of the spill, meteorological and oceanographic conditions, and the effectiveness of response operations. Generally, oil spreading rates in arctic waters are between 100 and 1,000 times less than they are in more temperate waters. For this reason, it is likely that the ocean area potentially affected by spilled oil would be small in comparison to the large ocean area available to migrating whales.

Migration Measures: Amoco's overall policy toward oil spills is zero spillage of oil. Sensitive habitat areas will be protected from oil contact by a variety of standard operating procedures. For example, under the general NPDES permit for the Beaufort Sea, the discharge of oil-based drilling muds or water-based drilling muds which contain diesel oil as an additive is prohibited. Also, the discharge of drill cuttings associated with diesel oil-based drilling muds or muds containing diesel oil is prohibited, as are all discharges of free oil. Moreover, prior to and during drilling operations, detailed data and information are gathered and analyzed to guard against loss of well control.

The threat of a major oil spill will be further minimized by Amoco's adherence to the drilling mud, casing, cementing and testing requirements contained in the applicable MMS regulations, the installation and frequent testing of blowout preventer equipment in

conformance with industry standards and the requirements of § 250.56 and 250.57 of the MMS regulations, and Amoco's continuing commitment to safe and workmanlike operating practices and procedures.

In the unlikely event that a major spill occurs, the drilling unit will be equipped with state-of-the-art containment and clean-up equipment and, if necessary, offshore equipment can be obtained from Alaska Clean Seas. In conformance with Stipulation No. 6 and Section 14(c) of the Information to Lessees portion of the Final Notice of Sale for Lease Sale No. 97, Amoco has submitted an Oil Spill Contingency Plan which demonstrates, among other things, that Amoco is prepared to respond to an oil spill in broken ice conditions. Finally, plans have been formulated to insure that Amoco can obtain a drilling unit to drill a relief well, should the need arise.

## B. FINDINGS

The proposed operations are consistent with the enumerated standards because:

- o They will be conducted at offshore locations which generally are situated away from sensitive habitat areas.
  - o Although the proposed operations will be conducted from vessels operating in a sensitive habitat area for migrating whales, the area potentially affected by the proposed operations will be extremely small in comparison to the large ocean area used by migrating whales.
    - Potential project-related impacts on sensitive habitat areas will be minimized by Amoco's compliance with the recommendations in Section 14(f) of the Information to Lessees portion of the Final Notice of Sale for Lease Sale No. 97 which suggest that:

- Vessels and aircraft maintain at least a 1-mile horizontal distance from observed wildlife or known wildlife concentration areas.
  - Vessel and aircraft traffic be minimized or rerouted to avoid disturbances to bowhead whales.
- Aircraft maintain a 1,500-foot altitude when in transit over areas where bowhead whales are present.
- o If bowhead whales are encountered by a project-related support vessel, the following MMS-mandated guidelines will be observed:
  - The vessel will operate at a speed that will make collisions with endangered bowhead whales unlikely; if visibility decreases to less than 3 miles, vessel speed will be reduced.
  - The vessel will maintain a minimum approach distance of 1 mile from endangered bowhead whales.
  - If the vessel inadvertently approaches within 1 mile of (an) endangered bowhead whale(s), the vessel operator will take every precaution to avoid harrassment of the animal(s) by:
    - reducing vessel speed within 300 yards of the animal(s);
    - steering around the animal(s), if possible;
    - operating the vessel in such a way as to avoid separating members of a group of animals from other members of the group;
    - operating the vessel to avoid multiple changes in direction; and
    - . checking the waters immediately adjacent to the vessel to ensure that no animal(s) will be injured when the propellers are engaged.

- O No toxic pollutants will be introduced into a sensitive habitat area.
- o Discharges from the proposed operations will be handled in a manner consistent with the provision of the general NPDES permit for the Beaufort Sea.
- Oil spill frequency rates have declined steadily since the institution of more stringent safety standards in the early 1970's.
- o Oil spill statistics confirm that most of the oil spills that do occur are very minor in nature.
- o According to the MMS, no oil spill of one barrel or more has occurred as a result of a blowout from an OCS exploratory well in the United States since 1971.
  - o According to an analysis prepared by Amoco, the estimated blowout rate for an exploratory well on the United States OCS is P = 0.62 percent chance per well with an upper 95 percent confidence bound of 0.80 percent.
  - o According to an analysis prepared by Amoco, the upper 95 percent confidence bound on a major oil spill occurring as the result of a blowout from an exploratory well is P≤.0004.
  - O The MMS oil spill trajectory analysis for Lease Sale No. 97 indicates there is a very low conditional probability that a major oil spill originating in the vicinity of the Galahad Prospect would affect sensitive habitat areas located on the barrier islands, in near-shore waters, and along the coastline.

- o The area most likely to be affected by a major oil spill occurring in the vicinity of the Galahad Prospect (i.e., the offshore area) is a sensitive habitat area for migrating whales; however, whales are broadly distributed in the offshore area thus reducing the likelihood that a major oil spill would have a significant impact on whales.
- O The potential for a major oil spill is mitigated by Amoco's compliance with all applicable MMS regulatory requirements.

### 6 AAC 80.140. AIR, LAND, AND WATER QUALITY (ACMP)

Notwithstanding any other provision of this chapter, the statutes pertaining to and the regulations and procedures of the Alaska Department of Environmental Conservation with respect to the protection of air, land, and water quality are incorporated into the Alaska coastal management program and, as administered by that agency, constitute the components of the coastal management program with respect to those purposes.

## 2.4.3(i) STANDARDS FOR DEVELOPMENT (NSBCMP)

Development shall comply with state or federal land, air and water quality standards or regulations.

## 2.4.4(c) REQUIRED FEATURES FOR APPLICABLE DEVELOPMENT (NSBCMP)

Development resulting in water or airborne emissions must comply with all state and federal regulations.

## A. ASSESSMENT

## (1) BACKGROUND INFORMATION

(a) Solid and Liquid Wastes: Solid and liquid waste discharges from the proposed operations will be made in a manner consistent with the provisions of the general NPDES permit for the Beaufort Sea.

Liquid discharges from the drilling unit will result from normal domestic activities, cooling systems, deck drainage, and ballast. Discharges of solids or solid suspensions will be generated as part of the proposed drilling operations and will include drilling mud, drill cuttings, and cement.

Domestic sewage will be treated prior to release. A marine sanitation device which meets the requirements of the U.S. Coast Guard will be used, and the resulting effluent will be chlorinated to a level greater than or equal to 1 mg/1 of total residual chlorine prior to discharge. Seawater discharges will form the largest (i.e., in terms of volume) discharge. These discharges will contain no entrained oil. Contaminated deck drainage will be released only after desilting, gravity separation, and oil/water separation processing.

Discharges of solids and solid suspensions will occur regularly during the proposed drilling operations. Cuttings and seawater gel mud will be discharged at the ocean floor while drilling the structural hole, and mud and a small quantity of cement will be deposited on the ocean floor while running and cementing the structural and conductor casing. Following the completion of these operations, all mud and cuttings will be discharged on the ocean surface adjacent to the drilling unit. Any oil-contaminated mud will be transported to shore for storage and eventual disposal at a state-approved site.

The composition of the drilling mud used and, thus, the composition of the mud discharged, will be determined by the conditions encountered as the well is drilled. All drilling mud systems will be EPA-approved in compliance with the provisions of the general NPDES permit for the Beaufort Sea.

Other solid wastes from the proposed exploratory drilling operations will include scrap iron or metal, packing materials, and miscellaneous items (e.g., boxes and paper). These materials will be transported to shore in containers for reclamation or disposal at a state-approved facility.

Discharges from the support vessels will consist primarily of ballast water. Additionally, small quantities of bilge water, domestic water, and treated sewage also will be discharged. The sewage will be treated prior to discharge to the ocean. Solid wastes, such as garbage and packing materials will be transported to shore for reclamation or disposal at a state-approved facility.

(b) <u>Air Emissions</u>: The major sources of air emissions from the proposed operations will be the diesel engines on the drilling unit (i.e., the "prime movers" used to generate electricity for moving and positioning the drilling unit, pumping and compressing operations, and running the drilling equipment). "Worst case" projected emissions would include flaring. "Worst case" projected emissions (i.e., in tons per well) for the drilling unit for a 70-day, 12,000-foot well are: nitrogen oxides (NO $_X$ ) = 43.37; sulfur oxides (SO $_X$ ) = 2.50; total suspended particulates (TSP) = 2.78; total hydrocarbons (THC) = 1.57; and carbon monoxide (CO) = 6.55.

Air emissions also will be generated by the ice class support vessels and helicopters associated with the proposed exploratory drilling operations, and from the vessel and aircraft involved in scientific research operations. These emissions will not have a significant affect on any onshore area.

## (2) ASSESSMENT OF IMPACT

(a) Solid and Liquid Wastes: The potential impacts of permitted discharges on living marine resources are discussed below.

Phytoplankton: Local, temporary increased turbidity caused by the discharge of materials (i.e., if a glory hole is constructed), and the discharge of drilling mud, drill cuttings, wash water, deck drainage, sewage waste, and excess cement could decrease phytoplankton photosynthesis by temporarily obstructing light penetration in the plume area. The decreased photosynthesis effect could cause minor, short-term impacts on the phytoplankton populations that pass through a plume extending 650 feet from the discharge point. Studies indicate that the effect of such a plume on solar energy available for photosynthesis is not significant compared to changes in water transparency due to coastal runoff, primary productivity, and typical cloud cover. The effect of these discharges on the productivity of the regional phytoplankton population, therefore, will be negligible.

Extensive research has demonstrated that drilling muds approved for use under the general NPDES permit for the Beaufort Sea could have adverse impacts on marine organisms only at very high concentrations. Such concentrations would occur only in the immediate vicinity of the discharge point. Any adverse effects on phytoplankton would be concentrated to a small area around the drilling unit and will have a negligible impact on regional phytoplankton populations.

Zooplankton: Increased turbidity caused by the discharge plume could have a smothering effect on some passive and slow-moving zooplankton species. Temporary clogging of the filter feeding mechanisms of some zooplankton could occur, resulting in decreased filtering and feeding efficiency. However, this effect would probably last only a few minutes for a given water parcel passing by the discharge point. For example, one study noted that there was no discernable impact on a sessile marine community 30 feet downstream of a drilling mud discharge source. Any adverse effects on zooplankton would be concentrated to a small area around the drilling unit and will have a negligible impact on regional zooplankton populations.

Entrainment mortality of planktonic organisms due to thermal shock in the cooling system of a proposed drilling unit could occur. However, due to the temporary nature of the drilling operations, the small volume of water to be pumped, and the regional abundance of organisms, the effect on the regional zooplankton population will be negligible.

Benthos: Short-term, highly localized effects to the benthic environment would be limited to temporary seabed accumulations of settled solids from discharged drilling mud, drill cuttings, and excavated sediments if a glory hole is constructed at one or more of the proposed well locations.

The majority of heavy cuttings together with some entrained drilling muds will settle to the bottom and could result in the smothering and burial of some benthic species inhabiting the ocean bottom within 325 feet of the drilling unit. In addition, the sediment composition of the bottom may be altered and impacts to benthic communities can occur from 500 to 2,500 feet of the drilling unit. Evidence indicates that smothering effects are limited to small areas where current energy is sufficiently low to allow solids to settle rapidly, and are not detectable in high-energy locations where solids are rapidly dispersed. Smothering either does not occur or the effects are limited to the bottom within 1,000 feet of the drill site. Recovery within the smothered area would begin within days and the bottom would be repopulated within a short period of time.

The greatest accumulation of settled solids would result from the discharge of excavated sediments if a glory hole is constructed. If excavated material is discharged near the construction site, covering of benthic organisms may result in mortality or reduced reproductive success caused by smothering, inability to feed, or other mechanisms. This effect would be limited to the area immediately around the drill site. Based on study results presented for shallow

water, seafloor accumulations of discharged solids would be indiscernible following project completion. The time required for replacement of benthic infaunal organisms lost as a result of accumulations of settled solids could vary from a few weeks (worms) to a few years (bivalves). However, the relative area affected would be so small that such losses would be negligible from a regional perspective.

The anchors used to moor the drilling unit and the anchor chains will adversely affect the bottom community within the immediate area of anchor placement. This effect will be negligible since the bottom community will rapidly repopulate the area once the anchors and anchor chains are removed.

In summary, most of the impact on the benthos will be through localized burial effects and displacement of some infaunal and epifaunal organisms that exhibit strong preferences for sediment particle size, microrelief, or availability of fouling organisms from the drilling unit. The changes will be temporary and highly localized in nature, and the impacts will be negligible from a regional perspective.

Nekton: Since the EPA-approved drilling muds are of very low toxicity and are rapidly dispersed, nekton are not expected to be adversely affected by the discharged materials. Also, most metals in the discharges are bound to particulates and are, therefore, unavailable for uptake by the organisms. In addition, the drilling activities will occur far enough offshore so as not to affect nearshore concentrations of important anadromous species.

Even in the most sensitive species, studies show that deleterious sublethal responses are observed only following protracted exposure to whole suspended mud concentrations in the range of 100 ppm. Such exposures from the proposed drilling activities are unlikely to occur for periods exceeding a few minutes. Thus, the impact of the discharges on nekton will be negligible.

Fish and most motile pelagic species should be able to avoid discharge plumes and areas of high turbidity resulting from the proposed exploratory drilling operations. Although some studies have indicated that fish may be attracted to a discharge plume, it is likely that the stress brought on by their encounter with particulates in the main body of the plume would restrict fish to the plume edges. Moreover, following cessation of the discharges, fish would likely return to the discharge area.

Fish eggs could be adversely affected by drilling discharges. The wider dispersion of discharged drilling fluids in deeper areas could result in a large area being covered with more than .04 inch (1 mm) of muds and cuttings. This could result in the smothering of eggs of cottids (i.e., Arctic cod) and other demersal fish. However, under actual field conditions, the area affected should be relatively small.

(b) <u>Air Emissions</u>: Consistent with the MMS regulations, Amoco has prepared a detailed air quality analysis to determine whether emissions from the proposed exploratory drilling operations will significantly affect any onshore area.

The analysis determined that air pollutants generated as a result of the proposed exploration activities will not have a significant affect on any onshore area. In all cases, the annual projected emissions are well below the MMS-prescribed emission exemption amounts. Because the emissions produced by the proposed operations are projected to be less than the emission exemption amounts established by the MMS, no further analysis of impacts of the proposed operations on onshore areas was required.

Offshore, the projected levels of air emissions will cause a minor, short term increase in the ambient concentration of these pollutants. The increase will not, however, cause a violation of the National Ambient Air Quality Standards which have been adopted by the State of Alaska in the State Implementation Plan.

## B. FINDINGS

The proposed operations are consistent with the enumerated standards because:

- o Solid and liquid waste discharges from the proposed operations will be made in a manner consistent with the provisions of the general NPDES permit for the Beaufort Sea.
  - Solid wastes that are not permitted to be discharged at the drill site will be transported to shore for disposal at a state-approved facility.
  - o Permitted discharges are not toxic to marine resources.
  - o Permitted discharges will not occur at levels where it is realistic to expect that heavy metals would be accumulated to concentrations that would pose a health hazard to marine resources.
  - O Discharges will occur after the main phytoplankton bloom in June. Moreover, they will affect a limited area and have a negligible impact on the regional phytoplankton population.
  - o Smothering or a decrease in the filter feeding efficiency of zooplankton will occur only in the immediate vicinity of the discharge point and for a short period of time. From a regional perspective, the number of zooplankton affected will be extremely small.
  - o A limited number of zooplankton will be entrained in the cooling water intake pipe on the drilling unit; from a regional perspective, the number of animals affected will be extremely small.

- Discharges will affect an area where the benthic biomass is highly variable and distribution is patchy. Moreover, the area affected will be small, normally within 1,000 feet of the drill site. Recovery will begin immediately and the area will be repopulated in a short period of time. Some local species populations may be displaced because of localized changes in physical properties of the sediment.
- o The impacts of air emissions will be negligible because the emissions will not cause a violation of the National Ambient Air Quality Standards.

# 6 AAC 80.150. HISTORIC, PREHISTORIC, AND ARCHAEOLOGICAL RESOURCES (ACMP)

Districts and appropriate state agencies shall identify areas of the coast which are important to the study, understanding, or illustration of national, state, or local history or prehistory.

## 2.4.3(f) STANDARDS FOR DEVELOPMENT (NSBCMP)

Development which is likely to disturb cultural or historic sites listed on the National Register of Historic Places; sites eligible for inclusion in the National Register; or sites identified as important to the study, understanding, or illustration of national, state, or local history or prehistory shall 1) be required to avoid the sites; or 2) be required to consult with appropriate local, state and federal agencies and survey and excavate the site prior to disturbance. (Descriptions of sites identified to date are contained in Appendix C of the North Slope Borough Coastal Management Program Background Report and referenced on Map 2 of the Resource Atlas).

# 2.4.3(g) STANDARDS FOR DEVELOPMENT (NSBCMP)

Development shall not significantly interfere with traditional activities at cultural or historic sites identified in the coastal management program.

## 2.4.3(h) STANDARDS FOR DEVELOPMENT (NSBCMP)

Development shall not cause surface disturbance of newly discovered historic or cultural sites prior to archaeological investigation.

## 2.4.5.2(h) BEST EFFORT POLICIES (NSBCMP)

Development is required to be located, designed, and maintained in a manner that does not interfere with the use of a site that is important for significant cultural uses or essential for transportation to subsistence use areas.

## A. ASSESSMENT

### (1) BACKGROUND INFORMATION

A number of historic and archaeological sites have been identified in the vicinity of the Alaska Beaufort Sea; however, the significance of many of these sites has not been established. Of known sites whose significance has been assessed, two are registered National Historic Sites and three have been approved but are not yet entered in the National Register. The former are the Ernest de Koven Leffingwell's camp on Flaxman Island and the archaeological site at Birnirk near Barrow. The latter three are at Cross Island, Tigvariak Island, and Flaxman Island-Brownlow Point. In addition, there was a recent discovery of an Eskimo family preserved for about two or three centuries in their house on the eroding edge of the Beaufort Sea near Barrow.

Recent studies have attempted to place a value on the potential for the occurrence of prehistoric archaeologic sites on the Outer Continental Shelf. Value judgements have been derived by comparing past environmental and geographic conditions with the conditions required for settlement of the area by northern hunters and gatherers. Based on these values, only two areas on the Alaskan Beaufort Sea Outer Continental Shelf have been described as having a significantly enhanced resource potential. The closer of these to the Belcher Prospect lies just offshore from Barter Island (note: the other area of interest lies in the far western Beaufort Sea, offshore from the present location of Point Barrow). The relatively steep seaward-facing slopes of this area might have been attractive to terrestrial grazers seeking fall range, and would have provided viewpoints for

hunters of both terrestrial and, later on, marine mammals. In addition, topographic evidence indicates that this area might have been the recipient of one or more rivers during submergence, hosting seasonal runs of anadromous fish.

Early man has occupied the Beaufort Sea shelf during the past 18,000 years, but there is little chance that any of his habituation sites would have survived the tremendous amount of ice gouging that has occurred. In addition, surviving sites could not be detected by seismic-reflection methods, due to the fact that subsurface sediments are jumbled and homogenized.

## (2) ASSESSMENT OF POTENTIAL IMPACTS

No known historic, prehistoric, or archaeological resource areas exist on or in the vicinity of the Galahad Prospect. If a cultural resource, like a shipwreck of historic significance, is discovered during site clearance activities or the drilling program, Amoco will notify the MMS and take immediate steps to protect the resource in compliance with Stipulation No. 1 of the Final Notice of Sale for Lease Sale No. 97.

## B. FINDINGS

The proposed operations will not effect the enumerated standard.