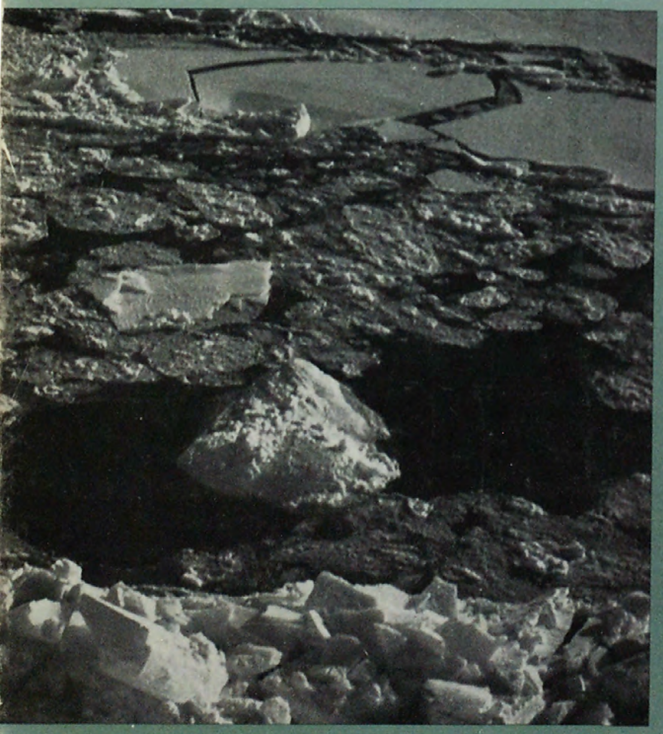
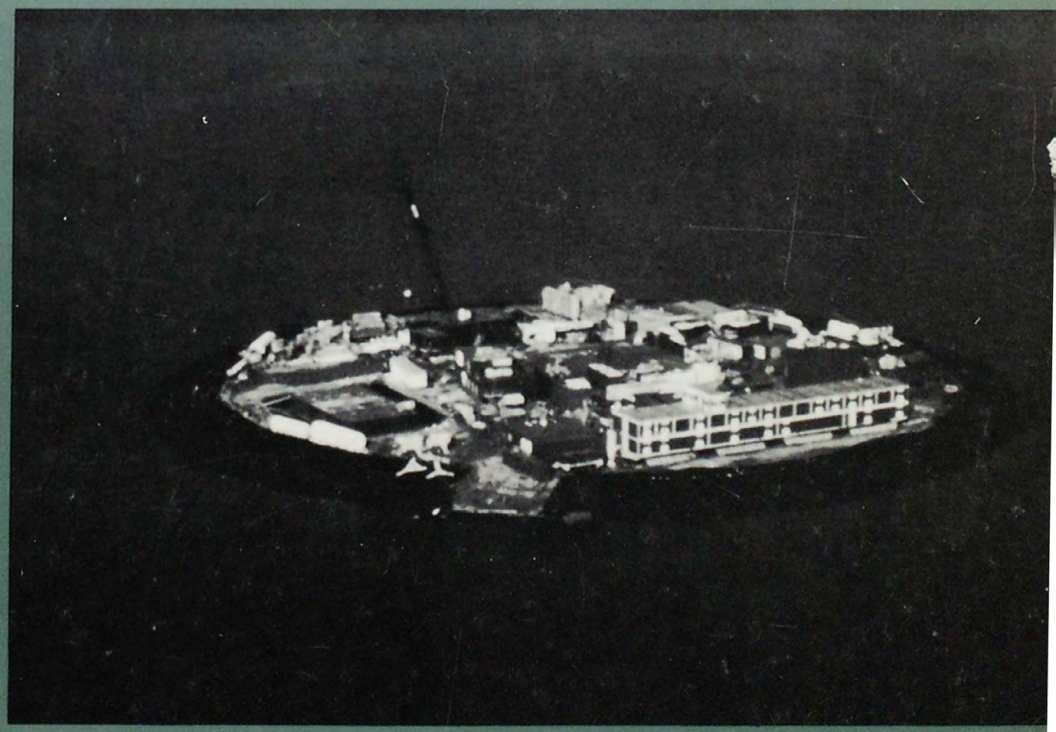
Outer Continental Shelf Oil and Gas Information Program

Arctic Summary Report





Prepared for the U.S. Department of the Interior, Geological Survey,
in cooperation with the Bureau of Land Management

U.S. Geological Survey Open-File Report 81-621

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To receive Arctic Summary Report revisions and updates, return the postcard attached to the back cover, or write to the above address.

PUBLICATION STATUS OF OCSIP DOCUMENTS

Type of Document	Initial	Updates			Revisions		
		1	2	3	1	2	3
Summary Report:							
North Atlantic	9/81	4/82	10/82				
Mid-Atlantic	11/79	6/80	2/81	9/81	9/82		
South Atlantic	7/80	2/81	9/81		5/82		
Gulf of Alaska	9/80				8/81	7/82	
Gulf of Mexico	9/80				10/81	8/82	
Pacific (So. Cal.)	5/80				3/82	12/82	
Arctic	11/81	3/82	9/82				
Indexes:							
Atlantic	5/79				5/81	10/81	11/82
Pacific	7/79				5/81	10/81	8/82
Alaska	7/79				5/81	1/82	2/82
Gulf of Mexico	9/79				5/81	2/82	5/82

COVER—The Story (alabaster, 1974) by John Kailukiak (photo by DOI, Indian Arts and Crafts Board); lead opening near pressure ridge (photo by Arctic Environmental Information and Data Center); typical gravel island (photo from Rogers, Golden & Halpern files).

Arctic Summary Report

Outer Continental Shelf and Onshore Oil and Gas Activities and Impacts in the Arctic: A Summary Report, October 1981

By Joanne Barnes Jackson, B. Fritts Golden, Anne Stadnychenko, and Sharon Kolasinski

Prepared for the U.S. Department of the Interior, Geological Survey, in cooperation with the Bureau of Land Management under Contract No. 14-08-0001-17919

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U.S. Geological Survey Open-File Report 81-621

English-Metric Conversion

(The following table gives the factors used to convert English units to metric units.)

Multiply English units	by	to obtain metric units
feet	0.3048	meters
miles	1.6090	kilometers
acres	0.4046	hectares
barrels	0.1589	cubic meters
cubic feet	0.0283	cubic meters
tons	0.9071	tons
gallons	3.7850	liters

Abbreviations and Acronyms

ABSORB - Alaska Beaufort Sea Oil Spill Response Body
AEC - Atomic Energy Commission
AFN - Alaska Federation of Natives
ANCSA - Alaska Native Claims Settlement Act of 1971
ANGTS - Alaska Natural Gas Transportation System
ANILCA - Alaska National Interest Lands Conservation Act of 1980
ANWR - Arctic National Wildlife Refuge
API - American Petroleum Institute
ARCO - Atlantic Richfield Company
ASNA - Arctic Slope Native Association
ASRC - Arctic Slope Regional Corporation
BIA - Bureau of Indian Affairs
BLM - Bureau of Land Management, DOI
BP - British Petroleum
CEAC - Citizen's Environmental Advisory Committee
CFR - Code of Federal Regulations
CIP - Capital Improvements Program
COE - U.S. Army Corps of Engineers
CZM - Coastal Zone Management
DEIS - Draft Environmental Impact Statement
DEW line - Distant early warning line
DM 655 - Order from the Secretary of the Interior on Inter-Bureau Coordination in the OCS Minerals program
DOI - Department of the Interior
EA - Environmental Assessment
EIS - Environmental Impact Statement
ESA - Endangered Species Act of 1973
FERC - Federal Energy Regulatory Commission
FPGP - Favorable Petroleum Geologic Province
GAO - Government Accounting Office
ICAS - Inupiat Community of the Arctic Slope
IPP - Intergovernmental Planning Program for OCS Oil and Gas Leasing, Transportation and Related Facilities, BLM
IRA - Indian Reorganization Act of 1934
IWC - International Whaling Commission
km2 - square kilometers
LBC - Local Boundary Commission, State of Alaska
LNG - liquefied natural gas
m2 - square meters
m3 - cubic meters
MLA - Mineral Leasing Act of 1920
MOU - Memorandum of Understanding
NEPA - National Environmental Policy Act of 1969
NOAA - National Oceanic and Atmospheric Administration
NPC - National Petroleum Council
NPR-4 - Naval Petroleum Reserve Numbered 4
NPRA - National Petroleum Reserve in Alaska
NTP - Northern Tier Pipeline
NWA - Northwest Alaskan Pipeline Company
OCS - Outer Continental Shelf (Federal jurisdiction)
OCSEAP - Outer Continental Shelf Environmental Assessment Program
OCSI - Office of Outer Continental Shelf Information, USGS
OFI - Office of the Federal Inspector
OSP - Office of Special Projects, Bureau of Land Management
OSRAM - Oil Spill Risk Analysis Model
PNS - Proposed Notice of Sale
PURPA - Public Utility and Regulatory Policy Act of 1978
RTWG - Regional Technical Working Group, BLM
SESP - Socioeconomic Studies Program, Alaska OCS Office, BLM
SGCF - Sales gas conditioning facility
SID - Secretarial Issue Document, DOI
TAPS - Trans-Alaska Pipeline System
TERO - Tribal Equal Rights Office
U.S.C. - United States Code
USGS - U.S. Geological Survey, DOI
WO - Washington Office, BLM

Acknowledgments

A number of people have provided information and insights to the authors. All of them deserve special thanks. Ralph Anderson, Shehla Anjum, and Karla Kolash of the North Slope Borough; Edward Hopson of the Arctic Slope Regional Corporation; Annie Brower and Al Stevens of the Inupiat Community of the Arctic Slope; Ronald Brower of Ukteagvik Inupiat Corporation; Michael Jefferies of Alaska Legal Services Corporation; Gretchen Keiser, Kurt Fredriksson, and Tom Lawson of the Office of the Governor, State of Alaska; Hoyle H. Hamilton and Lonnie C. Smith of Alaska Oil and Gas Conservation Commission; Bill van Dyke, Department of Natural Resources, State of Alaska; Michael E. Arruda and Jon Tillinghast, Department of Law, State of Alaska; Mark Stephens of the Department of Community and Regional Affairs, State of Alaska; Lenny Boston, Special Assistant to the Commission of the Department of Natural Resources, State of Alaska; Phyllis Casey of the Bureau of Land Management (BLM) Outer Continental Shelf Office, Anchorage; Jerry Wickstrom, Bureau of Land Management, National Petroleum Reserve in Alaska, Anchorage; Paul Lowry of the U.S. Geological Survey (USGS), Anchorage; Skip Braden of USGS, Reston; Lee Barkow, Alaska Program Staff, BLM, Washington, D.C.; and Stephen Lewis and Richard Knowles of ARCO Alaska Inc. were especially generous.

The Field Draft Review Committee helped improve the report in a number of ways. Its members were Paul Lowry, Tom Murrell, Jeff Walker, Charles L. Wilson, Stephen D. Adams, and J. Daniel Fortier, of USGS, Anchorage; Esther Wunnicke, Joan A. Hagans, and Phyllis Casey of BLM's Alaska OCS Office; and David A. Nystrom of the USGS Office of Outer Continental Shelf Information (OCSI), Reston, Virginia. In addition to the Field Draft Review Committee, Louis G. Hecht and Mary Davis, both of OCSI, and Eileen Carlton of the BLM's Washington OCS Office were important in the production of this report. Mr. Hecht gave the report its direction and Ms. Davis provided editorial assistance. Ms. Carlton coordinated the project for BLM.

At Rogers, Golden & Halpern, Fritts Golden provided overall project direction. Sue Gordon helped prepare appendix E. Sandy Dechert edited the report and supervised its production. Mark Yankoski, Kim Tomlinson, Gene Gilroy, Laurie Seniuk, Linda Berger, and Joan McCusker executed the graphics. Richard Barrett, Valerie Smith, Sue McGuire, Sam Karen Norgard, Grace Bader, Norman Hall, Dottie Schmidt, and Kristen Yiengst provided editorial, graphics, and technical support.

Abstract

Due to the amount of Federal and State oil and gas activity in the Arctic subregion and the need for comprehensive planning, State and local officials requested coverage of all oil and gas activity in the area.

The first lease sale of offshore lands in the Beaufort Sea was held by the State of Alaska in 1969. The leasing process for oil and gas exploration on the Beaufort Sea Outer Continental Shelf (OCS) began in April 1976 with the first Federal lease sale in the subregion (Joint Federal/State Beaufort Sea Lease Sale) held in 1979. This sale was held jointly by the Department of the Interior and the State of Alaska because of conflicting jurisdictional claims to certain tracts in the sale area. The jurisdictional dispute will be resolved by the U.S. Supreme Court, but a decision is not expected for several years. The joint sale was held on December 11, 1979. However, bids on the Federal tracts were not accepted until July 1980 because of litigation. Of the 117 tracts offered, 86 were leased as a result of the sale. Of these 86 tracts, 24 are federally managed and 62 are State-managed.

Two exploration plans have been submitted for the federally managed joint lease sale (Sale BF) area. Both plans call for building a gravel island and exploratory drilling of several tracts, but no drilling permits have yet been filed. Three exploratory wells have been drilled on or into State-managed tracts. These include one well drilled directionally into Tract 75, one into Tract 76, and one well drilled from Challenge Island, a natural barrier island. Additional exploratory wells are planned for the 1981-82 drilling season on State-managed tracts.

The next OCS sale in the Beaufort Sea, Lease Sale 71, is proposed for September 1982. The first two sales in the National Petroleum Reserve in Alaska are being planned for December 1981 and the late spring or early summer of 1982 and will involve a total of 2 million acres (809,200 hectares). In anticipation of future leasing, plans for geophysical surveys in the Arctic National Wildlife Refuge are also being formulated.

Four State lease sales have been held in the Arctic, in addition to the Joint Federal/State Lease Sale. These onshore sales have resulted in the leasing of lands on which a number of commercial discoveries have been made, including the discovery of the largest hydrocarbon accumulation in North America at Prudhoe Bay. Exploration, development, and production are continuing on these State lands. The State of Alaska has plans for three future lease sales in the Arctic to be held in the spring of 1982 and 1983 and the fall of 1984. Leasing and exploration are also under way on Arctic Slope Regional Corporation lands.

Transportation systems in the Arctic have been developed to accommodate production on State lands. Some of the production from OCS tracts, as well as other Arctic lands, may be handled by the existing Trans-Alaska Pipeline System. However, a number of additional transportation strategies are being considered, including the Alaska Natural Gas Transportation System, additional oil pipelines, and tanker transport. The pace of oil and gas production in the Arctic will depend in part on the number and type of transportation modes available.

The support bases at Prudhoe Bay are expected to be used to some extent for future activities on the OCS. However, expanded and new facilities will also be required, depending on the location of discoveries on the OCS and on other Arctic lands. The impacts resulting from OCS activities in the Arctic will be particularly important because of their contribution to the regionwide and cumulative impacts arising from Federal onshore, State, and regional corporation oil and gas exploration, development, and production in the Arctic.

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Introduction

The United States is engaged in an effort to extract the oil and gas resources of Federal lands open to petroleum development. The U.S. portion of the Arctic Ocean and the North Slope of the Brooks Range in Alaska (hereafter referred to simply as the Arctic) are of particularly high interest for oil and gas prospecting, and the Arctic is a region with a number of large Federal land holdings. The successful discovery, development, and production of petroleum from State leases at Prudhoe Bay and geophysical and geological data from other State and Federal lands are responsible for this interest. The Arctic is a major domestic petroleum source and the region is expected to be a prime supplier well into the future.

Previous summary reports in this U.S. Geological Survey (USGS) series, written about other regions of the United States, have concentrated on the Outer Continental Shelf (OCS) and offshore and onshore activities related to the exploration, development, and production of petroleum from offshore Federal lands (see sidebar). In the Arctic, a resource-exporting area, petroleum resource development and the transportation of oil and gas south to market are major regionwide issues. To gain a useful overview and to understand OCS development within this regional context, it is necessary to consider all oil and gas activity in the Arctic. The source of petroleum, whether Federal or State lands, onshore or offshore, is of great interest, but the regional view is needed to understand the significance of any one source or program. This report therefore relates information on OCS development from the perspective of all Arctic oil and gas activity. Figure 1 shows the Arctic.

Alaska has a long history of involvement with oil and gas onshore and in State waters. As early as 1853, while Alaska was owned by Russia, there were reports of petroleum in the Cook Inlet area. Claims were staked as early as 1892, and it is believed that the first drilling occurred in 1898 (Barry, 1973). Yet it was not until 1902, in the Gulf of Alaska upland area near Katalla, that a commercial discovery was made. Production continued until 1933, when the small refinery was destroyed by fire. The wells were shut in and never again brought into production. In 1957, another commercial discovery was made on the Kenai Peninsula, in the Swanson River area, by the Atlantic Richfield Oil Corporation. In 1962, the Pan American Petroleum Corporation discovered oil in State waters in Upper Cook Inlet, and by 1969, two refineries had been built at Nikiski, just north of Kenai. There are presently 14 platforms producing oil and gas from State-leased offshore areas in Upper Cook Inlet.

The need for planning to accommodate the impacts of oil and gas development has long been recognized. State and local governments need current information to make these plans. In response to requests of these governments for current information about offshore resources and related onshore activity, section 26 of the Outer Continental Shelf Lands Act Amendments of 1978 (43 U.S.C. 1352) created an Outer Continental Shelf Oil and Gas Information Program, which is now managed by the Office of Outer Continental Shelf Information (OCSI), U.S. Geological Survey, Conservation Division. Authorities and operating procedures are detailed in the Code of Federal Regulations (30 CFR 252), published in the Federal Register of August 7, 1979. Under this program, the Director of the U.S. Geological Survey, in conjunction with the Director of the Bureau of Land Management (43 CFR 3300), has prepared indexes of information used by the Federal Government in its OCS decisionmaking process. The Atlantic, Gulf of Mexico, Pacific, and Alaska Indexes are available to the public. The Alaska Index has been recently updated and is available from the OCSI Office.

The Director of the USGS is also required to make available to affected States regional summary reports of data and information designed to assist them in planning for the onshore impacts of potential OCS oil and gas development and production.

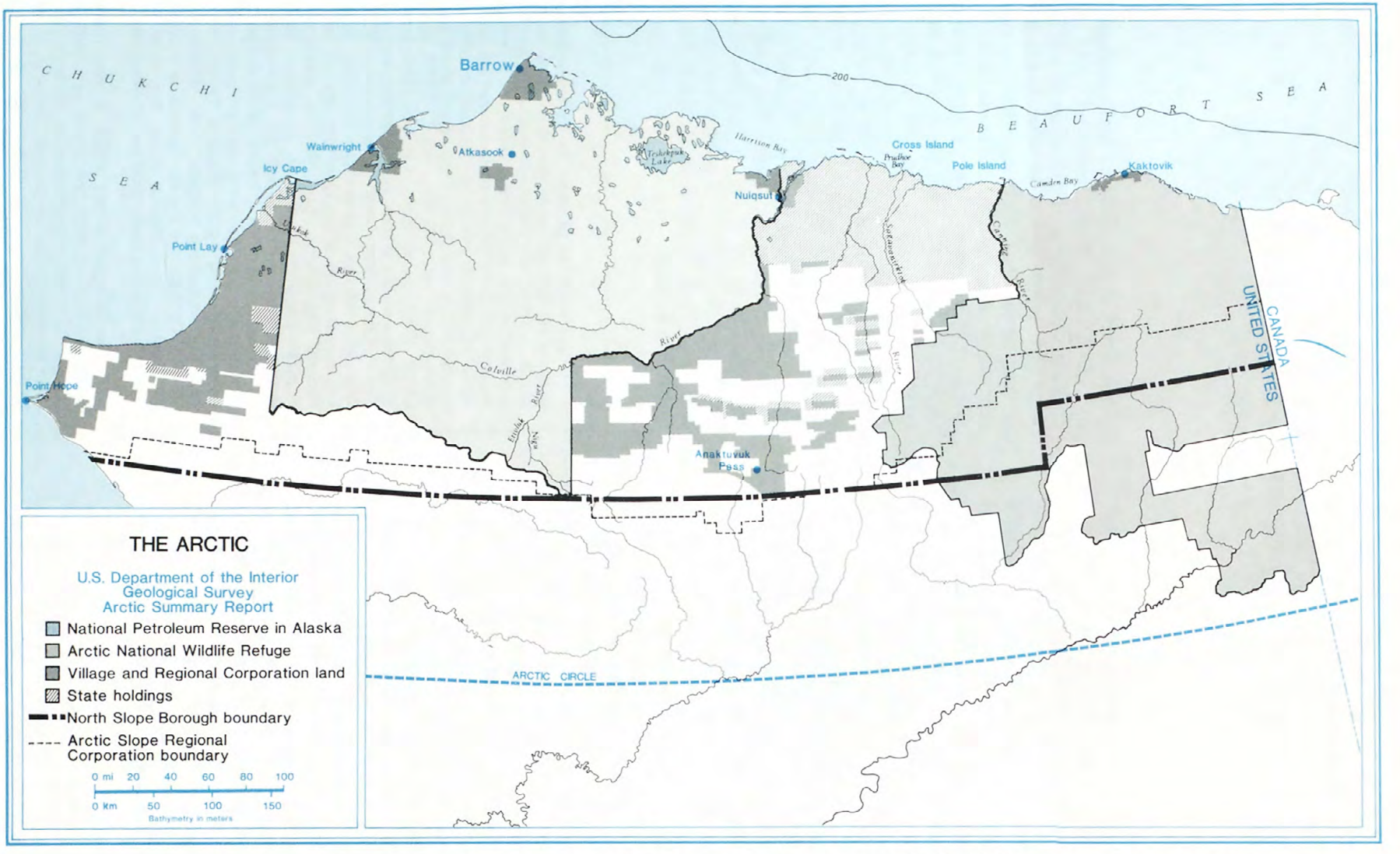

FIGURE 1.--The U.S. Arctic. (Base from USGS, 1976, and data from USGS, 1980b; adapted by Rogers, Golden & Halpern, 1981.)

In 1967, the North Slope petroleum fields were discovered onshore at Prudhoe Bay. The discovery of these fields at Prudhoe eventually led to the construction of the Trans-Alaska Pipeline System (TAPS), which carries oil to southern Alaska for export out of the State. Gas at Prudhoe is being reinjected into the formation until a gas transportation system is completed.

The Alaska OCS comprises 74 percent of the total area of U.S. offshore lands because of the State's 6,640-mile (10,686-km) coastline and the great width of the Continental Margin off Alaska (Jamison, 1981, oral commun.). The sizes of Alaska and the conterminous United States are compared in figure 2. The USGS Conservation Division has divided the State into three subregions for purposes of developing OCS operating orders--the Gulf of Alaska (including Lower Cook Inlet), the Bering Sea, and the Arctic (fig. 3). To date, Outer Continental Shelf Orders have been prepared for the Gulf of Alaska and the Arctic (USGS, 1980a, and USGS, 1981). However, the USGS is now developing operating orders that will apply to the entire Alaska OCS superseding all previous OCS orders. It is anticipated that the proposed orders will be published in the Federal Register in November 1981. The Bureau of Land Management (BLM) has divided the Alaska OCS into 15 proposed planning areas for administrative purposes (see sidebar and fig. 3). Two of the planning areas--Diapir Field and Barrow Arch--correspond to the USGS's Arctic subregion (DOI, 1981b).

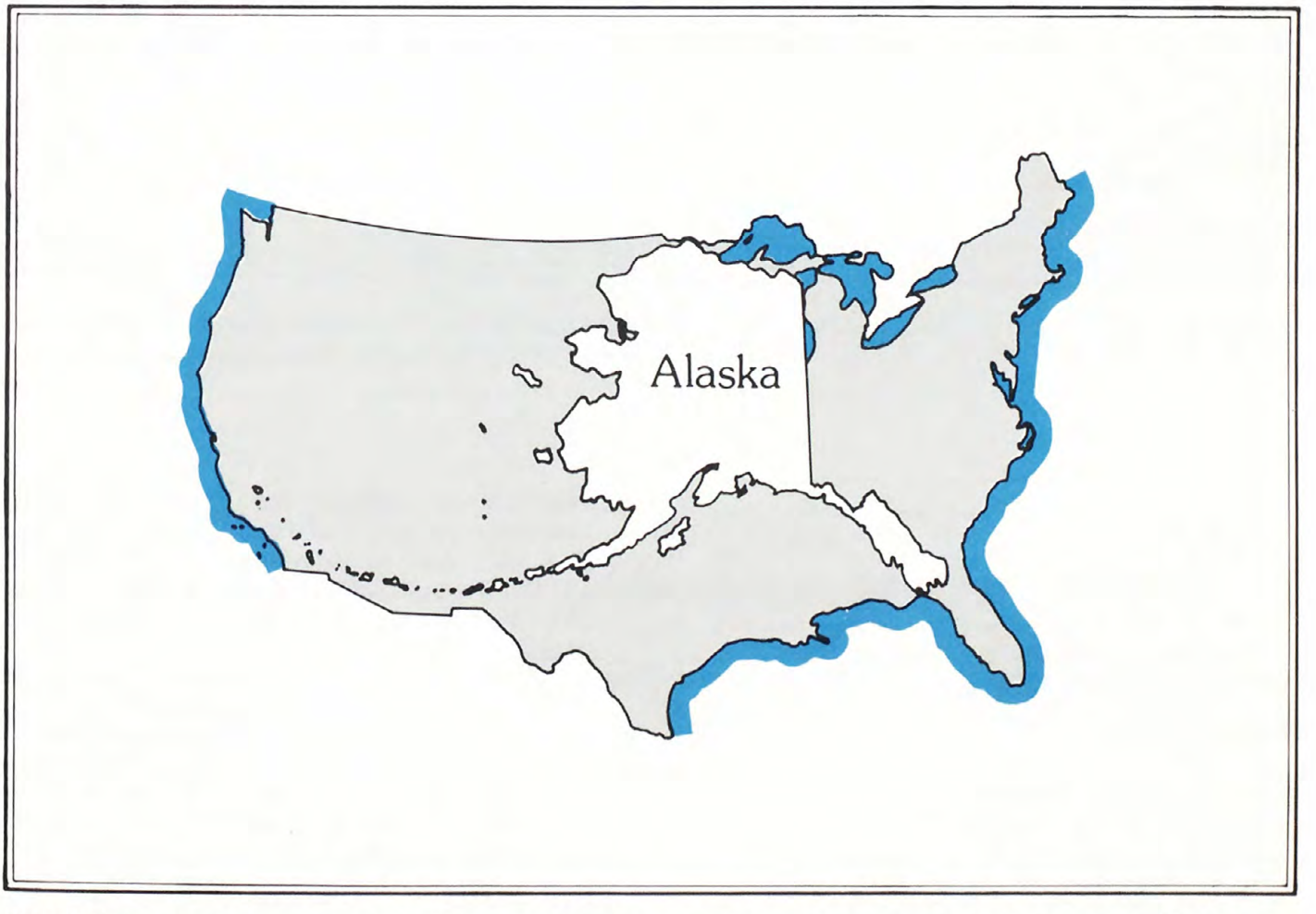

FIGURE 2.--A comparison of the State of Alaska with the conterminous United States. (Adapted from Alaska Geographic, 1980, by Rogers, Golden & Halpern, 1981.)

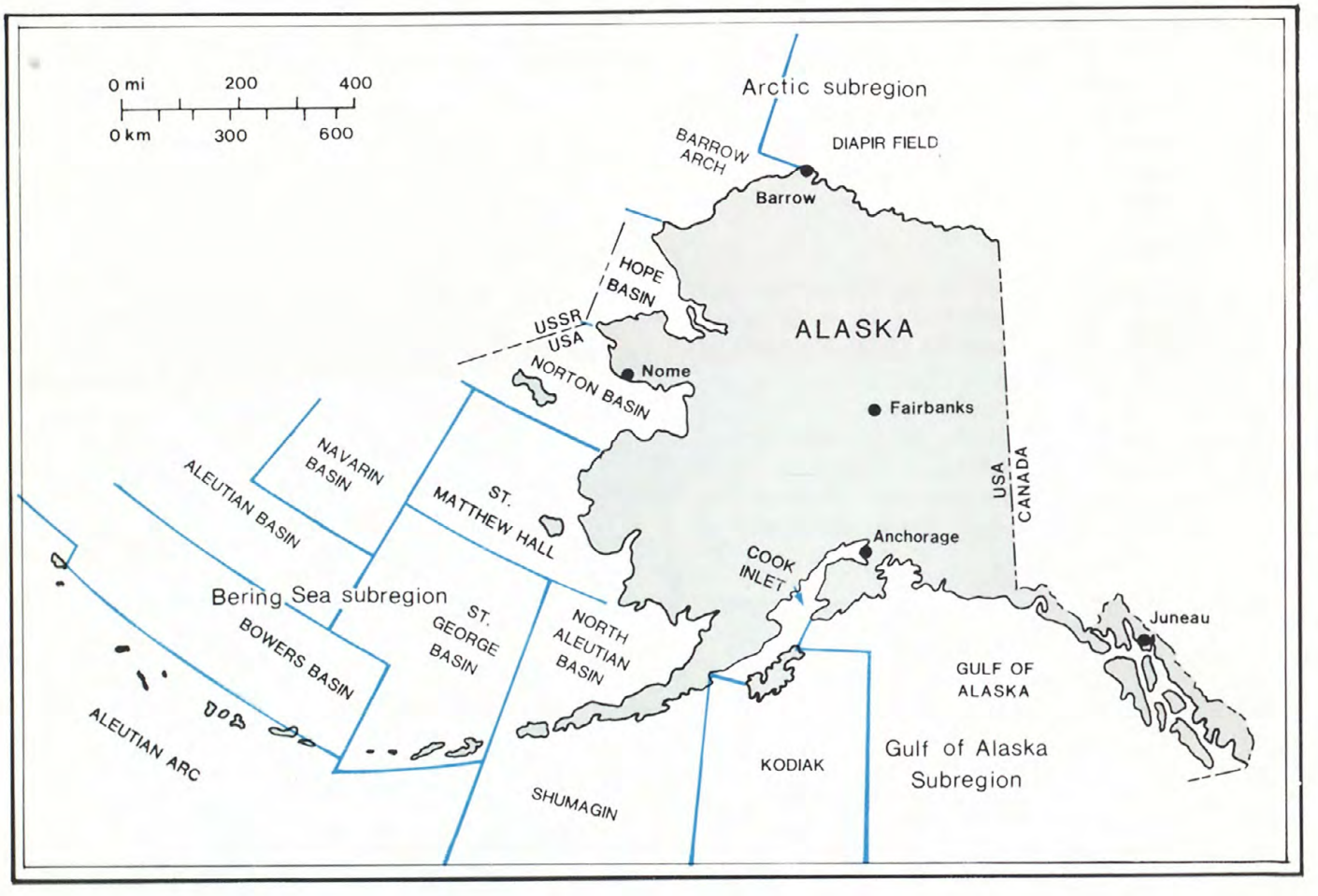

FIGURE 3.--Gulf of Alaska, Bering Sea, and Arctic subregions and planning areas. (Base from Jackson and Dorrier, 1980, and data from BLM, 1981, and DOI, 1981c; adapted by Rogers, Golden & Halpern, 1981.)

New planning areas have been proposed by the Department of the Interior for Alaska that reflect geologic basins more accurately than do the previous boundaries (Carlton, 1981, oral commun.). In addition, the names of several of the planning areas have been changed, and new names have been adapted for newly established areas. In the Arctic, the Diapir Field (formerly Beaufort Sea) and the Barrow Arch (formerly Chukchi Sea) are the revised names.

Six Outer Continental Shelf lease sales have been held in Alaska. Five of these have been in the Gulf of Alaska subregion. (See USGS Open-File Reports 80-1028 and 81-607.) The only OCS sale to be held in the Arctic subregion to date--the Joint Federal/State Beaufort Sea Lease Sale (Sale BF)--was held in Fairbanks on December 11, 1979, by the Department of the Interior and the State of Alaska. Conflicting jurisdictional claims over portions of the proposed sale area led to negotiations between the Federal and State Governments and, eventually, to the joint sale. The call for nominations, issued in March 1978, covered 236 blocks (650,330 acres or 263,124 hectares), all of which were nominated. As a result of State and local concerns, 50 blocks were deleted during the tract selection process by the Department of the Interior. A total of 86 tracts were leased, 24 of which are federally managed. Because of litigation, the Federal bids were not accepted until July 9, 1980, and leases were not issued until July 11, 1980. Three exploratory wells were drilled during the 1980-81 drilling season, all on State leases. Plans for the 1981-82 season include the construction of one gravel island and the drilling of as many as 10 exploratory wells on State-managed leases. Both Exxon and Shell plan to construct a gravel island and possibly begin exploratory drilling on Federal tracts.

The revenues produced by OCS lease sales go to the U.S. Department of the Treasury. These revenues are also used to fund the Land and Water Conservation Fund. Between 1965 and mid-1981, $22,567,028 was used to fund various projects in Alaska. Ninety percent of this money came from OCS revenues (Seacourt, 1981, oral commun.).

A number of other OCS lease sales are scheduled to take place in the region. The June 1980 final 5-year OCS oil and gas leasing schedule for Alaska is given in table 1, and the areas proposed for lease are shown in figure 4. Revisions to the program are currently under way to streamline sale preparation procedures, to offer areas of high potential earlier, and to offer more acreage for leasing. A proposed 5-year leasing schedule was released on July 15, 1981 (table 2). The proposed schedule is subject to revision and is expected to be approved and made final early in 1982. The new schedule increases the number of lease sales in Alaska from 10 to 16 and changes the dates of several previously scheduled sales. This report gives sale dates from both the June 1980 final 5-year leasing schedule and the July 1981 proposed schedule.

Two of the sales in the June 1980 final schedule are proposed for the Arctic subregion. Lease Sale 71, in the Beaufort Sea (Diapir Field), is scheduled for February 1983 (now proposed for September 1982 on the July 1981 schedule); and Lease Sale 85, in the Chukchi Sea (Barrow Arch) is scheduled for February 1985. The July 1981 schedule includes two additional Arctic lease sales in the Diapir Field: Lease Sale 87, scheduled for June 1984, and Lease Sale 97, scheduled for June 1986.

Lease sales are also planned for the Arctic subregion on other Federal lands, as well as State and local lands. The BLM is planning the first two lease sales on the National Petroleum Reserve in Alaska (NPRA) on December 16, 1981, and in spring or

TABLE 1.—Current 5-year OCS oil and gas leasing schedule for Alaska, June 1980.

SALE AREA	Proposed Date	1980	1981	1982	1983	1984	1985
57 Norton Basin	9/82						
70 St. George Basin	12/82						
71 Beaufort Sea	2/83						
61 Kodiak	4/83						
75 No. Aleutian Shelf	10/83						
83 Navarin Basin	12/84						
☆85 Chukchi Sea	2/85						
86 Hope Basin	5/85						

C – Call for Nominations
D – Nominations Due
T – Tentative Tract Selection
E – Draft Environmental Statement
H – Public Hearing
F – Final Environmental Statement
P – Proposed Notice of Sale
$^{S}_{C}$ – State Comments Due
R – Energy Review
N – Notice of Sale
S – Sale

☆ The holding of the Chukchi Sale at this time is contingent upon a reasonable assumption that technology will be available for exploration and development of the tracts included in the sale.

SOURCE: DOI, 1980.

TABLE 2.—Proposed 5-year OCS oil and gas leasing schedule for Alaska, July 1981.

SALE AREA	Proposed Date	1982	1983	1984	1985	1986
71 Diapir Field	9/82					
57 Norton Basin	11/82					
70 St. George Basin	2/83					
75 N. Aleutian Basin	4/83					
83 Navarin Basin	3/84					
87 Diapir Field	6/84					
88 Norton Basin	10/84					
89 St. George Basin	12/84					
85 Barrow Arch	2/85					
92 N. Aleutian Basin	4/85					
86 Hope Basin	7/85					
100 S. Alaska☆	10/85					
107 Navarin Basin	3/86					
97 Diapir Field	6/86					
99 Norton Basin	10/86					
101 St. George Basin	12/86					

C – Call for Information
D – Information Due
A – Area Identification
N – NEPA Document
H – Public Hearing
F – NEPA Document
P – Proposed Notice of Sale
G – Governors' Comments Due
R – DOE Review
N – Notice of Sale
S – Sale

☆ Includes Cook Inlet, Shumagin, Kodiak, Gulf of Alaska

SOURCE: DOI, 1981c.

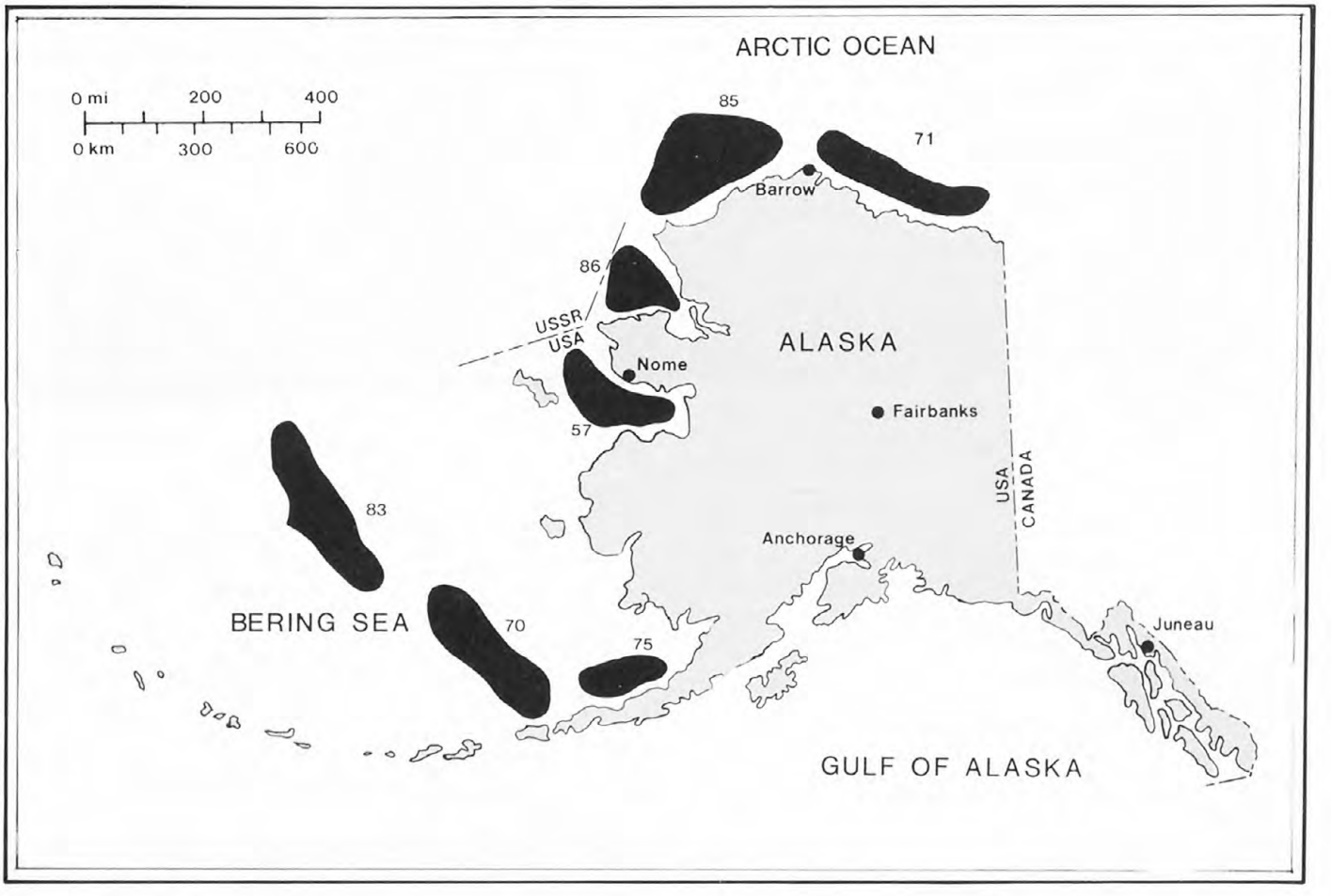

FIGURE 4.--General areas of proposed lease sales in current 5-year OCS oil and gas leasing schedule for Alaska, June 1980. (Adapted from Collins and Stadnychenko, 1981, by Rogers, Golden & Halpern, 1981.)

summer 1982. Approximately 2 million acres (809,200 hectares) of the NPRA are to be offered for lease at these two sales. These sales are the first onshore Federal lease sales in Alaska in 15 years and are the largest sales of onshore leases in history. As directed by the Alaska National Interest Lands Conservation Act of 1980, the Secretary of the Interior has also begun to plan for leasing in the upland area of the North Slope and for seismic work in the Arctic National Wildlife Refuge (ANWR). The investigations in the ANWR that are administered by USGS will include surface exploration and estimation of the potential of the Coastal Plain in this area as a source of petroleum. The State of Alaska has three lease sales planned for the subregion as well; and the Arctic Slope Regional Corporation is also planning to lease land for petroleum operations. Table 3 summarizes oil and gas activities on Federal lands in the Arctic, and table 4 summarizes oil and gas activities on State lands in the Arctic.

The natural gas being reinjected at Prudhoe Bay, as well as plans for increased leasing in the Arctic Ocean and on the North Slope, has resulted in efforts to construct a gas pipeline system. Portions of a gas pipeline network, the Alaska Natural Gas Transportation System (ANGTS), are now being constructed in Canada and the conterminous United States. These sections will carry surplus Canadian gas to the United States until an Alaska segment of ANGTS is constructed to deliver natural gas from the North Slope to the rest of the United States. If completed, the project will be the largest private venture in history. There is Federal Government interest in the completion of the ANGTS because of the gas potential of the North Slope and the expected savings on imported

TABLE 3.—Oil and gas activities on Federal lands in the Arctic

	Pre-lease-sale	Lease sale	Exploration
OCS	Seismic reflection profiles, total magnetic field measurements, refraction lines, gravity data; USGS and U.S. Coast Guard, 1969 through 1970's	Joint Federal/State Beaufort Sea Lease Sale; December 11, 1979	None to date
		Lease Sale 71; February 1983 (now proposed for September 1982)	None to date
NPRA	Geologic mapping; USGS; 1923-26	Two planned: December 1981 and spring/summer 1982	No private exploration to date; all exploration has been under Federal Government sponsorship, including development of Barrow gas fields
	Seismic reflection profiles, aeromagnetic flight lines, seismic refraction profiles, gravity data, shallow core and test wells; U.S. Navy; 1944-53		
	Seismic lines, geophysical and geochemical surveys, gravity data, test wells, USGS and U.S. Navy, 1953 to present		
ANWR	Geological and geophysical surface exploration by industry planned to begin early 1983	None planned	None to date
Other Federal Land	Assessment of industry and public interest in leasing under way	None planned	None to date

fuel. Several routes to refineries in the northern States have been considered by industry and the Federal Government. Another proposed pipeline, the Northern Tier Pipeline, would carry large volumes of Alaska oil from the West Coast to markets in the northern tier and inland States.

Although pipelines are presently the preferred transportation mode for oil and gas in the United States, the Departments of Transportation and Commerce are continuing to study the technical, economic, and operational feasibility of future tanker transport in the Arctic Ocean. Tankering is also being seriously considered by Canada for transport of Canadian Arctic oil and gas. Canadian studies on the feasibility of year-round tankering in the Arctic Ocean are presently under way.

The Arctic Summary Report, like other summary reports in the series, is designed to assist the State and local communities in planning for future OCS activity. The Arctic's

TABLE 4.—Oil and gas activities on State lands in the Arctic

(bpd = barrels per day)

Lease Sale[1]	Exploration	Discovery announced	Development	Production
Lease Sale 13 December 9, 1964	Prudhoe	January 1968	1968 to present	1977 to present: 1.5 million bpd
Lease Sale 14 July 14, 1965	Kuparuk	Early 1970's	Under way	Expected to begin April 1982: 60,000 bpd
Lease Sale 18 January 24, 1967	Lisburne West Mikkelsen Point Thomson	Early 1970's None to date 1972		
Lease Sale 23 September 10, 1969	Duck Island Sag Delta Milne Point Gwydyr Bay	October 1980 April 1981 April 1981 April 1981	June 1981	
Joint Federal/ State Beaufort Sea Lease Sale December 11, 1979	Sag Delta Challenge Island	1980-81		
Lease Sale 31 September 16, 1980	None to date			
Lease Sale 34 May 26, 1982				
Lease Sale 36 May 26, 1982	None to date			
Sale planned Spring 1983				
Sale planned Fall 1984				

[1] Acreage from these sales overlaps.

SOURCES: Alaska Oil and Gas Conservation Commission, 1981; Keiser, 1981, oral commun.

social and environmental factors differ dramatically from those of other OCS regions. The development of the Prudhoe Bay field stimulated the formation of the North Slope Borough, the only Native-controlled regional government in the nation (McBeath, 1981). Incorporated in July 1972, it is the largest U.S. municipality in land area, covering approximately 88,000 square miles (227,920 km2), or 15 percent of the State. Yet it has one of the smallest regional populations: about 4,300 permanent residents live in eight widely dispersed Native villages.

This summary report begins with a chapter describing the Arctic subregion. Sections of this chapter discuss the geology of the area, including the most recent OCS oil and gas resource and reserve estimates, climate, sand and gravel, the biological environment, the people, and current land use. The magnitude and timing of oil and gas activity are discussed in chapter 2. The third chapter presents information on oil and gas transportation strategies. Chapter 4 describes the nearshore and onshore facilities and impacts that are occurring and/or probably will occur as a result of current and projected lease sales. Appendixes provide further detail, and a glossary presents definitions of geologic, industry-specific, and other special terms used in the report.

OCS resource and reserve estimates presented in the summary report reflect the most recent Federal Government information. In preparing this report, interviews were conducted with Federal officials, oil industry representatives, and State and local officials. Two trips to Alaska were made in April and May, 1981. Concerns voiced in these interviews and those already identified in published documents resulted in the identification of issues that are treated in this summary report. As a result, this report differs from other summary reports produced in this series. State and local officials desired a report that covered all oil and gas activity in the subregion. The report is based in part on data collected by Federal agencies in the course of planning, leasing, and managing the Arctic OCS and on studies and reports of OCS activities that have been prepared outside the Federal Government.

As exploration of the Arctic subregion continues, our knowledge of the subregion's resource potential will improve. In the event of either a discovery of oil or gas in commercial amounts or another lease sale, future editions of the summary report will include the most recent resource and reserve estimates, anticipated production curves, transportation strategies, and descriptions of existing and anticipated nearshore and onshore support activity and production facilities.

Due to the uniqueness of social and environmental factors encountered in Alaska and the number of lease sales scheduled for the State, the Office of Outer Continental Shelf Information prepares separate reports for each of the three Alaska subregions.

This report, the **Arctic Oil and Gas Summary Report,** is the seventh in a series of summary reports. It was preceded by reports on the Mid-Atlantic, Pacific (Southern California), South Atlantic, Gulf of Mexico, Gulf of Alaska, and North Atlantic. After an initial summary report has been published, it is periodically updated. A new summary report is prepared when a significant event--usually either another lease sale or a commercial discovery--takes place in the region. New summary reports for the Gulf of Alaska and Gulf of Mexico have just been published, and a summary report for the Bering Sea subregion of Alaska will be written after the first Bering Sea OCS lease sale is held.

The Office of OCS Information staff is available to assist State agencies if additional information or clarification is desired (telephone: (703) 860-7166).

1. The Setting

The Arctic is unique among OCS leasing regions in its climate, the importance of geomorphic features such as permafrost and sea ice, the amount of wildlife habitat that it includes, and the lifestyle of its residents, the Inupiat people. This chapter provides a discussion of many of the geologic, environmental, and cultural features of the Arctic. A broad overview of the North Slope and its adjacent offshore areas is given first, followed by a discussion of the arctic climate. The next section discusses geologic aspects of the subregion, including bedrock geology, sand and gravel, and environmental geology, that affect petroleum exploration and development. The area's geologic setting is presented in more detail in appendix A. A discussion of various procedures used by the Federal Government to estimate hydrocarbon potential is given in the third section, as well as the most recent information available on oil and gas resources in the subregion. Appendix B provides further information on hydrocarbon potential estimates. The fifth section provides an overview of the biological environment and the final sections provide information on the Inupiat and land use in the Arctic. A history of the Inupiat is presented in appendix C.

OVERVIEW

The North Slope includes an area of over 88,000 square miles (228,000 km2). The Arctic is generally divided into three physiographic provinces: the Brooks Range-Southern Foothills, the Northern Foothills, and the Coastal Plain. The extent of these provinces is shown in figure 5. The Continental Shelf north and west of the North Slope is essentially an extension of the Coastal Plain Province.

The Brooks Range (fig. 6) consists of rugged, glaciated, east-trending ridges, rising to elevations of 8,000 feet (2,438 m). Cliff and bench topography, typical of glacially carved sedimentary rocks, is characteristic of these mountains. North of the Brooks Range, the Southern Foothills rise to heights varying from 1,200 to 3,500 feet (365-1,065 m). These hills are characterized by irregular buttes, east-trending ridges, and intervening tundra plains. The Northern Foothills have similar features, but they rise to only between 600 and 1,200 feet (183-366 m). The flat topography of the Coastal Plain extends from the northern edge of the foothills to its limit beneath the Beaufort and Chukchi Seas. Numerous large rivers and smaller streams flow northward across the Coastal Plain, and thousands of thaw lakes dot its surface. Drainage is quite poor, as a consequence of the flat terrain and the occurrence of impermeable permafrost beneath a shallow active freeze-thaw layer. A system of lagoons and barrier islands lies beyond the Beaufort Sea and Chukchi Sea coastlines. The islands are approximately 2 to 20 miles (3.2-32.2 km) offshore. The Continental Shelf of the Chukchi Sea is quite shallow, with depths of less than 300 feet (91.5 m) extending several hundred miles offshore. The Beaufort Sea, however, has a narrow shelf which extends 30 to 60 miles (48.3-96.5 km) from the coast where depths are less than 600 feet (200 m) (University of Alaska, 1975).

CLIMATE

The North Slope is within the Arctic Climate Zone, characterized by windy, dry, and cold conditions. Seasonal variations in

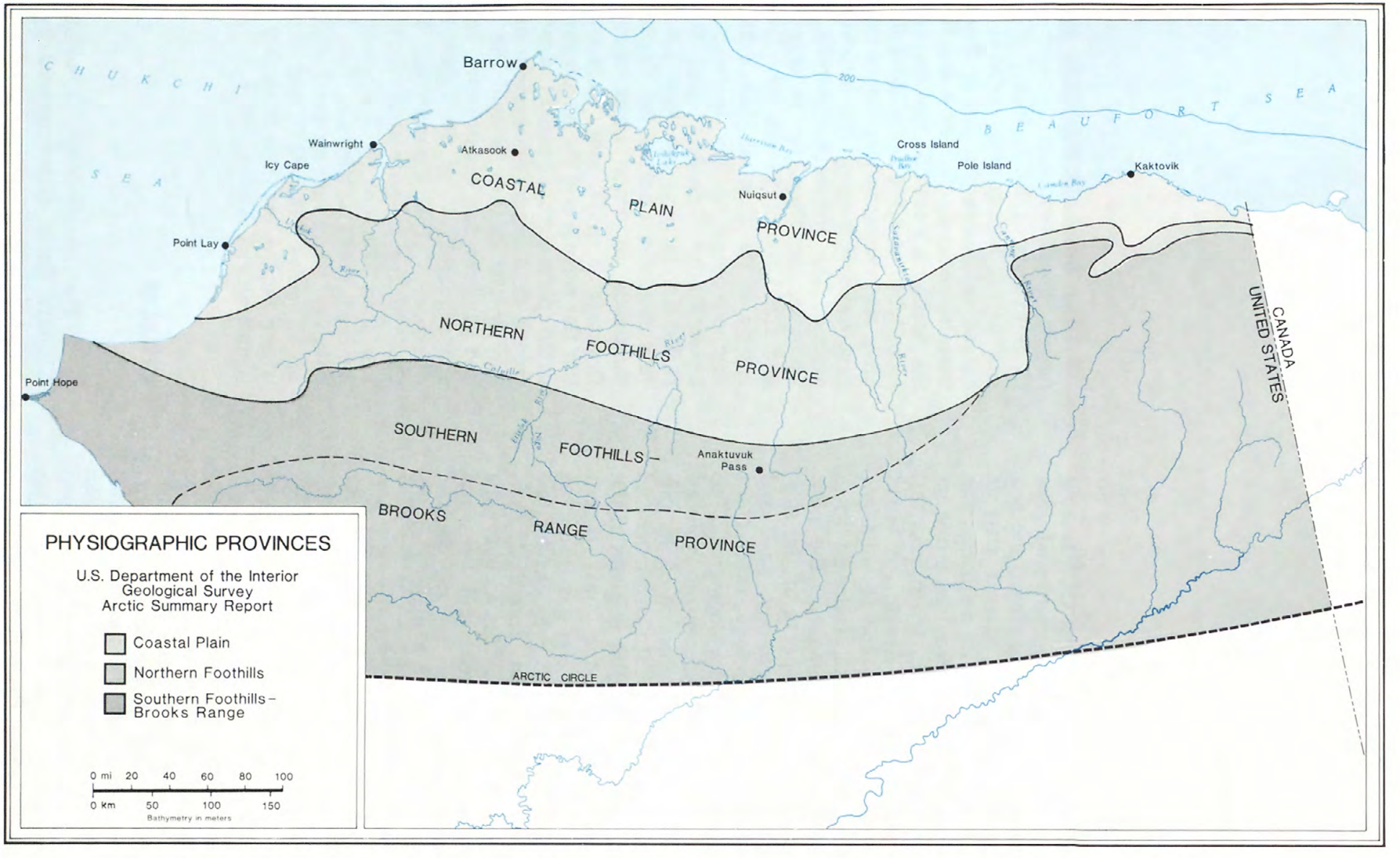

FIGURE 5.--Physiographic provinces of the Arctic. (Base from USGS, 1976, and data from Bird, 1981; adapted by Rogers, Golden & Halpern, 1981.)

FIGURE 6.--The Brooks Range. (Photograph by Joseph C. LaBelle, Arctic Environmental Information and Data Center.)

temperature, photoperiod, and ice conditions are extreme. These climatic conditions control aspects of topography, hydrology, and the biological environment. Climate also contributes to the existence of some of the most important hazards to oil and gas development in the Arctic.

Winds are persistent, with a prevailing easterly direction at the coast. Precipitation is low throughout the area. Average annual precipitation ranges from more than 40 inches (102 cm) in the highest elevations of the Brooks Range to less than 5 inches (12.7 cm) in the foothills and Coastal Plain. Rain accounts for most of the annual precipitation. Fresh water is a scarce resource because of the lack of precipitation, as well as the fact that groundwater is not available due to the presence of permafrost. In winter, when most surface water is completely frozen, fresh water must be obtained by melting snow, from artificial reservoirs, or from the major streams.

The average annual minimum temperature in the foothills is about -35 degrees F (-37 degrees C), while on the coast it is about -25 degrees F (-32 degrees C). Average annual maximum temperatures range from the mid-40's to the mid- to low-60's F (5 to 20 degrees C) (University of Alaska, 1975).

Strong winds can cause whiteouts, during which blowing snow obscures even nearby objects. Fog frequently reduces visibility, especially along the coast when open water is present from May through September (University of Alaska, 1975). Reduced visibility can constitute a hazard, especially to aviation. This is significant because air transportation is virtually the only reliable means of year-round access to the Arctic.

Storm frequency is highest during the summer months, peaking in August. Along the coast, gale-force winds have been reported to cause surges as high as 10 feet (3 m). Sea surges are known to occur even in the presence of nearly complete ice cover (BLM, 1979b).

Seasonal changes in temperature and other climatic factors govern the freeze-thaw cycle on land and in offshore areas. The average annual depth of thaw on land is about 2.5 feet (0.8 m). Sea ice completely covers offshore areas for up to 10 months and retreats in summer to a distance of only 30 to 40 miles (48.3-64.4 km) north of the Beaufort coast. A discussion of the important features of sea ice with regard to oil exploration and development activities is given below under Environmental Geology.

Seasonal variations in the amount of time during which the sun is above the horizon are extreme. At Barrow, for example, the total elapsed time without complete darkness is more than 110 days and includes May, June, and July. The latter half of this period corresponds to a high level of biotic productivity and the presence of numerous migratory species. For more than 66 days, including the months of December and January, the sun does not appear above the horizon. This extended period of darkness falls during the middle of the long winter when most animals have migrated south.

GEOLOGY

Bedrock Geology

The boundaries of the three physiographic provinces of northern Alaska are given definition by three major tectonic features: the Brooks Range Orogen, the Colville Trough, and the Barrow Arch (Bird, 1981). Figure 7 shows the extent of these structural elements.

The bedded rocks of northern Alaska range in age from Precambrian to Holocene and are generally divided into three sequences that reflect the major stages of the tectonic development of the area. The three sequences are the Franklinian (pre-Mississippian), the Ellesmerian (Mississippian to Jurassic), and the Brookian (Cretaceous and Tertiary). The petroleum potential of these sequences has been indicated by stratigraphic test, exploratory, and development wells drilled as a result of both Government and private efforts.

Franklinian rocks constitute basement for petroleum activities (Grantz, Holmes, and Kososki, 1975). Derived from sources north of the present coastline, Franklinian rocks slope from shallow depths along the Barrow Arch southward into the Colville Trough, where they reach a depth of 30,000 feet (9,100 m), and crop out in the Brooks Range (Bird, 1981).

Ellesmerian sediments, also derived from a northern source, extend over the Franklinian strata from the Barrow Arch throughout the foothills and Coastal Plain. Along the northern flank of the Arch, the sequence is truncated and appears to be absent from the eastern Beaufort Shelf (Grantz and others, 1980). The exact distribution of Ellesmerian rocks in the Coastal Plain areas east of the Canning River is unknown (Grantz and Mull, 1978). The Ellesmerian sequence contains

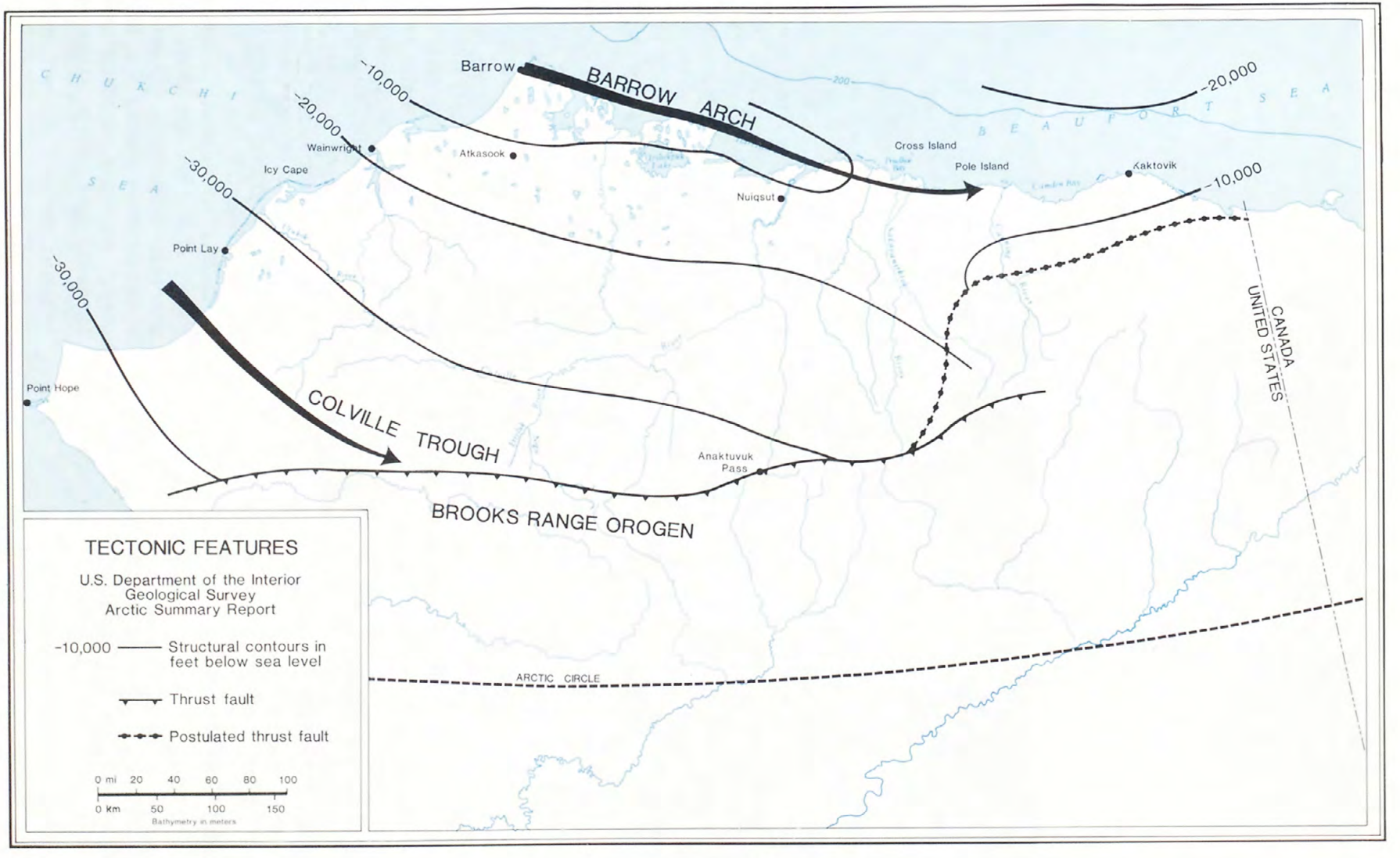

FIGURE 7.--Tectonic features of northern Alaska. (Base from USGS, 1976, and data from Bird, 1981; adapted by Rogers, Golden & Halpern, 1981.)

some hydrocarbon source rock and the best reservoir found to date on the North Slope, that at Prudhoe Bay (Carter and others, 1977).

The third sequence, the Brookian, derives from southern sources. As the Brooks Range was uplifted, regional subsidence led to the formation of the Colville Trough to the north. Large volumes of debris were shed northward, and Brookian sediments consequently crop out over most of the foothills and the entire Coastal Plain (Bird, 1981). Continued uplift led to a northward migration of centers of deposition such that Cretaceous sediments are now found in the southern Chukchi Sea, and Tertiary deposits, overstepping the Barrow Arch, are found on the Beaufort and northern Chukchi Shelves (Grantz and others, 1975). In addition, some shale diapirs are found in the northern Chukchi Sea and along the Beaufort Continental Slope north of the Arctic National Wildlife Refuge. Overpressured shale diapirs may cause problems for deep drilling (Grantz and Dinter, 1980). The major sources of principal oil accumulations are believed to be the Shublik (Triassic), Kingak (Jurassic), and the deep Post-Neocomian shales (Seifert, Moldowan, and Jones, 1979).

Geohazards in the Beaufort and Chukchi Seas include permafrost, shallow gas, sea-ice hazards, earthquakes, slumping and sliding of unconsolidated sediments, and coastal erosion. These hazards are discussed below under Environmental Geology. Additional hazards posed by storm surges and overpressured shale were noted above.

Further discussion of the petroleum geology of the Arctic and a generalized cross section are presented in appendix A.

Sand and Gravel

In the Arctic, sand and gravel are essential materials for the construction of both onshore and offshore structures. Gravel, in particular, is required for building artificial islands in offshore areas and onshore pads on which housing, land-based support facilities, airstrips, and roads are constructed. These sand and gravel pads provide a working surface for construction that helps to prevent permafrost degradation, and gravel islands are also used to withstand ice movements.

Many millions of cubic yards of gravel will be required for continued exploration and development activities in the Arctic (USGS, 1979). Gravel requirements for artificial offshore islands vary with the depth of water in which the island is constructed and with whether it is to be used for exploration or development. Typically, a gravel island for exploration is about 300 feet (91.5 m) in diameter, with the working surface about 10 feet (3 m) above the water (fig. 8). In 20 feet (6 m) of water, about 250,000 cubic yards (192,125 m3) of gravel are needed. In 30 feet (9.1 m) of water, the requirement rises to 500,000 cubic yards (384,250 m3), and at 60-foot (18.3-m) depths, to 2.5 million cubic yards (1,900,000 m3). If production is undertaken from an exploratory artificial island, the diameter must be doubled to about 600 feet (183 m) (Wilson, 1981, oral commun.).

Gravel is in short supply in some parts of the Alaskan Arctic, and it is scarce west of the Colville River (Barkow, 1981, oral commun.). In addition, not all deposits are available for use. Gravel deposits occur along the floodplains of streams and major rivers, such as the Colville and the Sagavanirktok. These deposits may exist only as thin surface layers, requiring extensive mining (USGS, 1979). The Colville, Utukok, and Etivluk-Nigu Rivers are currently under study for inclusion in the Wild and Scenic River System and may not be available for mining. A sheet of Pleistocene gravel underlies the Coastal Plain and Continental Shelf to the 50- to 66-foot (15.2-20.1 m) isobath east of the Colville River and Harrison Bay. This gravel is generally perennially frozen and icebound, and it lies beneath waters less than 5 feet (1.5 m) deep. However, deposits beneath wide river channels and deep lakes are thawed to

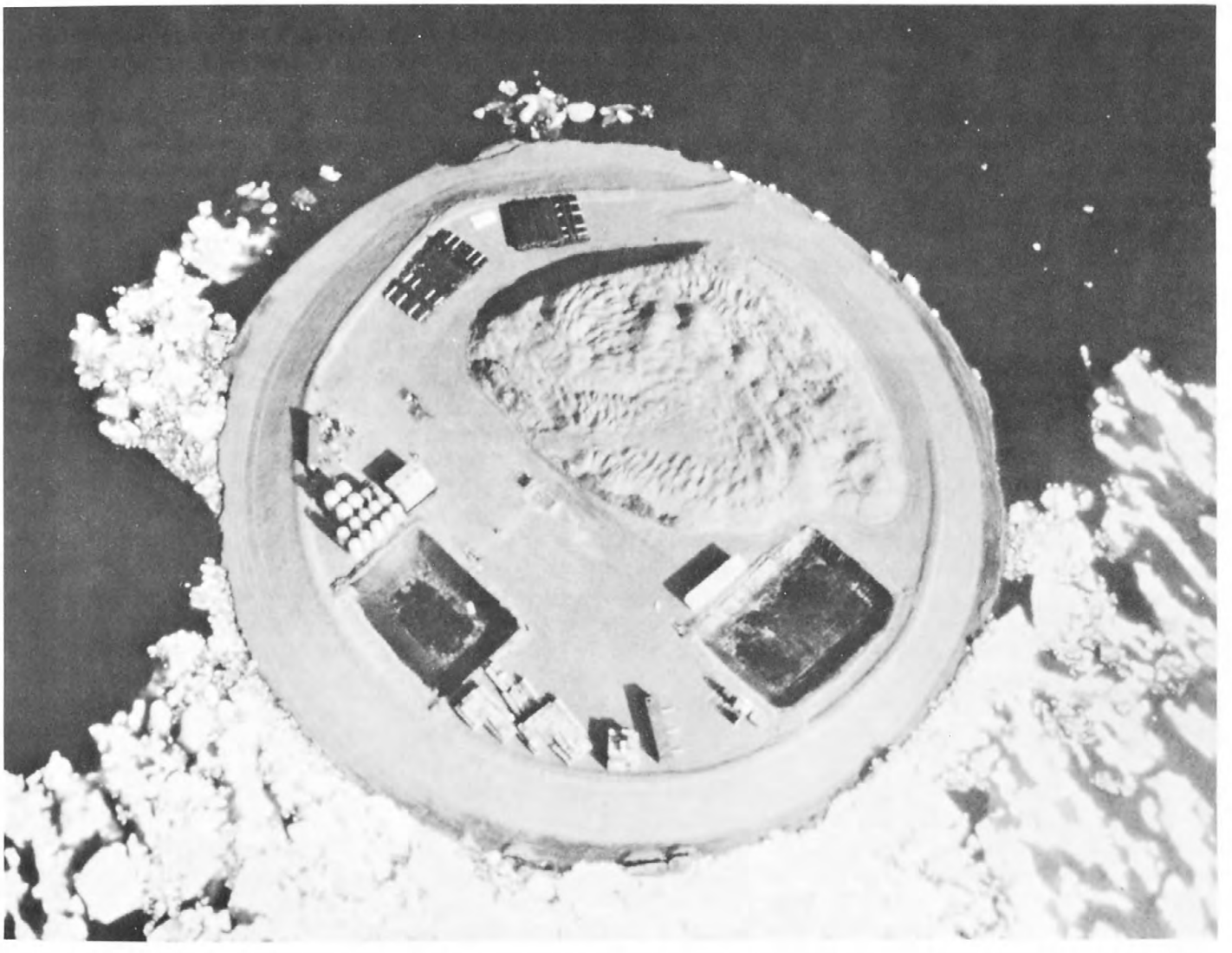

FIGURE 8.--Offshore gravel island. (Photograph from Rogers, Golden & Halpern files.)

considerable depths. Finally, sand dunes are found in areas just west of the Colville River, and small supplies of sand and gravel exist on beaches and barrier islands (BLM, 1979b). However, extraction of sand and gravel from barrier islands is prohibited under State law.

Environmental Geology

The geomorphology of the North Slope and its adjacent Continental Shelf has resulted from the interaction of geologic and climatic characteristics. Permafrost, sea ice, and glaciers have been extremely influential in shaping the geologic environment of both onshore and offshore areas. Permafrost and sea ice continue to be important geohazards to oil and gas operations.

Permafrost is permanently frozen ground. It is overlain by what is called the active layer, a zone of soil that freezes and thaws annually as seasons change. The active layer varies in thickness from several inches to 3 feet (a few centimeters to 1 m). The

thickness, areal extent, and temperature of permafrost and its active layer depend on local differences in climate, topography, vegetation, geology, hydrology, the rate of heat flow within the earth, and surface reflectivity. Changes in one or a combination of these factors as a result of construction or other activities can lead to degradation of permafrost and thickening of the active layer. Changes in the thermal regime can, in turn, result in thermokarst subsidence, ponding, gullying, slumping, siltation, and erosion (USGS, 1979).

Permafrost occurs throughout the Coastal Plain, as well as in the foothills and Brooks Range. It reaches depths of 1,300 feet (400 m) at Barrow and 1,970 feet (600 m) at Prudhoe Bay (University of Alaska, 1975). Between the shore and the barrier islands, permafrost lies at highly variable depths beneath the sea floor. Relict permafrost (permafrost that formed when changes in sea level exposed land which is now submerged) may occur seaward of the barrier islands, although its exact distribution is unknown (Grantz and others, 1980). Ice-bonded permafrost probably aggraded to depths of 985 feet (300 m) during the last glacial period. When it was reflooded by the rising sea, most of the permafrost warmed and melted. However, some of it probably survived as relict permafrost (Grantz and Dinter, 1980).

A detailed understanding of the vertical and horizontal distribution of offshore permafrost is important for a number of reasons, including pipeline construction considerations. First, care must be taken during installation of subsea pipelines when fully ice-bonded permafrost is encountered offshore. Precautions are required to avoid melting-induced failures beneath pipelines and drill platforms. Shallow free gas may pose another hazard. Though the extent of shallow gas is not well established, it is found within and beneath permafrost and is inferred to underlie solid gas hydrates beneath the deepest parts of the Outer Continental Shelf and Slope and to form scattered concentrations in loosely consolidated Quaternary sediments. Pockets of gaseous methane, occurring within permafrost or sediments or resulting from the decomposition of gas hydrates, can be released during drilling operations unless drilling mud is properly cooled (Grantz and Dinter, 1980). Knowledge of permafrost distribution is also important in determining whether directional drilling can reach below the center of critical sea-floor habitats (BLM, 1979b).

One special factor in the Arctic is the seasonal ice conditions. Ice is a significant constraining factor on development (BLM, 1979b). In the Chukchi Sea, south of Icy Cape, the period of ice cover averages 7 to 8 months in a single year, and sea ice melts and reforms each year. In the Beaufort and northern Chukchi Seas, ice cover is present for 9 or 10 months of the year and often longer, and the same ice lasts for more than 1 year (University of Alaska, 1975). Sea ice in the Arctic is generally described in terms of three zones: the thin annual landfast, or shorefast, ice of the inner shelf; the shear zone (stamukhi zone), which is the area of interaction between the landfast ice and the polar ice pack and contains grounded ice ridges; and the polar pack of new and multiyear floes, pressure ridges, and ice island fragments (Grantz and others, 1980).

The landfast ice zone extends from shore out to the 33- to 66-foot (10.1- to 20.1-m) isobath, and by May, landfast ice is in continuous contact with the sea floor to the 7-foot (2.1-m) isobath (Grantz and others, 1980). Throughout most of the year, ice movements landward of the barrier islands, where water is up to 26 feet (7.9 m) deep, are limited. However, large movements can be anticipated during freezeup (fall and early winter) and breakup (late spring and early summer), especially when summer storm surges carry ice into shallow water or, during winter, when extreme pressure from the pack ice causes grounded ice to be thrust toward shore (BLM, 1979b). The potential for ice damage to floating drilling vessels, the short period of ice-free water, and the shallowness of the water have resulted in the development and use of artificial gravel islands as drilling platforms. Gravel causeways and elevated pipelines running along them would be particularly sensitive to lateral

ice movements and the formation of tidal and tension cracks (BLM, 1979b). At Prudhoe Bay, however, the docks and extended causeways have been designed to withstand such lateral ice movement (Smith, 1981, written commun.).

The location of the shear ice zone is controlled by coastal and subsea topography. Pronounced linear pressure and shear ridges form along the landfast-polar pack ice boundary (fig. 9), and many are stabilized by grounding. These ridges are interspersed with floes of first-year and multiyear ice and ice island fragments. Grounded pressure ridge keels exert tremendous stress on the sea floor and on any structures present in a band of varying width between the 33- and 130-foot (10.1- and 34.6-m) isobaths (Grantz and others, 1980).

The pack ice zone beyond the shear zone consists predominantly of multiyear floes 7 to 13 feet (2.1-4.0 m) thick that are constantly in motion. The general drift of the pack ice in the Beaufort Sea is westerly, under the influence of the clockwise-rotating currents of the Arctic Gyre. Pack ice pressure, combined with wind and current influences, can cause ice to extensively gouge the sea floor from the 33-foot (10.1-m) isobath out to water depths of at least 200 feet (61 m) (Grantz and others, 1980). Knowledge of the depth and extent of ice gouging will be critical for routing buried pipelines to the mainland. Information on pack ice conditions, which has never been gathered or assessed, will be increasingly important for future Federal OCS lease sales. Studies intended to fill these critical gaps in

FIGURE 9.--Pressure ridges in Arctic sea ice. (Photograph by Joseph C. LaBelle, Arctic Environmental Information and Data Center.)

environmental data are not expected to be completed before Lease Sale 85 is held in 1985 (BLM, 1981).

Hazards associated with other aspects of the geology of the Arctic OCS include earthquakes, sediment instability, and coastal erosion. Seismic activity on the Beaufort OCS appears to be confined to an area of young faulting and Holocene uplift off Camden Bay. The largest earthquake recorded in northern Alaska since 1935 occurred in February 1968 and registered 5.3 in magnitude. Areas adjacent to the active seismic zone near Camden Bay, as well as the Beaufort Sea OCS, are underlain by poorly consolidated Holocene sediments. These sediments have low shear strength and are susceptible to tectonically triggered instability. This instability poses the greatest potential hazard to pipelines and platforms seaward of the 165- to 215-foot (50.3- to 65.5-m) isobaths, where massive slumps and active slides have been noted. Shoreward of the 165-to 215-foot (50.3- to 65.5-m) isobath, Holocene sediments thin and regional slopes become gentler. Surficial sediments are, however, frequently disrupted by sea ice gouges, and coastal bluffs are subject to mass wasting and slumping. The Beaufort Sea coastline retreats an average of 3 to 10 feet (0.9-3 m) per year as a consequence of the erosion of ground ice and frozen soil by surface water. Coastal erosion rates of 100 to 165 feet (30.5-50.3 m) have been recorded at promontories during storms. Coastal thermokarst erosion and barrier island migration will be significant factors in the lifetime of structures sited in coastal areas (Grantz and others, 1980; Alaska OCSEAP Newsletter, 1981).

HYDROCARBON POTENTIAL

Estimating Hydrocarbon Potential

It is extremely difficult to estimate how much oil and gas are in any given area until that area has been extensively explored by drilling.

For Arctic areas that have not been extensively drilled, such as the Beaufort Sea OCS, the region's resources are estimated in terms of undiscovered resources: quantities of oil and gas that have been postulated to exist outside known fields. Estimates of undiscovered resources are made by identifying areas of resource potential on the basis of broad geological knowledge and theory. Until a well has been drilled, investigators derive all their knowledge of subsurface geology indirectly, from geologic and geophysical data collected at the surface. Using available data as a basis for further investigations, petroleum geologists then conduct a variety of geologic assessments of the region.

An undiscovered recoverable resource estimate is an assessment of resources that can be extracted economically under existing technology and price/cost relationships, assuming normal short-term technological growth. This figure provides a regionally based estimate of the possible amounts of recoverable oil and gas in a broad area. Once the leasing process begins and blocks are selected for environmental study and analysis, this estimate is refined to one that represents the possible amounts of resources that may exist in blocks subject to study.

Two kinds of estimates are produced for study purposes in the pre-leasing process: a conditional resource estimate and a risked resource estimate. A conditional resource estimate is developed for an environmental impact statement (EIS). This estimate assumes that geologic conditions exist such that oil and gas are present and may be contained in traps within the proposed lease area. The possibility that the area is devoid of all oil or gas is not considered in this estimate. Based on conditional estimates, scenarios of exploration, development, and production activities are developed. These scenarios are then evaluated in terms of their potential impacts. Conditional resource estimates produced for a sale are probabilistic in nature. They are generated by a computer simulation model that utilizes the available geologic, engineering, and economic data and allows the uncertainty associated with various geologic and engineering parameters to be incorporated in the estimate.

The risked resource estimate takes this process one step further by incorporating an

economic risk. The effect this step has on the estimate is to lower it by some amount due to the risk that oil or gas may not be present in commercial quantities. The risked resource estimates are developed prior to the notice of sale. They are provided to assist the Secretary of the Interior in deciding which tracts will be offered for sale.

Another computer simulation model is used to derive a resource economic value for each tract, so that the Government can efficiently evaluate the bids received at a lease sale. This model considers the degree of uncertainty associated with various economic, geologic, and engineering parameters and yields a range of resource economic values for the tract. The statistical mean of this range is used as an aid to determine bid adequacy.

The procedures described above are currently in effect. However, the Department of the Interior is considering the adoption of a substantially modified leasing process that would allow additional acreage to be offered for sale. This process may require use of different estimation techniques.

After a discovery is made and the commercial potential of a reservoir has been established, petroleum engineers and geologists are able to calculate reserves. Reserve estimates are estimates of the portion of the identified resource that can be economically extracted. A preliminary reserve calculation might be based on information obtained from one or several wells and from maps of the subsurface geology. Estimates of reserves allow a much closer approximation of the level of development activity that can be expected in an area than do conditional or risked resource estimates.

Once a commercial discovery has been made, site-specific planning that a State or local government undertakes in response to OCS development and production should be based on reserve estimates. However, in the absence of a commercial discovery, the most appropriate figure to use is the risked resource estimate. Although considered less accurate than the reserve estimate due to insufficient exploratory data, it is the most useful resource estimate for general--as opposed to site-specific--planning because it has been modified by the likelihood of any discovery being commercially attractive.

Resource and Reserve Estimates for the Arctic

The U.S. Geological Survey's latest resource and reserve estimates for the Beaufort and Chukchi Seas, for onshore areas on the North Slope, and for offshore areas currently under lease as a result of Sale BF are presented in table 5.

The undiscovered recoverable resource estimates for the Arctic are given in the first five lines. They provide a measure of the petroleum potential of each of the five areas noted. It is important to understand that these mean estimates are based on interpretation of broad-scale geologic data and therefore provide only a preliminary approximation of the total hydrocarbon potential of each area. It should also be noted that the quantities of oil and gas estimated for the Beaufort and Chukchi Seas can be considered recoverable only if technology permits their exploitation beneath Arctic pack ice (Dolton and others, 1981).

In addition to the undiscovered recoverable resource estimates made for broad geologic areas of the Arctic, estimates of undiscovered hydrocarbon resources in place have been made specifically for the National Petroleum Reserve in Alaska. In-place estimates include undiscovered recoverable and unrecoverable resources. These figures were calculated and published as part of a study authorized by the Naval Petroleum Reserves Production Act of 1976. Oil in place was estimated at 7.1 billion barrels (1,128,190,000 m3) and associated (with oil) and nonassociated (without oil) gas in place was estimated at 14.1 trillion cubic feet (399,030,000,000 m3) (DOI, 1979b). A 1980 update of these figures gave oil in place as 6.0 billion barrels (953,400,000 m3) and gas in place as 11.3 trillion cubic feet (319,790,000,000 m3) (Callahan, 1981, oral commun.).

The risked resource estimates are given next in table 5. These estimates are mean

*TABLE 5.—Arctic oil and gas resource and reserve estimates**

(n.a. = data not available)

	Oil (billion barrels)	Gas (trillion cubic feet)
Undiscovered recoverable resources		
Beaufort Sea (water depth 0-200 m)	7.0	35.0[a]
Chukchi Sea (water depth 0-200 m)	1.4	6.4[a]
Arctic Coastal Plain	4.4	18.1[a]
Northern Foothills	1.4	11.7[a]
Southern Foothills and Brooks Range	0.2	2.0[a]
Risked resources		
Beaufort Sea leased lands (86 offshore tracts in Joint Federal/State Lease Sale)	0.179	0.135[a]
Reserves		
Beaufort Sea	0	0
Chukchi Sea	0	0[b]
Prudhoe Bay	7.819	28.831[b]
Kuparuk River	0.448	0.206[b]
South Barrow	n.a.	0.024[c]

*All resource estimates presented in this table are mean estimates.
[a]Associated (with oil) gas and nonassociated (without oil) gas.
[b]Associated (with oil) gas only.
[c]Nonassociated gas only.

SOURCES: Dolton and others, 1981 (undiscovered recoverable resource estimates); DOI, 1981a (risked, economically recoverable resource estimates); Alaska Oil and Gas Conservation Commission, 1981 (onshore reserve estimates).

estimates and cover only tracts leased in the Joint Federal/State Beaufort Sea Lease Sale. These estimates are based on the assumption that the potential geologic traps that have been identified contain economically recoverable quantities of hydrocarbons. These quantities are then risked to account for the probability of noneconomic accumulations.

Reserve estimates approximate the cumulative production that can be expected from an actual discovery. No Federal exploratory drilling has been carried out in the Beaufort Sea or Chukchi Sea OCS. Therefore, the entry for reserve estimates is zero for these offshore areas. However, the Alaska Oil and Gas Conservation Commission has compiled reserve estimates for onshore areas in Alaska. The most recent estimates include information on three locations on the North Slope: Prudhoe Bay, Kuparuk River, and South Barrow (gas field). These reserve estimates are

defined as oil or gas discovered, defined, and producible, but not yet produced (Alaska Oil and Gas Conservation Commission, 1981).

BIOLOGICAL ENVIRONMENT

Practically all of the Arctic is currently in a wilderness state. Many of its biological communities, which have adapted to the unique physical circumstances presented by the arctic environment, have experienced little significant disruption until relatively recently. The importance of maintaining the quality of the arctic environment lies in the fact that it provides habitat for millions of migratory animals, many of which provide food, garment material, and other products for the Inupiat people.

The Arctic includes areas of eight ecosystems: coastal and marine; wet tundra; moist tundra; high brush; alpine tundra; low brush, muskeg bog; bottomland spruce-poplar forest; and spuce hardwood forest (University of Alaska, 1975, and Joint Federal-State Land Use Planning Commission of Alaska, 1973). Figure 10 shows the distribution of these ecosystems. However, only the first five are in areas of oil and gas potential. These are discussed in the following section.

The marine and coastal environments of the Beaufort and Chukchi Seas support an array of organisms ranging from plankton to the great whales. Numerous birds, fish, and marine and terrestrial mammals make use of resources in this area. A unique, discontinuous boulder patch community of kelp and bottom and near-bottom organisms supports large fish and bird populations in nearshore areas. The lagoon-barrier island system provides nesting and feeding habitat for migratory birds, as well as important ringed seal pupping grounds.

Marine mammal and fish species congregate near the edge of the pack ice and move in response to ice motion. In winter, animals such as the walrus and bearded seal migrate south, while the polar bear and ringed seal are found along the shorefast ice. Bowhead and beluga whales follow ice leads in the spring (University of Alaska, 1975).

The bowhead and gray whales are endangered species. The bowhead is of particular importance as a subsistence resource and has significant social and cultural value. Figure 11 shows the path of its migration. Seasonal restrictions have been imposed on drilling on offshore tracts leased in Sale BF to protect the endangered whales (see ch. 2). A determination of the effects of the lease sale on whales, required under the provisions of the Endangered Species Act of 1973, has not been completed due to lack of information. However, numerous studies are in progress to determine the normal behavior of whales, as well as their response to noise, pollution, and other disturbances.

Wet tundra exists, interwoven with thousands of small thaw lakes (fig. 12), on the Coastal Plain. The pattern of ice-wedge polygons, typical of a zone of continuous permafrost, occurs even under the lakes. The lakes themselves cover 50 to 75 percent of the total Coastal Plain area and continue to change in shape, location, and size under the influence of the freeze-thaw cycle. Teshekpuk Lake, the largest in the Coastal Plain Province, extends over more than 300 square miles (780 km2) and is of unique importance in the Arctic as a waterbird feeding and molting area. Sedges are the most common vegetative type on the wet tundra, and lemmings are the most abundant mammal. The wet tundra also provides feeding and calving grounds for caribou, as well as habitat for Arctic foxes, shorebirds, waterfowl, and an enormous seasonal insect population. Coastal wet tundra areas are especially important for caribou when they migrate during the summer to seek relief from insects.

Moist tundra is the dominant plant community of the foothills, but it also extends into the Brooks Range and the Coastal Plain. Tussock-forming cotton grass is the most common plant species, and mosses and lichens grow in the moist channels between tussocks. Three caribou herds, the Western Arctic, the Central Arctic, and the Porcupine, range throughout the moist tundra, which includes many important feeding and calving grounds. The Western and Central Arctic herds live in Alaska year-round; the Porcupine herd winters in the Canadian Yukon on the Porcupine River

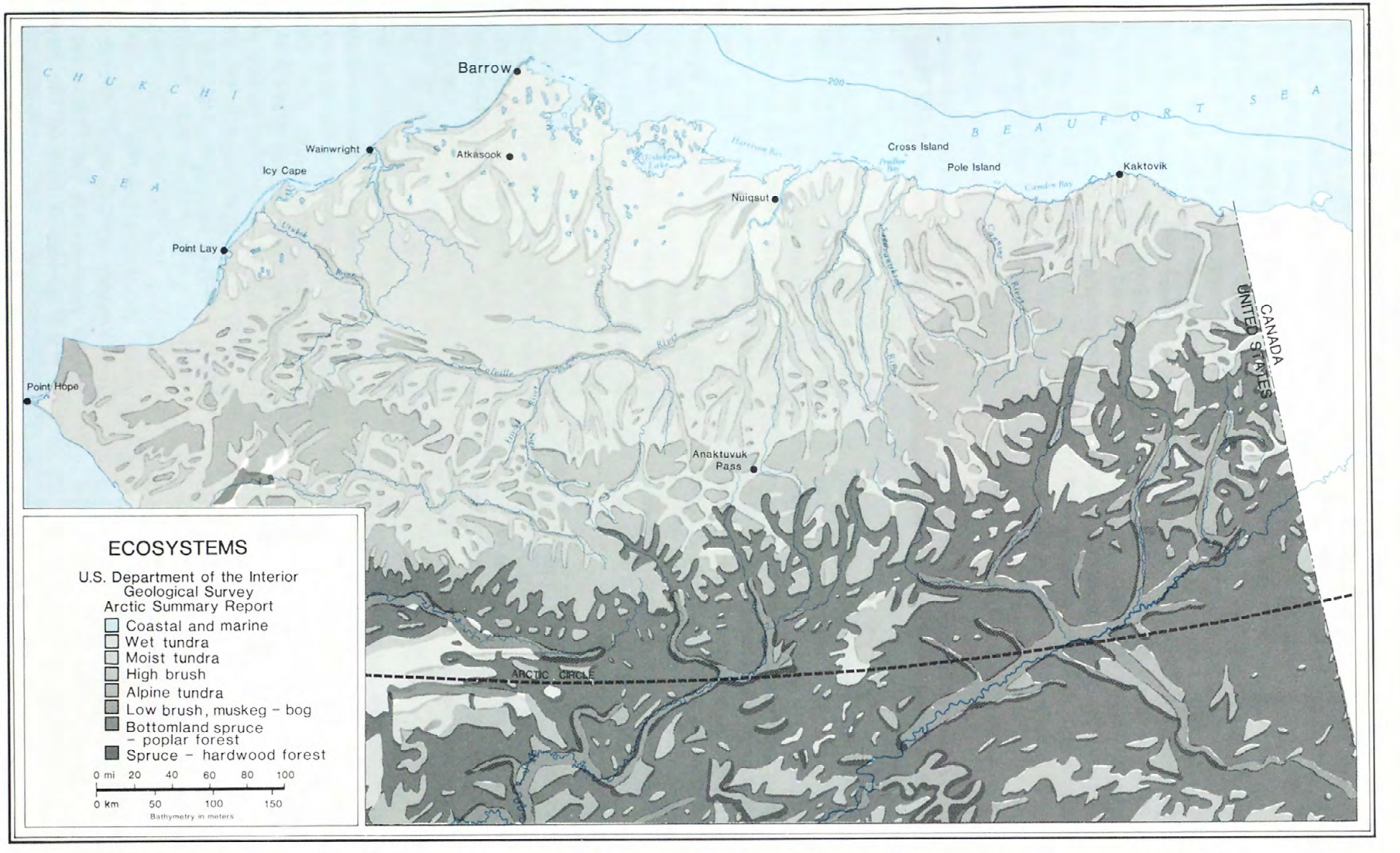

FIGURE 10.--The five ecosystems of the Arctic. (Base from USGS, 1976, and data from Joint Federal State Land Use Planning Commission for Alaska, 1973; adapted by Rogers, Golden & Halpern, 1981.)

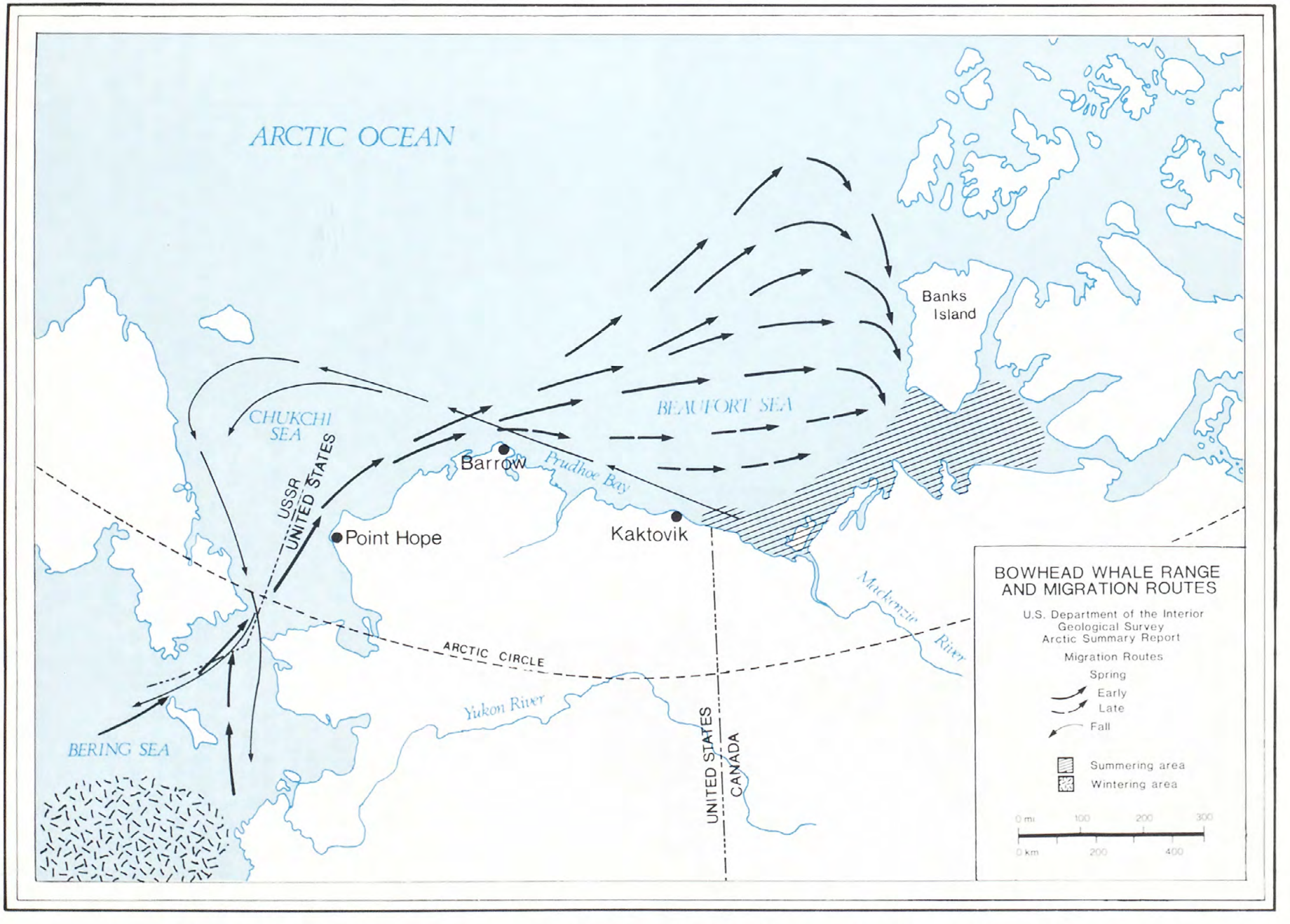

FIGURE 11.--Bowhead whale range and migration routes. (Base from USGS, 1980b, and data from LGL Ecological Research Associates, Inc., 1981; adapted by Rogers, Golden & Halpern, 1981.)

FIGURE 12.--Thaw lakes. (Photograph by Joseph C. LaBelle, Arctic Environmental Information and Data Center.)

and uses the Arctic Coastal Plain as a spring calving ground and summer habitat. The extent of the caribou range and their migration routes are shown in figure 13. Tussock tundra also provides important habitat for wolves, foxes, bears, rodents, and numerous bird species.

High brush communities exist in areas adjacent to many major rivers on the North Slope, particularly in the foothills. Undisturbed high brush areas include shrub thickets of willow and alder. Shrub thickets provide food and cover for moose, bear, small mammals, birds, and migrating caribou. Freshwater streams and rivers that do not freeze to the bottom provide seasonal spawning and overwintering sites for anadromous fish species, as well as year-round habitat for freshwater fish.

Alpine tundra occurs in mountainous areas and along well-drained, rocky ridges throughout the Brooks Range and scattered in the foothills. It is characterized by low, mat-forming vegetation and is used extensively by numerous bird species, including the endangered arctic peregrine falcon. Many terrestrial mammals den in the dry soils of the alpine tundra.

PEOPLE

The history of the Inupiat people of the North Slope and a summary of the legislation and litigation that has affected them are given in appendix C. This section discusses the population, employment trends, and social organization of the region.

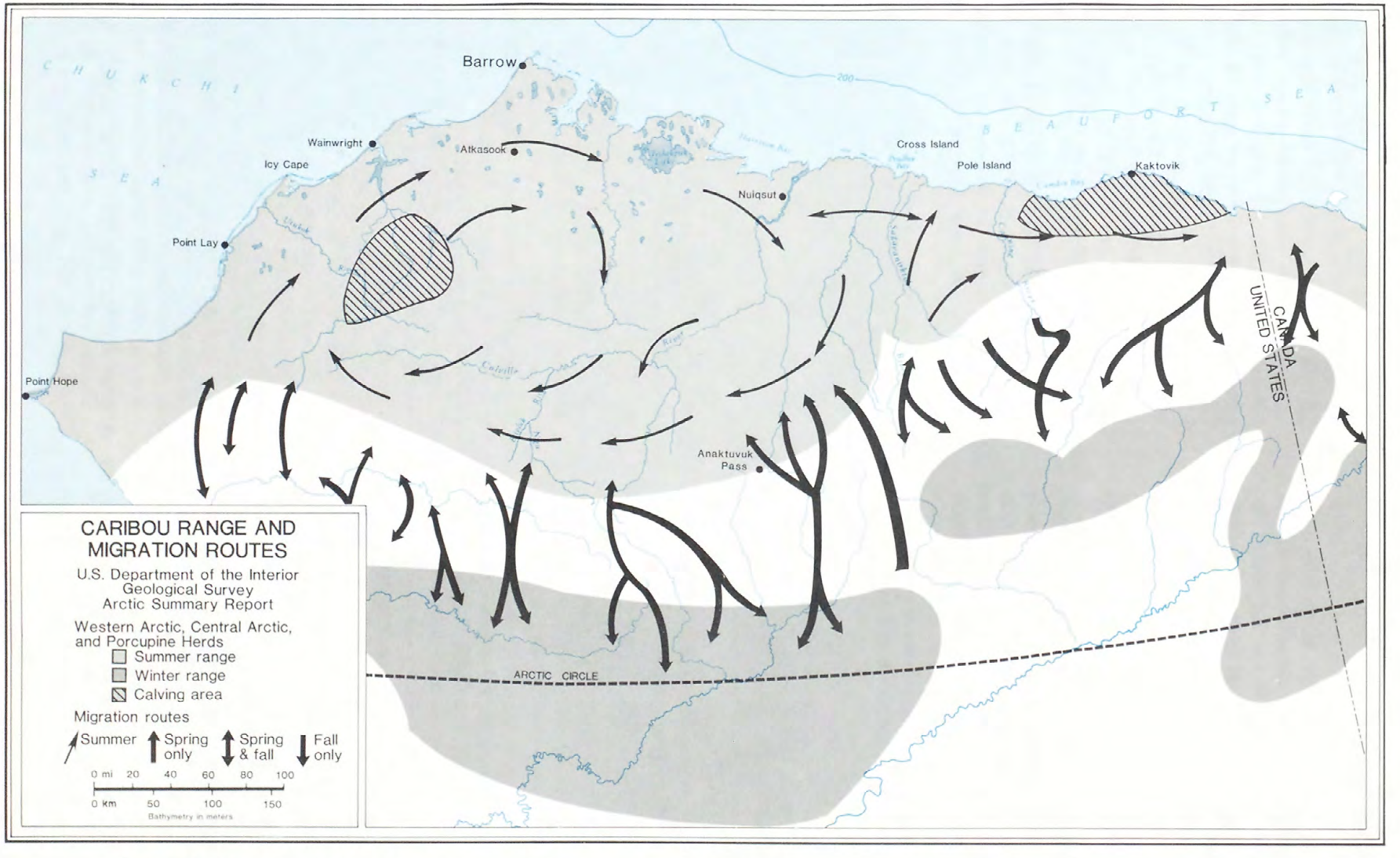

FIGURE 13.--Caribou range and migration routes. (Base from USGS, 1976, and data from University of Alaska, 1975; adapted by Rogers, Golden & Halpern, 1981.)

Population

According to the North Slope Borough (1979b) figures, the resident population of the North Slope Borough is 4,305. Advance reports of the 1980 U.S. Census cite the population as 4,199 (Bureau of the Census, 1980). The population is divided among eight villages, of which Barrow (fig. 14) is the largest by far, with a population of 2,715. The population and municipal status of these villages are given in table 6.

The Native population of the North Slope increased about 25 percent between 1970 and 1979. During the same period, the non-Native population quintupled, going from less than 1,000 to more than 5,000. Most of the non-Natives on the North Slope are employed at Prudhoe Bay and are not permanent residents. Some whites and other non-Natives do live in the villages: in 1979, about 20 percent of Barrow's population was white, and whites made up smaller percentages of the population in other North Slope villages. Most of the non-Natives in villages teach or work for government agencies. Recently, non-Natives have been hired as construction workers on the North Slope Borough's capital improvement projects (Kruse and others, 1980).

Virtually no one lived at Atkasook, Point Lay, or Nuiqsut in 1970, but the Inupiat had lived in these locations in earlier periods. When the Alaska Native Claims Settlement

FIGURE 14.--Barrow, Alaska. (Photograph by Arctic Environmental Information and Data Center.)

TABLE 6.—North Slope Borough population by village, 1978

Village	Population	Municipal status
Barrow	2,715	First-class
Point Hope	464	Second-class
Wainwright	429	Second-class
Anaktuvuk Pass	173	Second-class
Nuiqsut	182	Second-class
Kaktovik	192	Second-class
Atkasook	93	Unincorporated
Point Lay	57	Unincorporated
Total	4,305	

SOURCE: North Slope Borough, 1979b.

Act was passed in 1971, Natives claimed these three locations as historic village sites, and in the early 1970's, under the auspices of the Arctic Slope Regional Corporation, Natives began to resettle there.

The level of education among North Slope Natives increased dramatically after statehood. In 1960, when Natives of 25 years and older had a median of less than 4 years of education; by 1977, this median had increased to 8.8 years (Kruse and others, 1980).

Employment

The conventional definitions of labor force participation work poorly on the North Slope. Many Natives participate in both wage and subsistence economies. Although working for pay and hunting for food are both forms of economic activity, only wage work is considered labor force participation. Therefore, it is difficult to apply the concept of unemployment to the people of the North Slope. According to the census definition, for a person to be unemployed and counted in the labor force, he or she must be actively seeking work. In small Native villages, people may not be looking for work because they are aware that no jobs are available at the time. To overcome this, Natives are frequently asked not whether they are looking for work, but whether they want work (Kleinfeld and others, 1981).

In 1970, the State Department of Labor estimated that 60 percent of Inupiat adults who wanted work in Barrow and Wainwright were unable to find jobs (Alaska Department of Labor, Employment Security Division, 1970). At that time, most Natives who had jobs worked for the State and Federal Governments, which provided health clinics, schools, and other facilities and services that the villages could not pay for themselves. Many of these government jobs were construction projects that were active only during the brief Arctic construction season. Barrow is the regional center for Federal and State Government activities, and more jobs were available there than in the smaller villages (Dupere and Associates, 1973).

The formation of the North Slope Borough in 1972 and the inclusion of Prudhoe Bay in the borough made possible hundreds of new jobs. (The history of the borough's formation is presented in appendix C; current operations are described in the following section.) Between 1973 and 1980, the borough collected about $150 million in property taxes from oil companies and an additional $88 million from the State and Federal Governments (Arctic Slope Technical Services, Inc., 1981).

A report prepared by the University of Alaska as a part of its Man in the Arctic Program indicates that 5 years after it was established, the North Slope Borough was the largest employer of the local Native population (Kleinfeld and others, 1981). The borough had employed 57 percent of the Inupiat adult population at some time. In contrast, the oil companies, during construction of the Trans-Alaska Pipeline and construction and operation of the Prudhoe Bay oil facility, had employed only 14 percent of Inupiat adults since 1970, and only 8 percent of those worked longer than 12 weeks (Kruse and others, 1980). However, jobs created by the borough and the regional corporation did not succeed in eliminating unemployment among the Natives of the North Slope. During 1976-77, unemployment among Inupiat adults between the ages of 18 and 54 averaged 12 percent of the total

male population and 8 percent of the total female population. Part of this unemployment was due to the short seasonal nature of construction work and part was due to Native reliance on subsistence activities.

The borough's local hire program is designed to reduce many of the barriers to rural Native employment. To minimize conflicts between wage work and subsistence, the borough and the Arctic Slope Regional Corporation grant leaves of absence for subsistence activities.

Private corporations have also developed strategies to increase Native employment. Pingo, Inc., a corporation owned by a conglomerate of North Slope Native village corporations, provides oil field services such as manpower to operate rigs and do house keeping (Adams, 1981, written commun.). These services are offered on a task basis rather than an individual basis. This will allow individuals greater flexibility in arranging work schedules (Anderson, 1981, oral commun.).

A joint venture, Veco-Nana Drilling Company, Inc. (of which Veco, Inc., a support company, owns 44 percent, NANA Regional Corporation owns 51 percent, and the village corporations of Nuiqsut and Kaktovik each own 2.5 percent) was established in September 1980 to supply Veco, Inc., with people qualified to operate drilling rigs. Currently, Veco-Nana employs over 100 people, 20 of whom are Natives. The two rigs operated by Veco-Nana are currently drilling for Sohio at Prudhoe Bay. There is considerable competition for these jobs, with over 70 applicants for five positions. Veco-Nana is currently constructing a third rig (Cross, 1981, oral commun.).

Presently, most Inupiat employment on the North Slope is created by the borough. Many jobs will be available as long as substantial Prudhoe Bay tax revenues continue. Current North Slope Borough revenue projections anticipate a stable property tax base through 1993 (Arctic Slope Technical Services, Inc., 1981). Prudhoe Bay revenues are expected to persist at least through the turn of the century, and oil and gas development on the Outer Continental Shelf or in other areas of the borough may maintain the tax base. However, oil revenues have not led to the growth of a diversified, self-sustaining economy.

Social Organization

Four organizations operate regionally on the North Slope--the North Slope Borough, the Arctic Slope Regional Corporation, the school district, and the Inupiat Community of the Arctic Slope. A discussion of the borough, the regional corporation, and the Inupiat Community of the Arctic Slope, as well as the local village corporations, is needed in order to understand the subregion's philosophy concerning land claims and oil and gas development.

NORTH SLOPE BOROUGH. For the initial 18 months of its existence, the Borough concentrated on organizing itself as a municipal government and withstanding challenges to its existence (see appendix C for further details on the borough's formation). Along with the usual functions of a borough government, the borough has consistently demonstrated a commitment to maintaining traditional values.

Founders of the borough thought that the regional government would give Natives influence in future petroleum development on the North Slope (McBeath, 1981). The borough encourages development onshore, but it is opposed to offshore leasing in the Beaufort Sea beyond the barrier islands, and in the Chukchi Sea. The opposition to leasing in these areas is based on concern about possible effects on the bowhead whale and questions concerning the adequacy of oil and gas technology in sea ice (Anderson, 1981, oral commun.). Although it encourages onshore leasing, the borough opposes leasing tracts in the National Petroleum Reserve in Alaska (NPRA) that are identified as cultural resource areas or as areas long used by borough residents for subsistence-related activities, as well as wildlife habitat, migratory, and calving areas (Adams, 1981, written commun.).

The borough feels that coastal zone planning and zoning are the most effective

means of regulating oil and gas development and protecting subsistence resources. The Alaska Coastal Zone Management Act, passed in 1977, provided for a coastal management program based on a partnership of State and local management. In early 1977, the North Slope Borough Planning Department initiated a local coastal management program for the Prudhoe Bay area. This plan was published in 1978. Because approval of the plan by the Alaska Coastal Policy Council looked doubtful before the Joint Federal/State Beaufort Sea Lease Sale in December 1979, the borough engaged the public-interest environmental law firm, Trustees for Alaska, to draft recommended zoning ordinances based on the 1978 program. The aim of the ordinances was to regulate land and water uses at Prudhoe Bay until the program is approved. The borough zoning ordinance and ancillary documents and maps that evolved from this process became collectively known as the Mid-Beaufort Coastal Management Program. This program established an overall Mid-Beaufort Coastal Zone District between the Colville River and the Canning River, including the Prudhoe Bay area and the area leased in the joint Federal/State sale.

Opposition to the Mid-Beaufort program by the oil and gas industry and critical reviews by several State agencies indicated that an approved Mid-Beaufort program would be impossible to implement without litigation. North Slope Borough Assembly President Jacob Adams therefore withdrew the Mid-Beaufort Coastal Management Program from consideration by the Alaska Coastal Policy Council on January 10, 1980.

The North Slope Borough is now drafting a revised and expanded coastal management program that will have four sections: Point Hope/Point Lay; NPRA; Mid-Beaufort; and Arctic National Wildlife Refuge. A draft of the program is scheduled to be produced on June 30, 1982, for public hearings. If this schedule is followed, the Alaska Coastal Policy Committee would approve or disapprove the program by December 20, 1982 (Maynard and Partch and Woodward-Clyde Consultants, 1981).

As a part of the coastal management program, the borough is preparing a comprehensive land use plan. A draft of this plan was published in July 1981. The borough's coastal planning and zoning efforts also include a number of resource inventories and preservation plans (Brown, 1979; Carnahan, 1979; Lowenstein, 1980; Nielson, 1977; North Slope Borough, 1979a, 1980b; Shinkwin and North Slope Borough Planning Department, 1978). These resource inventories and plans document the way in which the Inupiat regard land and the special significance of historic sites.

In summary, the borough is not opposed to onshore oil and gas activity, provided proper safeguards are employed to protect the environment from irreparable damage. The borough would like to see offshore activity begin slowly and proceed gradually offshore as industry gains experience. It is the borough government's opinion that oil and gas will not provide the subregion with funds forever and that a subsistence lifestyle should still be available to residents of the North Slope when oil and gas activities have ceased (Anjum, 1981, oral commun.).

ARCTIC SLOPE REGIONAL CORPORATION (ASRC). The Arctic Slope Regional Corporation was formed in 1971 as a result of the Alaska Native Claims Settlement Act (ANCSA). It is a wealthy organization with current assets of $81,250,350 and liabilities of $33,014,019 (ASRC, 1981). The corporation holds title to 4,614,958 acres (1,867,212 hectares), situated primarily in the central and western sections of the borough and adjacent to the western and southeastern boundaries of NPRA. Included in this total are lands in which the corporation holds title to the subsurface estate (847,124 acres or 342,746 hectares) in the central and western Arctic and at the villages of Point Hope, Point Lay, Anaktuvuk Pass, Nuiqsut, and Kaktovik.

The ASRC has directed its efforts toward the development of the area. It held 51 percent of Arctic Slope Alaska General, in partnership with Alaska General Construction Company, a wholly owned subsidiary of General Construction Company of Seattle, from 1977 until 1980, when it bought Alaska General. In addition, the regional corporation purchased General Construction's Hawaii division. As a result of these purchases, Arctic Slope Alaska General Construction Company,

Inc., is the largest minority construction firm in the State. Other subsidiaries, partnerships, or joint ventures of ASRC include Eskimo, Inc., SKW/Eskimo, Inc., Tundra Tours, Inc., Arctic Slope Technical Services, Inc., Barrow Cable TV, ASRC/ARCOM, and Anglo Alaska Drilling Associates, Ltd.

The ASRC is in favor of oil and gas activity on the North Slope, although it is opposed to any leasing beyond the barrier islands because of questions concerning the adequacy of oil and gas technology and possible effects on the bowhead whale (Hopson, 1981, oral commun.).

INUPIAT COMMUNITY OF THE ARCTIC SLOPE (ICAS). The Inupiat Community of the Arctic Slope is a regional Native corporation chartered under the terms of the Indian Reorganization Act of 1936 and organized in 1971 to protect Native lands and provide government and social services to Natives. In 1979, the council increased its membership to represent villages more effectively. ICAS programs are regularly funded by the Bureau of Indian Affairs. Programs include assistance in real estate management, career counseling, health and welfare assistance, and aid for higher education. There is some overlap with the functions of the borough, regional, and village corporations. A new and potentially significant function is the Tribal Equal Rights Office, which may become the area's major local hire and equal opportunity monitoring office, as well as a training program for pipeline employment (McBeath, 1981).

ICAS is opposed to oil and gas activities. Members feel that the potential damage to the environment and the stress caused by rapid change far outweigh the benefits of oil and gas development. However, they state that they would regard such development more favorably if they had more control over it (A. Brower, 1981, oral commun.).

VILLAGE CORPORATIONS. In addition to the regional organization, each village has a local government and a village corporation. Of these organizations, Barrow's village corporation--Ukteaqvik Inupiat Corporation--appears to be most opposed to offshore oil and gas development, primarily because of environmental concerns. Corporation members feel that oil and gas technology is not advanced enough to operate successfully in the arctic environment and fear that there will be irreversible environmental damage, especially to the bowhead whale. They also feel that, historically, the Federal Government has not always acted in good faith in dealing with the Inupiat (R. Brower, 1981, oral commun.). As a result, the corporation is considering a number of lawsuits against the Federal Government. The issues in these proposed suits include the following:

- tribal law vs. common law;
- ownership of land, including the OCS;
- the status of North Slope land ("in trust" for Natives or a part of the public domain); and
- antitrust actions aimed at the Justice Department (R. Brower, 1981, oral commun.).

The legal bases for these possible suits are somewhat complicated. They rest on the Treaty of Cession, the Organic Act of 1884, the Native Allotment Act of 1906, the second Organic Act of 1912, and the Indian Reorganization Act of 1934. (See appendix C for further details.)

SUMMARY. Attitudes concerning oil and gas development in the Arctic subregion range from the very pro-development position of the ASRC to the anti-development stance of the Barrow village corporation. However, all organizations find onshore leasing preferable to offshore leasing, and all organizations agree that leasing beyond the barrier islands is unacceptable.

LAND USE

Despite the political, social, and economic changes that have occurred during recent decades, traditional land uses continue to predominate in terms of amount of acreage used in the Arctic. Subsistence hunting and fishing are practiced to provide food, clothing,

and other products. In some instances, Western goods have replaced subsistence resources, and modern technology has been incorporated into hunting techniques that evolved over centuries. However, the considerable expense of substituting goods that must be flown in from the conterminous States for those obtained from the surrounding natural environment is prohibitive for many Inupiat. In addition, the unpredictable availability of imported products and the preferences and tastes of the Natives suggest that subsistence harvesting will continue to be relied upon despite the growing importance of a wage economy. Finally, and perhaps most importantly, subsistence activities form the basis for Inupiat cultural identity.

The level and type of resource and land uses vary among North Slope villages, as well as within villages from year to year. This variation arises from differences in the reliability of access to and abundance of resources, rather than from their availability per se. The coastal communities continue to rely primarily on marine resources, while those further inland depend more heavily on terrestrial species. However, the widespread use of snow machines (snowmobiles) has permitted coastal dwellers to exploit inland resources more than in the past (USGS, 1979).

Whaling remains of central importance. The bowhead and beluga are the principal species taken. Beluga do not occur with sufficient predictability to be considered a reliable subsistence resource, and when bowhead are available, they are preferred to beluga.

The number of bowhead whales landed has increased dramatically throughout the 1970's. From 1970 to 1977, when quotas were first imposed by the International Whaling Commission (IWC), a total of 259 bowhead were landed. This figure corresponds to 37 percent of the total take during the previous 60 years. This increased catch reflects the significant rise in the number of whaling crews during the 1970's. Outfitting crews, previously beyond the means of most Inupiat, was made possible by increases in the cash income of North Slope residents resulting from oil and gas activities (Marquette and Bockstoce, 1980).

The major beluga hunting villages are Point Hope and Wainwright because of their more favorable locations along the beluga migration route. Beluga are also occasionally taken at Barrow and, less frequently, at Point Lay and Barter Island. The actual number of beluga landed each year is extremely variable: at Point Hope, the average catch may be from 20 to 25 animals, while at Wainwright the average is less than 15 per year (Burns, 1981, oral commun.). The future of whaling will depend on the response of the Natives to the IWC quota of 17 bowhead per year, which is still in effect, and the enforcement policy of the National Marine Fisheries Service.

Caribou and seal are also subsistence resources of considerable importance throughout the North Slope. While the rise in use of Western goods has decreased the dependence of some Natives on caribou and seal products, they remain a dietary mainstay. The level of seal and caribou hunting fluctuates greatly, depending on the relative take of other resources and the variability in migratory routes followed by the animals. Seal hunting is of primary importance in Point Hope, where over 300 seal were taken in the 1980 season (Lowenstein, 1980), as well as in Barrow. Caribou hunting is particularly important in all major North Slope villages, and especially in Anaktuvuk Pass, where caribou is the central subsistence food in the diet (DOI, 1979c).

Numerous types of freshwater and ocean fish, ducks, geese, and other birds, and terrestrial and marine mammals are also harvested by North Slope residents. While every community relies on all these resources to some degree, certain differences are noteworthy. The greatest variety of fish resources is taken in Barrow. Kaktovik is the only village that annually takes Dall sheep, since the proximity of the village to mountains permits easy access. Anaktuvuk Pass residents take furbearers, such as wolves, wolverines, and foxes, in larger numbers than other North Slope villages. Finally, polar bear and walrus are taken in small numbers by several coastal communities (DOI, 1979c).

The areal extent of land used by members of each village in conducting subsistence activities is vast. Hunting, fishing, and trapping grounds may extend for hundreds of miles

from a village center. These grounds largely coincide with lands used by the Inupiat for thousands of years. The fact that land use areas are so large reflects the existence of enormous ranges covered by many subsistence species and the adaptation of hunting strategies and techniques to resource population dynamics. It also underscores the necessity of maintaining the integrity of a large number of species and their habitats if subsistence harvesting is to remain a viable way of life.

Other categories of land use include the village centers of Point Hope, Point Lay, Wainwright, Barrow, Atkasook, Nuiqsut, Kaktovik, and Anaktuvuk Pass. The development site at Prudhoe Bay is the only area of industrial operations in the Arctic. Lands under Federal jurisdiction include the National Petroleum Reserve in Alaska and the Arctic National Wildlife Refuge.

This chapter has discussed many of the features of the Arctic that distinguish it from other OCS leasing areas. The regional perspective used in this chapter, and throughout the report, provides a framework for understanding the Arctic as a whole. This regional view is employed for a number of reasons. First, this is the initial summary report for the Arctic. The regional information provided is important for understanding the special considerations and problems in the subregion. Second, an assessment of the cumulative impacts of Arctic oil and gas activities of concern to State and local planners is impossible without a regional view. Finally, OCS activities in the Arctic will depend somewhat on oil and gas exploration, development, and production facilities elsewhere in the subregion. They will also be heavily influenced by transportation modes for other oil and gas produced in the Arctic. Activities on the OCS and on other Federal and State lands are discussed in chapter 2.

2. Magnitude and Timing of Development

Oil and gas activities are being carried out on Federal, State, and regional corporation lands in the Arctic. These activities include leasing, exploration, development, and production. There are plans for future activities as well. Federal, State, and local planners are concerned with the cumulative impacts of oil and gas activities in the Arctic. Therefore, a review of all activity in the area is presented.

This chapter summarizes offshore and onshore leasing, exploration, development, and production in the Arctic. The first section reviews Federal OCS leasing, including the Joint Federal/State Beaufort Sea Lease Sale and upcoming Lease Sale 71. The second section summarizes leasing on Federal Arctic lands other than the OCS. This includes Federal oil and gas activity in the National Petroleum Reserve in Alaska (NPRA), the Arctic National Wildlife Refuge (ANWR), and additional Federal lands. The third section provides a discussion of activities that have resulted from State leasing, including the discovery of the largest hydrocarbon accumulation in North America at Prudhoe Bay. The final section summarizes the leasing activities of the Arctic Slope Regional Corporation.

FEDERAL OCS ACTIVITY

Joint Federal/State Beaufort Sea Lease Sale (Lease Sale BF)

The Joint Federal/State Beaufort Sea Lease Sale (Sale BF) was the first sale in which OCS lands were leased in the Arctic. The sale was held on December 11, 1979, under the joint authority of the State of Alaska and the U.S. Department of the Interior (DOI). The sale was conducted jointly because although both the Federal and State Governments wished to hold a lease sale in the Beaufort Sea, both claimed jurisdiction over certain tracts in the proposed lease area. These claims originated from conflicting interpretations of the correct method of defining the Federal/State boundary along the row of islands adjacent to Prudhoe Bay.

Negotiations between the Federal and State Governments resulted in the issuance of a memorandum of understanding (MOU) in March 1978. The MOU identified general policies and procedures for joint leasing activities and guidelines for the allocation of costs and responsibilities (BLM, 1979b). Of the 117 tracts included in the final notice of sale, 27 were in dispute. An interim agreement dated October 1979 designated that the Federal Government manage 23 of the disputed tracts and that the State manage the other four, which are located in the Dinkum Sands area. These four tracts are disputed because it is uncertain whether the "island" at Dinkum Sands is above mean high tide, and therefore constitutes an island, or if it is only an impermanent natural feature with no concomitant territorial sea belonging to the State. The interim agreement required that all bonuses, rentals, and royalties attributable to disputed tracts be paid into an escrow account pending solution of the boundary question. Of the undisputed tracts, 23 are under Federal jurisdiction and management, and 67 are under State jurisdiction and management.

In October 1979, a Beaufort Sea Management Committee was formed for the management and administration of leases in the sale area in accordance with the Interim Agreement and Management Plan for the Joint

Federal/State Beaufort Sea Lease Sale, initiated pursuant to section 7 of the OCS Lands Act, 43 U.S.C. 1336. The committee is composed of the principal State and Federal agencies having Beaufort Sea regulating authority. These agencies are the U.S. Geological Survey (USGS), Bureau of Land Management (BLM), Alaska Oil and Gas Conservation Commission, and the Alaska Department of Natural Resources (Division of Minerals and Energy Management). Among other things, the committee is responsible for the consistency of operations throughout the duration of the dispute. The committee consults with other agencies, as appropriate, to ensure coordinated lease management in accordance with requirements of the interim agreement (Casey, 1981, written commun.).

The distribution of revenues in the escrow account for the disputed tracts will not take place until a decision is issued by the U.S. Supreme Court in **United States** v. **Alaska.** Pleadings have been filed in the case, but additional evidence resulting from monitoring efforts at Dinkum Sands will not be introduced until monitoring is completed in the spring of 1982. A special master, appointed to hear the case and make recommended rulings on the points of contention, will probably not make his recommendations to the Supreme Court before the summer of 1982. Therefore, it could be several years before the final decision is issued in the case (Casey, 1981, oral commun.; Ott, 1981, oral commun.).

Resource reports for the joint sale area were requested in April 1976 and again in September 1977. Concerns addressed in these reports included arctic oil spill technology, protection of biological resources, ice hazards, effects of drilling operations on the bowhead whale, subsistence activities, and the need for further studies on potential environmental impacts. The Department of the Interior and the State of Alaska issued a call for nominations for 236 blocks in March 1978, requesting nominations and comments from all interested parties. The call area included 650,330 acres (263,124 hectares) in waters less than 66 feet (20.1 m) deep off the coast between the NPRA and ANWR (BLM, 1978). In response, 13 companies nominated all 236 blocks, 191 of which were of high industry interest. Comments were submitted by groups including Native corporations, environmental organizations, and government agencies. As a result of recommendations made by these groups, 50 blocks at the western end of the call area were deleted (BLM, 1979a). The remaining 186 blocks (514,000 acres, or 208,200 hectares) were the subject of detailed environmental study in the EIS.

A joint task force of Federal and State representatives was formed in May 1978. The task force was to work on legal issues, impact analysis, and technical problems involved in Lease Sale BF, including mitigating measures. The Anchorage OCS Office of the Bureau of Land Management released a draft environmental impact statement (EIS) in April 1979. Hearings were held on the draft EIS in Fairbanks, Barrow, Nuiqsut, and Kaktovik, and a final EIS was made available in August 1979. As a result of legislative action by the State of Alaska, the size of offshore tracts allowed to be leased under State law was increased to conform to the size specified by the Outer Continental Shelf Lands Act, as amended (BLM, 1979b). Consequently, a total of 105 blocks, covering the same acreage as the original 186, were considered in the final EIS. Issues raised during public hearings prior to preparation of the final EIS included the following:

- potential adverse effects on Inupiat lifestyle and culture, including acceleration of a cash economy and reduction in availability of subsistence resources;
- impacts on wildlife, including alteration of migratory patterns of land and sea animals and destruction of habitats;
- consequences of an oil spill on the marine and nearshore environments and the absence of adequate oil spill cleanup technology; and
- the possibility of restricting drilling to within areas landward of the barrier islands and to limited times of the year.

Because of the large number of environmental concerns raised prior to the lease sale, a series of stipulations to be made part of the leases was developed by State and Federal agencies. These stipulations were reviewed and reworked by the task force and were

published as part of the notice of sale in November 1979. The stipulations included the following:

- restricting exploratory drilling and other downhole activities to the period from November 1 to March 31 on all federally managed tracts and on State tracts beyond the barrier islands, and from November 1 to May 15 on State tracts inside the barrier islands, to protect the endangered bowhead and gray whales during their migration and to allow time to gather additional information on the whales so that the Department of the Interior can evaluate and make a decision regarding seasonal drilling. The stipulation is effective for 2 years from lease issuance, and the same restriction may be extended beyond that time;

- prohibiting disposal of solid wastes on artificial islands or into marine waters, and prohibiting discharge of produced waters, drilling muds, and cuttings into shallow marine waters except by permit;

- providing certain requirements for protection of historical and archeological sites and structures;

- requiring that environmental surveys be carried out by lessees to determine presence or absence of unique marine communities associated with boulder patches (Tracts 36 to 41, 43, 62, 70, 71, 76 to 79, 82, 83, 98, and 116) and prohibiting emplacement of structures and pipelines on Block 700 (parts of Tracts 78 and 40) for the protection of areas where marine life is unusually diverse; and

- prohibiting surface entry on Cross Island and Pole Island from May 15 to August 15, when these islands serve as bird nesting areas.

In addition, all structure types proposed for use beyond the barrier islands in water depths greater than 43 feet (13.1 m) were required to be tested for two winter seasons before drilling could begin. This requirement was intended to allow assessment of ice hazards and the technical requirements necessary to withstand them. The 43-foot (13.1-m) isobath was determined by BLM studies to be the critical boundary between the landfast and shear ice zone (BLM, 1979b).

Information to lessees also included provisions to protect ringed seal pupping and overwintering fish; to allow free movement and safe passage of marine mammals and fish; and to restrict aircraft overflights, thus minimizing disturbances to wildlife. In addition, notice was given that surface use would be controlled to prevent unreasonable conflicts with local subsistence harvests. The BF notice of sale also specified that leases be issued for a 10-year period rather than the normal 5-year period due to the fact that seasonal drilling restrictions shortened the time for which drilling was to occur. Finally, the boundaries of the tracts were reconfigured to accommodate different categories of ownership. One hundred seventeen tracts were listed in the final notice of sale.

Also pursuant to the notice of sale, the Beaufort Sea Management Committee initiated the formation of a Biological Task Force composed of representatives from the BLM, Fish and Wildlife Service, USGS, Environmental Protection Agency, National Marine Fisheries Service, Alaska Department of Fish and Game, Alaska Department of Environmental Conservation, and Alaska Department of Natural Resources. The task force was established to provide consultation to the USGS and Alaska Division of Minerals and Energy Management on the conduct of biological surveys by the lessees, the appropriate course of action after surveys have been conducted, and the administration of the biological/environmental aspects of specified Federal and State lease stipulations. The Biological Task Force is to remain in existence throughout the operating life of the leases (Casey, 1981, written commun.).

In November 1979, the North Slope Borough, the village of Kaktovik, and others filed lawsuits. The basic thrust of these suits was the conflict between subsistence activities and oil and gas development offshore. Requests for injunction of Lease Sale BF were filed against Federal tracts in the Federal District Court for the District of Columbia and against

State tracts in the Alaska Superior Court. Injunctions were denied in both cases and the sale was held on December 11, 1979, in Fairbanks. However, on January 22, 1980, the district court enjoined (prohibited) the Secretary of the Interior from accepting bids and issuing leases on the federally managed tracts. Of the 46 federally managed tracts, 25 received bids. Of the 71 State-managed tracts, 62 received bids. Leases for all State tracts receiving bids were issued in January and February 1980 (BLM, 1980a). Four regional corporations were among the lessees awarded leases on nine tracts. Figure 15 shows the locations of federally and State-managed leased tracts, as well as unleased tracts.

The district court injunction resulted from the findings that, among other things, the Secretary of the Interior had violated the National Environmental Policy Act (NEPA) because the final EIS failed to adequately assess cumulative impacts of the sale, alternative lease stipulations, and alternative management schemes and that he had violated provisions of the Endangered Species Act. In addition, the court held that the Secretary had not assured that NEPA and the Endangered Species Act could be complied with on the four disputed tracts under State management (Dinkum Sands). Since leases on these disputed tracts had already been issued, the court enjoined the lessees from conducting pre-exploratory, exploratory, development, and production activities on the tracts. To address the findings of the district court, a draft supplemental environmental statement was prepared in May 1980 (BLM, 1980a).

In July 1980, the injunction on bid acceptance was vacated (lifted) by the U.S. Circuit Court of Appeals for the District of Columbia. The Secretary of the Interior accepted the high bids on 24 federally managed tracts, which totaled $488,691,137.60. One high bid had been rejected for insufficiency in March 1980 (DOI, 1980). Because the injunction was vacated, no final supplemental environmental statement was released.

One lawsuit in State court resulting from Lease Sale BF remains in litigation. This suit involves a claim by the North Slope Borough, the village of Kaktovik, and a number of environmental groups concerning the validity of the Beaufort Sale beyond the barrier islands. A decision is expected shortly from the Alaska Supreme Court on this case.

In February 1981, Arctic Outer Continental Shelf Orders were published in the Federal Register. These orders, issued by the USGS, consist of standards governing oil and gas lease operations in the Arctic. They include requirements for the identification of drilling structures, platforms, and artificial islands, for equipment and materials, and for pollution prevention and control.

No exploratory drilling has yet occurred on federally managed Lease Sale BF tracts. To date, only two exploration plans have been submitted for these tracts. The first plan, submitted by Exxon in December 1980 and approved by the USGS in January 1981, included the construction of a gravel island as well as the drilling of several wells. Exxon constructed the gravel island during the 1980-81 drilling season in 18 feet (5.5 m) of water on Tract 37. The island was constructed by cutting a hole through the sea ice to unfrozen water, then filling it with more than 300,000 cubic yards (230,550 m3) of gravel that had been trucked from an onshore pit over an ice road to the site. The gravel island is 480 feet (146 m) in diameter, with a working surface about 11 feet (3.4 m) above mean high water. Plans for this island include drilling a 12,500-foot (3,810-m) exploratory well during the 1981-82 season, as well as eventually testing the hydrocarbon potential of Tracts 35 to 39. Leases for these tracts are held by Exxon, Union, and ARCO. The second plan, known as the Tern Project, was submitted by Shell and approved by USGS in September 1981. Shell plans to build a gravel island on Tract 42 during the 1981-82 season, and if possible, exploratory drilling will be conducted during the same season (Lowry, 1981, oral commun.).

Three exploratory wells have been drilled on State-managed leases, all during the 1980-81 drilling season. Two of these were directionally drilled by Sohio from artificial gravel islands on tracts acquired in previous State lease sales. Sag Delta wells No. 7 and No. 8 were drilled into Tracts 75 and 76, respectively. Sag Delta No. 7 was drilled in 11 feet (3.4 m) of water and yielded 4,400

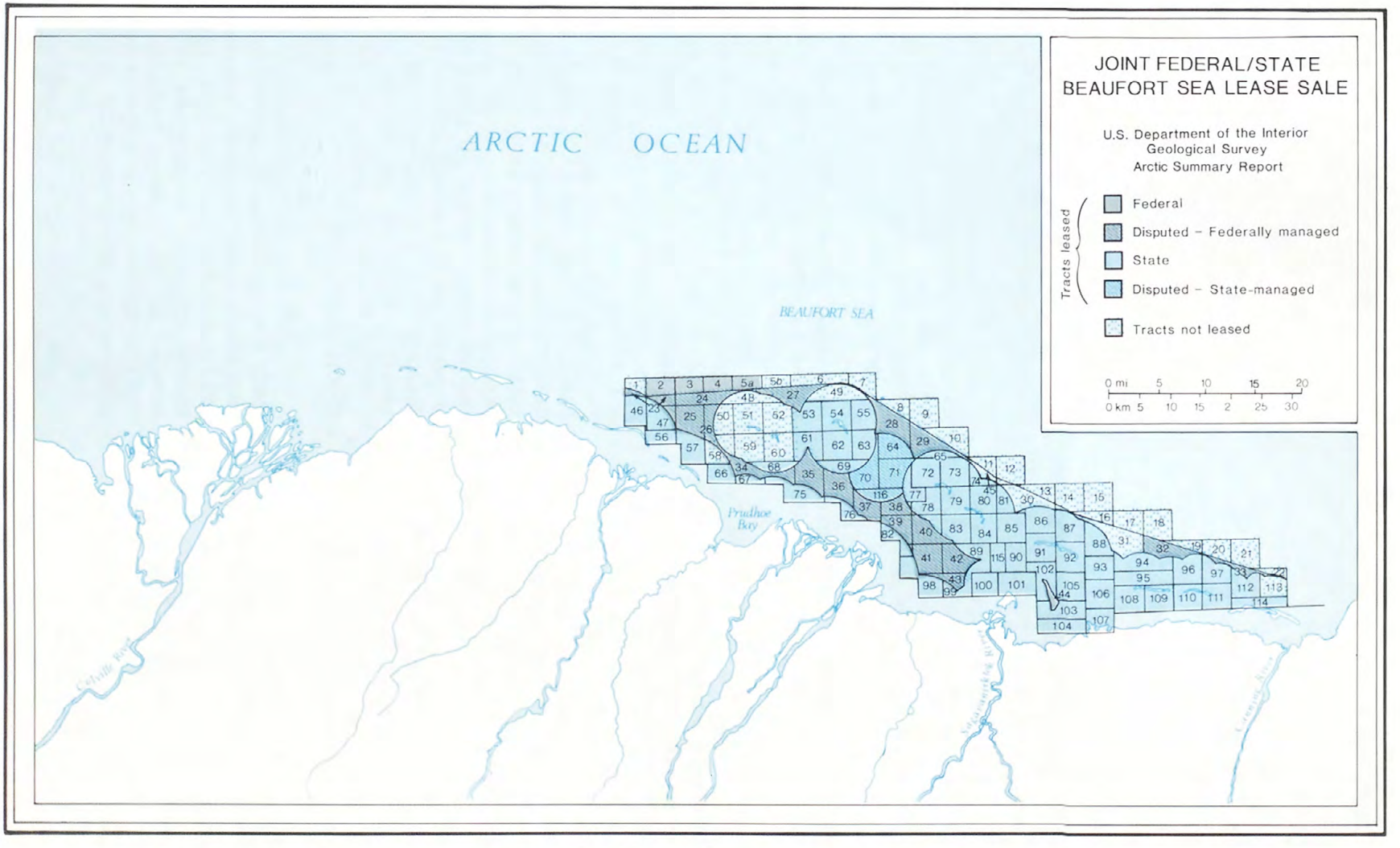

FIGURE 15.--Locations of tracts offered and leased in Joint Federal/State Beaufort Sea Lease Sale. (Base from DOI, 1979a, and data from Oil & Gas Journal, 1981a; adapted by Rogers, Golden & Halpern, 1981.)

barrels (699 m3) of oil per day from a depth of 12,100 feet (3,688 m). Information about Sag Delta No. 8 is proprietary, but Sohio plans to continue drilling in the same area next season, possibly indicating that hydrocarbons were found (Oil & Gas Journal, 1981a). Sohio also drilled one well in the eastern end of the lease sale area from Challenge Island, a natural barrier island. This well was intended to test a structure that cuts across Tracts 95, 109, and 108. It reached its target depth of 13,587 feet (4,141 m), but downhole problems were experienced and the well could not be tested or logged.

Plans for future exploratory activities on State-managed leases include the construction of at least one gravel island and the drilling of as many as 10 exploratory wells in the 1981-82 season. The exploratory wells planned for State-managed leases next season are summarized in table 7. In addition, Shell may build an artificial island on Tract 47, with drilling possible in the 1983-84 season (Oil & Gas Journal, 1981a).

TABLE 7.—Exploratory wells planned for 1981-82 season on State-managed Sale BF tracts

Tract to be drilled	Location of well	Operator	Status
111	North Star Island	Exxon	Approved
54	Cross Island	Tenneco	Approved
62	No Name Island	Amoco	Approved
76	Endeavor Island (artificial)	Sohio	Planned
75 or 76	Resolution Island (artificial)	Sohio	Planned
79	Jeanette Island	Chevron	Approved
109	Alaska Island	Sohio	Approved
114	Flaxman Island	Exxon	Approved

SOURCE: Oil & Gas Journal, 1981a; van Dyke, 1981, oral commun.

Lease Sale 71

A second Federal Beaufort Sea lease sale, Sale 71 (Diapir Field), is currently scheduled for February 1983 (now proposed for September 1982). In preparation for the sale, the Bureau of Land Management requested resource reports in September 1979 from Federal and State agencies for the Beaufort Sea area. Reports received indicated concern about adequate wildlife protection, ice hazards, and the effect of drilling rig discharges on the arctic environment. The call for nominations was issued in October 1979 and covered an area of 12.6 million acres (5,097,960 hectares), including over 2,300 blocks. The call area extended from the 3-mile (4.8-km) Federal-State boundary, where water depths are approximately 7 feet (2.1 m), out to a distance where depths reach 650 feet (198 m) (BLM, 1979d). A supplemental call was issued in January 1980, seeking additional nominations and comments on the original acreage and adding federally managed or owned tracts that had been rejected from or not leased in Sale BF (BLM, 1980c). In response to the two calls for nominations, 18 companies nominated 1,880 blocks comprising 9.9 million acres (4,005,540 hectares). After the nominations and comments were received and reviewed, Department of the Interior selected 424 blocks totaling over 1.9 million acres (768,740 hectares) in April for environmental study (BLM, 1980b). Figure 16 shows the locations of the tracts under study.

The draft environmental impact statement for Lease Sale 71 is currently in preparation and is expected to be released in January 1982, according to the July 1981 proposed leasing schedule. Scoping meetings, held in a number of North Slope villages during late 1980 to determine the scope of concerns prior to EIS preparation, raised the following issues:

- protection of endangered species and marine mammals;
- protection of the subsistence harvest, habitat areas, and village subsistence livelihood;

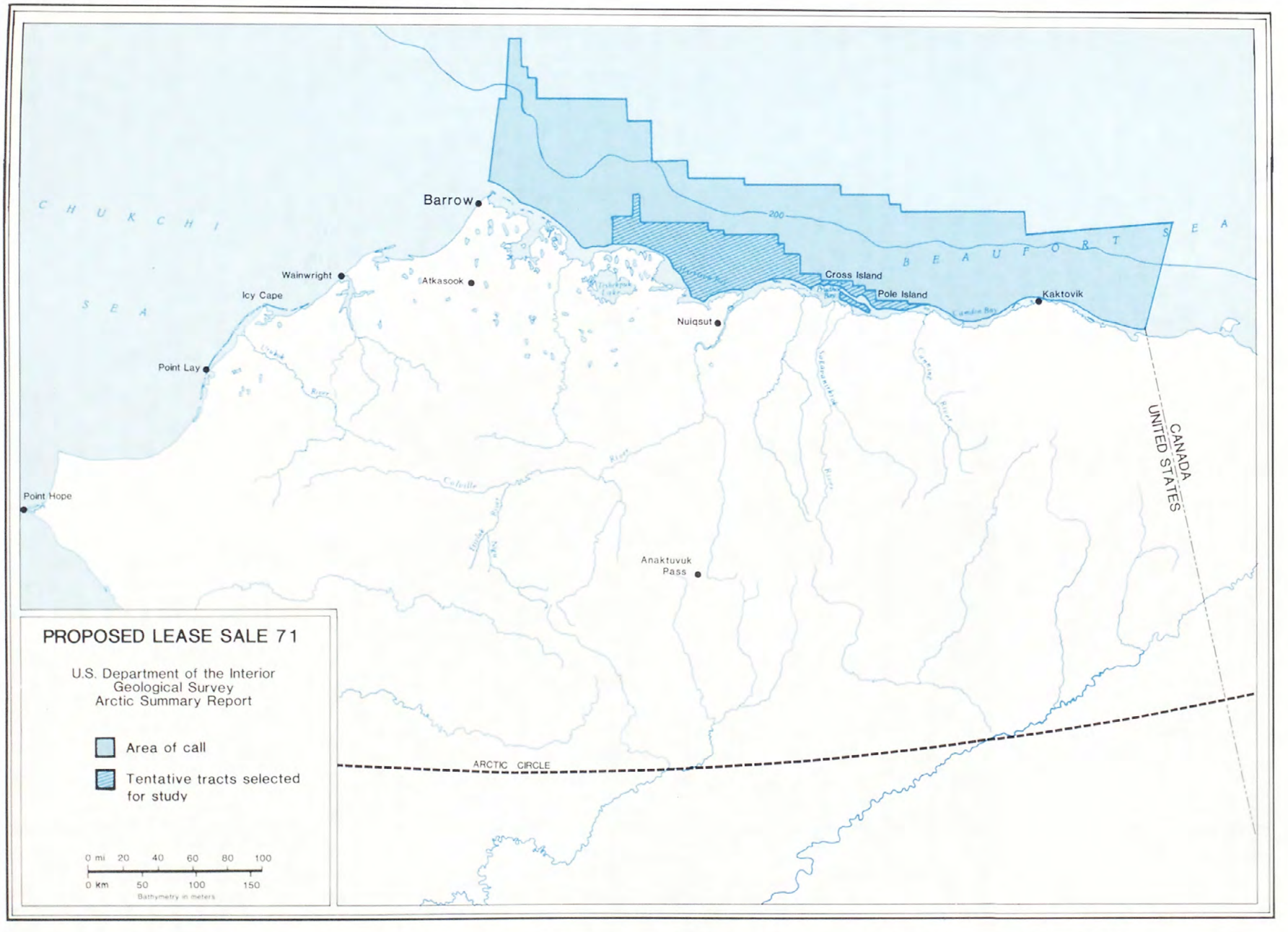

FIGURE 16.--Locations of tracts tentatively selected for Lease Sale 71. (Adapted from BLM, 1980b, by Rogers, Golden & Halpern, 1981.)

- preservation of and respect for Inupiat culture;
- the implications of the North Slope Borough coastal management program;
- cumulative impact assessment of North Slope energy development;
- oil spills and their impact on marine and coastal environments;
- ice hazards and the adequacy of offshore drilling technology;
- tankering of Canadian Beaufort Sea oil; and
- the importance of public participation in the decisionmaking process for leasing.

OTHER FEDERAL ACTIVITY

National Petroleum Reserve in Alaska (NPRA)

The National Petroleum Reserve in Alaska is a 37,000-square-mile (96,000-km2) reserve on the western half of Alaska's North Slope. The reserve extends from the Brooks Range to the Arctic Ocean (fig. 17) and constitutes a significant portion of the North Slope Borough. Barrow is situated at the northern extremity of the NPRA. Major onshore oil and gas lease sales are scheduled for this area.

By Executive Order 3797-A, signed on February 27, 1923, President Harding created Naval Petroleum Reserve Numbered 4, the last of four such reserves to be placed under the control of the U.S. Navy. Exploration programs have occurred periodically since the reserve was created. Until 1977, the reserve was known as NPR-4. The Naval Petroleum Reserve Production Act of 1976 (Public Law 94-258) transferred NPR-4 to the Secretary of the Interior, who assumed responsibility for NPR-4 on April 5, 1976, the date the act took effect. Actual transfer of jurisdiction took place on June 1, 1977, at which time all lands within NPR-4 were redesignated as the National Petroleum Reserve in Alaska.

Production of oil and gas from NPRA was prohibited under section 104 of the act unless authorized by Congress. An exception was made for natural gas fields supplying Barrow and government installations and those that may be necessary to supply natural gas to the Native people of the region. In 1980, Congress passed the Department of the Interior's Appropriations Act (Public Law 96-514), which authorized an expeditious program of competitive leasing for oil and gas exploration and development within NPRA. This legislation provides that if no more than 2 million acres (809,200 hectares) are initially leased, then already completed studies on NPRA fulfill the requirements of the National Environmental Policy Act, and no pre-lease-sale environmental impact statement is required.

The Secretary of the Interior directed the Bureau of Land Management to lease up to 2 million acres (809,200 hectares) in two sales to be held on NPRA. The first sale must be held within 20 months of the enactment of the Appropriation Act (i.e., by August 1982).

The Bureau of Land Management has prepared an environmental assessment (EA), based on available information, rather than an EIS. The draft EA was published in June 1981 (BLM, NPRA Program Staff, 1981). Following a public comment period, a final EA is to be prepared. It is expected to be published by October 1, 1981.

The first of the two initial sales in NPRA, Sale 821, is scheduled to occur on December 16, 1981. The second sale is expected to occur in late spring or early summer 1982.

In consultation with the U.S. Geological Survey, on February 20, 1981, the BLM selected about 5.8 million acres (2,400,000 hectares) of the reserve for further consideration for leasing. The 2 million acres (809,200 hectares) to be leased would come from this land, which has been divided into seven study areas designated A through G. The BLM plans to offer 1.5 million acres (606,900 hectares) at the December 1981 sale and 0.5 million acres (202,300 hectares) at the second sale (DOI, 1981d).

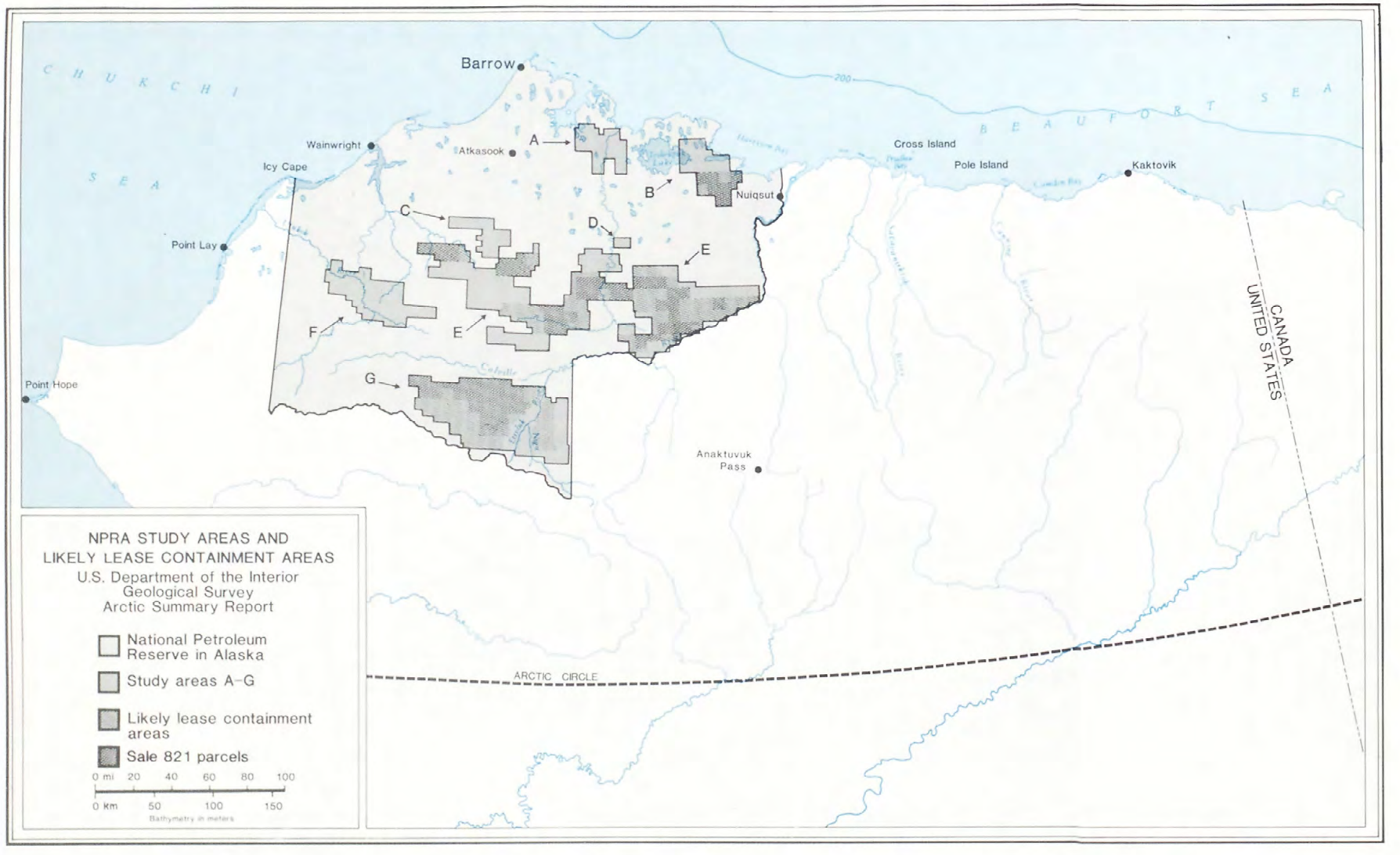

FIGURE 17.--National Petroleum Reserve in Alaska study areas, likely lease containment areas, and tentative tract selection. (Base from USGS, 1980b, and data from BLM, NPRA Program Staff, 1981; adapted by Rogers, Golden & Halpern, 1981.)

Based on the issues identified in the draft EA, in June 1981, the BLM refined the study area by identifying approximately 3 million acres (1,200,000 hectares) as likely lease containment areas, the areas from which it is most likely that the 2 million acres (809,200 hectares) will be selected for the two sales. On September 10, 1980, the BLM tentatively selected 59 parcels of land totaling 1.5 million acres (606,900 hectares) for Sale 821 (DOI, 1981b). The notice of sale, which will include final tract selection, will be issued in November 1981. Figure 17 shows the seven study areas, the likely lease containment areas, and the tracts tentatively selected for Sale 821.

The likely lease containment areas were identified in response to concerns voiced by various groups. The State of Alaska, the North Slope Borough, and environmental groups wanted an early identification of areas likely to be offered so they could better focus their attention on the impacts of leasing and development. The oil industry wanted to avoid conducting geophysical survey work in areas that would not be offered for lease (BLM, NPRA Program Staff, 1981). According to the draft EA, portions of the lease containment areas may still be withheld from leasing or have special lease stipulations attached to them to protect the environment.

As directed in the 1981 Appropriations Act, leased tracts will be no larger than 60,000 acres (24,276 hectares) and the lease term will be 10 years, subject to extension for oil and gas production. The BLM will use bidding systems based on those employed in OCS bidding.

Fifty percent of the receipts from the leases will be paid to the State of Alaska semiannually. The 1981 Appropriations Act provides that in allocating the funds, the State will give priority to subdivisions of the State that are most directly or severely affected by NPRA oil and gas development.

EXPLORATION HISTORY OF THE RESERVE. Surface exploration of the NPRA area has occurred intermittently since 1904, when oil seeps were observed. Following designation of NPR-4 in 1923, geologic mapping was undertaken by the USGS from 1923 to 1926. From 1944 to 1953, the Navy conducted extensive geological and geophysical surveys, which included test wells in and near NPR-4. This first full-scale exploration program, called Pet-4, was recessed in 1953 after having drilled 45 shallow core tests and 36 test wells (including 4 wells at Barrow). Geophysical work included seismic reflection (3,358 miles or 5,404 km), seismic refraction (391 profiles), gravity (6,118 stations), and aeromagnetic (12,600 line miles) surveys (Carter, 1981).

Between 1953 and 1974, the South Barrow gas field development wells 5 through 11 were drilled and minor geophysical surveys were made in the Barrow area.

Following the oil embargo, the Navy undertook a second exploration program from 1974 to 1977. Seven medium-depth exploratory wells were drilled in the northeast area of NPR-4, and additional wells were drilled in the South Barrow field. Geophysical surveys were continued.

Since 1977, when NPR-4 was transferred to DOI and became NPRA, the USGS has continued the Navy program. The USGS program has included 6 additional wells at Barrow and 21 widely scattered test wells (as of April 1981). Extensive geophysical surveys have been conducted by the USGS, and geochemical data have also been collected. This program has been discontinued because industry exploration has been authorized on the 2 million acres (809,200 hectares) to be leased in the next year.

Since 1953, the combined Navy and USGS programs have included a total of 17 Barrow area wells, 28 exploratory wells, 13,455 seismic line miles, and 57,748 gravity stations (Carter, 1981). Figure 18 shows the location of petroleum exploration wells drilled under NPR-4 and NPRA programs.

The USGS is custodian of petroleum-related NPRA records. This information has been released through the Environmental Data and Information Service of the National Oceanic and Atmospheric Administration. A USGS Professional Paper incorporating the work of some 40 to 50 authors and covering all aspects of operations and research on the reserve is in preparation. No publication date has been set.

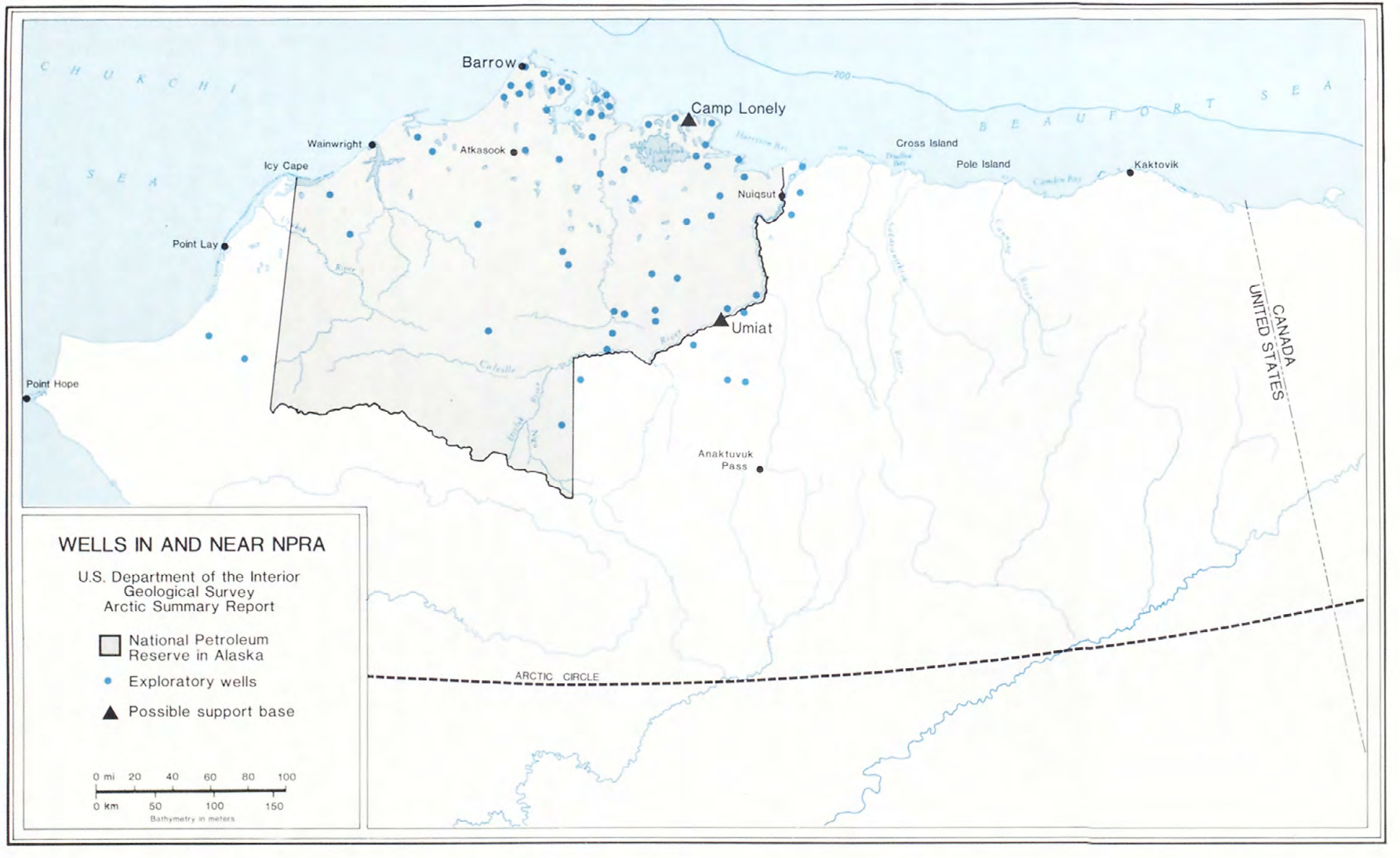

FIGURE 18.--Locations of wells drilled under NPR-4 and NPRA programs. (Base from USGS, 1980b, and data from USGS, 1979, and Zadnik, 1981; adapted by Rogers, Golden & Halpern, 1981.)

ISSUES IN NPRA LEASING. Most of the Native population of the North Slope Borough live in or near the NPRA. As noted in chapter 1, the Inupiat have a long tradition of using the area for subsistence hunting and fishing. Thus, a primary concern is the impact of oil and gas development on this lifestyle and the animals and habitat that support it.

The Bureau of Land Management has identified both regional impacts and impacts by study area in the draft EA. The regional impacts include land surface disturbances, lake and stream disturbances, noise and human activity, land and water pollution, and air pollution. There is concern that these potential impacts could reduce animal and fish populations, restrict access to subsistence areas, or reduce the area used for subsistence gathering activities. All of these may adversely affect residents of the borough and their subsistence lifestyle. Oil and gas activity may also affect wilderness and scenic values, as well as scientific and educational values and archeological remains.

Arctic National Wildlife Refuge(ANWR)

The 8.9-million-acre (3,600,940 hectare) Arctic National Wildlife Refuge occupies the northeast corner of Alaska (fig. 19). A large part of the refuge has been designated a wilderness by Congress. Other portions have not been so designated to permit assessment of their oil and gas potential. The Coastal Plain portion of the refuge borders the Beaufort Sea and is of great interest to the oil and gas industry. It lies 60 miles (96.5 km) east of Prudhoe Bay and is west of the Canadian Mackenzie Delta-Beaufort Sea region. Both of these neighboring areas are rich oil and gas domains.

The Alaska National Interest Lands Conservation Act (ANILCA) provides, in section 1002, for a Coastal Plain study to be conducted by the Department of the Interior. The Fish and Wildlife Service is developing a baseline study of fish and wildlife values in the area. Under the provision of the Act, limited geological and geophysical surface exploration may be undertaken by industry, but no wells are to be drilled and no development is to take place. The Secretary of the Interior has almost 6 years from the date of the enactment of ANILCA (December 2, 1980) to submit a report to Congress on the oil and gas potential of the refuge.

The U.S. Geological Survey, to whom the Secretary of the Interior assigned "lead agency" responsibilities for oil and gas exploration in the ANWR, is beginning to develop regulations and stipulations on permits to engage in surface exploration. The final regulations are expected to be published in July 1982. An environmental impact statement on possible impacts from exploration activity is also expected to be published in July 1982. The present schedule anticipates that private exploration plans would be filed after mid-August 1982. No plans could be approved prior to December 1982. The USGS will administer the permit program allowing private geophysical surveying provided for in the Act.

A lawsuit was filed in the U.S. District Court in Anchorage on May 1, 1981, against Secretary of the Interior James Watt, claiming that he did not have the authority to transfer responsibility for oil and gas exploration from the Fish and Wildlife Service to the USGS. Joining Trustees of Alaska, who brought the suit, are the Alaska Center for the Environment, Fairbanks Environmental Center, the village of Kaktovik, and two individuals (Anchorage Daily News, 1981). Of particular concern to those who brought the suit is the Porcupine Caribou Herd (see ch. 1, p. 23).

Additional Federal Lands

The Department of the Interior is beginning to develop an onshore oil and gas leasing program for additional Federal lands in Alaska. Leasing of other public lands in Alaska is authorized by section 1008 of the Alaska National Interest Lands Conservation Act of 1980 and the Mineral Leasing Act of 1920, as amended.

A notice by the BLM requesting expressions of industry and public interest in oil and gas leasing was published in the Federal Register on April 30, 1981. This notice also included a map of the area under consideration, which encompases all Federal lands except

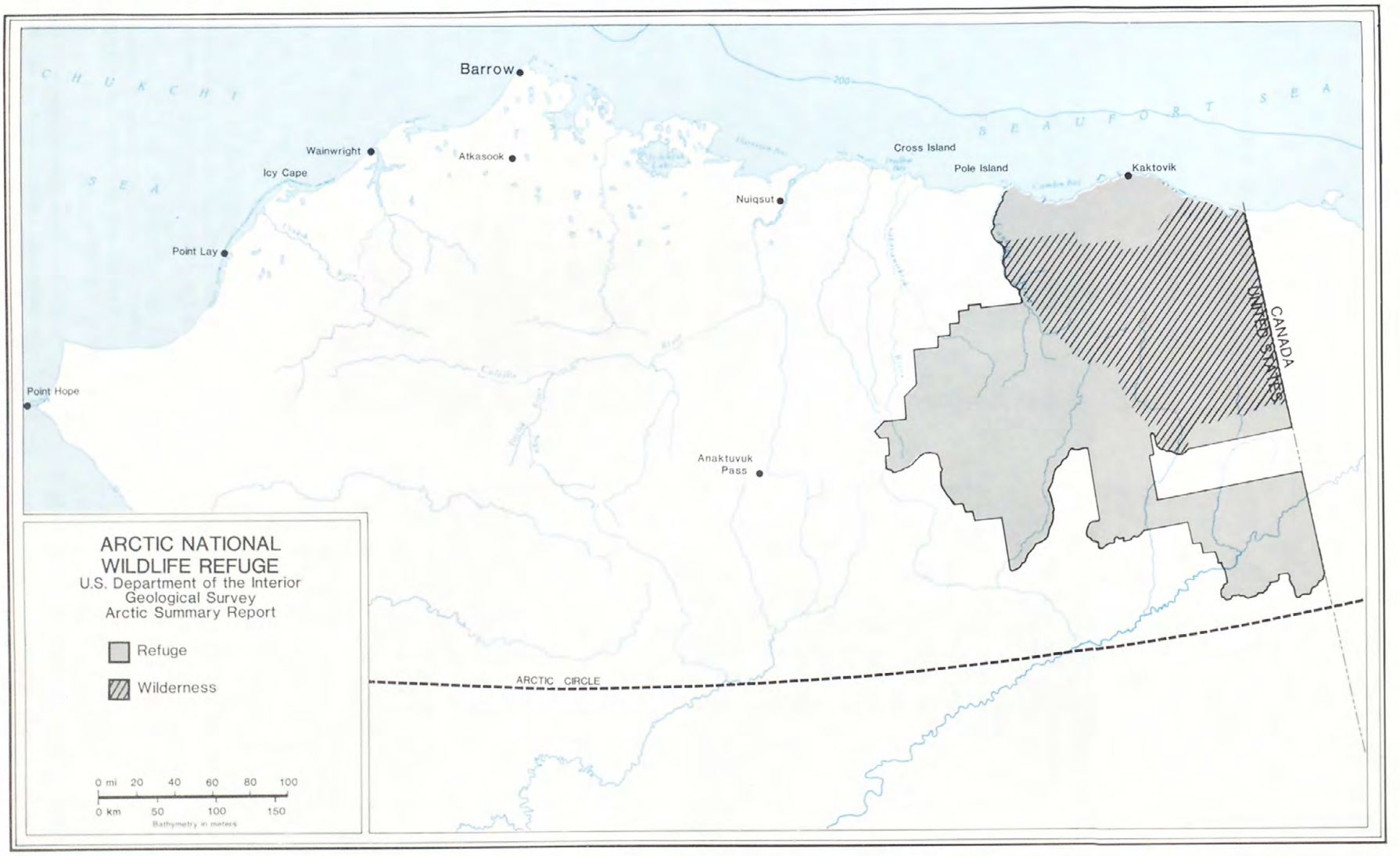

FIGURE 19.--Arctic National Wildlife Refuge. (Adapted from USGS, 1980b, by Rogers, Golden & Halpern, 1981.)

those in the National Petroleum Reserve in Alaska, the Arctic National Wildlife Refuge, the National Park System, the National Wilderness Preservation System, the National Monuments administered by the Forest Service, and other Federal lands that are closed to oil and gas leasing by statute.

The identification of industry and public interest is the first step in opening millions of acres in Alaska to oil and gas leasing. The USGS will use information from these expressions of interest to aid in determining which areas should be classified as Favorable Petroleum Geological Provinces (FPGPs). Responses were due June 17, 1981.

FPGPs, as specified in the Alaska National Interest Lands Conservation Act, are determined by the Secretary of the Interior to be regions of Alaska where the probability of finding oil and gas are higher than elsewhere in Alaska. They are similar to "Known Geologic Structures" in the conterminous 48 States. FPGPs must be leased competitively while most other public land in Alaska outside of NPRA can be let over-the-counter. No FPGPs have been designated at this time.

STATE ACTIVITY

In January 1964, under the 1958 Statehood Act, the State selected for leasing 1,601,582 acres (648,000 hectares) of federally owned land on the Arctic Coastal Plain. This first selection of land in the Prudhoe Bay vicinity, chosen because of its high oil and gas potential, was tentatively approved by the BLM on October 9, 1964. Shortly after approval, on December 9, 1964, the State held the first lease sale in the area. In this sale (Lease Sale 13), the Atlantic Refining Company acquired some 35,000 acres (14,161 hectares) of leases immediately east of Prudhoe Bay, and British Petroleum (BP) acquired all of the western acreage, including extensive leases in the Kuparuk area.

The first three State lease sales in the Arctic subregion (Lease Sale 13, December 9, 1964; Lease Sale 14, July 14, 1965; and Lease Sale 18, January 24, 1967) were all held prior to the discovery of oil in commercial quantities at Prudhoe. At that time, there were still many questions about the feasibility and expense of operating in the Arctic. Bonuses for the three sales totaled a little more than $14,000,000. (By contrast, the State lease sale on September 10, 1969, after the discovery at Prudhoe was announced, received $900,000,000 in bonus bids.)

In April 1967, ARCO and Exxon spudded a well at the Prudhoe Bay State No. 1 location. The operation was shut down in May and resumed after freezeup. The first significant shows were encountered in December, and the discovery was announced in January 1968. In July of that year a second well, drilled at the Sag River State No. 1 location, confirmed the discovery of a new field of major proportions. The main formation is known as the Sadlerochit reservoir. About 45 miles (72.4 km) long and 18 miles (29 km) wide, the reservoir lies about 9,000 feet (2,743 m) below the surface. It is estimated to contain 9.6 billion barrels (1,525,440,000 m3) of recoverable oil and in excess of 20 trillion cubic feet (566,000,000 m3) of salable natural gas. Subsequent drilling has resulted in the discovery of the smaller Kuparuk and Lisburne fields.

Delineation and production drilling of the Prudhoe Bay area were carried out between 1968 and 1977, when limited production of oil from the Sadlerochit reservoir was initiated. Transportation of oil to the tanker terminal in Valdez began in 1977 with the completion of the Trans-Alaska Pipeline. These facilities are discussed in detail in chapter 3. A producing well is pictured in figure 20.

The operators are continuing to develop the field. When all development wells have been drilled, there will be over 900, including water and gas injection wells. ARCO and

It was not until 1966 that Atlantic Refining Company and Richfield Oil Corporation were merged, becoming the Atlantic Richfield Corporation (ARCO). In 1969, ARCO merged with Sinclair Oil Corporation but retained the name ARCO. In January 1981, ARCO created ARCO Alaska, Inc., a wholly owned subsidiary, to manage all oil and gas operations formerly handled by ARCO in Alaska.

British Petroleum (BP) merged with the Standard Oil Company of Ohio (Sohio) in 1970. Sohio's subsidiary, the Sohio Alaska Petroleum Company, now owns and operates leases originally held by BP.

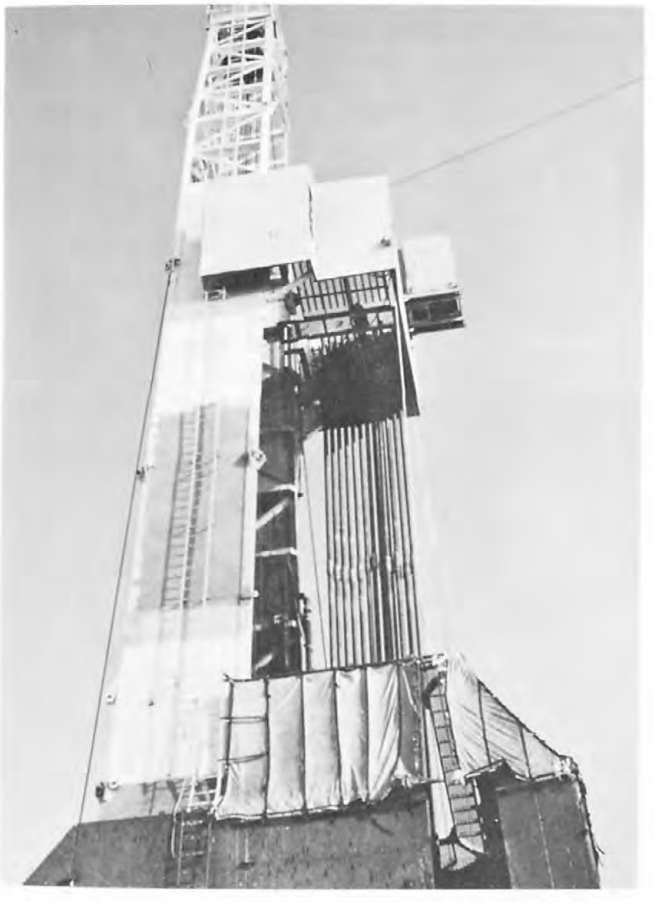

FIGURE 20.--Producing well on State-leased land in the Arctic. (Photograph by Rogers, Golden & Halpern.)

Sohio share operating responsibility for the Prudhoe Bay Unit. The location of the unit, as well as those of other units subsequently formed by oil companies drilling on State lands in the Arctic, is shown on figure 21. ARCO is responsible for the eastern half, operating 82 producing wells that average 7,000 barrels (1,112 m3) per day but vary in output from 2,000 to 20,000 barrels (318-3,178 m3) per day. Sohio's responsibilities are in the western half of the unit, operating 71 wells, each of which produces between 2,500 and 23,000 barrels (397-3,655 m3) per day. The average 1.5 million barrels (238,350 m3) of crude oil that are produced daily at Prudhoe represent 18 percent of the nation's crude oil production. Gas reinjection is handled by ARCO for the entire field. The unit produced an estimated 627.8 million cubic feet (17,800,000 m3) of natural gas in 1980. Of this total, 576.2 million cubic feet (16,306,460 m3) were reinjected into the formation. The remainder was either used for pipeline pump station fuel and electric power generation or flared for safety purposes.

The most recent plan to recover about 1 billion additional barrels (158,900,000 m3) of oil from the Sadlerochit formation is to waterflood the formation. Chapter 4 provides further detail on these plans.

The Kuparuk field is located 40 miles (64.3 km) to the west of the present producing field, perhaps extending as far as the Colville River. It is estimated to contain 3.5 billion barrels (600,000,000 m3) of original oil in place, making it the third or fourth largest such field in the United States. This field is relatively shallow, at 6,000 to 8,000 feet (1,829-2,438 m), and has no gas cap associated with it, in contrast to the Sadlerochit field.

The first phase of development of the Kuparuk field was a pilot project west of the main producing field that will determine if development will be economical. It is estimated that production of 80,000 barrels (12,712 m3) per day from the pilot project will begin in April 1982, although total field production may not start until 1984 or later (Alaska Construction & Oil, 1981b). A field life of 20 to 35 years is projected. The production schedule and field life will depend in part on the throughput allocated to Kuparuk oil in the Trans-Alaska Pipeline.

Due to reservoir thickness, quality, fluid properties, and geology, more wells and well pads and associated facilities will be needed to produce from the Kuparuk field than were necessary at the Prudhoe Bay field. Early water injection to maintain or build the field pressure is also being considered. Further information on facilities at the Kuparuk field is presented in chapter 4.

The Lisburne field is primarily east and north of the present producing zone and lies below the Sadlerochit formation. Exploration to date indicates that a commercial field of 400 million barrels (63,560,000 m3) of oil in association with gas and gas fluids is probably present in this formation. Apparent reservoir discontinuities will make delineation and production both difficult and expensive.

In addition to these three oil zones in the immediate Prudhoe Bay Unit area, there are

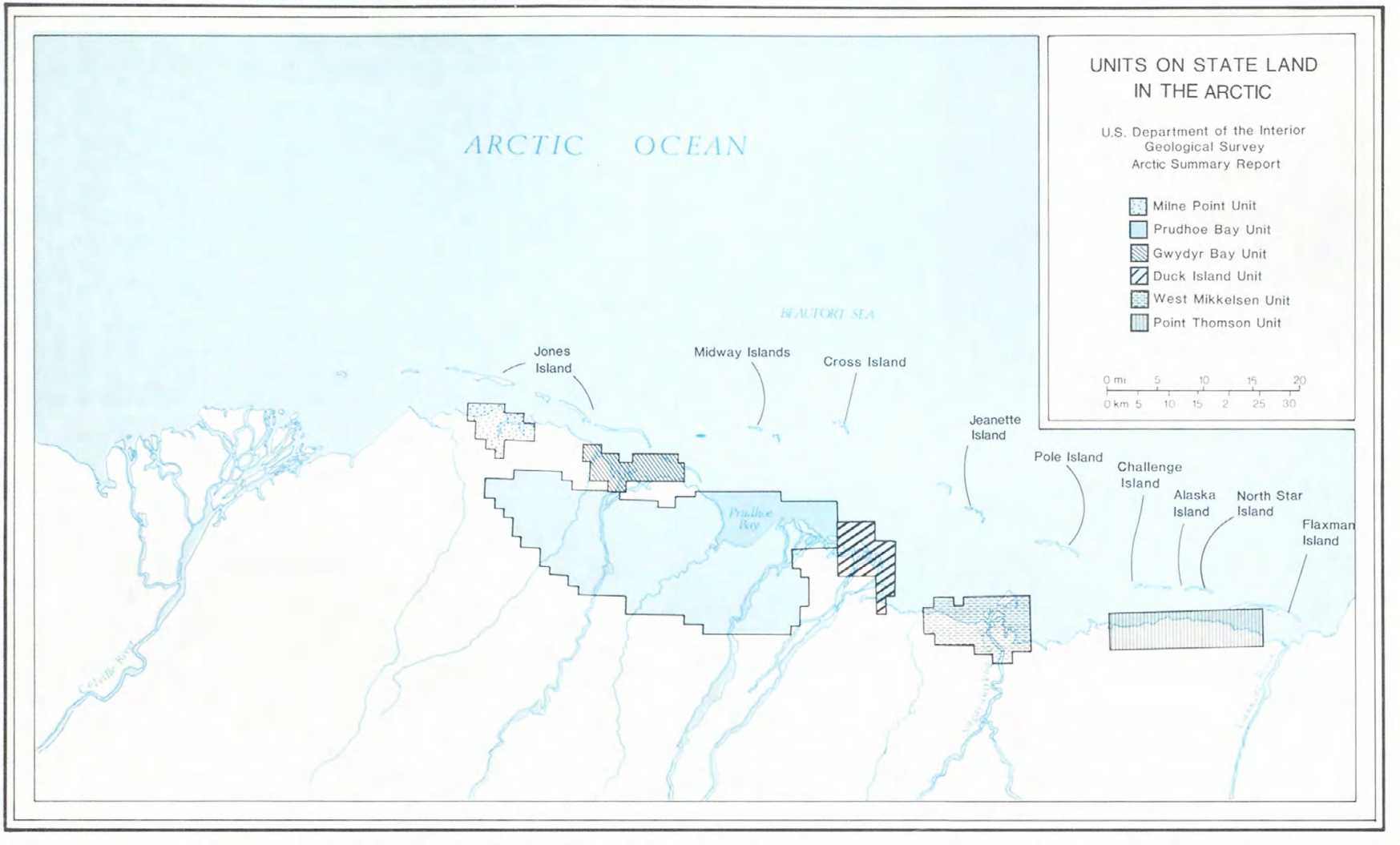

FIGURE 21.--Locations of units on State land in the Arctic. (Base from USGS, 1980b, and data from Alaska Oil and Gas Conservation Commission, 1980; adapted by Rogers, Golden & Halpern, 1981.)

several areas to the north, east, and west of it that are being explored. A discovery in the Point Thomson area was announced in 1972. The area was unitized in 1977 and is operated by Exxon. In August 1981, Exxon released test results from two more of the six wells that have been drilled in Point Thomson area. Five of the six wells that have been drilled in this unit have indicated significant volumes of oil or gas. Exxon plans to drill two more test wells in the Point Thomson Unit this winter (Oil & Gas Journal, 1981c). The upper limit of the field has not been determined, but at least 100 million barrels (15,890,000 m3) would probably be needed for profitable development (Keiser, 1981, oral commun.).

There has been exploratory activity both offshore and onshore southeast of the Prudhoe Bay Unit. West Mikkelsen was unitized in 1978, but no discoveries have been announced for this unit. Duck Island was also unitized in 1978, and in October 1980, Exxon announced that its Duck Island wells No. 1 and No. 2 indicated a good possibility of commercial amounts of oil in the area. In April 1981, Sohio announced a promising area about 3 miles (4.8 km) northwest of the Exxon wells. The area was tested by three wells, Sag Delta No. 7, No. 4, and No. 3, and two of these found producing zones believed to be continuous with the zone encountered by the Duck Island wells. The Duck Island and West Mikkelsen areas are shown in figure 21.

The Sag Delta No. 7 well was drilled during the winter of 1980-81 from an artificial gravel island in 11 feet (3.3 m) of water. The well yielded 4,400 barrels (699 m3) of oil per day through an opening of 0.3 inch (0.8 cm), from a depth of about 12,100 feet (3,688 m). Sag Delta No. 4, suspended March 22, 1978, tested the same oil-bearing sands and yielded 2,473 barrels (393 m3) of oil per day from depths of about 11,900 to 12,000 feet (3,627-3,658 m). The other well, Sag Delta No. 3, drilled in 1977 to 11,279 feet (3,438 m), had oil and bitumen indications but tested only water. Sohio has announced that it will evaluate the well results to determine the next step. Development of the area may be made easier because of the area's proximity to Prudhoe (Wall Street Journal, 1981).

Northwest of Prudhoe, two additional units have been established--the Milne Point Unit and the Gwydyr Bay Unit. Exploration is under way in both.

In April of this year, Conoco, Inc., reported that it had a commercial field in the Milne Point area, 4 miles northwest of Prudhoe Bay. The well at 2 Milne Point, drilled to 9,580 feet (2,920 m), indicated 22-degree API gravity oil in three zones, flowing at 1,900 barrels (302 m3) per day from the middle zone. The 2 Milne Point well is a confirmation of the 1 Milne Point discovery well, drilled during 1979-81 seasons, 2 miles (3.2 km) to the west. The discovery had combined flow rates of 785 to 1,340 barrels (125-213 m3) per day.

Conoco also reported results from another well, 2A Gwydyr Bay State, which is located 35 miles (56.3 km) east of the 2 Milne Point well and just north of the Prudhoe Bay field. Two zones were tested. One zone flowed 37-degree API gravity oil at a rate of 3,000 barrels (477 m3) per day; the other flowed 740 barrels (118 m3) per day of 19-degree API gravity oil. During the 1979-81 seasons, Conoco drilled the 1 Gwydyr Bay State well, a dry hole, 4 miles (6.4 km) to the west of Prudhoe Bay. The company says that more wells are needed in both the Milne Point and Gwydyr Bay areas in order to evaluate the reservoirs.

Areas off the Point Thomson, Duck Island, and Gwydyr Bay Units received high bids in the Joint Federal-State Beaufort Sea Lease Sale. Further offshore activity in these three areas can thus be expected.

The most recent State lease sale--Sale 31--took place on September 16, 1980, in Anchorage. It was a sale of exempt acreage (acreage that can be leased without having been included in the schedule). It is expected that relinquished acreage will be reoffered on a regular basis as it becomes available. Seventy-eight tracts were offered, covering approximately 198,801 acres (80,435 hectares). Most of the acreage was south of Prudhoe Bay, with the remainder to the east and west. A total of 195 bids were received on the 78 tracts. All tracts received bids. The lease terms reserved a 20 percent royalty and a 30 percent net profit share to the State. Nine companies, four individuals, and two organized bidding groups submitted bids. A total of $12,771,301.72 was offered in winning bids,

which ranged from a high of $1,256,000 or $500 an acre to a low of $7,665, or $3 an acre. Five tracts to the south and southwest of Prudhoe received winning bids in excess of $1 million. These tracts alone accounted for over 44 percent of the bonus monies.

Four additional State lease sales are planned for the Arctic area. The first two of these proposed sales, Lease Sales 34 and 36, are scheduled for May 1982. The State plans to offer acreage in the Prudhoe Bay upland area and between the Sagavanirktok and Canning Rivers, as well as submerged lands in the Flaxman and Midway Islands areas. The second sale is scheduled for the second quarter of 1983. Originally this sale was to be coordinated with the Federal OCS Lease Sale 71. The Federal sale has been given an earlier sale date on the proposed schedule, but the State does not plan to alter its schedule. Land near or adjacent to that offered in the Federal sale is expected to be offered. The third sale is scheduled for the third quarter of 1984 and will again offer leases in the Beaufort Sea. Additional sales may be scheduled during the next 5 years.

ARCTIC SLOPE REGIONAL CORPORATION ACTIVITY

The Arctic Slope Regional Corporation (ASRC), the regional profit-oriented organization set up by the Alaska Native Claims Settlement Act of 1971 (ANCSA), has title to 4.3 million acres (1.7 million hectares) located in the North Slope Borough. Beginning in 1973, the corporation entered into a number of exploratory agreements with major oil companies that, among other things, enable the oil companies to conduct exploratory work on lands subject to selection or selected by the Corporation and grant those companies contractual options to acquire oil and gas leases on a significant portion of such lands. This work has included surface geological studies, geophysics (including seismic, gravity and aeromagnetic surveys), and aerial photography. Several wells have been drilled southeast and west of NPRA, all of which have been reported as dry holes. Drilling is currently under way at three locations, two southeast of Umiat and the other near Point Lay.

The ASRC has title to lands with oil and gas potential and will probably continue its low-level exploratory activities for some time. Since this is a private project, environmental impact statements are not required, nor have future plans been made available. Through June 30, 1980, the corporation received a total of $33,199,355 from agreements and oil and gas leases resulting from options. The leases cover approximately 2,700,000 acres (1,092,420 hectares) (Arctic Slope Regional Corporation, 1981).

CONCLUSION

This chapter has discussed the magnitude and timing of oil and gas operations throughout the Arctic. Presently, exploratory activities are being carried out on the OCS. However, activities elsewhere in the subregion range from pre-lease-sale planning in NPRA and ANWR to development and production on State lands. Production activities at Prudhoe Bay have resulted in the construction of the Trans-Alaska Pipeline System (TAPS) and related facilities. It is anticipated that these facilities will accommodate some of the future production from OCS areas. Existing and proposed transportation systems and their relationship to OCS operations are discussed in the next chapter.

3. Oil and Gas Transporation Strategies

The commercial discovery of hydrocarbons at Prudhoe Bay necessitated the development of a transportation system to carry the oil from the North Slope to U.S. marketplaces. The Trans-Alaska Pipeline System (TAPS) was constructed as a result of the major find, and it will be used for future oil transport in the event of OCS discoveries.

The first section of this chapter summarizes the role of the Intergovernmental Planning Program (IPP) in planning for and regulating oil and gas transportation.

Section two begins by briefly describing the advantages of using pipelines as a predominant transportation mode and the process by which pipeline routes are selected. It then examines the existing and proposed transportation systems for Alaska oil and gas. Offshore planning efforts designed to help determine how oil and gas will be transported from the Beaufort Sea gravel islands to TAPS are also examined. Possible future pipeline corridors as a result of further onshore resource development are also reviewed in terms of how they would affect the eventual throughput capacity of TAPS and the probability of new terminal locations. The final portion of section two identifies year-round tankering plans proposed by the U.S. Government and a Canadian oil company as a possible means of transporting oil and gas from the Canadian Arctic past the northern coast of Alaska to potential West Coast markets.

Section three serves as a conclusionary passage and provides an outlook on future planning strategies for OCS and onshore transportation systems.

OCS TRANSPORTATION PLANNING

Intergovernmental Planning Program

Many government agencies and private industries have roles to play in planning for and regulating oil and gas transportation. The Bureau of Land Management (BLM), through its Intergovernmental Planning Program for OCS Oil and Gas Leasing, Transportation and Related Facilities, takes the lead role in transportation planning.

The IPP was officially initiated on September 20, 1979, when the private-sector appointments were made to the Regional Technical Working Group (RTWG) Committees. These working group committees are composed of Federal and State officials and representatives of industry and other special and private interests. The members of the Alaska RTWG Committee, as of July 1981, are listed in table 8.

The movement of oil and/or gas from the Outer Continental Shelf to processing points and to users is an important part of the overall RTWG planning function. The principal end product of this planning effort is a Regional Transportation Management Plan (RTMP). If commercially producible quantities of oil or natural gas are discovered in the Alaska leasing region, an RTMP will be developed. At a minimum, the RTMP will include the following information and recommendations:

- analyses and recommendations for discrete transportation corridors

and alternatives, including all routes to onshore facilities or to offshore terminals serving as collection points for more than one production area;

- identification of environmentally sound areas for the possible location of onshore facilities;
- alternatives regarding surface vessel transportation, in accordance with appropriate regulatory agencies;
- plans for monitoring construction and operations and any required follow-up studies; and
- any stipulations and use restrictions identified as applicable to transportation rights-of-way.

At the June 24 and 25, 1981, meeting of the Alaska RTWG, a decision was made to start on a Phase I status report for the Beaufort Sea. This represents the RTWG's first transportation planning effort for the Arctic subregion. Transportation planning was discussed at the group's September 9 and 10 meeting in Juneau (Euler, 1981, oral commun.). A detailed description of the IPP is presented in appendix D.

EXISTING AND PROPOSED TRANSPORTATION SYSTEMS

Transportation of Alaska oil is presently executed in two steps: transport of the mineral resources from the production field via pipeline to a terminal, and transport from the terminal to a destination in the conterminous United States. Crude oil from Prudhoe Bay is presently being transported to the port of Valdez in southern Alaska by TAPS (fig. 22), then tankered to the conterminous States. In addition, a more extensive pipeline network is being considered to deliver oil and gas from potential fields in the Arctic to central gathering stations in Alaska.

The use of pipelines as the predominant method of transporting oil and gas from onshore, offshore, and OCS areas is a result of economic and safety considerations. Pipelines benefit from economies of scale: the larger the pipeline, the lower the unit transportation cost. For each barrel or cubic foot of capacity, construction and operating costs for a

TABLE 8.—Alaska Regional Technical Working Group Committee

Member	Affiliation
Mr. Gerald Reid	Fish and Wildlife Service
Mr. Rod Smith	U.S. Geological Survey
Capt. John Hansen	U.S. Coast Guard
Mr. Jim Sweeney	Environmental Protection Agency
Mr. Ron Morris	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
Ms. Esther Wunnicke	BLM Alaska OCS Office
Mr. John Bates	State/Federal Transportation Planning Organization
Mr. Bill Van Dyke	State of Alaska
The Hon. Alan Beardsley	Mayor, City of Kodiak
(vacant)	League of Women Voters
Mr. Dave Benton	Friends of the Earth
Mr. Geron Bruce	United Fishermen of Alaska
Ms. Kay Diebels	Private citizen
Mr. Gil Jemmott	Alaska Oil and Gas Association
Mr. Caleb Pungowiyi	Kawerak, Inc.

For further information concerning the Alaska Regional Technical Working Group Committee membership, contact Gordy Euler, Bureau of Land Management, 620 East 10th Avenue, P.O. Box 1159, Anchorage, AK 99510 (telephone: (907) 276-2955).

FIGURE 22.--The Trans-Alaska Pipeline, viewed from Atigun Pass looking south. (Photograph by BLM, Fairbanks District Office.)

larger line are smaller than for a smaller line. As long as the total volume, or throughput, is sufficient to keep the pipeline essentially filled, considerable economies of scale are possible (American Petroleum Institute, 1979). In terms of environmental safety considerations, alternatives to pipeline transportation (usually barge and tanker operations) have a disadvantage of being subject to more severe climatic constraints. This is especially true for Arctic regions, where year-round tankering is hampered by the presence of sea ice for 9 to 10 months each year.

Before pipelines can be installed, operators must file applications for Federal and State permits and approval must be granted. Pipeline permit applications are reviewed by a number of agencies, depending on the purpose of the pipeline, the mineral resource being transported, and the method of transport and supplementary facilities required. Route selection is also considered. Decisions concerning the selection of a pipeline corridor depend on the length of route, terrain elevations, number of river crossings, and stability of soil conditions with respect to thaw. Proposed delivery routes now under consideration can apply much of the technology and experience gained from the existing transportation system in Alaska.

Trans-Alaska Pipeline System (TAPS)

The 1968 announcement of the discovery of major petroleum reserves at Prudhoe Bay was followed by intense negotiations on the most feasible method of producing and marketing the oil from the North Slope of Alaska. The negotiations resulted in the creation of the Alyeska Pipeline Service Company by a consortium of companies sharing interest in the Prudhoe field, with the objective of transporting oil through an 800-mile (1,287-km) pipeline from Prudhoe Bay to the Port of Valdez in southern Alaska. Companies forming the Alyeska consortium were the Amerada Hess Pipeline Corporation, ARCO Pipe Line Company, Sohio Pipe Line Company, Exxon Pipeline Company, Mobil Alaska Pipeline Company, Phillips Alaska Pipeline Corpora-

tion, Union Alaska Pipeline Company, and BP Pipelines, Inc. Alyeska planners originally considered several transportation alternatives, such as ice-breaker tankers, railroads, air cargo, and a trans-Canada pipeline, but an all-Alaska overland route was selected as the most practical method (fig. 23).

After a route for TAPS had been chosen by Alyeska, the consortium applied for a 54-foot (16.5-m) pipeline right-of-way from the Department of the Interior, along with a request for special land use permits for an additional 11 feet (3.4 m) on one side and 35 feet (10.7 m) on the other side of the right-of-way and for a 200-foot (61-m) space necessary for the construction of a haul road along the segment of the pipeline from Livengood to Prudhoe Bay. Environmental groups, alarmed by the potential danger that the pipeline posed to the Alaska tundra and wildlife, sought to block Federal approval of its construction on the grounds that the rights-of-way and special land use permits were in violation of the Mineral Leasing Act (MLA) of 1920 and the National Environmental Policy Act (NEPA) of 1969. In March 1970, conservation organizations filed suit against the Department of the Interior **(Wilderness Society, et al.** v. **Morton)** and won. Several Native groups, who sought to block rights-of-way permits for the pipeline to cross village lands, were also granted an injunction against DOI permit approvals.

In 1972, the final environmental impact statement (EIS) on TAPS was completed. President Nixon then directed the Department of the Interior to immediately authorize the construction of the 800-mile (1,287-km) pipeline and haul road. Environmentalists appealed again solely on the basis of the 1920 MLA, which limited rights-of-way across public lands to a width of 50 feet (15.2 m). The U.S. Supreme Court upheld the appeal. The only remaining avenue for President Nixon was to seek congressional authorization for the pipeline, which changed the 1920 law and exempted TAPS from further provisions of NEPA. The 1973 Trans-Alaska Pipeline Authorization Act--TAP Act (Public Law 93-153)--removed the 50-foot (15.2-m) right-of-way limit and barred any future pipeline challenges based on NEPA. Construction subsequently began in 1974, and TAPS began transporting oil from the North Slope in June 1977.

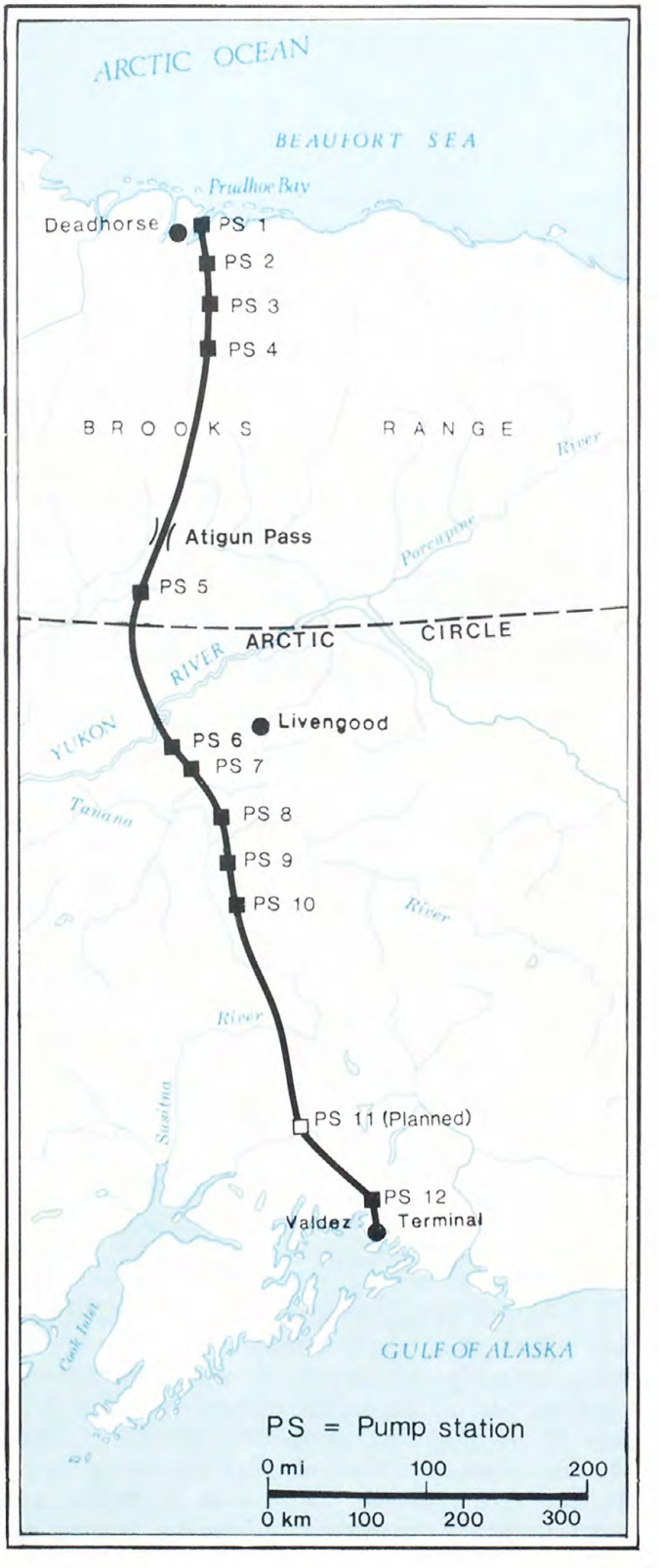

FIGURE 23.--Trans-Alaska Pipeline System route. (Base from USGS, 1980b, and data from Alyeska Pipeline Service Company, 1980; adapted by Rogers, Golden & Halpern, 1981.)

Currently, the throughput for TAPS is 1.5 million barrels (238,350 m3) of oil per day, a rate that has been set as a maximum efficient rate by the Alaska Oil and Gas Conservation Commission. The oil is moved through the 48-inch (122-cm) diameter pipeline by 11 operational pump stations, one of them providing draindown capability (rather than pumping) on the south side of the Brooks Range. In the early stages of operation, before all pump stations were built, the pipeline carried about 750,000 barrels (119,175 m3) of oil daily. The addition of pump stations gradually increased the rate to its present throughput, a level matching the current production rate of the Prudhoe Bay oil field. Although ultimate design capacity is 2 million barrels (317,800 m3) of oil per day with a total of 12 pump stations operating, it is unlikely that the rate will be achieved unless the last planned station (Pump Station 11) is built and new sources of North Slope oil are found.

After the oil from Prudhoe Bay is transported through the pipeline, it is stored in tanks at the Valdez terminal and then loaded aboard tankers for shipment to West Coast and Gulf of Mexico ports. Valdez is the northernmost ice-free harbor in the United States, and it provides a deepwater channel with a minimum width of approximately 3,000 feet (914 m). The 1,000-acre (405-hectare) terminal site is located across the bay from the city of Valdez. The site is composed of 18 storage tanks with a total capacity of 9,180,000 barrels (1,458,702 m3) of oil, four tanker berths designed to accommodate tankers up to 250,000 tons (226,775 metric tons), tanker loading and ballast water treatment facilities, vapor control facilities, a fire-pump building, oil spill contingency equipment, and the Operations Control Center for the entire pipeline system. All operations at the terminal are coordinated through the control center, where the flow of the oil is monitored and can be adjusted or shut off, if necessary. Throughput and storage statistics for TAPS are provided in table 9.

THE HAUL ROAD. Before construction of the Trans-Alaska Pipeline could begin, a road was required for equipment and supplies. The road would also be used during the operation of the pipeline. The Haul Road (now officially called the Dalton Highway) was completed in 1975, and it runs along a 424-mile (682-km) route from Livengood, north of Fairbanks, to Deadhorse. It is 28 feet (8.5 m) wide and has a 200-foot (61-m) right-of-way (fig. 24). Included in the Haul Road are 20 bridges, over 1,000 culverts, and 135 gravel pits (Army COE, CRREL, 1980).

The road was built by Alyeska after the Department of the Interior granted the necessary right-of-way for such a route, then given to the State of Alaska with the understanding that the State would maintain it. Recognizing the road's significance to the future growth and development of northern Alaska, the State changed the status and use of a section of the Haul Road from a private access route for TAPS-related transportation to a public highway on June 1, 1981. The section of the Haul Road from the Yukon River to the Dietrich construction camp remained open for summer public use until September 1, 1981. Plans for public use of this section are now the same for following years; however, they may change in the future. Governor Hammond has the authority to close the road to public traffic, but it is unlikely that he will order this restriction. North of Dietrich to Deadhorse, traffic along the road is restricted to TAPS-related use for at least another year.

The North Slope Borough is bisected by the northernmost part of the Haul Road, and

TABLE 9.—Trans-Alaska Pipeline statistics

1980	Throughput, Pump Station 1 (bbl oil)	Closing storage, Valdez (bbl oil)	Number of ships loaded	Ship average volume (bbl oil)
January	47,299,999	3,412,824	56	840,000
February	44,228,161	7,659,308	48	823,200
March	47,844,227	5,137,724	61	816,999
April	46,329,657	2,896,719	54	889,600
May	47,259,011	2,306,550	54	875,100
June	45,712,368	3,924,374	54	822,600
July	46,942,528	5,346,532	55	817,200
August	46,956,856	3,372,591	58	834,400
September	45,488,046	3,705,767	51	873,200
October	46,176,556	1,565,241	59	813,100
November	43,934,449	2,889,320	50	838,500
December	46,762,185	3,045,037	58	791,500
Total	554,934,043		658	
Average per month	46,244,503.6		54.83	

SOURCE: Alaska Oil and Gas Conservation Commission, 1980.

FIGURE 24.--The Haul Road. (Photograph by Alyeska Pipeline Service Company.)

its administrators feel that the opening of the road to the general public will create several negative impacts. If the proposed Alaska gas pipeline is built, it will undoubtedly produce a significant amount of increased truck use along the Haul Road that might create traffic hazards for private cars. In addition to the possible continued disruption of historical and archeological sites, the road opening could severely affect the wildlife populations important Native subsistence. The North Slope Borough has maintained a policy emphasizing industrial use only for the northern portion of the road (North Slope Borough Planning Department, 1980). The borough administrators believe that if the gas pipeline is built, the Haul Road should be used only as an industrial development road for the duration of the pipeline construction. The TAP Act has made some provisions for limited public access during pipeline construction; however, this would be a limited closure and therefore applicable to sites only when construction is in progress.

The environmental consequences of public access to the Haul Road are the concern of all agencies involved. Federal Government stipulations incorporated in the grant of the right-of-way issued to the State of Alaska for the Haul Road require that all operations be conducted to minimize environmental damage and to protect wildlife and humans. However, problems have already arisen. Erosion has threatened Haul Road integrity, various fish passages in streams have been blocked, and in some areas the road is sinking as the underlying permafrost melts (GAO, Energy and Mineral Division, 1981). Road construction and vehicle use are among the most extensive and severe causes of surface soil disturbance in

arctic regions. Increased traffic to remote sites as a result of public access to the Haul Road may further disrupt the fragile environment. Agencies involved in and concerned with the status of the Haul Road should take into consideration the State of Alaska's plans for public travel in the future.

NATIVE AND COMMUNITY IMPACTS. One of the most controversial issues arising from the construction of TAPS was the question of hiring Native (Eskimo, Aleut, and Indian) workers. While no hiring provision specifically naming Alaska Natives was written into the pipeline legislation, a general statement was included on minority hire that charged the Department of the Interior with the responsibility for ensuring that no person was excluded from working on the project because of race, creed, color, religion, sex, or national origin (TAP Act, 1973). Throughout the entire construction period, 5,770 Natives were hired to work on the pipeline, representing 9.7 percent of the pipeline workforce--a total of 60,000 individuals. The Native workers on an average filled two to three different jobs each, amounting to 15,047 actual jobs, 11.5 percent of the total of 131,000 jobs filled during the course of the project (Naylor, 1978). A large number of Native Alaskans were affected, and the effects filtered down into their families, communities, and culture. Some communities in Alaska were more affected than others, depending on the number of Natives hired in the area and the proximity of the community to the pipeline corridor. Smaller communities were not only affected by the amount of local hiring of Natives, but also by the influx of other pipeline-related workers, whose lifestyle and culture were in conflict with those of Native Alaskans. Larger communities also experienced impacts. Fairbanks was able to absorb impacts better than other places mainly because of its relatively larger existing population, but it was still faced with housing shortages (vacancy rates dropping from 7.5 percent to 0.5 percent between 1973 and 1975) and fiscal policy decisionmaking difficulties (Dixon, 1978).

It is certain that Alaska communities will continue to be affected by transportation technology and its impacts in the future. However, measures can be taken to ensure a more equitable distribution of responsibility in developing and implementing strategies responding to resource development. The TAPS experience shows the need for more Federal, State, and industry cooperation as well as local input in an effort to alleviate future negative impacts on Alaska communities.

Northern Tier Pipeline (NTP)

When TAPS went into operation in 1977, large amounts of oil from the North Slope were transported to Valdez and shipped by supertankers to the nearest West Coast ports. The increases in Alaska crude oil and foreign oil being transported to West Coast refineries created a surplus of oil there. The absence of a transportation system that could efficiently move these larger volumes of oil from the West to markets in the northern and inland states necessitated further tanker transportation through the Panama Canal to terminals on the Gulf of Mexico and the East Coast; then the oil had to be pumped upland through existing pipelines leading to northern marketplaces. Although workable, this system was considered both slow and expensive (BLM, 1979d).

As a result, a Northern Tier Pipeline (NTP) System (fig. 25) was selected by the Carter Administration to receive crude oil from the North Slope of Alaska, thereby curtailing the existing oil tanker route by thousands of miles. The NTP would hold a capacity of 900,000 barrels (143,010 m3) of oil per day with 40- and 42-inch (102- and 107-cm) diameter pipe running from Port Angeles, Washington, to Clearbrook, Minnesota. Operation of the proposed NTP is now contingent upon Washington State's permit approval. All other States through which the pipeline would cross have already issued permits. If Washington approves the permit, operation of the system would begin in 1983. When completed, the NTP will provide a quicker and more economical means of transporting North Slope crude oil to the rest of the conterminous United States.

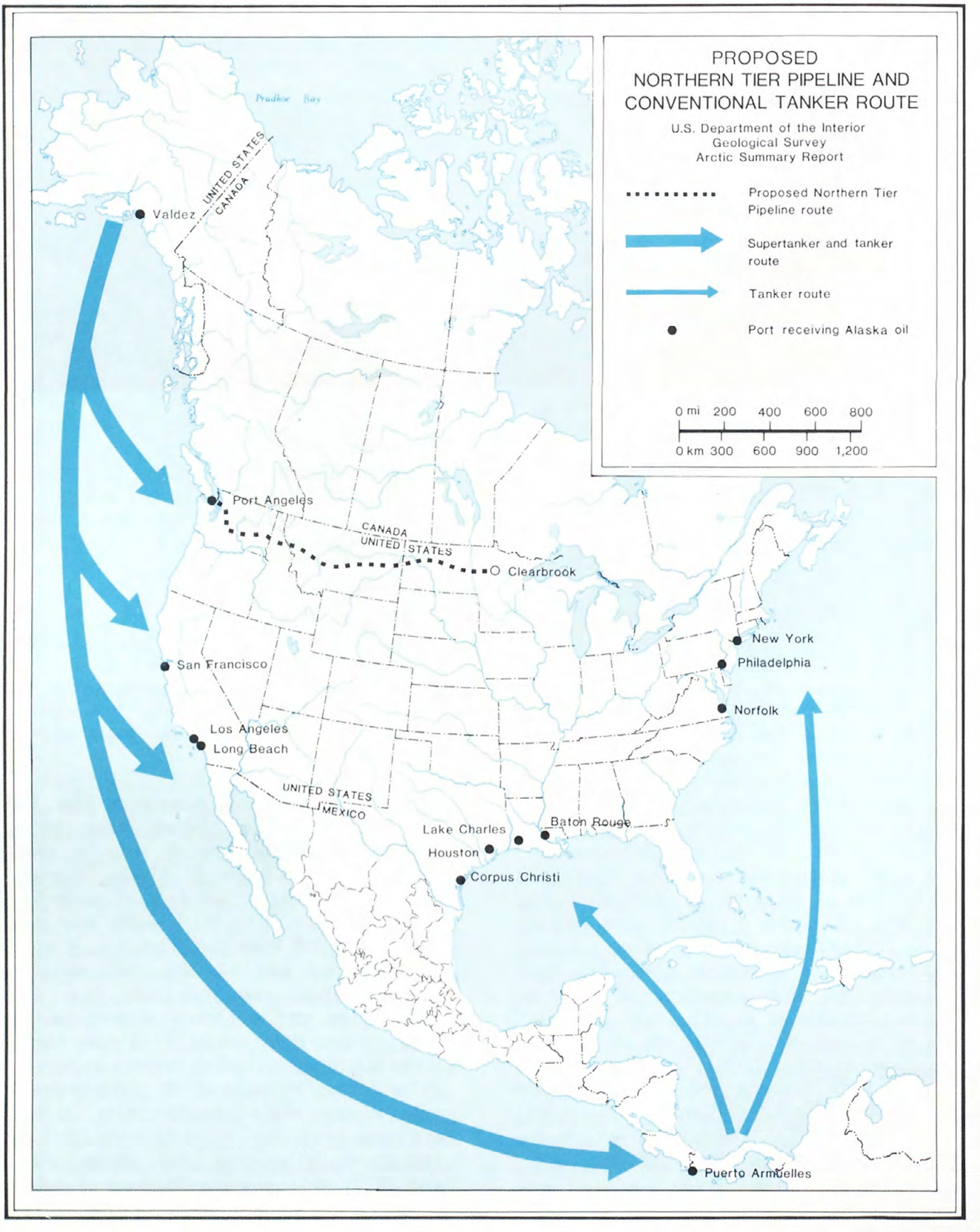

FIGURE 25.--Proposed Northern Tier Pipeline and conventional tanker routes for shipment of oil from Valdez. (Base from U.S. Department of Agriculture, Forest Service, 1971, and data from BLM, 1979a, and Bassett, 1981; adapted by Rogers, Golden & Halpern, 1981.)

Alaska Natural Gas Transportation System (ANGTS)

In 1976, Congress approved the Alaska Natural Gas Transportation Act (Public Law 94-586), setting out procedures to expedite the construction of a natural gas pipeline to carry Alaska gas to markets in the conterminous United States. One of the major provisions of the law required the Federal Power Commission (now the Federal Energy Regulatory Commission) to recommend the best route for a gas line from the North Slope. A route was approved by President Carter and ratified by Congress in 1977.

Upon completion, the Alaska Natural Gas Transportation System will stretch for 4,790 miles (7,709 km), beginning at Prudhoe Bay and ending in the conterminous United States (fig. 26). Construction has already begun on the Canadian, western, and eastern portions of ANGTS. Construction on the proposed Alaska leg should begin in 1982. Until the Alaska portion is completed, the other sections will carry surplus Canadian gas to the conterminous States. Based on current use rates, the life span of ANGTS will be 25 years. Completion and operation of the entire pipeline route is presently scheduled for the winter of 1986-87.

In order to ensure that all pipeline activity be carried out expeditiously, Congress and President Carter in 1979 created the Office of the Federal Inspector (OFI) to serve as a bridge between Federal agencies and private companies and to oversee all construction and initial operation of the U.S. portions of the gas pipeline. Major duties of the OFI include the following:

- coordinating the scheduling and issuance of all Federal permits and related activities to ensure timely and unified decisions;
- monitoring activities to ensure that cost control, safety, and environmental protection objectives are fulfilled while still meeting the project completion schedule;
- keeping the President and Congress informed on project progress, including potential delays or problems;
- establishing a joint surveillance and monitoring agreement with the State of Alaska; and
- enforcing all Federal statutes that affect the project, ensuring that builders are complying with all conditions or stipulations attached to any Federal approval (Federal Register, 1979).

The Federal agencies involved in permit issuance for ANGTS are the Department of Transportation, Department of Energy, Department of the Interior, Department of Agriculture, Department of the Treasury, Environmental Protection Agency, U.S. Army Corps of Engineers, and Federal Energy Regulatory Commission (Chairman).

FINANCING MECHANISMS FOR ANGTS. The current administration in Washington has favored the complete private financing of ANGTS. It is supported by the 1977 legislation that prohibits Federal loan guarantees for the pipeline (Executive Office of the President, 1977). Financing for the Alaska leg of the project has been difficult to obtain, however.

Recently, an agreement has been reached between the 11-member consortium of pipeline companies sponsoring the project (Northwest Alaskan Pipeline Company, or NWA) and the three major oil companies (Exxon, ARCO, and Sohio) that will be producing the natural gas from reserves in Prudhoe Bay. The financing agreement furnishes the oil companies with 30 percent of the gas conditioning facility and gas pipeline ownership, and the pipeline consortium with the remaining 70 percent (OFI, 1981a). Participation from the oil companies in the project was considered necessary due to the consortium's lack of financial power to raise the huge amounts of capital needed. Although the financing agreement would give NWA the backing it has needed from the oil companies, the deal will further depend on private capital

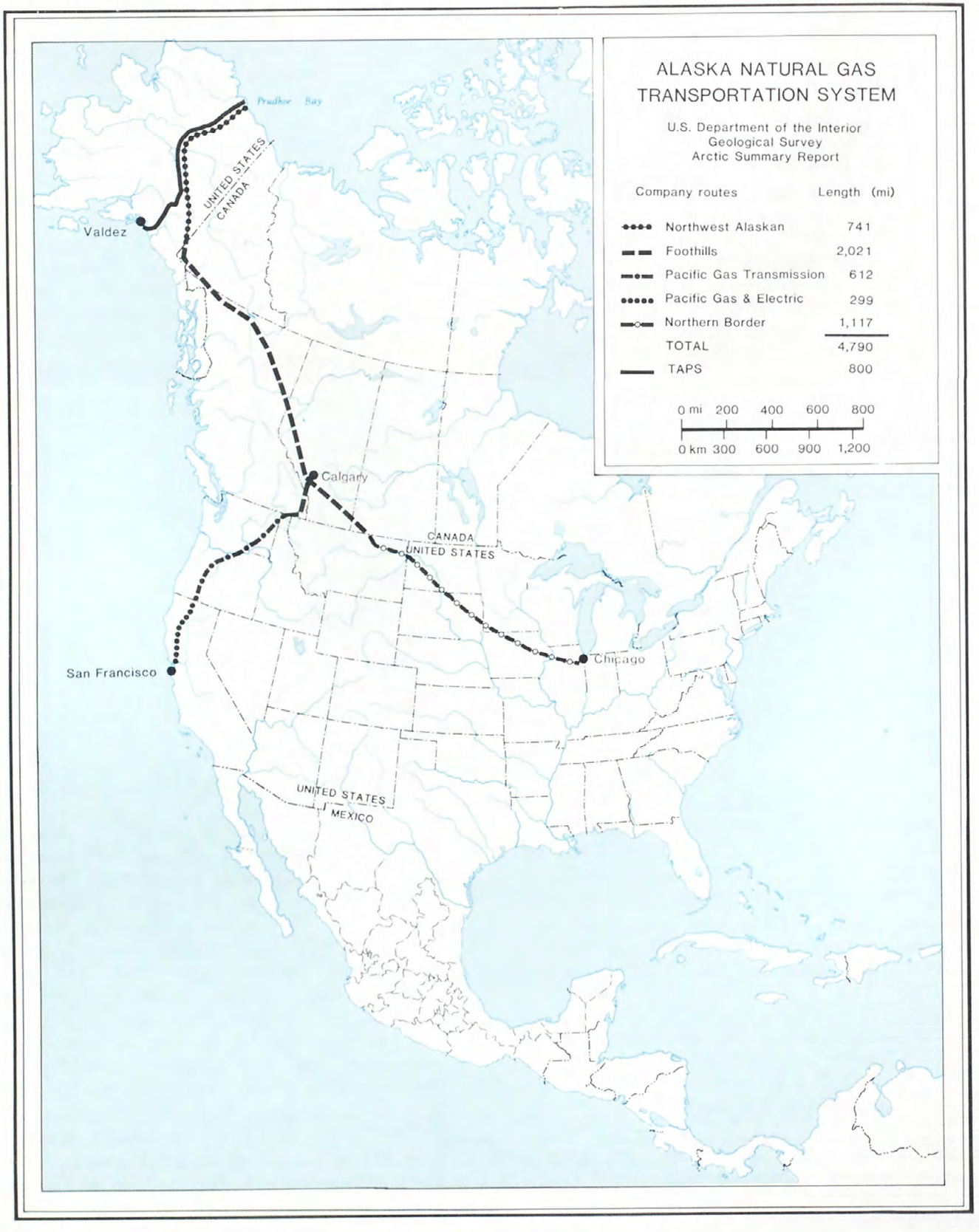

FIGURE 26.--Alaska Natural Gas Transportation System. (Base from U.S. Department of Agriculture, Forest Service, 1971, and data from OFI, 1979; adapted by Rogers, Golden & Halpern, 1981.)

markets for a part of the project's current cost estimate (Energy Resources and Technology, 1981).

Despite Federal Government legislative and administrative requirements that provide a reasonable work schedule and approval of a funding operation for ANGTS, the project's estimated construction completion date has been repeatedly revised from an initial target date of 1983 to the current 1986-87 completion schedule, and the cost estimates for the pipeline have increased dramatically. Current cost estimates for the entire ANGTS project, including Canadian and all U.S. portions, the sales gas conditioning facility (discussed in detail in chapter 4), and a cost-overrun pool, are approximately $37.5 billion (OFI, 1981a) and can be expected to increase if construction delays persist.

The cost increase is mostly concentrated within the Alaska portion of the gas pipeline, where construction has not yet begun. Due to harsh climatic conditions and other environmental constraints, the Alaska leg requires more preparation prior to construction, and therefore more capital. New projections show a cost estimate of $21 billion for the pipeline, $6 billion for the sales gas conditioning facility and $3 billion for cost overruns, all within the Alaska segment of ANGTS.

The present controversy over the deregulation of natural gas prices may further jeopardize the private financing of ANGTS. The uncertainty of the Reagan Administration's gas plans and the future price of gas may discourage private investors. Higher gas prices may lead to a decrease in U.S. gas consumption, thereby reducing the profits of the gas transporter (the principal financiers of the pipeline). Reduction in gas demand as a result of decontrol could potentially prevent private investors from financing a large-scale project such as the ANGTS.

In view of the difficulties still facing the Alaska portion of ANGTS, oil companies have considered other potential ways of handling natural gas from the North Slope. Although they are committed to ANGTS, one such alternative would be to convert the gas to methanol and transport it by pipeline to Valdez. The natural gas pipeline, however, seems to be the most practical method for their purposes.

Future Pipeline Transportation Routes

If not for the presence of the Trans-Alaska Pipeline, the chance of transporting and marketing OCS oil from the Beaufort Sea would be very small. Already in place and operating, TAPS has enough spare capacity to carry initial commercial hydrocarbon finds from the Beaufort Sea gravel islands south to Valdez. If commercial deposits were discovered, TAPS could increase its capacity to 2 million barrels (317,800 m3) per day. If a number of new sizable discoveries are made, a line could conceivably be built at the existing pipeline corridor to handle the excess amounts of oil. Gas would be transported through the proposed ANGTS.

Producers of OCS oil and gas would lay parallel lines from the center of a designated basin by the shortest feasible route to selected onshore gathering stations. These gathering stations, or landfalls, would then connect to the TAPS line or other possible pipelines that would run south to terminal destinations.

The difficulties in constructing marine connecting pipelines to onshore facilities mainly concern offshore ice and scouring and gouging of the ocean bottom. During the winter, shallow water in the Beaufort Sea (3 to 4 feet, or 0.9 to 1.2 m) is frozen to the bottom (Oil & Gas Journal, 1981a). Burial of the pipelines beneath the ocean bottom may be required at these shallow depths. This, in turn, may disrupt the subsea permafrost found in OCS areas. In deeper water, where ice scouring and gouging may occur, pipelines would also have to be buried. However, alternatives are available in almost every aspect of petroleum development. One alternative now being considered by the industry to protect the permafrost is using gravel causeways to bring the pipelines ashore.

The length of the connecting OCS lines would depend on the location of the reservoir. If oil is found in the nearest leased area, just off the coast of Prudhoe Bay, distance would be about 12 miles (19.3 km) to TAPS Pump Station 1. If the eastern portion of the leased area holds oil and gas deposits, the marine pipeline distance could be relatively longer. Several possibilities for best marine pipeline production and maintenance are now being

evaluated by oil companies. Consideration is also being given to bringing the OCS lines to closer shore points and then building a connecting onshore pipeline to TAPS Pump Station 1.

Presently, the National Petroleum Council (NPC) is researching the routing, construction feasibility, land requirements, cost, and schedule for constructing various new overland pipelines to carry production from offshore and/or onshore basins in Alaska. Offshore areas from which new pipelines might extend are shown in figure 27. These areas are located in the Chukchi Sea and Hope and Norton Basins (fig. 3, p. 4), as well as western extensions of the future Beaufort Sea production areas. Onshore areas under consideration are the National Petroleum Reserve in Alaska and the Arctic National Wildlife Refuge.

The north-south lines would eventually extend to shipping terminals. A proposed terminal based in Nome would require economic studies for the cost of bringing icebreaking tankers to the port. An alternative to Nome would be a Cook Inlet terminal, free of ice but requiring a connecting overland pipeline. These proposed north-south pipelines on Alaska's western coast would extend through a much more heavily populated area than TAPS and ANGTS, thus potentially facing more regulatory and permitting delays than other possible corridors and necessitating further detailed analysis on the sociological and environmental impacts of the proposed pipelines.

The east-west pipeline corridors considered would join the TAPS corridor at various locations. Based on preliminary studies done by Exploration and Production Task Groups of the NPC, oil production rates of 1 million barrels (158,900 m3) a day have been estimated for each of the east-west pipelines. In light of these large oil estimates, the NPC Transportation Task Group has proposed in a draft report a "stand-alone" concept for a new north-south pipeline to be located 200 feet (61 m) away from the existing TAPS line where a line parallel appears appropriate (Wahrmund, 1981). Even with Prudhoe Bay reserves declining towards the end of the decade, the NPC presently feels that enough oil will be produced to warrant construction of a supplementary oil pipeline, rather than assuming that capacity would be available within TAPS. A final report on land pipelines and carrying capacity will be available from the NPC in December 1981.

Tanker Transport

Generally, the U.S. Government and the petroleum industry have regarded pipelines as the safest and most practical method of transporting oil and gas from the Arctic to southern markets. However, in the interest of maximizing U.S. Arctic energy resource potential, increased consideration has been given to the development of tankering as a supplementary means of transporting hydrocarbons from OCS and onshore areas. Preliminary studies conducted by the Maritime Administration of the Department of Commerce and the U.S. Coast Guard of the Department of Transportation indicate that Arctic marine transportation capability is an essential prerequisite to the development and exploitation of the Arctic (Department of Commerce, 1981a).

The 1969 effort by the petroleum industry to send the U.S. tanker SS Manhattan through the Northwest Passage established the technical feasibility of a marine mode for Arctic transportation. Since then, the Maritime Administration has performed an economic study that projected Arctic marine commerce requirements and a series of other feasibility studies on drilling support ships, submarines, and icebreaking surface tankers (both nuclear and conventionally powered). Such systems were found to be technically and economically attractive for year-round service in the Arctic (Department of Commerce, 1981a).

There has been some interest expressed by commercial enterprises in Arctic tanker transport; the petroleum and tankering industries will become more involved once the U.S. Government establishes a firm policy on marine transport in Arctic waters.

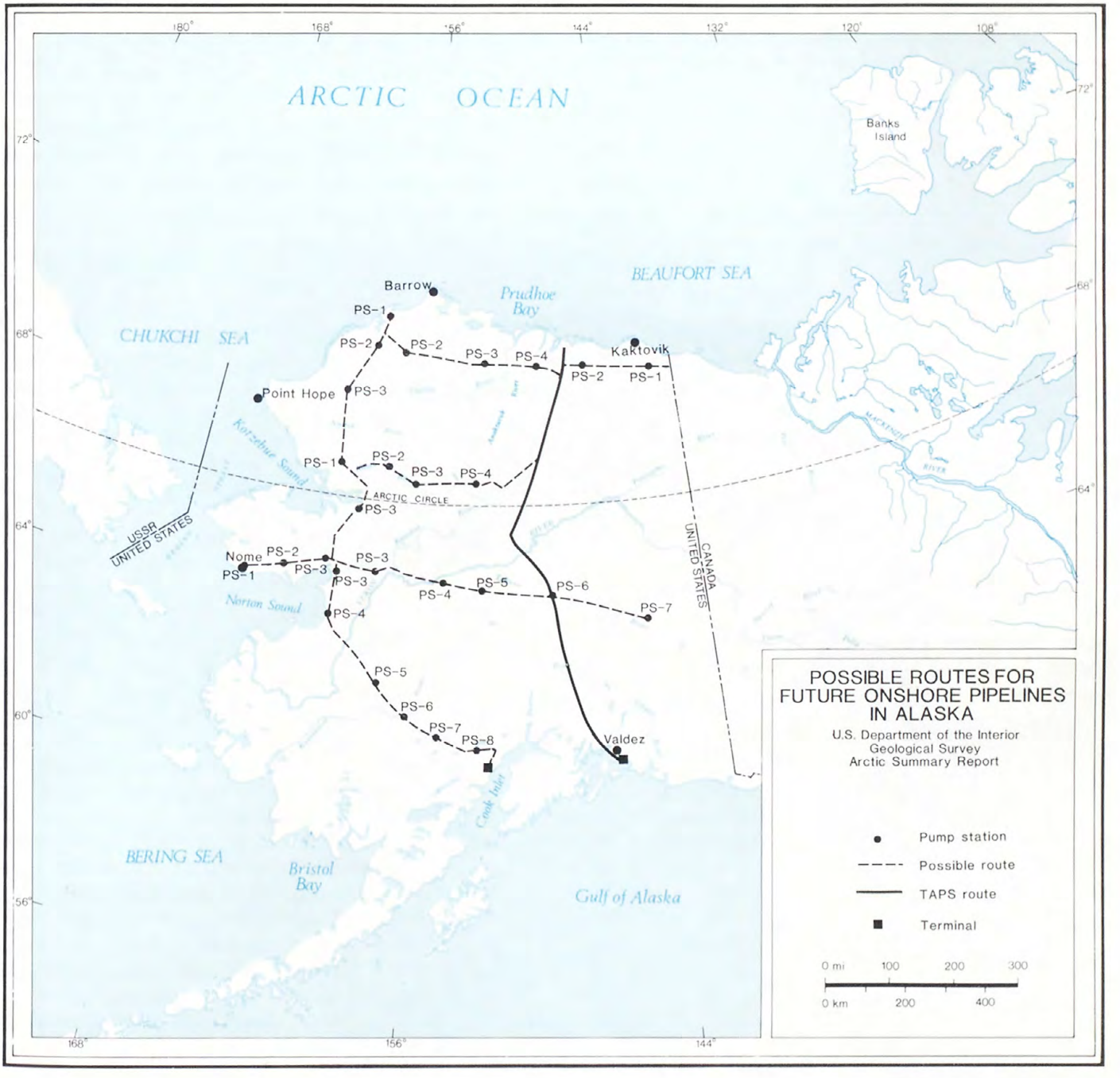

FIGURE 27.--Possible routes for future onshore pipelines in Alaska. (Base from USGS, 1980b, and data from Wahrmund, 1981; adapted by Rogers, Golden & Halpern, 1981.)

Major activity is now occurring in the Canadian Arctic. Canadian petroleum companies have been planning to open shipping lanes through the Arctic Ocean as an alternative to pipeline transport of oil and gas. Dome Petroleum, a major explorer of the Canadian Beaufort Sea, is considering using the Arctic Ocean on a year-round basis for tankering oil and liquefied natural gas (LNG) to consumers in the south. The company now has the technology to permit year-round drilling operations and is projecting the year 1986 as a

target date for initial production and movement of Beaufort Sea oil and gas to southern markets (Government of Canada, 1980).

Two major tanker routes are being considered by Dome: one to the east, leading through the Northwest Passage and supplying oil and gas to domestic markets; and a route to the west, past the northern coast of Alaska and through the Bering Sea for the possibility of exporting Beaufort Sea hydrocarbons to international markets (fig. 28). Presently, the

FIGURE 28.--Proposed western route of Canadian tankers. (Base from USGS, 1980b, and data from Dome Petroleum, 1980; adapted by Rogers, Golden & Halpern, 1981.)

route to the east is favored by Dome, and is Canada's first priority to supply oil and gas to eastern domestic ports.

Although Dome views the Northwest Passage route as more environmentally sensitive than the western route, the company feels that the technology now exists to build an environmentally safe oil tanker designed to operate year-round in the Canadian Arctic (Hoos, 1981, oral commun.). The western route is proposed by Dome for the 1990's. Its use will be contingent on the safety and environmental record of tankers transporting hydrocarbons through the Northwest Passage and on the location of future oil and gas markets (Cattanach, 1981, oral commun.).

Future commercial production and export from the Canadian Beaufort Sea to foreign markets are now feasible. An agreement was recently made between Dome Petroleum and five Japanese utility companies for the sale of 400,000,000 cubic feet (11,326,800 m3) per day of Canadian LNG to Japan (Dome Petroleum, news release, 1980). Although much of the gas would come from British Columbia and Alberta reserves, some of it could eventually be delivered from the Canadian Arctic via LNG ships traveling along the western route past Alaska. Dome plans to build a shipyard for constructing icebreaker tankers and LNG ships in Southern Canada, which would ultimately increase tanker traffic for all Arctic routes. The Japanese National Oil Company has recently invested $400 million in Dome's Beaufort Sea exploration operations for a possible share of the production to be developed in the future, provided the Government of Canada allows oil and gas exports (Dome Petroleum, news release, 1981).

An alternative to the use of surface tankers for LNG shipment was recently proposed by General Dynamics Corporation. The proposal is to construct a fleet of submarine tankers to carry LNG beneath the arctic ice. Each tanker would be capable of carrying 3,215,547.7 cubic feet (91,000 m3) of gas per day and would be loaded from a submerged terminal. It is estimated that the tankers would cost $700,000,000 each if powered by gas and $725,000,000 each if nuclear-powered. These costs are thought to be competitive with a fleet of ice-breaking tankers and cheaper than a pipeline (Washington Post, October 1981).

The possibility of surface tankers passing the northern coast of Alaska has raised a number of concerns for the residents of the North Slope Borough. To avoid heavy ice concentration along the U.S. portion of the Beaufort Sea, tankers would ideally navigate as close to the shoreline as possible. Several mammals, such as the endangered bowhead whale, migrate close to the shoreline, and land species (polar bears and arctic foxes) have also been observed on sea ice. Officials of the North Slope Borough are concerned with tanker traffic causing negative impacts on Native subsistence and traditional hunting activity, as well as on the mammals themselves (Knowlton, 1981).

Tanker spills and their impacts are another concern of the North Slope Borough. Studies are continuing on the behavior and effects of an oil spill in icy waters. New technology would be required to avoid or mitigate adverse impacts of oil spills if tanker traffic were planned for the Beaufort Sea. Recently an agreement was reached between the United States and Canada to cooperate in marine transport research and development. The agreement focuses on tanker transportation in arctic inland and coastal waters. The United States Marine Administration (MARAD) will share with the Canadian Maritime Transport Administration (CMTA) information from the 1969 and 1970 arctic voyages of the SS Manhattan. The two agencies will analyze the data's relevance to arctic ship design and operation, and they will publish a joint report. In return, CMTA will provide MARAD with information on icebreaking tankers built under a joint Canadian industry program (Department of Commerce, 1981b).

FUTURE TRANSPORTATION PLANNING

The current level and pace of exploration, development, and production activity

offshore as well as onshore have required the development and implementation of transportation strategies. Future production will require additional transportation planning.

If commercially producible quantities of oil and gas are discovered in an offshore Arctic leasing region, they will have to be transported onshore for processing, refining, and distribution. The process of planning and constructing oil and gas pipelines is complex. Economic, environmental, and physical factors need to be included to ensure that the alternatives being considered are both technically and economically feasible. Furthermore, pipelines cannot be designed and built with absolute assurance against breaks and spills. This is particularly a problem in areas subject to natural phenomena such as sea ice movement (offshore areas) and soil instability (onshore). Because of the complexity of the process, it is desirable to begin planning as early as possible, before oil and gas lease sales take place, so that measures to minimize and eventually avoid hazards concerning pipeline and tanker transportation strategies can be thoroughly studied and incorporated into the transportation planning network.

4. Facilities and Impacts

Existing support bases at Prudhoe Bay for onshore and offshore activities resulting from State leasing have been used for exploration in the Joint Federal/State Beaufort Sea Lease Sale area. Future onshore exploration-related activity resulting from Lease Sales BF and 71 will probably also be concentrated in the Prudhoe Bay area. The impacts of OCS activity will arise in onshore and offshore areas and will influence aspects of the social, physical, and biological environments. Some effects of this activity will be felt in isolated areas, while others will be felt regionwide. All impacts resulting from OCS activities will contribute to the cumulative effects of Federal onshore, State, and regional corporation oil and gas exploration, development, and production in the Arctic.

Because facilities at Prudhoe Bay have been and will be used to support activity on Federal leases, existing and proposed facilities for Prudhoe Bay are discussed in the first section of this chapter. This is followed by a description of facilities at the Kuparuk field, the Beaufort Sea OCS, and the National Petroleum Reserve in Alaska. The second section provides information concerning the impacts of OCS oil and gas operations on the Inupiat and the physical and biological environments.

EXISTING AND PROPOSED FACILITIES

Prudhoe Bay

The facilities at Prudhoe Bay are contained in an area of approximately 250 square miles (647 km2), which measures about 20 miles (32.2 km) from east to west and 10 miles (16.1 km) from north to south. ARCO operates the eastern part of the Prudhoe Bay unit and Sohio operates the western part. The two operators use different terminology for the same types of facilities. This practice probably results from an attempt by the operators to maintain their own identities at Prudhoe Bay and the competitive nature of oil and gas operations there. The construction undertaken by Sohio also shows more European influence as a result of Sohio's relationship with BP.

The facilities currently at Prudhoe Bay include six flow stations (ARCO) or gathering centers (Sohio), a base camp for each operator at which employees are housed and from which field operations are controlled, over 150 miles (241 km) of gravel roads, two gravel docks, two airstrips, one central and several smaller power stations, a field refinery, and the shops and warehouses of contractors and service companies. ARCO drills wells from at least 17 drilling sites and Sohio drills from at least 15 drilling pads (Sohio Alaska Petroleum Company, 1981). A total of over 120 gravel pads have been constructed to accommodate buildings and drilling equipment (Knowles, 1981, oral commun.). A detailed discussion of facilities relating to transportation of oil from Prudhoe Bay was provided in chapter 3 (p. 54). Figure 29 shows the location of the facilities at Prudhoe Bay.

The production structures called gathering centers by Sohio and flow stations by ARCO are designed to remove gas and water from 300,000 barrels (47,670 m3) of oil per day fed from the wells through gathering lines. About 12 employees man each gathering center. From the gathering center, oil is passed to Pump Station 1 and through the Alyeska pipeline. Gas is routed to a gas compression plant (fig. 30), operated by ARCO, in the

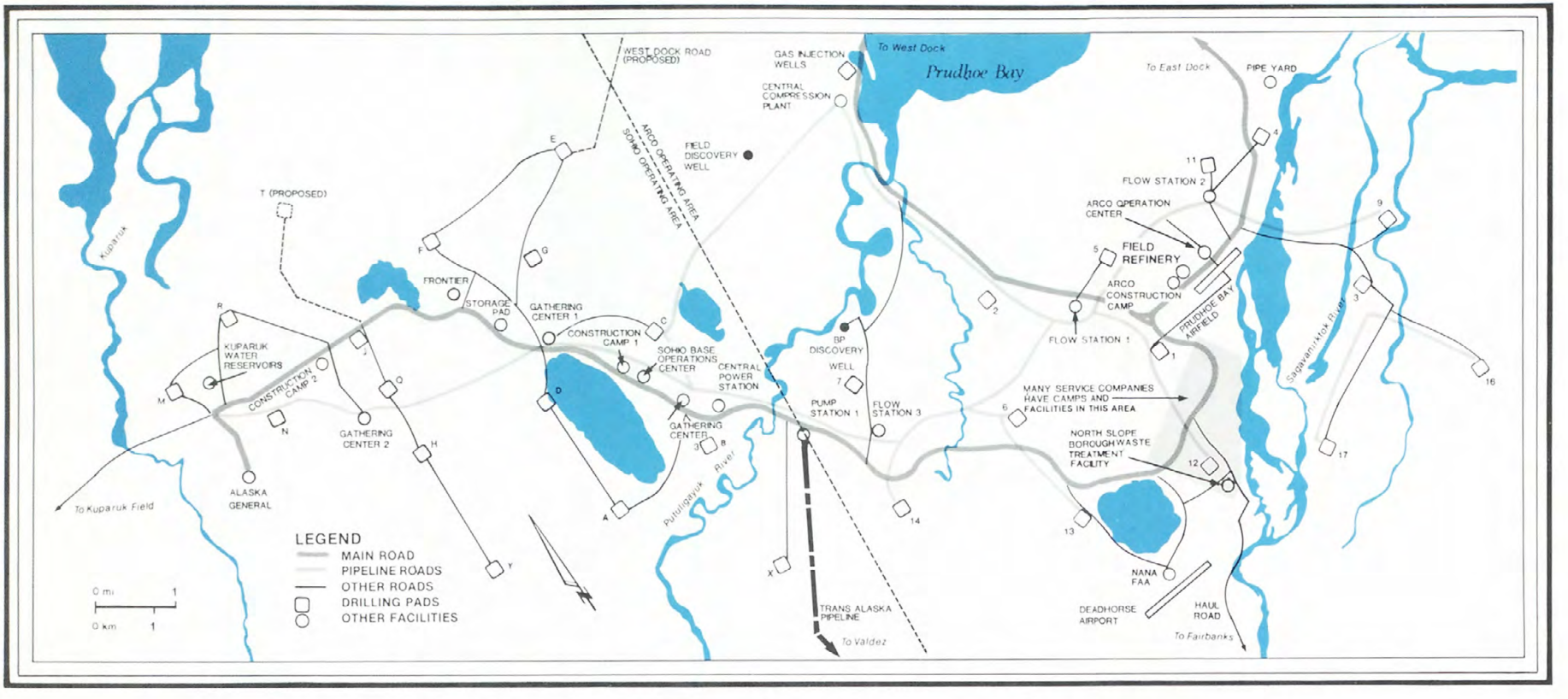

FIGURE 29.--Location of existing facilities at Prudhoe Bay. (Adapted from Sohio Alaska Petroleum Company, 1981, by Rogers, Golden & Halpern, 1981.)

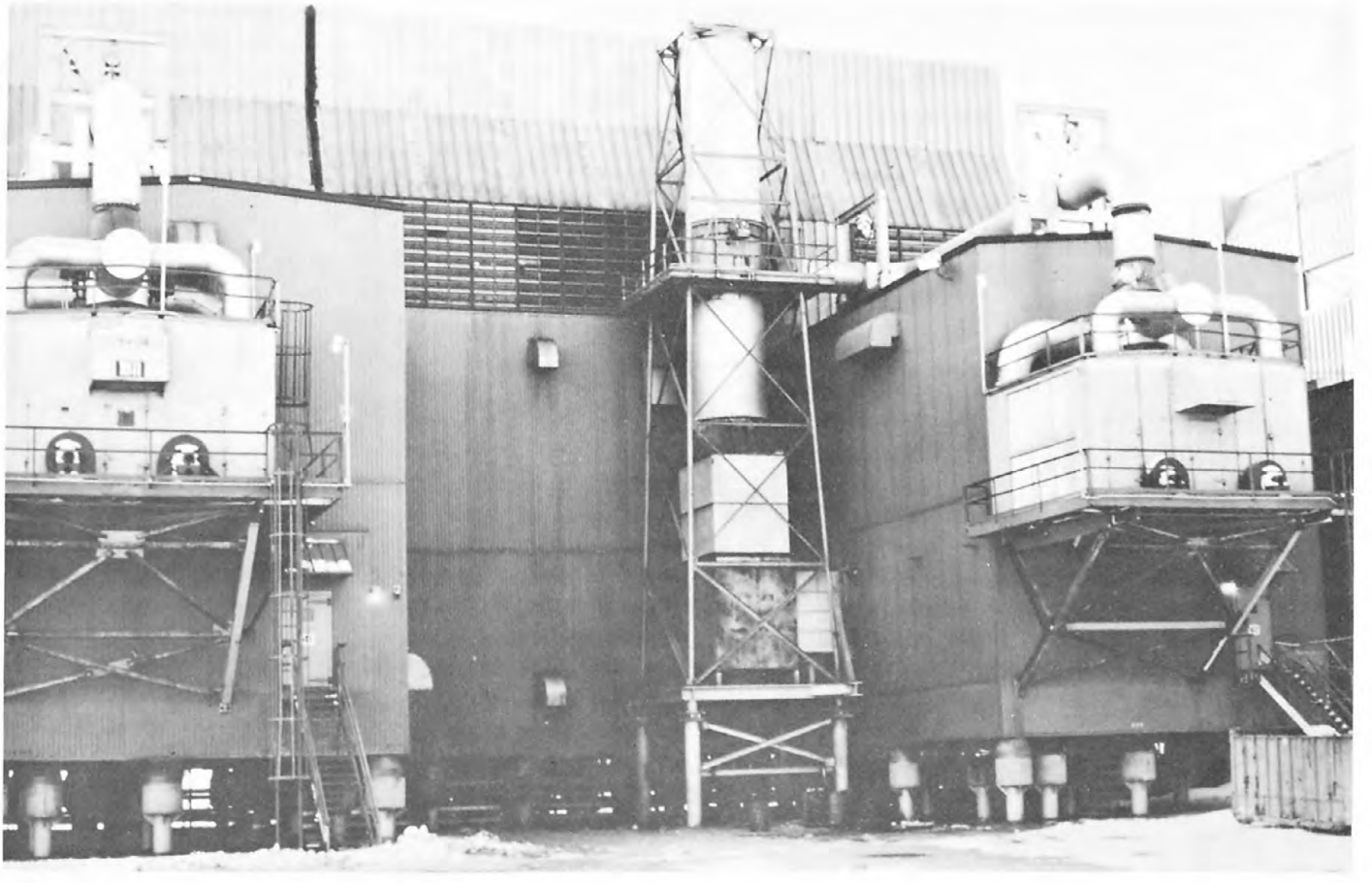

FIGURE 30.--ARCO's gas compression plant, which handles reinjection for the Prudhoe Bay Unit. (Photograph by Rogers, Golden & Halpern.)

northern part of the Prudhoe Bay area (Sohio Alaska Petroleum Company, 1981). The average injection rate for June 1981 was 1,654 million cubic feet (46,808,200 m3) per day (Smith, 1981, written commun.) Water is currently reinjected at each gathering center to a depth of about 5,000 feet (1,524 m).

ARCO and Sohio maintain separate operations centers. The ARCO operation center, a 2-story complex, can accommodate 436 workers, while the 3-story Sohio Base Operations Center (fig. 31) can accommodate 476 workers. These centers include recreation, dining, and sleeping areas, and sewage treatment facilities. Three additional construction camps have the capacity to house about 2,750 workers (Sohio Alaska Petroleum Company, 1981). The Prudhoe Bay total work force currently ranges between 2,000 and 3,500, including employees of Sohio, ARCO, and the contractors and service companies (Knowles, 1981, oral commun.). The equipment used to control processing and to monitor the flow of oil is housed adjacent to the operations centers, as is communications equipment.

Significant amounts of supplies are transported on the Haul Road by truck, but aircraft transport is especially important for moving personnel, mail, rush cargo, and perishable items. Boeing 727 and Hercules aircraft carry over 500,000 pounds (226,800 kg) of cargo and approximately 4,000 passengers per month. One airstrip at Prudhoe, the Deadhorse Airport, is operated by the State of Alaska. This 6,500-foot (1,982-m) airstrip is located in the southeastern section of the Prudhoe Bay Unit. The Prudhoe Bay airfield, a 5,500-foot (1,676-m) gravel airstrip, is operated for the unit by ARCO and is located near ARCO's operations center. Bulk supplies, construction modules, and heavy equipment are brought in by barge during the annual sealifts.

FIGURE 31.--Sohio's Base Operations Center. (Photograph by Rogers, Golden & Halpern.)

Sealift operations are limited to a 6-week period from late July to early September when sea ice retreats far enough offshore to permit navigation. The large barges are accommodated by the 1.5-mile (2.4-km) gravel West Dock on the northwest shore of Prudhoe Bay (fig. 32). The smaller East Dock in shallower water lies on the southeast shore of the bay.

In addition to small diesel generating units used by contractors or for emergency purposes, one main power station serves the Prudhoe Bay Unit. This power plant is operated by Sohio and is fueled by natural gas produced from the field. The plant has a generating capacity of 154 megawatts.

A small field refinery has been in operation in the ARCO operating area of the Prudhoe Bay Unit since 1969. This crude oil topping plant refines approximately 15,000 barrels (2,384 m3) of crude oil each day. The end products include between 3,000 and 5,000 barrels (477-795 m3) of diesel fuel and jet fuel for local consumption (Sohio Alaska Petroleum Company, 1981).

A number of new facilities are proposed for the Prudhoe Bay area. First, a new dehydration plant is expected to be in operation by early 1983. A sales gas conditioning facility is also planned and should be completed in conjunction with the Alaska Natural Gas Transportation System (ANGTS) in the mid- to late-1980's. Finally, a waterflood project is being designed that will include a number of facilities and is intended to boost the quantity of oil recoverable from the Prudhoe field.

DEHYDRATION PLANT. During the summer of 1982, a new dehydration plant will be assembled at Prudhoe to separate oil from water. Modules for the project will be fabricated in California. This plant is needed because increasing amounts of water are produced with the crude oil as the field is drained. Two water treating units are already in operation at Prudhoe Bay. The new plant will boost treating capacity to 275,000 barrels (43,698 m3) per day of water from 55,000 barrels (8,740 m3) per day. The cost of the unit is estimated to be about $35 million, and it is expected to be operating early in 1983 (Oil & Gas Journal, 1981b).

SALES GAS CONDITIONING FACILITY. A sales gas conditioning facility (SGCF) is presently being planned to condition the natural gas from Prudhoe Bay. By removing high concentrations of carbon dioxide and heavy hydrocarbons from the natural gas, the SGCF will make it acceptable for delivery by the proposed ANGTS. The removal of certain hydrocarbons is required in order to avoid possible hydrocarbon condensation in the pipeline, which could cause operational problems and possible pipeline shutdown (FERC, 1980).

Prudhoe Bay was chosen over two other alternatives for the SGCF site because it maximized economic feasibility and minimized the environmental disruptions associated with the construction and operation of a gas conditioning plant. The Prudhoe Bay site was also chosen because of its proximity to the sources of the unconditioned gas and to a large body of water on which ocean-going barges can transport construction materials to the site.

The SGCF will be built in conjunction with the Alaska portion of the Alaska Natural Gas Transportation System. Current cost estimates for the SGCF are $6 billion. Companies involved in the financing of the facility are required to file a petition for approval or rejection by the Federal Energy Regulatory Commission (FERC). To date, no petition has yet been filed by industry, but various interim discussions and reports on the SGCF have been

FIGURE 32.--Tugboats at Prudhoe Bay's West Dock. (Photograph by Rogers, Golden & Halpern.)

submitted. Financing arrangements for the SGCF have not yet been resolved by private companies and the State of Alaska. The construction schedule and final design of the SGCF are contingent upon the pending settlement of ANGTS financing and final design.

Preliminary engineering design work on the SGCF is being conducted, however. The plant would cover 1 million to 1.5 million square feet (90,000-135,000 m2) and would require about 100,000 tons (90,000 metric tons) of steel. To protect the tundra, the plant would be built over a 6-foot (1.8-m) gravel pad. Some of the main process pipes may range up to 72 inches (182.9 cm) in diameter for certain areas (Oil & Gas Journal, 1981d).

Construction material for modules to be built at Prudhoe Bay would be hauled up by barge during August or September, when ice conditions permit travel by sea. Approximately 200 to 220 modules would be built for the SGCF, some of which would weigh up to 2,000 tons (1,800 metric tons), 170 feet (51 m) long by 65 feet (19.5 m) wide (Oil & Gas Journal, 1981d). Although plans call for actual construction on the SGCF to begin by late 1982, no definite scheduling has been adopted until financing arrangements for the entire ANGTS have been settled.

WATERFLOOD PROJECT. Reservoir engineers have anticipated from early studies that water injection may be desirable to continue long-term oil production at Prudhoe Bay. The proposed waterflood project will inject 2.2 million barrels (349,580 m3) of seawater and 1 million barrels (158,900 m3) of produced water per day to flood the Sadlerochit reservoir. The project has been designed to recover approximately 1 billion barrels (158,900,000 m3) from the supergiant field (Army COE, 1980b). The cost of the waterflood is currently estimated at $3 billion (Pacific Oil World, 1981).

A number of facilities will make up the proposed waterflood project. First, a seawater intake and treating plant will be located offshore at a 12-foot (3.7-m) water depth, as a floating platform inside a gravel berm at the

end of an extension of the West Dock. Approximately 550,000 cubic yards (422,675 m3) of gravel will be required for the berm area taking up approximately 11 acres (4.5 hectares). The plant will pump and filter sea water from the Beaufort Sea, remove the oxygen, and treat the water with chemicals to eliminate bacteria and algae in the water lines. One outfall pipeline (a pipeline draining off into the ocean) will then transport process effluents from the plant to a discharge site in a water depth of about 10 feet (3.0 m), located north and west of the plant. Another outfall line will transport marine life removed from the plant to a location approximately 500 feet (152 m) east of the plant.

Treated water from the plant will then be piped along a proposed causeway connected to the existing West Dock and causeway, ultimately leading onshore. Construction and modification of the 3,700-foot (1,128-m) proposed causeway extension from the seawater treating plant to the West Dock will require an estimated 1,300,000 cubic yards (999,050 m3) of gravel and cover some 52.4 acres (21.2 hectares) of sea bottom (Army COE, Alaska District, 1980).

Once onshore, the treated water will be moved by pipeline to two injection plants. The eastern pipeline route will follow an existing road and pipeline route for its entire length. The western route leading to the western injection plant will partially follow an existing route. The remainder of the pipeline route is in the proposal stages. One injection plant will be located adjacent to ARCO's Flow Station 1 on the east side of the field, and another will be located at Sohio's Gathering Center 1 on the west. High-pressure water will be injected into the ground at the injection plants through water wells. In most cases these wells will be on existing gravel pads. A total of 154 injection wells will be used, located on 28 injection sites, 14 on each side of the Prudhoe Bay field.

Kuparuk

Because the Kuparuk field is about 40 miles (64.4 km) from Prudhoe Bay, most of the facilities required for production will have to be reproduced at the Kuparuk field. Presently, an airstrip and a modular operations center are in place at Kuparuk (Knowles, 1981, oral commun.).

During 1980, ARCO constructed a water treatment plant, power plant, warehouse, hangar, shop, and 200-foot (61-m) communications tower. The operations center and utilidor building were also moved in during 1980. The 3-story operations center was designed to provide living accommodations for 96 workers. It includes 40,000 square feet (3,716 m2) and houses bedrooms, dining areas, and recreation facilities. The building was constructed using four major modules, each weighing about 400 tons (363 metric tons) and measuring 35 feet (10.7 m) wide by 84 feet (25 m) long by 36 feet (11 m) high. The approximate cost of the operations center was $12.2 million (Alaska Construction & Oil, 1981b).

Construction has also begun on a 26-mile (41.8-km) pipeline from the Kuparuk field to Pump Station 1 at Prudhoe Bay. By January 1982, five gravel pads that will support 40 wells should be completed. Production of 80,000 barrels (12,712 m3) of oil per day is set to begin in April 1982 (Alaska Construction & Oil, 1981b).

Eventually, the Kuparuk field development is expected to cover at least 130,000 acres (52,598 hectares). ARCO and Mobil have applied for permits to construct gravel pads in addition to the five that are expected to be completed in January 1982. Water injection facilities may also be built for use in maintaining and building field pressure (Alaska Construction & Oil, 1981a).

Beaufort Sea OCS

No onshore facilities have been built for the express purpose of accommodating OCS oil and gas activities as a result of Lease Sale BF or in anticipation of Lease Sale 71, although Sohio has done some work on the East Dock. Many of the facilities in place at Prudhoe Bay will be used to handle exploration, development, and production from offshore tracts. These include the airstrips, service company

supply bases, construction crews, TAPS, and roads. Other facilities could be used as well, depending on the distance of offshore tracts from shore. However, certain equipment must be reproduced on each artificial gravel island. Dehydration and preliminary cleaning of oil must be carried out close to the wellhead and equipment will be required for these operations on each island. Each production island will also need equipment for oil manifolding, a flow station, housing, and sewage treatment facilities (Knowles, 1981, oral commun.).

No siting has yet been carried out for onshore facilities to be used for OCS production because no commercial discoveries have been announced. The location of onshore facilities is highly speculative at this time. Siting will depend on the availability of land, the proximity of an offshore field to Prudhoe Bay, environmental considerations, and the logistics of establishing a staging area (Knowles, 1981, oral commun.). It is certain, however, that oil and gas pipelines will be required between the gravel islands and shore. Offshore pipelines would be constructed by pipe-laying barges working during the short ice-free season. A gravel causeway would be constructed at the landfall site to protect the pipeline from sea ice where it comes onshore. An estimate made prior to Lease Sale BF assumed that 20 miles (32.2 km) of offshore pipeline and two 13,123-foot (4,000-m) causeways would be needed. One of the causeways would be required to protect the offshore pipeline and the other would be needed as a dock (BLM, 1979b). The location of pipelines and landfalls will also depend on the location of producing fields.

National Petroleum Reserve in Alaska

No facilities currently exist in the National Petroleum Reserve in Alaska (NPRA) that could handle exploration, development, and production of a major field. At least one support base, and possibly others, will be required to develop hydrocarbon resources in NPRA. A support base in NPRA would probably be similar to but smaller than the facilities presently at Prudhoe Bay. It would include an operations center, service company shops and warehouses, a staging area, and possibly a primary transportation pipeline. Equipment used would be similar (fig. 33). The staging area would ideally include both a waterfront docking area and an all-weather airstrip.

The location of a support base is uncertain at this time because tracts have not yet been leased. However, two criteria used for siting a staging area will be important. These criteria are accessibility to water transportation and accessibility to air transportation. A number of sites were identified during the preparation of the pre-lease-sale environment assessment for NPRA. However, there are unresolved problems with most of these sites.

Two particularly attractive sites are Camp Lonely and Umiat (figure 18, p. 45). Camp Lonely, located near the coast, could be reached by both sea and air transport. However, the airstrip and DEW line station there are military property. The area is currently used by the Department of the Interior under a cooperative agreement with the Department of Defense, but there is presently no provision for private use of Camp Lonely. Umiat, located inland along the Colville River, is in an area that has a high hydrocarbon potential. However, it could only be reached by air transportation. Umiat is also on State-owned land; therefore, agreements for use of the area would have to be negotiated with the State of Alaska.

If a commercial discovery is made, well siting could occur in one of two ways, depending on the depth of the field being developed. A large number of wells could be drilled directionally from a single gravel pad, as has been done at Prudhoe. An alternative would be to build many smaller gravel pads from which one or a small number of wells could be drilled. The various drilling pads would be connected by pipelines and possibly by a road system (Barkow, 1981, oral commun.).

FUTURE IMPACTS OF OIL AND GAS ACTIVITIES

OCS oil and gas operations in the Arctic will have a complex range of interrelated impacts. The Inupiat will continue to face

FIGURE 33.--Vehicles used to support Arctic oil and gas operations. Low-pressure tires on ground vehicles are designed for use on permafrost. (Photograph by Fritts Golden, Rogers, Golden & Halpern.)

political, cultural, and economic changes resulting from petroleum development. The physical and biological environments will be altered and this, in turn, will affect the Inupiat, especially in relation to subsistence harvesting. Impacts will occur in both offshore and onshore areas and their extent and severity will be variable. Some impacts will be site-specific. Others will have regionwide implications because of the cumulative effects of OCS activity in combination with Federal onshore, State, and regional corporation oil and gas exploration development, and production. The nature of and potential for impacts, however, remain unclear because of technical inexperience in the Arctic and lack of information.

Impacts on the Inupiat

The discovery of oil and gas at Prudhoe Bay led to the establishment of the North Slope Borough, a tax base for the borough, over 500 new housing units, new schools in each village, and per-student expenditures of $15,000, the highest in the State. But because of the value judgments inherent in any discussion of impacts to people, positive and negative effects on the Inupiat cannot be identified. For example, to some Natives and most whites, increased participation in a wage economy may be viewed positively. A conservative Inupiat, however, sees greater reliance on money as divergence from the subsistence lifestyle and traditional values, and therefore as a disaster (USGS, 1979).

The severity of impacts associated with increased oil and gas activity may be determined in part by the type of coastal zone planning that is adopted by the borough. Nevertheless, it is possible to predict that increased oil and gas activity on the North Slope will increase the population of the borough. Past history of construction projects in the area suggests that most new workers brought into the area will be non-Native and male. The effect of such a population change on the existing population will depend to a

large extent on where development is located. Prudhoe Bay is not near any traditional village, and the social impacts of development there were minimal. If new development occurs close to existing villages, the impacts could be severe. Among the social problems that can be anticipated are increase in alcohol and drug abuse, racial intolerance, and competition for women (USGS, 1979).

Increases in the need for infrastructure, transportation facilities, and housing accompany almost all petroleum-related activity. As with population, the impacts associated with these factors depends to a large degree on where development takes place. The closer development is to villages, the greater the impacts. If development occurs at some distance, life in the villages will be less affected but subsistence may suffer.

The physical and psychological health of North Slope Natives depends heavily on subsistence activities. These activities occur over vast areas of land and sea. As discussed in chapter 1, they involve social and cultural tradition, health, and nutrition, as well as the simple economics of providing for food, clothing, and shelter.

Exploration and development of oil and gas on the North Slope will alter the land and its resources and thus affect subsistence patterns. Subsistence hunting, fishing, and gathering activities cannot be discussed in terms of current patterns or harvest areas. Animal source areas, migration routes, and other seasonal factors form a variable system in time and space that determines what resources are harvested, and where and when subsistence activities take place (USGS, 1979).

Impacts on the Physical Environment

Because sand and gravel requirements will be extensive, the major impacts on the physical environment will arise from sand and gravel extraction and use. Estimates of sand and gravel needs resulting from Lease Sale BF range from 9.4 million to 12.6 million cubic yards (7,200,000-9,600,000 m3). The estimate for gravel use associated with Lease Sale 71 has not yet been made public. The exact location of quarry sites to fulfill these requirements has not yet been decided, but a combination of inland mining and sea-floor dredging is likely (BLM, 1979b; Alaska OCSEAP Newsletter, 1981). Impacts associated with inland extraction on the North Slope include removal of vegetation, exposing underlying sand and gravel to erosion; release of underlying clay in surface water bodies, causing increased suspended sediment concentrations; and destruction of fish and wildlife habitat (USGS, 1979). Impacts associated with offshore gravel mining include disruption of bottom and near-bottom organisms, possibly affecting animals higher in the marine food chain, including whales, creation of turbidity plumes (BLM, 1979b), and noise that may disturb whale migration (Keiser, 1981, oral commun.).

Sand and gravel will be needed for onshore support facilities, including airstrips, roads, and building and equipment sites. The use of these pads frequently alters drainage patterns and destroys vegetation. These changes can result in ponding, gullying, degradation of permafrost, erosion, and habitat destruction (USGS, 1979). The use of gravel islands for offshore drilling could adversely affect marine organisms and migrating mammals and birds. Noise and other disturbances could lead to reproductive failure and avoidance of certain areas (BLM, 1979b).

Finally, gravel pad removal, as part of the rehabilitation of a building or equipment site, is a major and costly undertaking. It leads to compression or removal of vegetation, which can alter the freeze-thaw cycle. Even when disturbed areas are reseeded and recontoured, conspicuous scars can remain for decades (USGS, 1979).

Other possible impacts on the physical environment relate to the hydrological characteristics of the Arctic. A considerable amount of fresh water will be required for human use and for drilling. Depending on the level of development resulting from Lease Sale BF, between 6 and 60 million gallons (22.7-227 million liters) of water could be required per year (BLM, 1979b). Projections of water requirements for Lease Sale 71 activities are not yet available. Water withdrawals on State lands are under State permitting requirements and, during summer, it may be possible to obtain water from one of several large rivers that empty into the Beaufort Sea if permits

are obtained. However, during winter, meeting water requirements can pose problems. First, most surface water freezes completely. Second, water bodies deep enough to remain unfrozen to some extent may provide critical overwintering habitat for fish, and water withdrawals from these areas are prohibited under Lease Sale BF stipulations. Therefore, the construction of onshore storage reservoirs or snow-melting facilities will be required. Reservoirs for storage of summer runoff for winter use have been utilized successfully at Prudhoe Bay (BLM, 1979b).

Waste disposal could have significant adverse impacts on water quality. Sources of contamination include sewage, drilling effluents, and oil spills. Hydrologic and climatic conditions that cause difficulties for waste disposal include low precipitation, low temperatures, limited nearshore circulation, and permafrost. Enforcement of State and Federal water quality standards should, however, maintain water quality at acceptable levels (BLM, 1979b).

Impacts on the Biological Environment

As was noted in chapter 1, the Arctic provides summer breeding and feeding grounds for millions of migratory animals. In discussing the impacts associated with oil and gas activities on the biological environment, it is important to note three points. First, niches and changes in population levels of some species can be vast in arctic regions compared to more temperate regions. For example, the range of the Western Arctic caribou herd is about 140,000 square miles (362,578 km2). Estimates of population changes over the past few decades vary widely. It seems clear, however, that a significant decline in numbers took place during the seventies. One estimate is that the population dropped from 200,000 in 1962 to 60,000 in 1975. The reason for this decline is not known but it appears that caribou populations can be viewed as stable only over relatively large time periods and spatial distributions (USGS, 1979). Second, although arctic wildlife species have adapted to a severe environment, additional stress will not necessarily be easily absorbed (Skoog, 1980). Third, while numerous wildlife studies have been completed or are under way, a certain amount of controversy and uncertainty remains concerning the impacts of petroleum operations on the Arctic environment. As data collection and analysis continue in response to oil and gas activities, many outstanding questions may be answered.

A great deal of controversy, concern, and study has focused on the potential impacts of OCS activities on the bowhead and gray whales. As has been noted in chapter 1, the bowhead is the subsistence resource of central importance to the Inupiat. It is also an endangered species. The Endangered Species Act requires that any Federal agency consult with the Fish and Wildlife Service or the National Marine Fisheries Service (NMFS) on any action that could affect an endangered species. In the case of the endangered whales, NMFS must issue a biological opinion on whether the proposed action would threaten the existence of the endangered species. Prior to Lease Sale BF, NMFS determined that insufficient information was available to issue an opinion. As a result, the Naval Arctic Research Laboratory in Barrow was contracted by the Bureau of Land Management to collect the required information under Project Whales. The final report was released in March 1980 (Naval Arctic Research Laboratory, 1980). In addition to Project Whales, numerous other studies have been completed or are under way. Among these are aerial observations, bioacoustics, ice observations, and plankton, benthic, and tissue studies conducted under a comprehensive program begun by the BLM in spring 1979 (Imm, 1981). NMFS will issue the biological opinion when these studies are completed.

Potential impacts of oil and gas development on the whales include the following:

- prevention of cutaneous respiration, fouling of the baleen, and degradation of the quality and quantity of food available to the whales due to oil spills or the release of pollutants into the marine environment;
- disturbance of migration patterns, feeding behavior, and breeding due to noise from boats, aircraft, seismic surveys, and activities on gravel islands;
- injury resulting from encounters with underwater structures or gravel dredging operations; and

- cumulative effects resulting from Lease Sale BF and Lease Sale 71, in addition to those arising from activities in the Canadian Beaufort Sea (BLM, 1979b).

Many of these impacts may also be important for other endangered species, such as the polar bear, as well as nonendangered marine species including ringed seal, numerous birds and fish, and members of lagoon communities. Oil spills reaching shore may have serious and possibly long-term effects on coastal ecosystems by destroying vegetation and possibly preventing its reestablishment. Destruction of primary producers would affect organisms throughout the marine food chain. Computer projections estimate that over 18 oil spills of greater than 10,000 barrels (1,589 m3) will occur, based on production and transportation of 7.9 billion barrels (1,255,310 m3) of oil from the offshore Barrow Arch and Diapir Field leasing areas (BLM, 1981). However, these estimates may be high. Since June 1977, when TAPS first went into operation, an estimated 1.5 billion barrels (238,350,000 m3) of oil have traveled the 800-mile (1,287-km) distance from Prudhoe Bay to Valdez. Twelve spills have been documented along the route with a total estimated volume of 22,330 to 26,330 barrels (3,550-4,185 m3), spilled. The largest spill, approximately 12,000 to 14,000 barrels (1,900-2,225 m3) was the result of sabotage. Based on the estimated maximum spill volume of 26,330 barrels (4,185 m3), a spillage of 0.0017554 percent of the pipeline's throughput has occurred (Alaska Office of the Govenor, State members of the Advisory Committee on Leasing, 1981).

Another risk associated with oil and gas activities is the probability of small chronic spills of diesel fuel, hydraulic fluid, crankcase oil and other petroleum products. In the Prudhoe Bay Unit, there are approximately 20 to 100 reports a month of these small spills, most of which are less than 20 gallons (75.7 l); however, one spill of diesel fuel totaled approximately 50,000 gallons (189,250 l).

Only one blowout has occurred in the drilling of the 699 wells that have been drilled in Alaska north of the Brooks Range as of April 1981. On June 17, 1976, ARCO was drilling a gas reinjection well into the gas cap of the Sadlerochit formation, in the main Prudhoe resevoir, when the well blew out. Gas was discharged into the atmosphere for 3 days before the well was brought under control. According to the State's Department of Environmental Conservation, the detrimental impact on the environment as a result of the blowout was negligible (State of Alaska, 1981).

Recent studies have addressed questions about the behavior of oil spilled on and under sea ice, but little data exists on the effects of spilled oil in arctic nearshore areas or the efficacy of cleanup technology (BLM, 1979b; Alaska OCSEAP Newsletter, 1981). The Outer Continental Shelf Environmental Assessment Program (OCSEAP) has carried out a large number of studies related to oil spills in the Beaufort Sea area, as well as other environmental issues. The OCSEAP is sponsored by the Bureau of Land Management and, in Alaska, a large part of the overall study program is conducted by the OCSEAP offices of the National Oceanic and Atmospheric Administration. Information about obtaining studies from OCSEAP is given in appendix E. The Alaska Beaufort Sea Oil Spill Response Body (ABSORB), an industry group, has also conducted research on oil spill cleanup technology, including drilling techniques, incineration, plastic explosives, and equipment designed for ice-infested water. ABSORB is also carrying out studies on oil disposal, dispersants, and identification and ranking of environmentally sensitive areas along the Beaufort coast. For further information, ABSORB should be contacted in Anchorage.

Onshore facilities will affect wildlife and vegetation on the North Slope, especially in coastal areas and along pipeline routes. Potential sources of adverse effects are the following:

- activities that remove, scar, or cover vegetation or change drainage patterns, leading to alterations in the thermal regime and habitat destruction (fig. 34);
- blowouts and oil spills;
- activities increasing the frequency of tundra fires;
- disposal of solid and liquid wastes, drilling muds, formation waters, and toxic materials that would lead to degradation of the quality of the land surface or water bodies;

FIGURE 34.--Impacts of summer driving on tundra vegetation and permafrost. (Photograph by Joseph C. LaBelle, Arctic Environmental Information and Data Center.)

- creation of physical barriers, such as roads or pipelines, that would separate previously continuous fish and wildlife habitats (fig. 35);
- removal of sand, gravel, or water that could degrade habitat quality;
- movement of aircraft, vehicles, people, and materials creating noise, dust, and disturbances; and
- artificial feeding and sport hunting, which could disrupt predator-prey balances (USGS, 1979).

In addition to having direct impacts on the biota, these activities would indirectly affect the Inupiat, whose subsistence lifestyle depends on wildlife resources. For example, availability of caribou in the Sale BF area could be reduced by 50 percent over the life of the activities resulting from the lease sale. This estimated loss could correspond to 25 percent of the Inupiat diet and increase reliance on a cash economy (DOI, 1979a). However, other Government studies have shown that in recent years the central Arctic caribou herd has been increasing in numbers. From this it could be inferred that oil activity has been good for the caribou, at least for the central Arctic herd. Discussion with the Alaska Department of Fish and Game biologists have indicated that some of the reasons might be a decrease in hunting pressure and a reduced wolf population in the area. There-

FIGURE 35.--Caribou crossing under the Trans-Alaska Pipeline. (Photograph by American Petroleum Institute.)

fore, instead of the caribou supply being reduced by 50 percent, the population may actually increase (Smith, 1981, written commun.).

It has recently been estimated that up to 10,000 acres (4,046 hectares) of coastal wildlife habitat in Alaska could be destroyed as a result of onshore facilities for OCS activities alone (BLM, 1981). In addition to causing local disruption, facilities sites may have impacts over larger areas, causing range abandonment beyond the limits of a narrow corridor. For example, it has been noted that the Central Arctic caribou herd has already been displaced from approximately 96,000 acres (38,841 hectares) of its calving grounds and summer range by the development at Prudhoe Bay (Cameron and Whitten, 1981). Other sources, however, show that many caribou are seen in and around the Prudhoe Bay facilities in the summer.

Cumulative Environmental Impacts

In addition to site-specific impacts, cumulative impacts of oil and gas exploration and development will be significant because of the wide range of ongoing and proposed Federal, State, and regional corporation leasing activities. The effects of increased air traffic, construction, and other disturbances can sum up over larger areas and longer time periods when viewed from a cumulative, regional perspective, than would be expected from isolated activites. The mitigation of large-scale,

cumulative impacts will depend on strict compliance with existing Federal and State regulations and lease stipulations, as well as the formulation of new regulations as needed (BLM, 1980a).

CONCLUSION

This initial Arctic Summary Report was written to provide State and local officials in Alaska, as well as other interested parties, with up-to-date planning information concerning oil and gas activity on the North Slope.

Although exploratory drilling on Federal OCS leases in the Arctic will not begin until the winter of 1981-82, the area has had a long history of oil and gas activity. The State has leased land on the North Slope since 1965, and the discovery of oil and gas at Prudhoe Bay was announced in January 1968. Increased oil and gas activity in the area is anticipated, and exploration of the tracts leased in the joint sale will continue. Four additional Federal OCS sales are proposed for the region. The first lease sale in NPRA will be held on December 16, 1981, and pre-lease-sale activity is planned for ANWR and other Federal lands. In addition, the State has 3 lease sales planned for the Arctic area.

The pace of development will be determined by a number of factors. Among the most important of these are the following:

- the amount of oil and gas discovered in the subregion;
- the outcome of existing and proposed litigation;
- the type of coastal zone management program implemented by the North Slope Borough;
- the type of transportation systems built or adopted; and
- the date when these transportation systems are built or adopted.

Some impacts resulting from development will be significant: the physical, biological, and social environments of the Arctic will continue to be altered. However, because of the length of time needed for the planning and construction involved in development of oil and gas facilities in the Arctic, it is unlikely that any new facilities, other than those discussed in this report, will be built during the next year.

An update to this report will be issued in 6 months. When a significant event occurs, a new summary report will be issued. The Office of OCS Information staff is available to assist State agencies if additional information or clarification is desired (telephone: (703) 860-7166).

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Appendix A. The Geologic Setting

PETROLEUM GEOLOGY

Hydrocarbons are formed within the upper part of the earth's crust, where accumulations of organic matter are transformed through heat and pressure into various mixtures of crude oil and natural gas. The time between deposition of organic material and the formation of hydrocarbons is on the order of millions of years (Tissot and Welte, 1978).

The occurrence of hydrocarbon accumulation depends on many factors (Miller and others, 1975):

- an adequate thickness of sedimentary rocks;
- the presence of source beds (rocks containing large amounts of organic matter);
- a suitable environment for maturation of the organic matter into oil and/or gas;
- the presence of porous and permeable reservoir rocks;
- hydrodynamic conditions permitting the migration of hydrocarbons and their ultimate entrapment in reservoir rocks;
- a thermal history that favors production and preservation of hydrocarbons;
- formation of adequate geologic traps for accumulation of the hydrocarbons; and
- suitable timing of petroleum generation and migration to ensure the entrapment and preservation of the hydrocarbons.

In a prospective hydrocarbon province, geologists look for structural or stratigraphic traps, in which oil and gas can accumulate. Structural traps include anticlines, sediments draped over salt diapirs and other dome-like intrusions, and fault traps. Examples of stratigraphic traps are reefs and the edges of porous strata truncated by impermeable strata. Traps may also be formed by a combination of structural and stratigraphic elements.

THE ARCTIC REGION

The occurrence of petroliferous rocks in the onshore and offshore areas of northern Alaska has been identified throughout the history of exploration and development activities dating from the early 1900's. Exploratory efforts by government and industry researchers have indicated that northern Alaska is a major petroleum province.

The bedded rocks of northern Alaska have been divided into three sequences reflecting the major phases of tectonic development: the Brookian, Ellesmerian, and Franklinian. The distribution of these sequences is shown in the stratigraphic column in figure 36. The pre-Mississippian Franklinian sequence consists of a variety of deformed and mildly metamorphosed clastic and carbonate geosynclinal rocks. During the late Devonian, orogenic uplift in what is now northern Alaska

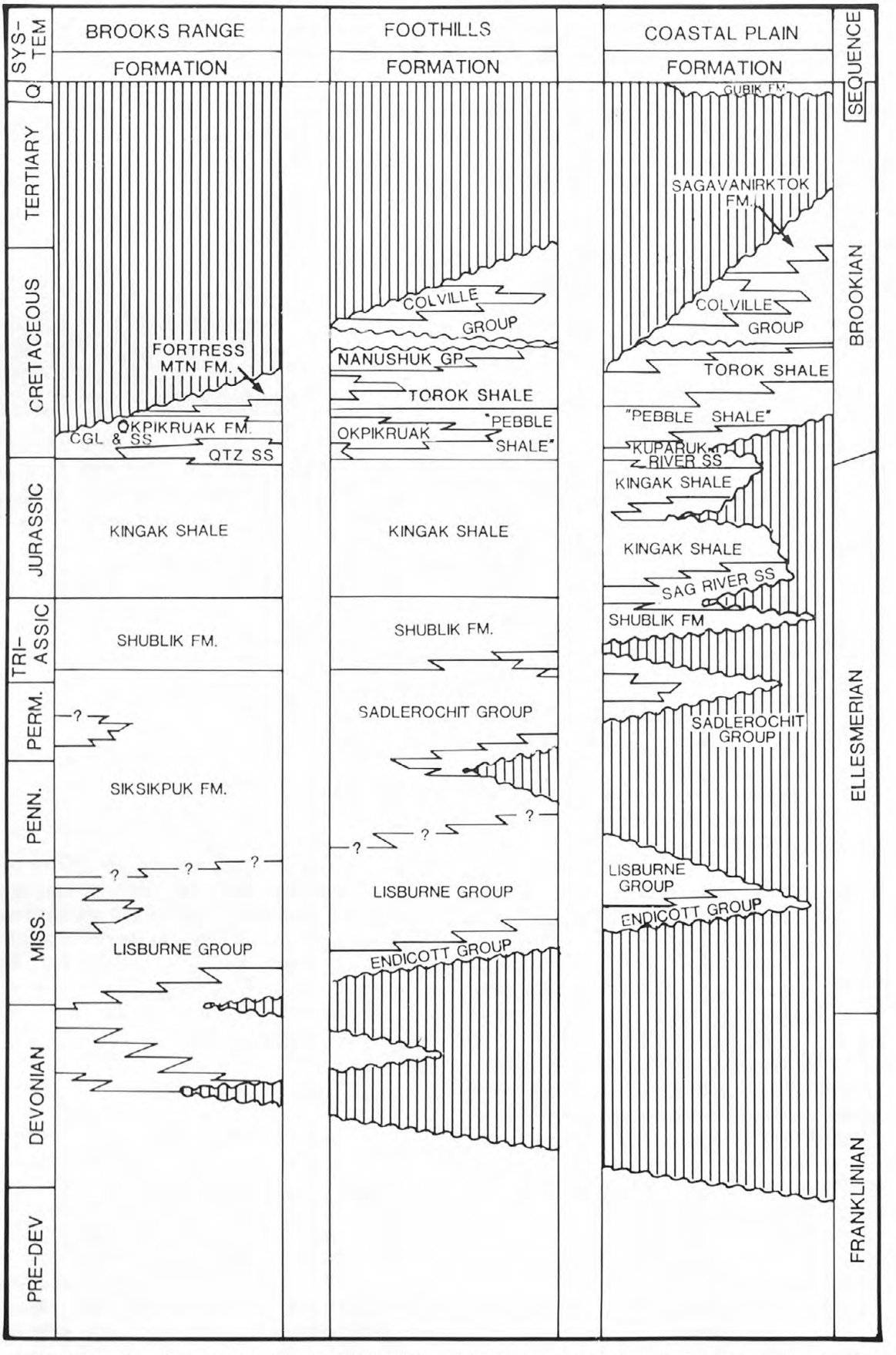


FIGURE 36.--Generalized stratigraphic section of northern Alaska. (Adapted from Carter and others, 1977, by Rogers, Golden & Halpern, 1981.)

shed large amounts of clastic debris southward. Subsequent erosion and subsidence of the Devonian orogen provided a platform for deposition of the Ellesmerian sequence. The Franklinian sequence is considered nonprospective for petroleum (Bird, 1981).

The Ellesmerian (Mississippian to Jurassic) sequence consists of shallow marine and nonmarine clastic and carbonate rocks of northern derivation. Mississippian clastic rocks and coal of the Endicott Group grade upward and laterally into the shallow marine carbonate rocks of Carboniferous and Permian age (the Lisburne Group). Important sandstone reservoir rocks were deposited during the Permian and Triassic (the Sadlerochit Group), late Triassic (the Sag River Sandstone), middle Jurassic (unnamed sandstone), and late Jurassic-early Cretaceous (the Kuparuk River Sandstone). The Sadlerochit Group is the prime oil reservoir at Prudhoe Bay. All sandstone units are of limited areal extent and grade southward into potential source rocks. Important petroleum source-quality rocks were deposited during the late Triassic (the Shublik Formation), Triassic (the Kingak Shale), and the early Cretaceous (pebble shale unit) (Bird, 1981; Carter and others, 1977; Seifert, Moldowan, and Jones, 1977). Ellesmerian beds occur in the Brooks Range and throughout the foothills and coastal plain to the Barrow Arch. At Prudhoe Bay and eastward, the entire sequence is truncated and overlapped by Cretaceous marine shales (Bird, 1981). Thus, Ellesmerian rocks appear to be absent from the coastal plain east of the Canning River (Grantz and Mull, 1978) and on the adjacent Beaufort Shelf (Grantz and others, 1980).

Major tectonism in late Jurassic and early Cretaceous times resulted in replacing northern sediment sources with southern sources. This tectonic event resulted in the formation of the ancestral Brooks Range, the opening of the Arctic Ocean, and the formation of the trap at Prudhoe Bay. As the Brooks Range was uplifted, regional subsidence led to the formation of the Colville Trough just north of the range. The newly formed Continental Margin of northern Alaska subsided and tilted in the direction of the newly opened Arctic Ocean, forming the Barrow Arch (Bird and Jordan, 1977). Throughout the orogeny, large volumes of clastic debris were shed northward. Debris continued to accumulate in clastic wedges in the Colville Trough throughout the remainder of Cretaceous and Tertiary times. These wedges were separated by sections of thick marine shales during periods of relative basin subsidence (Bird, 1981). The centers of deposition (depocenters) of each wedge moved successively northward such that the Barrow Arch was overlapped and the truncated rocks of the Ellesmerian sequence were sealed by Cretaceous shales. The depocenter of middle Cretaceous sediments is southwest of the National Petroleum Reserve in Alaska and Cretaceous beds are now found in the southern Chukchi Sea. The late Cretaceous and Tertiary depocenters lie near Prudhoe Bay and offshore such that Tertiary deposits are found on the Beaufort and northern Chukchi Shelves (Bird, 1981; Grantz and others, 1975). The Cretaceous and Tertiary sediments of the Chukchi north of Barrow Arch, as well as on the Continental Slope east of Prudhoe Bay, are interrupted by shale diapirs. Strata underlying the Chukchi and Beaufort Shelves are generally only slightly deformed to the western edge of Camden Bay. To the east, however, they have been dislocated into long, east/northeast-striking folds. The folds resemble those in the Cretaceous rocks in the Northern Foothills and may also be thrust folds. However, the folds are developed in rocks as young as Neogene and may be related to the young uplift and thrusting that created the Romanzof Mountains. The sedimentary rocks of the Chukchi and Beaufort Shelves appear to have sufficient thickness to be prospective for oil and gas (Grantz and others, 1975).

Surficial hazards in the Beaufort and Chukchi Seas include sea-ice hazards, storm surges, seabed faulting, earthquakes, submarine sliding, and unconsolidated sediments. Shallow gas, permafrost, and overpressured shales pose additional drilling and development problems. The nature of these surficial hazards was discussed in chapter 1.

Appendix B. Estimating Oil and Gas Resources

Before exploratory drilling, both the Federal Government and industry undertake analyses of geological basins to determine their oil and gas potential. The Government uses different methods of analysis, depending on the purpose of the estimate and the availability and level of detail of the data. The data base for resource estimation is regularly updated with new geologic and geophysical information, and as more data for a given area are gathered, processed, analyzed, and interpreted, the resource estimate is updated to reflect them.

Prior to a lease sale, the process of estimating the amount of oil and gas in a tract or a lease sale area involves a high degree of uncertainty. The U.S. Geological Survey makes these pre-lease-sale estimates for a variety of purposes. Regionwide estimates are used to aid in the preparation of proposed lease sale schedules. More specific resource estimates are made for the lands tentatively selected to be offered for lease. Later estimates are made on a tract-specific basis to establish resource economic value for each tract offered. However, it should be reemphasized that estimates of undiscovered resources are extremely uncertain. The existence of resources cannot be confirmed until an area has been thoroughly explored by drilling.

REGIONWIDE RESOURCE ESTIMATES

In the early stages of exploration, when only broad interpretations of regional geology are possible, it is necessary to use expert judgment based on these minimal amounts of data to make resource estimates. As more data become available, the resource estimates and the methods used become more refined. When data are abundant and detailed, the choice of method used depends on the purpose of the resource estimate. The quality of the estimate, however, depends on the quality of the geologic and geophysical data and other studies upon which it is based.

A number of estimation techniques are available for making regionwide or basin resource estimates. For an area that has not been extensively drilled, the most useful group of techniques may be classified as the **volumetric-yield methods** In these methods, the volume of potentially hydrocarbon-producing rocks is calculated, and a yield of oil and/or gas based on known yields from geologically analogous basins or regions is derived. Other methods, more useful in regions that have experienced extensive exploratory drilling, are **performance** or **behavioristic extrapolation methods.** In these, various indices of past performance such as discovery rates, cumulative production, and productive capacity are fitted by various mathematical derivations into logistic or growth curves that are then projected into the future. In addition to these, more sophisticated methods involving geological, engineering, and statistical models may be used (Miller and others, 1975, p. 18).

TRACT-SPECIFIC RESOURCE ESTIMATES

Each tract selected for leasing for exploration and development of oil and gas resources must be evaluated prior to the lease

sale. After the lease sale, resource estimates on leased tracts are periodically updated.

Resource evaluations of tracts consist of three parts: a geophysical and geological evaluation of potentially recoverable resources of possible hydrocarbon-bearing structures and stratigraphic traps underlying the tract; an assessment of the risk that, for whatever reason, hydrocarbons are not present in the quantities foreseen by the geologic evaluation; and an engineering and economic evaluation of those resources, taking the assessed risk into account.

Data used for resource estimation are seismic records, well data, other geologic data, and production histories from wells and fields in or near the lease sale area. In the case of frontier areas, the drilling and production histories of geologically analogous petroleum-producing basins and fields are substituted. Once an area has been leased and exploratory drilling has commenced, the result of drilling may allow updating of resource estimates. Changes in exploratory drilling and production techniques and costs may also necessitate reevaluation.

The tract-specific resource estimates are derived by using the **Monte Carlo computer program.** In this program, geologic, engineering, and economic information is used to calculate economically recoverable resources and an economic value of the resources for each tract. Some parameters, such as tract size, are entered as fixed values. Others, such as pay thickness and production rates, are given a range of values. Each variable is assigned a range and distribution of possible values. The program then randomly selects values for each variable from the specified distribution and combines them with the fixed parameters to calculate a resource estimate and resource economic value. The process is run many times, resulting in the determination of a mean resource estimate and mean resource economic value.

A **risk factor** is used to discount the mean resource estimate. The risk factor represents the probability that hydrocarbons may not be present in the quantities calculated by the geologic evaluation. The risk factor is a subjective appraisal by a geologist, geophysicist, and engineer based on the data available to them. It is determined through a knowledge of an area's (or an analogous area's) exploration history, together with an assessment of how strongly the data indicate the presence of a trap, of source rocks, and of other elements that make a good prospect.

RESERVE ESTIMATES

Reserves are the portion of identified resources that can be economically extracted (Miller and others, 1975, p. 8). The techniques available for estimating reserves are similar to those used in making resource estimates, only in the case of reserves, they are more refined and are based on more information.

In **volumetric estimation** of reserves, the bulk volume of a reservoir can be calculated from interpretation of seismic data and information gained by drilling. Porosity and permeability of the rock and the relative amounts of oil, gas, and water in its pore spaces can be interpreted from borehole logs and analyses of cores.

For reservoirs in which some production has taken place, the **decline-curve method** may also be used. In this method, future production is estimated by extrapolating plots of actual production rates and fluid percentages into the future. By adding past production to predicted future production, an estimate of original reserves can be obtained (Bird, 1980, p. 3-4).

Appendix C. History of the People of the Northern Alaskan Arctic

This appendix presents a history of the people of the northern Alaskan Arctic. Legislation that has affected Natives is also discussed in some detail, since legislation plays an important role in Native opinions concerning land claims and oil and gas activity.

ABORIGINAL PERIOD

The first people of Alaska came across the Bering Land Bridge, or Beringia, from eastern Asia during the last glacial advance of the Pleistocene Epoch. Archeological evidence suggests that there were probably two separate migrations: the first occurred between 30,000 and 40,000 years ago; the second occurred between 10,000 and 28,000 years ago. The first group did not stay in the north, but fanned across the continent. The people of the second migration were probably related to the hunters of northeastern Siberia and Japan, people who had developed the skills necessary to survive in the Arctic. These people, known as Paleo-Eskimos, remained in the north. Their culture formed the basis of the current Eskimo culture of Alaska (University of Alaska, 1975).

The Eskimos of the North Slope are known as the Inupiat. The early population can be divided into two subgroups which had complementary adaptations. The Taremiut, or people of the sea, lived in small settlements along the coast. These people were primarily dependent on sea mammals. Seals were the major food source, but the social and ritual life of the Taremiut centered on whaling. In contrast, the Nunamiut, or people of the land, lived a nomadic life inland. They were dependent on the caribou, following the migrations of these animals throughout northern Alaska (Spencer, 1959). Figure 37 shows the area occupied by these groups.

Early population figures for the area are sketchy and not reliable. In the early nineteenth century, it is thought that Tigera (Point Hope) had a population of about 2,000 and Utkiauik (Barrow) had a population of 1,000. The area between Barrow and Barter Island seems to have been sparsely populated. Settlement patterns were determined by the resources. The locations of Native villages strategically correspond to the pathways of migratory marine and terrestrial species, and the timing of the harvest of northward-migrating resources is successively later in spring in the northern and eastern villages. Areas having fewer exploitable resources could sustain fewer people. Tigera and Utkiauik had large stable populations because they were located at points most favorable for sea mammal harvesting.

The Taremiut whaling culture was established along the Arctic coast by 500 A.D. By that time the Taremiut had perfected the tools and techniques of sea and ice hunting, principally the umiak, kayak, and the sealskin float, known as a pok. Sea mammal hunting, especially whaling, required a high degree of cooperation in each village. The partnerships and alliances formed in whaling, as well as the palatable meat and by-products, did much to give whaling its prime position in Inupiat culture (Spencer, 1972).

The more nomadic Nunamiut established semipermanent campsites along caribou migration routes. Each band bore the name of the place it habitually frequented, and the bands were united in a common sense of territory. The culture developed by the

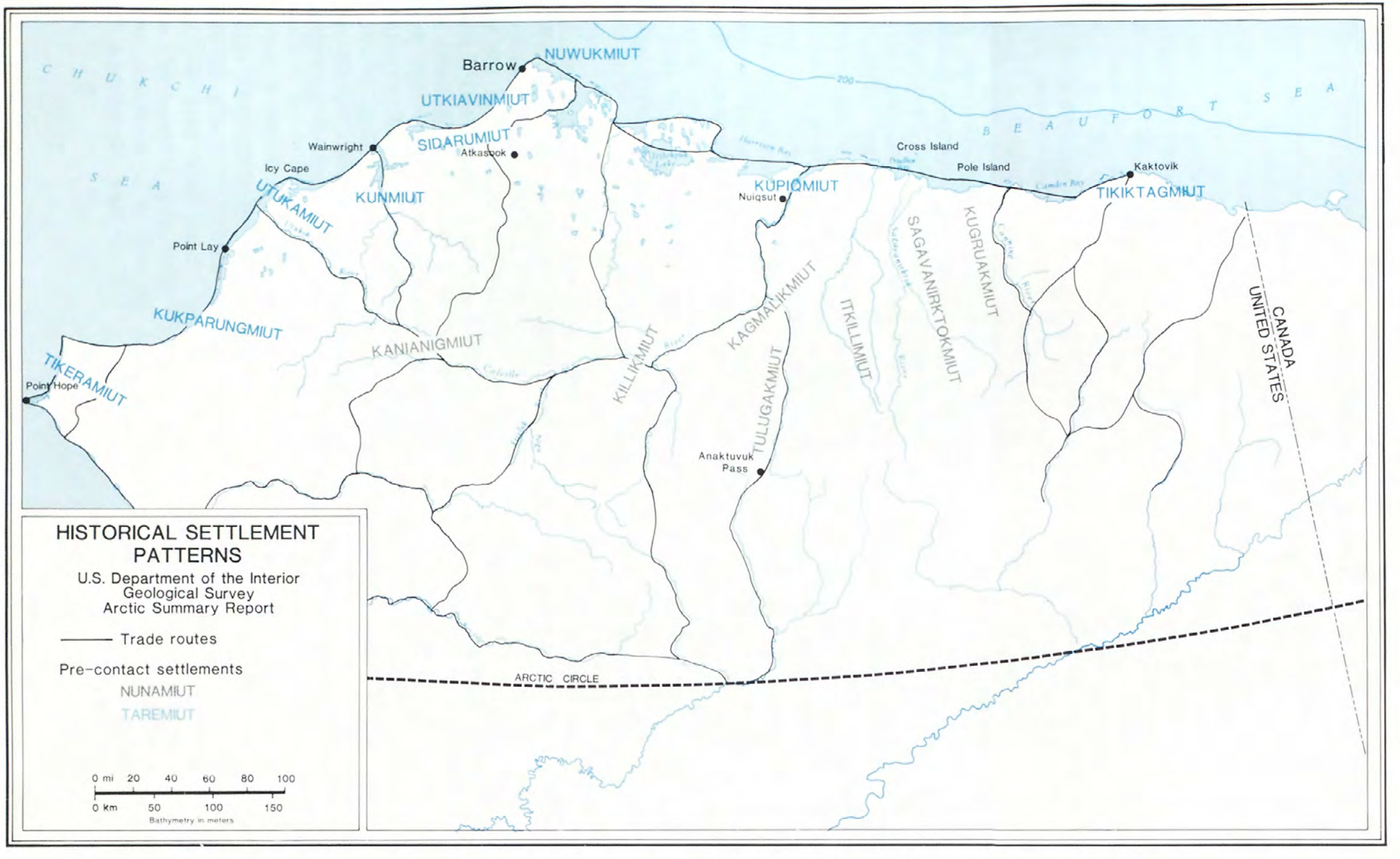


FIGURE 37.--Historical settlement patterns of the Taremiut and the Nunamiut on the North Slope. (Base from USGS, 1976, and data from University of Alaska, 1975; adapted by Rogers, Golden & Halpern, 1981.)

Nunamiut, based as it was on hunting, developed cooperative social relations as well.

The Nunamiut and Taremiut were also cooperative and mutually dependent. The specialized hunting practices of these two groups represented a division of labor that encouraged a full use of resources of the area, with the products of land and sea shared through trade. Every year trading fairs, at which the inland Nunamiut and the coastal Taremiut met to exchange goods, were held. This type of trade helped to maintain the cohesiveness of the Inupiat (University of Alaska, 1975).

HISTORICAL PERIOD

The Natives of the North Slope were perhaps the last group of Alaska Natives to come in contact with Western civilization. Russian activity did little to affect either the Nunamiut or the Taremiut. The first Europeans to reach to Arctic coast were Sir John Franklin and Captain F. W. Beechey, in 1826. They had been commissioned by the British Admiralty to map the Arctic coast west of the Mackenzie River as part of the effort to find a Northwest Passage. It was Beechey who gave Barrow its name, in honor of Admiral Sir John Barrow.

In the 1830's and 1840's, commercial whalers began to make trips to the Arctic Ocean. This marked the beginning of regular contact between Westerners and Eskimos of the North Slope. The movement of the whales formed the pattern of contact: the commercial whalers followed the whales to their spring feeding grounds in the Beaufort Sea and Banks Island, to the Canadian Arctic in the summer and, finally on their return trip through the western Chukchi Sea. In 1879, this pattern was altered by the introduction of steam-powered whaling ships. These ships led to the establishment of shore-based whaling stations where crews spent the winter. The whalers sought two species of baleen whales, the Pacific Right, **Eubalaena galacialis,** and the bowhead, **Balaena misticetus.** Baleen was used for buttons, corset stays, buggy whips and surgical instruments. In the 1850's, baleen was sold for $.32 per pound, and by 1890 the price was as high as $2.00 per pound.

The sale of Alaska by Russia to the United States in 1867 for $7.2 million had received little notice from the Inupiat. However, with the cession of Alaska to the United States, all of its lands and water became public domain--land held and controlled by the Federal Government. Transfers to private ownership or designation for specific uses required Congressional action. The Organic Act of 1884 was passed by Congress with a similar lack of attention by the Inupiat. This Act made Alaska a civil and judicial district. It did not permit Natives to acquire title to land, but decreed that Natives were not to be disturbed in the possession of the land they used, occupied, or claimed. A second Organic Act was passed in 1912 that made Alaska a territory.

During the late 1800's, the Nunamiut began to decline. This has been attributed to the cessation of trade with the coastal Eskimo (Spencer, 1959) and to a declining caribou population (Gubser, 1965). Starvation may have been the prime killer, but it was aided by disease. Both inland and coastal Eskimo population were decimated by diseases such as measles, smallpox, influenza, and whooping cough, for which they had no immunity. The secondary effects of contact with Western civilization began to be felt at this time also. Among these were the introduction of liquor and firearms, formal schooling, and Christianity. Whaling continued until the period just prior to World War I, when both the supply of whales and the demand for corset stays declined sharply.

Reindeer herding was introduced in the early 1900's by the Federal Government to stem the effects of the declining caribou population and provide a basis for a commercial economy. However, the Inupiat were essentially hunters, not herders, and the reindeer herd declined as a result.

Furs, especially fox, became fashionable in the United States and Europe during the 1920's. As a result, many Inupiat shifted from hunting to trapping. By doing so they obtained cash and hence access to the trading post

supplies on which they had become dependent. A fox pelt sold for as much as $50, and for a time annual incomes were as much as $5000 per year. However, as had happened with whales, the demand for fox pelts did not remain stable. The depression of the 1930's brought an abrupt end to the market for fox coats.

The Inupiat were then forced to return to their earlier lifestyle. Fortunately, during the late 1930's the principal animal populations that were used for subsistence--whales, walrus, seals, and caribou--began to increase. Village life and group solidarity were revitalized.

During the early part of the century, several pieces of legislation were passed by Congress that were to have an effect on the Inupiat. The Native Allotment Act of 1906, as amended, authorized the conveyance of up to 160 acres (64.7 hectares) of public land in Alaska to each Native Alaskan. Individual Natives could acquire title to lands that they traditionally occupied or used for hunting and fishing. Approximately 200 claims were filed and most were rejected because the applicants had not displayed exclusive use and occupancy for the required period. The establishment of the Naval Petroleum Reserve Numbered 4 (NPR-4) in 1923 precluded future appropriation of land, including native allotments, within NPR-4 boundaries.

Under the terms of the Indian Reorganization Act of 1934 (IRA), also called the Wheeler Howard Act, which was extended to Alaska in 1936, Eskimos were given the right to draft village constitutions and bylaws. A village became a formal corporation under Federal law after being ratified by majority vote in the village and approved by the Secretary of the Interior. Barrow formed an IRA corporation in 1940. Increased governmental aid, also the result of this 1934 legislation, did little to help the Arctic Eskimos, however: death rates from tuberculosis and infant mortality were very high until the late 1950's.

In 1942, an opinion issued by Nathan R. Margold, Solicitor of the Department of the Interior, concluded that original occupancy under the Organic Act of 1884 established possessory rights in Alaska waters and submerged lands and that such rights had not been extinguished by an treaty, statute, or administrative action (Morgan, 1979). This opinion strengthened Native arguments for title to land.

World War II emphasized the strategic importance of Alaska. Within an short period defense installations were established in the Arctic. Natives were mustered and organized as the Eskimo Scouts of the Territorial Guard under the command of Col. Marvin "Muktuk" Marston. These scouts served without pay throughout the war. World War II also marked the start of another period of great change for North Slope Natives. There were at least three primary reasons for this change: (1) increased self-identity and self-awareness of the Inupiat; (2) the establishment of the State of Alaska and the resulting attention by both State and Federal Governments; and (3) the discovery of hydrocarbons.

CONTEMPORARY PERIOD

Following World War II, various economic and social opportunities drew the Inupiat to the villages. Oil and gas exploration on NPR-4 between 1944 and 1953 and the construction of the DEW line between 1954 and 1957 created a number of jobs for natives. Many Natives become involved in a cash economy as a result of the employment.

By 1949, the Secretary of the Interior had created reservations for Alaska Natives under the terms of the Indian Reorganization Act of 1934. The Natives of Barrow turned down a reservation by a vote of 231 to 29. Only one village, Hydaberg, accepted its reservation, but a 1952 ruling of the U.S. District Court found that the reservation had been created illegally. This decision ended the practice of creating reservations to dispose of aboriginal or possessory claims.

Alaska was proclaimed the forty-ninth State of the United States on January 3, 1959. The State constitution, drafted in 1955 and approved by the voters, took effect immediately.

However, the issue of land claims was still unresolved. The 1958 Statehood Act reaffirmed Native rights to land, although the State was authorized to select 104 million acres (42,078,400 hectares) of land from a public domain of some 375 million acres (151,725,000 hectares). Congress reserved but did not exercise the power to define and resolve the problem of Native claims. Instead, Congress authorized State land selections while attempting to maintain the status quo with respect to Native land rights. This set the stage for direct clashes between the Natives and the State government.

In 1960, the Atomic Energy Commission (AEC) put forth a plan to use nuclear explosives to dredge a harbor at Point Hope. This facility was expected to be used eventually for the shipment of minerals and other resources from the northwest coast (Arnold and others, 1976). It has also been described as an experiment to determine the dispersal and duration of radioactivity. Contamination was anticipated to spread approximately 300 miles (483 km) inland, effectively wiping out caribou migration as a food resource of the Natives (Kresge and others, 1977). As a result, a group of Natives formed a group called the Inupiat Paitot--the first Native regional organization on the North Slope. Point Hope leaders were joined by representatives from Barrow and Wainwright in opposing the proposed project. Meetings of the Inupiat Paitot enabled members to share concerns about a number of issues. The group was disbanded when the AEC dropped its proposal, but the meeting of the group led to the establishment of the first Native newspaper in the State, the Tundra Times. This newspaper became an important instrument in the growing Native displeasure with the State concerning land claims.

The State's land selections under the Statehood Act were to be made by January 1984 through a lengthy and complex process involving notification, adjudication of conflicting claims, tentative approvals, surveys, and finally, issuance of patents. However, because of the State's need for revenues, it quickly selected those lands of obvious commercial value. Alaska's Indians and Eskimos, who maintained aboriginal title to lands under the Federal acts discussed earlier, had filed claims to 122 million acres (49,300,000 hectares) of land before the 1951 filing deadline of the Indian Claims Commission. These claims were still pending.

By 1966, a total of 272 million acres (110,000,000 hectares) had been claimed by the Natives, either directly or in response to the land selections the State was making. The State's plans to sell oil and gas leases on land it claimed on the North Slope resulted in further protest from the Natives. Consequently, Secretary of the Interior Stewart Udall put a moratorium on transfers of all public domain lands in Alaska until the matter of Native ownership was settled. BLM offices in Anchorage and Fairbanks were instructed to suspend all final actions, including granting of tentative approvals on State selections, mineral leases, and issuing of final patents. Federal leasing activity in the North Slope area was largely curtailed because of this decision.

The State, however, went ahead on its leasing program on tentatively approved lands. It leased 20 tracts on the North Slope, including those in Prudhoe Bay, where oil was found in 1968. Governor Hickel, who had ordered the lease sale, stated: "Alaska is on its way to becoming one of the major oil-producing States of the Union, and artificial barriers to development must be broken down for the benefit of all" (Berry, 1975).

The State's 1966 lease sale also led to the formation of the Arctic Slope Native Association (ASNA). ASNA was primarily a land claims organization, one of a number of regional land claims organizations that Natives were forming throughout the State. In addition to the regional Native organizations, a statewide Native organization, the Alaska Federation of Natives (AFN), was also formed.

ASNA claimed that 58 million acres (23,400,000 hectares)--all of the North Slope--belong to the Inupiat by aboriginal right. In addition to its campaign for land, ASNA called for jobs, housing, and schools for North Slope Natives.

The desire for land was a passionate one. Loss of land was equated with a loss of food

and a decrease in an already low standard of living. Most Native food supplies were gained through harvest activities (figures 38 and 39). Each harvest had to produce supplies that would last until the next season. However, there was not always a satisfactory balance between supply and demand, the availability of fish and game varied from year to year, and at times supplies were insufficient to meet the basic subsistence needs of the population, let alone provide entry to the cash economy. When statehood was achieved in 1959, housing, sanitation, health, education, and income were all below the norms necessary for well-being (Bureau of the Census, 1960). As late as 1973, a report described Barrow as the largest community in Alaska with no safe source of drinking water and no high school (Dupere and Associates, Inc., 1973).

The Alaska Native Claims Settlement Act (ANCSA)

The Secretary of the Interior's administrative freeze on Alaska land transactions precipitated a settlement of the claims. A number of Alaska land claims bills were introduced in Congress from 1967 until the Alaska Native Claims Settlement Act (ANCSA) was passed in 1971. The Act established 12 regional corporations within the State and an additional corporation was formed for nonresident Natives (this corporation participates only in the money settlement and receives no title to land); it also required all Native villages to form village corporations that, with the advice of the regional corporations, were to make land selections and plan for the use of the money received under ANCSA.

The direct cash compensation for Native claims given up will total $962.5 million, of which $462.5 million comes directly from congressional appropriations. These installment payments will end in 1982. The remaining $500 million is not being paid according to a fixed time schedule, but will be received as 2 percent of mineral revenues from State and Federal lands.

FIGURE 38.--Whale meat and antlers. (Photograph by Rogers, Golden & Halpern.)

Village corporations receive title to 22 of the total 40 million acres (8,901,200 of the total 16,184,000 hectares) under the land settlement portion of ANCSA. The land going to villages is determined by population, and only rights to the surface are conveyed. The subsurface rights belong to the regional corporation. Sixteen million acres (6,473,600 hectares) are being selected by six of the regional corporations on the basis of land claims in their region. The remaining 2 million acres (809,200 hectares) are set aside for special purposes of all regional corporations. ANCSA also repealed the authorization of the Native Allotment Act of 1906.

One of the most significant changes resulting from the 1971 land claims act was the creation of economic organizations operating for profit. Currently, 190 Native corporations (12 regional, 178 village) operate in the State. Although ANCSA defined the role of regional corporations, the legislation contained no provision for the regional Native associations from which they had grown. These regional associations had provided a number of social programs that could not be operated by corporations whose main responsibility was to earn a profit. Thus, many regional Native associations continue as nonprofit corporations. In the Arctic, the profit corporation is the Arctic Slope Regional Corporation (see ch. 3). Two groups, the Inupiat Community of the Arctic Slope and the Arctic Slope Regional Housing Authority, have taken on the social service functions that were provided by ASNA before the passage of ANCSA.

Formation of the North Slope Borough

The concept of forming a regional government of the North Slope people was developed in the context of the land claims movement, when the prospect of a favorable settlement for the North Slope appeared dim. But the idea found support and soon existed independently of the land claims struggle. In January 1971, ASNA prepared petition forms and circulated them among the local people--

FIGURE 39.--Arctic fox pelts. (Photograph by Rogers, Golden & Halpern.)

the first step in the formal incorporation of a borough. Petitioners sought incorporation as a first-class borough in order to gain a home-rule charter. The Local Boundary Commission (LBC) held a hearing on the ASNA petition in Barrow in December 1971. Joe Upicksaun, ASNA president, testified that the primary motivation behind the proposal was a desire for "the maximum amount of self-determination for the people." He maintained that existing conditions on the Arctic Slope were deplorable: Federal agencies had violated the environment, the State had not provided land use planning, and the lack of local government powers threatened to allow further depredation of the North Slope (Alaska Office of the Governor, 1971). In February 1972, the Local Boundary Commission unanimously approved the petition for establishment of a first-class borough with areawide powers of education, taxation, and planning and zoning.

The final step of incorporation is an areawide election. Voters approved the incorporation by a vote of 593 to 33. Eben Hopson, who had resigned from a post in the Governor's office, won the mayoral race (see sidebar). The Lieutenant Governor of Alaska certified the election on July 1, 1972. However, a court battle concerning the formation of the borough was already in progress.

In March 1972, seven oil companies and five industrial firms filed a petition in the Superior Court in Anchorage for a judicial review of the findings of the Local Boundary Commission. The commission also moved for a summary judgment which would stay the holding of North Slope Borough incorporation elections. The Superior Court denied a summary judgment in June 1972.

A motion to stay the certification of the borough's incorporation was then sought by the companies, but this motion was also denied by the Superior Court. The oil companies then appealed in the Alaska Supreme Court. The oil companies had three major arguments: that the LBC had not properly reviewed the standards of borough incorporation, that Prudhoe Bay had been illegally included in the Borough (Prudhoe would provide 98.5 percent of the

In order to understand the particular character of the North Slope Borough, some discussion of Eben Hopson is necessary. Eben Hopson was mayor of the Borough from its incorporation until his death in June 1980. He was the grandson of a Liverpool whaler, who settled on the North Slope in 1886, and an Inupiat woman. The mayor's father, Alfred Hopson, Sr., operated a cafe in Barrow, but maintained a lifestyle that was more Inupiat than European or American. Eben Hopson attended the Bureau of Indian Affairs (BIA) School in Barrow. When he was 15 years old, he wrote a letter to the Commissioner of Indian Affiars to complain about the school principal's use of unpaid student labor on BIA public work projects. When BIA forwarded the letter to the principal in Barrow for his disposition, Eben was branded a troublemaker and was prevented from boarding the BIA ship to travel to the boarding high school (Arctic Coastal Zone Management Newsletter, August 1980, p. 6). The formal education he received had little relevance to Inupiat life and he regarded it as an attempt to suppress and even eradicate his culture and language.

During World War II he served in the Army, and afterwards in the Alaska National Guard. In the late 1940's and early 1950's Hopson worked as a heating and furnace mechanic and heavy equipment operator on DEW-line sites.

His political career began in 1946, when he became a member of the Barrow City Council. Later he served as mayor of the city. In 1956 he was elected to the Alaska Territorial House of Representatives. After Statehood he served two terms in the State Senate. As mentioned in the text, Hopson played an active role during the Native land claims movement. He was executive director of the Arctic Slope Native Association in 1967 and represented ASNA on the board of the Alaska Federation of Natives. Later he served as the executive director of AFN. In 1970 he became Governor Egan's Special Assistant for Native Affairs. He resigned from this post in 1972 to run for mayor of the borough (McBeath, 1981).

assessed valuation of the borough but would receive no services), and that legislative approval of the petition to form a borough was necessary.

In January 1974, the Supreme Court rejected all arguments of the oil companies. But for its first year and a half of operation, the North Slope Borough operated without full legal sanction and with very little money, because the oil companies would pay no taxes until the Supreme Court reached a decision.

In 1972, the new borough had only statutory powers of education, assessment and taxation, and planning and zoning. Existing village governments retained power to exercise municipal functions in such areas as flood control, housing renewal, and police protection. For the borough to create a uniform, areawide social service system, it had to absorb the power of villages. Therefore, borough leaders proceeded to seek the transfer of village government powers to the borough. At the same time, leaders sought a broader grant of power through the adoption of a borough home rule charter.

The accumulation of areawide powers in important fields of activity allowed the borough to develop a large-scale capital improvements program (CIP). The CIP was originally planned to implement basic services within a period of 6 years at a projected cost of more than $60 million; the projected cost is currently more than $375 million. The program began in 1975 with the construction of a school at Anaktuvuk Pass, a vocational school in Barrow, and low-income housing units in all of the villages.

Planning of the CIP has been impaired by the State legislature's per capita limitation of the borough's property taxing authority. In order to circumvent revenue limits, the mayor used a provision of State law which seemed to allow local governments to tax without limitation in order to pay off bonds. In 1976, the oil companies sued the borough over its interpretation of this provision. The suit temporarily prevented the borough from marketing general-obligation bonds, thereby bringing most construction programs to a halt. In the 1977 legislative session, an amendment was attached to a general authorization bill which explicitly allowed municipalities to tax without limit in order to finance interest and the repayment of bonds.

The Alaska National Interest Lands Conservation Act of 1980 (ANILCA)

On December 2, 1980, Congress passed the Alaska National Interest Lands Conservation Act (ANILCA) after nearly 4 years of intense debate. ANILCA resolves certain problems in the Alaska Native Claims Settlement Act (ANCSA). Section 17(d)(1) of ANCSA withdrew all unreserved public lands in Alaska from all forms of appropriation under all public land laws. It also directed the Secretary of the Interior to review these public lands and determine whether they should be withdrawn under other Federal conservation

legislation. Section 17(d)(2) authorized the Secretary to withdraw up to 80 million acres (32,300,000 hectares) for inclusion as part of the National Park Forest Wildlife Refuge and the Wild and Scenic Rivers Systems. All lands withdrawn under (d)(2) were simultaneously withdrawn under (d)(1), but certain additional lands outside (d)(2) boundaries were also included under (d)(1). In accordance with these two sections of ANCSA, Secretary Morton submitted a legislative proposal to Congress in December 1973. This proposal recommended the addition of 83 million acres (33,500,000 hectares) to the conservation system. Several other legislative proposals were eventually submitted, and in May 1978 the House of Representatives passed a version of what was to become the Alaska National Interest Lands legislation. However, no agreement was reached between the House and the Senate on a compromise bill before the 5-year time limit on (d)(2) withdrawals ran out. Because the administration wished to protect (d)(2) lands until Congress could formulative legislation, Secretary Andrus made an emergency withdrawal of lands under the Federal Land Policy and Management Act of 1976, through Public Land Order 5653. After extensive debate and lobbying efforts, the Alaska National Interest Lands Conservation Act was passed and was signed into law on December 2, 1980.

ANILCA designates new and expanded conservation system units throughout Alaska. It also addresses numerous issues that remained confused and unresolved as a result of ANCSA. Particularly pertinent to the North Slope, ANILCA designated the entire central Brooks Range as the Gates of the Arctic National Park and Preserve and made a significant addition to the existing Arctic National Wildlife Refuge (ANWR). Section 1431 settles most of the outstanding issues concerning land entitlement of the Arctic Slope Regional Corporation (ASRC) and most North Slope Village corporations. One subsection permits an exchange of certain ASRC lands along the northern boundary of the Gates of the Arctic National Park for public lands within the Arctic Slope Region. Another subsection permits ASRC to obtain subsurface rights beneath village corporation lands within NPRA and ANWR.

Other issues addressed by ANILCA include giving the taking of fish and wildlife from Alaska public lands for nonwasteful subsistence use priority over the taking of fish and wildlife for other purposes. In the course of exercising this discretion, the State is required to consult with affected local governments, including the North Slope Borough. In addition to these provisions, ANILCA directs the Secretary of the Interior to initiate numerous studies concerning land use issues. Among those of particular interest to North Slope residents are the following:

- an ecological study of the caribou herds north of the Yukon River;
- studies for possible inclusion of the Colville and Utukok Rivers, among others, within the Wild and Scenic Rivers Systems;
- an 8-year study of oil and gas resources, wilderness characteristics, and wildlife resources of public lands between NPRA and ANWR, to be carried out by DOI in consultation with affected village and regional corporations and the borough;
- a study assessing the fish and wildlife resources of the Coastal Plain of ANWR and the impacts of oil and gas activities on these resources;
- and a review of all Alaska public lands to determine whether mineral exploration, development, or extraction should occur, notwithstanding the prohibitions of other provisions of Federal law.

These and other measures provided for by ANILCA address issues of critical importance to residents of the North Slope Borough and those with interests in Arctic natural resources. Because of the complexity and scope of issues involved, it seems clear that many years will be needed to determine the implications of ANILCA.

This appendix has traced the history of the Inupiat from their arrival in Alaska through the Prudhoe Bay discovery and the formation of the borough. The present social organization of the North Slope Natives was discussed in chapter 1.

Appendix D. Intergovernmental Planning Program of the Bureau of Land Management

The Intergovernmental Planning Program for OCS Oil and Gas Leasing, Transportation and Related Facilities (IPP) was implemented to provide a formal coordination and a long-range planning mechanism for three major national OCS program elements administered by the Bureau of Land Management (BLM). These elements are pre-lease-sale activities, the environmental studies program, and transportation planning. The organization of the IPP and the three program elements are presented in this appendix. The appendix also includes a discussion of the four phases of BLM's IPP program and of how the three elements of the OCS program and the four phases of the IPP are integrated for a given lease sale.

In each of the six OCS leasing regions, a Regional Technical Working Group (RTWG) Committee is established and, if a commercial discovery of oil or gas is made, a State Technical Working Group subcommittee is formed. However, due to the fact that Alaska is a single-State region, there is no State Technical Working Group subcommittee. One of three types of committees comprising the National OCS Advisory Board, the RTWG Committee is the nucleus of the IPP.

The National OCS Advisory Board provides advice to the Secretary of the Interior and to other offices in the Department of the Interior in the performance of discretionary functions of the OCS Lands Act, as amended (43 U.S.C. 1331 et seq.), including all aspects of leasing, exploration, development, and production of the resources on the Outer Continental Shelf. The organization of the National OCS Advisory Board and its reporting structure are presented in figure 40.

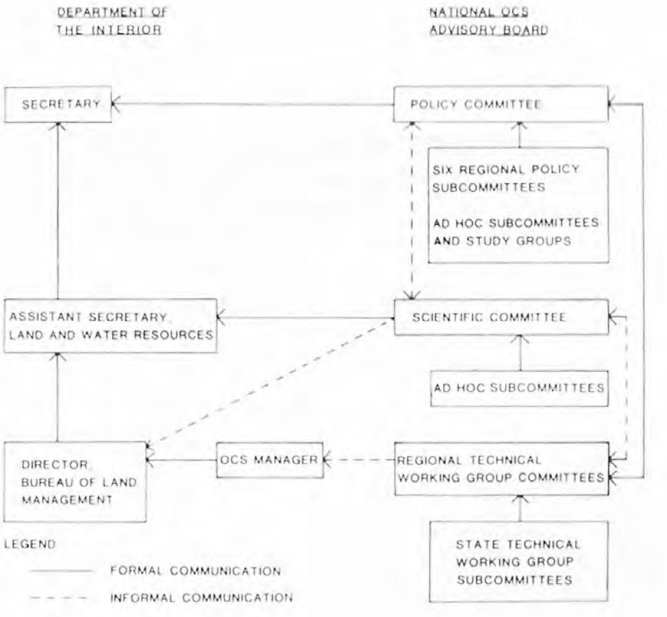


FIGURE 40.--Organization and reporting structure of the National OCS Advisory Board. (Adapted from Aronson, 1979, by Rogers, Golden & Halpern, 1981.)

Through the accumulation and evaluation of information, the RTWG provides guidance to the Bureau of Land Management and information to other bureaus within the Department of the Interior. Each RTWG is composed of representatives of the participating States, the Bureau of Land Management, the Fish and Wildlife Service, the U.S. Coast Guard, the U.S. Geological Survey, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the petroleum industry, and other special and private interests, including private citizens, within a leasing region. Every RTWG is co-chaired by a State representative, who is elected by all

the State representatives of the group, and by the BLM representative. The State representative's term of service is determined by all the State representatives of the group.

The IPP was officially initiated on September 20, 1979, when the private-sector appointments were made to the RTWG Committees. The current membership of the Alaska RTWG Committee was given in table 8, (p. 54). There have been nine meetings of the Alaska RTWG Committee.

The first meeting of the Alaska RTWG was held in Anchorage on November 6 and 7, 1979. At this meeting, the members of the Alaska RTWG were introduced to each other, to the Intergovernmental Planning Program, and to the various aspects of the OCS leasing program.

Norfolk, Virginia, was the scene of the second meeting, held on December 6 and 7, 1979. This meeting was also the plenary session of the National OCS Advisory Board. The Alaska OCS office presented environmental portrayals for proposed Lease Sales 57 (Norton Basin) and 70 (St. George Basin) and discussed issues relevant to Lease Sale 60 (Lower Cook Inlet-Shelikof Strait). These issues, which were reiterated in the third (February 1980) meeting, included tourism and other recreational activities, competition between sport and commercial fishing, seismic hazards and subsea faults, and impacts on lifestyles, the economy, and recreational activities.

The third meeting was held in Anchorage, Alaska, on February 19 and 20, 1980. During this meeting, the Alaska RTWG identified issues for study in the environmental statement for Lease Sale 60. The group was also presented with information on the environmental studies program, BLM's prelease-sale activities, and the status of proposed Sales 57 and 70.

At the fourth meeting, held on April 2 and 3, 1980, in Anchorage, Alaska, the RTWG identified issues for discussion in Lease Sales 57 and 70 environmental statements, considered resolutions from the City Council of Nome and the Association of Village Council Presidents concerning Lease Sales 57 and 83 (Navarin Basin). For proposed Lease Sale 57, the issues identified included commercial herring fisheries, extreme storm conditions, meteorology, climate, the adequacy of available drilling technology, exploration restrictions, and test structures. For proposed Lease Sale 70, issues raised included geohazards and transportation development scenarios. The group also listened to presentations on the coastal energy impact program, the final 5-year OCS leasing program for Alaska, and a case history of the Lower Cook Inlet Sale.

During the fifth meeting of the Alaska RTWG, held on June 2 and 3, 1980, in Juneau, the group reviewed proposed lease stipulations for Sale 55 (Gulf of Alaska). It also identified factors that needed consideration in the petroleum development scenarios for proposed Lease Sales 57 and 70 and formed a subcommittee to review the FY 1981 studies plan and the draft FY 1982 studies plan.

The sixth meeting of the Alaska RTWG was held in Anchorage on July 23 and 24, 1980. The group considered and adopted the subcommittee recommendations on the FY 1981 and FY 1982 regional studies plans and identified issues for consideration in the environmental impact statement for proposed Lease Sale 71 (Diapir Field). Issues identified for proposed Lease Sale 71 included impacts on resident species of marine mammals and caribou, impacts on the subsistence lifestyle, and dynamic ice conditions. In addition, a subcommittee was formed to begin work on a Phase I status report for Lease Sale 55.

The seventh meeting was held in Anchorage on December 4 and 5, 1980. This meeting was convened in order to discuss issues surrounding Lease Sale 55. At this time, the Phase I status report for Lease Sale 55 was presented. The status report discussed possible pipeline corridors and criteria to be used in evaluating these corridors, how planned regional studies will fill data gaps, lease stipulations regarding transportation operations, and physical and environmental constraints to oil and gas transportation.

The eighth meeting of the Alaska RTWG was held on June 24 and 25, 1981. The major topics of this meeting were the draft proposed 5-year oil and gas leasing schedule, the streamlining of the leasing process, and the designation of new planning units. The group discussed the effects these developments would have on environmental assessment, area

and tract selection, the quality of studies, and information gathering. Other subjects included Lease Sale 60 (Cook Inlet), the environmental and socioeconomic studies programs, and reports on transportation strategies. The group decided to begin work on a Phase I status report for the Beaufort Sea. This is IPP's first step toward transportation planning for the subregion. The group was also presented with information on the scoping meetings that were held for Lease Sale 75 (North Aleutian Shelf) and on the State of Alaska 5-year leasing schedule update (Euler, 1981, oral commun.).

The ninth meeting of the Alaska RTWG was held in Juneau on September 9 and 10. Discussion items included (1) proposed mitigating measures for the Norton Sound Lease Sale 57 area, specifically centering on a proposed seasonal drilling stipulation for some tracts in the western portion of the sale area, and a stipulation on the transportation of hydrocarbons; and (2) a scoping meeting for the North Aleutian Shelf Lease Sale 75, in which issues were presented to the RTWG for consideration. General discussions included a presentation of the functions, roles, and activities of a State/Federal Transportation Planning Organization and the RTWG's role in transportation planning, as some involvement may be required of the RTWG soon as a result of activity in the Beaufort Sea. The next meeting of the RTWG is scheduled for November 18 and 19, in Anchorage.

PRE-LEASE-SALE ACTIVITIES

The leasing of OCS lands sets in motion a process that can affect interests at local, State, regional, and national levels. Many decisions are made in this process that determine the manner in which development will take place. A summary of the IPP pre-lease-sale activities and their relation to OCS field office actions is presented in table 10. The IPP has been divided into four phases, which are discussed in this section and are shown in figure 41.

Phase I

The objective of Phase I of the IPP is to assist in coordinating all activities leading up to a lease sale decision. This phase begins prior to the call for nominations and terminates with the lease sale decision. Most activities in Phase I concern the exchange and assessment of information. Inventory and analysis of information related to the later preparation of regional studies plans and transportation management plans are also a part of this phase. Phase I can extend about 2 years, and it is completed by the time of a lease sale decision.

Lease Sale 71 (Diapir Field), scheduled for February 1983 (proposed September 1982), Lease Sale 57 (Norton Basin), scheduled for September 1982 (proposed November 1982), and Lease Sale 60 (Lower Cook Inlet and Shelikof Strait), held in September 1981, as well as all other lease sales on the current or proposed 5-year leasing schedule (table 1, p. 5), are in Phase I.

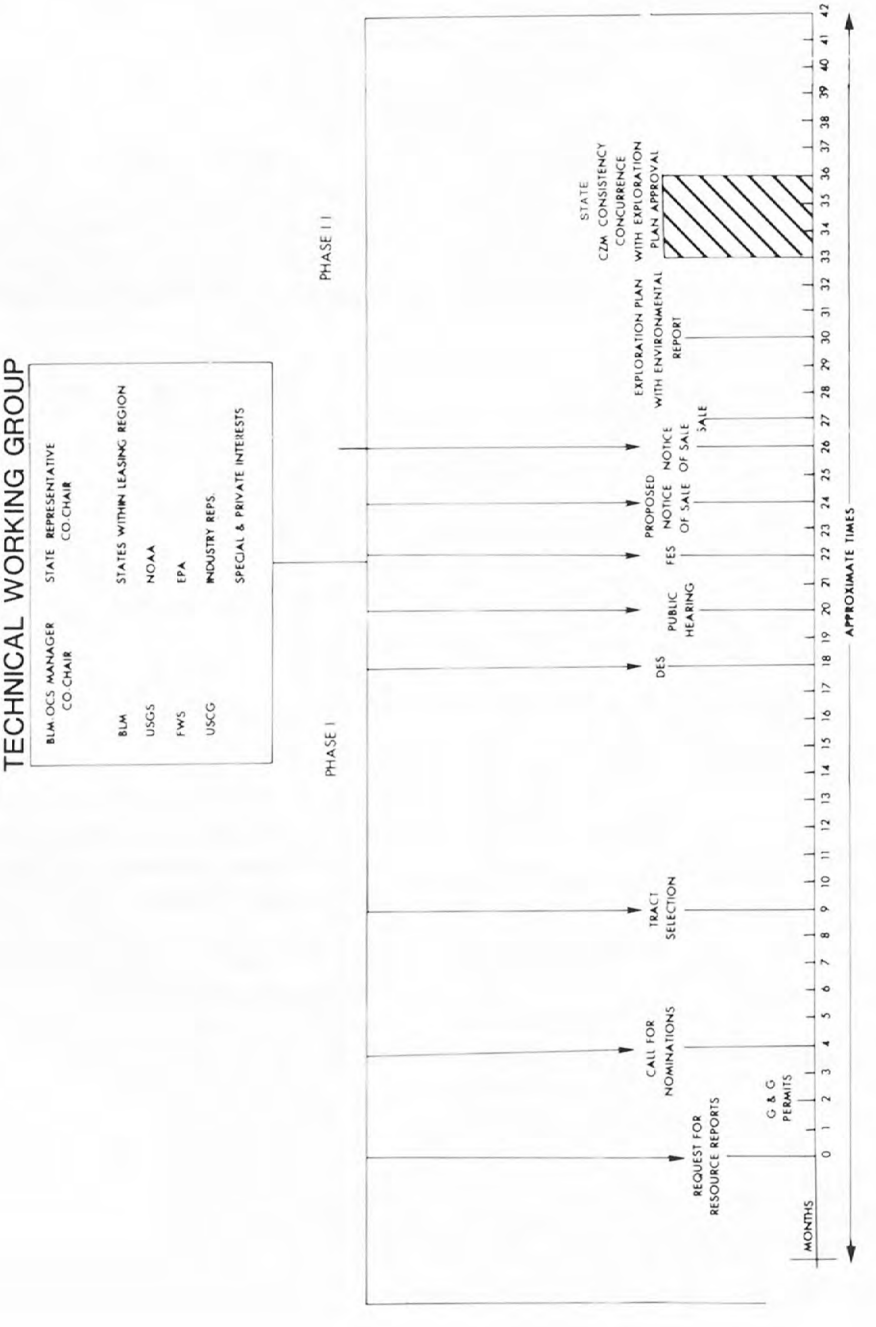
Phase II

Phase II of the IPP is formally implemented with the publication of the proposed notice of sale in the Federal Register. During this phase, each RTWG recommends site-specific and generic studies that should be included in a regional studies plan to be prepared during Phase III. Other Federal, State, or local agencies may also identify and fund OCS-related studies independent of the IPP leasing process.

Phase II should be completed by the time a commercial discovery of oil and/or gas is made. Lease Sales 55 (Gulf of Alaska) and BF (Beaufort Sea) are in Phase II. Technically, Lease Sales CI (Lower Cook Inlet) and 39 (northern Gulf of Alaska) are in Phase II of BLM's OCS program; however, these lease sales were held prior to the formation of IPP and have not been incorporated into the process due to the low level of activity.

Phase III

Phase III of the IPP begins with the announcement of a discovery of hydrocarbons in marketable quantities in the region. At this time, the RTWG Committee will refine potential transportation corridors and recommend site-specific studies.


REGIONAL
TECHNICAL WORKING GROUP
BLM-OCS MANAGER CO-CHAIR
STATE REPRESENTATIVE CO-CHAIR
BLM
USGS
FWS
USCG
STATES WITHIN LEASING REGION
NOAA
EPA
INDUSTRY REPS.
SPECIAL & PRIVATE INTERESTS
PHASE I
PHASE II
REQUEST FOR RESOURCE REPORTS
G & G PERMITS
CALL FOR NOMINATIONS
TRACT SELECTION
DES
PUBLIC HEARING
FES
PROPOSED NOTICE OF SALE
NOTICE OF SALE
SALE
EXPLORATION PLAN WITH ENVIRONMENTAL REPORT
STATE CZM CONSISTENCY CONCURRENCE WITH EXPLORATION PLAN APPROVAL
MONTHS
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
APPROXIMATE TIMES

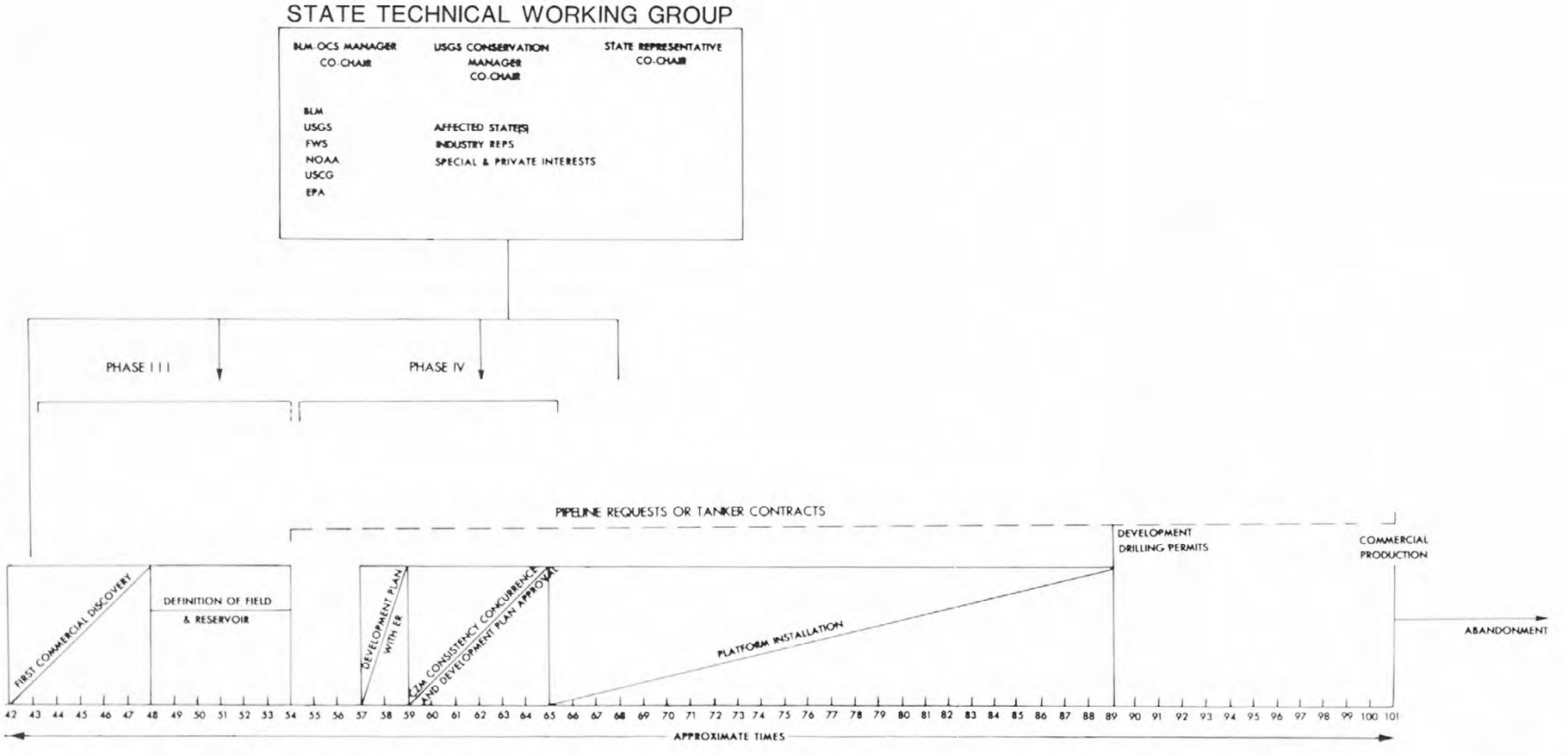


FIGURE 41.--Relationship of the OCS oil and gas leasing process to the IPP. (Adapted from Jackson and Dorrier, 1980, by Rogers, Golden & Halpern, 1981.)

TABLE 10.—OCS pre-lease-sale activities

OCS Pre-Lease Sale Activity	OCS Field Office action	OCS Field Office IPP action
Area of Call outlined	Letter to Federal and State Agencies.	
Resource Reports requested, received, and analyzed	Inter-Bureau Coordination (DM 655) meeting with U.S. Geological Survey (USGS).	
Call for Nominations and Comments issued	Notice of Call sent to the Federal Register. Nominations comments sent to BLM Washington Office (WO), USGS, and OCS office.	IPP working group has an opportunity to review the Area of Call and to provide comments on any aspect of the area to BLM.
Resource Portrayals for Tentative Tract Selection	Environmental Assessment (EA) and Operations staff prepare resource portrayals as one of four inputs to tract selection. Other inputs are: (1) resource estimates from USGS, (2) nominations from industry, and (3) comments from concerned individuals, organizations, and governmental agencies.	IPP working group has an opportunity to listen to and view the resource portrayals and to make its own recommendations on blocks to be deleted and those to be included for further consideration.
Joint Tract Selection Meeting	DM 655 meeting to develop joint recommendations for tentative tract selection.	
Tentative Tract Selection	Joint tract selection memo prepared for transmittal to WO.	
Scoping	Meetings held and responses solicited from various publics, including communities adjacent to or affected by the proposed sale to solicit a listing of critical issues to be discussed in the Environmental Impact Statement (EIS) process, and to develop alternatives to the proposal.	IPP working group has an opportunity to act as a "technical public" in identifying issues that need addressing in the EIS process, and to develop alternatives to the proposal.
Development of Petroleum Development Scenarios for use in the EIS	BLM letter to USGS asking for information on resources, the timing of resource development, methods and modes of OCS exploration and production, possible facility sites and facility types, pipelines if necessary, support activities, and locations and oil spill cleanup capability. BLM develops tentative scenarios for the EIS on which subsequent impacts are based. This includes the proposal as well as alternatives.	IPP working group has an opportunity to be involved in early planning stages by assisting in developing the scenarios. Important time to utilize local ad hoc members. Recommendations based on local Coastal Zone Management (CZM) plans, land use and land status, and the most current information available. In addition, a look at what information is not available and what additional information will be needed. Recommendations could be in the form of potential facility sites needing further study as well as possible corridor routes.
Oil Spill Risk Analysis Model (OSRAM)	Letter from BLM to USGS requesting that the OSRAM be run.	
Draft Environmental Impact Statement (DEIS)	Preparations of DEIS by EA with input from operations and studies.	IPP may be contacted as a group or as individuals to support/assist in EIS preparation and review throughout.
Review of DEIS	Public hearings held.	IPP working group has an opportunity to comment on the proposed mitigation measures designed to reduce or eliminate problems that may occur when a lease area is developed, and on other aspects of the DEIS.
Final Environmental Impact Statement	Rewrite based on comments.	
Secretarial Issue Document (SID)	WO and FO staff prepare the SID, which summarizes and analyzes the major issues and options available to the Secretary.	
Proposed Notice of Sale (PNS)	Federal Register notice describing proposed terms and conditions of the proposed sale.	IPP working group has an opportunity to review and comment on the PNS.

OCS Pre-Lease Sale Activity	OCS Field Office action	OCS Field Office IPP action
Receipt of Comments on PNS's	Comments received, in particular those from the State, are evaluated and changes in notice are made as appropriate.	
Notice of Sale	Copies of Federal Register notice sent to interested OCS publics describing terms and conditions of the proposed sale.	
Sale	Opening and reading of bids by the office manager at time and place specified in the Notice of Sale.	

SOURCE: Euler, 1979.

Phase IV

During Phase IV of the IPP, a regional technical management plan is developed. Phase IV begins as soon as transportation studies are completed and should either precede or coincide with the first development plan.

The IPP is a long-range planning effort. While its actual timing varies from region to region, the estimated minimum time for completion of the four phases of the process is approximately 4-1/2 to 5 years. However, the process could conceivably take as long as 9 years.

ENVIRONMENTAL STUDIES PROGRAM

The BLM's environmental studies program was initiated in 1973 by the Secretary of the Interior through a commitment to perform investigations of certain environmental features of the Gulf of Mexico. The program was formalized in section 20 of the Outer Continental Shelf Lands Act Amendments of 1978, 43 U.S.C. 1331 et seq., which requires the Secretary to conduct a study of any area or region included in any oil and gas lease sale in order to establish information needed for assessment of the human, marine, and coastal environments of the Outer Continental Shelf and the coastal areas that may be affected by oil and gas development there.

The environmental studies program is under the direction of the Bureau's Deputy Director, Energy and Mineral Resources. The program consists of an environmental studies division in each of the Bureau's OCS offices (New York, New Orleans, Los Angeles, and Anchorage) and the Branch of Offshore Studies in Washington, D.C., and a socioeconomic studies program in Alaska. The OCS offices have the responsibility for developing statements of regional study needs (regional study plans), preparing statements of work, and monitoring contractor performance on all approved regional studies. The Branch of Offshore Studies in Washington has the overall management, planning, and budgeting responsibility for the studies program. The Chief of the Branch of Offshore Studies is responsible for the technical adequacy of the program and its component studies. The Branch of Offshore Studies prepares program guidance for the OCS offices to use in the preparation of regional study plans, establishes national priorities, compiles the national study plan, and manages studies that are applicable to more than one leasing region.

The normal process of defining the national study plan usually begins with the Branch of Offshore Studies, through the Assistant Director, establishing the schedule for the OCS offices to prepare regional study plans. These plans include statements of regional study needs, the regional perspective on the priorities of these needs, and a brief description of each proposed study. The Branch of Offshore Studies reviews draft regional study plans from all four OCS offices for programmatic consistency, cost, use of ranking criteria, and relevance to issues of national interest, and the OCS offices revise their respective study plans accordingly. Following the submission of final study plans, the Branch of Offshore Studies compiles a preliminary national study list.

The total cost of all studies nominated for funding during any fiscal year has historically exceeded available funds. As a result of this, the BLM has devised a set of ranking criteria to establish the priority of studies on the national study list. The current ranking criteria, developed jointly by the Bureau and the Office of Management and Budget, are as follows:

- importance of the information to the decisionmaker;
- date of the decision for which the study is designed;
- generic applicability of results or techniques from the study;
- status of the information; and
- applicability of the study to issues of regional or programmatic concern.

Each proposed study is ranked by the nominating OCS office using these five criteria. The Branch of Offshore Studies then reviews each OCS office's use of the criteria, makes any revisions that are required, and prepares a preliminary national study list from the regional study plans. The resulting list of studies is reviewed and approved by all four OCS managers and then submitted for the Assistant Director's approval. Each OCS office is formally notified of its list of approved studies and its studies allocation. Each OCS office then provides Washington with a schedule for procurement of the approved studies.

The OCS offices are required to procure the studies on the approved studies list unless a proposed change is approved by the BLM's Assistant Director, Energy and Mineral Resources. This permits the OCS offices to respond to unanticipated study needs that arise after compilation of study plans.

The RTWG Committees are also involved in the development of regional study programs. These groups help to determine the issues that require study and their importance to regional decisionmakers. They may recommend studies and become involved in ranking the candidate studies using the BLM's criteria. Each working group reviews the draft study plan for its region. The RTWG's are briefed on the status of regional studies on the national list and may be involved in preparing the final drafts of the regional study plans. The working groups are advised of studies that are approved for funding, and they compile the plans for the following year's regional study plan based upon this information. The working groups may also be involved in the design of approved studies.

The environmental studies program is reviewed by the scientific committee of the OCS Advisory Board. This committee has the responsibility to review the appropriateness, feasibility, and scientific merit of the program's component studies. The committee may comment on any study in the program, including those nominated by the RTWG's.

The Alaska OCS socioeconomic studies program (SESP) was created by the BLM as a part of the environmental studies program to determine and assess the potential social, economic, and physical impacts onshore from OCS oil and gas development in Alaska. The SESP is concerned with the entire development process, beginning with the assembly of predevelopment information. Economic analyses of rural and urban communities, regions within the State, and the State as a whole, with assessments of both natural and manmade features, are also performed under the SESP.

The SESP began in 1976, when oil and gas exploration activities were under way following the first Alaska OCS lease sale--Lease Sale 39, in the northern Gulf of Alaska. Because the decisionmaking process requires a long lead time before a sale, the SESP studies that began in 1976 focused on the proposed December 1979 Federal/State Beaufort Sea Lease Sale (Sale BF). These studies were completed early in 1978. Studies have also been completed for Lease Sales 55, 60, 61, and 57.

Some studies have been completed, and most of the remainder should be completed by the end of the year, for Lease Sales 70 (St. George Basin), 71 (Diapir Field), and 75 (North Aleutian Shelf). Some baseline data has been

collected for Lease Sales 83 (Navarin Basin) and 85 (Barrow Arch). Studies will begin for the Navarin Basin sale area in late 1981 and for the Barrow Arch sale area in 1982.

The general process followed in all SESP impact evaluations is based on a comparative analysis of changes likely to occur at the State, regional, or local levels. The small, local coastal communities are generally expected to receive the direct, physical effects of OCS development, while the State as a whole is usually expected to receive the indirect, nonphysical effects of such development. The SESP conducts both baseline and impact investigations, which are often combined.

The current structure of the environmental studies program is complex. It contains checks and balances designed to support both regional and national needs. Although the system is still in an evolutionary phase, the results to date are encouraging.

TRANSPORTATION PLANNING

The movement of oil and/or gas from the Outer Continental Shelf to processing points and to users is an important part of the overall RTWG planning function. The principal end product of this planning effort is a regional transportation management plan (RTMP). If commercially producible quantities of oil or natural gas are discovered in an offshore Alaska leasing region, an RTMP will be developed. At a minimum, the RTMP will include the following information and recommendations:

- analyses and recommendations for discrete transportation corridors and alternatives, including all routes to onshore facilities or to offshore terminals serving as collection points for more than one production area;
- identification of environmentally sound areas for the possible location of onshore facilities;
- alternatives regarding surface vessel transportation, in accordance with appropriate regulatory agencies;
- plans for monitoring construction and operations and any required follow-up studies; and
- any stipulations and use restrictions identified as applicable to transportation rights-of-way.

A number of aspects of oil and gas transportation in Alaska have been discussed at RTWG Committee meetings. These were presented at the beginning of this appendix. An RTMP has not been prepared for Alaska. Additional information about transportation was discussed in chapter 3 of this report.

Appendix E. OCS-Related Studies

There are several excellent sources of information on Federal, State, and local oil- and gas-related activities. Among them are the Arctic Environmental Information and Data Center (AEIDC), the Alaska Office of the Outer Continental Shelf Environmental Assessment Program (OCSEAP) of the Bureau of Land Management (BLM) and National Oceanic and Atmospheric Administration (NOAA), and the BLM's Alaska OCS office. Studies available from or for inspection at these locations are discussed in this appendix, as well as Alaska oil- and gas-related studies produced for other Federal, State, and local agencies.

One of the best sources of Federal, State, and local studies concerning Alaska is the Arctic Environmental Information and Data Center. AEIDC, a research unit of the University of Alaska, was established in 1972 by the Alaska State Legislature. The major objective of AEIDC is to provide referral to and disseminate resource information about Arctic regions, with emphasis on the Alaska environment.

The Information Services staff of AEIDC provides information referral, continually develops and maintains specialized information files, and retrieves and distributes information. These services are augmented by computerized data bases. AEIDC's collection of 8,000 documents includes materials that are unpublished or out-of-print. Those not restricted by copyright can be reproduced for a minimal charge. For more information on AEIDC reports, contact:

AEIDC
707 A Street
Anchorage, AK 99501
(907) 279-4523.

Another source of information for OCS-related studies is a newsletter published for the National Oceanic and Atmospheric Administration by the Alaska Office of the BLM/NOAA Outer Continental Shelf Environmental Assessment Program Studies in Alaska. The Alaska OCSEAP Newsletter is published periodically. An annual report series is also available from the OCSEAP Studies Office in Alaska. These studies, funded by the BLM, include technical reports on OCS activity and synthesis reports prepared prior to each major lease sale. Requests for copies may be sent to:

Writer/Editor
NOAA/OMPA, Alaska Office
P.O. Box 1808
Juneau, AK 99802
(907) 586-7441.

A third source of OCS information is the BLM Alaska OCS Office, which administers the BLM's environmental studies program for Alaska and the Alaska Socioeconomic Studies Program (SESP). (See appendix D for further details on these programs.). The SESP researched socioeconomic, sociopolitical, and transportation impacts and the effects on the man-made and natural physical environment in preparation for the Joint Federal-State Beaufort Sea Lease Sale. Additional studies will be conducted by the SESP in preparation for future lease sales in the Arctic. Reports are available from:

Coordinator,
Environmental Studies Program **or**
Socioeconomic Studies Program
P.O. Box 1159
Anchorage, AK 99510.

FEDERAL STUDIES

U.S. Department of Commerce

National Oceanic and Atmospheric Administration, Office of Coastal Zone Management, and State of Alaska, Office of the Governor, Division of Policy Development and Planning, Office of Coastal

Management, 1979, State of Alaska coastal management program and final environmental impact statement: Washington, D.C., 315 p. and appendixes. Limited number of copies available from the Office of Coastal Zone Management, 3300 Whitehaven Street, NW, Washington, DC 20235.

This combined final environmental impact statement (EIS) and coastal zone management program document was prepared as part of the process of review and approval of major actions by Federal agencies that significantly affect the quality of the human environment. Part I of this EIS includes a summary of the Alaska coastal management program. Part II provides a detailed description of the State's program and fulfills a Federal requirement for the description of the proposed action. The remaining sections of this document discuss the affected environment, probable impacts of proposed action, and the relationships between the proposed action, and land use plans, policies, and controls of the area. Alternatives to proposed action, as well as extensive consultation and coordination, have been included to fulfill Federal requirements for preparing this report. Detailed appendixes have also been attached.

National Oceanic and Atmospheric Administration, Environmental Data and Information Service, 1980, National Petroleum Reserve in Alaska: Boulder, Colo. Available from the National Geophysical and Solar-Terrestrial Data Center, NOAA/EDIS, 325 Broadway, D62, R.B. 3, Boulder, CO 80303.

This information list for the NPRA includes announcements on geological data, multichannel seismic data, gravity data, well logs, an interpretation of seismic survey data, palynology and micropaleontology reports for recent years.

National Oceanic and Atmospheric Administration, Office of Marine Pollution Assessment, 1980, Final technical development plans, FY81, Arctic: environmental assessment of the Alaskan Continental Shelf: Juneau, Alaska. Available from NOAA/OMPRA, Alaska Office, P.O. Box 1808, Juneau, AK 99802.

The objective of the development plan is to meet information requirements outlined by the BLM Outer Continental Shelf office. It covers specific regional problems and lease area information needs in the Arctic. In addition to reviewing the regional setting, status of lease sales, and major environmental issues of the Arctic, the study also focuses on research unit descriptions and their rationale for selection in the Arctic region. A technical development plan is also available on the Arctic for FY 1982.

U.S. Department of the Interior

U.S. Department of the Interior, 1978, Final environmental supplement: alternative administrative actions/Alaska National Interest Lands. Available for inspection at the Department of the Interior Library, C Street, NW, Washington, DC 20204.

This supplementary document provides a description of alternative actions for protecting National Interest Lands in Alaska. They are Executive Branch options that include Presidential proclamation of national monuments under the Antiquities Act, administrative segregation and/or withdrawal of National Interest Lands under the Federal Land Policy and Management Act, withdrawal of lands under the Alaska Native Claims Act, and taking no action. These Executive Branch alternatives supplement the alternatives discussion contained in the 28-volume EIS prepared in 1974 on the Secretary's recommendation of Alaska National Interest Land legislation to Congress.

U.S. Department of the Interior, 1979, Report to the President: west to east crude oil transportation systems, required by Title V, Public Law 95-617: Washington, D.C., 189 p. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, $5.50 (Stock no. 024-000-00863-1).

The report to the President sets forth descriptions of the four proposals received under Title V of the Public Utility and Regulatory Policy Act of 1978 (PL95-617) for a west to east crude oil transportation system. The proposals

were submitted by the Northern Tier Pipeline Company, the Northwest Energy Company, the Trans-Mountain Oil Pipeline Corporation, and the Kitimat Pipe Line Ltd. An analysis of the overall crude oil supply is provided, along with a comparison of each proposed system and how it would affect the supply of oil in the northern tier States. Comments and recommendations of pertinent Federal agencies are also reviewed.

Bureau of Land Management

Bureau of Land Management, 1976, Alaska natural gas transportation system: final environmental impact statement: Washington, D.C., 251 p. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, $4.75 (Stock no. 024-011-00065-8).

This environmental impact statement was prepared in response to applications made to the Secretary of the Interior for permits to cross Federal lands with a natural gas pipeline. It identifies and evaluates environmental impacts that could be expected from construction and operation of the Alaska Natural Gas Transportation System. The report was prepared by an interdisciplinary team that devoted most of its research to examining the environmental impacts of the proposed action, mitigating measures considered, and adverse effects that cannot be avoided should the proposal be implemented. The relationship between short- and long-term maintenance and productivity is also discussed, along with alternatives to the proposed route.

Bureau of Land Management, 1979, Beaufort Sea final environmental impact statement: Washington, D.C., 3 vols. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, $9.50 (Stock no. 024-011-00110-7).

This environmental impact statement presents a detailed description of proposed action for the Joint Federal/State Lease Sale in the Beaufort Sea. As with other environmental impact statements, considerable attention is given to environmental characteristics. Environmental impacts of the proposed action are also discussed, followed by a discussion of mitigating measures and unavoidable adverse effects. Alternatives to the proposed action have also been considered. Volumes I and II contain the literature on the Beaufort Sea; Volume III is comprised of pertinent graphics.

Bureau of Land Management, 1979, Crude oil transportation systems: final environmental impact statement: 4 vols. and summary. Available from BLM, 222 North 32nd Street, P.O. Box 30157, Billings, MT 59107.

This document is divided into four volumes plus a separate summary. Volume 1 contains a description of the four Title V proposals and a description and analysis of the proposed Northern Tier Pipeline Company system. Volume 2 describes and analyzes systems proposed by Northwest Energy Company, Kitimat Pipe Line Ltd., and the Trans-Mountain Oil Pipeline Corporation. The third volume contains alternatives to each of the four systems and public comment on the draft environmental statement. Environmental statement team responses are included, along with a glossary and references. Volume 4 contains maps relating to each of the four proposals.

Bureau of Land Management, 1980, Beaufort Sea final environmental impact statement draft supplement: Washington, D.C., 82 p. and appendix. Available for inspection at BLM Alaska OCS Office, P.O. Box 1159, Anchorage, AK 99510.

The purpose of this draft supplemental environmental statement is to address comments and holdings on the final environmental statement concerning the Beaufort Sea Lease Sale. Four major issues are addressed: (1) cumulative impacts of the lease sale, (2) alternative lease stipulations intended to mitigate the impacts of the sale, (3) alternative management schemes for the sale area, and (4) the impact of State leasing and management of 4 of the 27 disputed tracts over which the United States claims jurisdiction. This report is intended to supplement the original analysis already provided in the final environmental impact statement.

Bureau of Land Management, Fairbanks District Office, 1980, The Utility Corridor: land use decisions, Washington Creek to Sagawon Bluffs: Fairbanks, Alaska, 55 p. Available from BLM, Fairbanks District Office, P.O. Box 1150, Fairbanks, AK 99707.

The document is a part of the Management Framework Plan that establishes, for a given planning area, projected land uses and management objectives to meet identified public needs. It provides a general description of the Utility Corridor, major issues and conditions that determine the land use decision in the Corridor, and land, mineral, range, watershed, wildlife, and recreation programs set up to protect the environment from planned development along the corridor.

Bureau of Land Management, Fairbanks District Office, 1980, Utility Corridor off-road vehicle management plan: Yukon River to Sagawon Bluffs (draft): Fairbanks, Alaska, 41 p. Available for inspection at BLM, Fairbanks District Office, P.O. Box 1150, Fairbanks, AK 99707.

The purpose of this management plan is to designate public lands in the Utility Corridor between the Yukon River and Sagawon Bluffs as open, limited, or closed to the use of off-road vehicles and to establish policy governing the use and operation of off-road vehicles. It solicits information from the public as to which specific routes or areas shall be designated open for off-road vehicle use.

Bureau of Land Management, NPR-A Program Staff, Alaska State Office, 1981, National Petroleum Reserve in Alaska final environmental assessment: Anchorage, Alaska, 154 p. and appendixes. Available from BLM Alaska State Office, P.O. Box 13, Anchorage, AK 99510.

This environmental assessment was prepared to examine the anticipated effects of oil and gas leasing in the National Petroleum Reserve in Alaska. It describes the regional environment and discusses impacts on physical, biological, and socioeconomic resources. Mitigating measures, alternatives to the proposed leasing, and legal and regulatory considerations are also discussed.

Casey, Phyllis J., 1981, Legal mandates and Federal regulatory responsibilities: prepared for the Alaska OCS Office, Bureau of Land Management, Technical Paper no. 4, 31 p. and appendixes. Available from BLM Alaska OCS Office, P.O. Box 1159, Anchorage, AK 99510.

This paper summarizes the Federal Statutory and regulatory authorities governing oil and gas operations on the OCS, which in the past have been included in the Environmental Impact Statements produced by the Federal government. This technical document provides a compilation and discussion of Federal laws and regulations that relate to the OCS leasing program mandated by the OCS Lands Act of 1953, as amended. It will be updated, as necessary, to provide for changes in statutory and regulatory requirements.

LGL Ecological Research Associates, Inc., 1981, Behavior, disturbance responses and feeding of bowhead whales in the Beaufort Sea, 1980: prepared for the Bureau of Land Management, Bryan, Tex., 273 p. Limited number of copies available from BLM Alaska OCS Office, P.O. Box 1159, Anchorage, AK 99510.

This study was prepared to investigate various aspects of potential industrial disturbance resulting from oil and gas activities on the bowhead whale. The focus of the project involved study of the response of the bowhead to boat traffic, aircraft, and waterborne noise. Other sections of the report address the normal, undisturbed behavior of the bowhead and the characteristics of bowhead feeding areas. Field studies on which this report is based were carried out in the eastern Beaufort Sea in August and September 1980.

National Petroleum Reserve in Alaska Task Force, 1979, National Petroleum Reserve in Alaska 105(c) final study: pre-

pared for the U.S. Department of the Interior, Secretary of the Interior, Anchorage, Alaska, 3 vols. Limited number of copies available from BLM Alaska State Office, P.O. Box 13, Anchorage, AK 99510.

This report discusses the 105(c) study and its interrelationship with other related studies mandated by the Naval Petroleum Reserves Production Act. Volume 1 summarizes best land uses and values contained in the NPRA. A description of the planning area is also provided, along with options on future land uses, development scenarios, and resource development conflicts. Volume 1(b) reviews planning issues on the NPRA from an Inupiat point of view. Analyses of land tenure and the use of natural resources are provided, and Inupiat land use preferences and recommendations are given. Volume 2 provides summaries of studies regarding physical, socioeconomic, ecological, and regional profiles. Public participation has been included in the preparation of all three documents.

Naval Arctic Research Laboratory, 1980, Investigation of the occurrence and behavior patterns of whales in the vicinity of the Beaufort Sea lease area: prepared for the Bureau of Land Management, Alaska OCS Office, Anchorage, Alaska, 548 p. and appendixes. Limited number of copies available from BLM Alaska OCS Office, P.O. Box 1159, Anchorage, AK 99510.

The objective of this report is to bring together results of research gathered and analyzed on the bowhead and gray whales. Investigations and observations were conducted from October 1978 to November 1979 to obtain an understanding of the relationship between the animals and their habitats. Background information is provided on the specific environment of the Beaufort Sea, as well as an overview of the Arctic coastal marine environment. The overview consists of sections on climate, seafloor topography, circulation and tides, ice, physical and chemical oceanography, food chains, the distribution and movement of whales, and reproduction and survival of whales. Three major techniques were used (acoustics, radio tracking, and physiological studies) to acquire data on the migration path of the whales, especially to determine if this path included any of the proposed lease area.

In addition to the studies abstracted above, the BLM Alaska OCS Office has prepared hundreds of reports concerning all aspects of the physical, biological, and cultural environment of northern Alaska. Time and space limitations make it impossible to present abstracts of all of these studies; however, a partial listing is presented below. For more information concerning these studies, contact the BLM Alaska OCS Office in Anchorage. The address of the BLM Alaska OCS Office is presented in the beginning of this appendix.

Alaska Consultants, 1978, Beaufort Sea region--man-made environment.

Barnes and Reimmitz, 1980, Geologic environment of the Beaufort Sea Shelf and coastal regions.

Barry and Jenner, 1979, Study of climatic effects on fast ice extent, seasonal decay along Beaufort Sea/Chukchi Sea Coast.

Bendock, 1977, Beaufort Sea estuarine fishery study.

Broad, 1980, Littoral survey of the Beaufort Sea.

Burns, Ely, and Frost, 1979, Natural history and ecology of bearded seal and ringed seal.

Callaway, 1976, Transportation of pollutants in the vicinity of Prudhoe Bay.

Carey, 1977, Summarization of existing literature and unpublished data on distribution, abundance, and life histories of benthic organisms of the Beaufort Sea.

Carlson, 1977, Seasonality and variability of stream flow important to Alaska nearshore coastal areas.

Cooney, 1976, Zooplankton and micronekton studies in the Bering-Chukchi/Beaufort Sea.

Crittenden, Cassaetta, Cannon/Hellmuth, Obata, and Kassabaum, 1978, Beaufort Sea baselines studies: interim report.

Crittenden, Cassaetta, Cannon/Hellmuth, Obata and Kassabaum, 1978, Prudhoe Bay case study.

Dames and Moore, 1977, Beaufort Sea basin petroleum development scenarios for the Federal Outer Continental Shelf: interim report.

Dames and Moore, 1978, Beaufort Sea region natural physical environment.

Dames and Moore, 1978, Beaufort Sea region petroleum development scenarios.

Dames and Moore, 1978, Natural physical environmental impact of the Beaufort Sea petroleum development scenarios.

Dennis Eooley and Associates, 1978, Transportation impact of the Beaufort Sea petroleum development scenarios.

Divoky, 1981, Distribution, abundance, and feeding ecology of birds assessment, Bering Sea and Beaufort Sea pack ice.

English and Harner, 1977, Beaufort Sea plankton studies.

Fay, 1980, Morbidity and mortality of marine animals.

Feder, 1981, Bering Sea - Chukchi Sea benthic study.

Fiscus and Braham, 1978, Abundance and seasonal distribution of bowhead and beluga whales.

Hays, 1979, Coastal morphology, sedimentation, and oil spill vulnerability.

Hopkins, 1980, Shoreline history of the Beaufort Sea and Chukchi Sea as an aid to predicting offshore permafrost conditions.

Hufford, 1976, Beaufort Shelf surface currents.

Hunt and Nashe, 1979, Baseline study of historic ice conditions in Bering Strait, Chukchi Sea, and Bering Sea.

Institute of Social and Economic Research, University of Alaska, 1978, Economic and demographic impacts of the Beaufort Sea petroleum development scenarios.

Malins, 1979, Assessment of available literature: oil pollutants on biota, Subarctic/Arctic.

Marita and Griffiths, 1980, Microbial activity and crude oil-microbial interactions in the water and sediments of Lower Cook Inlet, Beaufort Sea, and Norton Sound.

McCain, 1977, Determine the incidence and pathology of marine fish diseases in the Gulf of Alaska, Bering Sea, and Beaufort Sea.

Meyers, 1976, Seismicity of the Beaufort Sea, Bering Sea, and Gulf of Alaska.

Morrow, 1977, Literature search on the density and distribution of fishes of the Beaufort Sea.

Mueller and Schamel, 1976, Airfaunal utilization of the offshore island near Prudhoe Bay.

Peat, Marwick, Mitchell & Co., 1978, Socio-economic impacts of the Beaufort Sea petroleum development scenarios.

Policy Analysts Limited, 1978, Anchorage impacts of the Beaufort Sea petroleum development scenario.

Schell, 1979, Nutrient dynamics and trophic system energetics in nearshore Beaufort Sea waters.

Stringer, 1978, Morphology of Beaufort Sea, Chukchi Sea, and Bering Sea nearshore ice conditions by means of satellite and aerial remote sensing.

Whorl Associates, 1978, Sociocultural systems impacts of the Beaufort Sea petroleum development scenarios.

Whorl Associates for Peat, Marwick, Mitchell, & Co., 1978, Beaufort Sea region socio-economic cultural systems.

Wordsmiths, 1978, Alyeska-Fairbanks case study.

Geological Survey

Bird, Kenneth J., 1981, Petroleum exploration of the North Slope in Alaska, U.S.A.: Menlo Park, Calif., U.S. Geological Survey Open-File Report 81-227, 43 p. Available from Open-File Services Section, USGS, Box 25425, Federal Center, Denver, CO 80225.

This report discusses the geologic setting and exploration history of the North Slope. It summarizes the geologic history, distribution of strata, and hydrocarbon potential of the area. In addition, it discusses exploratory activities undertaken by government and industry. This study also includes resource estimates for the National Petroleum Reserve in Alaska.

Carter, R.D., and others, 1977, The petroleum geology and hydrocarbon potential of Naval Petroleum Reserve No. 4 North Slope, Alaska: U.S. Geological Survey Open-File Report 77-475. Available from Open-File Services Section, USGS, Box 25425, Federal Center, Denver, CO 80225.

The objectives of this report are to provide background information, to describe the state of knowledge of the geology of Naval Petroleum Reserve No. 4, and to recommend studies necessary for an evaluation of the hydrocarbon potential of the Reserve. Geology of the Prudhoe Bay area is compared with that of the Reserve. This document was based on unpublished data, U.S. Geological Survey data, and previous Navy exploration.

Grantz, Arthur, and Mull, C.G., 1978, Preliminary analysis of the petroleum potential of the Arctic National Wildlife Range: Menlo Park, Calif., U.S. Geological Survey Open-File Report 78-489, 19 p. and 6 plates. Available from Open-File Services Section, USGS, Box 25425, Federal Center, Denver, CO 80225.

This report analyzes the petroleum potential of the Arctic National Wildlife Range. Using information from multichannel seismic surveys, subsurface compilation, and reconnaissance geologic mapping, the study provides a synopsis of petroleum geology in the ANWR and areas with potential hydrocarbon deposits.

Grantz, Arthur, Barnes, P.W., Dinter, D.A., Lynch, M.B., and others, 1980, Geologic framework, hydrocarbon potential, environmental conditions, and anticipated technology for exploration and development of the Beaufort Shelf north of Alaska: Menlo Park, Calif., U.S. Geological Survey Open-File Report 80-94, 42 p. Available from Open-File Services Section, USGS, Box 25425, Federal Center, Denver, CO 80225.

This report presents an overview of the geologic framework, petroleum potential, environmental conditions, geologic hazards, and anticipated technology for development of the Continental Shelf beneath the Beaufort Sea. It is geared to assist the Bureau of Land Management in the selection of areas most attractive for leasing, to identify the geologic constraints and hazards and environmental conditions, and to make projections concerning the technology that will be required for petroleum exploration and development.

Reed, Katherine M., ed., 1980, The U.S. Geological Survey in Alaska 1980 programs: U.S. Geological Survey Circular 823-A, 112 p. Available from Text, 604 South Picket Street, Alexandria, VA 22304, (703) 756-6141.

This circular describes the 1980 programs and projects of the U.S. Geological Survey in Alaska. A brief description of the Alaska operations of each major division of the USGS is followed by project descriptions arranged by geographic regions in which the work takes place. A directory table lists all project chiefs and other summary information.

U.S. Geological Survey, 1979, An environmental evaluation of potential petroleum development on the National Petroleum Reserve in Alaska: prepared under Sec-

tion 105(b) of the Naval Petroleum Reserves Production Act of 1976, 100p. and appendixes. Available on microfiche at AEIDC.

This study consists of an environmental analysis--a description of the environment, a discussion of environmental and planning controls related to petroleum development, and a description of current and standard practices for petroleum development in the Arctic. The preface encapsulates the purpose of the study, the assumptions of the environmental analysis, and major environmental concerns identified in the analysis. The analysis consists of a detailed description of all impacts identified by the task force--major or minor, long-term or short-term. The three appendixes provide information upon which the analysis is based.

Office of Minerals Policy and Research Analysis

Office of Minerals Policy and Research Analysis, 1979, Final report of the 105(b) economic and policy analysis: 145 p. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 (Stock No. 024-000-00865-7).

This analysis reviews the best overall procedures for the development, production, transportation, and distribution of petroleum resources of the National Petroleum Reserve in Alaska. It includes an economic and policy analysis to study alternative procedures for NPRA petroleum resource development and an analysis of the environmental consequences of alternative development procedures.

U.S. General Accounting Office

U.S. General Accounting Office, 1981, Environmental and other problems along the Alaska Pipeline Corridor (EMD-81-69): Washington, D.C., 9 p. Available from the U.S. General Accounting Office, Document Handling and Information Services Facility, Box 6015, Gaithersburg, MD 20760.

This report supplements the report entitled Trans-Alaska Oil Pipeline Operations: More Federal Monitoring Needed (January 1981). It addresses the need for more action by the Department of the Interior to assure that the State of Alaska complies with haul road right-of-way provisions. Objectives of the report are to determine what negative environmental impacts, if any, have occurred on Federal lands traversed by the State of Alaska's Haul Road, and to assess the adequacy of Federal and State efforts to mitigate present environmental damage and prevent unnecessary environmental degradation in the future.

U.S. General Accounting Office, Comptroller General, 1981, Report to the Congress of the United States: impact of regulations --after Federal leasing--on Outer Continental Shelf oil and gas development: Washington, D.C., 63 p. Available from the U.S. General Accounting Office, Document Handling and Information Services Facility, P.O. Box 6015, Gaithersburg, MD 20760.

The Report to the Congress evaluates the effects of requirements stemming from the amendments and other legislation on industry efforts to explore and develop oil and gas resources after leases are awarded. The roles of the State, local governments, and industry are discussed in terms of their involvement in permit processing and environmental specifications. Recommendations regarding exploration and development of the OCS areas are also provided. A list of agency and company contacts and agency roles in regulating OCS activities is presented in the appendix.

U.S. General Accounting Office, Comptroller General, 1981, Report to the Congress of the United States: Trans-Alaska oil pipeline operations: more Federal monitoring needed: Washington, D.C., 139 p. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

This report evaluates the effectiveness of the Department of the Interi-

or's monitoring of the Trans-Alaska Pipeline System operations. Several technical and environmental stipulations that are imposed on the Alyeska Pipeline Service Company (the operator) are examined. These stipulations establish the conditions for the pipeline's right-of-way across Federal lands.

Other Federal Studies

Brown, J., and Berg, R.L., eds., 1980, Environmental engineering and ecological baseline investigations along the Yukon River-Prudhoe Bay Haul Road: prepared for the U.S. Department of Transportation, Federal Highway Administration, by U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Hanover, N.H., CRREL Report 80-19, 203 p. Available from NTIS, 5285 Port Royal Road, Springfield, VA 22161.

This report presents a summary of existing and proposed environmental guidelines that are applicable to road construction and related pipeline activities on arctic and subarctic regions. Guidelines include the minimization of impacts during construction; consideration of fish and wildlife; criteria for drainage and erosion control; the effect of road cuts in ice-rich soils; stabilization of roadway embankments; and criteria for revegetation and restoration. The report presents approaches, results, conclusions, and recommendations based on the investigations conducted under these guidelines. Maps of Haul Road study site locations are also included.

Federal Energy Regulatory Commission, Office of Pipeline and Producer Regulation, 1980, Prudhoe Bay Project: final environmental impact statement: Washington, DC, 416 p. Limited number of copies available from the Federal Energy Regulatory Commission, Office of Public Information, Room 1000, 825 North Capitol Street, NE, Washington, DC 20426 (FERC/EIS 0009).

This EIS evaluates the environmental impact of gas conditioning and processing facilities to be constructed at Prudhoe Bay. It deals with the construction and operation of facilities to process, condition, and compress natural gas to meet Northwest Alaskan Pipeline Company's proposed pipeline specifications. The report also analyzes the environmental impact of an alternative site near the Yukon River and two alternative sites at Fairbanks, Alaska. The study concludes that the proposed Prudhoe Bay site is environmentally acceptable.

Jack Faucett Associates, 1980, Analysis of the permitting processes associated with exploration of Federal OCS leases: Study no. DOE/RA/35012-1, prepared for the U.S. Department of Energy, Assistant Secretary for Resource Applications, Office Leasing Policy Development, Chevy Chase, Md., 2 vols. Available from the Department of Energy, Office Leasing Policy Development, Washington, DC 20585.

This report provides a description and analysis of regulatory activities associated with the exploration of federally leased areas on the OCS. Recommendations have been developed that will lead to the elimination of unnecessary delays in the securing of permits required for domestic oil and gas exploration. Volume I examines the regulatory activity associated with exploration activities on the Federal OCS. Volume II identifies the various Federal and State agencies and programs that have a major role in the regulatory process.

U.S. Army Corps of Engineers, Alaska District, 1980, The Prudhoe Bay oil field waterflood project; Prudhoe Bay, Alaska: final environmental impact statement: Anchorage, 3 vols, Vols. 1 and 3 available from U.S Army Corps of Engineers, Alaska District, P.O. Box 7002, Anchorage, AK 99510. Vol. 2 not available.

This environmental impact statement has been prepared to aid the permit decisionmaking process necessary for the construction and operation of a waterflood facility in Prudhoe Bay. The existing environment is described and potential future impacts on the environ-

ment are also examined for the area of proposed action and alternative areas. The document also provides a summary of potential monitoring programs that may be instituted to evaluate various aspects of the waterflood project, along with a discussion of conditions that may be placed on permit approvals to maximize environmental protection. Additional background information is provided in the appendixes.

U.S. Army Corps of Engineers, Alaska District, 1980, The Prudhoe Bay waterflood project: a summary of the final environmental impact statement: Anchorage, Alaska, 27 p. Available from U.S. Army Corps of Engineers, Alaska District, P.O. Box 7002, Anchorage, AK 99510.

This summary provides a concise analysis of the proposed Prudhoe Bay waterflood project. It is written in the native dialect as well as in English and includes a series of simplified illustrations showing the major steps in the proposed waterflood project permit process. Significant issues such as location of necessary high- and low-pressure water lines, seawater intake and treating plants, and the water injection plants are identified relating to the existing proposal. Alternative measures are also discussed in terms of methods of enhancing oil recovery and other ways to accomplish water flooding. Delay of action and no action at all are also considered.

U.S. Department of the Navy, 1977, Naval petroleum and oil shale reserves, final environmental impact statement: continuing exploration and evaluation of Naval Petroleum Reserve No. 4: Washington, D.C., 2 vols., 830 p. and appendixes. Available for inspection at BLM Alaska Program Staff, Washington, DC 20240.

This study examines the impact of additional exploratory wells at various locations throughout Naval Petroleum Reserve No. 4. A preliminary inventory of renewable resources was made for evaluation of the best uses of the reserve. Volume 1 reviews background material on NPR-4 and gives a general description of project operations, focusing on various aspects of the existing environment. The relationship of proposed action to land use plans, policies, and controls for the affected areas is also discussed. Volume II examines probable impacts of the proposed action and alternatives to continuing exploratory drilling. Public comments are also included in this report. Appendixes show the result of geophysical exploration.

Walker, D.A., Everett, K. R., Webber, P.J., and Brown, J., 1980, Geobotanical atlas of the Prudhoe Bay Region, Alaska: prepared by U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Hanover, N.H., CRREL Report 80-14, 73 p. Available from USA CRREL/TIB, Box 282, Hanover, NH 03755, $25.00.

This atlas illustrates the relationships among the landforms, soils, and vegetations of a portion of the Arctic Coastal Plain of Alaska. Forty-two vegetation communities, 13 major landforms, and 8 soil types are described. Other aspects of the Prudhoe Bay environment, including geology, permafrost, and winter and summer climate, are discussed and illustrated. Also included are historical descriptions of the development of the oil field and of selected scientific investigations in the Alaska arctic. Geobotanical special-purpose maps useful for land use planning and management of the ecosystem are also provided.

STATE STUDIES

Clement, M., Swift, W.H., Hendrickson, P.L., Jacobsen, J.J., and others, 1978, North Slope royalty oil market, pricing, and revenue analysis: prepared for the Alaska State Legislature, Legislative Affairs Agency, Division of Research Services by BATTELLE, Pacific Northwest Laboratories, Richland, Wash. Available for inspection at the Legislative

Reference Library, Legislative Affairs Agency, Pouch Y, State Capital, Juneau AK 99811.

This report examines two basic options ("in value" and "in kind" concepts) that are available to the State of Alaska for determining royalty income. It includes a quantitative assessment of the condition for each State royalty option and probable revenue resulting from it. Major issues deal with what option is most compatible with the State's goals and objectives; what changes will there be and whether the State and industry should plan for them; and what long-term commitments the oil industry will be making. The study has been expanded to include an assessment of relevant world market conditions, an evaluation of the crude oil supply, and requirements for the Petroleum Administration for Defense District market and interior U.S. markets. It can assist in the State's evaluation of a variety of policy matters relevant to disposition of royalty of oil and gas.

Hartman, Charles W., and Johnson, Philip R., 1978, Environmental atlas of Alaska: University of Alaska, Institute of Water Resources, Fairbanks, Alaska, 95 p. Available at cost from Institute of Water Resources, University of Alaska, Fairbanks, AK 99701.

This atlas gives an overall picture of many aspects of physical Alaska. General information is presented in the form of maps, tables, and text. Much of the material for this document was obtained from published sources and data collected from various U.S. Government agencies. Principal studies include physical conditions of Alaska, water, light, climate, and engineering information.

Kleinfeld, Judith, Kruse, John A., and Travis, Robert M., 1981, Different paths of Inupiat men and women in the wage economy: the North Slope experience: University of Alaska, Institute of Social and Economic Research, Man in the Arctic Program, Monograph No. 2, Anchorage, Alaska, 53 p. Available from Institute of Social and Economic Research, University of Alaska, 707 A Street, Suite 206, Anchorage, AK 99501.

This study examines the responses of the North Slope Inupiat to the employment opportunities created through oil development. The first section analyzes the general effects of new job opportunities on the Inupiat population. The second section examines the different responses of Inupiat men and women to job opportunities. The conclusion discusses issues arising from the particular adaptations of Inupiat men and women to the wage economy. The study is based primarily on a household survey conducted in 1977 by the Institute of Social and Economic Research in cooperation with the North Slope Borough. It represents over 59 percent of North Slope Inupiat households with over 20 percent of the North Slope Inupiat adult population in the communities surveyed.

Kruse, John, Kleinfeld, Judith, and Travis, Robert, 1980, Energy development and the North Slope Inupiat: quantitative analysis of social and economic change: University of Alaska, Institute of Social and Economic Research, Man in the Arctic Program, Monograph No. 1, Anchorage, Alaska, 132 p. Available from Institute of Social and Economic Research, University of Alaska, 707 A Street, Suite 206, Anchorage, AK 99501.

This report presents the findings of a 1977 household survey conducted in six native villages on Alaska's North Slope. Its central purpose was to assess the social and economic effects of petroleum development in Alaska. The focus of the study was on the Inupiat of the North Slope and on social and economic changes they have experienced during Arctic oil and gas development activities.

McBeath, Gerald, A., 1981, North Slope Borough government and policymaking: University of Alaska, Institute of Social

and Economic Research, Man in the Arctic Program, Monograph No. 3, Anchorage, Alaska, 94 p. Available from Institute of Social and Economic Research, University of Alaska, 707 A Street, Suite 206, Anchorage, AK 99501.

This report begins with a description of conditions from which the North Slope Borough government was formed. It then traces the development of the borough, analyzing its centralization of power, specialization of functions, and differentiation of institutions. Borough leadership and the way in which borough leaders perceive problems are examined. An evaluation is presented on the way in which the regional government has distributed public goods on the North Slope and on how it has regulated public activity. Finally, long-term effects of borough government are considered with respect to the welfare, security, and participation of borough residents.

Selkregg, Lidia, 1975, Alaska regional profiles: Arctic region, Anchorage, 218 p. Available for inspection at AEIDC.

This Arctic regional profile is one of a series of six volumes describing the material and man-made environments of Alaska. Collectively, they present a data base for planning the future use, development, protection, and management of Alaska's resources and natural endowment. The compilation of text, maps, and tables offers scientific and technological data that can be used by planners and policymakers as well as the general public. The information is generalized, but it represents a comprehensive summary of current knowledge. Studies providing greater detail on specific resources, geographic areas, and scientific topics are cited in the bibliography.

State of Alaska, Coastal Policy Council and Office of Coastal Management, 1981, Annual report for 1980 on the Alaska Coastal Management Program: Juneau, 63 p. and appendixes. Available from the State of Alaska, Office of the Governor, Division of Policy Development and Planning, Office of Coastal Management, Pouch AP, Juneau, AK 99811.

The objective of this annual report is to provide information on the continued development and implementation of the Alaska Coastal Management Program (ACMP) for 1980. Part I provides a brief introduction to the report, outlining the conflicts which occur within the ACMP. Part II recounts the 1980 authorization and amendment of the national Coastal Zone Management Act (CZMA). Revisions of the substantive portions of ACMP are explained in part III. Part IV provides a summary of the meetings held by the Alaska Coastal Policy Council during 1980. Part V summarizes the activities pursued by the Office of Coastal Management (OCM), and part VI lists grants and loans awarded to coastal resource districts and State agencies for preparing for coastal impacts expected as a result of energy-related projects. Part VII lists publications prepared for ACMP during 1980. Appendixes include the Alaska CZMA, ACMP regulations, and the national CZMA as amended.

This report should be considered a supplement to the ACMP program document, the Alaska Coastal Management Program and Final Environmental Impact Statement, June 1979.

State of Alaska, Department of Commerce and Economic Development, Division of Energy and Power Development, 1981, State of Alaska long-term energy plan (draft): Anchorage, Alaska, 3 vols. Vols. available for inspection and executive summary available for distribution from Division of Energy and Power Development, 7th floor, MacKay Building, 339 Denali Street, Anchorage, AK 99501.

This plan provides a centralized State-wide overview of energy development and conservation programs in Alaska. It is designed to give a broad view of public and private energy activities. Major topics include a report on the "end-use" of energy in the State; an

analysis of energy conservation activities and potential; a presentation of measures that the Governor of Alaska could choose to implement in the event of an energy shortage; and a report on areas or subjects of energy research, development, and demonstration. The plan attempts to improve the decision-making process within the State government. The long-term energy plan is revised annually.

State of Alaska, Department of Natural Resources, Division of Minerals and Energy Management, 1981, State five-year leasing programs: Anchorage, Alaska, 172 p. Available from Department of Natural Resources, Division of Minerals and Energy Management, 555 Cordova Street, Pouch 7-005, Anchorage, AK 99501.

Five-year schedules are submitted annually to the legislature for the leasing of State land for oil and gas exploration. The major purpose of establishing a petroleum leasing schedule is to provide a plan to facilitate the orderly assessment and development of Alaska petroleum resources. Input is provided by local citizens and governments, environmental groups, the oil industry, and the business sector.

LOCAL STUDIES

Brown, William E., 1979, Nuiqsut heritage: a cultural plan: prepared for the Village of Nuiqsut and the North Slope Borough Planning Commission and Commission on History and Culture, Alaska, 56 p. Available from the North Slope Borough P.O. Box 69, Barrow, AK 99723.

This cultural plan was prepared for the village of Nuiqsut in order to help the people protect their traditional land use area and perpetuate their subsistence way of life. The timing of this cultural plan is especially important. It can be integrated at the planning and political levels and provide a better understanding of the dynamics of change affecting the cultural landscape valued and used by the Nuiqsut heritage community. Several settlement areas (past and present) are described in detail to illustrate the many historical values of the Inupiat people.

Burch, Ernest S., Jr., 1981, The traditional Eskimo hunters of Point Hope, Alaska: 1800-1875: 209 p. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

The purpose of this study is to present a comprehensive account of land use by the people of the Point Hope region between 1800 and 1875. This period was chosen because it is the last span of time in which Native activities reasonably can be considered to have occurred with a minimum of Euro-American influence. It is also the earliest for which there were direct eyewitness accounts by Europeon explorers. The study includes an analysis of the native people, their production of raw materials, and the social and temporal dimensions of their land use.

Carnahan, John, 1979, Cross Island: Inupiat cultural continuum: Anchorage, Alaska, North Slope Borough, 43 p. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

This report documents traditional use and occupancy of Cross Island by the Inupiat. It discusses subsistence activities on the barrier island and is based on oral history provided by Inupiat North Slope residents.

Finkler, Earl, 1980, North Slope Borough comprehensive policy plan, Haul Road area: prepared for the North Slope Borough, Alaska, 34 p. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

This report examines the comprehensive policies on the Haul Road area, which falls under three jurisdictions--Federal, State, and Arctic Slope Regional Corporation. It helps to identify areawide issues, powers, and responsibilities of the North Slope Borough and reflects ongoing village communication

and input. Mineral, watershed, wildlife, recreation, historical, and cultural findings are reviewed, as well as suggested Borough policies for each issue.

Lowenstein, Tom, 1980, Some aspects of sea ice subsistence hunting in Point Hope, Alaska: prepared for the North Slope Borough's Coastal Zone Management Plan, 83 p. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

The purpose of this report is to sketch briefly some of the patterns of sea and sea ice subsistence hunting among the Point Hope peoples. Areas of concern are the pre-contact period, up to 1880; a transitional period from 1900 to 1950; the super change, 1950 to 1975, marked by the increase in use of modern technology; and the contemporary super change, 1975-1980, the period of village relocation, housing construction, high local employment, and television. The report examines Point Hope as its own center and looks at the present and the relationship of today's practices to past patterns, while also addressing future issues that may confront the community.

Maynard and Partch and Woodward-Clyde Consultants, 1981, North Slope Borough Coastal Management Work Program. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

This draft work program discusses the coastal management of the Point Hope area and the remainder of the coastline not covered in the mid-Beaufort program. It is the intent of the North Slope Borough to consolidate all coastal management work carried out into a single borough-wide program. A brief history of the North Slope Borough coastal management program is included, followed by a summary of program elements and regulations. Emphasis on public participation is evident throughout the study. Community needs and goals are reviewed for the mid-Beaufort, as well as for the Point Hope district. An evaluation of literature and ongoing studies is also included, along with the scope and methodology for work program elements. A schedule for the development of the North Slope Borough Coastal Management Work Program has been incorporated, showing program elements over time and the process for the Alaska Coastal Policy Council review.

Nielson, Jon M., 1977, Beaufort Sea study--historic and subsistence site inventory: a preliminary cultural resource assessment: Barrow, Alaska, North Slope Borough, 113 p. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

This study indentifies historic sites, cultural resources, and subsistence patterns of the Beaufort Sea region that may be affected by OCS development. A literature compilation is made for the area from the Colville River to the Canning River for the purpose of describing traditional subsistence practices and considering certain locations for nomination to the National Register of Historic Sites. The literature has been integrated Native oral and ethnographic accounts of the Beaufort Sea region and its history. Maps based upon the literature and Native oral accounts are included, locating historic sites and areas of subsistence activities.

North Slope Borough, 1980, A report on cultural resources in the mid-Beaufort Sea region: prepared under contract with the Department of Community and Regional Affairs, Division of Community Planning, 129 p. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

This paper reflects the continuing efforts by the North Slope Borough and identify, protect, and manage the historic and cultural resources in the mid-Beaufort Sea region. The first section reports field work done by an ethnohistorian who visited and interviewed

residents of the area. His study allowed for on-site determination of house and ice cellar location in places where signs of such activity had been eradicated by wind, water, and ice. The second section addresses known cultural resources and investigates the possibilities of encountering further evidence of past human activity there. Scientific, legal, practical, and cultural parameters of exploiting the mid-Beaufort Sea coast's resources are also discussed within the context of a cultural resource management plan for this area. Several photographs taken near the turn of the century have been included by USGS team members and by others who contributed historical material.

North Slope Borough, 1979, An analysis of historic preservation alternatives along the Alaska pipeline Haul Road and Utility Corridor: Barrow, Alaska, 31 p. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

The study is an analysis of the alternatives that the North Slope Borough may wish to adopt in its desire to protect and to preserve the integrity of cultural and historic sites located along or adjacent to the Alaska pipeline Haul Road. Historic zoning techniques, districts, and overlays are studied in order to apply them in the planning program for the region traversed by the Haul Road, where it falls under borough jurisdiction. Some specific sites receive special attention as provided for in Federal, State, and local statutes.

North Slope Borough, 1979, North Slope Borough Coastal Management Program: Alaska. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

This plan describes in outline form the North Slope Borough's district coastal management program for the mid-Beaufort Sea region. It is the Borough's intent that the framework plan be extensively used and easily understood by the public. Objectives and policies for coastal management are provided, along with maps of the coastal zone district and a resource inventory. A more detailed borough management scheme is also included in the proposed zoning ordinance. The borough intends to continue its work on coastal management for other segments of the North Slope coastal region.

North Slope Borough, 1979, Resource inventory: Galbraith Lake: Barrow, Alaska, 34 p. and plate. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

The objective of this study is to focus on the culture, traditions, and present subsistence economy of the people of the Galbraith Lake-Atigun Gorge area. A major component of the report is actual testimony of North Slope Borough residents about the area. Ecological, historical, and archeological inventories are also documented for a better understanding of the unique nature and resources of the Galbraith Lake-Atigun Gorge area.

North Slope Borough Contract Staff, 1979, Native livelihood and dependence: a study of land use values through time: Field Study 1, prepared for the U.S. Department of the Interior, National Petroleum Reserve Study in Alaska, Work Group 1, 105(c) Land Use Study, Anchorage, Alaska, 166 p. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

This study attempts to determine the values of and best uses for land contained in the National Petroleum Reserve in Alaska, taking into consideration the Natives who live there or depend upon this land. The research area, however, embraces the entire Arctic Slope north of the Brooks Range because the subsistence range of the inhabitants extends beyond the boundaries of the NPRA. The report primarily focuses on describing the relationship of the Inupiat

to their environment and demonstrating how this relationship links with social and cultural values that have been developing over many generations. Archeological, historical, and present subsistence research methods were used, creating a blend of traditional and present land use data for a flexible land use planning process.

Shinkwin, Anne, and North Slope Borough Planning Department, 1978, A preservation plan for Tigara Village: prepared for the City of Point Hope and the North Slope Borough Commission on History and Culture, Point Hope, Alaska, 66 p. Available from the North Slope Borough, P.O. Box 69, Barrow, AK 99723.

This report presents background information on the setting of Tigara village and summarizes present knowledge of the prehistory and history of the area. It also describes the present status of Old Tigara and the nature of its archeological resources. The report concludes with recommendations regarding a preservation plan for the historic village site.

Glossary

Definitions presented in the glossary describe terms as they have been used in this summary report. The glossary is intended for general reference only: for detailed descriptions of technical or specialized terms, the reader should seek a reference in the field of particular interest. Abbreviations and acronyms are presented in tabular form on p. ii.

Sources used in compiling this glossary were the Arctic Summary Report itself; the other Office of OCS Information (formerly OCSIP) summary reports and Atlantic, Pacific, Gulf of Mexico, and Alaska Indexes; Webster's Third New International Dictionary; the American Geological Institute's Dictionary of Geological Terms; and Langenkamp's Handbook of Oil Industry Terms and Phrases (2d ed.).

Active layer - The area above permafrost that freezes each winter and thaws each summer.

Anticline - An upfold or arch of stratified rock in which the beds or layers bend downward in opposite directions from the crest or axis of the fold.

API gravity - The standard American Petroleum Institute method for specifying the density of crude petroleum in degrees.

Basement rock - Rock in the earth's crust beneath all sedimentary rocks.

Basin - A depression of the earth in which sedimentary materials accumulate or have accumulated, usually characterized by continuous deposition over a long period of time; a broad area of the earth beneath which the strata dip, usually from the sides toward the center.

Block - A geographical area, as portrayed on an official BLM protraction diagram or leasing map, that contains approximately 9 square miles (5,693 acres or 2,304 hectares).

Breakup - The period during which ice in water bodies thaws and breaks up (late May to mid-June for river ice, early July to mid-August for ocean ice).

Conditional resource estimate - An assessment of oil and gas resources that assumes that favorable geologic conditions exist such that oil and gas are present in commercial quantities.

Continental Margin - A zone separating the emergent continents from the deep sea bottom.

Continental Shelf - A broad, gently sloping, shallow feature extending from the shore to the Continental Slope.

Continental Slope - A relatively steep, narrow feature paralleling the Continental Shelf; the region in which the steepest descent to the ocean bottom occurs.

Decline-curve method - A method used for estimating reserves. It estimates future production by extrapolating plots of actual production rates and fluid percentages into the future; by adding past production to predicted future production, an estimate of original reserves can be obtained.

Development - Activities that take place following discovery of minerals in commercially attractive quantities, including but not limited to geophysical activity, dril-

ling, platform construction, and operation of all directly related onshore support facilities; and that are for the purpose of ultimately producing the minerals discovered.

Diapir - A piercing fold; an anticlinal fold in which a mobile core, such as salt, has broken through the more brittle overlying rocks.

Discovery - A find of significant quantities of hydrocarbons on a given lease.

Economically recoverable resource estimate - An assessment of the hydrocarbon potential that takes into account (1) physical and technological constraints on production and (2) the influence of costs of exploration and development and market price on industry investment in OCS exploration and production.

Economic risk factor - The probability that a particular trap will not contain hydrocarbons in sufficient quantities to be commercially productive.

Environmental impact statement (EIS) - A document required by the National Environmental Policy Act of 1969 (NEPA) or similar State law in relation to any action significantly affecting the environment.

Exploration - The process of searching for minerals. Exploration activities include (1) geophysical surveys where magnetic, gravity, seismic, or other systems are used to detect or infer the geologic conditions conducive to the accumulation of such minerals and (2) any drilling, whether on or off known geological structures. Exploration also includes the drilling of a well in which a discovery of oil or natural gas in paying quantities is made and the drilling of any additional well(s) after such a discovery that is needed to delineate a reservoir and to enable the lessee to determine whether to proceed with development and production.

Fault - A fracture in the earth's crust accompanied by a displacement of one side of the fracture with respect to the other.

Field - An area underlain by one or more geologically related hydrocarbon reservoirs.

Formation - The primary unit in lithostratigraphy, consisting of a succession of strata useful for mapping or description.

Freezeup - The period during which lakes, rivers, and other water bodies freeze (in autumn).

Geohazard - (See **geologic hazard**).

Geologic hazard - A feature or condition that, if undetected, may seriously jeopardize offshore oil and gas exploration and development activities and, once identified, may necessitate special engineering procedures or relocation of a well.

Geologic risk factor - The probability that a particular trap will not contain hydrocarbons in the quantities predicted by the geologic evaluation.

Geologic trap - An arrangement of rock strata, involving their structural relations or varied lithology and texture, that favors the accumulation of oil and gas.

Hydrocarbon - Any of a large class of organic compounds containing only carbon and hydrogen, comprising paraffins, olefins, members of the acetylene series, alicyclic hydrocarbons, and aromatic hydrocarbons, and occurring in many cases in petroleum, natural gas, coal, and bitumens.

Ice leads - Large, linear openings in sea ice.

Ice-wedge polygons- Patterned ground that results when extremely low temperatures cause the ground to contract and water and snow collect in the cracks to form wedges.

Landfast ice zone - The area adjacent to shore in which winter sea ice freezes to the bottom.

Lease - A contract authorizing exploration for and development and production of minerals; the land covered by such a contract.

Lease sale - The public opening of sealed bids made after competitive auction for leases granting companies or individuals the right to explore for and develop certain minerals within a defined period of time.

Magnitude - A rough measure of earthquake size based on the ground motion recorded by a seismograph. Richter magnitude is calculated by taking the common logarithm of the largest motion (revealed by a deflection on the seismograph) recorded during the arrival of a seismic wave.

Mass movement - Unit movement of a portion of the land surface, as in creep, landslide, or slip. Mass movement, or slumping, can occur where unconsolidated sediments are distributed over a steep gradient.

Mass wasting - The downslope movement of rock debris.

Orogen - A belt of deformed rocks, in many places accompanied by metamorphic and plutonic rocks, resulting from the mountain-formation process.

Outer Continental Shelf (OCS) - All submerged lands that comprise the Continental Margin adjacent to the U.S. The OCS remains subject to Federal jurisdiction and control after enactment of the Submerged Lands Act (43 U.S.C. 1301 and 1302).

Pack ice zone - The area in which sea ice consists predominantly of multiyear floes; the area in which ice does not melt annually.

Pay thickness - The vertical extent of the stratigraphic section of an oil field containing reservoir beds that will yield gas or petroleum in economic quantities.

Permafrost - Permanently frozen ground.

Permeability - The capacity to be penetrated or diffused through; the ability to transmit fluids.

Permeable - Capable of being penetrated or diffused through.

Petroleum - An oily, flammable bituminous liquid that occurs in many places in the upper strata of the earth, either in seepages or in reservoir formations; essentially a complex mixture of hydrocarbons of different types with small amounts of other substances; any of various substances (as natural gas or shale oil) similar in composition to petroleum.

Photoperiod - The relative lengths of alternating periods of lightness and darkness.

Platform - A steel or concrete structure from which offshore wells are drilled.

Pressure ridge - A raised strip of ice formed by the pressure created by interaction of landfast and pack ice.

Province - An area throughout which geological history has been essentially the same or that is characterized by particular structural, petrographic, or physiographic features.

Recoverable resource estimate - An assessment of oil and gas resources that takes into account the fact that physical and technological constraints dictate that only a portion of resources or reserves can be brought to the surface.

Relict permafrost - Permanently frozen ground that was formed during an earlier period.

Reserve estimate - An assessment of the portion of the identified oil or gas resource that can be economically extracted.

Reserves - Portion of the identified oil or gas resource that can be economically extracted.

Reservoir - A porous, permeable sedimentary rock formation containing quantities of oil and/or gas enclosed or surrounded by layers of less permeable or impervious rock.

Resource - Concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust.

Rig - Apparatus used for drilling an oil or gas well.

Risked resource estimate - An assessment of oil or gas resources that has been modified to take into account (1) physical and technological constraints on production; (2) the influence of the costs of exploration and development and market price on industry investment in OCS exploration and production; and (3) the estimator's confidence in the estimate.

Salt diapir - A structure resulting from the upward movement of a salt mass; oil and gas fields are frequently associated with salt diapirs.

Sandstone - A sedimentary rock made up of sand that usually consists of quartz more or less firmly united by some cement (as silica, iron oxide, or calcium carbonate).

Scoping - A series of public meetings that are held by regional Bureau of Land Management OCS Offices to determine OCS issues of concern, possible options, and possible mitigating measures.

Seismic - Pertaining to, characteristic of, or produced by earthquakes or earth vibration; having to do with elastic waves in the earth.

Shear zone (stamukhi zone) - The area of interaction between pack ice and landfast ice.

Slumping - (See **mass movement**).

Source rock - The geologic formation in which oil and/or gas originate.

Spud - To begin drilling a well.

Stratum (pl., strata) - A tabular mass or thin sheet of sedimentary rock or earth of one kind formed by natural causes and made up usually of a series of layers lying between beds of other kinds.

Stratigraphic trap - A reservoir, capable of holding oil or gas, that is formed from a change in the character of the reservoir rock. Such a trap is harder to locate than a structural trap because it is not readily revealed by geological or geophysical surveys.

Structural trap -A reservoir, capable of holding oil or gas, that is formed from crustal movements in the earth that fold or fracture rock strata in such a manner that oil or gas accumulating in the strata are sealed off and cannot escape. In some cases "structure" may be synonymous with structural trap.

Subsidence - A sinking of a large part of the earth's crust; movement in which there is no free side and surface material is displaced vertically downward with little or no horizontal component.

Subsurface geology - The study of structure, thickness, facies, correlation, etc. of rock formations beneath land or seafloor surfaces by means of drilling for oil or water, core drilling, and geophysical prospecting.

Summary report - Document prepared by the Department of the Interior pursuant to 30 CFR 252.4 that is intended to inform affected State and local governments as to current OCS reserve estimates, projections of magnitude and timing of development, transportation planning, and general location and nature of nearshore and onshore facilities.

Supply boat - Vessel that ferries food, water, fuel, and drilling supplies and equipment to a rig and returns to land with refuse that cannot be disposed of at sea.

Surficial - Characteristic of, pertaining to, formed on, situated at, or occurring on the earth's surface.

Thaw lake - Water body formed as the result of summer thawing of permafrost beneath shallow-standing water.

Thermokarst - Settling or caving of the ground due to melting of ground ice.

Tract - The geographic and legal extent of a single lease area; a convenient way of numbering blocks offered for sale.

Trap - A geologic feature that forms a reservoir enclosing and preventing the escape of accumulated fluids (hydrocarbons or water).

Tundra - A rolling, treeless, often marshy plain.

Tussock - A tuft or clump of grass or sedge.

Undiscovered resources - Quantities of oil and gas estimated to exist outside known fields.

Volumetric yield method - Method of calculating the bulk volume of a reservoir from interpretation of seismic data and information gained by drilling. Porosity of the rock and the relative amounts of oil, gas, and water in its pore spaces can be interpreted through analyses of borehole logs.

Wildcat strike - A discovery of oil or gas in an unproved area.

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