ARCTIC NATIONAL WILDLIFE REFUGE COASTAL PLAIN
RESOURCE ASSESSMENT

INITIAL REPORT
BASELINE STUDY
OF THE FISH, WILDLIFE, AND THEIR HABITATS

Section 1002 c

Alaska National Interest Lands Conservation Act

S. Steinacher ©

U.S. Department of the Interior
U.S. Fish and Wildlife Service
Region 7
Anchorage, Alaska
April 1982

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

April 30, 1982

Dear Reader:

The Initial Baseline Report for the Arctic National Wildlife Refuge Coastal Plain Resource Assessment has been prepared in accordance with Section 1002(c) of the Alaska National Interest Lands Conservation Act (ANILCA). The purpose of the report is to present existing baseline information regarding the fish, wildlife, habitat and other resources of the northeastern part of the Arctic National Wildlife Refuge, Alaska. This document forms the basis for the continuing studies now in progress.

The ANILCA also authorizes seismic exploration of the study area and the development of guidelines governing seismic exploration for oil and gas resources within the study area. The environmental impact statement that will accompany the guidelines will be based upon the information contained in this report and other pertinent data. Following completion of seismic studies, the Secretary will prepare a report to Congress describing the results of the seismic exploration and the concurrent baseline studies. The report will also describe the oil and gas resources of the study area and will make recommendations to Congress on the desirability of further exploration, development and/or production of those resources and will also describe the expected impacts of that action upon other resources of the coastal plain.

As an interested party, your comments on the Initial Baseline Report will be useful to us in our efforts to implement this important aspect of ANILCA.

Sincerely,

G. Ray Arnett
Assistant Secretary for Fish
and Wildlife and Parks

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CONVERSION TABLE

For those readers who may prefer the commonly used American units, rather than the metric (Sl), the conversion factors for the units used in this report are given below.

Multiply Metric (Sl) Units	By	To obtain American Units
Centimeters (cm)	0.3937	Inches (in)
Meter (m)	1.0936	Yards (yd)
Kilometers (km)	0.6215	Miles (mi)
Grams (g)	0.0352	Ounces (oz)
Kilograms (kg)	2.2046	Pounds (lb)
Liters (L)	0.2642	Gallons (gal)
Square kilometers (km^2)	0.3861	Square miles (mi^2)
Square kilometers (km^2)	247.1050	Acres
Hectares (ha)	2.4711	Acres
Kilograms per hectare (kg/ha)	0.8262	Pounds per acre (lb/acre)
Cubic meters per second (m^3/s)	35.7143	Cubic feet per second (ft^3/s)
Degrees Celsius (°C)	(°Cx1.8)+32	Degrees Fahrenheit (°F)

Chapter 1

INTRODUCTION

The Alaska National Interest Lands Conservation Act (ANILCA) became law on 2 December 1980 (Public Law 96-487). In addition to the numerous other provisions contained in the act, Title X (Federal North Slope Lands Studies, Oil and Gas Leasing Program and Mineral Assessments) included provisions for an assessment of the resources on the coastal plain of the Arctic National Wildlife Refuge (Section 1002 - Arctic National Wildlife Refuge Coastal Plain Resource Assessment). The following materials are the complete text of Section 1002 of Title X:

ARCTIC NATIONAL WILDLIFE REFUGE COASTAL PLAIN RESOURCE ASSESSMENT

Sec. 1002(a) PURPOSE - The purpose of this section is to provide for a comprehensive and continuing inventory and assessment of the fish and wildlife resources of the coastal plain of the Arctic National Wildlife Refuge; an analysis of the impacts of oil and gas exploration, development, and production, and to authorize exploratory activity within the coastal plain in a manner that avoids significant adverse effects on the fish and wildlife and other resources.

(b)DEFINITIONS - As used in this section -

(1)The term "coastal plain" means that area identified as such in the map entitled "Arctic National Wildlife Refuge", dated August 1980.

(2)The term "exploratory activity" means surface geological exploration or seismic exploration, or both, for oil and gas within the coastal plain.

(c)BASELINE STUDY - The Secretary, in consultation with the Governor of the State, Native Village and Regional Corporations, and the North Slope Borough within the study area and interested persons, shall conduct a continuing study of the fish and wildlife (with special emphasis on caribou, wolves, wolverines, grizzly bears, migratory waterfowl, musk oxen, and polar bears) of the coastal plain and their habitat. In conducting the study, the Secretary shall -

(A)assess the size, range, and distribution of the populations of the fish and wildlife;

(B)determine the extent, location and carrying capacity of the habitats of the fish and wildlife;

(C)assess the impacts of human activities and natural processes on the fish and wildlife and their habitats.

(D)analyze the potential impacts of oil and gas exploration, development, and production on such wildlife and habitats; and

(E)analyze the potential effects of such activities on the culture and lifestyle (including subsistence) of affected Native and other people.

Within eighteen months after the enactment date of this Act, the Secretary shall publish the results of the study as of that date and shall thereafter publish such revisions thereto as are appropriate as new information is obtained.

(d)GUIDELINES - (1) Within two years after the enactment date of this Act, the Secretary shall by regulation establish initial guidelines governing the carrying out of exploratory activities. The guidelines shall be based upon the results of the study required under subsection (c) and such other information as may be available to the Secretary. The guidelines shall include such prohibitions, restrictions, and conditions on the carrying out of exploratory activities as the Secretary deems necessary or appropriate to ensure that exploratory activities do not significantly adversely affect the fish and wildlife, their habitats, or the environment, including, but not limited to -

(A)a prohibition on the carrying out of exploratory activity during caribou calving and immediate post-calving seasons or during any other period in which human activity may have adverse effects;

(B)temporary or permanent closing of appropriate areas to such activity;

(C)specification of the support facilities, equipment and related manpower that is appropriate in connection with exploratory activity; and

(D)requirements that exploratory activites be coordinated in such a manner as to avoid unnecessary duplication.

(2)The initial guidelines prescribed by the Secretary to implement this subsection shall be accompanied by an environmental impact statement on exploratory activites. The initial guidelines shall thereafter be revised to reflect changes made in the baseline study and other appropriate information made available to the Secretary.

(e)EXPLORATION PLANS - (1) After the initial guidelines are prescribed under subsection (d), any person including the United States Geological Survey may submit one or more plans for exploratory activity (hereinafter in this section referred to as "exploration plans") to the Secretary for approval. An exploration plan must set forth such information as the Secretary may require in order to determine whether the plan is consistent with the guidelines, including, but not limited to -

(A)a description and schedule of the exploratory activity proposed to be undertaken;

(B)a description of the equipment, facilities, and related manpower that would be used in carrying out the activity;

(C)the area in which the activity will be undertaken; and

(D)a statement of the anticipated effects that the activity may have on fish and wildlife, their habitats and the environment.

(2)Upon receiving any exploration plan for approval, the Secretary shall promptly publish notice of the application and the text of the plan in the Federal Register and newspapers of general circulation in the State. The Secretary shall determine, within one hundred and twenty days after any plan is submitted for approval, if the plan is consistent with the guidelines established under subsection (d). If the Secretary determines that the plan is so consistent, he shall approve the plan: except that no plan shall be approved during the two-year period following the date of enactment of this Act. Before making the determination, the Secretary shall hold at least one public hearing in the State for purposes of receiving the comments and views of the public on the plan. The Secretary shall not approve of any plan submitted by the United States Geological Survey unless he determines that (1) no other person has submitted a plan for the area involved which meets established guidelines and (2) the information which would be obtained is needed to make an adequate report under subsection (h). The Secretary, as a condition of approval of any plan under this section -

(A)may require that such modifications be made to the plan as he considers necessary and appropriate to make it consistent with the guidelines;

(B)shall require that all data and information (including processed, analyzed and interpreted information) obtained as a result of carrying out the plan shall be submitted to the Secretary; and

(C)shall make such data and information available to the public except that any processed, analyzed and interpreted data or information shall be held confidential by the Secretary for a period of not less than two years following any lease sale including the area from which the information was obtained.

(f)MODIFICATION TO EXPLORATION PLANS - If at any time while exploratory activity is being carried out under an exploration plan approved under subsection (e), the Secretary, on the basis of information available to him, determines that continuation of further activities under the plan or permit will significantly adversely affect fish and wildlife, their habitat, or the environment, the Secretary may suspend the carrying out of activities under the plan or permit for such time, make such modifications to the plan or to the terms and conditions of the permit (or both suspend and so modify) as he determines necessary and appropriate.

(g)CIVIL PENALTIES - (1) Any person who is found by the Secretary, after notice and an opportunity for a hearing in accordance with section 554 of title 5, United States Code, to have violated any provision of a plan approved under subsection (e) or any term of condition of a permit issued under subsection (f), or to have committed any act prohibited under subsection (d) shall be liable to the United States for a civil penalty. The amount of the civil penalty shall not exceed $10,000 for each violation. Each day of a continuing violation shall constitute a separate offence. The amount of such civil penalty shall be assessed by the Secretary by written notice. In determining the amount of such penalty, the Secretary shall take into account the nature, circumstances, extent, and gravity of the prohibited act committed, and, with respect to the violator, the history of any prior offenses, his demonstrated good faith in attempting to achieve timely compliance after being cited for the violation, and such other matters as justice may require.

(2)Any person against whom a civil penalty is assessed under paragraph (1) may obtain review thereof in the appropriate district court of the United States by filing a notice of appeal in such court within thirty days from the date of such order and by simultaneously sending a copy of such notice by certified mail to the Secretary. The Secretary shall promptly file in such court a certified copy of the record upon which such violation was found or such penalty imposed, as provided in section 2112 of title 28, United States Code. The findings and order of the Secretary shall be set aside by such court if they are not found to be supported by substantial evidence, as provided in section 706(2)(E) of title 5, United States Code.

(3)If any person fails to pay an assessment of a civil penalty against him under paragraph (1) after it has become final, or after the appropriate court has entered final judgement in favor of the Secretary, the Secretary shall refer the matter to the Attorney General of the United States, who shall recover the amount assessed in any appropriate district court of the United States. In such action, the validity and appropriateness of the final order imposing the civil penalty shall not be subject to review.

(4)The Secretary may compromise, modify, or remit, with or without conditions, any civil penalty which is subject to imposition or which has been imposed under this subsection unless the matter is pending in court for judicial review or recovery of assessment.

(h)REPORT TO CONGRESS - Not earlier than five years after the enactment date of this Act and not later than five years and nine months after such date, the Secretary shall prepare and submit to Congress a report containing -

(1)the identification by means other than drilling of exploratory wells of those areas within the coastal plain that have oil and gas production potential and estimate of the volume of the oil and gas concerned;

(2)the description of the fish and wildlife, their habitats and other resources that are within the areas identified under paragraph (1);

(3)an evaluation of the adverse effects that the carrying out of further exploration for, and the development and production of, oil and gas within such areas will have on the resources referred to in paragraph (2);

(4)a description of how such oil and gas, if produced within such area, may be transported to processing facilities;

(5)an evaluation of how such oil and gas relates to the national need for additional domestic sources of oil and gas; and

(6)the recommendations of the Secretary with respect to whether further exploration for, and the development and production of, oil and gas within the coastal plain should be permitted and, if so, what additional legal authority is necessary to ensure that the adverse effects of such activities on fish and wildlife, their habitats, and other resources are avoided or minimized.

(i)EFFECT OF OTHER LAWS - Until otherwise provided for in law enacted after the enactment date of this Act, all public lands within the coastal plain are withdrawn from all forms of entry or appropriation under the mining laws, and from operation of the mineral leasing laws, of the United States.

This initial report for the baseline study presents the current status of the study as of mid-December 1981. The baseline study is a continuing study that will be conducted throughout the course of the seismic exploration program. During preparation of this report, guidelines were established to define the scope of the studies and the report. These guidelines were as follows:

1. The initial report of the baseline study is not a decision making document, nor is it a document that states Fish and Wildlife Service policies or positions on seismic exploration issues. The Regulations and accompanying Environmental Impact Statement (Section 1002d of ANILCA) will function in these capacities. This report is intended to provide the current state of knowledge concerning the fish, wildlife and their habitats, and the cultural resources on the Arctic National Wildlife Refuge (ANWR) study area and this information can then be used in the development of the EIS and Regulations.

2. The initial report of the baseline study and the baseline study program is not a planning document or process. It presents factual information that will be used for planning the seismic exploration program and in any subsequent comprehensive management planning (Section 303(2) of ANILCA).

3. This report is the initial report on the status of the continuing baseline study. Progress reports on the various studies and updated information for this initial report will be prepared annually. These reports will detail progress on the individual projects and will include an overall summary that presents new information, changes and additions to this initial report, and recommendations for altering current stipulations and Regulations for the seismic exploration program.

4. This initial report and the annual progress and update reports will be used to develop a final report in 1986 for the baseline studies on the ANWR study area. This final report will summarize all available data for the ANWR study area and will form the basis for the fish and wildlife section in the Report to Congress.

Information presented in this initial report on the baseline study was derived from a synthesis of available information on the resources of the ANWR study area and limited field studies during the spring, summer and fall of 1981. The information synthesized included published sources (professional journals, progress reports, environmental review documents, etc.) and unpublished data and reports in various agency files. Field investigations in 1981 included the following:

Caribou - Distribution, numbers, age, and sex were derived from photocomposition counts of the Porcupine herd, obtained in cooperation with the Alaska Department of Fish and Game (ADF&G) and the Yukon Territorial Wildlife Branch. FWS also developed more detailed caribou studies under contract with ADF&G.

Migratory birds - a) Studies were initiated to determine migratory bird use of coastal lagoon areas. These studies included a survey of invertebrate prey species using the lagoon system.

b) Snow goose use patterns and age/sex ratios were determined from a photocensus conducted in September, 1981.

c) Whistling swan distribution and productivity surveys were conducted in August, 1981.

Polar bears - Ongoing studies are documenting distribution, densities and timing of polar bear denning on the ANWR study area, using radio telemetry to track females to den sites.

Muskox - Studies documenting distribution, composition, productivity, and use by muskox of the ANWR study area.

Fisheries - Reconnaissance surveys were conducted on the Hulahula and Salderochit Rivers for depth profiles related to overwintering fish populations, water chemistries and fish species distribution.

Similar reconnaissance studies were conducted on the Canning River with additional studies of age/sex growth rates and some telemetry work to determine overwintering fish distributions and fish migration patterns.

Habitat mapping - A detailed habitat classification effort and a map are being prepared using available LANDSAT imagery, augmented by natural color and infrared aerial photography. Natural color photography of the study area was obtained in August 1981.

The following studies and surveys are planned for the ANWR study area during 1982. Detailed study plans should be developed by February 1982 for those projects being conducted by FWS personnel.

- Muskox calving ground studies - ANWR staff
- Muskox habitat interrelationship - University of Alaska - Alaska Cooperative Wildlife Research Unit (ACWRU)
- Muskox spring composition surveys - ANWR staff
- Central Arctic Caribou studies along the Canning River - ADF&G and ANWR Staff

- Porcupine Caribou studies on the calving grounds and wintering grounds - ADF&G and ANWR staff
- Porcupine Caribou studies of calf mortality on the calving grounds - ADF&G and ANWR staff
- Caribou migration studies - University of Alaska - ACRWU
- Caribou calving ground habitat studies - Research Division, FWS
- Porcupine Caribou photo census and composition survey - ADF&G and ANWR staff and Yukon Wildlife Branch
- Coastal lagoon studies of trophic structure - ANWR staff
- Coastal lagoon bird use surveys - ANWR staff
- Ecological studies of a "closed" coastal lagoon - OCS/BLM contractor
- Upland bird use surveys - ANWR staff
- Whistling swan surveys - ANWR staff
- Aerial survey of snow goose staging areas - ANWR staff
- Fisheries studies on the Canning River and other coastal plain rivers - FWS Fisheries field station personnel.
- Polar bear denning studies - FWS Research
- Archeological Reconnaissance Survey - FWS/USGS personnel (tenative)
- Vegetation (Habitat) mapping project - CRREL, INSTAR and NASA-Ames contractors
- Subsistence land and resource use within the range of the Porcupine caribou herd in Alaska - ADF&G personnel.
- Socioeconomic assessment of the Arctic NWR - USGS/AEIDC contractor.

Data from these and future studies and inventories will be utilized to meet ongoing information and monitoring needs, for incorporation into the annual progress/update reports of the baseline study, and for use in developing certain sections in the 1986 Report to Congress.

This report organizes information about the resources of the ANWR study area into several categories: 1) a general description of the study area and its physical environment (Chapter 2); 2) the state of knowledge about the fish, wildlife, habitat, and human culture and lifestyle resources of the study area (Chapters 3, 4, 5, 6, and 7); 3) the potential impacts of geophysical exploration and further exploration, development and production of the oil and gas resources on the study area (Chapters 8 and 9). Each chapter contains literature cited sections that are specific to that chapter, or subsection of a chapter.

Information contained in this volume constitutes the initial report for the baseline study of fish, wildlife and their habitats, and cultural and subsistence resources required under Section 1002c of ANILCA. A large portion of this information is not specific to the ANWR study area, but is a synthesis and extrapolation of available information from adjacent areas and other northern environments. The factual data base specific to the ANWR study area is incorporated into this report; unfortunately that data base is not extensive. Because the majority of this information is intended for use primarily by professional biologists and resource managers in the development of the guidelines (regulations) and environmental impact statement for the seismic exploration program on the ANWR study area, the reference citations follow the style recommended by the CBE Style Manual Committee (1978). Other conventions contained in this report were standardized to conform with the general style of the Journal of Wildlife Management, unless otherwise noted. Usage and spelling for place names generally follows those of Orth (1967), but some place names mentioned in the text, especially Inupiat place names in Chapter 8, are not listed in Orth (1967).

Literature Cited

CBE Style Manual Committee. 1978. Council of Biology Editors style manual: a guide for authors, editors, and publishers in the biological sciences. 4th ed. Amer. Inst. of Biol. Sci., Arlington, Virginia. 265 pp.

Orth, D.J. 1967. Dictionary of Alaska place names. Revised ed. U.S. Geol. Surv. Prof. Pap. 567. U.S. Govt. Printing Office, Washington, D.C. 1084 pp. and maps.

CHAPTER 2

DESCRIPTION OF THE STUDY AREA

Location

The study area is an irregularly shaped portion of the northern coastal plain and foothills of the Arctic National Wildlife Refuge (ANWR), lying between 142° and 146° W and north of 69°34'N, covering approximately 630,000 ha. It includes 135km of Beaufort Sea coastline between the mouths of the Canning and Aichilik Rivers, and excludes lands held by the Kaktovik Inupiat Corporation (Figs. 1 and 2); approximately 50km of coastline and about 26,700 ha of coastal plain surrounding Barter Island. The village of Kaktovik (pop. 175) and an adjacent U.S. Air Force Distant Early Warning (DEW) site on Barter Island represent the only permanent settlement in close proximity to the study area.

The ANWR study area is covered by the following USGS 1:63,360 topographic maps: Barter Island A-3 through A-5; Flaxman Island A-1, 3 and 4; Mt. Michelson D-1 through D-5 and C-1 through C-4; Demarcation Point D-2 through D-5 and C-3 through C-5.

Land Status

The Arctic National Wildlife Refuge is bordered on the east by the Yukon Territory, Canada. Adjoining lands along the western and portions of the southern boundaries of ANWR were selected by the State of Alaska under the provisions of the Statehood Act and ANSCA. Also adjacent to the southern extent of the refuge is the Yukon Flats National Wildlife Refuge.

Approximately 26,700 ha of land within the ANWR boundary along the arctic coast between Camden Bay and Oruktalik Lagoon (Fig. 2) has been conveyed to the Kaktovik Inupiat Corporation according to provisions of the Alaska Native Claims Settlement Act. ANILCA further provides for an exchange of lands which would allow for conveyance of an additional 9,324 ha of refuge lands to Kaktovik Inupiat Corporation, which are adjacent to existing corporation lands. This exchange has not yet been completed. Native land entitlements within the refuge (except for Barter Island) include surface rights only, the subsurface estate is retained by the Federal government. Also reserved are public easements across Native lands for trails, survey access, utilitites and transportation of energy, fuel and natural resources.

A number of approved Native Allotments and allotment applications pending final adjudication are located within the ANWR study area, primarily along the coast and certain rivers (Fig. 2).

In addition to the above lands, the status of land occupied by two abandoned DEW line stations remains undetermined. These sites, 185 ha on Camden Bay and 170 ha on Beaufort Lagoon, are both within the ANWR study area. While the property on these lands was transferred from the Navy to the Fish and Wildlife Service in 1971, the land has not been transferred to the Fish and Wildlife Service.

Physiographic Setting

Two of the major physiographic provinces of North America extend into northern Alaska - the Interior Plains and the Rocky Mountain System. The Arctic Coastal Plain is the only portion of the Interior Plains in Alaska, while the Brooks Range and Arctic Foothills represent the northernmost extension of the Rocky Mountain System (Wahrhaftig 1965). The entire area lies north of the Arctic Circle, between 141° and 166° West.

The Brooks Range is an arcuate belt of rugged mountains extending nearly 1000km from the Canadian border to Cape Lisburne on the Chukchi Sea, and rising in elevation to over 2700m in its eastern sections. The Romanzof Mountains of the eastern Brooks Range curve north to within 30km of the Arctic Ocean. The range forms an abrupt scarp on the north side, where it faces the low, rolling plateaus and mountains of the Arctic Foothills, which in turn range from 180 to 1700m in elevation. In the eastern Arctic, the belt of foothills is more restricted and the Romanzof Mountains front almost directly on the study area.

The 600 foot (180m) contour is generally considered to represent the break separating the Arctic Foothills from the Arctic Coastal Plain, although this distinction is less apparent in the eastern sections. The coastal plain rises imperceptibly from sea level, with its shore generally rising less than 15m, and frequently less than 3m above the Beaufort Sea. The Arctic Coastal Plain province is narrow (15-25km) and not well defined at its eastern end, widens to approximately 160 km south of Point Barrow, then converges with the Arctic Foothills at Cape Beaufort. Wahrhaftig (1965) divides the Arctic Coastal Plain province into the flat, lake-dotted Teshekpuk section on the west and the gently undulating White Hills section to the east. The ANWR study area lies entirely within the latter section, and, except for a few small areas of flat coastal plain, most of the terrain is rolling and merges gradually with the Arctic Foothills to the south that comprise a large proportion of the total study area.

The Arctic Coastal Plain is poorly drained, and crossed by rivers of generally low gradient which head in the highlands and mountains north of the Arctic Divide. While rivers of the western coastal plain (such as the Colville and Meade Rivers) tend to be meandering and deeply incised, those to the east run more directly north and display the braided channels and broad gravel floodplains characteristic of glacial streams. The eastern rivers, draining the higher, glacier-clad mountains of the Brooks Range, are actively building deltas into the Arctic Ocean. Within ANWR, the largest drainages are those of the Canning and Kongakut Rivers, the latter flowing entirely within the ANWR Wilderness east of the study area. The principle drainages within the study area are the Canning, Hulahula and Jago (Fig. 2).

The coastline of the Beaufort Sea is irregular and characterized by a series of barrier islands and lagoons, beaches, submerged bars, spits, and river deltas resulting from longshore erosion, transport and deposition of fluvial and marine sediments. This is in contrast with the Chukchi Sea coast to the west of Pt. Barrow, which is more regular with fewer islands, inlets, and bays.

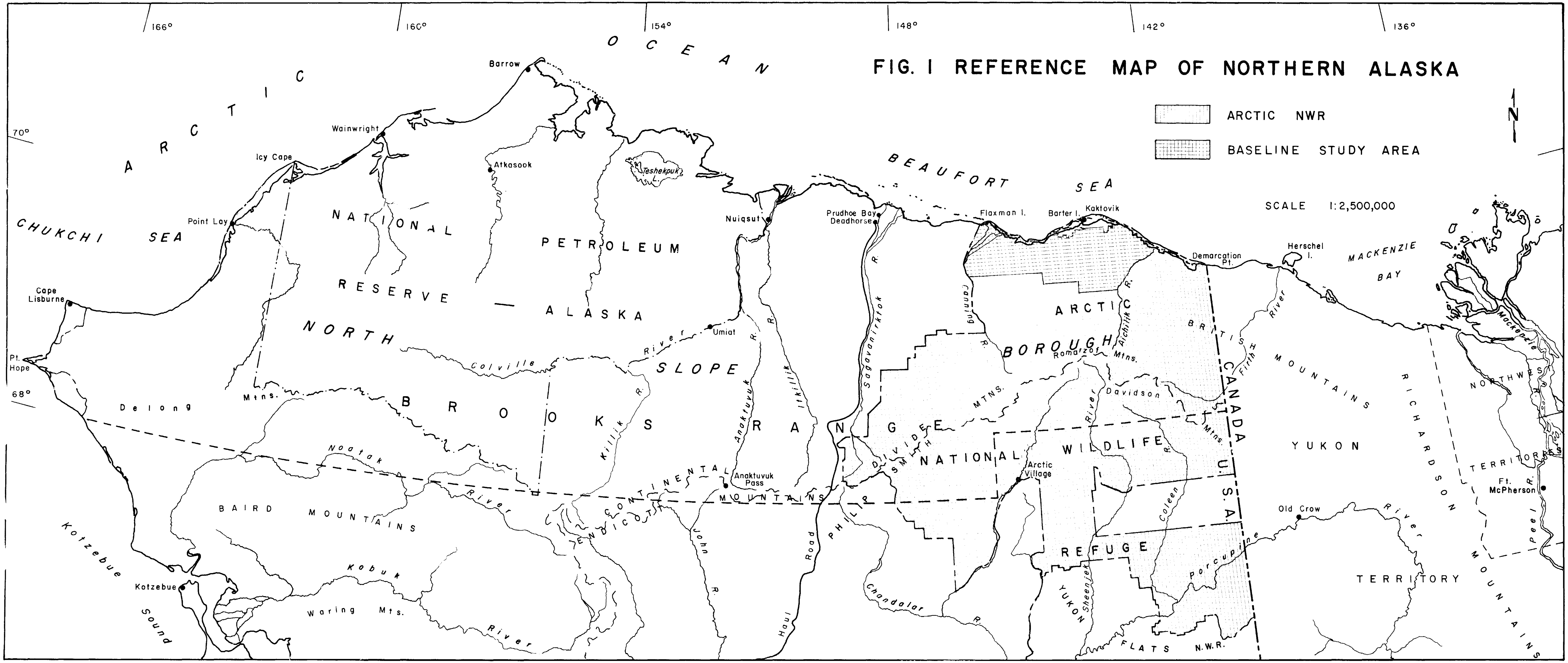
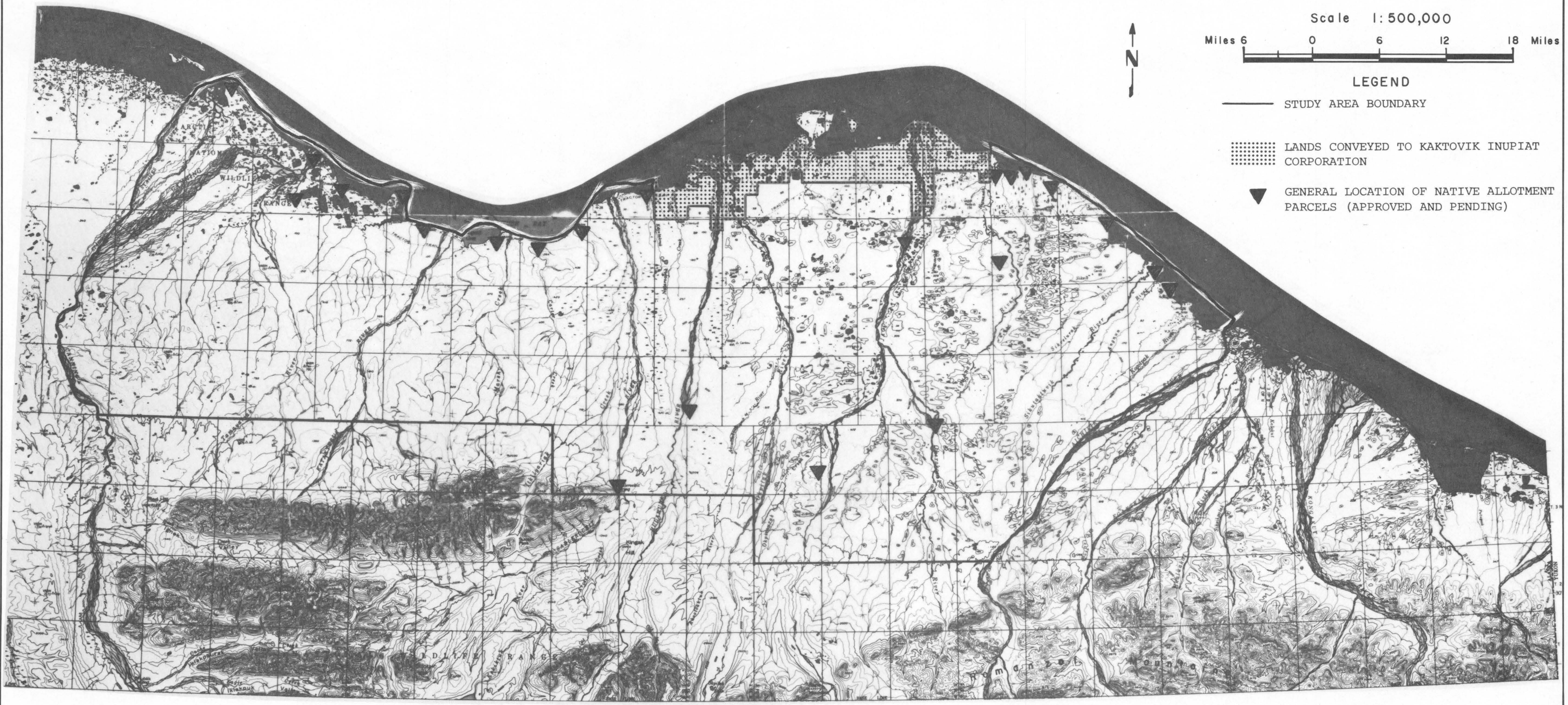


FIG. 1 REFERENCE MAP OF NORTHERN ALASKA

FIG. 2 ARCTIC NATIONAL WILDLIFE REFUGE BASELINE STUDY AREA



Bedrock Geology

The regional geology of the Arctic Coastal Plain has been reviewed by Adkison and Brosge (1970), U.S. Navy (1977), and Mast et al. (1980). Descriptions of rock units within the eastern coastal plain can be found in Reiser et al. (1971, 1980). The following discussion is derived largely from these sources.

The ANWR study area is located in an area of stratigraphic and structural complexity, where 3 regional sedimentary provinces (the Arctic Platform, Colville geosyncline and Camden-Demarcation Basin) and 3 major structural features (the Brooks Range fold belt, Barrow Arch, and Barrow Platform edge) converge and overlap. This rock sequence has been further complicated by a series of erosional unconformities which have resulted from removal of portions of the sequence during the geologic past. Beneath this sequence is a basement of pre-Mississippian age, an extension of metasedimentary rock units exposed in the Brooks Range.

The Arctic Platform is a product of an early major depositional episode, which began in pre-Mississippian time and continued through the Jurassic (400 to 150 million years ago). The rocks of this sedimentary group consist of marine or fluvial clastic and carbonate deposits (shales, siltstones and sandstones) which formed when northern Alaska lay beneath a shallow sea and the source of sediments was a major land mass to the north.

A second major depositional period occurred during the Cretaceous Period (130 to 70 million years ago), when folding, overthrusting and general uplift along the Brooks Range geanticline to the south and the Barrow Arch to the north formed the Colville geosyncline, a depositional basin filled by fluvial and marine clastic sediments to form calcareous sandstones, siltstones and shales. These deposits are very thick under the western arctic, and are thin and truncated to the east.

Underlying most of the eastern Arctic Coastal Plain are deposits which filled the Camden-Demarcation Basin. These range from Upper Cretaceous and Tertiary fluvial and marine clastics such as calcareous sandstone, siltstones and shale, to nonmarine strata of conglomerate, sandstone, micaceous and carbonaceous siltstone and shale. Closer to the coast, these are overlain by Upper Tertiary sediments of the Sagavanirktok Formation.

While nearly all of the oil and gas discoveries made in NPR-A, at Prudhoe Bay, and other locations in the western Arctic have been in deep strata of Cretaceous age, the majority of oil and gas reserves of the eastern Arctic are thought to occur in Tertiary strata which do not extend to the west. The largest potential oil and gas field located within the ANWR study area is thought to be beneath the coastal plain just south of Camden Bay, in a 60,000 ha area of uplift known as the Marsh Creek anticline. Mast et al. (1980) have concluded that the probable potential reserves in these and adjacent Tertiary rocks may contain most of the total oil and gas resources present within the ANWR, and that quantities of oil per square mile may be close to eight times those of NPR-A.

Quaternary Geology

Glaciers covered about half of Alaska during the Quaternary period. Most of the ice was concentrated in the 2 major mountain belts: the Alaska Range and coastal mountains in southern Alaska and the Brooks Range to the north. Largely due to lower precipitation and elevation in interior and northern Alaska, these areas remained unglaciated, and the northern and southern ice masses did not coalesce (Coulter et al. 1965, Flint 1971). This left the Brooks Range ice distinct from the Cordilleran Glacier Complex. During Illinoian and Wisconsinan time, the system of valley and piedmont glaciers was considerably more extensive on the south flank of the Brooks Range than on its north side, evidence that the primary source of moisture came from air masses moving north and northeast from the Pacific Ocean, a pattern similar to that of the present day (Hamilton and Porter 1975, Pewe 1975). Somewhat more area was covered by Illinoian and pre-Illinoian glaciers than Wisconsin glaciers, particularly in the western Brooks Range, but also in the northeast portion of the range. Late Wisconsin and Holocene age glaciers were successively less extensive (Coulter et al. 1965).

Although most of the Arctic Coastal Plain remained unglaciated during the Pleistocene, glacial moraines of early or middle Pleistocene age do extend to within 30km of the present coastline on portions of the narrow eastern coastal plain where the high mountains are in closer proximity. All of the coastal plain is covered by a mantle of Quaternary age glaciofluvial and marine deposits known as the Gubik Formation, which ranges in thickness from a few to 50 meters and consists of slightly consolidated brown gravels, sand, silt and clay (Detterman et al. 1958, O'Sullivan 1961). This formation consists of interbedded fluvial and marine sediments deposited during alternating periods of glacial outwash and marine transgression. Within the ANWR a broad area of fluvatile - deltaic sediments extends onto the coastal plain, thus fluvial deposits tend to predominate within this formation. To the west, the Gubik deposits are primarily marine (O'Sullivan 1961, Pewe 1975).

Recent fluvial and colluvial processes have eroded and reworked earlier Quaternary deposits. Alluvial deposits on the eastern coastal plain consist of well worked, poorly to well sorted silt and gravel on floodplains and low terraces. Well developed alluvial fans are present near the coast on most of the larger rivers within the study area, and some (most notably the Canning River) are actively building deltas into the Beaufort Sea. Further inland, where there is more topographic relief, colluvial deposits resulting from landslides, frost action and sheetflow are common (Reiser et al. 1980).

Periglacial Features

The term periglacial was originally introduced to describe the climate and climatically controlled features of an environment adjacent to glacial ice. Washburn (1973) and Pewe (1975) have since expanded this definition to include any environment which has a cold climate and is characterized by perennially frozen ground and intense frost action. The latter definition can therefore be applied to the environment of the Arctic Coastal Plain and the ANWR study area; a region in which continuous permafrost, frost action, mass-wasting of frozen ground and thermokarst erosion are widespread and significant factors governing geomorphic processes within surficial deposits.

Permafrost is defined as any earth material, soil or rock, within which the temperature remains below 0°C for two or more years, regardless of the amount of moisture present (Muller 1947). The Arctic Coastal Plain and the ANWR study area lie entirely within the zone of continuous permafrost (Ferrians 1965). In this zone permafrost occurs everywhere beneath the surface except under a few deep lakes, deep rivers and some coastal areas where surface water remains unfrozen throughout the year. Permafrost is present under the coastal waters of the Beaufort Sea, although its extent and characteristics in this area are unknown. Relictual subsea permafrost is known to exist in areas of coastal retreat (Lewellen 1974).

The thickness of the permafrost layer is thought to exceed 650m under some parts of the coastal plain, although the average depth is 200 to 300m in areas of flat coastal lowland underlain by thick, unconsolidated sediments (Pewe 1975). On the eastern coastal plain, where there is more relief, deep deposits are not as extensive, thus the average permafrost thickness is likely to be considerably less.

The layer of seasonally frozen ground overlying permafrost is termed the active layer. During the weeks between breakup and freezeup on the coastal plain, the depth of thaw can vary from less than a foot to more than 10 feet, depending upon topography, microclimate, vegetation, the presence of surface water and the thermal characteristics of the soil (Washburn 1973, Pewe 1975).

Frost action is a collective term describing a number of distinct processes brought about mainly by freezing and thawing (Washburn 1973), such as frost wedging, heaving and sorting. These processes are active near the surface on the Arctic Coastal Plain and are responsible for distinctive patterned ground features such as polygons.

One of the most important and widespread frost processes operating on the coastal plain is the formation of ice wedges, foliated ice masses which occur as wedge-shaped, vertical or inclined sheets or dikes 1cm to 3m wide and 1 to 10m deep (Pewe 1975). In general, they are formed when surface deposits exposed to subfreezing temperatures contract and crack, usually in a polygonal pattern. These cracks are filled with meltwater during the following thaw season, and then once again freeze and expand. Repeated expansion eventually causes the uplift of soil material to the surface and formation of elevated ridges on each side of the ice wedge. The resulting form is that of a "low centered" polygon (Washburn 1973). These ridges may impede drainage from within the polygons, leading to the formation of small ponds.

Another conspicuous feature of the Arctic Coastal Plain resulting from frost action is the presence of pingos; isolated, conical ice-cored hills, 20 to 400m in diameter and up to 70m high (Pewe 1975). These tend to form on nearly level ground (usually a draining lake bed) when unfrozen ground water migrates under pressure to a site where it then freezes and expands, heaving the ground to form a mound. Continued annual migration and heaving increases the size of the mound. On the flat, lowland sections of the coastal plain, pingos usually represent the sole relief features, thus they can be of biological as well as geomorphic significance.

The term thermokarst refers to topographic depressions resulting from the thawing of ground ice (Washburn 1973). Thermokarst features found on the Arctic Coastal Plain include polygonal troughs and pits, beaded drainages and thaw lakes. All are important erosional processes resulting from naturally induced thermal instability, although thermokarst erosion can also be initiated by anthropogenic surface disturbance.

Polygonal troughs and pits develop over degrading ice wedges. Thawing of ice wedges may result from climatic change, but more often they are caused by alteration of vegetation cover or changes in drainage patterns. When thermokarst pits formed at the intersection of polygonal troughs become interconnected, the result is a beaded drainage (Washburn 1973).

The most widespread thermokarst features on the Arctic Coastal Plain are thaw lakes, relatively small bodies of water which are formed or enlarged by the thawing of frozen ground. These lakes are dynamic features which go through a cyclic process of thawing, erosion and expansion, drainage and, ultimately, rejuvenation of ground ice (Billings and Peterson 1980).

Because the topography of the ANWR study area is more heterogeneous than that of the western Arctic Coastal Plain, thermoerosional features typical of arctic uplands are probably more widespread. Among these would be frost heaving and sorting and resulting patterned ground phenomena, as well as mass wasting processes such as solifluction and frost creep.

Solifluction is the gradual downslope movement of fine-grained water-saturated surficial deposits (both mineral and organic), usually over bedrock or a shallow permafrost table, which appears as lobelike or sheetlike flows on slopes with gradients as low as 1° and may move at rates of up to 6cm per year on slopes of 10 to 14° (Washburn 1973).

Frost creep is the downslope movement of material through a process of alternate frost heaving and settling. It may act together with solifluction or alone in areas of relatively low soil moisture or poor soil development. Rates of downslope movement through frost creep are generally comparable to those resulting from solifluction (Washburn 1973).

One other periglacial feature typical of braided streams and commonly encountered on most of the major rivers within the study area is aufeis, or overflow ice. After freezeup, aufeis may develop when the hydrostatic pressure which results as freezing approaches the stream bed forces repeated overflow of unfrozen water onto and around older ice, after which it freezes to form a new layer of ice. Aufeis may also accumulate in the vicinity of natural seepages or springs in the same manner. The result is a massive sheet of ice which usually persists on the river floodplain well after breakup and may be several hectares in area and up to 4m thick (Washburn 1973). On many rivers within the study area, aufeis is a conspicuous feature on deltas and on floodplains below springs throughout the summer season.

Climate

Sources for most of the following discussion of general climatic conditions on the Arctic Coastal Plain are National Weather Service data and summary publications by Searby (1968) and Searby and Hunter (1971).

The climate of Alaska north of the Brooks Range is classified as arctic; summers are short, cool and generally cloudy, with temperatures of the warmest month (July) averaging about 5°C and maximum temperatures rarely exceeding

30°C. Subfreezing temperatures and snow may occur at any time during the summer months. Winters are very cold, with temperatures of the coldest month (February) averaging about -20°C. Extreme lows frequently drop below -40°C. Since high surface winds are common throughout the year, the combination of wind and temperature results in equivalent chill temperatures well below the actual temperatures.

Within the arctic zone, there is a trend toward increasing continental and diminishing marine influence on temperature with distance from the coast. The arctic coast experiences more frequent cloudiness and fog, with higher winds; while inland, clear skies are more common and winds are variable, thus temperature ranges and extremes tend to be greater. This contrast is intensified during late summer and fall months when there is open water along the coast, although even in winter when the Arctic Ocean is frozen over, air temperatures reflect some marine influence.

Based on precipitation alone, the Arctic Coastal Plain can be considered arid, with the average annual precipitation being less than 25cm, including the water equivalent of 30 to 120 cm of snowfall. Most of the total is in the form of summer rainfall. However, due to low evaporation rates and the effects of permafrost and generally level terrain on drainage, soils in summer are usually saturated, thus available moisture is considerably greater than the low annual precipitation would indicate. In general, precipitation is slightly higher on the eastern coastal plain than to the west.

Limited data are available on the amounts and distribution of snow cover within the ANWR study area. Given the greater topographic extremes and high surface winds, snow cover can be expected to be unevenly distributed, with the extensive rolling uplands being blown nearly free of snow in winter, and deep drifts collecting in depressions and below river bluffs. This distribution is likely to be of physical and biological importance, since vegetation and other surface features at higher elevations may remain exposed throughout the winter, while depressions and drainages provide areas of late-lying snow well into summer.

Relatively high surface winds prevail along the arctic coast throughout the year. At Barter Island, a calm condition exists only 4% of the time. Average wind speeds are generally 15 to 25kph with occasional intense storms generating winds in excess of 115kph. The winds are predominantly northeasterly, although most of the strongest winds (greater than 40kph) are westerly.

Of considerable importance in determining patterns of temperature, precipitation and wind is the position of the arctic front, a belt of maximum frontal frequency marking the transition from a warmer, low pressure southern air mass characterized by westerly winds to a cold, high pressure polar air mass with easterly winds. In Alaska, the mean summer position of the arctic front is over the Arctic Coastal Plain. During the winter, the frontal belt is less intense and generally lies over southern Alaska (Reed 1960; Hare 1968). It has been suggested that the thermal contrast which develops in summer between the strongly heated land surface and the cool, ice-filled Arctic Ocean contributes to intensification of the front (Reed 1960).

There are few long term climatic records available for the Arctic Coastal Plain. Barter Island, a station close to the ANWR study areas is the only continuously maintained weather recording station in the eastern Alaskan arctic. Climatic data from Barter Island are summarized in Table 1. Although Barter Island is close to the study area and can be considered a good example of general climatic conditions, the data presented should be viewed in light of the station's atypical geographic position; it is located at the northern end of an island which projects nearly 6.4 km north into the Beaufort Sea at the apex of a north-trending coastline. Therefore in summer it is more likely to experience high winds, fog and correspondingly lower temperatures than an "average" location on the eastern coastal plain.

Table 1. Temperature and precipitation data for Barter Island, Alaska, latitude 70°08'N, longitude 143°35'W, elevation 12 m (data from Searby 1968).

	Temperature (oC)			Precipitation
Month	Max	Min	Mean	(mm)
January	-23.3	-30.9	-27.1	10.2
February	-25.2	-32.2	-28.7	8.9
March	-22.1	-30.1	-26.1	5.1
April	-13.0	-21.6	-17.3	4.3
May	-3.4	-9.2	-6.3	6.4
June	3.9	-1.5	1.2	13.0
July	8.6	1.7	5.2	22.4
August	7.3	1.5	4.4	26.7
September	2.2	-2.1	0.1	23.9
October	-5.2	-11.3	-8.2	21.3
November	-14.2	-21.2	-17.7	10.2
December	-19.8	-27.3	-23.6	7.4
Annual	-8.7	-15.3	-12.0	159.5

Hydrology

The rivers flowing into the Beaufort Sea between the Itkillik River and the Canadian border represent approximately 28% of the total streamflow within the arctic drainage (H.J. Walker 1974). These streams flow almost directly north on narrow floodplains and have few tributaries. Annual precipitation and glacial discharge are low, thus total runoff is low. The size and relative streamflow of the principle rivers within the ANWR study area are summarized in Table 2. Very little information is available on discharge rates of arctic rivers, and apparently no data have been collected on streams within the study area.

The extreme arctic climate of the coastal plain results in wide seasonal fluctuations in stream discharge. During winter, streamflow virtually ceases. In the deltas, the absence of fresh water flow allows sea water to move upstream under the river ice and leads to vertical zonation of salinity, with the lowest layers being most saline. In the Colville River, this salinity gradient may extend up to 60km inland (H.J. Walker 1974), although the low volume of rivers within the study area would prohibit penetration on this scale. Within the deltas, freshwater is entirely replaced by seawater.

Table 2. Selected drainage and streamflow data for principle rivers within the ANWR study area (from U.S. Army 1957).

River	Drainage Area (km^2)	Length of Main Stream (km)	Estimated Average Annual Flow (cfs)
Canning	5,843	188	1,125
Tamayariak	873	60	170
Katakturuk	728	68	140
Sadlerochit	1,971	113	380
Hulahula	2,023	140	390
Okpilak	1,109	113	215
Jago	2,587	127	500
Aichilik	616	63	120

In spring (May and June), melt water begins to accumulate and flow over the surface of the ice inland and on the deltas. As the river ice fractures and breakup begins, meltwater combines with the increasing downstream flow of freshwater to rapidly flush seawater from the lower rivers and deltas. As breakup continues, extensive flooding permits rapid movement of ice toward the sea, where floodwater and block ice move onto and beneath the sea ice to a point just beyond the seaward limit of bottomfast ice. Sediment loads are at their peak during flooding, and considerable deposition (several centimeters) of fine material may occur on the sea ice surface. The fresh water and sediments are soon drained through cracks and holes in the sea ice which develop with changes in the thermal regime (H.J. Walker 1974). Following breakup, flooding drops off rapidly. Due to the low summer rainfall of the arctic slope, there is little chance of summer flooding.

The numerous small thaw lakes typical of the western coastal plain are much fewer in number to the east. Within the ANWR study area they are most common on the broad, nearly level deltas of the Canning and Jago Rivers. Except for a few larger lakes on the deltas of the Canning and Hulahula Rivers, nearly all of the lakes within the study area are less than 2.6 km^2 (259 ha) in area. Most of these lakes are less than 2 m deep and freeze to the bottom in winter. There are no lakes of glacial origin within the study area.

Due to the widespread occurrence of permafrost, ground water supplies are probably nonexistant in the study area except in thaw zones under the deeper lakes and rivers. Permafrost is impermeable, and limits recharge, discharge, movement of ground water and the formation of shallow aquifers, thus little or no ground water storage is available (Williams 1970). Ground water occuring beneath the permafrost zone is likely to be saline (D.A. Walker et al. 1980).

In winter, springs and related icings are active and conspicuous hydrologic features at higher elevations along the southern boundary of the study area, where less permeable sedimentary strata are overlain by limestone. Three major springs have been documented within the study area on the upper Sadlerochit, Hulahula and Okerokvik Rivers (Childers et al. 1977). The Sadlerochit Spring at the east end of the Sadlerochit Mountains is the largest known spring in the study area. At its source, it has a fairly constant discharge of 37 cfs at a temperature of 13°C, and maintains an open channel for nearly 80km downstream during the coldest part of the year.

Coastal Environment

The Beaufort Sea coastal zone along the northern boundary of the ANWR study area is defined here as the area between the terrestrial limit of marine influence and the 10m depth contour, including all barrier islands, reefs and bars. This corresponds to the beach and nearshore zone described by Short et al. (1974). The 10m depth contour is generally considered to represent the inshore limit of the winter shear zone between shorefast ice and offshore ice (Reimnitz and Barnes 1974).

The Beaufort Sea is ice-covered most of the year, and coastal morphology is largely determined by open water influences (from mid-July to mid-September) such as wind-generated waves, currents and surges superimposed upon the lesser effects of an astronomical tide of 15cm. Since the arctic ice pack usually lies only a few tens of kilometers offshore, the potential wind fetch is small, thus wave energy is limited (wave heights rarely exceed 2-3m). The geomorphic processes controlled by these meteorlogical factors include beach erosion, longshore transport, offshore bar formation and barrier island migration (Short et al. 1974).

Beach and bluff erosion and sediment transport do not begin until winter snow and ice cover has melted, and the open water allows the wind to generate waves and currents. Coastal erosion starts with the thawing of previously eroded bluff sediments and saturated soil flow. Thermal erosion proceeds with the undercutting and thawing of exposed ground ice features such as ice lenses and vertical ice wedges, frequently leading to thermokarst collapse of massive soil blocks (Lewellen 1977, Hopkins and Hartz 1978). Ice push, and the accumulation and incorporation of sea ice into beach sediments during the summer and fall may contribute significantly to beach erosion.

Coastal erosion rates of 20m or more per thaw season have been measured, although coastal retreat between Demarcation Point and Brownlow Point has averaged 1.5m per year over the last 23 years (Lewellen 1977). Periodic storms of greater than average intensity can cause more erosion and movement of sediments in a few hours than would normally occur over several years (Hume and Schalk 1967, Reimnitz and Maurer 1978). Where coastal bluffs are protected by deltaic deposits, retreat is much less rapid than on coastal segments adjoining deeper water (Barnes and Hopkins 1978).

The prevailing northeasterly winds generate west-setting nearshore currents which reach velocities of 50cm per second and, when combined with the northeast wave set, result in net longshore sediment transport to the west. Longshore transport of sediments has been measured on the order of 5,000 to 10,000m^3 per year. However, longshore transport, particularly of coarser sediments, may be limited by the low-energy coastal circulation characteristic of this area, with deep lagoons or inlets acting as barriers to long distance movement of deposits (Short et al. 1974, Hopkins and Hartz 1978, Truett 1981).

One of the characteristic features of the arctic coastline is an extensive and continuous system of offshore bars. These develop in the shallow nearshore environment in response to wave action directed by the prevailing northeast winds and west-setting longshore current. The bars migrate onshore at rates up to 70m per year and alongshore up to 300m per year (Wiseman and Short 1976). The net westerly movement of sediments within bar systems of the

Beaufort Sea has been estimated as approaching 400,000m^3 per year, two orders of magnitude greater than rates of sediment transport within the beach zone (Short et al. 1974). Offshore bars have a significant influence on the movement of sea ice, which frequently grounds on the bars and can form breakwaters protecting the beach from wave action.

The islands of the arctic coast play an important role in determining the nature of the coastal environment. They affect water circulation and sediment transport, anchor sea ice and extend the zone of shorefast ice. Islands on the Beaufort Sea coast fall into 3 general categories: emergent depositional shoals on the outer fringes of river deltas, erosional remnants of the coastal plain which have become separated from the mainland by rapid thermal erosion, and recent constructional islands of unconsolidated sand and gravel, some of which have developed around cores of Pleistocene barrier island remnants. Constructional islands forming barrier chains are a prominent morphologic feature of the study area coastline; the island chains are made up of broadly arcuate island groups separated by passes which are sites of strong currents and water exchange between shallow lagoons and the open ocean. They are typically low (less than 2m above sea level) and narrow (less than 2km), and are likely to be breached or innundated by storm surges or flooding during breakup (Hopkins and Hartz 1978).

Migration of islands, filling of old passes and development of new ones occur rapidly; westward and landward migration rates of barrier islands have been estimated as ranging up to 30m per year and 7m per year, respectively. Since landward migration rates of islands and coastal erosion rates (above) are comparable, lagoon widths tend to remain relatively constant for long periods (Short et al. 1974, Truett 1981).

Recent evidence indicates that the barrier islands are migrating with little loss of area or mass, but the sand and gravel sources from which they were derived are assumed to have largely disappeared, thus it is likely that any material removed from them would not be replaced through natural processes (Hopkins and Hartz 1978, Truett 1981).

The lagoons and lagoon systems lying inshore of the barrier islands are typically shallow (less than 3m in depth) with flat, featureless bottoms composed primarily of fine sediments. The mainland shorelines of most lagoon systems in the study area are characterized by stretches of low, eroding bluffs broken by river deltas of varying size.

Much of the information available on the physical processes of arctic lagoons is derived from research conducted in Simpson Lagoon on the western Beaufort Sea coast. It is assumed that the processes described by Truett (1981) and Craig and Haldorson (1981) for this area are also operating within the lagoons of the ANWR study area. The following summary is based on these sources.

In the lagoons, as elsewhere, the summer ice-free period is short, normally lasting from early July to late September or early October. Breakup in the lagoons begins in June with an influx of fresh, relatively warm water originating from stream runoff. By mid-July, lagoon waters are nearly ice-free and largely fresh (salinities usually less than 10ppt). Water temperatures rise rapidly from -2°C to 10°C by mid-summer. As breakup of coastal marine ice proceeds during late July and early August, there is an influx of marine water through lagoon inlets and lagoon waters become increasingly brackish, reaching 25-30ppt by late August. Freshwater input is low during the open water season due to low stream discharge rates.

Although exchange of lagoon and marine waters is dominated by longshore currents, local meteorological conditions play an important role in determining circulation patterns within the lagoons. In Simpson Lagoon, flushing rates are normally 10 to 20% per day, but may reach 100% per day when winds are strong (greater than 65kph). Turbidity and dissolved oxygen levels also increase significantly with increasing wind speed.

Winter freezing of lagoon waters generally begins in late September or early October, several weeks ahead of the sea outside the barrier islands. Ice cover is usally complete by early November, with ice thickness steadily increasing until approximately 90% of the lagoon volume is frozen. Unfrozen water near the centers of the lagoons and in deeper channels becomes hypersaline, reaching levels of 60ppt by late winter.

Although the lagoon systems of the ANWR study area can be expected to display similar patterns of circulation, exchange and water conditions to those of Simpson Lagoon, such factors may vary with changes in location, lagoon morphology and the relative input from freshwater sources.

Offshore Marine Environment

The ANWR study area fronts entirely on the Beaufort Sea, that portion of the Arctic Ocean which extends east from Pt. Barrow to the Candian Arctic Archipelago. The Beaufort Sea has a shallow, relatively narrow continental shelf which generally extends from 50 to 100km off the northern Alaska coast to a well-defined shelf break at the 100m isobath (USDI-BLM 1979).

The Beaufort Sea, and the Arctic Ocean in general, can be divided vertically into 3 water masses: arctic surface water, Atlantic water, and arctic bottom water. Arctic surface water occupies the upper 200m and covers most of the continental shelf; the upper 50m of this layer originates primarily from terrestrial runoff and is characterized by relatively low salinities (28.5 to 33.5 ppt) and temperatures (0^o to -1.5^o). Atlantic water is injected into the Arctic Basin through the passage between Greenland and Spitsbergen and is found from 200m to 900m in depth. It is of higher salinity and temperature (greater than 0^oC). Arctic bottom water, found below 900m, is cold (below 0^o C) and highly saline (35 ppt) (Herlinveaux and de Lange Boom 1975, O'Rourke 1974).

The principle component of the general circulation pattern of surface water in the Beaufort Sea is the Beaufort Gyre, which rotates clockwise over the Canada Basin and reaches a velocity of 10cm per second along the outer shelf of northern Alaska (Herlinveaux and de Lange Boom 1975). Nearshore currents are most strongly influenced by local winds which are prevailing easterlies and periodic strong westerlies (see discussion of coastal environment), but may also include an eastward component resulting from an intrusion of Bering Sea water (Namtvedt et al. 1974, Herlinveaux and de Lange Boom 1975). Tidal currents are weak, with the mean lunar tide ranging between 15 and 30cm (Reimnitz and Barnes 1974), thus nontidal factors are of greater significance.

The continental shelf waters of the Beaufort Sea are generally ice-free for no more than three months of the year (mid-July to mid-October), during which time the polar pack ice usually moves offshore 50 to 65km north of the coastline. The dates of breakup, freezeup and the distance the ice moves offshore are extremely variable from year to year; heavy ice may be present on the coast at any time during the open water season, particularly during periods of northerly winds (Namtvedt et al. 1974, NARL 1979). In October, the pack ice moves southward toward the coast, and by the end of month it has joined with newly formed ice near the coast to create a nearly continuous cover.

In winter, 3 major zones of sea ice can be recognized: landfast ice, deformed and dynamic ice of the transition or "shear" zone, and the pack ice beyond (Namtvedt et al. 1974, NARL 1979, USDI-BLM 1979). The distance which landfast ice extends outward from land is dependent upon water depth, interaction with pack ice and the degree of protection provided by the shoreline (Kovacs and Mellor 1974). The seaward limit of landfast ice is generally over depths of 10 to 30m and it is often bottomfast out to depths of 2 to 3m. The outer boundary is influenced significantly by the degree of pressure exerted upon it by the expanding pack ice in late fall. Pressure of sufficient intensity and duration will cause the ice to buckle and form hummocks, pressure ridges and keels. If pressure continues, the keels may eventually ground, leading to further deformation and ice gouging of the sea floor (Kovacs and Mellor 1974, Reimnitz and Barnes 1974). This zone of deformation and shearing is also an area where intermittent leads and patches of open water may occur, particularly in spring (USDI-BLM 1979).

Beyond the shear zone is the pack ice zone, which consists of seasonal and multiyear floe ice. The seasonal pack ice extends from the shear zone to the toe of the continental shelf, is highly mobile, and contains a large proportion of first year ice which has formed over open water between the limit of landfast ice and the polar ice pack. Seasonal pack ice normally reaches an average thickness comparable to that of the seasonal landfast ice (approximately 2m) and may also undergo some deformation (Kovacs and Mellor 1974).

To the north of the seasonal pack ice and beyond the continental shelf lies the polar pack ice, which consists of thick (average 2 to 10m) multiyear floes which are almost fresh (0 to 6 ppt) and considerably stronger than seasonal ice (Kovacs and Mellor 1974, USDI-BLM 1979). The polar pack ice is constantly in motion, with leads opening and closing throughout the year.

In spring (July) major leads begin to appear in the vicinity of the shear zone, particularly in areas offshore of the principle river drainages. In the Beaufort Sea, the most prominent of these occurs between the Mackenzie River delta and Banks Island (NARL 1980). During late July and early August, the pack ice moves northward and open water extends along the coast to the west towards Pt. Barrow. The landfast ice usually persists along the coast, becoming thinner and weaker, until it is broken up under the influence of wind, currents and the influx of fresh water (Namtvedt et al. 1974).

Due to the influence of fresh and relatively warm water discharge from terrestrial sources into the coastal waters of the Beaufort Sea, there is a strong gradient of decreasing seawater temperature and increasing salinity with distance from shore during the open water season. This relationship may vary alongshore according to source proximity, coastal morphology and meteorological effects, and has a significant effect upon freezing rates, ice conditions and the pattern of breakup (Wiseman et al. 1974, NARL 1979).

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Chapter 3.

SOILS AND VEGETATION

The mapping and classification of Alaskan soils and vegetation in general and those of the arctic region in particular remain largely in the earliest states of refinement when compared with the existing knowledge for the lands of the conterminous United States. Growing interest in the development of the Alaskan Arctic within the past 20 years has resulted in the establishment of an increasing body of knowledge for certain localized regions lying north of the Brooks Range, e.g., Barrow, Prudhoe Bay, the Kuparuk River Delta region, and currently the ANWR study area as defined by Section 1002c of the Alaskan National Interest Lands Act.

The following discussion provides: 1) a summary of the development of knowledge about the soils and vegetation of the ANWR study area, 2) an account of the soils and vegetation of the coastal plain based upon major terrain features, and 3) a brief summary of known data gaps and the steps necessary to refine available information to assist ongoing and future resource management.

The information presented in the following sections has been derived from a number of sources including a ground truth reconnaissance survey conducted in 1981. From that survey, which used color infrared photographs (1:60,000 scale), the soil landform key and vegetation cover classification were developed.

Soils Background

Soil as used in this report refers to the August active layer. Nomenclature used is that of the U.S. Department of Agriculture, Soil Conservation Service Manual 430, 1981 Draft and Handbook 436 (Soil Taxonomy) 1975 unless otherwise noted. To date no detailed, regional soil survey exists for any portion of Alaska north of the Brooks Range with the exception of the Prudhoe Bay production area (Walker et al. 1980) and the Ogotoruk Creek watershed (Holowaychuk et al. 1966). In the early 1960's, Brown (1966) developed a soils-landform map for approximately 19 km^2 in the Okpilak lakes area and described, soils along the Jago and Hulahula Rivers. In 1974 Hettinger and Janz described, in the course of route selection studies for Alaskan Arctic Gas Study Company, several soils from the foothills near the Kongakut, Aichilik, and Okerokovik Rivers and from the flood plain of the Canning River (Fig. 1).

With the exception of discontinuous areas of flat, lake dotted coastal plain between the Hulahula River and Pokok Bay and the northern portion of the Canning River delta east to the delta of the Katakturuk River, the ANWR study area is composed of rolling uplands. The majority of the area is designated as belonging to the White Hills section of the coastal plain (Wahrhaftig 1965, Fig. 1). That area between the Canning River and the Katakuruk River in particular is physiographically and geologically similar to the White Hills area in the Franklin Bluffs region. The majority of the study region is probably best described as Foothills.

Regardless of its final physiographic designation the study area is characterized by rounded, north trending interfluves between the major drainages. Elevations range from 90 m at the coastward boundary to about 375

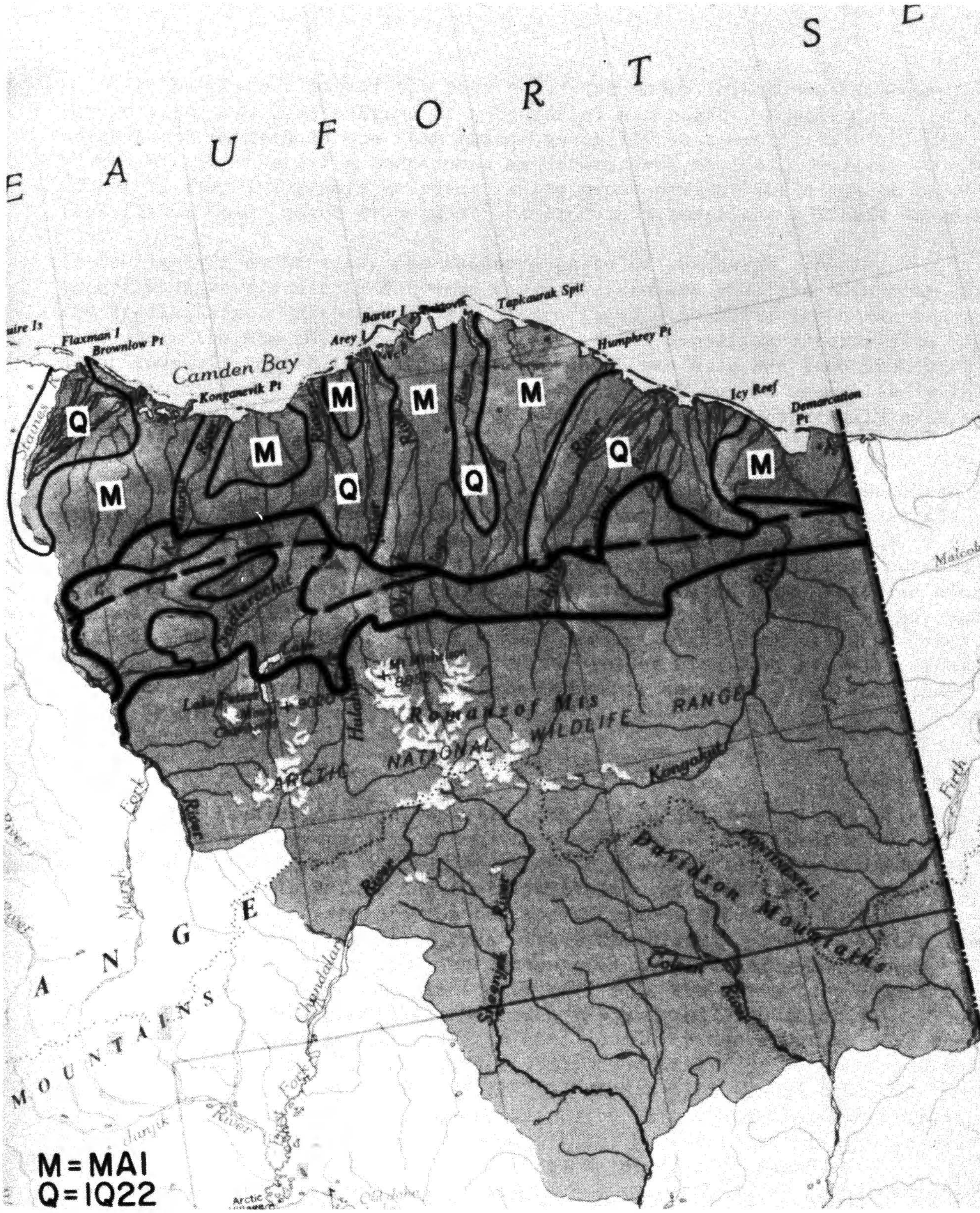


Figure 1. Coastal Plain Land Resource Region with principal soil associations.
M = MAI Pergelic Cryaquolls-Histic Pergelic Cryaquepts
I = IQ22 Pergelic Cryaquepts.
Foothills Land Resource Region is bounded by heavy lines.
(Modified from Rieger et al. 1979).

m at the southern limit of the province. The major interfluves are subdivided into a finer textured pattern of subparallel drainages. Superimposed on the north-south pattern is one that trends generally east-west reflecting the strike of the underlying Cretaceous sandstones and shales. Outcrops of some of the flatter lying more competent units produce mesa-like elements on the interfluves while north dipping strata produce discontinuous linear trends.

It is likely that at least the southern parts of the north trending interfluves were sculptered by the early Pleistocene glaciers advancing from the Brooks Range. Although moraines associated with later ice advances can be found near the mountain front; the extent of ice deposited materials on the interfluves is uncertain. The extent to which the area has been inundated by interglacial marine transgressions is also unclear, but it seems likely that such deposits may extend a considerable distance inland, especially east of the Okpilak River.

Nearly the entire study area falls within the Coastal Plain Land Resource Region as defined in the Exploratory Soil Survey of Alaska (Rieger et al. 1979). Within this region the survey recognized 2 soil associations, i.e., "segments of the landscape with a distinctive topographic and soil pattern": 1) Pergelic Cryaquolls-Histic Pergelic Cryaquepts, with loamy textured mineral components occurring on nearly level to rolling topography - the broad, smooth north trending interfluves and flat near coastal areas with oriented lakes, 2) Pergelic Cryaquepts on nearly level topography with very gravelly mineral components - the braided river valleys and their associated terraces and deltas (Fig. 1).

Vegetation Background

The earliest studies of plant species occuring in northern Alaska were the result of exploratory parties along the north slope. The first major attempt to compile and present a unified approach to Alaskan flora was provided by Hulten (1968). This effort was followed by Anderson (1974). The result of these 2 works has been to provide the basic framework for the current knowledge of the vascular plant taxa within the Alaskan arctic. Within recent years, the studies of arctic plant communities have steadily increased. The more detailed discussions of plant communities in the north have come from Sigafoos (1952), Britton (1957), Spetzman (1959), and Johnson et al. (1966). A number of more geographically restricted community descriptions have been developed by Wiggins (1951), Hanson (1953), Churchill (1955), Hettinger and Janz (1974), Murray (1974), Batten (1977), Meyers (1981), and others. Successional processes within tundra vegetation types have been described by Churchill (1955), Churchill and Hanson (1958), and Spetzman (1959). A major undertaking by Viereck et al. (1979, 1981) to produce an exhaustive bibliography for the vegetation of Alaska has resulted in an annotated list of references that currently contains over 300 literature citations.

Few studies have been reported for the ANWR study area and most community descriptions have addressed very limited community ranges. Murray (1974) discussed the flora and vegetation at several sites within the refuge including Beaufort Lagoon, Shublik Springs and the vicinity of Cache Creek. The flora of the Beaufort Lagoon coastal environment is being investigated by Meyers (1981).

Hettinger (1974) included 4 sample sites in or adjacent to the study area and assumed that the coastal plain physiographic province included 6 major vegetation types:

a) wet sedge meadows
b) low shrub - sedge meadow and hummocky tundra
c) tussock tundra
d) riparian willow shrub
e) dwarf shrub - Dryas meadow
f) heath-sedge tussock tundra

A number of classification and mapping systems have been developed over the years and some have been applied to the North Slope of Alaska. None have yet met with broad scale acceptance due to variations in terminology, methodology, or conceptual framework. To a large degree, much of the work thus far has been performed to the west of the ANWR study area in NPR-A near Barrow, along the Trans-Alaska Pipeline System, and in the region near Prudhoe Bay.

The Barrow and NPR-A areas have received coverage through the studies by Spetzman (1951, 1959), Wiggins (1951), Churchill (1955), Walker (1977), Komarkova and Webber (1978, 1980), Webber (1978), and others. Markon (1980) provided a mapping system for terrestrial and aquatic habitats along the Alaska National Gas Pipeline System. Brown (1978) has reported on ecological baseline studies along the haul road. The Prudhoe Bay area has been described by Webber and Walker (1975), Bergman et al. (1977), Everett and Parkinson (1977), Everett et al. (1978), and Walker et al. (1979).

Several general classifications of wetland habitats in the United States have been produced for the U.S. Fish and Wildlife Service (Martin et al. 1953, Shaw and Fredine 1971, Cowardin et al. 1979). Although none of these has been applied to Alaskan wetlands or incorporated into Alaskan vegetation classification systems. Arctic tundra wetlands were studied by Bergman et al. (1977) near Prudhoe Bay. Eight wetland categories were recognized based on their degree of innundation, morphology, vegetation, and utilization by waterfowl and shorebirds. These wetland categories were as follows:

Class I - Flooded Tundra
Class II - Shallow Carex ponds
Class III - Shallow Arctophila wetlands
Class IV - Deep Arctophila wetlands
Class V - Deep open lakes
Class VI - Basin complex wetlands
Class VII - Beaded streams
Class VIII - Coastal wetlands

This system has been applied to a few bird habitat studies within the ANWR study area (Martin and Moitoret 1981, also see Chapter 4). While this system has not been applied widely within the ANWR study area, the obvious desirability of the approach lies in the relationship developed between vegetation, certain abiotic factors, and habitat values to an important class of resources.

In an attempt to portray the potential natural vegetation of Alaskan land, Kuchler (1966) listed 10 phytocenoses or vegetation groups. For essentially all of the study area, the potential vegetation was characterized as cottonsedge tundra with Eriophorum representing the principle dominant genus. The only exception to this approach that Kuchler presents is a narrow band of the water sedge tundra assemblage, characterized by Carex, that runs along the coast from the Canning River east to approximately the Katakuruk River and inland for about 8 km.

The ecosystem maps for the state of Alaska in the Alaska Regional Profiles (Selkregg 1975, Arctic Region) provided a very generalized classification system for the major plant community types. The approach that was taken employed a series of maps at a scale of 1:1,000,000 upon which were superimposed the generalized boundaries of the 4 major community types (Fig. 2).

In addition to the 4 terrestrial plant communities presented, 2 aquatic communities were identified, the freshwater and marine. The commonly occurring plants of each of these 6 communities were listed in the atlas (Selkregg 1975). The communities represented follow those of the earlier map Major Ecosystems of Alaska (Joint Federal-State Land Use Planning Commission, 1973).

A method of wetlands classification developed by the Fish and Wildlife Service. The basis of the National Wetland Inventory (NWI) system was presented by Cowardin et al. (1979) with additional information presented in the 1978 Interagency Task Force Report: Our Nations Wetlands (Horwitz 1978). Presently, only 2 NWI maps (Mt. Michelson C4 and C5) in draft format are available for the study area; an additional 5 (Flaxman Island A3-5 and Mt. Michelson D 4-5) are in various steps of development. No definite plans are yet made for the completion of the Barter Island and Demarcation map areas.

The mapping system described by Walker et al. (1979) and later in the Prudhoe Bay Geobotanical Atlas (Walker et al., 1980), is based on the production of master maps that relate landforms, soils, and vegetation. This method is particularly useful in areas like the arctic coast where the occurrence of vegetation assemblages is closely related to variations in the patterns of ground features. Data from independent soil and vegetation field studies are integrated on master maps, and the soils and vegetation information for specific sites are coded as fractions in the following manner:

Numerator: Dominant vegetation type followed by subdominant vegetation types,, each of which compose at least 20% of the unit.

Denominator: Dominant soil, landform and slope class (the last is not included if slope is less than 2%).

For example, a single plant community might be represented as:

S_d23 = (Dwarf shrub physiognomy)(community code 23)

1,1,0 (featureless landform),(microrelief>0.5 m),(slope 2°)

From the coding scheme thus far developed by these workers, large numbers of highly descriptive map codes can be developed. Likewise, by translating the information within the master map codes, a number of special purpose maps can be generated, eg. soil depths, off-road vehicle sensitivity, etc.

The most recent and detailed statewide vegetation classification is one developed by Viereck et al. (1981). This is a hierarchical system based strictly on existing vegetation attributes which includes 5 levels of resolution, from major formations (forest, tundra, shrubland, herbaceous, and aquatic vegetation) to documented individual plant communities. Individual communities are characterized by the dominant species in each physiognomic stratum and in some cases by indicator species. This classification system incorporates an earlier provisional classification of Alaskan arctic tundra by Murray and Batten (1977).

In the current revision of the Viereck et al. system, the tundra communities that occur within the study area are placed at level III of the shrubland and herabeous vegetation major formations. The system in general has received fairly widespread interest by the state, federal and private sectors. As the system continues to evolve, a major companion effort that must be addressed is the development of efficient cross-walk capabilities with other classification systems currently in use (eg. NWI, Walker et al., Bergman).

Current Habitat Mapping Effort

Recognizing the need for baseline management information and the legal mandates set forth in Section 1002 of ANILCA, the Arctic National Wildlife Refuge has undertaken an effort to obtain detailed updated information about vegetation and habitat occurrences within the ANWR study area.

At the beginning of the 1981 summer season, the only vegetation map that was available for the coastal plain study area was the 1977 LANDSAT map produced by LaPerriere (1977) for the refuge. This map depicted 13 vegetation classes by 11 colors (Table 1) and has been used on several occasions in the field to determine if there existed a close correlation between habitat usage and vegetation classes that were portrayed. To date it has generally been found that there did exist a reasonably good correlation between the coastal and riverine tundra areas characteristically utilized by waterfowl. However, the upland sedge tundra and upland tussock tundra classes did not appear to correlate well with observed use by such species as caribou.

An updated and expanded LANDSAT classification effort was undertaken during the 1981 summer season by the Cold Regions Research and Engineering Laboratory (CRREL), the Institute of Arctic and Alpine Research (INSTAAR), and the U.S. Geological Survey's Geography Program at the NASA facility in Moffett Field, California. The USGS laboratory secured the latest high quality satellite imagery tapes that were available. A field crew of personnel from the USGS-INSTAAR program visited numerous ground sites within the ANWR study area and collected information on the vegetation communities that occurred along with soils and surface geology data. The field visits were correlated with signatures observed on the high altitude infrared (1:60,000) imagery flown by NASA in 1978 and 1979.

FIG. 2 MAJOR PLANT COMMUNITIES

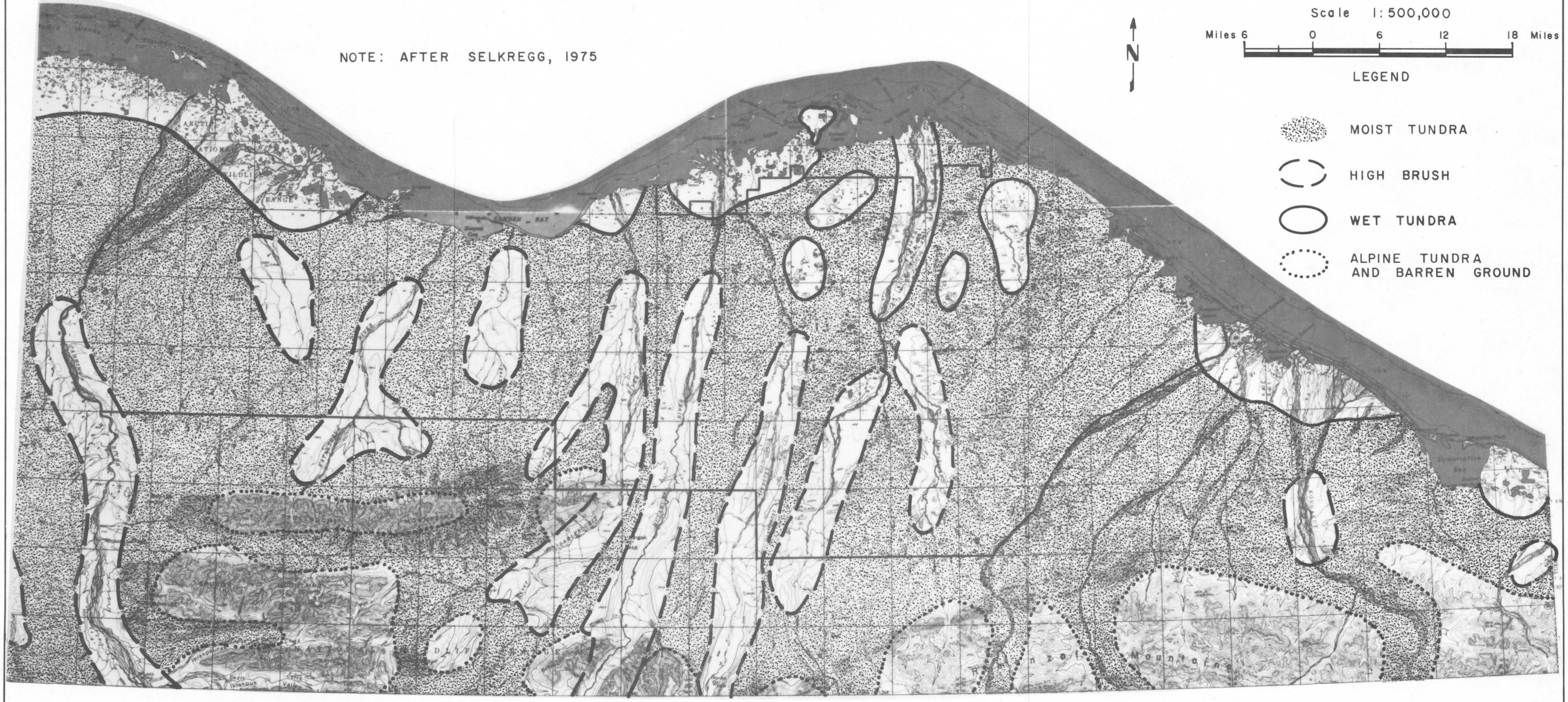


Table 1. Color Key and Vegetation Descriptions for LANDSAT Scene 1698-20470 (by LaPerriere 1977).

Color	Unit(s)
WHITE	I. ICE, SNOW, AUFEIS
BLUE	II. WATER: SHADOWS
GRAY	III. BARRENS
YELLOW	IV. PARTIALLY VEGETATED GROUND
MEDIUM GREEN	V. WET TUNDRA; SHADOWS A) Shallow Water Communities B) Flooded Wet Sedge Meadows C) Flooded Salt Grass Meadows D) Areas Temporarily Flooded by Spring Runoff
YELLOW GREEN	VII. INTERMEDIATE WET-MOIST TUNDRA
ORANGE	VIII. UPLAND DRYAS-HEATH TUNDRA A) Dryas-Heath Meadows B) Dryas Terrace Community
OCHRE	IX. UPLAND SEDGE TUNDRA A) Sedge Meadows (moist to dry) B) MOSAIC Sedge Meadow (boggy to moist) Tussock Meadow (moist to dry) $<$ 50%
DARK BROWN	X. UPLAND TUSSOCK TUNDRA A) Tussock Meadow (moist to dry) B) MOSAIC Tussock Meadow (moist to dry) $>$ 50% Sedge Meadow (boggy to moist)
" "	XI. ERICACEOUS SNOW BED COMMUNITY
" "	XII. HUMMOCKY FROST HEAVED GROUND
RED	XIII. DRY TUNDRA

The results of the summer field effort were utilized by the USGS-INSTAAR teams to construct an updated land cover map from 3 recent satellite tapes for the area that were obtained during the summer of 1981. To supplement the information on the high altitude imagery, a series of low altitude, natural color photographs were also obtained by the FWS during the same summer period that corresponded with the in-field studies. The scale on this photography is 1:18,000. The cover maps that were produced were derived from the following LANDSAT scenes of the coastal plain study area:

1) Scene 20420, Barter Island, 22 July 1980.
2) Scene 20531, Flaxman Island, 13 July 1979.
3) Scene 20462, Flaxman Island, 14 August 1976.

The cover types identified in each scene, the map color assigned, and the spectral categories included in each cover type are listed in Tables 1, 3, and 5 of Appendix I. The summaries for the cover types, the area of each type in each scene, and the number of scene pixels for each type are shown in Tables 2, 4, and 6 of Appendix I. The field verification of the LANDSAT cover categories remains to be accomplished and is scheduled for the summer 1982.

Soils and Vegetation of the Study Area

The materials presented in this section are the result of the studies initiated in the 1981 summer season. The soils and vegetation classification is preliminary and subject to revision following more extensive ground truthing. The vegetation of the ANWR study area lies within the tundra formation. This formation occurs in cold climates, principally alpine areas and arctic areas north of the 10° (C) July mean isotherm. The Arctic Foothills and Arctic Coastal Plain of northern Alaska are in the tundra region of the Arctic as defined by Alexandrova (1980). The tundra region is differentiated from the polar desert region of more northerly latitudes, where plant cover is only continuous in wet sites. In the tundra region, mesic habitats are mostly continuously vegetated with low-growing plants, such as sedges, grasses, mosses, lichens, small herbs, and dwarf shrubs. Taller shrubs are restricted to drainages that are protected from winter winds and snow abrasion, and also to slopes with southerly exposures where the amount of solar radiation is maximized. The general character of Alaskan arctic vegetation has been thoroughly described by Britton (1957), Spetzman (1959), and Wiggins and Thomas (1962). Hettinger and Janz (1974) studied several sites within the study area as part of the survey work for the Arctic Gas pipeline route.

For purposes of discussion, the region is divided into the following terrain types: 1) flat thaw-lake plains, 2) coastal plain with low hills and well developed drainages, 3) foothills, 4) alpine areas, and 5) river floodplains including deltas and braided drainages and ancient deltas (Fig. 3). Land cover categories for the study area are depicted in Fig. 4. Area of each land cover type within the regional terrain types is presented in Table 2. See Tables 7 and 8, Appendix I for detailed descriptions of land cover categories and soils within each land cover category. A preliminary crosswalk between several classification systems and the updated LANDSAT system is provided in Table 9, Appendix I.

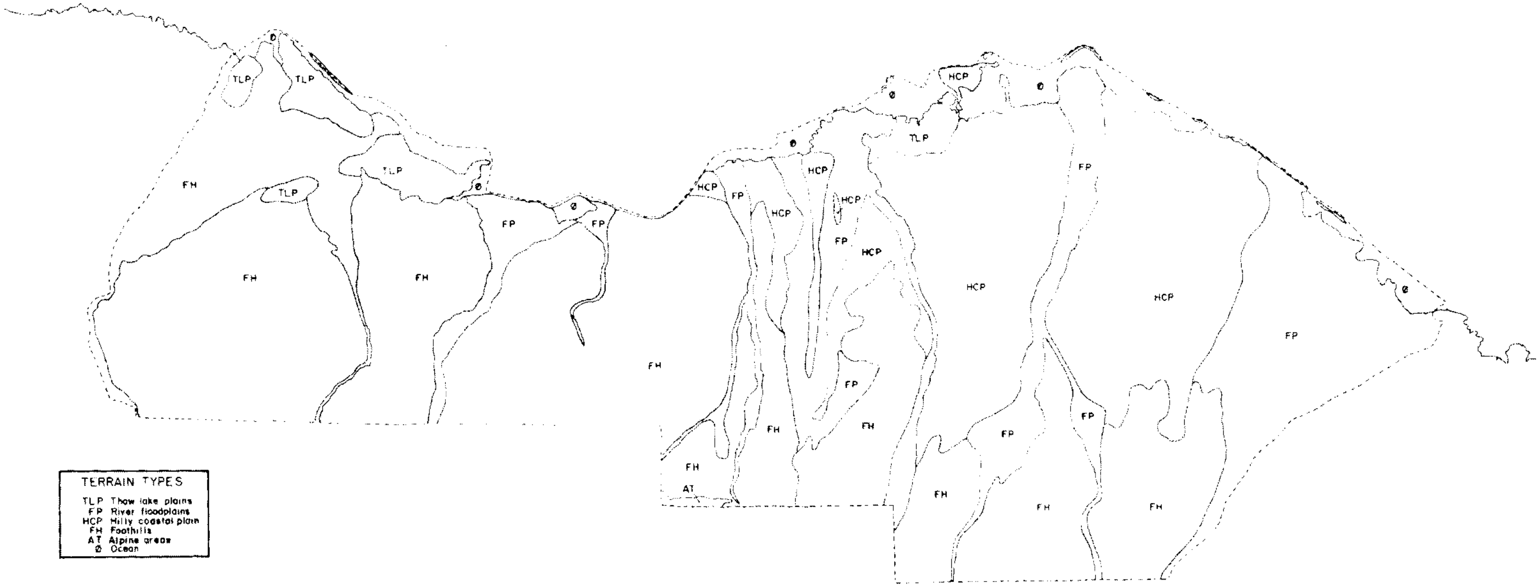


Fig. 3 Regional terrain types recognized in ANWR, Walker, Webber and Acevdo and referred to in text.

Table 2. Area (ha) of the land cover types within each regional terrain type, ANWR study area.

Land Cover Type	Regional Terrian Types: Thaw Lake Plains	Hilly Coastal Plains	Foothills	Alpine Tundra	Flood Plains	Totals
Water	3,954	2,685	735	32[1]	7,141	14,547
Pond/Sedge Tundra Complex or Aquatic Tundra or Shallow water	1,711	1,724	308	41[1]	2,858	6,642
Wet Sedge Tundra	9,422	33,785	4,034	20	56,080	103,341
Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub-Forb Tundre	2,615	49,970	15,827	9	40,557	108,978
Moist Sedge-Prostrate Shrub Tundra or Moist Sedge/Barren Tundra Complex	1,507	55,380	90,871	25	27,946	175,729
Moist Tussock Sedge-Dwarf Shrub Tundra	167	2,897	159,732	13	5,191	168,000
Moist Dwarf Shrub-Tussock Sedge Tundra or Moist Tussock Sedge-Dwarf Shrub/Wet Dwarf Shrub Tundra Complex	15	0	20,624	7	262	20,908
Shrub Tundra	20	0	1,251	1	14	1,286
Partially Vegetated Areas	128	1,249	1,074	122	8,271	10,844
Barren Gravel or Rock	273	996	2,255	59	7,205	10,789
Wet Gravel or Mud	379	121	133	9	6,469	7,111
Ice	234	115	17	0	1,495	1,861
Totals	20,425	148,922	296,861	338	163,490	630,036

[1] Shadow

Flat Thaw Lake Plains

The proximity of the Brooks Range and Sadlerochit Mountains to the coast causes a much narrower belt of coastal plain than is found further west such as at Prudhoe Bay and in the National Petroleum Reserve-Alaska (NPR-A). In fact, the typical coastal plain topography with large oriented thaw lakes, drained lake basins and expenses of low-centered ice-wedge polygons is found in only a few small areas, primarily near the flat braided deltas of rivers (Fig. 3).

These areas are best developed in the delta confluence of the Canning and Tamayariak Rivers and extends for some 12-15 km eastward in a narrow coastal belt and a narrow zone between the delta of the Hulahula River and a point some few km east of the Jago River. Barter Island is included in this zone (Fig. 3). With the exception of the delta area of the Canning River, the thaw lake plains appear to be remnants of a once more extensive plain. They are topographically similar to the lake plain east of the Canning River being composed of upwards of 30% water confined to small (generally $<$ 260 ha) shallow, eliptical oriented lakes. Areas between the lakes are poorly drained as a result of very low surface hydraulic gradient and thin active layer. Except for the vegetation covered basins of relatively recently drained lakes some form of microrelief is nearly always present. It consists mostly of low centered non-orthogonal polygons, strangmoor or complexes of disjunct low centered polygons, strangmoor and featureless areas associated with pond complexes (Table 3).

The area is underlain by ice-rich permafrost at depths of about 40 cm. Except for polygon rims the perched water table is very close to the surface or slightly above it for most of all of the thaw period. Fibro Histic Pergelic Cryaquepts or occasionally Histic Pergelic Cryaquolls and Pergelic Cryaquepts are common to the wet and very wet areas. Pergelic Cryaquolls occur on the more mesic polygon rims. The soils are all neutral to slightly alkaline in reaction, even the saline Fibro Histic Pergelic Cryaquepts and Cryohemists inundated by storm surges along some coastal areas. (Note: See Appendix I, Item A for an expanded discussion of soil taxonomy applicable to the ANWR study area.)

The vegetation in these areas is similar to that described at Barrow (Brown et al. 1980, Tieszen 1978), Fish Creek (Lawson et al. 1978) and Prudhoe Bay (Brown 1978, Walker et al. 1980, Walker 1981). The dominant LANDSAT land-cover categories are Aquatic Tundra and Pond Complex in the wettest areas and Wet Sedge Tundra and Moist/Wet Sedge Tundra Complex in areas that are at least partially drained.

Table 3. Tentative outline of soil/landform associations within the coastal plain province - ANWR

		Mesoscale		Microscale*			Soil*
Riverine	(1)	Terrace	(1)	High centered polygons (t)[1]	Inceptisols	(1)	Pergelic Cryaquepts
	(2)	River Island Complex	(2)	Low centered polygons (t)		(2)	Sparohistic Pergelic Cryaquepts[4]
	(3)	Flat	(3)	Mixed high and low centered polygons (t)		(3)	Fibro/hemihistic Pergelic Cryaquepts
Thaw Lake	(1)	Thaw lake complex	(4)	Disjunct polygons	Histosols	(4)	Peregelic Cryosaprists
	(2)	Drained lake basin (4km^2)	(5)	Frost boils (r)[2]		(5)	Peregelic Cryofibrists
						(6)	Peregelic Cryohemists
	(3)	Flat	(6)	Strangmoor		(7)	Peregelic Cryaquolls
Foothills	(1)	Crest/interfluve	(7)	Pond complex			
	(2)	Slope (2%)	(8)	Reticulate (c)[3]	Mollisols	(8)	Histic Pergelic Cryaquolls
	(3)	Stream complex	(9)	Featureless		(9)	Ruptic-Entic Pergelic Cryaquolls
	(4)	Flat	(10)	Solifluction and/or mudflow			
						(10)	Pergelic Cryoborolls
Alpine	(1)	Crest			Entisols	(11)	Pergelic Cryorthents
	(2)	Slope (10%)				(12)	Fluventic Pergelic Cryorthents[4]
	(3)	Flat					
Rolling Coastal Plain	(1)	Crest/interfluve				(13)	Cryopsamments
	(2)	Slope (2%)			Non-soils	(14)	Riverwash
	(3)	Thaw lake complex				(15)	Rock
	(4)	Pond complex					
	(5)	Drained lake basin (4 km^2)					
	(6)	Flat					

* Any microscale type can occur in any mesoscale association. Any soil type can occur in any microscale or mesoscale association.

[1] (t) thermokarst

[2] (c) channels

[3] (r) strips

[4] unofficial taxonomic terms

Micro-topography on a scale of less than 1 m of elevational difference is the major influence on the distribution of communities. The small elevational differences associated with ice-wedge polygons create distinct patterns of plant communities and soils that are associated with the various topographic elements within individual ice-wedge polygons (Wiggins 1951, Britton 1957, Cantlon 1961, Everett 1980, Walker 1981).

Patterns of plant succession in the thaw-lake plains are intimately linked to the oriented thaw-lake cycle (Hopkins 1949, Carson and Hussey 1962, Britton 1967, Everett 1980). This cycle describes the formation, expansion, and eventual drainage of thaw lakes. The process starts with formation of small thaw ponds that form in ice-rich terrain. These small ponds are enlarged by heat from the pond-water and also by the action of winds that cause erosion of the pond's edges. The pond enlarges until it intercepts another lake, the coast or a stream, which causes drainage. Succession can take place on the barren drained-lake surface or in small ponds that may remain in the basin (Britton 1957, Billings and Peterson 1980). The ponds that remain may initiate another cycle.

Although much has been written regarding thaw-lake mechanisms, the cycle and successional patterns are still incompletely understood (Mackay 1963). Probably the biggest questions relate to the time scale, i.e., how long it takes for the cycle to operate and how long the present wet coastal plain environment has existed. For a number of reasons, climatic fluxes in arctic regions are more dramatic than in temperate regions (Miller 1981). These are important considerations to evaluate whether the present environment is in a steady state or whether it is still in a period of relatively rapid climatic and vegetational change. They are also important to evaluate the effect of man-related changes.

The thaw-lake plains are located primarily along the coast and within this coastal strip, summer temperature plays a primary role. A steep temperature gradient is associated with the coastal strip. Data from Prudhoe Bay and the Trans-Alaska Pipeline show that mean July temperatures at the coast are within a few degrees of freezing, due to the ice-covered Beaufort Sea; more moderate temperatures are found inland (Conover 1960, Cantlon 1961, Haugen and Brown 1980, and Walker 1981). Low levels of radiation are associated with coastal fog. Low amounts of total summer warmth, reflected in the number of annual thaw-degree days are primarily responsible for a distinctive band of coastal vegetaion that has few shrub species, limited tussock formation, reduced moss and lichen growth and few species in the total flora (Cantlon 1961, Clebsch and Shanks 1968, Walker 1981). This band of coastal tundra which Cantlon (1961) termed "littoral tundra" lies north of the 7^{o} (C) July mean isotherm. Worldwide, this zone is equivalent to the arctic subregion of Aleksandrova's (1970) tundra region. At Prudhoe Bay, the coastal strip is about 25 km wide; near Barrow it is about 100 km wide. It is less than this within ANWR because of the narrowness of the coastal plain, and there is likely to be a more compressed coastal temperature gradient.

Along the northern limit of the "littoral tundra" band, there is yet another band of vegetation that is associated with the saline soils found immediately adjacent to the coast. This area is affected by tidal influences, wind-blown salt spray, and occasional storm-surges that flood large areas of inland tundra. Taylor (1981) divides this shoreline vegetation into 6 habitat types: tidal salt marsh, upper storm zone salt marsh, gravelly beach, raised beach, coastal dunes, and coastal bluffs. Coastal vegetation in northern Alaska has been described by Jefferies (1977), Taylor (1981) and Walker (1981). Within ANWR it has been studies by C. Meyers (1981) in the Beaufort Lagoon area.

Rolling Coastal Plain Terrain

Stretching inland between the Hulahula and Jago Rivers from the flat thaw lake plain is a complex region of very gently undulating tussock tundra, thaw lake plains, and pond complexes (HCP in Fig. 3). Elevations within the region rise gradually from near 30 m to about 100 m. The lowland portions of this area have a surface with 50% wet gramminoid tundra and Fibro Histic Pergelic Cryaquepts and Pergelic Cryaquepts. Pergelic Cryaquolls are associated with positive microrelief elements and tussock tundra slopes.

The gently sloping (5% or less) interfluves have mostly moist (75%) tussock tundra with flat centered polygons. Frost scars occupy 30% of most surfaces and are considered to have Pergelic Cryaquept soils with loam and fine sandy loam textures. Soils between the frost scars are Pergelic Cryaquolls and commonly have from 8-12 cm of sapric organic material as a surface horizon overlying loam, or occasionally silt loam textured mineral soil. Permafrost is 35 to 45 cm in August. A water table does not develop in the polygon centers but may in the narrow troughs between polygons where soils in these areas are Fibro Histic Pergelic Cryaquepts.

Vegetation on the ridges is mainly Moist Sedge-Prostrate Shrub Tundra (Table 7, Unit 5a, Appendix I) that may or may not contain cottongrass tussocks. The dominant LANDSAT landcover categories are Moist Sedge-Prostrate Shrub Tundra and Moist Sedge/Barren Tundra Complex. The latter category is associated mainly with uplands frost-scar terrain (Table 7, Unit 5b, Appendix I). The depressions between ridges contain thaw lakes and wet tundra similar to that found on the oriented thaw lake plains near the coast. The region of rolling coastal plain topography is quite different from the areas with large oriented thaw lakes. Stream drainages are well defined and have large expanses of relatively well-drained terrain associated with them. This type of terrain is common within the coastal plain portion of the ANWR, covering over 22% of the study area, but the vegetation and habitat values have received little attention.

Foothills

Foothills cover about 44% of the study area. Between the Canning River and the Sadlerochit River, an east-west distance of about 75 km, low foothills rise from Camden Bay to the base of the Sadlerochit Mountains. These mountains are 30 to 55 km from the sea coast. The hills in this region are interspersed with the drainages of the Tamayariak River, Katakturuk River, Marsh Creek, Carter Creek, Itkilyariak Creek, and the Sadlerochit River. The crests of several hills, particularly in the vicinity of the Katakturuk River have barren gravel outcrops. East of the Sadlerochit River, the foothills are further from the coast. In the vicinity of the Jago River, which is the widest part of the coastal plain within the refuge, the coastal plain is about 40 km wide and there are another 20 km of foothills to the boundary of the refuge wilderness.

Interfluves throughout much of the foothills area are elongate convex features or nearly flat mesa-like forms. In either case the crests are commonly sites of complex patterns of soils and microscale landforms e.g., areas of tussock covered high centered polygons juxtaposed with patternless areas, strangmoor, and low centered polygons. Thermokarst pits are a common adjunct and reflect substantial amounts of wedge ice. The soils of the better drained moist elements of the landscape i.e., the raised centered polygons are Cryaquolls with up to 12 cm of hemic or sparic organic overlying dark colored organic rich mineral materials; Cryaquepts occur as frost scars that may occupy up to 40% of the polygon surface. Mineral horizons of both soils are loams or fine sandy loams with variable amounts of pebbles. Active layer thickness ranges from near 30 cm beneath the Aquolls to > 60 cm beneath the Aquepts. A water table is absent or well below the surface. The wet areas commonly have Histic (20 cm of fibrous organic) Pergelic Cryaquolls or Histic Pergelic Cryaquepts if colors (and organic carbon content) below the histic epipedon do not conform to the criteria for the mollic epipedon. In either case a water table occurs at or above the surface and permafrost is between 40 and 45 cm. In the wettest areas there is enough bouyancy in the fibrous organic-root-rich mat that its true thickness is difficult to determine.

Relatively dry areas which include prominent (> 50 cm high) rims of low centered polygons and some high centered polygons have Histic Pergelic Cryaquolls with a sapric organic horizon. Permafrost is generally between 20 and 30 cm and no water table develops.

The proportion of dry, moist, wet and very wet areas of the flat or concave crest landscape ranges considerably, however, the moist tundra generally exceeds 30% (70% if the tussock areas are included) wet - very wet 10-20% and dry 10-20%.

Other interfluves are mostly convex in shape. Narrow central or crestline depressions similar to the more extensive ones just described are common. These crests give away to tussock slopes (> 5%). Parallel and subparallel water tracks are commonly present giving the topography a decidedly ribbed appearance. Areas referred to as water tracks are shallow vegetated channels that conduct snow melt waters and perhaps subsurface waters as well a during the thaw season (Everett 1981). Strangmoor are often found in the channels suggesting slow mass movement of the saturated soil column. Willow and birch are concentrated in these features and impart distinct color patterns on color infrared photographs in summer and on standard color film in the fall. The inter water-track areas are tens to hundreds of m wide, convex to the adjoining track and from 0.15 to 1.0 m above the track. Vegetation is characterized by tussocks of *Eriophorum vaginatum*. Willow or birch commonly are a significant component of the vegetation but are dispersed. Frost scars are almost always a component of tussock tundra and can comprise up to 50% of a given surface with anywhere from a few percent to 75% showing some activity (i.e., having bare mineral soil exposed). It is a common occurrence where slope breaks occur that both the density and activity of frost scars increases. In such cases 65-80% of surface may be comprised of active frost scars. Tussocks are generally absent and grasses especially *Arctogrostis latifolia* are common. Where bedrock is very close to the surface, frost scars, and or patterned lag gravel may comprise 70 to 80% of the surface. Because of the exposed nature of such surfaces, snow cover is thin or absent and abrasion by blowing snow may be severe. However, soil development beneath stable microsites may be relatively intense. The soils are Pergelic (Lithic)

Cryumbrepts if sufficient enmixed organic matter is present or Pergelic (Lithic) Cryochrepts if it is not. Active layer thickness is 1 m and ice volumes beneath are generally low.

Solifluction forms such as discontinuous stripes of frost scars or lobes are common downslope from some outcrops and where slope breaks exceed 7-10% - this is due principally to the water added from snow bank melt. Microrelief is relatively great, which when combined with the high moisture environment makes such areas quite susceptible to vehicular impacts.

The water track portion of the slope presents a relatively smooth and graded cross-section. Polygonal outlines are usually not apparent and the forms generally lack microrelief contrast. Ice wedges may still be extensive beneath such slopes. Soils are Pergelic Cryaquolls or Pergelic and Histic Pergelic Cryaquepts (the latter soil is not common). In most cases 4-15 cm of Hemic or Sapric organic matter overlie mineral materials into which organic material is commonly enmixed. Active layer thicknesses range between 30 and 50 cm. The presence of a water table is uncommon. Frost scar soils are composed of greyish brown, usually mottled sandy textured mineral material. The lack of discernible profile development should dictate placement within the Entisols (possibly as Cryorthents) however, under the present system the soil pedon is considered a Ruptic Entic Cryaquoll. Active layer thickness ranges between 70 cm and 1 m.

Histic Pergelic Cryaquepts are most common within the water tracks. Active layer thickness here is between 40 and 50 cm and a water table is almost always present, commonly within 10 cm of the surface.

Vegetation in the foothills is predominantly Moist Tussock Sedge-Dwarf Shrub Tundra (Table 7, Unit 6, Appendix I). In some areas the shrub vegetation is dominant and the landcover class is a Moist Dwarf Shrub-Tussock Tundra (Table 7, Unit 7a, Appendix I). Many areas in the foothills have numerous small drainage tracks on the sides of hills. The vegetation in the water tracks is commonly dominated by dwarf shrubs, mainly dwarf birch (*Betula nana*) and diamond-leafed willow (*Salix planifolia* spp. *pulchra*). Terrain with water track complexes is classed as Moist Tussock Sedge-Dwarf Shrub/Wet Dwarf Shrub Tundra Complex (Table 7, Unit 7d, Appendix I). A few steep, mainly south-facing slopes, have well-developed Shrub Tundra (Table 7, Unit 8, Appendix I). Tussock tundra can have a broad array of subtypes that are difficult to classify. These are related to a number of factors such as slope stability, soil moisture, cryoturbation, and successional history. The effect of frost-activity is of primary importance (Sigafoos 1952, Hopkins and Sigafoos 1951, Racine and Anderson 1979). This is apparent within the ANWR where areas with numerous frost-scars have completely different communities than non-frost-scar areas (compare 5b and 6a in Table 7, Appendix I). Successional patterns related to tundra fires has recently been recognized as another important factor in the foothills (Racine 1980).

Alpine Areas.

There is only a small area (a few km^2) of alpine terrain in the study area in the vicinity of Sadlerochit Spring. The spring is of special interest because of the presence of poplars (*Populus balsamifera*) and other disjunct plant species (Murray 1979). This area includes limestone rocks that comprise the major outcrops of the Sadlerochit Mountains. It was not visited as part of this survey because of the small areal extent, but the terrain is similar to other alpine areas in the Brooks Range. Crests here range narrowly around 1250 m and have only sporadic vegetation and ground pattern.

Soils consist of Pergelic Cryorthents (Cryochrepts may occur if textures are fine enough) interspersed with rock land. Although permafrost is present beneath such surfaces it is difficult to detect since the excessive drainage and exposed snow free slope position precludes any significant accumulation of ice. However, experience elsewhere (Everett 1975, 1980) has shown that ice may be present in some quantity in bedrock fractures.

Upper steeper portions of most alpine slopes are mantled by scree or blocky talus (Fig. 5). These deposits commonly display block stripes and/or block bordered terraces. It is common that ice fills the interstices of the finer cobble gravel size fragments below the large surface blocks. Pockets of Pergelic Cryumbrepts, Cryochrepts or on occaison Pergelic Cryaquolls do occur in finer texutred materials. Their presence and degree of development indicate at least local stability or very slow rock glacier movement on such slopes.

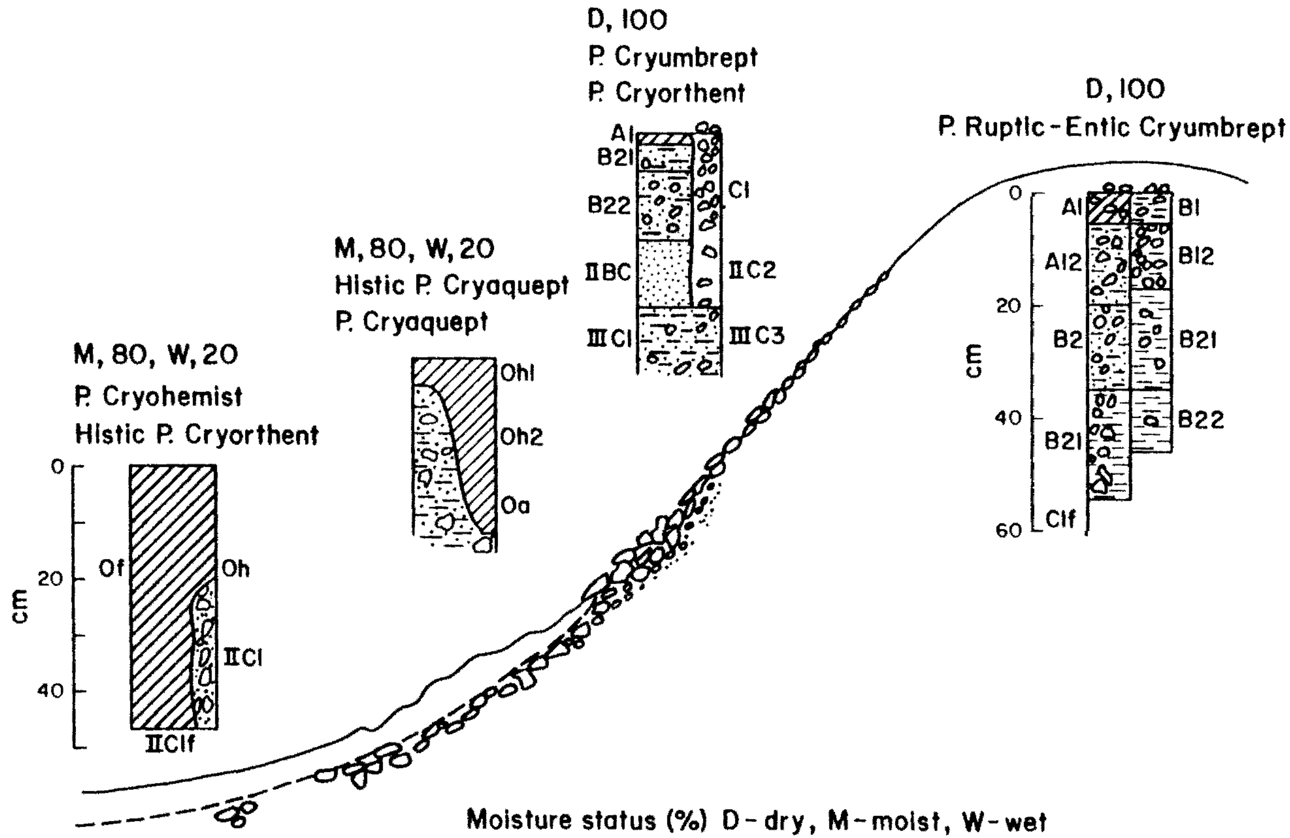
Below the talus, where vegetation cover is commonly complete and snow banks develop, the slopes display a variety of solifluction forms including turf banked terraces, lobes and stripes. A complex of soils is found on such slopes that includes Pergelic Cryohemists or Cryosaprists where slow deformation has produced folded and over thickened organic horizons (Fig. 5). Active layer thickness on such slopes varies considerably, ranging to 70 cm or more in the wetter areas to less than 30 cm on some of the better drained microtopographic elements with organic rich soils. Where coarse blocky talus underlies the solifluction slope water movement in spring may cause piping and the distribution of mineral material over the surface of otherwise organic rich soils. Solifluction slopes are naturally unstable with a complex of perched water tables and subsurface drainage and are very susceptible to vehicle traffic that can produce mechanical and thermal erosion.

Vegetation communities in these areas are complex and interspersed with unvegetated rocks and talus slopes. The character of the well-vegetated slopes varies considerably, but the more completely vegetated areas have extensive moss mats with numerous prostrate shrubs, such as mountain avens (Dryas octopetala), and prostrate willows (Salix arctica, S. chamissonis, S. phlebophylla), and small forbs (see Table 7, Unit 9, Appendix I). Limestone areas are of particular interest because of the presence of unique assemblages of plants such as the bryophytes associated with wet limestone seeps (Steere and B. Murray 1976, Murray et al. 1977).

River Floodplains

River environments are among the most complex in the study area and are of particular interest because of their extent (over 25% of the study area), their value as wildlife habitat, and because they are likely to be affected by exploration and drilling operations. This discussion includes the barren deltas and braided channels of the larger rivers, the terraces and alluvial areas associated with old river channels, and the delta formations at the base of the foothills that possibly represent an ancient sea level.

Fig. 5 **Idealized Toposequence Across Alpine Terrain Type Arctic National Wildlife Refuge**



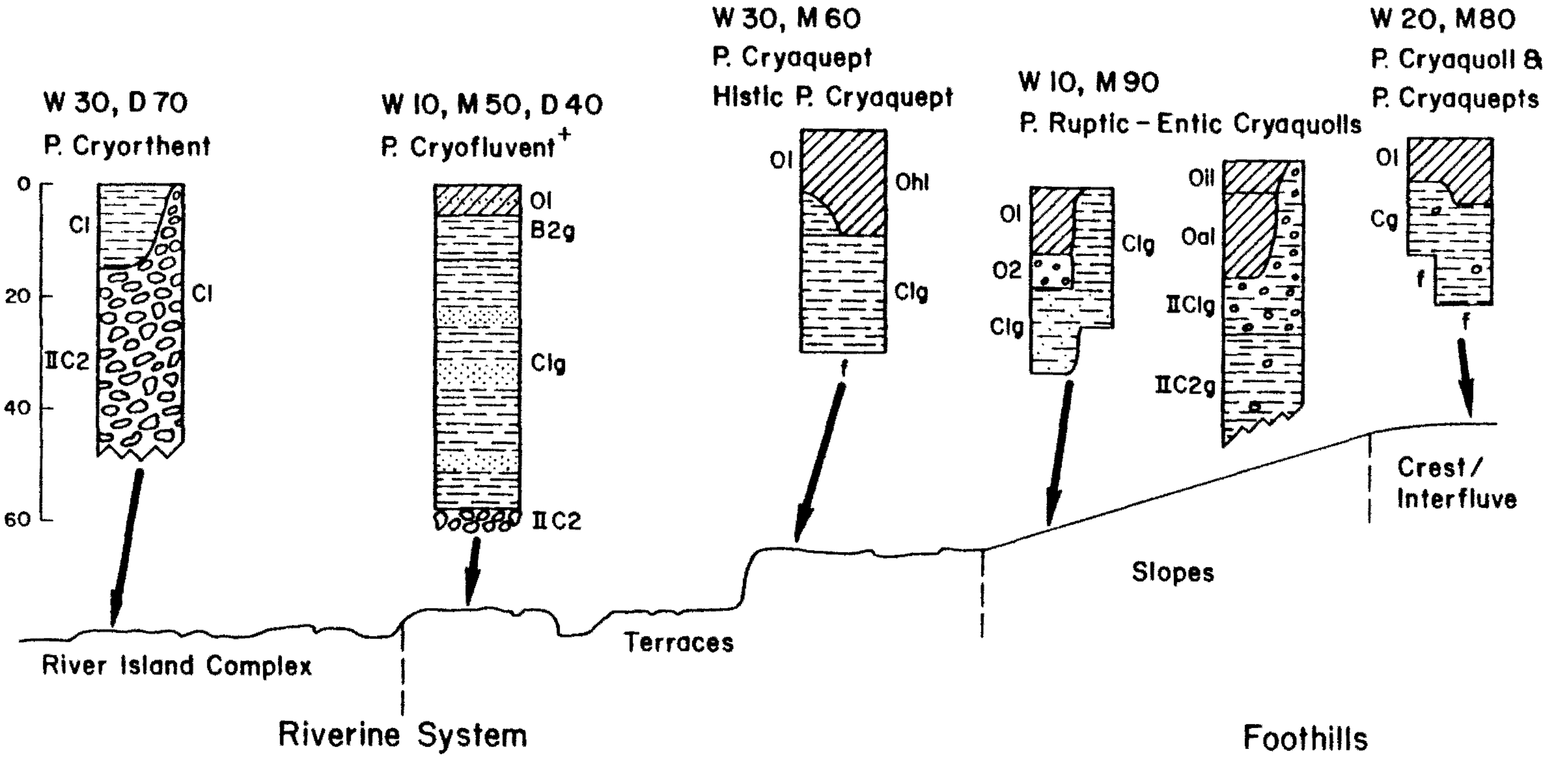
Riverine systems consist of the active channel and usually one or more terraces. The majority of the major rivers within the ANWR study area are braided channels ranging in width from about 1 km to 4 km. Most of the diamond shaped islands between channels are probably inundated at least sporadically in most years during the period of meltoff (usually late May to early June). Two types of islands can be recognized. Those consisting of unvegetated gravels with no gravelly soil development are recognizable by these features and are mapped simply as river wash (Table 2). Other islands now spatially and recently removed from the main channel or elevated slightly above the normal high water mark because of channel cutting have widely ranging vegetation coverage - depending upon the extent and frequency of inundation. The soils consist of various thicknesses of silt loam, loam and fine sandy loam over gravel and gravelly sands. In the most stable positions a thin A^1 horizon has developed and some mottling occurs in the fine sediments. The active layer normally exceeds 1 m. The soils are classified as Cryorthents. Most islands are complexes of Cryorthents and river wash. In a few cases where fine sandy surface sediments have been reworked into low discontinuous sand dunes Cryopsamment soils are recognized. Permafrost is in excess of 1 m or may be absent.

On the mesolandform scale the braided river channel is considered as a river island complex. Beyond the confines of this complex are a number of paired and non-paired terraces most of which are above the influence of snow melt flooding (Fig. 6). The youngest of the terraces commonly retain the relict pattern of channels and islands. For the most part, soils of the islands are Cryorthents and are well drained. The overlying fine materials may be 20 cm or more thick and are commonly bedded. The coarser layers are composed of fine sands. An organic rich surface (A) horizon may be from a few to 15 cm thick. The channel areas are poorly to very poorly drained with fibrous organic O horizons up to 20 cm or more thick overlying mottled grey silt and silt loam textured materials. Permafrost is encountered usually within 0.5 m. These soils are Pergelic Cryaquepts. A surface pattern consisting of 1 to 2 m diameter polygon cells is common to the better drained, island elements. Other of the terraces may lack any surface pattern and consist mostly of wet graminoid tundra while others may have weakly expressed (disjunct) polygons and strangmoor. Vehicle impact may be extensive in the moist and wet components of the landscape. In these cases the soils are Pergelic Cryaquepts and occasionally Histic Pergelic Cryaquepts. Outward from the river the trend in soil and ground pattern development is toward the establishment of shallow active layer, poor and very poor drainage with Cryorthents and Fluvent-like soils giving way to Pergelic and Histic Pergelic Cryaquepts in which the surface organic horizon is composed of fibrous sedge peat and roots. Disjunct low centered polygons and/or strangmoor mask the relict River Island pattern. Soils of the Riverine areas are with few exceptions near neutral to moderately alkaline in reaction (pH). This is true even of the more organic rich soils on the higher terraces since they receive frequent additions of alkaline loess.

Steep bluff slopes (24-30%) marginal to the rivers and a narrow strip along their crests are included within the Riverine system (Fig. 7). Bluffs may be undergoing active erosion or they may be fossil, in the sense that they rise above long abandoned river terraces. In either case they are subject to rapid failure by mudflow or by solifluction. The result is commonly a complex of soils (and non-soil) on which the solifluction lobes which may stand 50 cm or more above the surrounding slope exhibit over thickened (thapto) A horizons.

Fig. 6 **Idealized Toposequence Across Riverine & Foothills Terrain Type Arctic National Wildlife Refuge**

Moisture Status (%) W- wet, M-moist, D-dry
\+ Term is not currently recognized in U.S. Soil Taxonomy



Wetter areas occur upslope from and behind the lobes. In either case, the soils are Pergelic Cryaquolls.

The topographic contrast associated with this bluff produces a microtopographic reversal of former low centered polygons (see Brown et al. 1980). During the course of this reversal the low, highly organic rich centers (often Pergelic Cryaquepts or Histic Pergelic Cryaquepts) undergo oxidation. Commonly the soils are enriched with mineral materials eroded from the exposed bluff or derived from the river island complex below. The resulting soils are well drained Pergelic Cryaquolls or in some cases Pergelic Cryoborolls. The organic rich surface horizons are underlain by variable thicknesses of oxidized sandy textured materials that thaw to depths of 1 m or more. The processes of topographic reversal are quickly attenuated inland from the bluff edge and generally within a distance of 100 m low centered polygons (or some other surface pattern) are well developed. The addition of windblown fine sand can usually be recognized for distances well beyond 100 m.

Bluff crests and their soils undergo natural profile disruption by congeliturbation and by wind abrasion. By virtue of their exposed position they are commonly snow free during winter and are always susceptible to damage by vehicles which can lead to increased wind abrasion and erosion should the turfy A horizon be broken. The natural instability of the bluff face indicates it is probably very susceptible to outside disturbances especially those that induce channeling or ponding of melt waters.

Vegetation associated with river systems ranges from totally barren river gravels and mud to tundra that is indistinguishable from that in non-alluvial areas. The braided channels are subject to intense disturbance during spring break-up. In addition, meandering streams and braided rivers are constantly changing their channels. The first plants to colonize river gravels include river beauty (Epilobium latifolium) and arctic wormwood (Artemisia arctica). Slightly more stable areas are often only partially vegetated but may contain a wide variety of taxa (Table 7, Unit 9a, Appendix I). These are among the most floristically rich sites in the region.

Willows (Salix spp.) are common on partially vegetated gravel bars, and may form fairly extensive thickets; however, these thickets are nowhere near as extensive as riparian willow communities further west, such as on the Sagavanirktok, Kuparuk, and Colville Rivers. This is most apparent on the LANDSAT classification, which shows only partially vegetated areas adjacent to the larger rivers within the refuge. The willow communities are not distinct at the 1:250.000 scale, and examination of aerial color infra-red photography confirms that willows are not extensive. The relatively limited supply of riparian willows within the study area may be of significance to the numerous wildlife species that compete for this resource.

Dry terraces just above the main braided channels often have distinctive Dry Prostrate Shrub-Forb Tundra (Dryas river terraces, Table 7, Unit 4b, Appendix I). These communities are fairly extensive, especially along the Canning River. However, they have spectral signatures similar to that of the Moist/Wet Sedge Tundra category (Table 7, Unit 4, Appendix I), and are presently not separable in the LANDSAT classification. The dark shade of these areas is due to the lack of erect dead vegetation and lichens which are annually washed away during the spring floods. The dry soils of these terraces are excellent habitat for arctic ground squirrels, foxes, and lemmings, and are also favorite hunting grounds for foraging grizzly bears.

Smaller streams and quieter interchannel areas of the larger rivers have lush sedge and willow stands. The heights of the willows vary according to the amount of winter snow cover and the summer temperature regime. Willows near the coast are mostly prostrate, while near the southern boundary of the study area, shrubs can exceed 2 m in height (Walker 1981). Riparian areas are not well-portrayed on the LANDSAT images, mainly because of their conplexity and the confusion that exists between the land-cover categories.

Beaches, Spits and Bars

Such features occupy a very small percentage of the study area. Soil development is either lacking or in some stable sites Cryorthents are recognized. Permafrost, although it probably underlies these sites does not enter into the soil taxonomy. Vehicular impact in these areas may be severe producing ruts. Such features are usually transitory, being obliterated by storms.

Sand Dunes

Sand dunes are rare in ANWR, and are confined mostly to the delta areas of the Canning and Jago Rivers. The features are small, mostly less than 1.5 m high and composed of fine sand with a significant silt component. The soils are Pergelic Cryopsamments. Small sand dunes are highly susceptible to vehicular traffic, which may cause extensive reshaping and erosion as a result of it.

Summary of Vegetation and Soils of the Study Area

Terrain of the study area has a predominantly upland character. About 56% of the area consists of upland types. Tussock-Sedge-Dwarf Shrub Tundra is the predominant upland land-cover. This can have varying amount of shrubs, consisting mainly of dwarf birch and willows. Water tracks and south-facing slopes are likely to have well-developed shrub communities. Soils in the uplands are often poorly drained and have organic horizons overlying gleyed mineral horizons. Frost-boils occur in most upland situations and are predominant along many slopes.

Riverine flood plains and landforms associated with old river channels and deltas cover nearly 25% of the region. Vegetation, soils and landforms in these areas are highly varied and complex and include features such as bluffs, terraces, wet tundra, gravel bars, dunes, mudflats, and river icings. The 1:250,000 scale of the Landsat product is too small to locate areas of valuable wildlife habitat within the riverine complexes.

The rolling coastal plain topography is the predominant terrain type east of the Hulahula River. The terrain cosists of numerous low ridges and depressions. The ridges have upland soils and vegetation, and the depressions have wet terrain vegetation-soil complexes.

Flat areas with true oriented thaw lake topography comprise only about 3% of the total area. Soils, vegetation and landforms are similar to those described at the IBP intensive study sites at Barrow (Britton 1957, Brown et al. 1980) and Prudhoe Bay (Walker et al. 1980). Near the coast, cold temperatures and fog cause reduced plant growth. The vegetation near the coast has fewer shrubs, lower productivity and is floristically less rich than that further inland.

There is only a small amount of alpine terrain within the study area. This comprises about 344 ha near Sadlerochit Spring. Vegetation, soils, and landforms in this area are very complex, but are probably similar to that in other alpine areas of the Brooks Range (See Battan 1977, Walker and Webber 1979, Everett 1981).

The majority of the soils are neutral to slightly alkaline in reaction. A high percentage (perhaps 50% of more) belong to the soil taxonomic order of Mollisols, i.e., they have a surface horizon (epipedon) 20 cm thick that is dark in color and contains considerable organic carbon. They are the principal soils of the Tussock-Sedge-Dwarf Shrub Tundra of the Foothills and much of the Rolling Coastal Plain Terrain Types. The majority are saturated throughout the thaw period and belong to the subgroup of Pergelic Cryaquolls. Many Cryaquolls have an additional epipedon (20 cm +) of peaty material overlying loamy or fine sandy loam textured subhorizons. Pergelic Cryaquolls and Histic Pergelic Cryaquolls commonly comprise an association with Pergelic Cryaquepts where frost scars make up 5 to 20% of the surface. Perched water tables range from a few to 10 or more centimeters below the surface and permafrost lies between 40 and 60 cm.

The Thaw Lake Plains and terraces within the Riverine Complex Terrain Types are dominated by Pergelic Cryaquepts (Taxonomic order of Inceptisols). These soils are commonly neutral to alkaline but lack other characteristics of Mollisols. Many have thick (20-40 cm) fibrous organic surface horizons over loamy or fine sandy loam mineral soil. Commonly they form complexes with Pergelic Cryaquolls and or Pergelic Cryofibrists or Bryohemists (Histosols) in lowland areas of the Thaw Lake Plain or in drainage heads within the Rolling Coastal Plain. A perched water table is at or above the surface of Pergelic and Histic Pergelic Cryaquepts and Pergelic Cryofibrists (Hemists) for most if not all of the thaw period. Permafrost is between 30 and 50 cm depth in August.

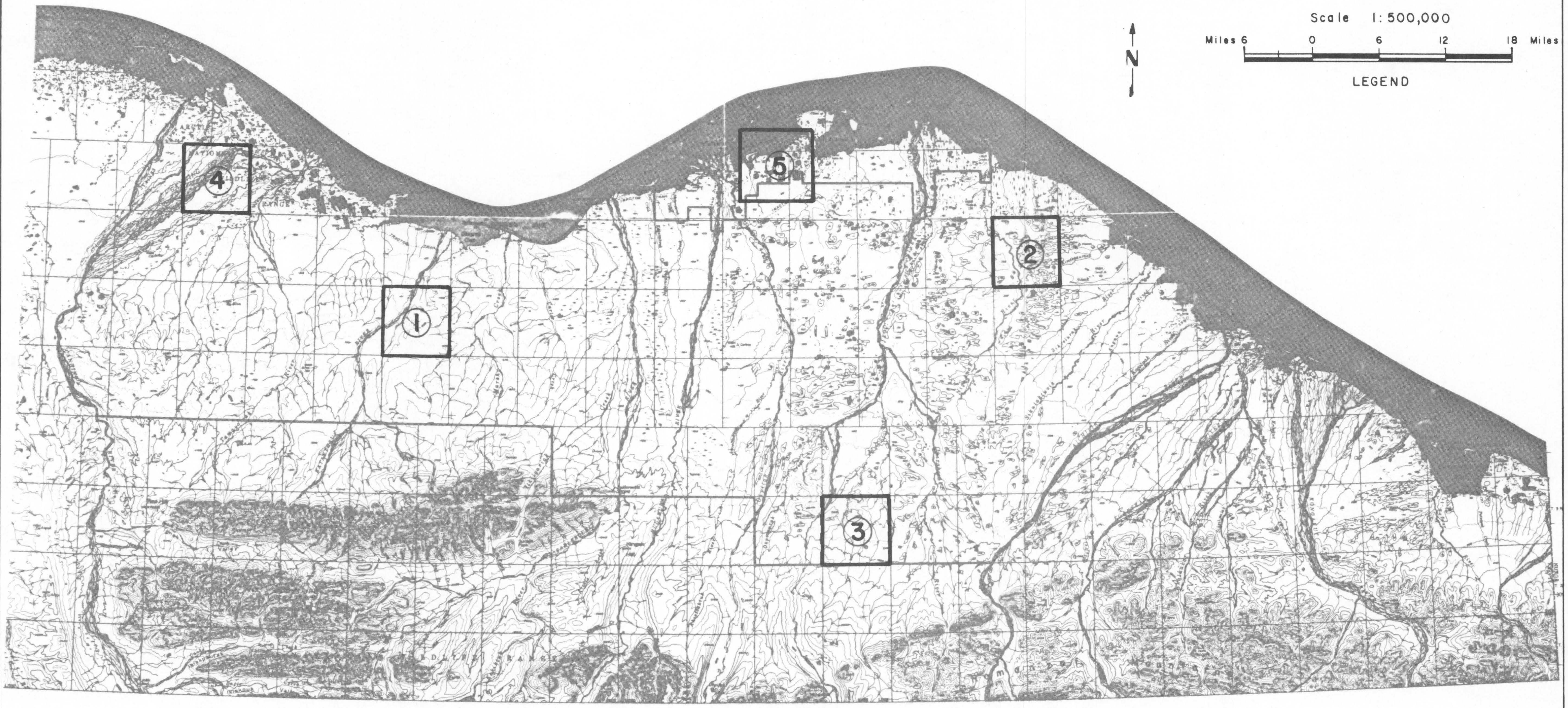
Pergelic Cryorthents are the principal soils within the Riverine terrain type, especially the islands and low terraces. These soils are neutral to slightly alkaline in reaction and composed of sands, gravelly sands and gravels commonly with 5 to 50 cm of overlying silts or silts interbedded with fine sands and organic materials. Water tables are deep or absent and permafrost is 70 to 200 cm + deep.

In Alpine terrain, Pergelic Cryorthents form areally restricted complexes with rockland, Pergelic Cryochrepts, Pergelic Cryaquepts, and rarely, (on steep solifluction slopes) Pergelic Cryohemists.

Coastal areas subject to aperiodic marine inundation have Pergelic and Histic Pergelic Cryaquepts with very high salt contents.

Locally along some high river bluffs Pergelic Cryoborolls (Mollisols) may be found. Pergelic Cryopsamments (Entisols) are found only in the delta areas of the Jago and Canning Rivers where small areas of sand dunes are developed.

FIG. 7 STUDY SITE AREAS FOR DETAILED VEGETATION MAPPING



Data Gaps

Future vegetation and habitat information needs for the ANWR study area will require the development of base map products of a higher degree of detail than possible with LANDSAT data or other currently available mapped products. A study mapping program has been initiated with CRREL and INSTAAR to evaluate the use of the mapping technique utilized in the development of the Prudhoe Bay Geobotanical Atlas (Walker et al. 1980). The mapped products that will be produced will represent the 5 study sites (Fig. 7) on the coastal plain that were intensively visited during the 1981 summer field season. Maps will be developed at a scale of 1:63,360 to determine if this scale is appropriate and to evaluate the applicability of this scale with the mapping process employed. Additionally, further evaluations will be made to determine the feasibility of additional mapping at the LANDSAT scale and other scales in the order of 1:24,000 or 1:12,000. Field work during the summer of 1982 is anticipated to provide the needed verification of the mapping process to date, and establish a preliminary relationship between the structral and morphological characteristics of the derived vegetation cover classes.

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Chapter 4

BIRDS

Information in this chapter on avifauna is divided into 4 major sections. The first 3 sections discuss the major habitat types and their utilization by birds: 1) tundra - includes wetlands, uplands, and inland lakes, 2) shoreline habitats and, 3) coastal lagoons and offshore waters. The final section in this chapter is an annotated species list summarizing available records for each bird species known to occur on the ANWR study area, as well as other pertinent ecological information currently available.

Avifauna of the ANWR Study Area

A total of 108 species have been recorded on the ANWR study area, of which 58 species have been known to breed, and 34 species may be considered as rare, casual, or accidental in their occurrence (Table 1). Seven species are known to winter, of those 4 are present regularly each winter. Of the 58 species known to have breed, 40 may be considered primarily breeders in their occurrence on the ANWR coastal plain. Nineteen species are primarily and regularly migrants, molters, or stagers on the ANWR study area. Eight species are primarily and regularly summer residents or visitors. Table 1 is considered a provisional checklist of birds of the ANWR study area, since the status of several species is currently vague and may be clarified with further field work. The abundance and status codes used in Table 1 are defined by Kessel and Gibson (1978). The abundance code is presented first in Table 1 and is followed by the status code for each species. The abbreviations used in Table 1 are as follows:

Status

Resident (Res.)
Summer Resident (Su. Res.)
Breeder (B)
Migrant (M)
Spring migrant (Sp.M)
Fall migrant (FM)
Visitor (V)
Summer visitor (Su.V)

Abundance

Abundant (A)
Common (C)
Fairly common (FC)
Uncommon (U)
Rare (R)
Casual (Cas.)
Accidental (Acc.)

Other

Probable (prob.)
Possible (poss.)

Table 1. Status of birds known to occur on the coastal plain of ANWR, Canning River to Canada border as of 31 December 1981.

Species	Coastal plain in general	Inner coastal plain	Outer coastal plain and coast
Common loon	RV		
Yellow-billed loon		RB	UM
Arctic loon	CB	CB	CB, CM
Red-throated loon	CB, CM		CB, CM
Red-necked grebe			RV
Horned grebe			RV
Short-tailed shearwater		RV	
Whistling swan		UV	CB, C Su. Res.
Canada goose			UB
Brant			UB, AM
White-fronted goose			C SpM, CFM
Snow goose	U Sp.M, R SuV, AFM		
Ross' goose			Cas. Sp. M
Mallard	U Sp.M, R SuV, RFM		
Pintail	CM, C Su. Res., RB		
Green-winged teal	RB	UB	RB
American wigeon			U to FCM
European wigeon			Cas. V
Northern shoveler			R Su. V
Greater scaup		prob. FCB	U Su.V
Common goldeneye			R Su.V
Oldsquaw		CB	CB, A SuRes, AM
Harlequin duck		RSV, prob. RB	
Steller's eider			RB, R Su Res.
Common eider			UB, FCM, FCSu. Res., UB, UM
King eider			UB, UM
Spectacled eider			UB
White-winged scoter		poss. RB	UM, U Su. Res.
Surf scoter			UM, U Su. Res.
Black scoter			UM
Red-breasted merganser	U Su. Res., UB	RB, FC Su. Res., FCM	
Goshawk		R Su V	
Rough-legged hawk		U Su. Res., UB	
Golden eagle	FC Su. Res.	U Su. Res., RB	FC Su. Res.
Marsh hawk	R Su V		
Gyrfalcon	U Res.	U. Res.	RV
Peregrine falcon		R Su. Res., poss. RB	UFM
Merlin		poss. RB, RV	RV
Kestrel	Cas. V		
Willow ptarmigan		CB, poss. R. Res.	UB, poss. R. Res.
Rock ptarmigan		UB, U Res.	CB, prob. R. Res.

Table 1. (Continued).

Species	Coastal plain in general	Inner coastal plain	Outer coastal plain and coast
Sandhill crane			UB, U Su. Res.
Semipalmated plover			R Su. V
Killdeer			Cas. Su. V
Golden plover		FCB	FCB, CM
Black-bellied plover			RSp.M, RB, CFM
Hudsonian godwit	Cas. V		
Bar-tailed godwit	RM, RV		
Whimbrel	UM		
Spotted sandpiper		U Su. Res. prob. UB	
Wandering tattler		UV	
Lesser yellowlegs		RV	
Ruddy turnstone			FCB, UM
Northern phalarope	CB, AM	CB	CB, AM
Red phalarope	CB, CM	UB	CB, CM
Common snipe	UB	UB	RV
Long-billed dowitcher			RSpM, UB CFM
Red knot			RM
Sanderling			USpM, CFM
Least sandpiper			U Su. Res.
Semipalmated sandpiper	AB, AM	CB	AB, AM
Western sandpiper			Cas. SpM, UFM
White-rumped sandpiper		prob. RB, FCM	
Baird's sandpiper	UCB, UM	RM	FCB, UM
Pectoral sandpiper	CB, AM	UB	CB, AM
Dunlin	FCB west, RB east CM		FCB west, RB east, CM
Stilt sandpiper	UB, CM	UB, CM	UB, CM
Buff-breasted sandpiper	FCB, UM	UB	FCB, UM
Pomarine jaeger		UM	CSp.M, RSu.V, UFM
Parasitic jaeger	FC, Su. Res., B	FCSu. Res., B	FCSu. Res., B
Long-tailed jaeger		CSu. Res., B	UM, UV
Glaucous gull	CB, CM	UB, USu Res.	CB, AM
Slaty-backed gull			Cas. V
Herring gull			RM
Thayer's gull			prob. RM
Mew gull		U Su. Res.	
Black-legged kittiwake			RV
Sabine's gull			UB, Um
Arctic tern	FCB, FCM	FCB	FCB, FCM
Black guillemot			RB, UV, U Su. Res.
(Thick-billed) Murre			RM
Horned puffin			Cas. V
Snowy owl	R. to C. Res.	R. to C. Res.	R. to C. Res.
Short-eared owl		UB	U to CM

Table 1. (Continued).

Species	Coastal plain in general	Inner coastal plain	Outer coastal plain and coast
Common Flicker		RV	
Empidonax sp.			Acc. V
Horned lark	RM	Rm	RM
Barn swallow			Cas. M
Cliff swallow			Cas. M
Purple martin			Acc. V
Common raven	U Res.	U Res.	U Res.
Dipper	R Res.	R Res.	
American robin	R Sp. M	R Sp. M	Cas. V
Varied thrush	R sp. M	R Sp. m	Cas. V
Gray-cheeked thrush	prob. RM, RB	prob. RB	prob. RB
Yellow wagtail	RM, UB	CB	RM, RV
Water pipit	RV	Rv	RV
Orange-crowned warbler			Cas. M
Yellow warbler			Cas. M
Rusty blackbird			Cas. M
Redpoll		UB	UM, UV, RB
Savannah sparrow	UCB	FCB	UV, RB
Dark-eyed junco			R Sp.M, RFV
Tree sparrow		FCV, UB	RM
White-crowned sparrow			RV
White-throated sparrow			Acc. V
Lapland longspur	AB	AB	AB
Snow bunting	CB	CB	CB

Bird Use of Tundra Habitats

Since 1970 there have been several studies within the ANWR study area with the major objective being to describe intensity of bird use on various tundra habitat types. In 1970 near Beaufort Lagoon Schmidt (1970) censused birds on randomly-located quadrats (402 x 402m, 0.62 km^2) to determine waterfowl-use days. Also, in 1970 Andersson (1973) estimated densities of certain shorebird species using the Nuvagapak Point area. Salter and Davis (1974b) performed ground transect surveys to estimate levels of bird use in several Yukon and Alaska North Slope habitat types, including 5 sites and 10 habitat types on the coastal plain of ANWR. The most extensive study of total bird populations in most of the habitat types on the coastal plain of ANWR was conducted in 1977, by Magoun and Robus (1977). Eight different sites and 14 different habitats were surveyed using 86 km of linear transects (3.4 km^2 of area surveyed). In 1978 Spindler (1979a) censused nesting and transient bird populations on 4 different tundra habitat types prevalent near the Okpilak River Delta. A total of 1.75 km^2 was sampled by three 0.5 km^2 plots and one 0.25 km^2 plot each representing a different habitat type. At Demarcation Point in both 1978 and 1979 R. Burgess (unpubl. data) censused nesting birds on one 0.30 km^2 plot in an area of varied tundra habitats consisting mostly of aquatic tundra 2b, wet sedge meadow tundra 3b, and moist sedge barren tundra 5b[1]. The most intensive bird census of nesting and transient bird populations in relation to habitat conditions and prey base on ANWR was performed by Martin and Moitoret (1981) in 1979 and 1980,at the Canning River delta. They censused 3 different tundra habitat types.

Other studies conducted on the Alaska North Slope provide data on nesting populations: on the outer coastal plain near Pt. Thomson (Wright and Fancy 1980); near Prudhoe Bay (Norton et al. 1975, Hohenburger et al. 1980); near Barrow (Myers and Pitelka 1980); and, on the interior coastal plain at Atkasook (Myers and Pitelka 1980). In addition, Derksen et al. (1981) presented data on seasonal bird populations (including breeders and transients) at 2 interior coastal plain sites, Singiluk and Square Lake, and 4 outer coastal plain sites, Storkerson Pt., Meade River Delta, East Long Lake, and Island Lake.

These North Slope studies describe bird populations and species composition for one or more years in one or more habitats. Population levels can be analyzed to determine which habitat types consistently harbor more bird species and individuals, both for nesting and transient birds. For some of the more common or widespread species the variation in population levels by habitat, by season, and by year can be described. However, with the data currently available, extrapolations cannot be made for total populations of species, or the total number of individuals of a species either breeding, resident, or transient in any given area. To make such extrapolations would require replicate census plots in each habitat type sampled, each year, at each site, requiring considerably more manpower than field research projects have been able to afford (S.J. Harbo pers. comm., G. Garner pers. comm.). One project conducted by L.G.L. in 1981 to evaluate waterflood impacts at Prudhoe Bay has utilized replicate plots. Those data should provide some extrapolations of total populations, nesting and transient, in a mixture of major habitat types (D. Troy pers. comm.).

Bird use of tundra habitats on ANWR occurs in several major temporal/functional categories: spring migration (May 1-June 21); breeding (May 1-August 1); brood rearing, transient, non-breeding resident and molting (June 21-August 31); pre-migratory staging (25 June-25 September); and fall migration (1 July-30 September) (Bergman et al. 1977, Spindler 1978a, Martin and Moitoret 1981). In each of the above temporal/functional categories one major or several major and several minor species may be involved, and are identified in the annotated species list. The purpose of this section is to summarize that use on a biological community basis. In most cases species-specific details are covered in the annotated species list, and only

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[1] Habitat type classes used in this Chapter follow the LANDSAT names and descriptions given in Chapter 3; they are followed by the numeric abbreviation. Often more specific and desciptive subtypes have been identified and used by other authors and these subtypes are used in this report as non-capitalized habitat or plot names. For convenience, specific plot names are followed by the numeric abbreviation (in parentheses) of the LANDSAT habitat class to which they belong.

brief mention is made of the species in the text or tables in this section. However, a great amount of the available bird community information (e.g., patterns of habitat occupancy, productivity, diversity, etc.) applies to species groups (e.g., waterbirds, waterfowl, shorebirds, etc.) and hence will be discussed in more detail in this section.

Spring Migration

For most species, the coastal plain is the terminus of spring migration -- the birds arrive on the tundra and begin breeding activities. For a few species, the ANWR coastal plain tundra is part of their spring migration corridor and is used to varying degrees for resting and feeding while enroute to main breeding areas elsewhere (even though the species may breed in small numbers on the ANWR study area). Brant use the coastal plain primarily as a migratory corridor. They are dependent on tundra vegetation, specifically wet saline tundra 3d (coastal vegetated mudflats of Nodler 1977), for resting and feeding while enroute to the main breeding grounds in Canada. Large numbers of arctic and red-throated loons, as well as short-eared owls, arctic terns, and glaucous gulls use the coastal plain tundra for feeding and resting in early to mid-June. They move to other nesting or summering areas by late-June (Spindler 1978a, Martin Moitoret 1981). Snow geese use wet sedge meadows for grazing while enroute to breeding areas. Red knots migrating to Canadian breeding grounds occasionally stop to rest and feed in wet sedge tundra (3). Sanderlings in migration frequently stop to forage on coastal bluffs and dunes while enroute to breeding areas (Spindler 1978a, Martin and Moitoret 1981). Pomarine jaegers, perhaps many thousand, migrate low over the coastal plain feeding on birds and small mammals as they fly to Canadian breeding grounds (Spindler 1978a, Martin and Moitoret 1981).

Breeding

Small Birds

Fifty-five species are currently known to utilize the ANWR study area for breeding (Table 2). Nesting densities on 5 habitat types at 3 sites have been censused intensively (Table 3). Of the habitat types censused, a mosaic low-centered/high ridge polygon tundra (3c) on the Canning Delta produced the highest total nesting density, 138 nests/km^2. A mixed habitat plot at Demarcation Point (2b, 3b, 5b) consistently supported nesting densities in excess of 100 nests/km^2 (Table 3). Intermediate levels of nesting density were observed in a mosaic of low-centered/high ridge polygonal tundra (3c) on the Okpilak Delta in 1978, in an upland dry sedge tundra (5b) on the Canning Delta in 1980 and in a lowland very wet sedge tundra (3b) on the Canning in 1980 (Table 3). The homogeneous wet sedge tundra (3a), flooded sedge tundra (3b), and upland sedge-tussock tundra (6a) on the Okpilak in 1978, along with the lowland very wet sedge tundra (3b) and the upland dry sedge tundra on the Canning Delta in 1979 showed lower levels of nesting density. Higher numbers of nesting species were found in the flooded sedge tundra (3b) on the Okpilak, mosaic tundra (3c) on the Okpilak and Canning, and in the mixed habitat plot on Demarcation Point (Table 3).

Table 2. Species known to breed (or have bred) in tundra and/or tundra wetland habitats on the ANWR study area.

Yellow-billed loon	Common snipe
Arctic loon	Long-billed dowitcher
Red-throated loon	Semipalmated sandpiper
Whistling swan	White-rumped sandpiper
Canada goose	Baird's sandpiper
Brant	Pectoral sandpiper
Pintail	Dunlin
Green-winged teal	Stilt sandpiper
Greater scaup	Buff-breasted sandpiper
Oldsquaw	Pomarine jaeger
Harlequin duck	Parasitic jaeger
Steller's eider	Long-tailed jaeger
Common eider	Glaucous gull
King eider	Sabine's gull
Spectacled eider	Arctic tern
Red-breasted merganser	Snowy owl
Rough-legged hawk	Short-eared owl
Golden eagle	Raven
Gyrfalcon	Dipper
Peregrine falcon	American robin
Willow ptarmigan	Yellow wagtail
Rock ptarmigan	Redpoll
Sandhill crane	Savannah sparrow
Golden plover	Tree sparrow
Black-bellied plover	White-crowned sparrow
Ruddy turnstone	Lapland longspur
Northern phalarope	Snow bunting
Red phalarope	

The species nesting in the highest densities on the wet sedge tundra types (3a,b) include red phalarope, northern phalarope, pectoral sandpiper, and Lapland longspur. Species attaining high densities in mosaic tundra types (3c) were northern phalarope, semipalmated sandpiper, pectoral sandpiper, dunlin, buff-breasted sandpiper and Lapland longspur. In the upland dry sedge tundra (5b), types semipalmated sandpiper and Lapland longspur reached high densities. The only species reaching high nesting density in the upland sedge-tussock tundra (6a) was the Lapland longspur.

Substantial annual changes in nesting density were observed for some species in the plots where 2 years of census data are available. Northern phalarope dropped considerably on the Canning Delta lowland plot (3b) between 1979 and 1980, while red phalarope and Lapland longspur nesting density was approximately doubled in the same period (Table 3). Semipalmated sandpiper and Lapland longspur nesting density increased greatly on the Canning Delta upland plot (5b) between 1979 and 1980. At Demarcation Point, pectoral sandpiper nesting density dropped 78% in 1 year, while Lapland longspur increased 75% during the same period (Table 3). Myers and Pitelka (1980) noted that northern phalarope and pectoral sandpiper were among the more annually variable species at Barrow and Atkasook. They also found similar or

Table 3. Nesting densities (nests /km^2) of bird species on various vegetation types on the ANWR coastal plain. Determined from intensive plot census studies 1978-1980. Sources: Okpilak - Spindler (1978a), Canning - Martin and Moitoret (1981), Demarcation Point - R. Burgess, unpubl. data.

Vegetation Class	3a,b. Wet Sedge Tundra (wet or very wet complexes)				3c. Wet Sedge Tundra (moist complex)	
	3a.	3b.	3b.			
Habitat description	Homogeneous Wet Sedge Tundra	Flooded Sedge Tundra	Lowland Very Wet Sedge Tundra		Mosaic wet/dry-Low center/ high ridge polygons	
Location/date	Okpilak '78	Okpilak '78	Canning '79	Canning '80	Okpilak '78	Canning '80
SPECIES						
Arctic Loon		2				
Red-throated loon		6				
Green-winged teal						
Oldsquaw	2					4
Common eider		2				
King eider		2				
Willow ptarmigan						
Rock ptarmigan					4	4
Golden plover					1	4
Northern phalarope	4	18	11	4	6	8
Red phalarope	2	14	26	48	4	
Long-billed dowitcher	2					
Semipalmated sandpiper		2			6	20
Baird's sandpiper						
Pectoral sandpiper	6	4	11	15	8	31
Dunlin						8
Buff-breasted sandpiper					3	8
Glaucous gull		1				
Lapland longspur	29	10	11	22	55	51
Total nest density	45	61	59	93	87	138
Plot size (km^2)	0.50	0.50	0.27	0.27	0.50	0.25

Table 3. (Continued).

Vegetation Class	5b. Moist Sedge/Barren Tundra Complex		6a. Moist Tussock-Dwarf Shrub Tundra	Mixed Type 2b, 3b, 5b	
Habitat description	Upland dry sedge tundra		Upland sedge-Tussock Tundra	Demarcation Point	
Location/date	Canning '79	Canning '80	Okpilak '78	1978	1979
SPECIES					
Red-throated loon				3	3
Green-winged teal					3
Oldsquaw			1		
Willow ptarmigan			2		
Rock ptarmigan		4			3
Golden plover	4		4		
Northern phalarope	4		2	13	10
Red phalarope	8	8		3	3
Semipalmated sandpiper	8	24		27	33
Baird's sandpiper					3
Pectoral sandpiper		4		33	7
Dunlin	4	4			
Buff-breasted sandpiper	4			3	
Lapland longspur	20	35	40	40	70
Total nest density	52	79	49	122	135
Plot size (km^2)	0.25	0.25	0.25	0.30	0.30

greater annual fluctuations in shorebird nesting densities at Barrow and Atkasook as compared to ANWR areas, and pointed out that the magnitude of annual changes in nesting densities in arctic tundra are about the same as those experienced in temperate North American grasslands and less than the changes observed in desert bird communities. Nevertheless, annual fluctuations of the magnitudes commonly observed for some species on ANWR make comparisons between areas studied in different years, detection of trends in populations, and identification of before and after effects on populations difficult.

Breeding bird censuses conducted at other Alaska North Slope sites, indicate with a few exceptions that breeding densities reported from ANWR are lower than those from other North Slope locations, particularly Barrow (Table 4). Differences in analytical methods may be partly responsible for this discrepancy. All studies in ANWR used the conservative approach of basing nest densities only on actual nests found, while other studies used the presence of territorial males as well as actual nests. The former method is likely to underestimate nest density while the latter may overestimate nest density for some species. For example, Lapland longspurs at Barrow exhibit polygyny and utilize a nest "helper" male that raised young of a different male (Tyron and MacLean 1980), therefore the number of males present may not equal the number of nests present.

The Okpilak River Delta study may have detected lower densities because of less intensive coverage of large (three 50 ha. and one 25 ha.) plots. Recognizing the previously mentioned differences in census intensity and analytical methods, total nesting density on the ANWR plots appears to be consistently lower than nesting densities on coastal plain sites further wets. This difference may be related to habitat composition (more species nesting to the west), and perhaps other factors such as prey and predator abundance.

Studies at Barrow and Atkasook have resulted in several conclusions regarding nesting shorebire abundances and habitat use that may also apply to the ANWR coastal plain (Myers and Pitelka 1980):

> Four gradients reflect most stronly the range of conditions seen in different tundra habitats: polygonization, pondiness, vegetation density, and shrubiness.
>
> Coastal (Barrow) and inland (Atkasook) sites differ in that well-drained upland habitats are much more extensive at the latter, topographic relief is much stronger, and indices of vegetation density and shrubiness are higher. As a result, Atkasook has more varied terrain, especially along the polygonization and vegetation-related gradients.
>
> Breeding shorebirds are almost twice as dense coastally as they are inland....
>
> Shorebird species differ in habitat choice; in general more species and higher densities occur in wetter habitats both coastally and inland.
>
> Inland, breeding shorebirds select low, poorly drained, non-polygonized habitats strongly, meaning that shorebird activity is more strongly localized. Coastally, breeding shorebirds are broadly distributed over all habitats....

Table 4. Breeding bird densities (nests/km^2) from various locations on Arctic coastal plain. Range of densities is presented for sites which have been censused for more than one year. The category "others" includes ptarmigans, waterfowl, loons, etc. Adapted from: Martin and Moitoret (1981).

Location	Breeding Densities				
	Years	Shorebirds	Longspurs	Others	Total
ANWR					
Demarcation Bay[1]	'78-79	47-90	43-67	3-10	123-143
Okpilak River Delta[2]					
Flooded Tundra	'78	38	10	13	61
Mosaic Wet/Dry Sedge	'78	28	55	4	87
Wet Sedge Meadow	'78	14	29	2	45
Upland Sedge-Tussock	'78	8	40	5	49
Canning River Delta					
Upland	'79-80	31-39	20-35	0-4	51-78
Lowland	'79-80	48-67	11-22	0-4	59-93
Mosaic	'80	74	51	12	137
BARROW					
Wet Coastal Plain Tundra I[3]	'75-79	66-115	30-44	1-21	107-167
Wet Coastal Plain Tundra II[3]	'75-79	68-115	15-69	4-39	109-171
Wet Coastal Plain Tundra III[3]	'78-79	40-75	44-45	7	126-162
PRUDHOE BAY					
IBP sites[4]	'71-72	87-91	7-9	0	93-100
Wet Coastal Plain Tundra[5]	'79-80	74-101	44-45	7	126-152
INLAND SITES					
Atkasook[3]	'77-79	92-144	40-96	26-40	155-284
Pipeline Corridor (Franklin Bluffs)[6]	'79-80	27-37	25-29	14	72-76

1 source, R. Burgess pers. comm.
2 source, Spindler 1978a.
3 source, Myers and Pitelka 1980.
4 source, Norton et al. 1975.
5 sources: Hohenberger et al. 1980; Hohenberger et al. 1981.
6 sources: Jones et al. 1980; Garrot et al. 1981.

No intensive census work at inland coastal plain sites has been conducted on ANWR, therefore, these conclusions cannot be confirmed for ANWR at the present time.

Large Birds

Breeding densities of sparsely distributed large bird species are not adequately estimated by intensive plot surveys. Therefore, they were estimated by periodically traversing a 50 km^2 area on the Okpilak Delta in 1978 and a 20 km^2 area on the Canning Delta in 1979 and 1980. The estimates are a minimum estimate, since the intensity of coverage on this large area is not adequate to detect all nests. Intensity on both the Okpilak and Canning areas amounted to a systematic survey around all lakes and wetlands at 5-10 day intervals throughout the breeding season.

Both the Canning and the Okpilak Delta areas showed similar levels of total large bird nesting density, between 2.90 and 3.54 nests/km^2 (Table 5). The Canning area, in 1979 and 1980, had 1 and 3 more nesting species, respectively, than the Okpilak in 1978. Nesting densities of most species were similar between the 2 areas. However, the Okpilak had lower whistling swan and eider densities, and higher oldsquaw densities. In the Canning area, where 2 years data are available, annual variations in nesting density were low for large birds.

Table 5. Minimum estimated nesting densities (nests/km^2) for large bird species on two sites in the Arctic coastal plain of ANWR, 1978-1980.

	Okpilak Delta[a]	Canning Delta[b]	
	1978	1979	1980
Arctic loon	0.40	0.55	0.75
Red-throated loon	0.32	0.45	0.60
Whistling swan	0.12	0.25	0.15
Canada goose	0.04	0.25	0.30
Pintail	0.30	-	0.10
Oldsquaw	2.00	0.40	0.45
Common eider	0.04	-	-
King eider	0.04	0.45	0.30
Spectacled eider	-	0.10	0.05
Parasitic jaeger	-	-	0.10
Glaucous gull	0.28	0.25	0.20
Sabine's gull	-	0.10	0.20
Arctic tern	-	0.10	0.10
Total density	3.54	2.90	3.30
No. of species	9	10	12
km^2 censused	50	20	20

Sources:
[a]Spindler(1978a)
[b]Martin and Moitoret(1981)

The estimated nesting densities for the Okpilak and Canning areas are probably typical for river delta tundras with fairly large amounts of wetlands -- pond complex (2a) or aquatic tundra (2b) on ANWR. There are some delta areas on ANWR with higher concentrations of wetlands, such as the Tamayariak and Aichilik-Egaksrak, but most of the ANWR tundra, especially inland, has lower concentrations of wetlands. Therefore they are likely to have lower nesting densities of large birds. Use of wetland types by large birds varies by specific wetland type and by species (Bergman et al. 1977, Derksen et al., 1981). However, most data on species and wetland use are based on total seasonal use, breeding and non-breeding. Individual species nesting habitat preferences are discussed in the annotated species list.

Summer Residents and Transients

Small Birds

Following courtship in several shorebird species, one sex of each pair usually departs the nesting habitat and moves to premigratory staging grounds. In phalaropes the female usually departs leaving the male to incubate the eggs (Palmer 1967). In some cases this female mates with a second male before departing or incubating her own clutch (Schamel and Tracy 1977). In pectoral and buff-breasted sandpipers the males usually depart after courtship, while in Baird's sandpiper and dunlin the males may depart partway through incubation (Pitelka et al. 1974). These movements result in a shift in the center of distribution of summering adult birds, as well as a change in habitat use, which occurs in mid-to-late July (Myers and Pitelka 1980, Martin and Moitoret 1981). Most of these adults migrate by early August. They are followed by successive "waves" of failed breeders, females that have completed breeding, young non-breeders, and young birds of the year in early to mid-August (Myers and Pitelka 1980, Martin and Moitoret 1981). Additionally, large numbers of some species which do not commonly breed on the ANWR, or breed inland, move to the outer coastal plain to stage and feed in very wet and flooded tundra habitats, as well as shoreline habitats (Martin and Moitoret 1981). West of ANWR, Myers and Pitelka (1980) reached similar conclusions regarding shorebird movements and shifts in habitat use:

> ...The striking difference between Barrow and Atkasook is the post-breeding decline in numbers inland, against the post-breeding rise in numbers coastally. Thus during July and August, coastal habitats are used heavily by populations both local and by those moving coastward from inland habitats....
>
> Shorebirds show seasonal shifts in habitat use, the majority moving to lower, wetter sites as the summer progresses, both coastally and inland, but upland sites are never completely deserted. Numerically, this shift is strongest in coastal habitats....
>
> On the coast, seasonal fluctuations in shorebird numbers are characterized by highs each year in early summer (arriving birds), early July (non-breeding transients), and late August (drifting, departing birds).

Inland, seasonal fluctuation differs through much of the summer. There, shorebirds arrive a week earlier than coastally. But most important, no later peaks in numbers occur; that is, there is a slow drift away from the area beginning after breeding stops, in early July.

The chronology of bird use in 4 different habitat types on the Canning Delta is presented in Figs. 1 and 2. Martin and Moitoret (1981) reported that an upland dry sedge tundra plot on the Canning Delta had the greatest bird use in early June 1980. Throughout June, use on the mosaic (3c) and lowland (3b) plots increased to levels higher than the upland (5b): "Around 15 July the upland lost most of the shorebirds and a similar though less drastic decline in shorebird numbers occurred on the mosaic and lowland. From mid-July through the end of August the lowland diverged sharply from the upland and mosaic. Shorebird numbers on the lowland were 2 to 3 times higher in late summer than those recorded during June and July. This shorebird peak is exhibited less strongly on the mosaic and even less strongly on the upland. Longspurs, on the other hand, peaked most strongly in migration on the upland and the mosaic, although there was a substantial increase in Longspur use of the lowland in late summer". The wet saline tundra habitat showed extremely high use in mid-June and early-July, mostly due to flocks of staging phalaropes and migrating semipalmated sandpipers. Over much of the Alaska north slope, the shift of shorebird numbers from upland and inland areas to wet coastal tundra is coincident with an increase in use of shoreline habitats by shorebirds (Connors and Risebrough 1981, Martin and Moitoret 1981).

The transect data of Magoun and Robus (1977) (Table 6) provide an indication of how various ANWR coastal plain habitat types ranked according to levels of total breeding and non-breeding use, mostly because of the extensive coverage of many geographic areas with the same intensity. There are some problems with the transect methods on tundra since Richardson and Gollop (1974) noted that transect methods on open habitats of the Yukon Territory north slope tended to over estimate populations. However, extrapolations from such data for comparison of different sites and habitats within a study seem valid because the low manpower requirements of transects allow replicate samples in each habitat. Given the above qualifications, the densities given for each habitat type in Table 6 serve as a comparative index for bird use levels on the ANWR study area from early-June to early-August 1977.

Wet sedge meadow (3a) was the most important avian habitat type in terms of both numbers of species and individuals (Table 6). The most abundant species were northern phalarope, semipalmated sandpiper, pectoral sandpiper, red phalarope, and arctic tern. It should be noted, however, that arctic terns were only abundant in this habitat type if ponds, lakes, or very wet sedge meadow (2b, 3b) were adjacent to the wet sedge meadow. Magoun and Robus (1977) reported that "very wet sedge meadow and moist sedge meadow (4a) habitat types were often integrated with wet sedge meadow areas. The activity of birds in these areas overlap all 3 habitat types and the importance of these habitats should not be considered independent of each other. For example, the activity observed on the transect run on Barter Island through wet sedge meadow was closely associated with an adjacent large area of very wet sedge meadow through which no transects were run. The importance of the wet sedge areas on Barter Island is undoubtedly dependent on the presence of very wet sedge meadow nearby. This is probably true for all areas of the Arctic Slope where wet sedge meadow is present; therefore, wet sedge meadow, Lowland very wet sedge tundra (3 b).

Upland dry sedge tundra (5b).

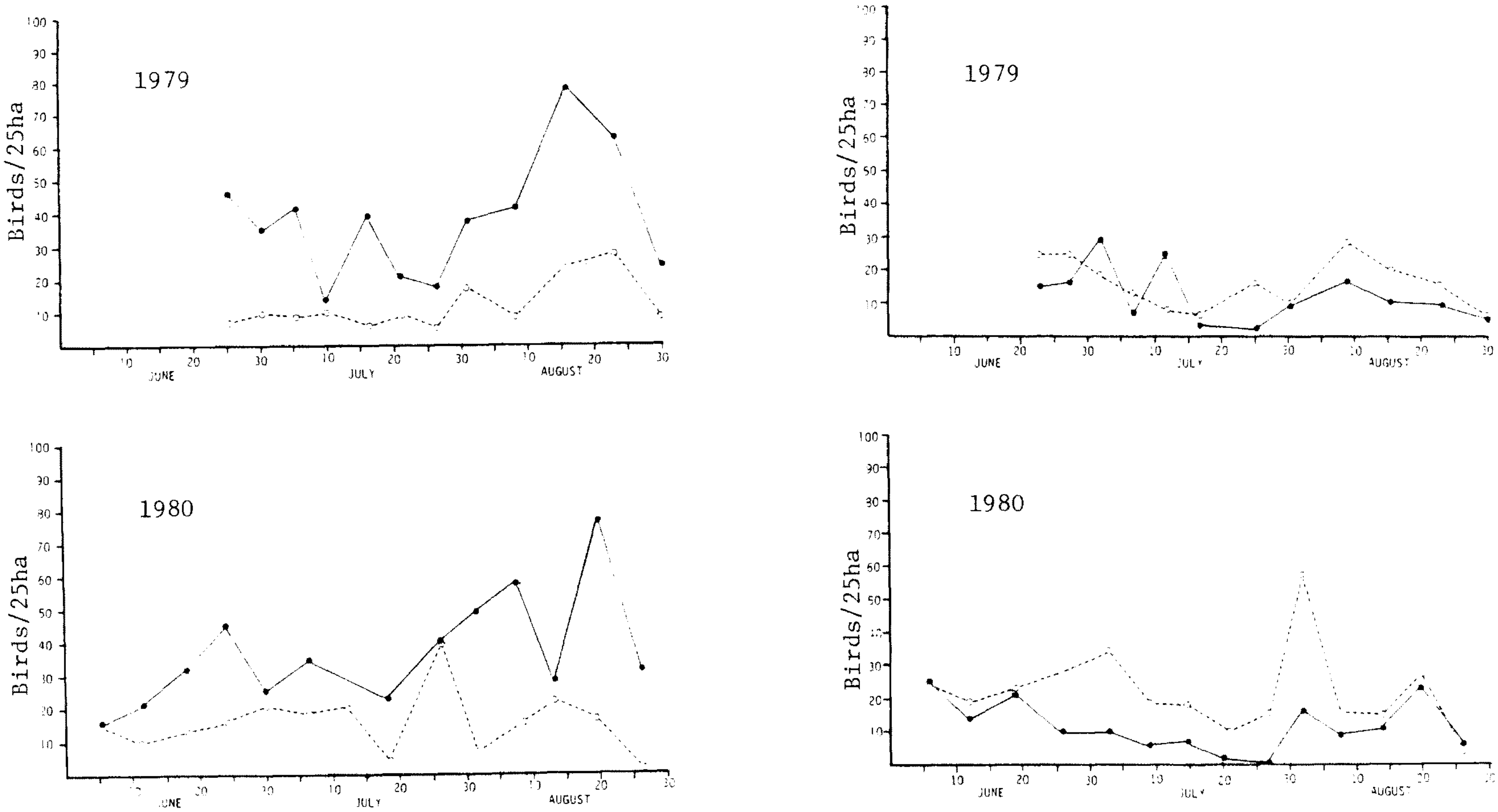

Figure I. Numbers of shorebirds (●) and longspurs (○) on upland and lowland study plots, Canning River Delta, 1979 and 1980. Sources: Martin and Moitoret (1981).

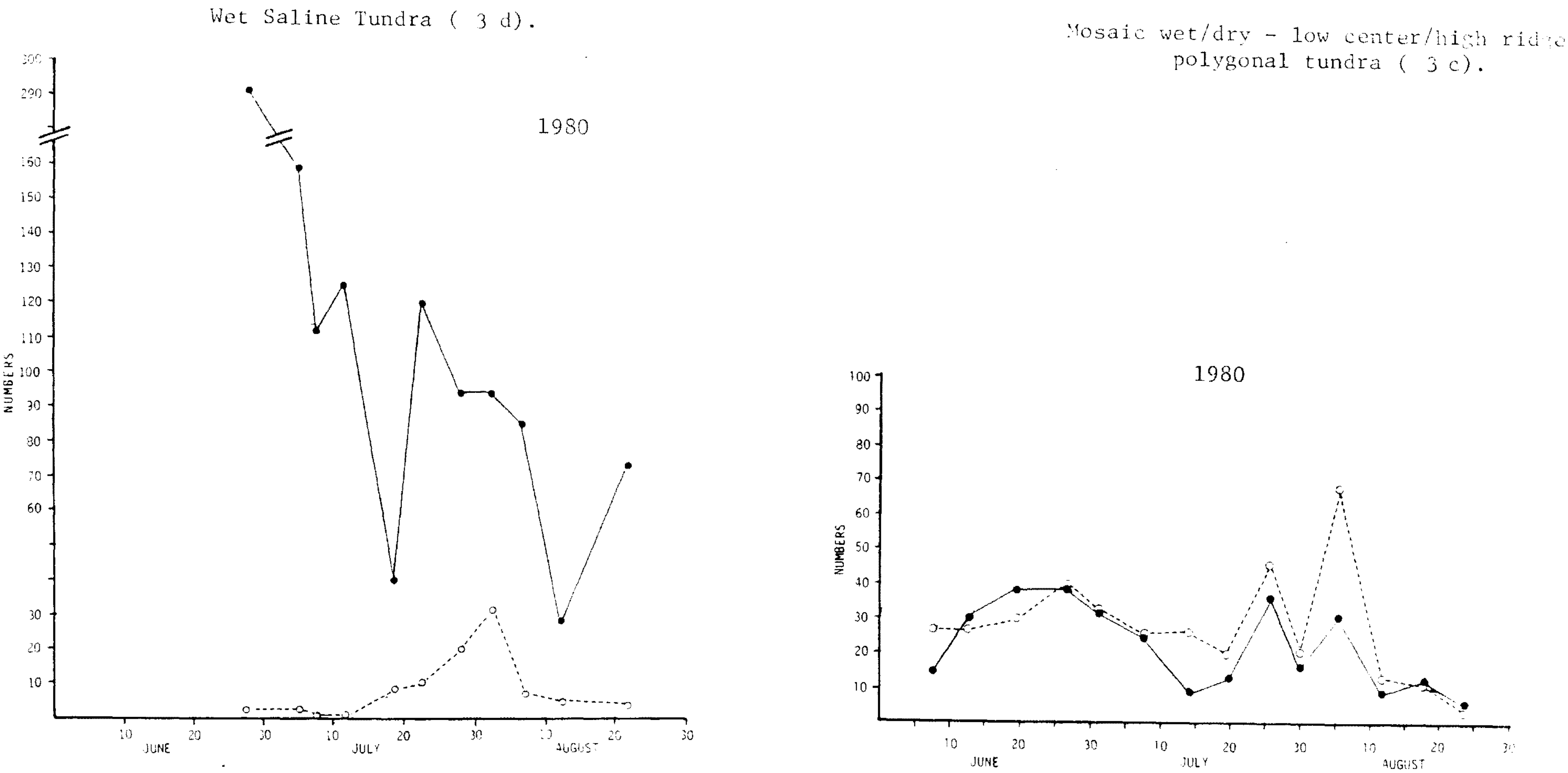

Figure 2. Numbers of shorebirds (●) and longspurs (○) on West Branch Flats and mosaic study plots, Canning River Delta, 1980. Source: Martin and Moitoret (1981).

very wet sedge meadow, and moist sedge meadow, where they are integrated, should be given equal value in terms of importance to avian species on the Arctic Slope."

In Magoun and Robus' (1977) transect data, riparian willow stands supported the second highest number of birds (Table 6). Though the number of species ranked fourth in this habitat type, the riparian willows were particularly important for 5 passerines: Lapland longspur, redpoll, savannah sparrow, yellow wagtail, and tree sparrow. The latter 4 species were almost entirely restricted to riparian willow thickets or adjacent habitat types such as riparian Dryas terrace or riparian gravel bars which supported willow growth.

The third most important habitat type was wet saline tundra 3d (coastal vegetated mudflats of Nodler 1977). These areas supported 15 species at an average density of 830 birds/km^2 (Table 6). The most abundant species were semipalmated sandpiper, pintail, dunlin, Lapland longspur, and pectoral sandpiper.

An approach to evaluating populations of summer resident and transient birds in North Slope habitats has been to repeatedly census plots ranging in size from 0.25 km^2 (Spindler 1978a, R. Burgess unpubl. data, Martin and Moitoret 1981) to clusters of small plots totaling over 1.0 km^2 (Derksen et al. 1981). The repeated census results are averaged to produce a mean density value for each species and total birds, reflecting the total seasonal use (Table 7). ANWR seasonal density data for the Okpilak sites were determined from mid-June to late-July. At the Canning site, the plots were censused early/mid-June to late-August, thus including the fall "peak" of staging and migrating shorebirds. Recognizing the differences in duration of study, the wet sedge, flooded sedge, and mosaic plots on the Okpilak would be expected to show lower densities than if their census period extended into August. Mean total density was highest in the wet sedge tundra 3d, mosaic wet/dry polygonal tundra 3c, flooded sedge tundra 3b and very wet sedge tundra 3b (Table 7). Lower seasonal bird densities were reported for homogeneous wet sedge tundra 3a, upland dry sedge tundra 5b, and upland sedge-tussock tundra 6a (Table 7).

Large Birds

Table 8 compares mean seasonal densities of large birds as determined by repeated censuses of 2.5-50.0 km^2 census areas in ANWR and areas to the west. Arctic loon densities on ANWR are comparable to other areas surveyed to the west, whereas red-throated loons are more abundant in ANWR. Canada geese were fairly abundant on the Canning, exceeded only at the Island Lake goose molting area in NPR-A. Pintail numbers are lower on ANWR than in the western areas. King eiders were more plentiful from Prudhoe Bay eastward. Oldsquaw numbers were higher on the Okpilak and Canning as compared to the western areas. Whistling swan densities were high on the Canning as compared to the other areas.

Seasonal mean density data mask the fact that there are restricted areas of very good habitat for some species where densities may be much higher than the regional average. Loons and Canada geese, for instance, have extremely patchy distributions. Another species with extremely patchy distribution is the Sabine's gull, which nests colonially or semi-colonially. Only 3 nesting areas are known for this species on the ANWR, all of which are on the Canning River Delta.

Table 6. Bird population densities (birds/km^2) in 12 habitat types on the ANWR coastal plain, June-August 1977.

Species	3a Wet Sedge Meadow	Riparian Willow	3d Coastal Veg. Mudflats	5a, 6b, 9b Upland Dryas Tundra	2b, 3b Very Wet Sedge Meadow	3c Mosaic wet/dry Sedge Meadow	4a Moist Sedge Meadow	4b Riparian Dryas terrace	5b Dryas Sedge Meadow/Upland Dryas Heath	9a Riparian Gravel Bars	5b Dry Sedge Meadow	7a, b, c Tussock Meadow
Arctic Loon	11											
Red-throated loon	29		6				2					
Pintail	15		234		13		45		2			
Oldsquaw	58		6		15							
King Eider							11					
Willow Ptarmigan		23									24	12
Rock Ptarmigan	1	22						34	11	5	12	7
Golden plover	80	15					7	37	110		5	26
Black-bellied plover								4				
Lesser yellowlegs			8				5					
Ruddy turnstone			15				4			37	4	
Northern phalarope	549		13	44	164	178	59	6				2
Red phalarope	154				126					12		
Long-billed dowitcher	1						21					1
Semipalmated sandpiper	418	13	266	29	21	68	22	5	32	25	57	4
Pectoral sandpiper	268	8	58	265	35		102	67	2	12		14
Dunlin	1		114									
Stilt sandpiper			8									
Buff-breasted sandpiper	3						11	2	27	6		
Pomarine jaeger	1		6									
Parasitic jaeger	4				3							6
Long-tailed jaeger	14	173	6	12	3		6	29		10	3	6
Glaucous gull	35	8	12				2	16	2	10	17	4
Arctic tern	143				9					6		
Snowy owl									2			
Yellow wagtail		32										1
Redpoll sp.		165								40		
Savannah sparrow	4	66					2	12		10		
Tree sparrow		28										
Lapland longspur	96	478	66	178	77	100	129	124	106	126	66	71
Snow bunting			12				5		2			
Unidentified shorebirds	72	1		4	6	30		4	24	6	4	2
Unidentified sparrows	9	21								7		2
Total Average pop.	1966	1053	830	532	472	421	388	340	330	312	198	152
Number of species	22	14	15	6	11	4	16	12	11	14	9	14
km of transect censused	11.4	3.7	3.2	4.3	4.6	0.04	13.6	5.8	6.7	3.5	8.8	17.2

Source:
Magoun and Robus (1977)

Table 7. Densities of breeding and non-breeding bird species on various vegetation types in the coastal plain of ANWR. Determined from intensive plot census studies 1978-1980. Sources: Okpilak - Spindler (1978a), Canning - Martin and Moitoret (1981). Densities are given as mean number of birds/km^2 observed on the plot for the duration of census effort; at Okpilak mid-June to mid-July 1978, at Canning early or mid-June through August 1979 and 1980.

Vegetation Class	3a,b,d. Wet Sedge Tundra (wet, very wet or saline complexes)				
	3a.	3b.	3b.		3d.
Habitat description	Homogeneous Wet Sedge Tundra	Flooded Sedge Tundra	Lowland very wet sedge tundra		Wet saline tundra (Coastal vegetated mudflats)
Location/date	Okpilak '78	Okpilak '78	Canning '79	Canning '80	Canning '80
SPECIES					
Arctic loon		5.2			1.7
Red-throated loon		6.4			0.8
Whistling swan		0.8			
Canada goose					0.8
Pintail		0.2			88.3
Northern shoveler					1.3
Oldsquaw	2.0	4.0			39.2
Common eider		0.4			
King eider		0.4			10.4
Willow ptarmigan				0.8	
Rock ptarmigan				2.6	1.7
Sandhill crane		0.8			
Golden plover		1.6	17.9	10.3	22.9
Black-bellied plover			9.6	9.5	8.3
Whimbrel			1.9		
Ruddy turnstone				0.5	8.8
Northern phalarope	6.5	38.4	8.6	1.6	125.0
Red phalarope	0.5	68.0	16.7	28.5	31.3
Long-billed dowitcher	3.0	6.0	19.1	7.2	3.2
Red knot					0.4
Semipalmated sandpiper		8.4	5.6	1.9	125.0
Western sandpiper					5.8
Least sandpiper	1.0				
White-rumped sandpiper				0.5	1.2
Baird's sandpiper					5.8
Pectoral sandpiper	31.4	86.4	51.2	63.7	31.3
Dunlin			10.2	6.9	31.3
Stilt sandpiper			0.9	1.3	12.5
Buff-breasted sandpiper				0.3	0.4
Unidentified shorebird			1.9		15.0
Pomarine jaeger		0.8			
Parasitic jaeger	2.0	0.8			0.8
Long-tailed jaeger	2.0	0.8			
Glaucous gull	0.5	2.0			
Sabine's gull		0.4			7.6
Arctic tern		2.4			12.5
Snowy owl		0.4			
Short-eared owl	0.5				
Lapland longspur	62.5	9.6	41.2	57.4	31.3
Mean Total Density	112.0	244.8	185.2	193.0	626.7
Plot size (km^2)	0.50	0.50	0.27	0.27	0.20

Table 7. (Continued).

Vegetation Class	3c. Wet sedge tundra (most complex)		5b. Moist sedge barren tundra complex		6a. Moist Tussock Dwarf shrub tundra
Habitat description tundra	Mosaic wet/dry - low center/high ridge polygons		Upland dry sedge tundra		Upland sedge tussock
Location/date	Okpilak '78	Canning '80	Canning '79	Canning '80	Okpilak '78
SPECIES					
Red-throated loon	1.0				
Pintail	2.0				
Oldsquaw	1.0				4.0
Willow ptarmigan		3.4			4.0
Rock ptarmigan	2.0	6.4	4.2	7.0	
Sandhill crane	1.0				
Golden plover	2.0	3.6	7.8	10.4	8.3
Black-bellied plover	2.0				
Whimbrel			0.3		
Northern phalarope	9.5	6.2	2.6		4.0
Red Phalarope	5.0	5.0	1.6	3.3	
Common snipe			0.3		
Long-billed dowitcher	1.0	0.8		1.2	4.0
Red knot		0.8			
Semi-palamated sandpiper	14.0		7.8	9.8	2.7
Least sandpiper	0.5				
White-rumped sandpiper		0.6			
Baird's sandpiper					
Pectoral sandpiper	45.0	37.2	11.1	9.2	6.7
Dunlin		10.6	3.6	3.1	
Stilt sandpiper		0.3		3.1	
Buff-breasted sandpiper	5.0	3.1	12.1	4.5	
Unidentified shorebird					
Parasitic jaeger	1.5				
Long-tailed jaeger	1.5				4.0
Horned lark				0.5	
Yellow wagtail				0.5	
Lapland longspur	96.0	109.5	61.6	89.6	97.3
Snow bunting				0.5	
Mean Total Density	191.0	203.2	113.4	138.8	141.2
Plot size (km^2)	0.50	0.25	0.25	0.25	0.25

Table 8. Comparison of mean seasonal densities for large birds (birds/km^2), ANWR and other Arctic coastal plain localities.

	ANWR		PRUDHOE BAY	NATIONAL PETROLEUM RESERVE		
	Canning River Delta	Okpilak River[1] Delta	Storkersen[2] Point	Meade River[2] Delta	East Long[2] Lake	Island[2] Lake
Arctic loon	1.3	1.6	1.6-1.9	2.1	1.2-1.5	0.8
Red-throated loon	1.6	1.0	0.5-0.6	0.2	0.5-1.3	0.1
Whistling swan	1.7	0.4	0.1-0.3	0.2	0.2	0.0
Canada goose	3.9	0.1	0.0	0.0	1.4-3.7	6.6
Brant	2.8	5.5	0.3-0.7	0.3	5.4-9.1	9.6
White-fronted goose	0.9	NA	1.0-2.2	0.7	1.0-1.1	0.9
Pintail	3.6	NA	6.2-14.1	5.1	6.5-17.1	2.3
King eider	2.6	0.6	1.9-2.4	0.1	0.0-0.3	0.3
Spectacled eider	0.9	0	0.2	0.3	0.5-0.6	0.1
Oldsquaw	3.3	10.0	1.8-2.3	1.1	3.2-3.3	2.3
Parasitic jaeger	0.6	NA	0.5	0.4	0.4	0.4
Glaucous gull	0.9	2.0	0.1-0.2	1.1	0.4-0.7	1.4
Arctic tern	0.4	NA	0.0	0.7	0.5-0.8	0.1

1. Source, Spindler (1978a).

2. Source, Derksen et al. (1981).

Most of the large bird use of the ANWR study area is concentrated within a few wetland types (as classified by Bergman et al. 1977). Bergman's types, 'basin-complex,' and 'coastal wetlands' (wet saline tundra 3d, Chapter 3; coastal vegetated mudflats, Nodler 1977) tend to receive the greatest large bird use on ANWR (Spindler 1978a, Martin and Moitoret 1981). Martin and Moitoret (1981) reported that large 'basin-complexes' on the Canning Delta, "which have irregular shorelines with islands and extensive beds of emergent vegetation (Carex aquatilis and Arctophila fulva) were often prime areas for nesting activity. In addition to providing protected nest sites on islands (Canada goose nests, for instance, were always on islands surrounded by deep water) these areas had dense stands of Arctophila which provided cover for waterfowl broods. Pintails used these grass beds during wing molt and migration, as well. The diversity and numbers of birds in these wetland types was markedly higher than the other wetlands in the study area." The other wetland type to receive extensive waterbird use was the coastal wetland, which on the Canning Delta in 1979 and 1980 were used primarily by brant, white-fronted geese, Canada geese, pintails, oldsquaw, king eiders, Sabine's gulls, and arctic terns. Intensive studies of habitat use by large birds have been conducted at NPR-A and Prudhoe Bay sites (Bergman et al. 1977, Derksen et al. 1981). The reader is referred to those studies and the annotated species list for more detailed habitat information.

Staging, Molting, and Fall Migration

Table 9 lists the species that have been observed during staging, molting and fall migration; approximately 1 August to 10 September 1978 - 1980. Major utilization of the coastal plain during this period is by: 1) large numbers of shorebirds which move into the wetter tundra types near the coast, 2) staging snow geese on the interior coastal plain; and 3) migrating brant using wet saline tundra.

The coastal shift in shorebird abundance referred to earlier resulted in about twice the density of shorebirds using lowland very wet sedge tundra in August ($320/km^2$) as compared to the June-July breeding periods at the Canning Delta (Fig. 1 and 2) (Martin and Moitoret 1981). The LANDSAT classes receiving the greatest use at this time were 2b, 3a, 3b, 3d.

Canada geese molt in river deltas, such as the Canning Delta, in mid to late July (Martin and Moitoret 1981). Snow goose staging usually begins in mid-to-late August and extends into mid-or-late September (see Annotated Species List for details). Both upland foothill tundra (classes 6a, 7a, b, c, and 8a) and coastal wet tundra (3a, b, c, d, and 4a) are used extensively. Small numgers of white-fronted geese stage in river deltas in August (Martin and Moitoret 1981). A significant eastward migration along the outer coastal plain occurs from mid-August to early September (see Annotated Species List for details). Brant migrating westward in fall along the Beaufort Sea coast frequently stop to feed in wet saline tundra (3d).

Table 9. Bird species which have been observed using coastal plain tundra habitats during staging, molting, and fall migration in ANWR, 1978-1980.

Arctic loon	Red phalarope
Red-throated loon	Common snipe
Whistling swan	Long-billed dowitcher
Canada goose	Sanderling
Brant	Semipalmated sandpiper
White-fronted goose	Western sandpiper
Snow goose	White-rumped sandpiper
Mallard	Baird's sandpiper
Pintail	Pectoral sandpiper
Green-winged teal	Dunlin
American wigeon	Stilt sandpiper
Oldsquaw	Buff-breasted sandpiper
Common eider	Pomarine jaeger
Spectacled eider	Parasitic jaeger
Red-breasted merganser	Long-tailed jaeger
Marsh hawk	Glaucous gull
Gyrfalcon	Herring gull
Peregrine falcon	Sabine's gull
Willow ptarmigan	Arctic tern
Rock ptarmigan	Snowy owl
Sandhill crane	Raven
Golden plover	Dipper
Black-bellied plover	Yellow wagtail
Bar-tailed godwit	Redpoll
Ruddy turnstone	Lapland longspur
Northern phalarope	Snow bunting

Pintails molt in 'basin-complex', 'deep *Arctophila*, shallow *Arctophila*', 'shallow-*Carex*', and 'beaded stream' wetland types (Bergman et al. 1977, Spindler 1978a, Martin and Moitoret 1981). Oldsquaw molt in 'deep-open lakes' on the coastal plain (Martin and Moitoret 1981, Taylor 1981), which fall under classes 1 and 2a, b on the LANDSAT map.

Winter

Only 7 species of birds are known to winter (or probably winter) on the ANWR study area: gyrfalcon, rock ptarmigan, willow ptarmigan, snowy owl, raven, and dipper. Habitat use during the winter by ptarmigan, snowy owl, and raven is unknown.

Bird Use of Shoreline Habitats

Prior to the intense period of coastal-oriented bird research conducted for the Environmental Assessment of the Alaskan Continental Shelf, 1975-1981, the majority of arctic bird research had emphasized ecology of tundra-nesting species. Little was known of the post-breeding activities which may involve extremely high densities of waterbirds, waterfowl, shorebirds, gulls, and terns using estuarine, shoreline, lagoon and offshore waters. Lagoon and offshore waterfowl and seabirds use shoreline habitats for some activities (e.g. nesting, roosting, etc.), however, this use is discussed in the section on lagoons and offshore waters. The objectives of this section are to describe the seasonal and spatial patterns of birds using the littoral and estuarine zone -- river mouths and mudflats, as well as shorelines of barrier islands and mainland.

On the ANWR, Divoky (1978b) surveyed breeding bird use of barrier islands in 1976. The same year, he also surveyed seasonal density of birds using spits and barrier islands at Barter Island (Divoky and Good 1979). In 1979 and 1980 intensive shoreline censuses were conducted at the Canning River Delta (Martin and Moitoret 1981). To the west at Simpson Lagoon, Johnson and Richardson (1981) performed shoreline transects in 1977 and 1978. Dependence of shorebirds on arctic littoral habitats at Barrow and other Beaufort and Chukchi Sea locations was studied by Connors and Risebrough (1977, 1978, 1981) and Connors et al. (1979).

Nesting

A total of 12 species have been found breeding in shoreline habitats on ANWR (Table 10). Glaucous gull, common eider, and arctic tern were the most common nesters. Divoky's (1978b) data for the entire ANWR barrier island system and Martin and Moitoret's (1981) data from the Canning Delta indicated 1.5 and 2.2 nests per lineal km of barrier island habitat, respectively for all species. When all shoreline habitat types at the Canning delta were considered together (e.g. barrier islands as well as mainland, mudflat, river delta, etc.) an esitmate of 1.1 nests per lineal km was obtained (Table 10), suggesting that barrier islands support higher numbers of shoreline nesters than do other shoreline habitat types.

Nests/lineal km of shoreline can be used as an index for general comparisons, but nests of some species are not evenly distributed, but rather occur in colonies. Common eider, glaucous gull, and arctic tern were frequently found in colonies of 2-8 nests for the eiders and terns, while up to 39 nests occurred in glaucous gull colonies. Such colonies were usually on an island or spit and nests were frequently only a few m apart (Divoky 1978b, Martin and Moitoret 1981, J. Levison unpubl. data, M. Spindler unpubl. data). For some species (notably common eider, glaucous gull, arctic tern, and black guillemot), barrier islands and other coastal islands represent the sole or major nesting habitat of the species on the refuge.

Table 10. Bird species found nesting in shoreline habitats of the Arctic National Wildlife Refuge, Alaska, 1976 and 1980. Index of nesting abundance is number of nests/lineal km of shoreline. Sources: 1976--Divoky (1978b); 1980--Martin and Moitoret (1981).

Species	1976 Barrier Islands Brownlow to Demarcation		1980 Barrier Islands Canning River delta		1980 All shoreline Canning River Delta	
	nests	index	nests	index	nests	index
Whistling swan					2	0.073
Brant	2	0.019				
Pintail			1	0.077	1	0.036
Oldsquaw	18	0.171	2	0.154	3	0.109
Common eider	21	0.199	10	0.769	6	0.218
Ruddy turnstone					5	0.182
Baird's sandpiper	1	0.009			3	0.109
Glaucous gull	113	1.071	6	0.462	1	0.036
Arctic tern	7	0.066	9	0.692	9	0.327
Black guillemot	1	0.009	1	0.077	1	0.036
Snow bunting			some	--	many	--
Total	163	1.545	29	2.231	41	1.126
Total km sampled	105.5		13.0		27.5	
Sampling frequency	once/year		every 4 days		every 4 days	

Summer Residents, Transients, and Migrants

Following the nesting season, tundra birds move coastally to wetter tundra habitats (Myers and Pitelka 1980) and arctic littoral habitats (Connors et al. 1979, Martin and Moitoret 1981). A dramatic increase in total bird use of all shoreline transects on the Canning River Delta was obvious in mid-July, and was composed mostly of oldsquaw and shorebirds (Fig. 3, Martin and Moitoret 1981). Overall numbers of oldsquaw and shorebirds roughly doubled or tripled between early summer and the period mid-July to early September, corresponding to the onset of molt in oldsquaw, and the post-breeding staging and fall migration of shorebirds. While shorebird use of shorelines declined steadily in August as emigration occurred (with the exception of a pulse in early September from a sanderling migration), oldsquaw use remained high into early September. Passerine use of shoreline areas increased in late July and August as the young had fledged (Martin and Moitoret 1981).

A total of 59 species were documented using the shoreline transects of the Canning River Delta in 1980 (Table 11, Martin and Moitoret 1981). "Some species, such as loons, oldsquaw, pintail, glaucous gull, arctic tern, parasitic jaeger, lapland longspur, and snow bunting were seen nearly constantly throughout the summer. Others, such as eiders, ruddy turnstone, golden plover, and Baird's and semipalmated sandpipers, disappeared only at summer's end. Some birds, such as the scoters, geese, black-bellied plover,

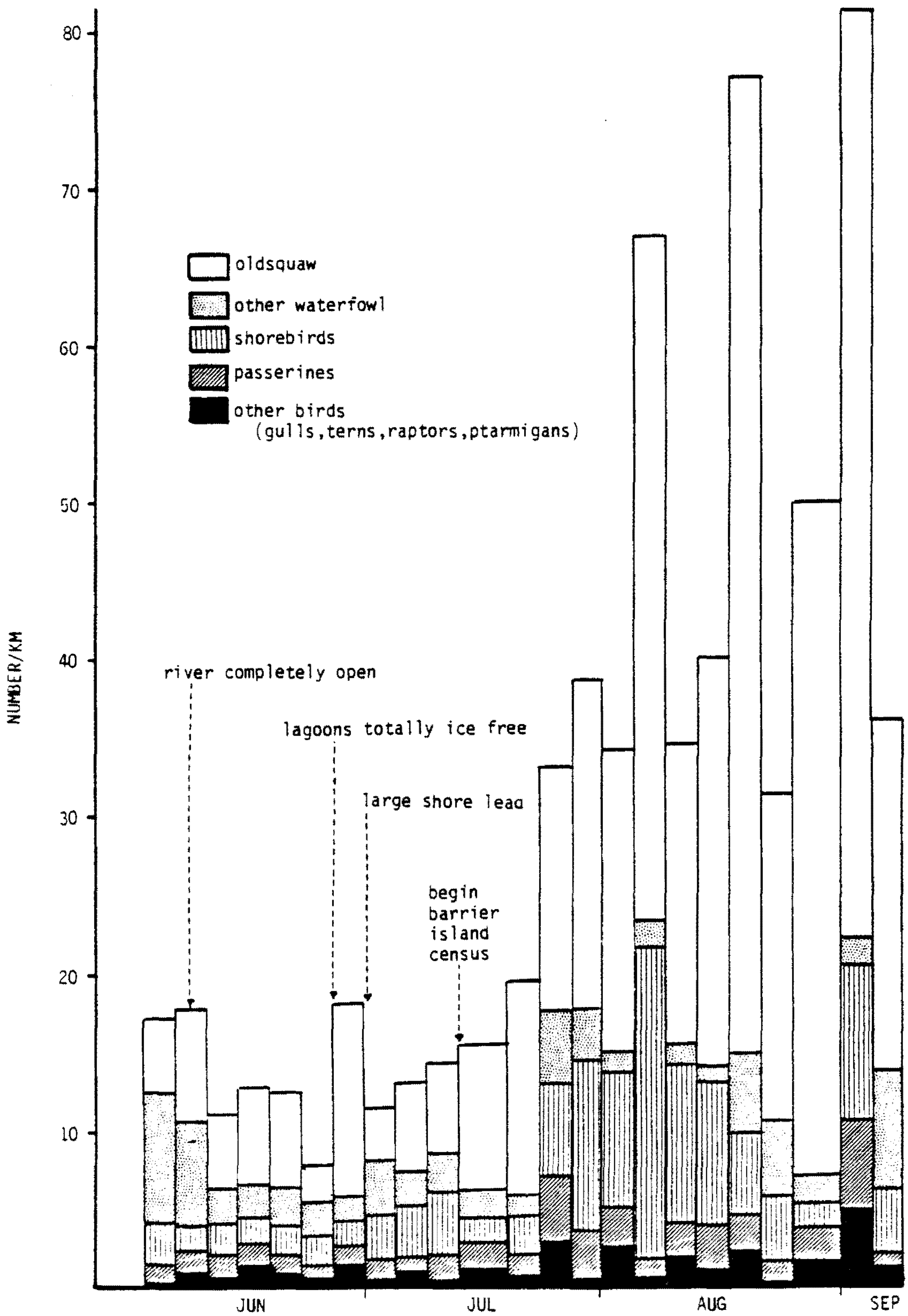

Figure 3. **Total bird use of shorelines, Canning River Delta, 1980.**
Source: Martin and Moitoret (1981).

Table 11. Presence/absence of bird species on shoreline transects by date, Canning River Delta, 1980.

Species	June	July	August	Sept.
Yellow-billed Loon	OOOOOOO	OOOOO◒●	O◒OO◒◒O	OO
Arctic Loon	◒◒●●●●●	●●●●●●●	●●●●●●●	●●
Red-throated Loon	OO●◒●●◒	●◒●◓●●●	●●●●●●●	●●
(unidentified loon)	●◓◓O◓◓O	◓O◓●●◓◓	◓◓O●◓◓●	●●
Whistling Swan	◒◒◒◒◒◒◒	◒◒◒◒OOO	OOO◒◒O◒	O◓
Canada Goose	●◓◓O◒●◒	●●OOOOO	OOOOO◒◒	OO
Brant	◒◓◓◓◓O◓	●●OOO◒O	◓OOO◓●●	●●
White-fronted Goose	●◓O◓OOO	OOOOOOO	OOOO●OO	OO
Snow Goose	◓◓OOO◓O	OOOOOOO	OOOOOO◒	OO
(unidentified goose)	◓OOOOOO	OOOOOOO	OOOOOOO	OO
Mallard	◒OOOOOO	OOOOO◒O	OOOOOOO	OO
Gadwall	◒OOOOOO	OOOOOOO	OOOOOOO	OO
Pintail	●●●●◓◒◒	●◒OO●●●	◒●●●●●O	●●
Green-winged Teal	◓OOOOOO	OOOOOOO	OOOOOOO	OO
Shoveler	OOOOOOO	OOOOOOO	OOO◓OOO	OO
American Wigeon	◒◒●O◓OO	OOOOOOO	OOOOO◓O	OO
Greater Scaup	OOOOOOO	OOOOOOO	OOOOO◓O	OO
Oldsquaw	●●●●●●●	●●●●●●●	●●●●●●●	●●
Common Eider	◓●◓●●O◒	●◓●●●●●	●●◓OOOO	OO
King Eider	◒●●●●◒●	●OO●◒●O	◓O◓OOOO	◒◒
(unidentified eider)	O●OOOO◓	●◒●●◒●●	OOOO◓◓◒	OO
White-winged Scoter	OOOOOOO	O●◓◒O◓O	OOOOOOO	OO
Surf Scoter	OOOO◒◓◓	◓O◒OOOO	OO◓OOOO	OO
Black Scoter	OOOOO◓O	OOOOOOO	OOOOOOO	OO
(unidentified scoter)	OOOO◓◓◓	◓OOOOOO	OOOOOOO	OO
Red-breasted Merganser	OOOO●●◒	◒●●●◒◓◒	◒OO◒O◒O	◒◓
(unidentified duck)	●◓◓OOO●	OOOOOO◓	OOOO◓◒O	OO
(unidentified waterfowl)	◓◓◓OOOO	OOOO◓◓◓	OOO◓O◓O	◓◒
Gyrfalcon	OOOOOOO	OOOOOOO	◓O◓OOOO	◒O
Peregrine Falcon	◓OOO◓◓O	OOOOOOO	OOOO◓◓◓	OO
Rock Ptarmigan	◒◒◒◒◒◒◒	◒◒◒◒OOO	OOOO◒OO	◒O
Willow Ptarmigan	OOOOOO◒	OOOOOOO	OOOOOOO	OO
(unidentified ptarmigan)	OOOOOOO	OOOO◒OO	OO◒OOOO	OO
Golden Plover	◒◒●◒◓◒◒	◒◒◒●●●◒	●◓O●●●O	OO
Black-bellied Plover	OOOOOOO	O◒O◒O●●	●●●O◒◒◒	◒◒
Ruddy Turnstone	◒◒●◒◒●◒	◒●◒●●◒●	●●●◒●●◒	OO
Pectoral Sandpiper	◓O◒◒◓◒O	◒◒●O◒◓O	◓O◒●O●●	◒O
Red Knot	OOOOOOO	OOOOOOO	OOOOO◒O	OO
White-rumped Sandpiper	◒OOOOOO	OOOO◒◒O	OO●●●OO	OO
Baird's Sandpiper	◒◒●●●◒●	●●●●●●◒	●●◒◒◒◒O	OO
Dunlin	●O◒O◓OO	●OOO◒◒◒	◒●●●●●●	●◒
Long-billed Dowitcher	OOOOOOO	OOOOOOO	OOOOO◓◓	◒O
Stilt Sandpiper	OOOOOOO	OOOOOOO	O◒◒O◒O◓	◒O
Western Sandpiper	OOOOOOO	OOOOOOO	OOO◒◒◒O	OO
Semipalmated Sandpiper	◒●●●●●◒	◒◒◒O◒◒◒	●●●◒◒◒O	OO
(Baird's/Semi/W-r Sandpiper)	OO◒OOOO	◒◒OO◒O◒	OO◒◒OOO	OO
Buff-breasted Sandpiper	OOOO●◒O	O◒◒◒◒◒◒	O◒◒◒◒◒O	OO
Bar-tailed Godwit	◒OOOOOO	OOOOOOO	OOOOOOO	OO
Sanderling	◒OOOOOO	OOOOOOO	OO◓O◓●●	●●
Red Phalarope	O◒O●●◒◓	◒O◒O◒◒●	◓●●●◒●O	●◒
Northern Phalarope	O◒●◓O◒◒	◒◒◓OO●◒	●●●●●●O	◒◒
(unidentified phalarope)	OOOO●OO	OOOO◒OO	O●●●◓●◓	◓O
(unid. small shorebird)	●◓●◓●◒O	◒OO◓●◒◒	◒◓●◓O◓◓	◓O
(unid. medium shorebird)	OO◓OOOO	O◒◒OOO◓	OOO◓OO◓	OO
(unid. large shorebird)	OOOOOOO	OOOOOOO	OOOOO◒O	OO
Pomarine Jaeger	◓◓◓O◓OO	◓OO◓◓OO	OOOOOOO	◓O
Parasitic Jaeger	◓◓O◓◓◓●	◓◓●◓◓O◓	◓O◓◓◓◓◓	◓◒
Long-tailed Jaeger	◓O◓◓◓O◓	OO◓◓OOO	◓O◓OOOO	OO
(unidentified jaeger)	◓OOO◓OO	OOOOOOO	OOOOOOO	OO
Glaucous Gull	◓●●●●●●	●●●●●●◓	●●●●●●●	●●
Sabine's Gull	O◒O◒●●O	◒◓OO◒OO	OO●●◒OO	◒O
Black-legged Kittiwake	OOOOOOO	OOOOOOO	OOOOOOO	●O
Arctic Tern	◓◒●●●●●	●●●●●●●	●●●●●◓◒	◒◒
Black Guillemot	OOO◒OOO	◒◒O●◒●◒	●●●◒●O◒	OO
Snowy Owl	OOOO◒O◒	OOO◒OOO	OOOOOOO	OO
Short-eared Owl	◓◒OOOOO	OOOOOOO	OOOOOOO	OO
Common Raven	OOOOO◓O	OOOOOOO	OOOOO◓O	O◓
Empidonax sp.	OOO◒OOO	OOOOOOO	OOOOOOO	OO
Redpoll	O◒O◓◓◓◓	OOOOOOO	OOOOOOO	OO
White-throated Sparrow	OOOOOOO	OOOOOOO	OO◒O◒OO	OO
Lapland Longspur	◒●◒◒◒◒●	◒◒◒●◒◒◒	●◒◒●◒◒◒	●◒
Snow Bunting	◒◒●◒◒◒●	●◒◒◒●◒◒	◒●◒◒◒◒●	◒●

O=species not observed ◓=species observed flying only ◒=species observed on shore or water only
●=species observed both on shore or water AND flying Source: Martin and Moitoret (1981).

sanderling, and other shorebird species appeared only during specific migration periods. Phalaropes, dunlin, pectoral sandpiper, long-tailed jaeger, and Sabine's gull, appeared sporadically throughout the summer, being seen principally during migration but also at other times" (Martin and Moitoret 1981).

Of the 10 shoreline transects sampled, the outside and inside barrier island and inside east spit transects showed the highest levels of bird use (Fig. 4) (Martin and Moitoret 1981). The outside west spit showed generally intermediate levels. Low levels of shoreline bird use were observed on River, Bay, Bluff, Inner lagoon shore and inside west spit transects (Martin and Moitoret 1981).

Shorebirds dominated bird use on the 4 mainland shore transects (Fig. 4) except during specific peaks of migration. With a few exceptions waterfowl dominated the spit and barrier island transects. Highlights of bird use within each of the 10 distinct shoreline habitat types (paraphrased from Martin and Moitoret 1981) include:

> The river transect received heavy use by waterfowl early in the spring, when it provided the only open water. Flocks of brant, pintail, wigeon, and king eider were seen feeding and staging in this area. The lack of snow accumulation on the higher windswept "dunes" section of the river transect made this area important to shorebirds in early spring, as it was the first habitat to become snow-free. Subsequent use of the river transect was low. The peak of "other birds" in mid-July corresponded to shorebird use of the mudflats at the river mouth.
>
> The inner lagoon shoreline transect showed relatively little bird use, especially in July. Waterfowl were seen infrequently on this transect until late August and September, when migrating brant used Wet Saline Tundra areas to stage and feed, and oldsquaw sometimes sought shelter from west winds in the lee of the shore bluffs. The "other bird" peak in mid-August corresponded to phalarope migration. In general, the use of lagoon transect by birds was similar to that of the bay transect, but use was less extensive due to the lesser amount of Wet Saline Tundra habitat on this transect.
>
> The bay transect received little use by waterfowl (although the adjacent ponds of the West Branch Flats and Wet Saline Tundra area sometimes received heavy use). The Wet Saline Tundra area at the head of the bay received heavy use by staging and feeding shorebirds (such as phalaropes, pectoral sandpipers, and semipalmated sandpipers) and Lapland longspurs, especially in mid-July. Use was low during spring migration, as this area was largely ice-covered.
>
> The bluff transect was little used except by Lapland longspurs, snow buntings, Baird's sandpipers, and ptarmigan. Within the bluff transect deep west-facing gullies provided shelter from the prevailing east winds and were found to be havens for the occasional accidental Passerine blown off-course during migration. Our sightings included an Empidonax flycatcher, a white-throated sparrow, rusty blackbird, yellow warbler, and tree sparrow.

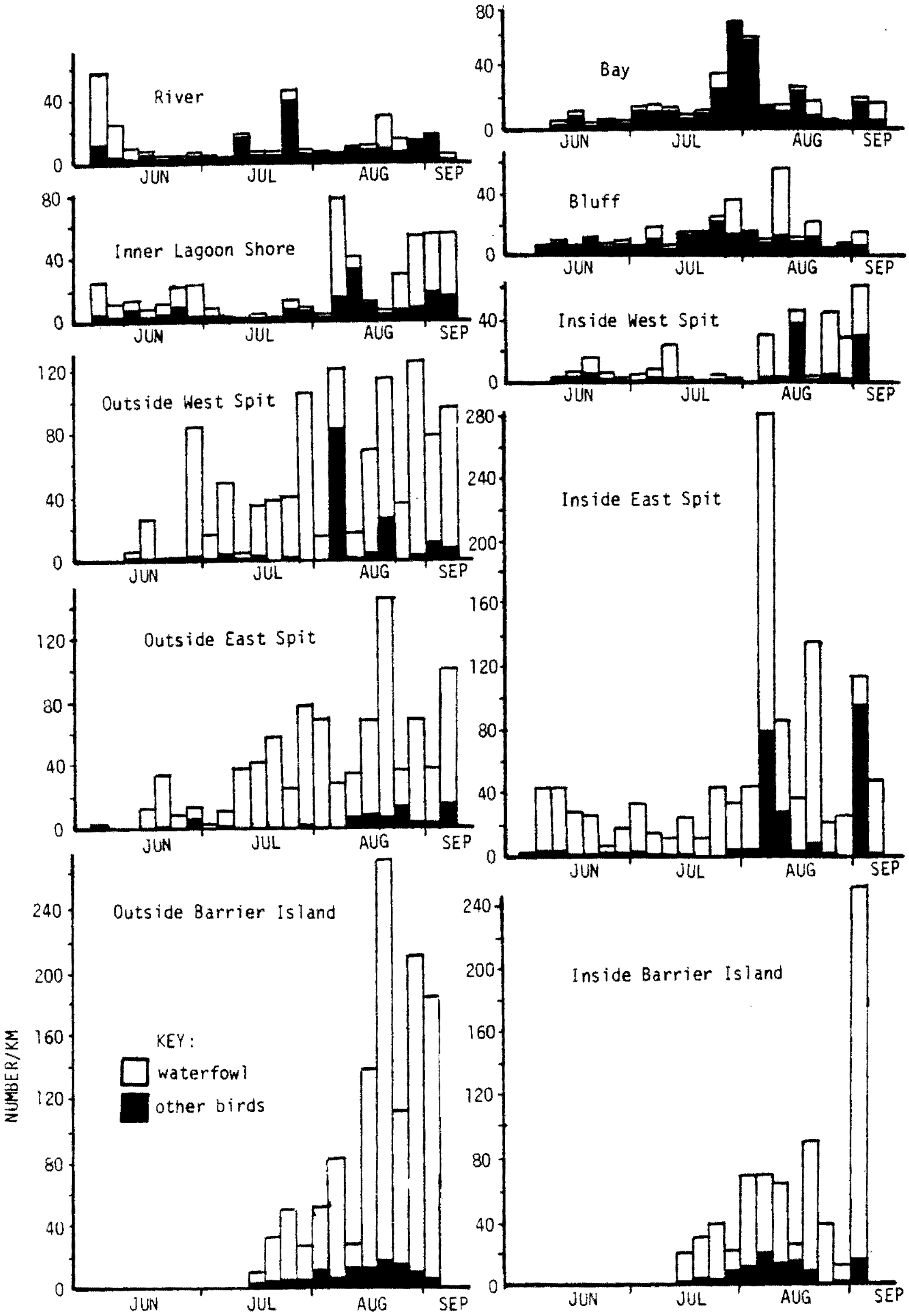

Figure 4. Bird use of shoreline habitats by transect, Canning River Delta, 1980. Source: Martin and Moitoret (1981).

The inner west spit transect received sporadic use by birds. A peak in "other birds" in August corresponded to phalarope migration, and in September to sanderling migration.

The inner east spit transect showed the same peaks of phalarope and sanderling migration. Oldsquaw numbers appeared to fluctuate widely in August, according to the daily movements of the birds.

The 2 barrier island transects showed less dramatic peaks of shorebird use during migration than did the spit transects.

In general, the 3 outer shore transects (lower 3 graphs on left) showed more use by waterfowl (especially Oldsquaw) than did the transects on inner shores of barrier islands (lower 3 graphs on right). Brownlow Lagoon and the eastern end of Flaxman Lagoon are quite shallow and were probably less preferred feeding areas for Oldsquaw, although the protection they provided was preferred for resting and molting periods.

The results of Divoky and Good's (1979) beach transects on sections of the ANWR coast on 24 June 1976 indicated 9.5 birds/lineal km of shoreline at Bernard Spit and 2.6 birds/lineal km at Barter Island in beach habitat (Table 12). A total of 4.0 birds/lineal km in Spit and Bar habitats were counted on the Bernard Harbor transect and no birds were recorded in like habitats on the Barter Island transect (Divoky and Good 1979). These indices exceeded values for all other June transects they performed to the west except for Cape Lisburne (40.1 and 17.2 birds/lineal km in Beach and Spit/Bar habitats, respectively). Total birds/lineal km of shoreline appeared to be somewhat lower near Barter Island in late June 1976 as compared to late June 1980 at the Canning River Delta (see Table 12, Fig. 3).

Table 12. Indices of abundance of birds seen along shoreline transects near Barter Island, Alaska, 24 June 1976 (Source: Divoky and Good 1979).

Species	Bernard Harbor		Barter Island
	Beaches	Spits & Bars	Beaches
Arctic loon	0.1*	-	
Red-throated loon	1.2*	-	
Pintail	-	1.5	
Oldsquaw	0.7	0.7	
Common eider	3.8	0.5	
Spectacled eider	-	0.2	
Surf scoter	3.7*	-	
Semipalmated sandpiper			0.3*
Baird's sandpiper	-	0.8	1.0
Red pharalope	-	0.1*	
Redpoll	-	0.1*	
Landland longspur			0.3*
Snow bunting	-	0.1*	1.0
Total birds/lineal km	9.5	4.0	2.6
Total km sampled	8.3	8.3	3.1

*Denotes single sighting

Late July-early August shoreline bird abundance at the Canning Delta in 1980 was similar to Barrow but was lower than Oliktok in 1977 (Table 13). Mid-August abundance at the Canning was lower than both Barrow and Oliktok. Late-August shorebird abundance at the Canning in 1980 was higher than Barrow in 1977 but lower than Oliktok in 1977 (Table 13).

Table 13. Comparison of shorebird abundance for 3 Arctic coastal areas. Index of abundance is birds/lineal km of shoreline. Sources 1977 -- Connors and Risebrough (1978); 1980 -- Martin and Moitoret (1981).

Year	Location	Date		
		28 July-9 Aug.	13 Aug.-25 Aug.	29 Aug.-7 Sept.
1977	Barrow	12.5	107.5	7.0
1977	Oliktok	31.5	45.5	17.7
1980	Canning-ANWR			
	Outside Barr. Isl.	8.2	7.6	5.1
	Inside Barr. Isl.	12.7	4.5	18.3
	Mainland	12.8	3.7	3.5
	Mean	11.3	5.3	9.0

The above comparisons of ANWR shoreline use data with other arctic areas, (Lisburne, Oliktok, and Barrow) do not indicate a clear pattern, but instead show seasonal, annual, and spatial variation in abundance. Some of the factors involved with this variability are physical, environmental, and biological (Connors and Risebrough 1981), and are discussed below. Connors and Risebrough (1977), working primarily at Barrow, but with sampling sites at Lonely, Wainwright, Peard Bay, and Icy Cape, 1975-1977, identified 4 major periods of shorebird littoral zone use:

(1) Early June, when pre-breeding adults forage along beaches, saline pools, or littoral slough edges.

(2) Late June through early July, flocks and individuals of non-breeding and post-breeding adults of several species move from the tundra to utilize habitats at the edges of small coastal lagoons and nearby brackish pools.

(3) Late July and early August, adults of both sexes of most species are released from nesting duties as young birds fledge and become self-sufficient. These flocking adults begin their southward migration by moving into littoral areas.

(4) The phase of heaviest use of littoral areas occured during the entire month of August, stretching into September for some species. Juveniles leave tundra areas where they had fed before fledging and flock in littoral habitats, beginning their southward movements independently of, and later than, the adults.

Two major gradients in littoral habitats were identified by Connors and Risebrough (1977) based upon foraging and microhabitat data "the first corresponded to the position of the foraging site with respect to the water line, while the second described changes in habitat relating to particle size of the substrate. Species using the littoral zone around Barrow responded differently to these gradients, in ways that probably affect their susceptibilities to oil damage". They noted several different types of shoreline habitats used most by shorebirds, including mudflats, Wet Saline Tundra (saltmarsh), inner lagoon margins, brackish pools, and outer coast gravel shores. Narrow mainland beaches backed by eroding tundra cliffs received the lowest levels of bird use.

Shorebirds foraging in brackish mudflats within the littoral zone west of ANWR lagoon edge, and Wet Saline Tundra pool areas ate oligochaetes and chironomid fly adults and larvae (Connors and Risebrough 1977). In contrast, birds foraging along the outer gravel coasts, and lagoon/barrier island beaches ate large marine zooplankton some of which were washed up along the shore. Connors and Risebrough (1977) have suggested that shorebird staging and feeding in the littoral zone preceeding fall migration, would function as an energy storage process immediately before migration. For this reason, they have suggested that littoral habitats are critical for arctic shorebirds. Additionally, banding recovery data near Barrow indicate high turnover rate whereby individual birds use a particular shoreline area for only a few days before moving on, indicating reliance of far more than just local birds upon each stretch of shoreline (Connors and Risebrough 1977). "Annual variation in numbers of birds using the littoral zone in late summer reflects more than just local breeding density fluctuations, and is not closely related to local weather during the breeding season. It is related to late summer weather, possibly mediated through changes in turnover rates of migrant birds" (Connors and Risebrough 1981).

The magnitude and timing of post-breeding shoreline movements were correlated with post-breeding season air temperatures: "In years of warmer late-summer temperatures, littoral zone densities are higher, and migration peaks are earlier... post-breeding migrant densities are influenced more by late summer temperatures than by local breeding season temperatures, and this suggests that birds respond to conditions within the littoral zone during late summer" (Connors and Risebrough 1981). Bird species which fluctuate annually in numbers similarly in the littoral zone "do not in general share the same breeding habitat...they do, however, occur together in the same post-breeding habitats". The different species groups and habitats described Connors and Risebrough (1981) were as follows:

<u>Gravel Beaches</u>

ruddy turnstone
sanderling
red phalarope

<u>Littoral Flats, Lagoon Edges</u>

golden plover
semipalmated sandpiper
western sandpiper
Baird's sandpiper
pectoral sandpiper
dunlin
long-billed dowitcher
northern phalarope

Bird Use of Lagoon and Offshore Habitats

The greatest concentrations of summer resident waterfowl on the Arctic National Wildlife Refuge (ANWR) occur in the shallow coastal waters of the Beaufort Sea. This area includes shallow coastal lagoons formed by gravel barrier islands and shoals; river deltas; mudflats; and offshore waters.

Previous surveys conducted on ANWR included Schmidt (1970), Frickie and Schmidt (1974), and Spindler (1979a, 1981b). Bartels (1973), Gollop and Richardson (1974), Ward and Sharp (1974), Harrison (1977), Divoky and Good (1979), and Johnson and Richardson (1981) conducted studies in nearby coastal waters. These studies identified Beaufort Sea lagoons as one of the most important habitats for molting waterfowl and staging shorebird populations in the arctic region of Alaska.

Comparable aerial transect surveys over the coastal lagoons and offshore waters of the ANWR were conducted periodically during the open water seasons of 1978, 1980, and 1981. The coastal lagoon transects included the 400 m band directly adjacent to the barrier islands for 11 selected lagoons. The offshore transect included the 400 m band directly seaward of the barrier island or shoreline along the entire north coast of ANWR. A major characteristic of bird populations using the lagoons of ANWR was extreme seasonality of use. In all years, 1978-1981, the use of lagoon by birds began with snow melt in early June. During this period, river overflow covered the deltaic portions of the lagoons and provided the first open water of the season (Spindler 1981b). Studies in other arctic coastal areas have confirmed this phenomenon (Bergman et al. 1977, Schamel 1978, Johnson and Richardson 1981). Bird use remained at low levels until ice-out occured, usually in late June to mid-July. Populations gradually increased through July until a peak was reached in August, then populations gradually declined. However, a second peak was often observed in mid-September as birds began staging for fall migration. Some birds were usually present until freeze-up in late September or early October (Spindler 1981b).

Habitats

Seasonal Use

Six key avian species groups were considered to be representatives of coastal lagoon waterbirds. The key species were: Arctic, red-throated, and yellow-billed loons, are fairly common breeders, migrants, and transients, and sensitive to disturbance; Oldsquaw - The most abundant migrant, molter, and major avian consumer in lagoon ecosystem; Phalarope sp. - abundant coastal nesters and common consumers in lagoons late in open water season (species not separable during aerial surveys); Glaucous gull - the second most abundant avian consumer in lagoon ecosystem, and a scavenger that may increase in abundance due to human activities; Eider sp. - are common nesters and migrants; Scoters - are uncommon transients.

Three surveys were conducted in 1980 and 5 in 1981 on the 11 selected coastal lagoons (Table 14 & 15). The 11 surveyed lagoons were selected as representing lagoons of various bird use levels (high, medium and low) based on previous years information (Spindler 1981b). A record of individual species was kept during these surveys. Two additional surveys were conducted in 1978. However, only a total of all bird species encountered was recorded. (Table 16)

Table 14. Summary of 1980 aerial bird population surveys of 11 selected coastal lagoons, Arctic National Wildlife Refuge, Alaska. Based on aerial transects flown on 1 August (1); 20 August (2); 9 September (3), 1980. Sigma (Σ) represents cumulative use of the lagoon by birds, a summation of total numbers of each species over the 3 surveys.

	Brownlow L.				Tamayariak L.				Simpson Cove				Arey Lagoon			
	1	2	3	Σ	1	2	3	Σ	1	2	3	Σ	1	2	3	Σ
Arctic loon	3		2	5	1			1		3		3	4	1		5
Red-throated loon	1			1	1			1	1		4	5		2	2	4
Loon, sp.		1	5	6			1	1			1	1				
Brant			21	21			103	103								
White-fronted goose																
Duck, sp.							4	4			2	2				
Eider, sp.	10			10							9	9	16			16
Oldsquaw	86	627	307	1020	248	3515	95	3858	1596	2012	39	3647	1402	214	166	1782
Falcon, sp.														1		1
Phalarope, sp.		5		5						3		3		29		29
Small shorebird						500		500					10			10
Medium shorebird							5	5							1	1
Glaucous gull		9		9		18	29	47	2	22	19	43	103	14	16	133
Arctic tern		1		1		89		89								
No. of taxa	4	5	4	9	2	5	6	10	3	4	6	8	5	5	4	9
Total no. of birds observed	100	643	335	1078	249	4123	237	4609	1599	2040	74	3713	1535	259	185	1979
Area sampled (km^2)		6.18				7.52				6.71				5.37		
Density (birds/km^2)	16	104	54	174	33	548	32	613	213	271	10	494	286	48	34	369

Table 14. (Continued)

	Jago Lagoon				Tapkaurak L				Orukatalik L.			
	1	2	3	Σ	1	2	3	Σ	1	2	3	Σ
Yellow-billed loon									1			1
Arctic loon	1			1								
Red-throated loon											2	2
Loon, sp	1		2	3			5	5			3	3
Diver	1			1								
Duck, sp		4		4								
Eider, sp.												
Oldsquaw	489	52	940	1481	327	286	300	913	425	354	779	1558
Surf scoter	12			12								
Phalarope, sp.		40		40								
Medium shorebird						4		4				
Shorebird, sp		15		15								
Black-bellied plover										1		1
Jaeger, sp.							2	2				
Glaucous gull	19	1	379	399		1	1	2	11		3	14
Arctic tern						1		1	9			9
Black guillemot						1		1				
No. of taxa	6	5	3	9	1	5	4	7	4	2	4	7
Total no. of birds observed	523	112	1321	1956	327	293	308	928	446	355	787	1588
Area sampled (km^2)		2.69				4.30				2.15		
Density (birds/km^2)	194	42	491	727	76	68	72	216	207	165	366	739

Table 14. (Continued)

	Pokok Lagoon 1	2	3	Σ	Nuvagapak L. 1	2	3	Σ
Yellow-billed loon						1		1
Arctic loon		1	1	2	1		1	2
Red-throated loon								
Loon, sp.						1	2	3
Whistling swan		2	2					
Dabbler, sp.								
Duck, sp							4	4
Oldsquaw			12	12	735	762	296	1793
White-winged scoter							4	4
Scoter, sp							4	4
Red-breasted merganser								
Phalarope, sp.			1	1		3		3
Small shorebird	65			65	7	6		13
Medium shorebird	16			16	201			201
Plover, sp.						8		8
Parasitic jaeger								
Glaucous gull	1		1	2	4	11	15	30
Arctic tern								
No. of taxa	3	1	5	7	5	7	7	12
Total no. of birds observed	82	1	17	100	948	792	326	2066
Area sampled (km^2)		2.01				5.91		
Density (birds/km^2)	41	1	8	50	160	134	55	350

Table 14. (Continued)

	Egaksrak L.				Demarcation B.			
	1	2	3	Σ	1	2	3	Σ
Yellow-billed loon								
Arctic loon					1		1	2
Red-throated loon	2			2				
Loon, sp.		2	2	4		1	1	2
Whistling swan							1	1
Snow goose								
Pintail		22		22				
Duck, sp.								
Common eider					3			3
Eider, sp.						4		4
Oldsquaw	139	261	178	578	198	1736	227	2161
Surf scoter			3	3				
Red-breasted merganser								
Phalarope.sp.	4			4	4			4
Small shorebird	16			16	1			1
Medium shorebird								
Parasitic jaeger								
Jaeger, sp.								
Glaucous gull	2	1	70	73	1		103	104
Arctic tern								
No. of taxa	5	4	4	8	6	3	5	9
Total no. of birds observed	163	286	253	702	208	1741	333	2282
Area sampled (km^2)		2.69				2.01		
Density ($birds/km^2$)	61	106	94	261	103	866	166	1135

Table 15. Summary of 1981 aerial bird population surveys of 11 selected Coastal Lagoons, Arctic National Wildlife Refuge, Alaska.

	Brownlow 6.2 km^2				Tamayariak 7.5 km^2			
Species	July 23, 1981	August 4, 1981	August 26, 1981	September 18, 1981	July 23, 1981	August 4, 1981	August 26, 1981	September 18, 1981
Oldsquaw	50	690	94	264	78	860	31	20
Glaucous gull	2	7	5	85	1	22	1	258
Eider sp.					1	75		37
Red-throated loon			1			2		
Arctic tern						1		
Phalarope sp.						2		
Shorebird						2		
Arctic loon		1	2					
Loon Sp.			3					
Total	52	698	105	349	80	964	32	315
Density(Birds/km^2)	8	113	17	56	11	129	4	42
Number of species	2	3	5	2	3	7	2	3

	Simpson Cove 6.7 km^2				Arey Lagoon 5.4km^2			
	July 23, 1981	August 4, 1981	August 26, 1981	September 18, 1981	July 23, 1981	August 4, 1981	August 26, 1981	September 18, 1981
Oldsquaw	180	1164	47	Not	267	461	97	1209
Glaucous gull			3		4	3	21	871
Red-throated loon		9		Separated	1	2		
Eider sp.						7		
Phalarope sp.						85		
Arctic loon		3				2		
Loon sp						2		
Small shorebird			30					
Total	180	1176	80	-	272	562	118	2080
Density(Birds/km^2)	27	176	12		50	104	22	385
Number of species	1	3	3		3	7	2	2

Table 15. (Continued)

	Jago Lagoon 2.7 km^2				Tapkaurak Lagoon 4.3 km^2			
	July 22, 1981	August 3, 1981	August 24, 1981	September 18, 1981	July 22, 1981	August 3, 1981	August 24, 1981	September 18, 1981
Oldsquaw	615	585	484	21	2149	1082	97	17
Glaucous gull	2	3	7	43	21			55
Pintail	1							
Arctic loon	2							
Loon sp.	1	3			1			
Scoter sp.					1			
Arctic tern			1					
Com. eider				2				
W.W. scoter				1				
Red-breasted merganser								2
Total	621	591	492	67	2172	1082	97	74
Density(-Birds/km^2)	230	219	182	25	505	252	23	17
Number of species	5	3	3	4	4	1	1	3

Table 15. (Continued).

	Oruktalik Lagoon 2.2 km^2				Pokok Lagoon 2.0 km^2			
	July 22, 1981	August 3, 1981	August 24, 1981	September 18, 1981	July 22, 1981	August 3, 1981	August 24, 1981	September 18, 1981
Oldsquaw	1828	517	9	35	7	36	1	
Glaucous Gull	21	5		3				23
Eider sp.	1							
Scoter sp.	1	2						
Yellow-billed loon	1				2			
Loon sp.	1					1	1	
Phalarope sp.		1						
Total	1853	525	9	38	9	37	2	23
Density(-Birds/km^2)	842	239	4	17	5	19	1	12
Number of species	6	4	1	2	2	2	2	1

Table 15. (Continued).

	Nuvagapak Lagoon 5.9 km^2				Egaksrak Lagoon 2.7 km^2			
	July 22, 1981	August 3, 1981	August 24, 1981	September 18, 1981	July 22, 1981	August 3, 1981	August 24, 1981	Sepetmber 18 1981
Oldsquaw	494	435	586	6	101	299	56	6
Duck sp.	4	1			4			
Glaucous gull	2	4	26	81	8	5		8
Arctic tern	1							
Arctic loon	2		1					
Com. eider					10			
White swan					16			
Medium shorebird					5			
Scamp sp.						1		
Loon sp.		2				1		
Pintail			25					
Total	503	442	638	87	144	306	56	14
Density (Birds/km^2)	85	75	108	15	53	113	21	5
Number of species	5	4	4	2	6	4	1	2

Table 15. (Continued).

	Demarcation Bay 2.0 km2			
	July 22, 1981	August 3, 1981	August 24, 1981	September 18, 1981
Oldsquaw	1272	726	864	No Separation
Eider sp.	1	11		
Scaup sp.	10			
Glaucous gull	3	1	2	
Arctic tern	1			
Arctic loon	1	1		
Loon sp.		1		
Scoter sp.		2		
Total	1288	742	866	--
Density Birds/km^2	644	371	433	
Number of species	6	6	2	--

Table 16. Summary of aerial survey data for all bird species on 11 selected coastal lagoons, Arctic National Wildlife Refuge, Alaska. 1978, 1980, 1981

	Lagoon										
	Brownlow	Tamayariak	Simpson	Arey	Jago	Tapkaurak	Oruktalik	Pokok Lag.	Nuvagapak	Egaksrak	Demarcation
Density - Birds/km^2 (all species):											
July 5, 1978	31	13	42	0	24	61	239	69	47	39	197
July 22, 1978	109	115	52	45	55	138	214	7	112	74	476
August 1, 1981	16	33	238	286	194	76	207	41	160	61	104
August 20, 1980	104	548	304	48	42	68	165	0.5	134	106	866
September 10, 1980	54	32	11	35	491	72	366	9	55	94	170
July 22, 1981	8	80	27	50	230	505	842	5	85	53	644
August 3, 1981	113	964	176	104	219	252	239	19	75	113	371
August 24, 1981	17	32	12	22	182	23	4	1	108	21	433
September 18, 1981	56	315	Not Done	385	25	17	17	12	15	5	Not Done
$\bar{X}$	56	237	108	108	162	135	255	18	88	63	408
Total Individuals:											
July 5, 1978	194	101	284	0	65	262	529	138	279	104	395
July 22, 1978	671	868	347	240	149	594	461	13	660	200	956
August 1, 1980	100	249	1599	1535	523	327	446	82	948	163	208
August 20, 1980	643	4123	2040	259	112	293	355	1	792	286	1741
September 10, 1980	335	237	74	185	1321	308	787	17	326	253	333
July 22, 1981	52	80	180	272	621	2172	1853	9	503	144	1288
August 3, 1981	698	964	1176	562	591	1082	525	37	442	306	742
August 24, 1981	105	32	80	118	492	97	9	2	638	56	866
September 18, 1981	349	315	Not Done	2080	67	74	38	23	87	14	Not Done
Total	3147	6969	5780	5251	3941	5209	5003	322	4675	1526	6529
$\bar{X}$	350	774	723	583	438	579	556	36	519	170	816
Number of taxa											
July 5, 1978	3	2	4	0	3	4	3	5	5	3	4
July 22, 1978	6	7	9	4	6	3	1	3	5	6	5
August 1, 1978	4	2	3	5	6	1	4	3	5	5	6
August 20, 1980	5	5	4	5	5	5	2	1	7	4	3
September 10, 1980	4	6	6	4	3	4	4	5	7	4	5
July 22, 1981	2	3	1	3	5	4	6	2	5	6	6
August 3, 1981	3	7	3	7	3	1	4	2	4	4	6
August 24, 1981	5	2	3	2	3	1	1	2	4	1	2
September 18, 1981	2	3	-	2	4	3	2	1	2	2	-
$\bar{X}$ No. taxa	3.8	4.1	4.1	3.6	4.2	2.9	3	2.7	4.9	3.9	4.6
No. different taxa	7	4.5	4.5	8	3	10	9	11	1	6	2

Fig. 5a portrays 3 years of surveys with density of all bird species combined for the 11 lagoons. The 1978 data indicate an increase in bird numbers early in the season. The peak is unknown. Data for 1980 indicate peak bird densities on the lagoons about 2 weeks later than 1981. This delay was probably a result of earlier ice-out in 1981. A second smaller peak occurred during the last survey of 1981.

Oldsquaw densities, also, peaked about 2 weeks later in 1980 than in 1981 (Fig. 6e). Glaucous gulls increased in density in the lagoons in 1980 and 1981 (Fig. 6.). Loons and phalaropes both show peaks of density later in 1980 than in 1981 (Fig. 6a and b).

Eiders and scoters show densities with 2 peaks (Fig. 6d and f). This probably reflects the molt migration of males several weeks before fall migration of females and young. Gollop and Davis (1974a) had similar findings for scoters in the Canadian Beaufort Sea. See Annotated Species List for detailed review of eider and scoter use of the Beaufort Sea coast.

These data illustrate that bird use in the coastal lagoons exhibits regular seasonal fluctuations, however, the timing of these fluctuations vary from year to year. Peak use by all birds and, particularly, oldsquaw and the other key species can vary by over 2 weeks (Fig. 6). These data also illustrate that lagoons are important to migratory birds throughout the period when open water is present. Gollop and Richardson (1974) and Johnson and Richardson (1981) have documented similar use curves for oldsquaw at other Beaufort Sea coastal areas.

An attempt was made to rank the 11 selected lagoons in order of importance to birds. This ranking scheme considered density, absolute number of birds present, and the number of species present. Obviously, a habitat with a high bird density that is limited in size and/or involves few individuals or species is not as important as a habitat of high bird density, with high population levels and high species richness. This scheme gives equal weight to total number of individuals present, density levels, and species or taxa present using data from a total of 9 aerial surveys conducted in 1978, 1980 and 1981 (Table 17). Population data were derived from the 400 m wide transect strip adjacent to the barrier island. In most cases, this area represented only a fraction of the total lagoon surface area. Therefore, all estimates should be considered a minimum.

Five of the 11 lagoons exhibited bird densities of over 100 birds/km^2. Seven lagoons supported an average of over 350 birds per survey. As mentioned earlier, the surveys utilize only a fraction of the lagoon surface area. Therefore, this ranking is tenative as the lagoon survey technique will be refined. However, these data suggest the importance of ANWR coastal lagoons to migratory birds.

Since oldsquaw are the most numerous migratory bird utilizing the lagoons, a separate ranking of lagoon use was made for this species. Only surveys from 1980 and 1981 delineated oldsquaw separately from all birds. Therefore, the ranking utilizes only these 2 years data and the ranking is made for density per survey and mean number per survey (Table 18). For a more detailed discussion of oldsquaw use of coastal lagoons see Annotated Species List - Oldsquaw.

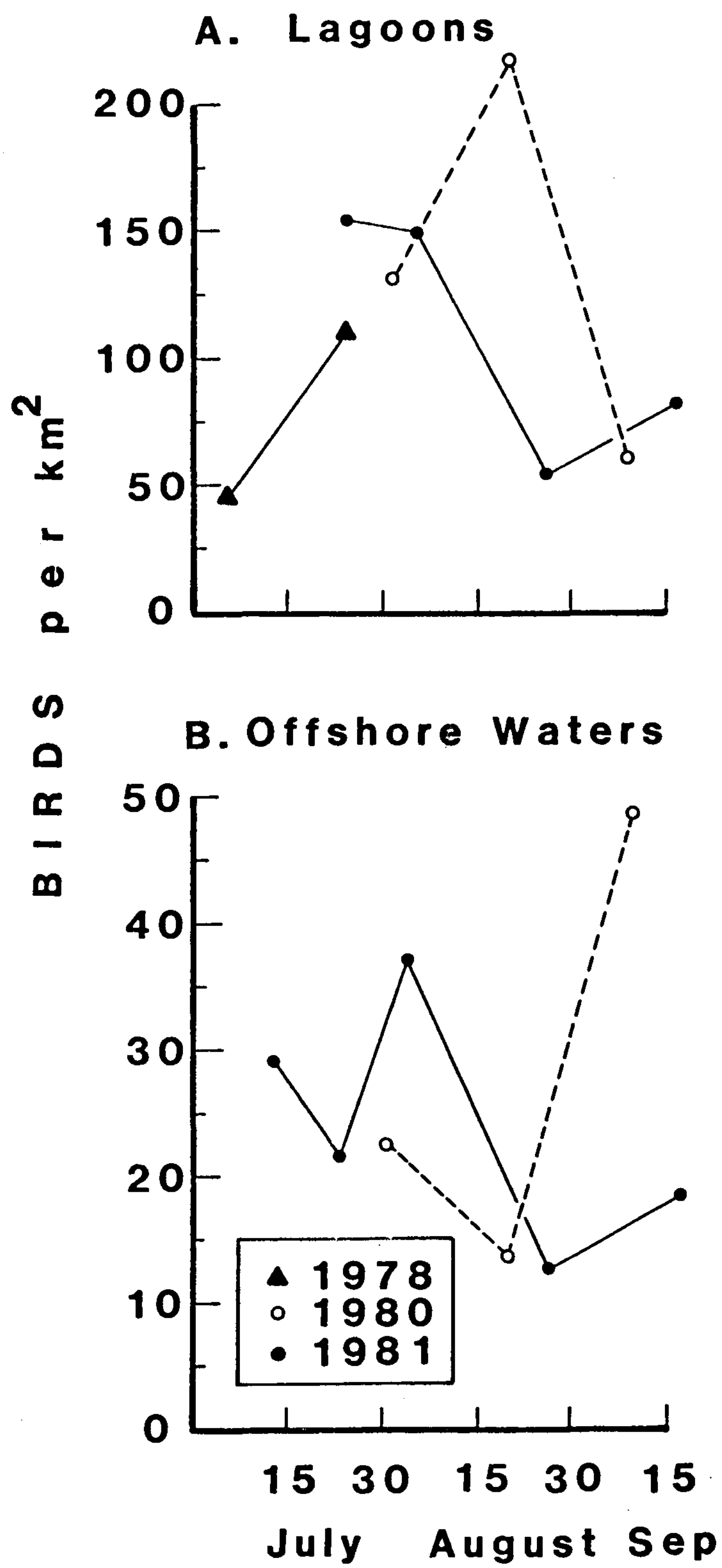

Figure 5. Seasonal abundance of all bird species combined for 11 selected lagoons of the Arctic National Wildlife Refuge.

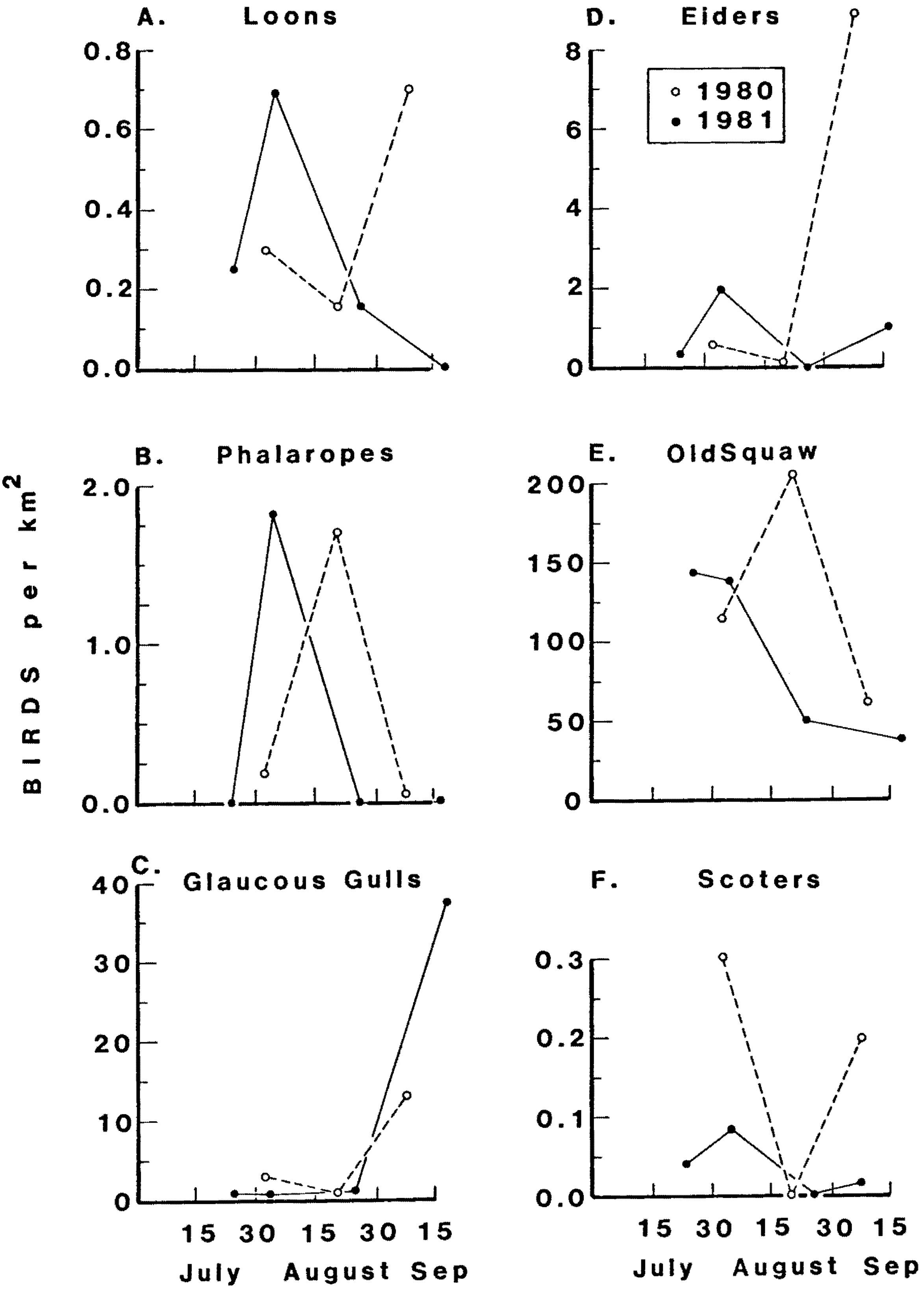

Figure 6. Seasonal abundance of 6 key species (or species groups) in coastal lagoons of the Arctic National Wildlife Refuge (1980-1981).

Table 17 Importance ranking of 11 selected coastal lagoons according to mean rank in bird population, density, and species richness. Arctic National Wildlife Refuge, Alaska, 1978, 1980 & 1981.

Lagoon	Mean Density /Survey Birds/km2	Rank	Mean No. Birds/ /Survey	Rank	Mean No. Taxa /Survey	Rank	Overall Mean Rank
Demarcation Bay	408	1	816	1	4.6	2	1.3
Tamayariak	237	3.5	774	2	4.1	4.5	3.3
Simpson Cove	108	6.5	723	3	4.1	4.5	4.7
Jago	162	5	438	8	4.2	3	5.3
Nuvagapak	88	8	519	7	4.9	1	5.3
Oruktalik	255	2	556	6	3	9	5.7
Arey	108	6.5	583	4	3.6	8	6.2
Tapkaurak	237	3.5	579	5	2.9	10	6.2
Egaksrak	63	9	170	10	3.9	6	8.3
Brownlow	56	10	350	9	3.8	7	8.7
Pokok Lagoon	18	11	36	11	2.7	11	11

Table 18. Importance ranking of 11 selected coastal lagoons for oldsquaw use. Arctic National Wildlife Refuge, Alaska, 1980 & 1981.

Lagoon	Mean Density /Survey Oldsquaw/km^2	Rank	Mean No. Oldsquaw /Survey	Rank	Mean Rank
Demarcation Bay	418	1	837	2	1.5
Simpson Cove	125	5	840	1	3
Oruktalik	256	2	564	5	3.5
Tapkaurak	141	4	608	4	4
Tamayariak	92	7	692	3	5
Jago	168	3	455	8	5.5
Arey	101	6	545	6	6
Nuvagapak	80	8	473	7	7.5
Brownlow	49	10	303	9	9.5
Egaksrak	55	9	149	10	9.5
Pokok Lagoon	4	11	8	11	11.0

Nine lagoons supported an average of over 300 oldsquaws per survey. Six lagoons exhibited densities of over 100 oldsquaw/km^2. Johnson and Richardson (1981) found average oldsquaw density at Simpson Lagoon of 145 oldsquaw/km^2.

Offshore Habitats

The species with the highest observed density in the offshore transects (generally 0-400 m offshore of the barrier islands) was oldsquaw. Second in density was glaucous gull. This held for all 1980 surveys and all but the 18 Sept. 1981 survey (Table 19). During the 18 Sept. 1981 survey, glaucous gulls were more numerous than oldsquaw. Total density ranged from 13 birds/km^2 on the 24 & 26 August 1981 survey to 48 birds/km^2 on 9-10 September 1980 survey.

Offshore bird use was not as consistent as in lagoons. In both 1980 and 1981 there was an increase in bird density during the September survey (Fig. 5b). In 1980, oldsquaws were the major reason for this increase. Possibly post-molting male birds move to the offshore areas to feed. In 1981, glaucous gulls increased dramatically during the Sept. survey. Oldsquaw use peaked about 30 days earlier in 1981 than in 1980 (Fig. 6e). Other lagoon data suggested an early season in 1981.

In summary, limited offshore data suggest that this area does not exhibit as high a level of bird use as the coastal lagoon system. However, the offshore area does host considerable bird use. As with the lagoons, the use can vary a great deal within a particular season and from year to year.

Data Gaps

Future shorebird population monitoring efforts will have to be designed to separate the weather-caused variability from impact caused variability, and that population changes may be exhibited in entire species groups rather than individual species.

More effort should be placed on determining which shoreline types are most valuable to birds on ANWR. This should be accomplished through a more extensive sampling effort using the sampling methods and intensity developed by Martin and Moitoret (1981). The coastline should be mapped according to shoreline type and levels of bird use. Additionally, gaps in barrier islands have been shown to concentrate birds both in the open water (Martin and Moitoret 1981, Spindler 1981b) and along shorelines (Martin and Moitoret 1981). The factors causing this concentration should be identified and the means developed to adequately protect gaps from disturbance and pollution.

In subsequent seasons the surveys of lagoons should be continued and expanded to cover the entire lagoon surface. Studies investigating physical factors such as lagoon depth, salinity, etc. when coupled with samples of epibenthic invertebrates will give a better understanding of why particular lagoons are more heavily utilized.

Major data gaps for brant are; frequency and fidelity with which brant use individual coastal mudflat area, the energetic importance of these foraging areas to the success of brant arriving at the breeding ground or staging areas in a healthy condition. Moreover, data on the origin and destination of oldsquaw using ANWR lagoons, their residence time, turnover rates, and comparisons of population levels among several differing lagoon types on ANWR and elsewhere along the Beaufort coast will be needed to elucidate the relative importance of coastal lagoons on ANWR to continued population maintenance (statewide and international).

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Table 19. Summary of 1980 and 1981 bird population data for offshore waters adjacent to the Arctic National Wildlife Refuge, Alaska. Based on aerial transects between Brownlow Point and the U.S. - Canada border. Densities are given in birds km/2.

	Aug. 1-3, 1980		Aug. 20, 1980		Sept. 9-10, 1980		July 12, 1981		July 22, 23, 1981		Aug. 3 & 4 1981		Aug. 24-26 1981		Sept. 18, 1981	
	No.	Dens.	No.	Dens.	No.	Dens.	No.	Dens.	No.	Dens.	No.	Dens.	No.	Dens.	No.	Dens.
Yellow-billed loon					1	0.01	5	0.06	8	0.09	3	0.03				
Arctic Loon	11	0.13	7	0.08	11	0.13	13	0.15			14	0.16	2	0.02		
Red-throated loon	14	0.16	1	0.01	19	0.22	9	0.10	4	0.05	20	0.23	2	0.02		
Loon, sp. 3	0.03	2	0.02	55	0.64	11	0.13	2	0.02	23	0.27	3	0.03			
Brant			25	0.29	53	0.61										
Duck, sp	7	0.08			1	0.01					3	0.03				
Common Eider	1	0.01			1	0.01	21	0.24			4	0.05				
Eider sp. 26	0.30	2	0.02	61	0.71	32		122	1.41	51	0.59	12	0.14	110	1.27	
Oldsquaw	1467	17.0	1034	11.98	3673	42.56	2224	25.77	1696	19.65	2868	33.23	824	9.55	240	2.78
White-winged Scoter					7	0.08	45	0.52	20	0.23						
Surf Scoter									1	0.01						
Scoter sp.	8	0.09			13	0.15	80	0.93	27	0.31	4	0.05				
Red-breasted merganser			2	0.02					1	0.01						
Pintail											12	0.14				
Small Shorebird	45	0.52	1	0.01							26	0.30	43	0.50		
Medium Shorebird	30	0.35	5	0.06	3	0.03					2	0.02	3	0.03		
Shorebird 50	0.58															
Parasitic Jaeger	2	0.02														
Jaeger sp.	1	0.01														
Glaucous Gull	285	3.30	67	0.78	241	2.79	75	0.87	52	0.62	194	2.24	115	1.33	1223	14.17
Dark Backed Gull															1	0.01
Sabine's Gull					1	0.0										
Arctic tern	34	0.39	18	0.21					8	0.09	1	0.01				
Black Guillemot	3	0.03	7	0.08					5	0.06						
Sandhill Crane							2	0.02			2	0.02				
Phalarope sp.	37	0.43	13	0.15	9	0.10					29	0.34				
Scamp sp.								1	0.01			82	0.95			
Black-Legged Kittiwake											1	0.01				
Total No. of taxa	17		13		15		11		13		17		9		4	
Total No. of individuals	2024		1184		4149		2537		1947		3257		1087		1574	
Total area sampled	86.3		86.3		86.3		86.3		86.3		86.3		86.3		86.3	
Total Density	23		14		48		29		23		38		13		18	

Annotated Species List

This annotated species list describes the currently known status, population levels, habitat use, and distribution of birds on the ANWR study area. Status/abundance catagories used are: abundant, common, fairly common, uncommon, rare, casual, accidental, resident, migrant, breeder, and visitant (adapted from Kessel and Gibson 1978). The annotated species list is presented in phylogenetic order. It includes the documentation used to arrive at the species status given in Table 1. Additionally, detailed species-specific data if available are presented for each species.

Status designations, particularly of the less common species, must be considered tentative because of the short period in which intensive bird studies on the ANWR coastal plain have been conducted (1970-1981). Additionally, most efforts were on the northern coastal plain, hence data from the interior coastal plain are scarce.

For the less common species, all information is summarized in a single paragraph. Accounts for species that are more common, or for which more data exist , are organized into several paragraphs including information on status and distribution on ANWR and adjacent areas, spring migration and chronology, breeding, molting and staging, habitat use, fall migration and chronology, and wintering on ANWR.

Where available, habitat use and population density information specific to the ANWR study area or immediate surroundings are incorporated into the discussion. Habitat names of tundra types follow those provisionally identified in Chapter 3 of this report and names of wetland types follow Bergman et al. (1977). The equivalent habitat types originally identified by Nodler (1977) on the first ANWR LANDSAT map are given if obviously different from those presented in Chapter 3 (e.g. very wet sedge tundra, flooded tundra). As with habitat and population data, migration routes, average arrival and departure dates and other life-history information specific to ANWR or its surroundings are given if available. Major data gaps in this type of information are also pointed out.

Each species discussion is specific to the ANWR study area, and does not necessarily apply to the species for the entire North Slope because status, populations, arrival, departure, and nesting dates, and occasionally habitat use patterns, differ between specific areas on the North Slope. The source material for the species discussions therefore rely heavily on studies specific to the ANWR, many of which have not been published in the scientific literature.

COMMON LOON - Probable rare migrant or visitant. The species breeds on the Mackenzie River Delta, NWT. (Johnson et. al. 1975) and on the south side of the Brooks Range (Gabrielson and Lincoln 1959). It has been documented as an uncommon visitant to the Yukon North Slope (Salter et al. 1980) and a possible migrant on the Okpilak delta, ANWR (Spindler 1978a). Olson and Marshall (1952) provide evidence that human activities (including aircraft overflights) cause nesting failures and mortality of young. The species should be considered susceptible to disturbance.

YELLOW-BILLED LOON - Uncommon migrant along the coastal lagoons and nearshore waters; probable rare breeder on coastal plain lakes. Eastward migration along the Yukon coast in late May-early June and westward migration between 10 July and 17 September was observed by Salter et al. (1980). Yellow-billed loons were observed in low numbers (less that 5 per transect) in lagoon and nearshore aerial transects in July, August and September of 1978-1981 (Spindler 1981b). Martin and Moitoret (1981) reported observations of 1 to 4 individuals along the coast near Brownlow Point in July and August of 1979 and 1980, although one observation was made in tundra wetlands. The nearest confirmed breeding record is at Schrader Lake (Bee 1958). J. Levison (unpubl. data) reported 3 yellow-billed loons on 7 June 1980 at Beaufort Lagoon, and, thereafter, the species was observed several times a week in coastal lagoons and near shore Beaufort Sea waters between Demarcation Bay and Pokok Bay.

ARCTIC LOON - Common breeder in drained basin wetlands and some coastal plain lakes; common migrant along Beaufort Sea coastal lagoons and nearshore waters. Arctic loons arrive from the west between 31 May and 12 June (Brooks 1915, Spindler 1978a, Salter et al. 1980, R. Burgess, unpubl. data, J. Levison, unpubl. data,). Upon arrival during the first week of June, tundra lakes and ponds are often unavailable, and loons rely on overflow water at river mouths (Martin and Moitoret 1981). Peak arrival was observed between 3 June and 7 June on the Canning River Delta in 1980 (Martin and Moitoret 1981). Loons were able to move onto tundra ponds and lakes by 7 June 1978 on the Okpilak Delta (Spindler 1978a) and by 10 June 1979 and 1980 at the Canning Delta (Martin and Moitoret 1981).

Arctic loons commonly nest on islands in the larger ponds of drained-basin wetland complexes (Johnson et al. 1975, Bergman et al. 1977, Spindler 1978a, Martin and Moitoret 1981). Deep-*Arctophila* and deep-open lakes were the most commonly used habitats during nesting in NPR-A (Derksen et al. 1981). Nest building starts in mid-June and the first eggs were laid at the Canning Delta about 21 June in 1979 and 1980. Nest density was 0.55-0.75 nests/km^2 1979 and 1980 on the Canning Delta (Martin and Moitoret 1981) and 0.40 nests/km^2 on the Okpilak Delta in 1978 (Spindler 1978a). Schmidt (1970) estimated a total population density at Beaufort Logoon of 1.5/ km^2 in 1970. Derksen et al. (1981) found densities of 0.6-2.1 birds/km^2 in NPR-A.

Use of lagoon and estuarine habitats by arctic loons increases dramatically in late July as family groups move from tundra wetlands to coastal waters and, as adults begin to make frequent flights to the lagoons (Spindler 1978a, Martin and Moitoret 1981). Arctic loons were observed at higher mean seasonal densities in lagoons (mean season density of 0.14 birds/km^2) than on nearshore Beaufort Sea waters (mean seasonal density of 0.11 birds/km^2) (Spindler 1981b).

Peak fall migration of arctic loons was observed from 28 to 30 August 1979 on the Canning Delta (Martin and Moitoret 1981), although westward movement occurred over a wider time range in 1980 (18 August to 6 September). Arctic loons were observed as late as 14 September 1978 and 18 September 1981 in coastal lagoon transects (Spindler 1981b), and some probably occur in low numbers until the lagoons freeze over in late September (M. Spindler unpubl. data).

RED-THROATED LOON - Common breeder in drained-basin wetlands, beaded streams and flooded sedge wetlands, especially within 5 km of the coast. A common migrant over Beaufort Sea coastal lagoons and nearshore waters. Arrival dates range from 30 May to 11 June (Bergman et al. 1977, Spindler 1978a, Salter et al. 1980, Derksen et al. 1981 and Martin and Moitoret 1981, R. Burgess unpubl. data). Eastward migration past Canning Delta was noted by Martin and Moitoret (1981) with a peak between 4 and 7 June 1981. As with the arctic loon, red-throated loons sometimes arrive before appreciable open water is available, and rely on overflow water on river deltas (Martin and Moitoret 1981). Red-throated loons use smaller ponds for nesting than do arctic loons especially shallow-*Arctophila*, deep-*Arctophila* and beaded streams (Derksen et al. 1981). Nest construction begins in mid-June and incubation starts about 23 June (Spindler 1978a, Martin and Moitoret 1981). Nesting density on ANWR was observed to range from 0.45 nests/km^2 to 0.50 nest/km^2 on the Canning Delta (Martin and Moitoret 1981) and 0.32 nests/km^2 on the Okpilak Delta (Spindler 1978a). Estimated total population near Beaufort Lagoon in 1970 was 2.3 birds/km^2 (Schmidt 1970), which is higher than the 1.3 birds/km^2 reported at East Long Lake in 1977 by Derksen et al. (1981). Following the hatch in late July, adult red-throated loons are observed making regular feeding flights to nearshore Beaufort Sea waters (mean August-September density of 0.13 birds/km^2), where they appear to be more common than in coastal lagoon waters (mean August-September density of 0.09 birds/km^2) (Spindler 1981a). The fall migration of red-throated loons occurred in 1980 between 18 August and 6 September, with the peak on about 1 September 1980 on the Canning Delta (Martin and Moitoret 1981).

RED-NECKED GREBE - Rare summer visitant to the Coastal Plain of ANWR. Schmidt (1970) recorded one individual on the Kogotpak River (near Beaufort Lagoon) on 15 June 1970. Salter et al. (1980) reported sighting one individual each at Clarence Lagoon, Y.T., Komakuk Beach, Y.T. on 1 and 17 June 1975, and Bloomfield Lake in late August 1973.

HORNED GREBE - Possible rare summer visitant to the Coastal Plain of ANWR. One adult was collected near Flaxman Island in July 1930 (Bailey 1948). There are 3 records for the Yukon north slope, 1 for the mouth of the Firth River (Johnson et al. 1975) and 1 for Peat Lake (June 1972), two 6 km south of Phillips Bay (July 1973), and 1-3 birds daily at Bloomfield Lake (14-17 September 1973) (Salter et al. 1980).

SHORT-TAILED SHEARWATER - rare summer visitant to Beaufort Sea coastal waters offshore of ANWR. This species was observed near the ANWR coast at Flaxman Island, circa 1936 (Johnson et al. 1975), but the only records are flocks seen 112 km offshore of Barrow by Watson and Divoky (1974), and 40 km offshore east of Barrow (Divoky and Good 1979).

WHISTLING SWAN - Common breeder in river delta areas, especially ponds and lakes in and near drained-basin complexes. Swans arrived on the Canning River Delta on 26 May 1979 and 25 May 1980 (Martin and Moitoret 1981), at Beaufort Lagoon on 25 May 1980 (J. Levison unpubl. data) and at the Okpilak Delta on 1 June 1978 (Spindler 1978a). Swans on the ANWR apparently arrive from the east and depart to the east (Bellrose 1976, Salter et al. 1980, Martin and Moitoret 1981).

Since whistling swans are conspicuous, easy to survey, and sensitive to disturbance it has been suggested by King and Hodges (1980) that they make an excellent indicator species.

Whistling swans nest and reside in traditional concentration areas on the ANWR coastal plain. Jacobson (1979) identified the major concentration areas as the Canning-Tamayariak Delta, the Hulahula-Okpilak Delta/Barter Island lakes, the Aichilik-Egaksrak-Kongakut Deltas, and Demarcation Bay lakes. These areas apparently offer the only highly desirable swan nesting and feeding habitat on the ANWR coastal plain. Fig. 7 identifies the swan concentration areas as defined by plotting swan observations from aerial surveys 1977-1979 (Jacobson 1979, Spindler 1981c).

Because their May arrival date is 1 to 2 weeks prior to break-up, swans seek out high ground that is blown free of snow. When such sites are adjacent to pond and lake wetlands they are often chosen as nest sites (Spindler 1978a, Martin and Moitoret 1981, Spindler unpubl. data). Clutch completion on the Canning was during the first week of June, 1979 and about a week later in 1980 (Martin and Moitoret 1981). Nesting density was determined to be 0.25 and 0.20 nests/km^2 in 1979 and 1980, respectively, on the Canning Delta, and 0.12 nests/km^2 on the Okpilak Delta in 1978 (Spindler 1978a). Aerial surveys indicated that swan densities within concentration areas ranged from 0.20 swans/km^2 at Demarcation Bay to 0.70 swans/km^2 on the Aichilik-Egaksrak-Kongakut Deltas for a total density of 0.30 swans/km^2 for all areas surveyed on the ANWR coastal plain in 1981 (Table 20) (Spindler 1981c). Schmidt (1970) estimated adult density of 1.2 birds/km ^{2} between Pingokraluk Lagoon and Pokok Bay.

Swans begin departing the ANWR coastal plain in mid-August. The non-breeders and failed breeders are the first to migrate (Jacobson 1979, Martin and Moitoret 1981, Spindler 1981c) in mid-August. Paired adults with young are not able to depart until the young can fly, which is probably as late as mid-or-late September, since swans with young have been seen on the coastal plain as late as 13 September (Jacobson 1979).

Mean swan densities on the entire ANWR coastal plain (including ideal concentration habitat and unproductive upland habitats) were 0.05 adult swans/km^2 in 1981 as compared to 0.08 and 0.12 swans/km^2 in NPR-A in 1977 and 1978, respectively (King 1979). Densities of 0.07 to 0.42 adult swans/km^2 have been observed for 6 sites between the Colville and Sagavanirktok Rivers (1970-1977 mean, Welling and Sladen unpubl. manuscript). From the above comparisons it is apparent that overall swan densities on the coastal plain of ANWR are lower than areas surveyed farther west. In contrast, densities within the ANWR concentration areas are as high as or higher than elsewhere on the North Slope.

Annual variation in swan density on North Slope habitats is substantial. Over the 4 years of survey on the ANWR, density on the Canning and Tamayariak Deltas has varied from 0.2 to 0.5 swans/km^2. This was more consistent than the 0.3-1.2 swans/km^2 variation observed at the Aichillik-Egaskrak- Kongakut Deltas (Table 21) (Spindler 1981c). These ranges in population density amount to 60% over 4 years for the Canning-Tamayariak area and to 75% over 3 years in the Aichilik-Egaksrak-Kongakut areas. By comparison, annual variation for 5 years data in the Colville Delta was 60%, whereas for the 6 years of data on the tundra east of the Sagavanirktok Delta it was 300% (Welling and Sladen unpubl. manuscript).

Table 20. Comparison of whistling swan population statistics for the major swan concentration sites and other areas on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 4 August 1981. (See text and Fig. 1 for delineation of areas) (source: Spindler 1981c).

Statistic	Canning-Tamayariak Deltas	Hulahula-Okpilak Deltas	Jago Delta and Wetlands	Aichilik-Egaksrak-Kongakut Deltas	Demarcation Bay	Other
Total broods	17	4	1	14	2	2
Mean brood size	2.7	3.4	4.0	2.3	3.0	1.0
% pairs with young	57	44	50	76	33	33
% young in pop.	25	16	33	19	25	13
Total young	46	13	4	32	6	2
Total adults	140	67	8	139	18	13
Total swamp	186	80	12	171	24	15
Swans/km.^{2}	0.4	0.5	-	0.7	0.2	0.1
No. of pairs	30	9	2	17	6	3
No. of singles	3	0	1	2	0	2
No. of flocks	10	8	1	11	1	1
Total swans in flocks	77	49	3	101	6	5
% paired birds in adult population	43	27	50	24	67	46
Cygnets: adult ratio	1:4.0	1:5.2	1:2.0	1:4.3	1:3.0	1:6.5
km.^{2} samples	491	168	358	259	159	172

[a] a flock was considered to be 3 or more birds.

FIG. 7 WHISTLING SWAN CONCENTRATION AREAS

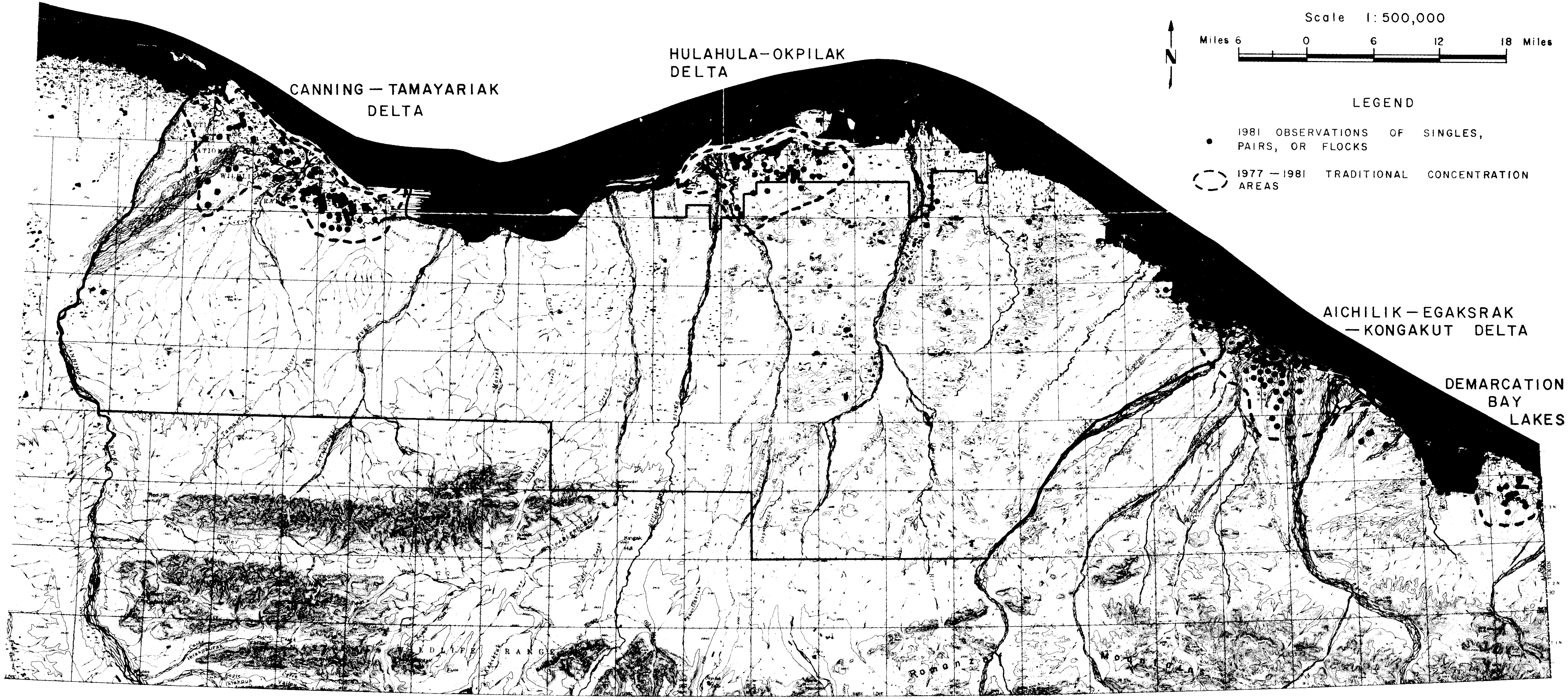


Table 21. Comparison of whistling swan population statistics trends for 2 swan concentration sites and for the entire coastal plain of the Arctic National Wildlife Refuge, Alaska 1977-1981[a] (Source: Spindler 1981c).

	Canning - Tamayariak Deltas				Aichilik - Egaksrak - Kongakut Deltas			Entire swan habitat area ANWR coastal plain	
Statistics	1977 (11 Aug.)	1978 (24 Aug.)	1979 (13 Sept.)	1981[b] (4 Aug.)	1978 (24 Aug.)	1979 (13 Sept.)	1981[b] (4 Aug.)	1979 (13 Sept.)	1981 (4 Aug.)
Total broods	7	13	15	6	6	4	8	27	40
Mean brood size	2.6	2.3	2.7	2.5	3.3	3.8	1.8	3.0	2.6
% pairs with young	50	43	94	50	46	67	73	82	57
% young in pop.	33	23	55	27	21	56	31	54	21
Total young	18	30	41	15	20	15	14	82	103
Total adults	37	98	33	55	75	12	45	70	385
Total swans	55	128	74	70	95	27	59	152	488
Swans/mi.^{2}	0.6	1.4	0.8	0.8	3.2	0.9	2.0	0.5	0.8
Swans/km.^{2}	0.2	0.5	0.3	0.4	1.2	0.3	0.8	0.2	0.3
No. of pairs	12	30	16	10	13	6	11	33	67
No. of singles	0	6	1	2	2	0	1	2	8
No. of flocks[c]	4	7	0	4	5	0	4	1	32
Total swans in flocks	13	32	0	29	47	0	16	3	241
% paired birds in adult pop.	65	61	97	36	35	100	49	94	35
Cygnets/adult	1:2.0	1:3.3	1:0.8	1:3.7	1:3.8	1:0.8	1:3.2	1:0.9	1:3.7
mi.^{2} sampled	92	92	92	92	30	30	30	304	618
km.^{2} sampled	161	161	161	161	78	78	78	787	1600

a Data were not gathered for all areas in all years.

b 1981 data summarized for area identical to that surveyed by Jacobson in 1977-1979, excluding new areas surveyed in 1981, hence some figures do not correspond to those in Table 22.

c A flock was considered to be 3 or more birds.

CANADA GOOSE - Uncommon breeder in river deltas and drained-basin wetlands, common migrant on coastal plain. The species migrates into the area in spring from the east and departs in the fall to the east (Salter et al. 1980). Reported arrival dates are: at the Canning River Delta on 27 May 1979 and 20 May 1980; at the Sadlerochit River on 16 May 1979 (M. Robus unpubl. data) at the Okpilak Delta 4 June 1978 (Spindler 1978a), and at Beaufort Lagoon on 6 June 1980 (J. Levison unpubl. data). On the ANWR study area nesting is on islands in basin-complex wetlands surrounded by deep water (Spindler 1978a, Martin and Moitoret 1981). Incubation was initiated on 12 June 1979 at the Canning Delta; the first brood was observed on 5 July 1979, and nesting density was estimated at 0.25 and 0.30 nests/km^2 in 1979 and 1980, repectively (Martin and Moitoret 1981). Parents with broods apparently seek large lakes and salt water in lagoons shortly after the hatch, as most observations of adults with broods subsequent to the hatch at the Canning were in those habitats (Martin and Moitoret 1981).

Following the breeding season a molt migration to the west is apparent in late June-early July as non-breeders and failed breeders vacate tundra habitats and are seen migrating west, probably to the Teshekpuk Lake goose molting area (Derksen et al. 1981, Martin and Moitoret 1981). Birds which do not reach Teshekpuk Lake before losing flight may end up spending the wing-molt period in July in river delta habitats on the ANWR study area, as did the 65-90 flightless Canada geese observed at the Canning Delta in late July 1979 (Martin and Moitoret 1981). Eastward fall migration began 14 August 1979 and 18 August 1980 and lasted until the end of August in both years at the Canning Delta (Martin and Moitoret 1981).

BRANT - Uncommon breeder in coastal plain basin-complex wetlands, locally abundant migrant along Beaufort Sea coast. Spring migration is eastward and peaks in the last week of May and the first week of June (Johnson et al. 1975, Spindler 1978a, Johnson and Richardson 1981, Martin and Moitoret 1981). In 1978 at the Okpilak Delta peak spring movement was 4-6 June, with about 10,000 birds (Spindler 1978a). In 1980 at Beaufort Lagoon J. Levison (unpubl. data) counted 2447 birds between 26 May and 11 June. At the Canning Delta in 1979 peak spring movement was 26 May-1 June and in 1980 it was 29 May-5 June (Martin and Moitoret 1981). The sharpness of the peak brant movements are borne out in migration watch data from the Canning Delta (Fig. 8). During spring migration along the ANWR coast brant tend to follow lagoon shorelines and cut across points of land, sometimes leading them 1-5 km inland (Fig. 9) (Spindler 1978a, Johnson et al. 1975, Martin and Moitoret 1981). The tendency for brant to use the lagoon shorelines in spring may be related to their use of the Wet Saline Tundra(coastal vegetated mudflats, Nodler 1977) which are usually located on gradually sloping lagoon shorelines. Brant were observed using these vegetated mudflats in early to mid-June near the Okpilak Delta where they grazed on *Puccinellia phyrganoides* and *Carex subspathacea* (Spindler 1978a). These coastal vegetated mudflats may be critical to brant during spring migration since there are often limited amounts of snow-free vegetation at this time. The critical condition may be exacberated during prolonged headwinds which would necessitate delays and feeding prior to arrival on the breeding grounds (M. Spindler pers. obs., R. Meehan pers. obs.).

Brant were found breeding on the ANWR coastal plain in a small colony of 15 pairs at the Okpilak Delta in 1978 (Spindler 1978a), and broods were seen at Beaufort Lagoon in 1970 (Schmidt 1970), and at the Canning River Delta in 1979 and 1980 (Martin and Moitoret 1981). As with Canada geese on the ANWR, brant

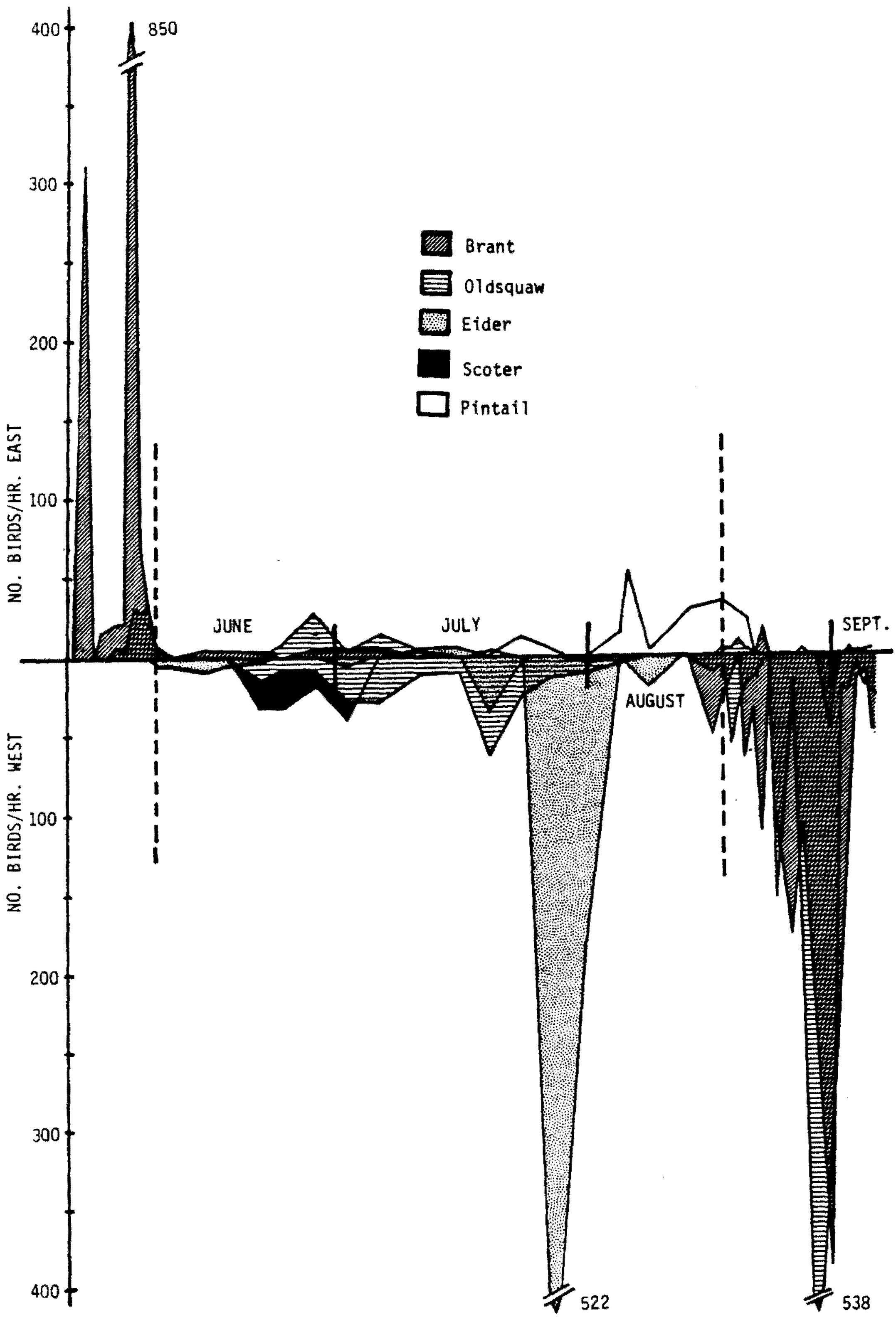


Figure 8. Migration movements of five major species, Canning River Delta, 1980. Source: Martin and Moitoret (1981).

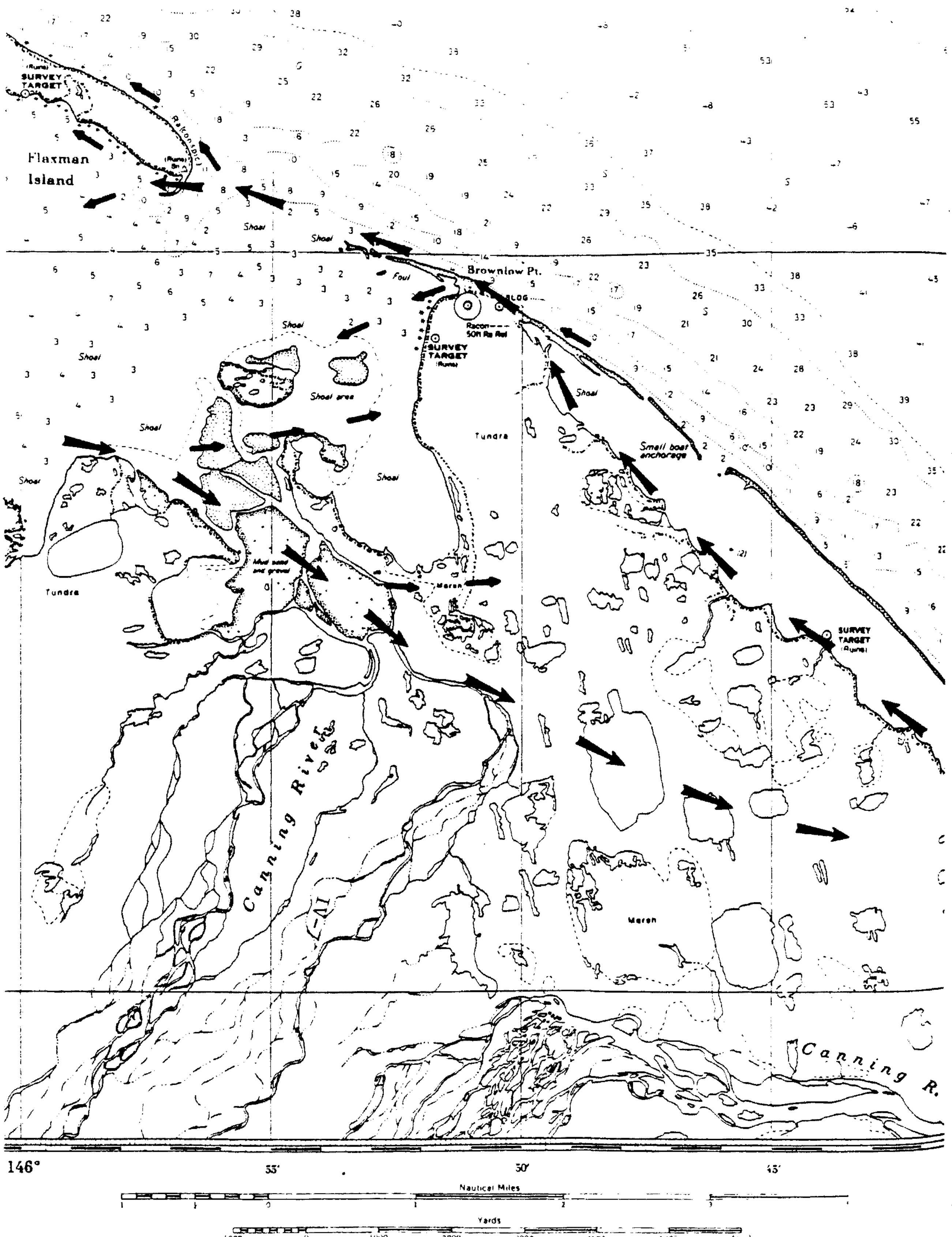


Figure 9. Map of Brant migration routes along Canning Delta shoreline. Arrows show routes of spring migration (east) and fall migration (west). Source: Martin and Moitoret (1981).

nest on islands and peninsulas within basin-complex and flooded tundra wetlands (Spindler 1978a). Nesting density in 1978 was estimated to be 0.3 nests/km^2 at the Okpilak Delta, which represents the highest nesting density determined on ANWR to date (Spindler 1978a).

Late June observations of brant moving west by Schmidt (1970) at Beaufort Lagoon in 1970, D. Troy at Demarcation Bay (unpubl. data) in 1978, Spindler (1978a) at the Okpilak Delta in 1978 and Martin and Moitoret (1981) at the Canning Delta in 1979 lend supporting evidence for a limited molt migration towards a westerly location. The western destination of these brant is probably the Teshekpuk Lake area, where Derksen et al. (1981) have observed up to 35 molting brant/km^2 along with white-fronted and Canada geese, in July. Such densities and numbers of molting brant and other geese have not been found elsewhere on the North Slope.

Fall migration past Beaufort lagoon began 22 August 1970 (Schmidt 1970) and 14 August 1980 (J. Levison unpubl. data). Peaks of fall migration in 1980 occured 26, 29, 30, 31 August, and 1-3 September. On 1 September alone 16,482 Brant were counted migrating W past Pingokraluk Point. A total of 28,863 Brant were counted during that fall migration watch (J. Levison unpubl. data), which is the highest actual count made on ANWR. Fall migration past Canning Delta was first observed 17 August 1979 and 18 August 1980. Duration of the migration in both years was about 3 weeks (Martin and Moitoret 1981) (Fig 8). The peak of the fall migration in 1979 was 24-26 August, but in 1980 it was delayed by strong westerly winds until 10 September (Martin and Moitoret 1981). In both years at the Canning Delta, fall migration tended to be more evenly spread through time than the spring migration (Fig. 8). The total count of brant passing Canning Delta in 1979 was 24,627, which was nearly double the previous eastern Beaufort Sea coastal fall count of 14,806 made by Schweinsburg (1974b) 25 August-6 September at Nunaluk Spit, Y.T., and nearly equals the estimated total of 26,000 for spring migration along the Yukon coast (Richardson and Johnson 1981). Canning Delta brant tended to migrate along the ocean shoreline in fall as compared to spring (Fig. 8, Martin and Moitoret 1981). Johnson and Richardson (1981) point out that because brant migrate in spring and fall along, or very close to the coast, (from the MacKenzie River west to about Cape Halkett) where an overland route then becomes discernable, they are especially vulnerable to development of the nearshore zone. High waters could carry spilled oil and contaminants onto the low-lying coastal vegetated mudflats upon which they depend for feeding areas.

WHITE-FRONTED GOOSE - Uncommon to fairly common spring migrant, common fall migrant over coastal plain tundra on ANWR. Spring migration is primarily westward (Salter et al. 1980), extending from late May to mid-June (Spindler 1978a, Martin and Moitoret 1981). At the Canning Delta arrival was on 17 May 1979 and 26 May 1980, and observations occurred until 29 June 1979 and 15 June 1980 (Martin and Moitoret 1981). First arrival at Beaufort Lagoon was 29 May 1980, and birds were seen fairly regularly throughout the month of June. Small groups were seen grazing on the tundra at the Okpilak Delta in June 1978 (Spindler 1978a) and on the Canning Delta in June 1979 and 1980 (Martin and Moitoret 1981). There are no July observations of white-fronted geese on the ANWR coastal plain. However, nesters (Sage 1974, Derksen et al. 1981) and molters (Derksen et al. 1981) occur commonly from the Sagavanirktok River west to Teshekpuk Lake.

White-fronted geese undertake a pronounced eastward migration over the ANWR coastal plain in fall, with totals of up to 25-150 having been observed in migration during snow goose staging surveys (Koski and Gollop 1974, Koski 1977a and 1977b, Spindler 1978a). Fall migration past Beaufort Lagoon/Pingokraluk Point began 21 August 1970 (Schmidt 1970) and 18 August 1980 (J. Levison unpubl. data). Peak movements in 1980 occurred 29 August (6,334 birds) and 2 September (3,304 birds). A total of 10,228 birds were counted in the 1980 Beaufort/Pingokraluk migration watch. Fall migration on the Canning Delta was observed beginning 16 August 1979 and 12 August 1980. In 1979 flocks of from 3-325 birds scattered widely to graze on the tundra. They left small areas of uprooted Carex plants that were "virtually stripped" of vegetation (Martin and Moitoret 1981). Maximum numbers on the Canning Delta occurred on 30 August 1979, when a flock of 325 birds was seen, and on 25 August 1980, when a flock of 350 was seen flying east. Migration past the Canning Delta in 1980 was apparently complete by 3 September when the last flock was seen (Martin and Moitoret 1981). However, flocks have been seen as late as 14 September 1978 over the Katakturuk Delta (M. Spindler unpubl. data).

SNOW GOOSE - Uncommon spring migrant, very rare summer visitor, and abundant fall migrant on coastal plain of ANWR. Snow geese are first observed during spring migration each year on or near the ANWR Beaufort Sea coast during the latter part of May and the first week of June (Johnson et al. 1975). The birds use several migration routes to reach their arctic coastal breeding areas. Perhaps the greatest numbers arrive by following the Mackenzie Valley northward (Barry 1967, Campbell and Shepard 1973, Salter et al. 1974). Others have been seen migrating across interior Alaska over the Yukon Flats and Porcupine River basin (Gabrielson and Lincoln 1959), crossing the Richardson Mountains through Blow River pass (Koski and Gollop 1974), and the Brooks Range through Anaktuvuk Pass (Irving 1960). Early arrival dates on and near ANWR have been 13 May 1974 at Clarence Lagoon; 16 May (no year given) at Herschel Island; 19 and 25 May 1979 at 10 km Sadlerochit River; 26 May 1979 at Demarcation Bay; 26 May 1972 at Prudhoe Bay; 29 May 1971 at Prudhoe Bay; 1 June 1979 and 1980 at Canning River Delta; 1 June 1972 at the Firth River; 3 June 1978 at the Okpilak River; 4 June 1980 at Beaufort Lagoon; 4-8 June 1971-1973 at Storkerson Point (respectively, Johnson et al. 1975, Rand 1946, M. Robus unpubl. data, R. Burgess unpubl. data, Gavin 1971, Martin and Moitoret 1981, Gollop et al. 1974b, Spindler 1978b, J. Levison unpubl. data, Bergman et al. 1977). The peak date of egg-laying on the Anderson River delta colony is reported to be about 9 June, and in the second week of June near Barrow (Johnson et al. 1975).

The major nesting colonies along the Beaufort and Chukchi Sea coasts are (estimated number of breeding birds in parentheses) Banks Island, NWT (150,000), Anderson River Delta, NWT (2,500), Kendall Island, NWT (50), Sagavanirktok River Delta, AK (80), and Wrangell Island, USSR (60,000) (Welling et al. 1981). On the Alaska North Slope scattered pairs have been reported breeding irregularly near the Meade River, Teshekpuk Lake, East Long Lake, the Colville River, and Flaxman Island (Johnson et al. 1975, Gavin 1976, Derksen et al. 1981). Snow geese once, commonly, nested on portions of the Alaska North Slope (Bailey 1948, Gabrielson and Lincoln 1959), but it has been hypothesized that introduced reindeer and their herdsmen destroyed geese and their nesting grounds (Bailey et al. 1933, Bailey 1948). There have been no recent reports of snow geese nesting or attempting to nest on ANWR.

Snow goose occurrenceson ANWR in the spring do not indicate a definite migration toward any one of the above-listed colonies. Observations which include information on direction of movement indicate both westerly and easterly movements. On 25 May 1979, 50 birds flew NW along the Sadlerochit River (M. Robus unpubl. data). On 25 May 1979, 8 birds flew E past Demarcation Point (R. Burgess unpubl. data). Between 26 May and 1 June 1975, 34 birds flew E and on 31 May 9 geese flew W past Clarence Lagoon, and between 31 May and 9 June westbound movement exceeded eastbound movement at Clarence Lagoon and Komakuk Beach (Johnson et al. 1975). Between 3 and 7 June 1978, 34 birds and on 19 June 14 birds flew E past the Okpilak delta (Spindler 1978). On 1 to 20 and 24 June 1970 45, 14, and 7 snow geese, respectively, flew NW near Beaufort lagoon (Schmidt 1970). Throughout June 1980, 5 records of snow geese at the Canning Delta indicated mostly westerly movement (Martin and Moitoret 1981). Also, spring migration of snow geese on the Yukon North Slope has been reported to be westward (314 birds flying W over Babbage River, 28 May 1972) (Salter et al. 1980).

Summer records on ANWR are of lone stragglers or widely scattered flocks grazing on the tundra: on 21 June 1980, 50 snow geese were seen resting on the shore of Brownlow Lagoon; a single bird was seen resting on the mudflats at the mouth of the Canning River on 10 July 1979 (Martin and Moitoret 1981). On 27 June 1970, 2 birds were seen grazing on the tundra of the Aichilik Delta (Schmidt 1970). On 18 July 1980, J. Levison (unpubl. data) saw a single bird at Siku Lagoon. On 5 August 1980 Martin and Moitoret (1981) reported a single flightless bird on a barren spit near Brownlow Point.

Snow geese stage annually in the autumn on the north slope of ANWR, Alaska and the Yukon Territory with total numbers of 706,277 birds in 1975 and 507,700 in 1976 being estimated for the entire staging ground between the Canning River, AK. and the Parry Penninsula, NWT (Koski 1977a and b). Johnson et al. (1975) summarized the chronology of fall staging on the Alaska and Yukon coastal plains:

> Adult geese and young of the year leave their nesting areas at the Anderson River delta at the end of August (Barry 1967) and probably leave the Banks Island nesting area at approximately the same time. They stop-over on the Parry Peninsula for approximately a week, where they exercise and feed ... They then move west, where, depending upon the season and weather, they either spread out along the section of the North Slope from the Mackenzie Delta westward (sometimes as far as the Canning River in Alaska) or, when poor weather hampers their movement onto this coastal plain they may stay in the Mackenzie Delta region... In this eastern portion of the Beaufort Sea, the initial westward movement of Snow Geese is generally noted around the third week of August. During a normal year, westward movement is followed by a one or two-week period of very little movement; during this period, birds spend a great deal of time feeding.

On the Alaska and Yukon North Slope staging area the first westerly migrating flocks have been sighted between 15 and 24 August, and the major influx has occurred 19 August to 1 September (Table 22). The latest date snow geese have been seen on the staging area has ranged from 9 September to 27 September (Table 22). However, A. Thayer (pers. comm.) has reported seeing snow geese

Table 22. Dates of arrival and departure of snow geese on the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope, August and September 1971-1976 and 1978-1981. The 1978-1981 data are from Arctic National Wildlife Refuge only.

Year	Date first flock sighted	Dates of Major arrival	Major departure	Date last flock sighted	Survey period[a]
1971[b]	15 Aug.	31 Aug.-2 Sept.	12-16 Sept.	17 Sept.	4 June-19 Sept.
1972[c]	17 Aug.	27-29 Aug.	7-10 Sept.	15 Sept.	10 July-17 Sept.
1973[d]	23 Aug.	1-12 Sept.	22-25 Sept.	4 Oct.	25 Aug.-29 Sept.
1974[e]	21 Aug.	22-25 Aug.	17-21 Sept.	30 Sept.	24 Aug.-30 Sept.
1975[f]	18 Aug.	3-5 or 6 Sept.	19-24 Sept.	25 Sept.	20 Aug.-25 Sept.
1976[g]	13 Aug.	25-28 Aug.	16-26 Sept.	30 Sept.	15 Aug.-2 Oct.
1978[h]	20 Aug.	25 Aug.-1 Sept.	16-27 Sept.	27 Sept.	10 June-5 Oct.
1979[i]	24 Aug.	26-28 Aug.	15 Sept.	N/D	10 June-12 Sept.
1980[j]	15 Aug.	19-21 Aug.	1-2 Sept.	9 Sept.	5 June-12 Sept.
1981[k]	24 Aug.	26-30 Aug.	16-18 Sept.	18 Sept.	11 July-20 Sept.

a Dates inclusive of aerial and ground observation period. Locations of ground observation and aerial survey coverage varied: 1971-1976 data emphasized Mackenzie and Yukon locations, while 1978-1981 data emphasized Alaskan locations. For details see respective sources:
b Schweinburg (1974b)
c Gollop and Davis (1974b)
d Koski and Gollop (1974)
e Koski (1975)
f Koski (1977a)
g Koski (1977b)
h Spindler (1978b)
i Spindler (1979b)
j Spindler (1981a)
k Unpublished data, ANWR files

as late as mid-October in the early 1970's. Johnson et al. (1975) reported that the main departure from the North Slope is gradual and occurs just ahead of freezing weather. Koski (1977b) suggested that snow geese remain on the staging area long enough to accumulate sufficient energy reserves, respective of the weather conditions. Further studies are needed to clarify why the major movement times vary so significantly between years.

The maximum estimated numbers of snow geese occurring on ANWR was 325,760 in 1978 (Table 23). During the period 1973-1981 there were 3 years in which the estimated numbers were greater than 190,000, there were 3 years in which they were between 20,000 and 50,000, and 2 years in which they were less than 20,000 (Table 23). Annual variation occurs in the staging areas used, the numbers of snow geese using each area, and duration of use (Koski 1977a and b, Spindler 1981a). Koski (1975) suggested that weather most likely exerted the major influence upon timing and extent of movements from the breeding areas to the staging areas.

Estimations of age-ratios are used as indicators of population productivity. Percent young observed varied annually, from 1% immature birds in 1974 to over 100% immature birds in 1973 and 1975 (Table 24). Productivity of the western arctic snow goose populations is affected significantly by inclement June weather (Barry 1967). Percent young has been shown to vary spatially on the staging grounds and these data (Table 24) indicate that samples including the Mackenzie Delta area have a tendency to yield higher percentages of immature birds than do samples including only the Alaska and Yukon north slopes. This pattern would be expected if family groups with a large proportion of young do not migrate as far west as do those with a low proportion of young.

Distribution of fall staging snow geese has been extremely variable for the years that data are available, 1973-1981 (Fig 10a, b, c). In 1974, 1976, 1978, and 1979 snow geese staged on a widespread portion of ANWR, generally east from the Hulahula River to the Aichilik River and extending from the coast inland to roughly the 305 m contour line (Fig 10a, b, c). Staging in other years was restricted to certain localities or portions of the coastal plain. In 1973, the use centered along the Aichilik River and extended NW to the Niguanak River. In 1975 no large concentrations were observed staging on the ANWR coastal plain (Koski 1977a). In 1977 no snow goose surveys were conducted. In 1980, snow goose distribution as determined from boat surveys in late August, along coastal lagoons extended from Demarcation Bay W to Beaufort Lagoon, however, it is not known how far inland the area was used (J. Levison unpubl. data). When the 1980 aerial survey was conducted (9-10 September 1980), the only snow geese observed on the ANWR coastal plain were north of VABM Dar near the Kongakut River and directly on the U.S.-Canada border; much of the population had apparently staged on the Yukon North Slope (Spindler 1981a). In 1981 distribution of snow geese on ANWR was again fairly widespread, extending in a 20-25 km wide band N of the 305 m contour line from the Okpilak River east in the Yukon north slope. There was also a small aggregation close to the coast between the Hulahula and the Jago Rivers (Fig. 10a).

Table 23. Total numbers of western Arctic snow geese counted during August-September staging surveys, Arctic National Wildlife Refuge coastal plain and areas to the east, 1973-1981.

Year	Alaska	Yukon North Slope	Mackenzie Delta	Total	Survey Dates
1973[a]	44,037	126,960	86,520	257,517	Sept. 2,3,5,6,11,12,18,22,23,25
1974[a]	48,591	37,435	28,913	114,939	Aug. 24,31, Sept. 5,11,16,25
1975[a]	0	20,972	685,305	706,277	Aug. 25-28, Sept. 8,10,11,13,17-18,20,23
1976[a]	228,793	224,401	18,363	471,557	Aug. 16-20,29-31, Sept. 4-6,10-13,18-21
1978[b]	325,760	N/D	N/D	N/D	Sept. 13-14
1979[c]	195,000	41,000	N/D	N/D	Sept. 6-7
1980	8,996[d]	7,500[e]	N/D	N/D	Sept. 9
1981	20,000[f]	80,000[f]	330,000[g]	430,000[g]	Sept 14,16,20

Sources:
- a Koski 1977b, extrapolation from transects at several points in time, not all areas covered on each date.
- b Spindler 1978b, extrapolation from transects at one point in time.
- c Spindler 1979b; note Yukon count incomplete, Demarcation Bay to Phillips Bay, estimates of all flocks seen, and photograph counts, at one point in time.
- d Ground counts by J. Levison, estimates of all flocks seen continuous count during daylight hours.
- e Estimated total; Actual photograph count was less; Demarcation Bay to Phillips Bay.
- f Visual esitmates of flock, Yukon sample includes only area from U.S.-Canada border to Phillips Bay.
- g Barry 1982. Includes 250,000 geese estimted to have staged south and west of Paulatuk, which is east of the Mackenzie Delta.

Table 24. Comparison of age ratios for western Arctic snow geese staging on the Alaska and Yukon North Slope, and Mackenzie Delta 1973-1976 (Koski 1977b) and 1979-1981 (Spindler 1981a, Barry 1982, and this study).

Year	Adults	Immature	% Immature	Area of Survey	Technique
1973	4533	5399	119.1	MD, YNS, AK[b]	Comp. count
1974	28647	29	1.0	MD, YNS, AK	Comp. count
1975	12223	13638	111.6	MD, YNS, AK	Comp. count
1976	7375	5541	75.1	MD, YNS, AK	Comp. count
1979	4275	133	3.1	YNS, AK	Photo
1980	1046	37	3.3 ± 1.2[a]	YNS, AK	Photo
1981	39693	5082	11.1 ± 8.5[a]	MD, YNS, AK	Photo
1981	17500	75000	30.0	Paulatuk and southwest	Comp. count (estimate)[c]

a Mean percent young ± standard deviation weighted according to flock size of samples.

b MD- Mackenzie Delta; YNS-Yukon North Slope; AK-ANWR, Alaska

c Since Paulatuk is a rarely used staging area, no quantitative survey was conducted. Data are reliable estimates made by pilots who have flown snow goose surveys before.

It is evident from the available data that certain "core" snow goose staging areas can be defined. In years of lower staging population on ANWR (e.g. 1973, 1974, 1980 and 1981) staging occurred on limited portions of the ANWR coastal plain, but in all these years (except possibly 1980) 2 "core" areas were used: 1 between the Okerokovik and Jago Rivers north of the 305 m contour line, and the other between the Aichilik and Sikutaktuvik Rivers between the 122 and 305 contour lines (Fig. 10a, b,c). These core areas were also used in years of high staging population (e.g. 1976, 1978, 1979), but in those years staging also occurred in more widespread areas over the entire coastal plain east of the Hulahula River. Significant staging was documented west of the Hulahula, only in 1976 and 1979, although medium sized groups of snow geese have been observed during the staging period at the Canning delta (in 1975 and 300 birds on 26 August 1979, 45 and 85 birds on 28 August 1980, 40 and 20 birds on 31 August 1980, and 16 birds on 9 September 1980) (Martin and Moitoret 1981). In 1976, a large staging aggregation was documented in the Carter Creek area and between the Hulahula River and the Sadlerochit River. In 1979 staging occurred along the lower 10 km of the Sadlerochit River (Fig. 10c).

Staging activities of snow geese on the eastern Alaska and Yukon North Slopes involve resting and feeding to allow accumulation of energy reserves sufficient to allow successful completion of fall migration (Patterson 1974). Significant gains in mean weight of adult and immature birds have been recorded between when the birds enter the staging area and when they depart (Patterson 1974). Snow geese on the outer coastal plain of ANWR have been observed feeding on sedge rootstocks. At the Okpilak Delta Spindler (1978b) described an area several ha in size in a homogeneous wet sedge-tundra habitat where 34 snow geese had been grazing overnight "...nearly every live Carex plant was uprooted and the tuber and green shoots eaten, leaving only the actual roots and dead or dying leaves in scattered feeding sites several m in diameter." On 26 August 1979, Martin and Moitoret (1981) observed 300 snow geese grazing on mesic mosaic wet Sedge-dry sedge tundra and on 28 August 1980 a flock of 45 were seen grazing on wet sedge tundra on the Canning Delta. J. Levison (unpubl. data) saw a flock of 180 birds feeding on wet sedge tundra, 0.8 km south of Pokok Bay on 26 August 1980. R. Lipkin (unpubl. data) observed snow geese clipping and uprooting Carex bigelowii in the Beaufort Lagoon area in late August 1978. Schmidt (1970) reported that snow geese left the coastal tundra near Beaufort Lagoon in early September 1970 and migrated inland to feed primarily on berries (probably Empetrum nigrum) located on higher dry tundra. The relative importance of inland berry food sources compared with coastal rootstock food sources is unknown, nor whether sedge rootstocks are also used in the interior coastal plain.

An examination of vegetation types within the "core" concentration areas indicated they were composed of moist tussock-dwarf shrub tundra (upland sedge tundra and upland tussock tundra, Nodler 1977), with lesser amounts of wet and very wet sedge tundra (Spindler 1978b; Fig 10a, b, c). The areas receiving snow goose utilization in years of less confined and more widespread staging included additional amounts of homogeneous wet sedge tundra and flooded sedge tundra vegetation types owing to their proximity to the coast (Nodler 1977; Spindler 1978a, Fig. 10a, b, c).

ROSS' GOOSE - Casual spring migrant on coastal plain tundra. One individual was observed by Martin and Moitoret (1981) on 13 June 1980 at the Canning River Delta. There are 2 other recent records of this species on the North

FIG. 10a DISTRIBUTION OF FALL STAGING SNOW GEESE

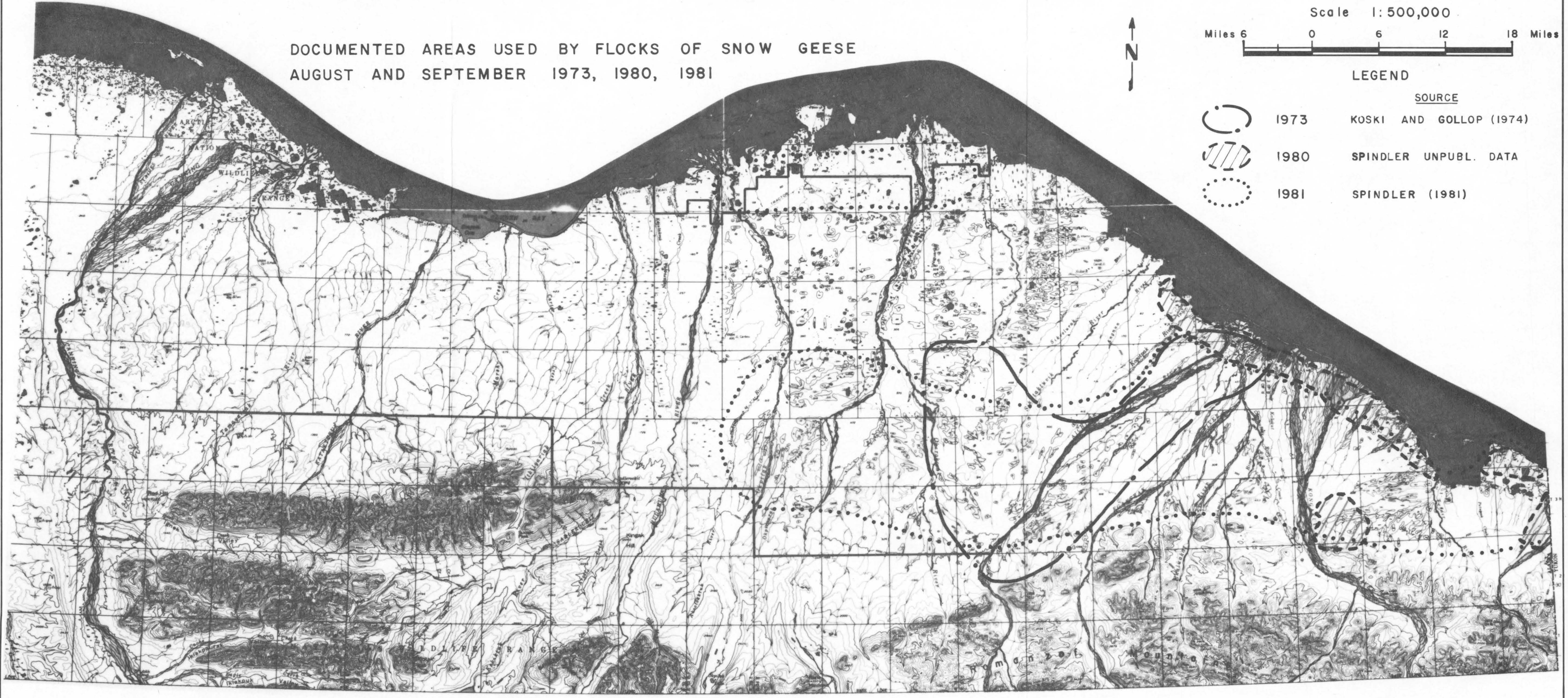


FIG. 10b DISTRIBUTION OF FALL STAGING SNOW GEESE

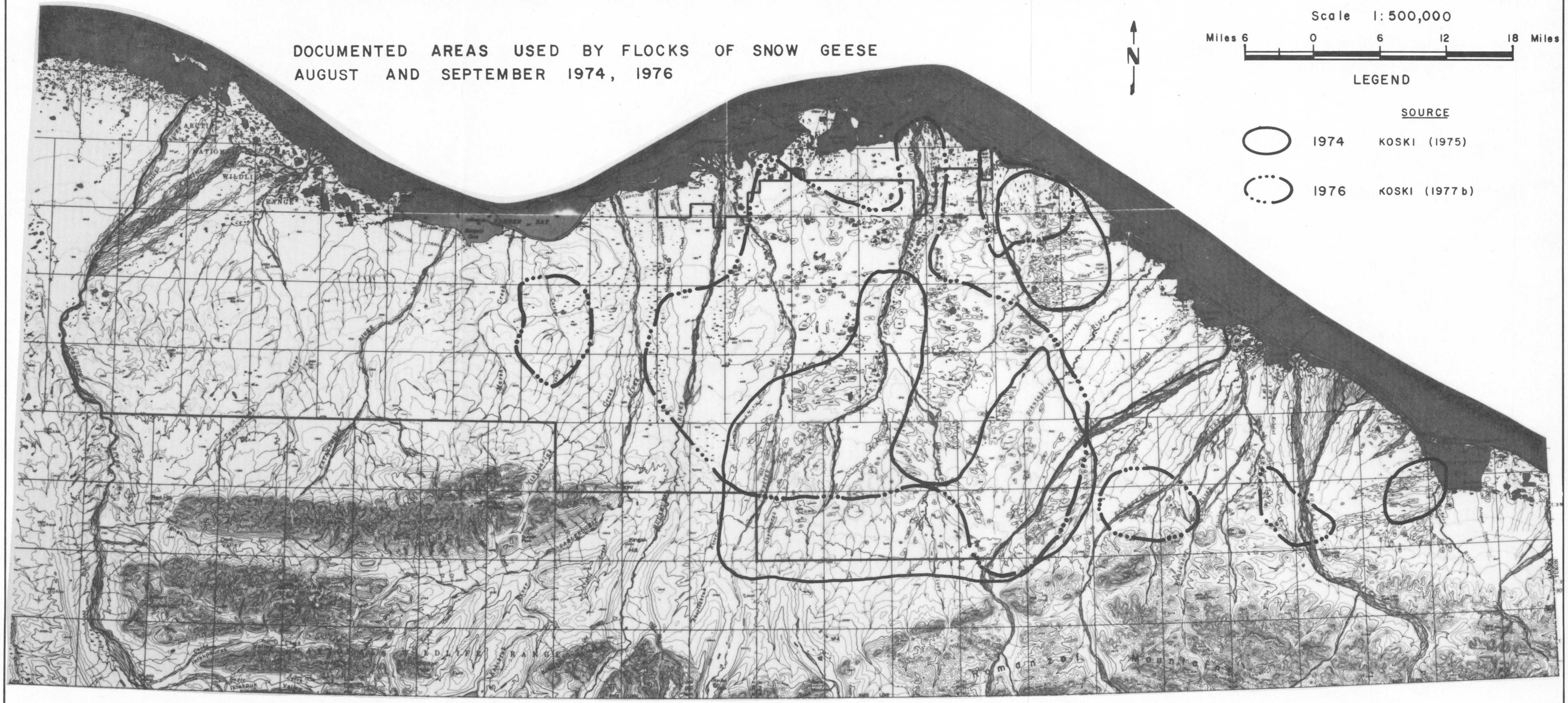
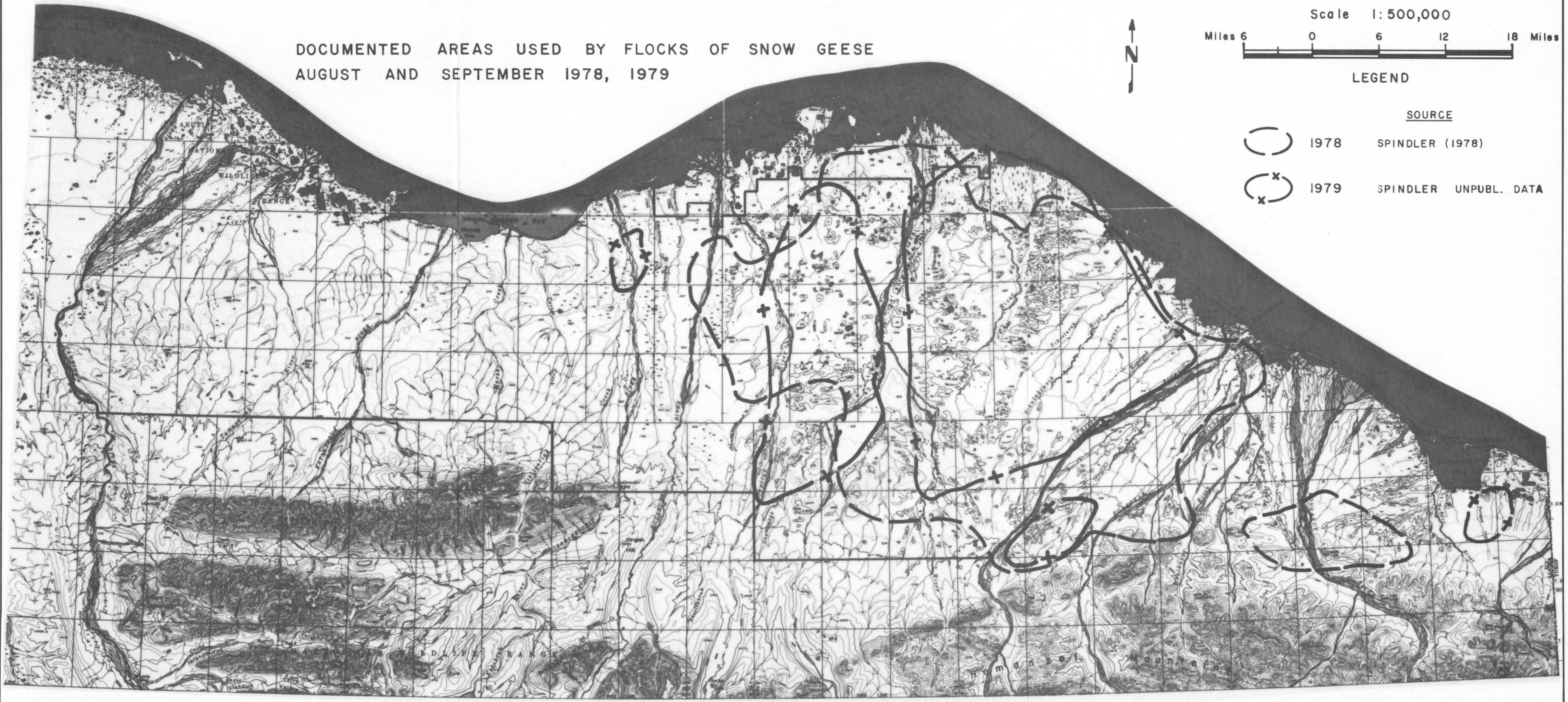


FIG. 10c DISTRIBUTION OF FALL STAGING SNOW GEESE

DOCUMENTED AREAS USED BY FLOCKS OF SNOW GEESE
AUGUST AND SEPTEMBER 1978, 1979



Scale 1:500,000

Miles 6 0 6 12 18 Miles

LEGEND

SOURCE

1978 SPINDLER (1978)

1979 SPINDLER UNPUBL. DATA

Slope, both near Teshekpuk Lake, 1 bird on 15 July 1976 and 4 birds on 18 August 1977 (Kessel and Gibson 1978). The breeding range of this species occurs on Banks Island and eastward, so it is not surprising that a few individuals are recorded on the Alaska North Slope (Johnson et al. 1975).

MALLARD - Uncommon spring migrant, rare summer visitant and fall migrant in coastal plain wetland habitats. At the Canning Delta, mallards were seen in small numbers on 1 occasion in 1979, and on 7 occasions in 1980, all between 2 June and 13 August (Martin and Moitoret 1981). Two to 3 were seen on 3 dates in 1970 at Nuvagapak Point (Andersson 1973) and in the Beaufort Lagoon area (Schmidt 1970). At Demarcation Point R. Burgess (unpubl. data) saw 2, 22 May 1979, and 5, 3 June 1979. M. Robus (unpubl. data) reported a drake at Sadlerochit Springs on 22 May 1979. J. Levison (unpubl.data) observed mallards in groups of 1-15 on 8, 9, 15 August 1980 near Beaufort Lagoon. Mallards occur as casual visitors in NPR-A (Derksen et al. 1981) and as a rare summer resident and very rare breeder on the Yukon North Slope (Salter et al. 1980).

PINTAIL - Very common migrant, common summer resident, and rare breeder in coastal plain tundra wetlands. Spring migration is probably both east to west (from the MacKenzie Valley west to the Alaskan North Slope) and south to north (from interior Alaska north across the Brooks Range to the North Slope), with ensuing dispersal along the North Slope in both easterly and westerly directions (Johnson et al. 1975). Arrival on the ANWR study area occurs in late-May to early-June; 2 June 1978 at Okpilak Delta (Spindler 1978a), 2 June 1980 at Beaufort Lagoon (J. Levison unpubl. data) 22 May 1979 at Demarcation Point (R. Burgess unpubl.data), and 27 May 1979 and 26 May 1980 at the Canning Delta (Martin and Moitoret 1981). The initial observations at the Canning Delta were followed by a pronounced influx several days later on 31 May 1979 and 5 June 1980. Open water at river delta mouths in late May-early June usually attracts the first pintails until open water becomes available in wetland basin complexes during the first or second week of June (Spindler 1978a, Johnson and Richardson 1981, Martin and Moitoret 1981).

Summer resident population densities on the ANWR study area 7.7 birds/km^2 at Beaufort Lagoon in 1970 (Schmidt 1970) and 3.6 birds/km^2 at the Canning River Delta in 1979 (Martin and Moitoret 1981) have been recorded. Both are lower than densities other workers have found at Prudhoe Bay and in 2 of 3 NPR-A sites (Derksen et al. 1981). Population levels and breeding efforts fluctuate widely on the North Slope, apparently increasing with corresponding drought conditions on the North American prairie potholes (Derksen and Eldridge 1980). Pintails were described as the most common duck species using the tundra habitats of NPR-A (Derksen et al. 1981) and as the most common dabbler using tundra habitats of the Canning Delta (Martin and Moitoret 1981). Despite the abundance in some years, breeding has been documented on ANWR with only 2 nests, a possible brood at the Canning Delta in 1980 (Martin and Moitoret 1981), and 2 broods in the Beaufort Lagoon/Aichilik Delta area in July 1970 (Schmidt 1970).

Perhaps more important than breeding habitat, the ANWR coastal plain provides molting and staging habitat in the form of basin-complex, beaded stream, and flooded tundra wetlands used during migration, wing molt, and premigratory staging (Spindler 1978a). In early July (8 July 1978) flocks as large as 23 birds were observed on the Okpilak Delta. In mid-to-late July, birds undergoing wing molt were observed in flooded *Arctophila* and *Carex* habitats

(Spindler 1978a). Martin and Moitoret (1981) noted that wetlands with extensive Arctophila were used by molting pintails on the Canning Delta.

Pre-migratory influxes of pintails were observed on the Canning Delta in late July and early August, and eastward migration was noted beginning by 3 August 1980 (Martin and Moitoret 1981). Peak migration of pintails from the North Slope occurred on 14 August 1980, when over 900 birds were counted flying east at the Canning Delta (Martin and Moitoret 1981). Major fall migration past the Canning Delta ended by 20 August 1980. However, small flocks (up to 30) were seen as late as 2 September using Brownlow Lagoon waters (Martin and Moitoret 1981). At Beaufort Lagoon, J. Levison (unpubl. data) observed the first eastward migrants on 6 August, with peak movement of 783 flying east on 18 August, and the last group seen on 3 September 1980.

GREEN-WINGED TEAL - Uncommon breeder in interior coastal plain, rare breeder in outer coastal plain. The earliest observation on the ANWR study area was of a pair at Sadlerochit Springs on 22 May 1979 (M. Robus unpubl. data). The species was confirmed breeding at Demarcation Point in 1979 (R. Burgess unpubl. data). Green-winged teal have usually been recorded as singles, or infrequent small flocks (up to 16 individuals) mostly in June. Sites of observation in addition to those given above have been Beaufort Lagoon and Aichilik Delta (Schmidt 1970, Andersson 1973, J. Levison unpubl. data), Okpilak Delta (Spindler 1978a), and Canning Delta (Martin and Moitoret 1981). On ANWR there has been only 1 observation in July of a female at the mouth of the Egaksrak River (Schmidt 1970) and only one observation in August (Martin and Moitoret 1981). Schmidt (1970) found a nest near Beaufort Lagoon and estimated 0.8 adults/km ^{2}). The species breeds in regular but small numbers to the east on the Yukon North Slope (Salter et al. 1980) to the west near Umiat (West and White 1966), and to the south in wetlands along north-flowing rivers of the Brooks Range (e.g. Hulahula River, M. Spindler unpubl. data).

AMERICAN WIGEON - Uncommon to fairly common migrant on the ANWR study area. The first observations during spring migration were on 22 May 1979 in the interior coastal plain at Sadlerochit Springs (M. Robus unpubl. data), where open water most of the winter provided an attractant for early-arriving waterbirds (D. Ross unpubl. data, M. Spindler unpubl. data). On the outer coastal plain, American wigeons arrive in the last few days of May (25 May 1979 at Demarcation Point (R. Burgess unpubl. data) and 29 May 1980 at Canning Delta (Martin and Moitoret 1981). Observations on ANWR in June are frequent: Schmidt (1970) recorded 3 flocks in June 1970 in the Beaufort Lagoon area, with a maximum of 50 seen just east of the Kongakut River Delta on 24 June 1970. Up to 13 were seen on 9 dates between 25 May and 10 June 1979 at Demarcation Point (R. Burgess, unpubl. data), and 2 pairs were at Sadlerochit Springs on 22 May 1979 (M. Robus unpubl. data). At the Canning Delta in 1979 observations were of singles to groups of 5, on 1 June, 25 June, and 16 August. In 1980, American wigeons were more common at the Canning Delta with singles, pairs and groups of up to 23 seen on 29 May, 5,7,8,13,14,16, and 21 June. No birds were seen in July and fall movement was few, with 2 flocks seen flying east on 19 August 1980 (Martin and Moitoret 1981). A group of 14 was seen on the Aichilik Delta on 18 August 1980 (J. Levison unpubl. data). Although there are no breeding records on ANWR, Salter et. al. (1980) observed broods at Phillips Bay, Yukon, and Pitelka (1974) listed the species as a regular breeder along the central sector of the Alaskan North Slope.

EUROPEAN WIGEON - Casual visitor to the ANWR study area. A pair was observed in an Arctophila marsh within a drained-basin wetland complex near the Okpilak delta (Spindler 1978a).

NORTHERN SHOVELER - Rare summer visitant. The earliest date on the ANWR study area was 7 June 1980, when 2 drakes and a hen were seen flying east at the Canning River Delta (Martin and Moitoret 1981). Schmidt (1970) reported a drake at the Aichilik River Delta on 24 June 1970. One to 3 individuals were seen on 4 occasions on 22 June 1979 at Demarcation Point (R. Burgess unpubl. data). A pair was observed on 22 May 1979 at Sadlerochit Springs (M. Robus unpubl. data). On the Canning Delta, the species was not recorded in 1979, but was fairly regular in 1980. Records are for 1 to 4 birds seen on 7, 11, 17, 18, 19, and 20 June, 5, and 29 July, and 3 and 14 August (Martin and Moitoret 1981). A few shovelers probably molted on the Canning Delta in 1980, using dense Arctophila beds for cover during the molt (Martin and Moitoret 1981).

GREATER SCAUP - Probably fairly common breeder in interior coastal plain and an uncommon summer visitant in outer coastal plain. In 1978 first arrival on the ANWR outer coastal plain was 6 June at the Okpilak Delta (Spindler 1978a); in 1979 and 1980 first arrival at the Canning Delta was 6 June, and 7 June, respectively (Martin and Moitoret 1981). June records for the greater scaup on ANWR are common: At the Okpilak River Delta, a group consisting of 2 drakes and a hen remained in a small drained basin wetland area from 11-29 June (Spindler 1978a). Three flocks numbering 10, 16, and 23 were seen in the Beaufort Lagoon area on 24 June 1970 (Schmidt 1970); at Demarcation Point small groups of unidentified scaup were seen several times in June 1979 (R. Burgess unpubl. data). At the Aichilik River delta at Beaufort Lagoon 50 scaup sp. (probably this species) were seen with scoters during the last week in June 1970 (Andersson 1973). At the Canning Delta, 5 drakes were observed in Arctophila wetlands on 6 June 1979; all other subsequent records on 7, 15 June 1979, 21 July 1979, 22 July 1980, 20 August 1979 and 21 August 1980 were of up to 5 birds flying over the area or in the Beaufort Sea nearshore and coastal lagoon waters (Martin and Moitoret 1981). There are no breeding records for the ANWR coastal plain. However, Sage (1974) stated greater scaup are probably "the most numerous breeding duck" in the interior coastal plain in the Sagavanirktok drainage. Salter et al. (1980) described the species as "second only to the oldsquaw in abundance" with breeding confirmed between the Firth and Blow Rivers.

COMMON GOLDENEYE - Rare summer visitant in lagoons and coastal plain wetlands. J. Levison (unpubl. data) observed 1 bird near Beaufort Lagoon on 17 July 1980. Adjacent to ANWR, Salter et al. (1980) reported a male in breeding plumage on 26 June 1975 at Clarence Lagoon, 10 km east of ANWR border. The species was also observed molting in low numbers in association with scoters, oldsquaw, and mergansers at Herschel Island from 8-15 August 1973 (Salter et al. 1980). Common goldeneye has also been recorded in wetlands along north-flowing rivers in the Brooks Range (e.g. Hulahula River, M. Spindler unpubl. data).

OLDSQUAW - Common breeder on coastal plain tundra near lakes, ponds, and wetlands; abundant summer resident in lagoons and nearshore waters; abundant migrant along coast. Oldsquaw are the most numerous breeding duck across the outer coastal plain from NPR-A (Derksen et al. 1981) to the Yukon North Slope (Salter et al. 1980). On the ANWR study area, it is probably the most abundant duck, and is the most numerous resident species in coastal lagoons and neashore waters (Spindler 1981b). The abundance of oldsquaw on Alaska's North Slope has prompted intensive study as a key species at Simpson Lagoon (Johnson and Richardson 1981) and elsewhere (Taylor 1981).

Oldsquaw migrate eastward along the Beaufort Sea coast from wintering areas in the Bering Sea and North Pacific to breeding areas on the Alaska and Yukon North Slopes and the Canadian arctic. There is some evidence for a northerly migration across interior Alaska and the Brooks Range to the North Slope (Johnson et al. 1975). Documented spring arrival dates on the ANWR coastal plain and nearby are 22 May (1979 at Canning River Delta), 24 May (1914 at Demarcation Point and 1980 at Canning River Delta), 25 May (1914 at Humphrey Point), 26 May (1980 at Beaufort Lagoon), 28 May (1975 at Clarence River), and 1 June (1972 at both Firth and Babbage Rivers) (Johnson et al. 1975, Martin and Moitoret 1981, J. Levison, unpubl. data). Peak spring movement occurred on 5 June 1980 at Canning Delta, where 2000 oldsquaw were estimated to have passed at the average rate of 30 birds/hour during systematic migration watches from 2-8 June 1980 (Martin and Moitoret 1981). Oldsquaw were observed using river delta overflow waters as soon as they became available at the Canning Delta: 31 May 1979, 65 birds at Flaxman Lagoon; 1-4 June 1979, 15-30 birds at West Branch Flats; 29 May-5 June 1980, 35-60 birds at West Branch Flats (Martin and Moitoret 1981). Spring movements of oldsquaw past Canning Delta were generally not as intense as the fall movements in 1980 (Fig. 8). The spring movement past Oliktok was apparently more intense with 178.3 birds/hour seen in systematic migration watches from 2-10 June 1977 (Richardson and Johnson 1981). The spatial distribution of spring bird migration of which oldsquaw represent a major portion was determined by Richardson and Johnson (1981) using radar and visual data. The spring migration near and west of Oliktok appeared to be a "broad front" extending from 50-60 km inland on the coastal plain to 50-60 km seaward of the coastline, while at Komakuk Beach on the Yukon North Slope, the route appeared to be concentrated along the coastline. Additionally, within Simpson Lagoon in 1977, the breakdown of migrants was 15 birds/hour along the southern half of the lagoon, 6.2 birds/hour long the northern half of the lagoon, and 3.4 birds/hour in the nearshore Beaufort Sea offshore of the barrier islands.

The earliest observation of oldsquaw using tundra wetlands on ANWR is 7 June 1978 at the Okpilak Delta (Spindler 1978a). By 9 June 1979 and 10 June 1980, paired birds moved onto open ponds and wet tundra that was beginning to melt free on the Canning Delta (Martin and Moitoret 1980). Initial food sources for oldsquaw arriving on tundra wetlands may be chironomid larvae, which appeared active in shallow tundra ponds at the Canning Delta in early June 1979 and 1980 (Martin and Moitoret 1981). "Along Alaska's arctic coast, oldsquaws nest most frequently near shallow lakes, which characteristically freeze solid during winter" (Johnson et al. 1975). On such lakes, birds find an abundant source of food in the form of euphyllopods, which appear to be an especially important food source of oldsquaw ducklings (Andersson 1973). Oldsquaw nests found on ANWR have been widely scattered (Spindler 1978a, Martin and Moitoret 1981). Elsewhere, Alison (1975) reported frequent nesting in small clusters or colonies. Of the 16 nests found on ANWR during recent studies (12 at Canning Delta, Martin and Moitoret 1981, and 2 at Okpilak Delta, Spindler 1978a), 7 were in wet tundra with shallow Carex ponds 15-100 m away; 3 were in narrow peninsulas or islands within 2 m of water; 2 were in basin-complex wetlands; 3 were on barren ground near a river distributary; and 1 was on dry tundra near a lake. At Canning Delta minimum estimated nesting density was 0.40 nests/km^2 in 1979 and 0.45 nests/km^2 in 1980 (Martin and Moitoret 1981).

Egg-laying was estimated to have peaked during the last week of June and the first week of July at the Canning Delta, with the first broods seen on 18 July 1979 and 23 July 1980. However, some nests were still incubated as late as 28 July (Martin and Moitoret 1981). Nesting females lead their young to the nearest water after they hatch and dry (Johnson et al. 1975). The chronology of departure of oldsquaw from tundra habitats is demonstrated by temporal changes in adult density observed at Canning Delta in 1979: 4.9 birds/km^2 in June, 4.0 in July, and 1.1 in August (Martin and Moitoret 1981). Adult oldsquaw densities in 1979 at Canning Delta were higher than those at Storkerson Point, Meade River, and Island Lake, but equal to or lower than those at Square Lake, Singiluk, and E. Long Lake (all NRP-A or Prudhoe Bay sites observed in 1978, 1979, or 1980) (Derksen et al. 1981).

Shortly after mating male oldsquaw vacate the tundra breeding areas and presumably go to nearby large deep-open lakes and coastal lagoons to molt (Martin and Moitoret 1981, Taylor 1981). The exodus of males occurs about 5 July, when an obvious westward migration along the lagoons and Beaufort coast is in progress (Spindler 1978a, Martin and Moitoret 1981). The occurence of a mid-summer molt migration and subsequent use of Beaufort Sea coastal waters by oldsquaw are well documented (Gollop and Richardson 1974, Johnson and Richardson 1981). However, the portion of birds molting in ANWR lagoons which bred on the ANWR coastal plain is unknown. The magnitude of movement from the east to west suggests that birds could be arriving from some distance to the east (M. Spindler unpub. data, J. Levison unpubl. data, Gollop and Davis 1974). Furthermore, the turnover rate of individual birds using of individual lagoons is unknown. Some data indicate that large flocks of flightless molting oldsquaw move (swam) from one lagoon to another (Johnson and Richardson 1981, and S. Johnson, pers. comm.). If this occurs frequently, then lagoon use by oldsquaw is a dynamic system in which the numbers of birds present and the individual birds present are not static.

Current knowledge of lagoon use by oldsquaw on ANWR is limited to periodic population samples throughout the open water season An ecological process study at Simpson Lagoon, 250 km to the west, in whic oldsquaw and their invertebrate prey base were examined provides the dat base for knowledge of oldsquaw trophic relationships and molting biology (Jo nson and Richardson 1981).

Along the Beaufort Sea coast the period of the male oldsquaw molt occurs between 15 July and 15 August, whereas, the period of the female molt occurs between 7 August and 18 August (Johnson and Richardson 1981). On ANWR coastal lagoons, peak oldsquaw abundance was observed on 5 August 1978 (115 birds/km^2), 29 July 1979 (229 birds/km^2), and 20 August 1980 (191 birds/km^2) (Spindler 1981b). In comparison Johnson and Richardson (1981) found the peak and average density of oldsquaw in Simpson Lagoon was 566 and 145 birds/km^2, respectively, with an estimated total population of 50,000 birds (in 1 lagoon) on 28-29 July 1977. Seasonal abundance curves for oldsquaw 1980-1981 indicate a gradual buildup of birds through July until a peak is reached in late July or early-mid August followed by a decline into mid-September (Fig. 6e).

The seasonal abundance curves of oldsquaw at Simpson Lagoon are similar to the ANWR coastal lagoonsyet the populations there appear denser (Johnson and Richardson 1981).

Aerial transect data at Simpson Lagoon and transects data east and west of Simpson Lagoon indicate spatial differences in the concentration sites for oldsquaw, but oldsquaw densities at Simpson averaged 20-30% higher than in areas to the east of Simpson Lagoon (Johnson and Richardson 1981). Spatial variation in concentration of oldsquaw was the greatest source of sample variability on ANWR lagoon surveys (Spindler 1981b). Johnson and Richardson (1981) determined that 90% of all birds seen in aerial surveys at Simpson Lagoon were in the lee of the barrier island chain. Johnson and Richardson (1981) compared oldsquaw distribution with prevailing wind patterns and invertebrate prey density patterns, and concluded "that the presence of protective (from wind, waves, ice) barrier islands and the availability of rich supplies of food in adjacent coastal lagoons at least partially account for the dense concentrations of molting (and feeding) oldsquaws in lagoon habitats".

Epibenthic invertebrte species Mysis relicta, M. littoralis and Onisimus glacialis were the primary food items in the crop of collected oldsquaw at Simpson Lagoon, and oldsquaw fed in areas where those invertebrates were more dense (Johnson and Richardson 1981). Among the 19 lagoons surveyed from 1978-1980, and the 12 lagoons surveyed in 1981 on ANWR, aerial survey data indicated great differences in levels of molting and feeding oldsquaw use (Spindler 1981b).

Oldsquaw also use large deep-open lakes on the tundra for molting (Derkson et al 1981, Taylor 1981), and limited data from the Canning Delta suggest that these inland lakes are used more frequently by females than by males (Martin and Moitoret 1981); however, an opposite pattern was observed at East Long Lake near Teshekpuk Lake (E. Taylor pers. comm.). In addition to coastal lagoons and inland lakes, flightless molting oldsquaw have been observed as the most abundant species in nearshore Beaufort Sea aerial surveys from 0-400 m offshore of the barrier islands (Spindler 1981b). Densities of oldsquaw seaward of the barrier islands have ranged from a low of 1.4 birds/km^2 on 14 September 1978 to a maximum of 42.6 birds/km^2 on 9-10 September 1980 (Spindler 1981b). Nearshore use by oldsquaw is generally low in July and increases during August and September. The cause for the wide range in oldsqauw densities in nearshore waters is undetermined, but may be due to oldsquaw avoiding offshore waters during high winds and rough seas (Spindler 1981b). Martin and Moitoret (1981) noted that in 1980 most oldsquaw sought protection inside the barrier islands while they were molting. They also noted that most oldsquaw were seen outside the barrier islands at Brownlow Lagoon before and after molting.

Fall migration along the ANWR coast is westward and intensive during the major movement, with a peak of 538 birds/hour determined from systematic migration watches at the Canning Delta in 1980 (Martin and Moitoret 1981). The actual westward movement begins with the male molt migration in late June and early July. Between 18 and 31 August 1979, 4,728 oldsquaw were observed flying west past the Canning Delta, with an estimated total of 20,800 birds migrating; for 1980 from 18 August to 6 September an estimated 32,000 oldsquaw migrated past the Canning Delta, but Martin and Moitoret (1981) caution that these figures represent only the earlier half of oldsquaw fall migration. By comparison, Johnson and Richardson (1981) counted 33,000 oldsquaw flying west past Pingok island 21 August-22 September 1977, and estimated that over 100,000 oldsquaw migrated through or past Simpson Lagoon. In 1978, they did not see nearly as many oldsquaw migrating west and warn that "oldsquaws do occur far offshore in the Beaufort Sea during late August and September (Searing et al. 1975, Divoky 1978a). Thus it is probable that a significant fraction of autumn migration is not near the coast" at Simpson Lagoon. Indeed Timson (1976) estimated that 240,500 oldsquaw passed Barrow, migrating west 3-16 September 1975.

A significant observation on the nature of fall migrating oldsquaw was that "more than other waterfowl, oldsquaw were noticed using the (Canning Delta) study area rather than just flying past. Often a 'leapfrog' type of movement was seen, with oldsquaw rafting just offshore at Brownlow Point and a constant stream of individuals joining and leaving the group" (Martin and Moitoret 1981). Johnson and Richardson (1981) noted "considerable turnover" of individual oldsquaw in Simpson Lagoon from 22 to 23 September 1977-1979. Oldsquaws have been seen utilizing ANWR lagoon and nearshore Beaufort Sea waters on aerial surveys as late a 20 September 1981 and elsewhere along the Beaufort Sea Coast as late as 15 October 1978, at Prudhoe Bay (Johnson and Richardson 1981), and 19 October (Bailey 1948).

HARLEQUIN DUCK - Rare summer visitor and possible breeder along rivers in northern foothills of Brooks Range and interior coastal plain of ANWR; casual visitor to arctic coast. Salter et al. (1980) observed the species in small numbers (less than 3) in coastal plain rivers, lakes, lagoons, and open ocean of the Yukon coast June, July, August 1972, August 1973, June 1975, and August 1976. They did not document breeding on the Yukon Territory coastal plain, but found a brood 13 km to the south in the Brooks Range foothills. ANWR records include several pairs, or single males and females at Sadlerochit Springs on June 1978, 21 May 1979, 7 June 1979, and 12 June 1979. Mostly males were observed on 20 June 1979; and only females were seen again on 18 and 19 July 1979 (M. Robus unpubl. data). One specimen was collected near Barter Island 26 June (no year given, Gabrielson and Lincoln 1959). There are additional records in adjacent areas including one brood to the west at the Ivishak River on 6 August 1971 (Gavin 1971).

STELLER'S EIDER - Rare breeder and summer resident on ANWR coastal barrier islands, lagoons, and shores of lagoons and large coastal lakes and wetlands. The regular breeding range of this species centers on the Siberian arctic coast and extends as far east as Point Barrow (Myres 1958). East of Barrow the species decreases in abundance and regularity of breeding (Myres 1958, Gavin 1970 and 1972, Watson and Divoky 1974). The only documented occurrences on ANWR are several birds at Humphrey Point on 13 June 1914, reported by Dixon (1943) who believed they nested in the area. Brooks (1915) saw a female Steller's eider at Demarcation Point in 1914. First arrival of the species is probably in the first to second week of June. At Storkerson Point, Bergman et al. (1977) reported arrival dates of 8 June 1971, 12 June 1972, and 7 June 1973.

COMMON EIDER - Uncommon breeder on barrier islands, along lagoon shores, and in outer coastal plain tundra wetlands of ANWR; fairly common migrant and summer resident in coastal lagoon and nearshore waters of the Beaufort Sea off ANWR. Barry (1974) estimated that over one million eiders summer in the Beaufort Sea area, and that slightly less than half are common eiders. In spring common eiders arrive from the west. On 11 June 1975, 30.8 birds/hour were observed flying east past Komakuk Beach (Salter et al. 1980). The first spring observations at Canning Delta were on 27 May 1979 and on 31 May 1980 (Martin and Moitoret 1981). A flock of 50 was seen flying east past Simpson Cove on 1 May 1980 (M. Spindler unpubl. data). This observation is unusually early for the ANWR coast considering that the main spring migration past Barrow is 10-15 May. It is also possible that common eiders occasionally winter in leads and polynias since they have been recorded at Banks Island as early as 10 April 1953 (Johnson et al. 1975). It is believed however, that the majority winters in the Bering Sea and North Pacific (Johnson et al. 1975). Spring migration along the ANWR coast (and most of the Beaufort Sea coast from Harrison Bay to Mackenzie Bay) is gradual with seldom more than a few hundred eastbound migrants observed as compared to the hundreds of thousands seen passing Barrow in mid-May (Johnson 1971) and Cape Dalhousie, N.W.T. in late-May to mid-June (Barry 1974). Johnson et al. (1975) summarized what little information is available on offshore Beaufort Sea eider migration. Following spring migration small numbers were seen on the tundra on the Okpilak Delta in mid-June 1978 (Spindler 1978b) and on open water in coastal lagoons and the Beaufort Sea near the Canning Delta in June 1979-80 (Martin and Moitoret 1981).

Nest initiation at the Canning Delta is generally during the last 2 weeks of June and the first few days of July (Martin and Moitoret 1981). A total of 9 nests in 1979 and 3 nests in 1980 were found in a colony on the spit west of Brownlow Point. Divoky (1978b) reported nests at the following locations in 1975 or 1976 (number of nests in parentheses): Konganevik Point Island (8), Arey Island ("several"), Arey Spit (1), Bernard Spit (1), Jago Spit (4), Egaksrak Island (1), S. of Siku Entrance (6). Schmidt (1970) found 23 active nests on 2 reefs 1.6 km south of Pingokraluk Point. Tundra nesting density in coastal flooded-Carex and basin-complex wetlands at the Okpilak Delta were estimated to be 0.04 nests/km^2 (Spindler 1978a). At the Canning Delta the first broods were seen 17 July 1980. "Broods were seen in the Beaufort Sea off Brownlow Point in mid-to-late August 1979. Only 5 brood sightings were made at the Canning Delta in 1980, despite intensive weekly shoreline surveys" (Martin and Moitoret 1981).

The earliest documentation of westerly migration of non-breeding eiders is mid-June. Birds were observed flying both east and west past Komakuk Beach, Y.T. and Clarence Lagoon, Y.T. after mid-June and a generally westerly movement past Nunaluk Spit, Y.T. began on 10 July 1972 (Salter et al. 1980). Small flocks were seen flying west past Nuvagapak Point in late June (Schmidt 1970, Andersson 1973). Martin and Moitoret (1981) noted extensive use by eiders in a developing shore lead between Flaxman Island and Brownlow Point with at least 500-800 birds were present on 27-30 June 1979. As the shore-lead opened closer to Brownlow Point, 200 eiders were observed on 10 July 1979. Comparable use of the Brownlow Point area by eiders was not seen in 1980 (Martin and Moitoret 1981).

In both 1979 and 1981 a major westward movement of eiders, of which "at least 90% " were male common eiders was noted past the Canning Delta from the end of July to 10 August. Peak movement was on 28 July 1980 when greater than 500 birds/hour were counted; in 1979 peak movement of 150 birds/hour was noted on 21 July (Martin and Moitoret 1981). By contrast Johnson and Richardson (1980) reported about 35 common eiders/hour migrating west past Pingok Island on 20-25 July 1977, at which time 157 king eiders/hour were reported flying west. During the molt migration Johnson and Richardson (1981) determined that most of the eiders migrated along shoreleads and over lagoon ice before breakup, and over the lagoons and open sea north of the barrier islands after breakup. They estimated a total of 3,602 eiders (both king and common) passing through Simpson Lagoon during molt migration.

During the molt migration and fall migration eiders stop and rest in the coastal lagoons and neashore waters of ANWR (Spindler 1979a and 1981b, Martin and Moitoret 1981). Eiders frequently cannot be identified to species in aerial surveys so estimates of eider density in lagoons is lumped as "all eiders". In 1978 there were 2 peaks in eider use of lagoons, 0.68 eiders/km^2 on 22 July and 0.85 eiders/km^2 on 5 August (Spindler 1981b). Maximum eider density ever observed was 9.0 eiders/km^2 on 10 September 1980. The 1981 seasonal abundance pattern for eiders showed a peak in abundance of 2.0 eider/km^2 in early August, followed by a decline in late-August and a second, lesser peak in mid-September (Fig. 6e). At Simpson Lagoon eider denstities offshore in the Beaufort Sea peaked at 1.5 eiders/km^2 on 28 and 29 July 1977. Along the south shore of the barrier islands they peaked at 1.6 eiders/km^2 on 28 to 29 July 1979 (Johnson and Richardson 1981). Eiders were not seen in mid-lagoon waters and denities along the mainland shore and mainland varied from 0-1.2 and 0-1.8 eiders/km^2 (Johnson and Richardson 1981).

Fall migration of common eiders is largely a movement of female and juvenile eiders since the majority of males have already departed during the molt migration (Thompson and Person 1963). At Brownlow Point, small numbers (about 10/hour for 74 hours of observation) migrated west between 14-31 August 1979, most of which were females and juveniles (Martin and Moitoret 1981). Fewer total numbers of eiders were seen passing Br wnlow Point between 19 August and 1 September 1980, but a peak rate 45 eiders, ɩour was counted on 1 September. By comparison, Johnson and Richardson (1981' counted a peak rate of 47 birds/day between 21 August and 22 Septembe 1977 and 135 birds/day in 1978 at Simpson Lagoon. These low numbers and the ɩbservations by Bartels (1973), Watson and Divoky (1974), and Divoky (197?) indicate that migration routes extend 13-16 km offshore in the Beaufort Sea whi(ɩ may not be detected by observers along the shore.

Johnson and Richardson (1981) saw eiders :n Harrison Bay as late as 22-23 September 1977-1979, and common eiders we:e observed on lagoon and nearshore transects along the ANWR coast as late as 9-10 September 1980 (Spindler 1981b) and 20 September 1981 (M. Spindler unpubl. data).

KING EIDER Uncommon breeder in outer coastal plain wetlands and uncommon migrant along the ANWR Beaufort Sea coast. The center of abundance of King eiders in Alaska is near Point Barrow and eastward (Gabrielson and Lincoln 1959). In Canada king eiders occur along the coasts of the Arctic Archipelago (Godfrey 1966). Barry (1974) estimated that about 700,000 king eiders migrate into and through the Beaufort Sea. As with the common eider, the bulk of the eastward spring migration probably occurs in the Beaufort Sea offshore of ANWR (Johnson et al. 1975). King eiders first appear along the eastern Beaufort Sea coastal tundra during the first 2 weeks of June, however, Searing and Richardson (1975) suggest that they probably arrive in offshore leads and polynias around the third or fourth week of May. Martin and Moitoret (1981) reasoned that "since king eiders probably arrive in the Canadian arctic during the last 2 weeks of May, the Alaska breeders must either wait in offshore leads for snow on the tundra to melt and/or there is a secondary movement of local breeders along the Beaufort Sea coast in late May or early June".

During a migration watch at Simpson Lagoon in 1977, king eider movement eastward peaked between 7-13 June, (Johnson and Richardson 1981), supporting the second hypothesis. Arrival dates for king eiders in ANWR and nearby areas were 14 May 1975 at Komakuk Beach, 15 May 1914 at Humphrey Point, 1 June 1979 and 4 June 1980 at Canning Delta, 7 June 1914 at Demarcation Bay and 7 June 1978 at the Okpilak Delta (Brooks 1915, Dixon 1943, Johnson et al. 1975, Spindler 1978b, Martin and Moitoret 1981). On the Canning Delta eastward migration was not detected, rather birds arrived and began using overflow water at the river delta and water in snow melt pools. Pairs became numerous between 12-22 June on tundra at the Canning Delta, and males began to decrease on the tundra during the last week in June, disappearing entirely by the end of the first week in July (Martin and Moitoret 1981).

Limited data on nesting at the Canning Delta indicated that egg laying began during the second week of June 1979 and 1980 (Martin and Moitoret 1981). A total of 7 nests were found during the 2 years of study at the Canning Delta in sites ranging from wet tundra with pools nearby, to mesic tundra with shallow-Carex ponds, and the deep-Arctophila portions of basin-complex wetlands. By comparison, king eiders were not found nesting east of the Okpilak at Beaufort Lagoon (Schmidt 1970), Demarcation Bay (R. Burgess unpubl. data), or the Yukon North Slope (Salter et al. 1980). At Storkerson Point to the west of ANWR, they are more common nesters in the similar shallow-Carex and deep-Arctophila habitats (Bergman et al. 1977).

A molt migration was not evident past Canning Delta in either 1979 or 1980. However, a few males were seen flying west on 1 August 1980 (Martin and Moitoret 1981). Johnson et al. (1975:74) in a literature review reported that:

> It is probable that king eiders migrate offshore past the Mackenzie Delta (Martel in prep.); Brooks (1915) recorded these birds migrating west past Demarcation Bay during mid-July 1914, and Dixon (1943) saw them migrating past Humphrey Point on 13 July 1914. Schmidt (1970) saw flocks that consisted mostly of king eiders flying west past Beaufort lagoon as early as the last days of June and the first days of July. According to King (1970), Thompson and Person (1963), and Johnson (1971), the molt migration of King eiders past Point Barrow begins in the second week of July; at this time flocks consist primarily of males.

At Simpson Lagoon, Johnson and Richardson (1981) noted a medium sized westward movement totalling 1,931 birds between 1-31 July 1977, most of which moved through between 21-25 July. No comparable movement of king eiders was noted near the shore there in 1978. Equal numbers of common and king eiders were seen during the 1977 molt migration at Simpson Lagoon (1,910 and 1,931 respectively). At Canning Delta in 1979 and 1980, common eiders were by far in the majority during the molt migration period (Johnson and Richardson 1981, Martin and Moitoret 1981). Since the fall migration of eiders along the ANWR coast consists mostly of females and juveniles, identification to species is usually impossible at distances greater than 20 m and during aerial surveys. Therefore, knowledge of species composition of eiders during the fall migration is quite limited. From the definite observations of eiders made at the Canning Delta 1979 and 1980, it appeared as though king eiders were in the minority. Schmidt (1970) reported "a few small flocks" flying past Angun Point during late August and early September 1970. Johnson and Richardson (1981) counted only 5 king eiders during intensive fall migration watches at Simpson Lagoon. Most king eiders have left the coastal lagoons along ANWR by

September (Spindler 1981b). However, individuals have been seen in Barrow coastal waters as late as 9 November and 2 December (Johnson et al. 1975).

SPECTACLED EIDER Uncommon breeder in basin-complex wetlands on ANWR outer coastal plain. The species was observed arriving at the Canning Delta on 1 June 1979 and 5 June 1980 (Martin and Moitoret 1981), and at Demarcation Bay on 12 June and 26 June (R. Burgess unpubl. data). The center of abundance of breeding spectacled eiders on the North Slope of Alaska is thought to be near Cape Halkett or Cape Simpson (Johnson et al. 1975). On the ANWR, Schmidt (1970) recorded a pair on a pond in the Aichilik River Delta on 6 July 1970 and occasional small flocks along the barrier spits of Beaufort Lagoon in late June. Andersson (1973) reported breeding at Nuvagapak Point. J. Levison (unpubl. data) observed 2 birds off shore of the [illegible] island at Beaufort Lagoon on 24 July 1980.. Brooks (1915) collected 5 at Hum[illegible] Point between 12-26 June 1914. A pair and a group of 2 females and 1 male were seen in mid-June 1979 at Demarcation Point (R. Burgess unpubl. data). Egg-laying is reported to commence on the North Slope during the second week in June (Gabrielson and Lincoln 1959, Andersson 1973). At the Canning Delta, 3 broods were located in 1979, the first of which was seen 28 July. Only 1 brood was found in 1980. Females with broods used shallow-*Carex* and deep-*Arctophila* wetlands (Martin and Moitoret 1981). Johnson et al. (1975) reported that spectacled eiders preferred coastal areas with shallow, muddy water. Departure of males from the Beaufort Sea nesting areas following the onset of incubation was reported by Gabrielson and Lincoln (1959). Three males and 1 female at Angun Point on 1 September are the only fall records for the species on ANWR (Schmidt 1970).

WHITE-WINGED SCOTER Uncommon migrant along the Beaufort Sea coast of ANWR, possible breeder near lakes of interior coastal plain. The species is a common breeder in the upper Yukon and Porcupine Valleys (Johnson et al. 1975), an uncommon breeder near eastern Brooks Range lakes (M. Spindler unpubl. data), and is a migrant and summer resident in the coastal lagoons of ANWR. White-winged scoters may arrive in the ANWR coastal region from the west, since eastward movements were noted past Nunaluk Spit and Clarence Lagoon, Y.T. in early June 1975 (Johnson et al. 1975), and past the Canning Delta in early June 1979-80 (Martin and Moitoret 1981). They also may arrive from the south, following rivers and passes through the Brooks Range and then eastward along the Beaufort Coast (Bent 1925). First arrival dates along the Beaufort coast near ANWR have been 1 June (1972 Firth River, 1979 Canning Delta); 5 June (1975 Babbage River, 1980 Canning Delta); 6 June (1975 Komakuk Beach); 8 June (1980 Beaufort Lagoon), 13 June (1914 Demarcation Point) (Johnson et al. 1975; Martin and Moitoret 1981, and R. Burgess unpubl. data, J. Levison unpubl. data.).

Most late June and July observations of white-winged scoters are of birds resting in lagoons or flying west: in the Beaufort Lagoon area 6 flew northwest on 17 June 1970 (Andersson 1973); single birds and a pair were seen at Angun Point in July 1976 (P.D. Martin unpubl. data); and a group of 6 males and a group of 4 males were seen on Beaufort Lagoon on 6 and 7 August, respectively. J. Levison (unpubl. data) observed groups of 2-72 from mid-June through late August 1980 at Beaufort Lagoon. Spindler (1978a) saw 4 flying west on 1 July 1978 at the Okpilak River Delta. At the Canning River Delta, Martin and Moitoret (1981) reported white-winged scoters resting or milling in the area with no definite migratory direction: "Three males and 2 females were on West Branch 16 June 1980." On 30 June 1979, 9 drakes were seen at the gap in the Brownlow Lagoon reef. On 10 July 1979, a high count of 100-150 was made at Brownlow Point. In 1980, 1-5 individuals were seen between 6-24 July flying along the barrier spits or in the lagoon or Beaufort Sea waters near Canning Delta. The maximum number of white-winged scoters seen in coastal aerial surveys was 45 birds in the nearshore transects between Brownlow Point and Demarcation Bay on 12 July 1980. Four birds were seen in Nuvagapak lagoon the same date and 3 birds were seen in lagoon transects on 22 July 1978 (Spindler 1981b). Johnson and Richardson (1981) noted a westward molt migration of white-winged scoters that was not as extensive as that of surf scoters past Simpson Lagoon in July 1978. Johnson et al. (1975) stated that "there is little evidence that white-winged scoters actually molt along the Beaufort Sea coast". It is suspected the migration seen along the Beaufort occurs prior to their departure for molting areas farther south.

"White-winged scoters apparently leave the Beaufort Sea earlier than surf scoters..." possibly as early as mid-to-late August (Johnson et al. 1975). Since more westbound molt-migrants were seen passing Nunaluk Spit in June-July than returning eastward as migrants in August, Johnson et al. (1975) and Gabrielson and Lincoln (1959) speculated that they may "fly directly south through the river passes in the Brooks Range and then to the Pacific coast via the Yukon river drainage." ANWR fall observations are inconclusive as regards direction of fall migration: 3 drakes flew west past Brownlow Point on 20 August 1979; 5 drakes flew east past Brownlow Point on 28 August 1979; and 1 hen flew west on 29 August 1979. On 1 September 1980 a drake flew west past Brownlow Point (Martin and Moitoret 1981).

SURF SCOTER Uncommon migrant and summer resident in ANWR coastal lagoons and nearshore waters. The major breeding areas of the species are in interior Yukon, the upper Yukon valley, and the Bering Sea coast (Gabrielson and Lincoln 1959). Occurrence of the species along the ANWR Beaufort Sea coast is primarily post-breeding males and an unusual pre-molt migration that is in a direction opposite to their fall migration route (Johnson et al. 1975, Johnson and Richardson 1981). There is no positive documentation of this species breeding on the Yukon North Slope or eastern Alaskan north slope (Johnson et al. 1975). Surf scoters usually first appear along the ANWR coast in mid-to-late June: At the Canning Delta "on 21 June 1980 12 drakes were seen in Brownlow Lagoon; 2 drakes were seen flying west over the lagoon on 24 June 1980; a flock of 35 flew west on 28 June; a flock of 53 flew west on 2 July" (Martin and Moitoret 1981). Surf scoters seem to occur regularly at Beaufort Lagoon where Andersson (1973) recorded 980 drakes foraging on the lagoon 28 June 1970 and saw flocks of 50-100 passing northwest past Nuvagapak Point at the end of June. P. Martin (unpubl. data) saw small numbers of surf scoters on 4 occasions between 13 July and 2 August 1974 with a maximum count of 15 flying west past Nuvagapak point on 13 July. There were 70 at the mouth of the Kogotpak River on 3 July 1976; 6 were seen at Angun Point on 16 July 1976; and flocks were seen passing west at Nuvagapak Point between 11-18 July (P. Martin unpubl. data). A definite westward molt-migration of surf scoters was noted in early July 1980 at Canning Delta (Martin and Moitoret 1981). J. Levison (unpubl. data) counted 562 surf scoters flying west or using the lagoons near or at Nuvagapak Lagoon between 25 June and 4 July 1980. Johnson and Richardson (1981) noted 906 westbound and 22 eastbound surf scoters flying past Simpson Lagoon during July 1978. Heavy westward movement has been noted on the Yukon coast with over 6,200 estimated going west past Nunaluk Spit between 10-25 July 1972 where surf scoters were classified as locally abundant in molting flocks in the Canadian Beaufort Sea especially near Herschel Island (Salter et al. 1980). The period of westerly movement at Clarence Lagoon and Komukuk Beach was 17 June-9 July (Salter et al. 1980).

Mid-summer densities of surf scoters in the ANWR coastal lagoons has been estimated at 0.30 birds/km^2 on 1-3 August 1980, 0.07 birds/km^2 on 9 September 1980, 0.24 birds/km^2 on 29 July 1979, and 0.31 birds/km^2 on 22 July 1978 in the transects just south of the barrier island chain. The only other transect on which the species was recorded at Simpson Lagoon was the mid-lagoon transect with a density of 0.70 birds/km^2 on 15 and 25 July 1978.

Following the mid-summer molt period surf scoters are not observed returning eastward in the same large numbers in which they are seen migrating westward prior to the molt... "These observations suggest that some surf scoters possibly migrated farther offshore and out of view of the observers stationed at Nunaluk Spit, Y.T., or that some birds of this species migrated south through passes in the Brooks Range (the same passes used during spring migration) and then down the Yukon River drainage" (Johnson et al. 1975). There is some evidence for eastward and southward migration, however, since "between 9 September and 10 October 1972, Salter (1974) specifically identified 35 surf scoters flying south up the Mackenzie Valley, N.W.T." (Salter et al. 1980).

BLACK SCOTER Uncommon migrant along Beaufort Sea coastal lagoons and nearshore waters of ANWR. The species nests mainly from the eastern Aleutians and Alaska Penninsula east through Interior Alaska to the Northwest Territories, northern Quebec, and Newfoundland (Johnson et al. 1975). Occurrence of the species on the eastern Alaskan north slope appears to be a 'post-breeding shuffle' and perhaps a westward molt migration. On ANWR, the species has been seen flying west past Brwonlow Point as a flock of 50 on 24 June 1980, and 4 males and a female on 29 August 1979 (Martin and Moitoret 1981). One black scoter was also observed swimming in the sea among a group of white-winged scoters off Brownlow Point (Martin and Moitoret 1981). A total of 200 black scoters on 21 June and 70 on 28 June were seen flying past Demarcation point in 1979 (R. Burgess unpubl. data). Black scoters may also frequent interior coastal plain lakes on ANWR; 3 males on 23 June and 1 female on 14 July were seen on a lake in the upper Hulahula River drainage in 1980 (M. Spindler unpubl. data). Elsewhere along the coastal plain near ANWR, Derksen et al. (1981) reported 4 flocks totalling 127 birds flying west past Point McIntyre near Prudhoe Bay on 30 June 1976. On the Yukon Beaufort Sea coast observations included single males seen at Nunaluk Spit on 11, 12 and 28 July 1972, a flock of 4 at Clarence Lagoon on 21 June 1975 and a flock of 30 two km north of Herschel Island on 26 June 1975 (Salter et al. 1980).

RED-BREASTED MERGANSER Uncommon summer resident and breeder along foothills and interior coastal plain rivers; rare breeder and summer resident along outer coastal plain rivers; fairly common migrant along coastal lagoons and nearshore Beaufort Sea waters. Initial spring migration routes into the Beaufort Sea area are uncertain at this time, however, Salter et al. (1974) suggested a possible migration down the Mackenzie Valley, thence westward along the coast. The earliest ANWR observations are 4 birds at Sadlerochit Springs on 22 May 1978 (M. Robus unpubl data); one bird at Beaufort Lagoon on 9 June 1980 (J. Levison unpubl. data); a pair at the Canning Delta on 16 June 1980 (Martin and Moitoret 1981), and a single bird at Demarcation Point on 22 June 1978 (R.M. Burgess, unpubl. data). Red-breasted mergansers were seen regularly along the Sadlerochit River from the springs to a point within 15 km of the coast (M. Robus unpubl. data). The species was seen regularly in late-June 1979 and 1980, and in July 1980 at the Canning Delta, including a maximum count of 10 in Brownlow Lagoon on 10 July 1980 (Martin and Moitoret 1981).

Evidence of breeding on the coastal plain includes 3 birds accompanying a brood of 9 at Demarcation Point on 7 August 1978, a female and a brood at Griffin Point on 2 August 1914 (Dixon 1943), a brood on the Canning River interior coastal plain (Valkenburg et al. 1972), and a hen with 3 young on the Staines River at Canning Delta (Martin and Moitoret 1981). Nest sites are usually on the shore of a river or lake, and concealed in brush or driftwood (Godfrey 1966).

A predominantly westbound molt-migration was noted past Nunaluk Spit, Y.T. between 10 July and 13 August 1972 (Gallop and Davis 1974b). Martin and Moitoret (1981) reported a late-August influx of mergansers on the Beaufort Sea and lagoon shores near Canning Delta. Most birds appeared to be males, with at least a few mergansers spending their wing molt period along the Beaufort Sea and lagoon shores, fishing or loafing along the barrier spits and islands. Seasonal occurence of red-breasted merganser in coastal lagoons increases in late-July and reached a peak of 0.70 birds/km^2 on 5 September 1978, and 0.18 birds/km^2 on 20 August 1980.

GOSHAWK Rare summer visitor to ANWR foothills and coastal plain. One adult was seen at Sadlerochit Springs on 20 May 1979 (M. Robus unpubl. data). The species occurred as an uncommon summer resident at Mancha Creek at the northerly limit of tree growth in ANWR, and it is likely that individuals may occasionally venture out onto the North Slope. Irving (1960) reported several goshawks at Anaktuvuk Pass, several km beyond tree-line in 1954-1956, and speculated that they may have wandered out onto the tundra because of an abundance of ptarmigan.

ROUGH-LEGGED HAWK Uncommon summer resident and breeder in ANWR interior coastal plain along river bluffs and near steep foothill slopes; rare visitant to outer coastal plain. The main breeding range of the species in northern Alaska consists of the Brooks Range north of the continental divide, the foothills, and portions of the interior arctic coastal plain, as well as the Seward Penninsula (Roseneau 1974). Rough-legged hawks arrive at their breeding grounds in NPR-A from 21 April to 7 May (NPR-A Task Force 1978). Migration routes are apparently across the interior and through Brooks Range passes. Irving (1960) reported northward migration through Anaktuvuk Pass between 5-19 May 1949-1952. M. Spindler (unpubl. data) has observed rough-legged hawks in migration through the Hulahula River pass in ANWR.

Rough-legged hawks arrive in the Brooks Range and foothills about mid-April (D. Roseneau pers. comm.). Earliest records are of single adults seen on 14, 18 and 20 May 1979 at Demarcation Point (R. Burgess unpubl. data). Spindler (1978a) observed 2 adults on the Okpilak Delta on 4 June 1980. One individual was seen at the Canning Delta on 9 June 1980 (Martin and Moitoret 1981). One adult was seen at its nest near Eagle Creek in mid-April 1975 (Roseneau pers. comm.). Most records for the study area are for early summer. However, Andersson (1973) and Martin (unpubl. data) observed rough-legged hawks at Beaufort Lagoon in July. Presence of rough-legged hawks on the coastal plain varies considerably between years. P. Martin (unpubl. data) noted 4 sightings in the Beaufort Lagoon vicinity in July 1976, but none for the same month in 1974. He felt this difference was caused by an abundance of lemmings in the area in 1976. Nesting areas on the ANWR coastal plain and foothills were documented by Roseneau (1974) "the species has commonly nested in the Canning drainage, the Shublik and Sadlerochit Mountain areas and along the northern edge of the Brooks Range between the Jago River and the Alaskan border. Some nesting has occurred along the high dirt/rock bluffs of the Katakturuk River and Marsh Creek drainages north of the Sadlerochit Mountains and some may occur along the upper Tamayariak and lower Carter Creek drainages. The upper Echooka River, upper Juniper Creek and upper Kavik River drainages also offer relatively good nesting habitat for ths species, as does the Kongakut River valley south of about 69°25'N [where search effort has been restricted by logistical considerations])." M. Robus (unpubl. data) found a nest at Sadlerochit Springs and a probable nest about 2.4-3.2 km west-northwest of the springs, where a pair of adults acted defensively on 16-18 June 1979. Roseneau 1974) and Roseneau et al. (1980) reported a rough-legged hawk nest on the bluffs near the 300 m contour line along the Katakturuk River in 1973. Intensive surveys in ANWR north of the continental divide in 1973 indicated about 20 active nests (Roseneau 1974). Nesting populations of this species are known to fluctuate widely between years and sufficient nesting habitat is available to support nesting populations double that number in a "high year" (D. Roseneau pers. comm.) White (as cited by Roseneau 1974) reported no nesting rough-legged hawks in the Canning drainage in 1971. Roseneau (1974) reported several pairs nesting there in 1972 and 1973 and fo[illegible] the Canning near Mt. Coppleston in August 1980 (Roseneau et al. 1980). Variation in populations could have been caused by changing microtine population levels (White as cited by Roseneau 1974). Preferred nesting habitat includes cliffs along river courses, some drier upland outcrops away from rivers (NPR-A Task Force 1978), and occasionally less stable mud-bluffs along rivers (Roseneau 1974). Rough-legged hawks appear to favor the lowest average nesting elevations (362 m) of the large cliff-nesting species (Roseneau 1974).

The NPR-A Task Force (1978) reported the range of nesting dates as 15 May to 21 July, brood rearing dates as 15 June to 21 August, and fledging dates as 31 July- 30 August (Table 25). Recommended management of rough-legged hawk habitat and other cliff-nesting raptor habitat consists of eliminating or minimizing disturbances during the critical nesting periods (NPR-A Task Force 1978).

Table 25. General chronology of raptor nesting on the North Slope of Alaska. Dates given are approximate for each species. Data from NPR-A Task Force (1978).

Species	Arrival	Nesting	Brood Rearing	Fledging
Peregrine Falcon	21 April to 7 May	15 May to 21 July	15 June to 21 Aug	31 July to 30 Aug
Gyrfalcon	Resident	1 April to 30 June	1 May to 15 Aug	21 June to 15 Aug
Rough-legged hawk	21 April to 7 May	15 May to 21 July	15 June to 21 Aug	31 July to 30 Aug
Golden eagle	1 April to 15 May	1 May to 30 June	7 June to 30 Aug	
Snowy owl	Resident	15 May to 7 June	21 June to 4 Aug	15 Aug on
Short-eared owl	25 May to 5 June	7 June to 7 July	7 July to 21 Aug	15 Aug on

There is apparently a southward fall migration through Anaktuvuk Pass, but Irving (1960) gives no dates, and comments that the southward movement is not as conspicuous as the northward movement.

GOLDEN EAGLE Uncommon summer resident and probable rare breeder in interior coastal plain; common summer visitant to outer coastal plain in years when calving and post-calving caribou are present on the outer coastal plain; otherwise uncommon summer visitant to the outer coastal plain. Golden eagles are one of the more abundant cliff-nesting raptors in the Brooks Range portion of ANWR (Roseneau 1974, Spindler 1979). Their occurrence on the coastal plain is largely hunting individuals and individuals feeding on carrion. M. Robus (unpubl data) observed 1 at Sadlerochit Springs on 14 June 1979, and 2 subadult there on 23 June 1979. Magoun and Robus (1977) observed an subadult at Sadlerochit Springs on 17 July 1977 and another subadult accompanied by an adult on 14 August 1977. Spindler (1978a) observed 1 subadult bird on 15 June 1978 "soaring above the Okpilak River, 14 km inland from the coast. One subadult was observed buzzing and swooping over 2 caribou calves along the Okpilak River 26 km inland on June 16. Another subadult bird was observed 10 km inland along the Okpilak on June 17." Golden eagles were also observed at Demarcation Point in 1978 and 1979 (R. Burgess unpubl. data). A golden eagle was observed at Beaufort Lagoon on 29 June 1980, at Pokok Bay on 17 July 1980 (J. Levison unpubl. data), and 1 was observed at Oruktalik Lagoon on 5 August 1981 (M. Spindler unpubl. data). Roseneau (1974) reported 33 subadults of 35 birds observed along the Tamayariak and Egaksrak Rivers, and 16 subadults of 22 birds elsewhere on the coastal plain between 2-14 July 1973. Many of these subadults aggregating on the coastal plain in June and early July are utilizing carrion from dead caribou calves, as well as preying on live calves (Roseneau and Curatolo 1976). These aggregations of subadult golden eagles have been seen following the migrating Porcupine caribou herd into Canada, and in this respect are exhibiting a behavior unique to the species (D. Roseneau pers. comm.).

On the ANWR coastal plain, nesting sites have been documented on bluffs near the 300 m contour line along the Katakturuk River (Roseneau 1974, Roseneau et al. 1980). Adjacent to ANWR, nesting has been reported in suitable river cliff terrain on the Yukon coastal plain (Salter et al. 1980) and in NPR-A (NPR-A Task Force 1978).

MARSH HAWK (NORTHERN HARRIER) Rare summer visitant to the ANWR coastal plain. The species breeds in interior Alaska (Gabrielson and Lincoln 1959), is an uncommon visitor in forested and open habitats in the eastern Brooks Range (Roseneau 1974, Spindler 1979a), and is a probable breeder in the Old Crow area (Irving 1960). Kessel and Gibson (1978) termed this species a "rare migrant, summer visitant, and possible breeder in the Brooks Range and northern foothills." Evidence for breeding on the coastal plain in Alaska is slight; a defensive pair was observed at the Sagavanirktok/Lupine River area on 31 July 1975 (Kessel and Gibson 1978). Salter et al. (1980) termed this species an "uncommon visitor" to the Yukon coastal plain and reported no nesting.

On the ANWR study area, the marsh hawk appears to be an infrequent spring visitor near the mountains. At Demarcation Point, 2 were seen on 20 May and 1 or 2 were seen on 4 more occasions up until 8 June, 1 was seen 21 July and single birds were seen on 8 days during the period 9-24 August (R. Burgess unpubl. data). Andersson (1973) recorded 7 observations of female or immature birds in the Beaufort Lagoon area from mid-June to early July 1970, while J. Levison (unpubl. data) observed 1 bird at Beaufort Lagoon on 5 June 1980. On 12 May 1979 1 was seen on the Sadlerochit River 1 km from the coast; a male was seen at Sadlerochit Springs on 22 May 1979, and 2 were seen on 27 May 1979 between 16 km Sadlerochit River and Sadlerochit Springs (M. Robus unpubl. data). At the Canning River Delta 1 bird was seen on 23 August 1979, and 1 bird was seen on 15 August 1970. Both birds appeared to be moving through the study area (Martin and Moitoret 1981).

GYRFALCON Uncommon permanent resident breeding in cliff, outcrops and river bluff terrain in interior coastal plain; uncommon visitor to outer coastal plain. Irving (1960), Roseneau (1974), Platt (1976), and Salter et al. (1980) reported that at least the adults winter near their nest site if prey abundance permits while immatures frequently migrated south into the taiga for their first winter. Adults may leave the nesting area for the winter if prey is scarce. Gyrfalcons nest earlier than other raptor species on the ANWR coastal plain (Table 26). The reported range of nesting dates on NPR-A was 1 April to 30 June, brood rearing dates were 1 May to 15 August, and fledging dates were 21 June to 15 August (NPR-A Task Force 1978). Snow (1974) and Platt (1976) described the characteristics of gyrfalcon nesting habitat as cliffs or bluffs in treeless terrain frequently between sea level and 1400 m elevation. Often the egg is laid on a ledge or platform protected from snow accumulation by an overhanging projection of rock. Cade (1960) found the average height above ground for Colville River gyrfalcon nests to be 29 m (range 8-91 m); the average distance below the brink of the cliff 13 m (0-61 m), and the distance above the base of the vertical face 15 m (range 2-61 m). Roseneau (1974) found that gyrfalcon eyries had the highest average elevation of the large cliff-nesting raptors in northeast Alaska.

In 1972-1973 Roseneau (1974) reported 12 active eyries in the ANWR north of the continental divide near the following locations: Red Hill near the Canning, Sadlerochit Springs and other areas in the Sadlerochit Mountains, the eastern Shubelik Mountains, the Canning drainage south of Cache Creek, the Jago River eastward to the Alaska-Canada border (and extending into Canada along the northern edge of the British Mountains), and the interior coastal plain and foothill bluffs such as VABM Atte, Hula, Nob, Gwen, and Dar. The Yukon North Slope had 22 total nest sites of which 10 were known active sites in 1973, 4 were active sites in 1974, 2 were active sites in 1975 and 6 were active sites in 1976 (Salter et al. 1980).

On the outer coastal plain most of the observations are apparently of hunting or migrating birds. R. Burgess (unpubl. data) observed 1 bird on 15 May 1979 and 1 on 30 August 1979 at Demarcation Point. Near Pokok Lagoon, Andersson (1973) observed 1 gyrfalcon flying northwest on 2 July 1970. At the Canning Delta Martin and Moitoret (1981) observed 1 bird on 8 August 1979. In 1980 they observed single birds on 8 dates during the period 2 August - 5 September. On the interior coastal plain along the Sadlerochit River, M. Robus (unpubl. data) observed a gyrfalcon on 25 May, 9 June, and 19 June. During the period 31 August to 2 September 1979, 3-4 immature gyrfalcons were observed in aerial play about 10 km inland along the Sadlerochit River (M. Robus, unpubl. data). Salter et al. (1980) reported numerous observations along the Yukon Territory coast between 22 August - 29 September 1973, and thought the birds may have been following the fall shorebird and waterfowl migration.

PEREGRINE FALCON Rare summer resident and possible breeder in cliff and river bluff terrain of interior coastal plain and foothills; uncommon fall migrant over coastal tundra and lagoons of outer coastal plain. Because of its endangered species status (Endangered Species Act of 1973, 16 U.S.C. 1531-1543), the populations and productivity of the arctic subspecies of peregrine falcon (Falco peregrinus tundrius) nesting on the North Slope of Alaska west of the ANWR are well documented and monitored annually or biannually (Roseneau et al. 1976, NPR-A Task Force 1978, Roseneau and Bente 1980). An estimated 12 nest sites were occupied and 9 nests were found in NPR-A in 1977. Occupancy and nesting populations were determined to be increasing, while productivity was extremely low (NPR-A Task Force 1978). Haugh (1976) estimated a total Alaska North Slope population of 100 nesting pairs for years, 1950-1970. Peregrine falcons in NPR-A arrive at the nest sites between 21 April and 7 May, nesting occurs from 15 May to 21 July, brood-rearing is from 15 June to 21 August, and fledging occurs between 31 July and 30 August (NPR-A Task Force 1978, Table 25). Fall migration occurs in late August through mid-September (Martin and Moitoret 1981, J. Levison unpubl. data). Routes of migration to and from the nesting areas are thought to occur both through the Brooks Range, and along the Beaufort Sea coast. (D. Roseneau pers. comm.).

The current status of arctic peregrine falcons on the North Slope of ANWR is uncertain because 1972-1973 survey efforts identified 3 active nests among 20 historical or suspected historical sites (Roseneau 1974, Roseneau et al. 1976), and 1980 surveys found no nesting activity (Roseneau et al. 1980). The decline in peregrine nesting activity on the ANWR North Slope may have been due to the generally poor habitat and limited extent of good habitat and/or unfavorable nesting conditions in the region as a whole which also affected the success of other raptor species nesting in the area (Roseneau et al. 1980). Roseneau (1974) identified known historical peregrine nest sites in ANWR through 1973, and Roseneau et al. (1980) evaluated these sites in terms of previous known use and habitat suitability (Table 26). Reasons given for recent declines in arctic peregrine falcon numbers in Alaska in general have been largely extrinsic: peregrines wintering in South America utilizing prey with high pesticide residue loads and high pesticide residue levels in migratory prey species of the peregrine summering in Alaska, but wintering elsewhere in developing nations ouside of N. America (NPR-A Task Force 1978).

Characteristics of nesting habitat have been described as "large relatively stable bedrock cliffs" along rivers (e.g. the upper Colville River) as well as "unstable earthern bluffs" along rivers (e.g. the Sagwon Bluffs) (NPR-A Task Force 1978, P. Bente pers. comm.).

Observations of non-nesting peregrine falcons in the ANWR study area are frequent. At Canning Delta on 2 June 1980 1 bird flew east across the spit at Brownlow Point, 1 adult landed briefly on a lake shore on 17 June 1980, one flew west across the West Branch flats on 21 June 1980, and 1 bird was startled from below a river bluff at the West Branch on 22 July 1979 (Martin and Moitoret 1981). At Sadlerochit Springs a pair was reported in early June and on 10 July an adult female was seen sitting on a grass tussock 2.5 km inland from the west end of Pokok Bay (Roseneau 1974). In July 1976 D. Roseneau (pers. comm.) observed a subadult male on Barter Island. August and September observations on the coastal plain of ANWR are much more numerous and predictable. In 1979 at Demarcation Point, R. Burgess (unpubl. data) observed 1 immature on 20 August, 1 adult on 21 August and 25 August, and 3 adults on

Table 26. Evaluation of North Slope river drainages in ANWR as potential and known peregrine falcon nesting habitat (Source: Roseneau et al. 1980).

River drainage	Habitat Rating[1]	Number of Nesting Locations	Potential Habitat
Kavik	2	1 reported[2]	Small portion of headwaters and near 610 m asl.
Canning	6-7	3 confirmed[3] 3 reported[2]	Small portion of headwaters and 69°29' N. Upper drainage, primarily between 69°21' and 69°00' N below 762 m asl. Best locations are generally at tributary valley entrances.
Tamayariak	2	--	--
Katakturuk	2-3	1 reported[2]	Upper drainage - primarily the west fork between 244 and 610 m contour lines.
Marsh Creek	2-3	--	Upper main drainage between 305 and 610 contour lines.
Carter Creek	2	--	Lower 4.8 - 6.4 km.

Table 26. (Continued).

River drainage	Habitat classification[1]	Number of confirmed or reported nesting locations	Potential habitat (if present)
Sadlerochit	4-5	1 confirmed[4]	Between 274 and 762 m contour lines, but centered in upper reaches and Sadlerochit Springs area.
Hulahula	2-3	1 reported[5]	Kingak Hill vicinity or Kikiktat Mountain vicinity.
Okpilak	2	--	--
Jago	2-3	2 reported[6]	VABM Bitty vicinity Marie Mountain vicinity
Aichilik	3-4	2 reported[2]	Primarily between $69^{\circ}29'$ and $69^{\circ}20'$ N.
Egaksrak	3-4	--	Primarily between $69^{\circ}35'$ and $69^{\circ} 25'$ N.
Ekaluakat	2-3	--	Headwaters area
Siksikpalak	1	--	--
Kongakut	5-6	3 reported[2]	Primarily between $69^{\circ}34'$ and $69^{\circ}00'$ N.
Clarence (Alaskan portion)	2-3	--	Between $69^{\circ}29'$ N and U.S.-Canadian Border.

Table 26. (Continued).

1 Habitat was rated on a scale of 1-10: 1=very poor, 5-6=fair, 10=excellent. Classifications were made on the basis of the total drainage. Even though a drainage may have a few potential nesting locations, its overall rating may be quite low.

2 Peregrines were reported to have nested at 1 location on the Kavik River in 1947; at 2 locations on the Canning River downstream of about 69 18' N in 1963 and at 1 location downstream of about $69^{o}18'$ N in 1947; at 1 location on the Katakturuk River in 1963 and 1966; at 2 locations, simultaneously, on the Aichilik River in 1966 and 1969; and at 3 locatons, simultaneoulsy, on the Kongakut River in 1966 (M. Mangus 1975, personal communication to C. White 1 November 1975, memorandum C. White to T. Cade and D. Roseneau).

3 Roseneau (1974)

4 Cade (1960) found a pair with 4 eggs at about the 670 m level in a headwater tributary on 4 June 1959. The site was definitely well upstream of the Sadlerochit Springs area (Cade 1976, personal communication). The area may include a series of escarpments between Snow and Gravel Creeks. No raptors were observed there in 1972-1975 (Roseneau 1974, Roseneau et al. 1976).

5 A nesting pair was reported present in 1975 (W. Mills personal communication with D. Roseneau 1975).

6 T. Cade received a report of 2 nesting pairs from J. Drew in 1957 (Cade 1976, personal communication with D. Roseneau).

26 August. On 28 August 1979, M. Robus (unpubl. data) observed 1 pair at Sadlerochit Springs, and on 31 August a pair was observed 10 km inland along the Sadlerochit River. Martin and Moitoret (1981) reported for the Canning Delta: "An adult was seen 1 August 1979 flying along the bluffs on the east side of Flaxman Lagoon. An immature female was seen 3 times near Brownlow Point 19 August 1979 and a similarly plumaged individual (or individuals) was seen 28, 29 and 30 August at or near Brownlow Point; 1 was flying north along the West Branch 31 August 1979. In August and September 1980, 4 definite peregrine sightings were made: one 20 August, one 25 August, and one 2 September were all juveniles and all flying east; an adult was seen 22 August flying upriver at the mouth of West Branch." In August-September 1980 J. Levison (unpubl. data) reported a fall movement of peregrines past Beaufort Lagoon and Pingokraluk Point; 14 definite peregrine falcons, including 7 immature birds, plus 10 falcon spp. were observed between 18 August and 3 September (Table 27). Salter et al. (1980) observed a fall movement of several birds along the Yukon Beaufort Sea coast, the latest of which was at Shingle Point on 17 September.

Table 27. Peregrine falcon and falcon sp. observations made during migration watches at Beaufort Lagoon and Pingokraluk Point, 15 August-4 September 1980, (Souce: J. Levison and D. Blomstrom unpubl. data).

Date	Number/Identity, Activity, and Location
18 August	1 Falcon spp., hunting over tundra, Egaksrak Lagoon.
20 August	1 Peregrine falcon, adult, Flying near Arey Island.
23 August	1 Peregrine falcon, imm., flying S over Beaufort Lagoon DEW.
24 August	3 Falcon spp., flying past Beaufort Lagoon DEW.
	2 Peregrine falcon, imm., flying past Beufort Lagoon DEW seemed like hunting in area for few hours then flying S.
	2 Falcon spp., flying SE past Beaufort Lagoon DEW.
	1 Peregrine falcon, flying E past Beaufort Lagoon DEW.
25 August	1 Peregrine falcon, imm, hunting over tundra near Beaufort Lagoon DEW.
26 August	Between noon and 6 p.m. Pingokraluk Pt.
	1 Peregrine falcon, adult, flying (direction unspecified).
	1 Peregrine falcon, imm., flying NW.
27 August	1 Peregrine falcon, imm., Beaufort Lagoon DEW.
	1 Peregrine falcon, ad., flying west Beaufort Lagoon DEW.
28 August	1 Peregrine falcon, ad., Hunting snow bunting at Beaufort Lagoon DEW.
	1 Falcon spp., Flying E along Siku Lagoon.
29 August	1 Peregrine falcon, adult, hunting near Pingokraluk Pt. direction unspec.
30 August	1 Falcon spp., migrating by Pingokraluk Pt. direction unspec.
31 August	1 Peregrine falcon, imm., by Pingokraluk Pt. direction unspec.
1 September	1 Peregrine falcon, by Pingokraluk Pt. direction unspec.
	1 Falcon spp., by Pingokraluk Pt. direction unspec.
3 September	1 Falcon spp. hunting over tundra Pingokraluk Pt.

In aggregate, these August-September sightings suggest an easterly coastal movement of peregrine falcons. The number of records far exceeds that which would be expected if only the small breeding population in ANWR were involved, so it is likely that some of these birds are from breeding areas farther west. Roseneau (unpubl. data) suggested that such a coastal migration corridor would be important for peregrines because they follow the pathway of their prey base consisting of fall migrating shorebirds and waterfowl.

MERLIN Very rare spring and summer visitant to the outer coastal plain; possible rare breeder in interior coastal plain and foothills. Merlins nest along the Kongakut River in the Brooks Range, near and upstream from Mt. Greenough (M. Spindler unpubl. data, P. Martin unpubl. data). They are also reported to be probable nesters on the south slope of the eastern Brooks Range (Roseneau 1974) and the central Brooks Range (Irving 1960). Reynolds (as cited by Roseneau 1974) observed a merlin in the upper Canning drainage. Irving (1960) thought they bred in the Anaktuvuk Pass area.

Occurrence on the ANWR coastal plain has been documented 3 times: P. Martin (unpubl. data) observed 1 bird near Nuvagapak Point on 11 July 1976, M. Spindler (unpubl. data) observed an adult perched on DEW line buildings at Beaufort Lagoon on 23 May 1978, and 1 individual was reported by R. Burgess (unpubl. data) at Demarcation point in 1978. On the Yukon coastal plain, Salter et al. (1980) reported an individual at Phillips Bay on 28 May 1972, and 4 records at Shingle Point between 21 August and 15 September 1973.

KESTREL Casual summer visitor to the ANWR coastal plain. The species nests in low numbers south of the continental divide in the Brooks Range (Spindler et al. 1980). It has been documented on the ANWR coastal plain on 3 occasions: 1 was seen at Demarcation Point in 1978 (R. Burgess unpubl. data), 1 was seen at Beaufort Lagoon in late May 1980 (J. Levison unpubl data), and a male was seen at Brownlow Point on 27 May 1980 using the DEW-line buildings as shelter and feeding on snow buntings (Martin and Moitoret 1981). One adult female was observed at Sadlerochit Springs on 5 June 1976 by D. Roseneau (pers. comm.) On the Yukon North Slope a female was seen near the foothills on 4 May 1974 (Salter et al. 1980).

WILLOW PTARMIGAN A common resident and breeder in tall riparian willow habitats of interior coastal plain; uncommon resident and breeder in sedge-tussock heath and dwarf shrub tundra of outer coastal plain, decreasing in abundance northward in proximity to coast where dwarf shrubs become scarce; uncommon to rare winter resident on outer coastal plain. In April and mid-May a general northward migration of willow ptarmigan has been observed through ANWR, with obvious flocks of several thousand seen predictably each May flying from the Brooks Range north toward the coastal plain (Spindler unpubl. data). Irving (1960), summarizing Eskimo reports and his own observations from Anaktuvuk Pass, found that the northward movement began in February and lasted until late May and that there were 2 "waves", one before the end of March and the other after the end of March.

Willow ptarmigan were present on the interior coastal plain near the Sadlerochit River on 11 May 1979 (M. Robus unpubl. data). They were first seen at Demarcation Point on 19 May 1979, although unidentified ptarmigan were seen there as early as 12 May 1979 (R. Burgess unpubl. data). At the Canning Delta, Martin and Moitoret (1981) recorded the first male on 30 May 1979, and displaying males on 13 and 22 June 1979. In 1980, single males, pairs or small groups were seen on numerous occasions between 27 May and 20 July, with most observations in late May and early June (Martin and Moitoret 1981). Spindler (1978a) found willow ptarmigan present on the Okpilak River study area on 30 May 1978. The species was observed most frequently inland along the Okpilak River, where several males were seen displaying on 16 June 1978. Observations of Brooks (1915) and Martin and Moitoret (1981) suggest that some willow ptarmigan appear earliest in the coastal areas because wind-swept bluffs initially provide easier foraging than the low-lying wind-drifted riparian willow thickets of the interior coastal plain. Magoun and Robus (1977) found willow ptarmigan more numerous than rock ptarmigan on Niguanak Ridge on 8-9 June, along the Sadlerochit River on 19 July, and along the Katakturuk River on 26 July. At the Okpilak Delta, willow ptarmigan were most common on an upland sedge tussock census plot (Spindler 1978a) with numerous patches of dwarf birch (4.0 birds/km^2, 2.0 nests/km^2). In 1978 Derksen et al. (1981) found willow ptarmigan more common than rock ptarmigan at 1 interior coastal plain site (Meade River) and 2 near-foothills sites (Singiluk and Square Lake) in NPR-A. Similarly, Salter et al. (1980) found willow ptarmigan the more common ptarmigan species at 3 sites on the Yukon north slope in 1972 and 1973, with estimated territory densities of 9.5, 12.7, and 11.8 territories/km^2.

Preferred breeding habitat on the north slope for ptarmigan was flat tussock-heath tundra with small patches of dwarf shrub or tall shrub if available (Spindler 1978a, Salter et al. 1980). In late August 1979 Martin and Moitoret (1981) noted flocking of this species at the Canning Delta. Such behavior was not noted there in 1980. Intense flocking (several hundred) was observed in low willow thickets along the Kavik River on the interior coastal plain west of ANWR, on 10 August 1981 (M. Spindler unpubl. data). Irving (1960) observed southward movement of willow ptarmigan through Anaktuvuk Pass beginning about 1 October. The southward movement was not as dramatic or as large as the northward movement. Weeden (1964) indicated that there is sexual and spatial segregation of willow ptarmigan on the wintering habitat with males more prevalent in alpine habitats and females more prevalent in the forested habitats. Porsild (1943) said that willow ptarmigan flocked in groups of 1 sex in winter in the Mackenzie River delta, N.W.T. These data indicate that mostly males winter on the coastal plain. Wintering status of the species on ANWR remains unknown. M. and E. Simms of Kaktovik (pers. comm.) reported willow ptarmigan to be the more frequently seen and hunted species near Barter Island in mid-winter, however, mid-winter populations are very low compared to those in April to August.

ROCK PTARMIGAN Uncommon resident and common breeder in outer coastal plain, uncommon resident and breeder in interior coastal plain of ANWR; rare winter resident on outer coastal plain. Little is known of the wintering status of this species on the ANWR coastal plain other than very small numbers are present in mid-winter near Barter Island (M. and E. Simms pers. comm.). Irving (1960) and Weeden (1964) stated that rock ptarmigan do not appear to undergo the large scale long distance migrations that the willow ptarmigan do.

Rock ptarmigan were observed on the interior coastal plain at the Sadlerochit River on 11 May 1979 (M. Robus unpubl. data), and on the outer coastal plain at Demarcation Point on 19 May 1979 (R. Burgess unpubl. data). The species was seen at the Canning Delta by the third week of May 1979 and 1980, and were most often seen in late May on wind-swept coastal or lake shore bluffs. Displaying peaked during the last week of May and the first week of June

(Martin and Moitoret 1981). Egg laying began on the Canning Delta by 8-10 June 1980 (Martin and Moitoret 1981). On the Okpilak Delta, hatching was observed on 7 July 1978 (Spindler 1978a). Broods were observed on the Canning Delta between 13-27 July 1980, with fledged young seen on the latter date; no nests or young were seen in 1979 (Martin and Moitoret 1981).

Magoun and Robus (1977) reported that rock ptarmigan were more common than willow ptarmigan at Marsh Creek on 23 June 1977. Rock ptarmigan were also the more common ptarmigan at Beaufort Lagoon (Andersson 1973, Martin unpubl. data), Demarcation Point (R. Burgess unpubl. data) and Storkerson Point (Derksen et al. 1981). Rock ptarmigan were present in the drier coastal tundra types, however they tended to use steep hillsides during the breeding season, indicating a dichotomy in habitat use (Salter et al. 1980). Apparently rock ptarmigan prefer windswept dry coastal sites (frost boil tundra), windswept ridges, and steep hillsides, hence, the distribution of rock ptarmigan is abundance near the coast and again near the foothills, if suitable steep or windswept slopes are available (M. Spindler unpubl. data). Estimates of abundance for rock ptarmigan on ANWR include 2.0 birds/km^2 with 4.0 nests/km^2 in mosaic wet sedge-dry sedge tundra at the Okpilak Delta in 1978; 7.0 birds/km^2 with 3.7 nests/km^2 on mosaic wet sedge-dry sedge tundra on the Canning delta in 1980 (Spindler 1978a, Martin and Moitoret 1981). Salter et al. (1980) estimated 8.5 and 1.3 territories/km^2 for 2 sites on the Yukon North Slope in 1972 and 1973.

Martin and Moitoret (1981) observed post-breeding flocking at the Canning Delta the first week of August: "by the end of August, flocks were sometimes quite large with groups of 35-50 seen 26-30 August 1979 and 1980. Ptarmigans seemed to increase at the end of summer. This observation may be due to a real influx on the coast or it may be due to increased conspicuousness of adults and juveniles as they flock together in fall". The subsequent movement and wintering areas of these post-breeding flocks is unknown. Weeden (1964) noted that the build-up of rock ptarmigan in wintering habitat east of Fairbanks occurred at the lower altitudinal limit of their nesting range in timberline areas and below in late October and November. Winter movements were largely nomadic, perhaps affected by food supply, weather, roosting conditions and predation. Spatial and habitat segregation of rock ptarmigan sexes occurred, with females using mostly areas below timberline and males using areas mostly at or above timberline (Weeden 1964).

Rock ptarmigan populations are apparently most susceptible to hunting mortality in late spring (April-May) as pair formation occurs. Any reduction in number of breeding pairs at that time reduced the breeding population (Weeden 1972). Conversely, reduction of adult populations in fall did not result in a corresponding drop in breeding populations the following spring (Weeden 1972).

<u>SANDHILL CRANE</u> Uncommon breeder and summer resident on outer coastal plain of ANWR. The earliest record is a pair flying west past Beaufort DEW site on 29 May 1980 (J. Levison unpubl. data). In 1978 on the Okpilak River Delta, Spindler (1978a) recorded 4 on 2 June, 10 on 5 June, and estimated that 6 spent the summer in the area. He also suspected breeding in the previous year based on the discovery of a weathered crane egg-shell. In the Beaufort Lagoon area, groups of 2-4 have been seen in 1970, 1974, 1976, and 1980 (Andersson 1973, J. Levision unpubl. data, P. Martin unpubl. data) in late June and July. M. Robus (unpubl. data) observed 1 bird flying east across the

Sadlerochit River 8 km south of the coast on 3 July 1979. Cranes were seen at Demarcation Point in 1978 and 1979, and at least 1 pair bred there in 1979 (R. Burgess unpubl. data). A pair of cranes was seen on the west side of Demarcation Bay on 4 August 1981 (M. Spindler unpubl. data). At the Canning River Delta 1 bird was seen flying northwest over the study area on 9 June 1979 (Martin and Moitoret 1981). They obtained 9 records for the species on Canning Delta from 3-30 June 1980, most of 1 or 2 birds flying but some in wet sedge tundra or wet saline tundra. The regularity and breeding status of the species on ANWR may be unique to the Alaska and Yukon Territy north slopes, since records are sparse to the west (Sage 1974, Derksen et al. 1981). There was no confirmed breeding despite fairly frequent observations to the east (Salter et al. 1980). Fall migration is probably to the east, since an easterly migration has been observed on the Yukon Territory north slope (Salter et al. 1980).

SEMIPALMATED PLOVER Rare summer visitant to outer coastal plain; probably rare breeder along braided rivers on interior coastal plain. M. Robus (unpubl. data) reported a pair at Sadlerochit Springs on 7 June 1979. Magoun and Robus (1977) observed several individuals along the Sadlerochit River in July 1977. Spindler (1978a) reported one on the mainland south of Barter Island on 17 July 1978. Semipalmated plovers were seen at Demarcation Bay in 1979 (R. Burgess unpubl. data). Salter et al. (1980) reported the earliest individual on 27 May 1975 and the latest on 4 August 1973 on the Yukon north slope, where they felt the species was a probable breeder based on observed courtship displays.

KILLDEER Casual summer visitant to ANWR coastal plain. Wiggs and Warren (as cited by Magoun and Robus 1977) observed a killdeer on Barter Island in early June 1977. Recorded as a casual spring migrant at Barrow and Umiat (Kessel and Gibson 1978) and very rare summer visitor on the Yukon north slope (Salter et. al 1980).

GOLDEN PLOVER Fairly common breeder on ANWR study area, very common fall migrant on outer coastal plain. Spring migration into ANWR probably occurs from west to east, since all flocks observed passing the Okpilak delta in early June were flying east (Spindler 1978a). Johnson et al. (1975) reported flocks flying in both directions, but predominantly eastward at Komakuk Beach. Earliest arrival date on ANWR was 26 May 1979 and 1980 at Canning Delta (Martin and Moitoret 1981); and the same date in 1979 at Demarcation Point (R. Burgess unpubl. data). J. Levison (unpubl. data) reported a 29 May 1980 arrival at Beaufort Lagoon and Spindler (1978a) reported a probable 28 May 1978 arrival at Okpilak Delta.

Territorial display was first noted at the Canning Delta on 27 May 1979 and 29 May 1980, while copulation was noted on 30 May 1980 (Martin and Moitoret 1981). Territorial behavior was first noted on 10 June 1978 at the Okpilak Delta (Spindler 1978a). Nests monitored on the Canning Delta indicated that egg-laying started on 9 June and incubation started between 15-20 June, with hatching noted on 17 and 19 July 1979 and 10 July 1980 (Martin and Moitoret 1981). Nests found at the Canning and Okpilak Deltas, and Yukon north slope indicated preferred nesting sites in upland dry sedge, frost-boil, and tussock-heath tundra types (Spindler 1978a, Salter et al. 1980, and Martin and Moitoret 1981). ANWR nesting densities included: 1.0 nest/km^2 in mosaic wet/dry tundra at the Okpilak Delta in 1978 (Spindler 1978a), and 3.9 nests/km^2 in upland dry tundra in 1979 and also in mosaic

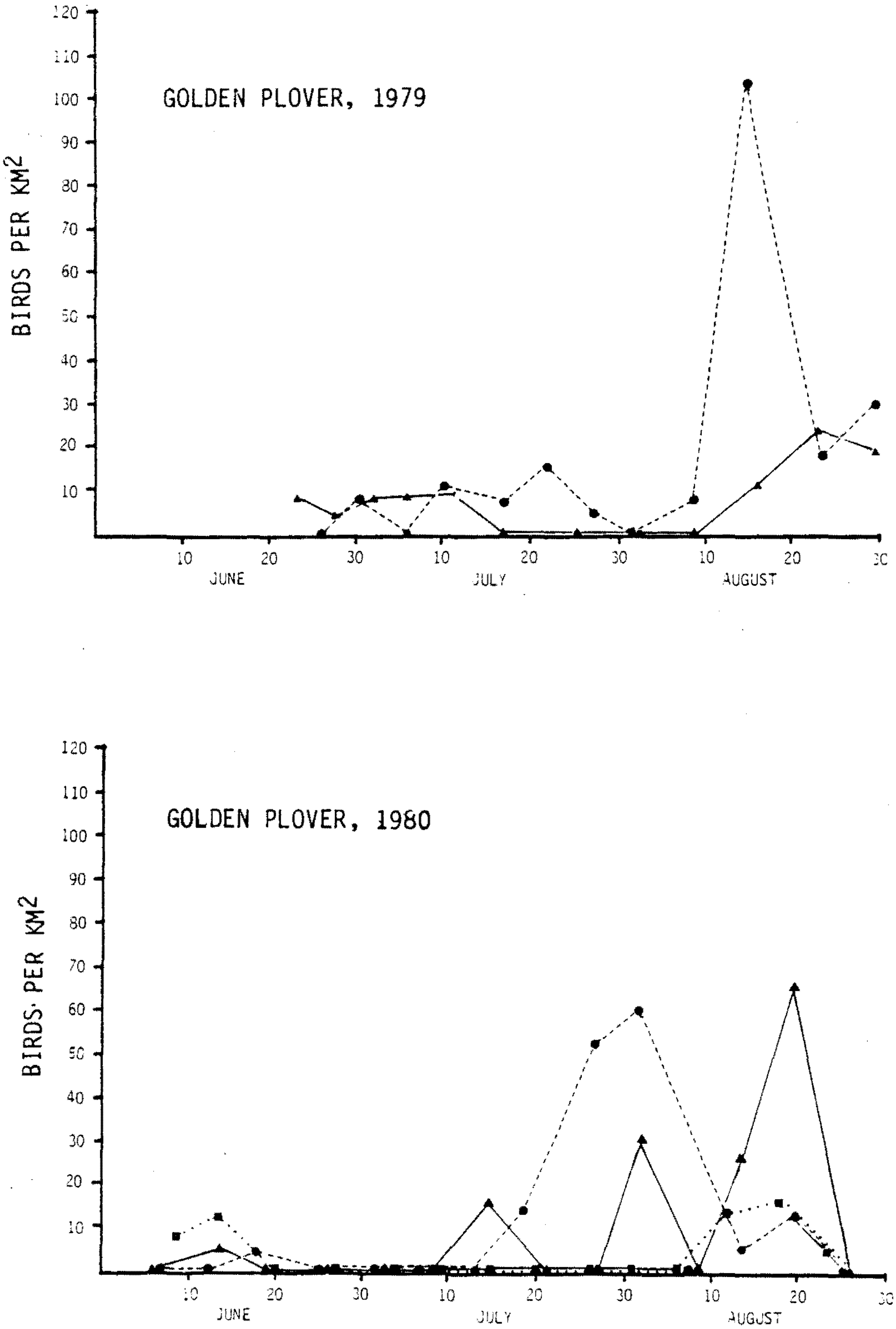


Figure 11. Densities of Golden Plovers on the upland (▲), lowland (●), and mosaic (■) study plots, Canning River Delta, 1979 and 1980.
Source: Martin and Moitoret (1981).

wet/dry tundra in 1980 at the Canning Delta (Martin and Moitoret 1981). Elsewhere, breeding densities ranged from 2.0 nests/km^2 at Atkasook in 1977 and 1978, 3.0-14.0 nests/km^2 at Barrow 1975-1979 (Myers and Pitelka 1980), and 5.0-12.7 nests/km^2 on the Yukon Territory coastal plain (Salter et. al 1980).

Martin and Moitoret (1981) observed that habitat use by golden plovers changed between the nesting and rearing period: upland tundra was used early in the season for nesting and foraging, June through mid-July, whereas adults accompanied by broods frequented lower wet and flooded sedge tundra after early-mid-July (Fig. 11). In addition to use as brood rearing areas, the lowland wet tundra types on the Canning Delta were used by fall migrating adults in mid-July and a second peak of migrant juveniles in mid-August (Martin and Moitoret 1981). The heavy use of low wet tundra habitat by both adults and juveniles during fall migration is striking in that most authors assign the golden plover to upland habitats only. At Barrow, late summer use of wet tundra was observed in 1979, but this phenomenon did not occur in 1976 (Myers and Pitelka 1980). Another annual difference in habitat use observed at Canning Delta was that "In 1980 the lowland plot had a peak of adult movement 25-31 July and a barely perceptible influx of juveniles in mid-August". In upland, the 1980 peak of juveniles was still larger, but it was of short duration (one census date) and was only two thirds the magnitude of the peak in 1979. Overall it appears that fewer juveniles moved through the area in 1980 than in 1979 (Martin and Moitoret, 1981).

Fall migration out of the study area is eastward. A steady stream of eastward migrating birds was seen flying past the Beaufort Lagoon area between 20-25 July and again between 11-24 August 1980 (J. Levison unpubl. data). Salter et al. (1980) noted eastward fall migration past the Yukon north slope. The latest record of the species in ANWR is 5 September 1980 (Martin and Moitoret 1981).

BLACK BELLIED PLOVER through SNOW BUNTING Table 1 lists the status of these species. Additional data on observation records, phenology, habitat use, and population are currently being synthesized and will be included in a subsequent annual updates to this report.

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Chapter 5

MAMMALS

This chapter presents information on mammalian species that occur in the ANWR study area and adjacent marine environments. Information is presented by species or species groups and each section includes data gaps and a literature cited section for the species/species groups being discussed. Caribou, musk ox, and moose are discussed individually, while marine mammals (polar bear, ringed seal, bearded seal, bowhead whale, beluga whale, and incidental species), carnivores (brown bears, wolf, wolverine, arctic fox, red fox), and rodents (arctic ground squirrel, microtine rodents) are discussed as groups.

Caribou (*Rangifer tarandus granti*)

Early biological studies of caribou in Alaska were initiated by E.W. Nelson (1887) and Murie (1935), and in Canada by Clarke (1940). These early efforts were general in nature, and concentrated on basic life history. The use of airplanes to survey caribou populations and map distributions began in the late 1930's in Alaska and in the 1940's in Canada (Banfield 1954). Aerial survey techniques were further developed and refined during the 1940's and 1950's (Banfield et al. 1955, Watson and Scott 1956, Olson 1957). As a result of these pioneering efforts, information on the distribution, movements, and populations of caribou in northeastern Alaska began to increase (Scott et. al. 1950, Munro 1953).

When large oil and gas reserves were found at Prudhoe Bay, Alaska and in the western Canadian Arctic over a decade ago, the welfare of large herds of barren ground caribou became an issue of concern as plans were made for industrial development in the Arctic. As a result, major investigations were undertaken by government and industry. In 1970 caribou studies were intitiated in northeastern Alaska and northern Yukon Territory by Renewable Resources Consulting Services Ltd. (under contract with Canadian and Alaskan Arctic Gas Studies) and Interdisciplinary Systems Ltd. (for the Environmental Protection Board of Canada). The Alaska Department of Fish and Game (ADF&G) and the Canadian Wildlife Service (CWS) also began caribou studies in the region in 1972. From these studies came the first in-depth documentation of the distribution, chronology of migration, migration routes, habitat use and population dynamics of caribou in northeastern Alaska. Industry sponsored caribou studies continued through 1975-77, while government efforts have continued to the present time.

Investigations at Prudhoe Bay on the effects of the Trans-Alaska Pipeline, haul road, and oilfield complex on caribou were started in 1974 by the ADF&G (Cameron and Whitten 1976). This ongoing effort has yielded significant information on the reactions of caribou to oil and gas development and promises to be of considerable value in the future.

As a result of these studies, the information on caribou in the region of the ANWR study area is fairly large. Of particular significance is the historical analysis provided by Skoog (1968) and further historical examinations by LeResche (1972). Updates on the distribution and movements of Alaskan caribou are provided by Hemming (1971) and Davis (1980). Much of the recent literature on the Porcupine caribou herd has been assembled by Calef (1974), Curatolo and Roseneau (1977), Thompson and Roseneau (1978), Davis (1978, 1980), Kelsall and Klein (1979), LeBlond (1979), and U.S. Dept. of State (1980). Kelsall and Bisdee (1980) compiled an extensive annotated bibliography featuring 682 cross-referenced entries on the Porcupine caribou herd and related references. A popular description of the life history and ecology of caribou has been recently completed by Calef (1981).

Barren ground caribou have inhabited northeastern Alaska and northern Yukon Territory for at least 54,000 years (Harington 1977). Evidence of human use of caribou in the region of the ANWR study area has been found dating back some 27,000 years (Irving 1968). Remnants of caribou fences and corral structures used by Kutchin Indians can be found throughout much of the current southern range of the Porcupine caribou herd (Warbelow et al. 1975). Stone fences used for the deflection and ambush of migrating caribou by Eskimos can be found in the northern foothills to the Brooks Range.

The first written reference of caribou in the ANWR study area is that of Franklin's exploration of the arctic coast of northeastern Alaska in 1825-27 (Franklin 1828). Later expeditions to the region by Dease and Simpson (1838), and Ibister (1845) confirm that caribou were abundant in the region. Caribou were used heavily by overwintering whalers at Herschel Island during the mid-to-late 1800's (Stone 1900). In an extensive review of historical records of Alaskan caribou herds, Skoog (1968) surmized that the northeastern Alaska-northern Yukon Territory caribou were at a high level prior to 1900. In the early 1900's these caribou allegedly shifted their range away from the arctic coast and more to the west (Skoog 1968). Caribou from the McKinley and Fortymile herds reportedly moved into the area during the 1920's. Skoog (1968) reported a decrease in caribou numbers in the 1940's with a gradual build up in the 1950's. A possible interchange of caribou from the Fortymile herd may have occurred in 1964. However, it was not determined if a permanent emigration had occurred (Skoog 1968). Although early accounts from which Skoog made the preceding summaries are sketchy and accurate population estimates were not possible, they indicate that a caribou herd has inhabited northeastern Alaska and northern Yukon Territory in a manner similar to current distributions, movements, and annual cycles since at least the late 1800's (LeResche 1972, Calef 1974, Roseneau et.al. 1974). This sub-population of caribou is called the Porcupine herd. Caribou herds or subpopulations are currently defined as any group of caribou that traditionally calve in an area that is distinct from other groups (Skoog 1968).

As investigations of caribou intensified in the Prudhoe Bay area as well as northeastern Alaska, it became clear that a separate, previously undescribed herd (the Central Arctic herd) occupied the region from the Colville River to slightly east of the Canning River (Cameron and Whitten 1976, 1979b). Currently these 2 caribou herds, the Porcupine herd and Central Arctic herd use the study area during various periods of the year (Fig. 1).

Porcupine Herd

Size, Range, Distribution, and Movements

The Porcupine caribou herd currently numbers about 110,000 individuals (Whitten and Cameron 1980a) and ranges over an area of about 250,000 km^2 (Mair and Cowan 1978). Seven distinct phases based upon behavior and distribution have been identified in the annual life cycle of caribou (Skoog 1968, Bergerud 1974b).

Spring Migration. In early March the spring migration begins with a gradual drift of caribou towards the northern limits of their wintering areas (Calef 1974). The timing and selection of routes for spring migrations are most likely due to snow conditions, topography, weather factors, and the advancing pregnancy of the adult cows (Pruitt 1959, Henshaw 1968, Thompson 1978).

Three major spring migration routes Richardson, Old Crow, and Arctic Village - South Brooks Range) have been identified (Fig. 1). The extent a spring migration route is used in any given year depends on where wintering takes place (Thompson 1978). The Richardson route runs through the Richardson, Barn, and British Mountain ranges and is usually used by caribou that have wintered in the area of the lower Wind, Bonnet Plume, Snake and Arctic Red Rivers of the Yukon and Northwest Territories (Calef 1974, Roseneau et al. 1974, Roseneau and Curatolo 1976). Caribou that have wintered in the Ogilvie Mountains (Hart, Ogilvie, Blackstone, Tatonduk, and Kandik drainages) migrate north through the Keele Mountains, cross the Porcupine River in the vicinity of Old Crow and continue north through the Old Crow Flats and over the British Mountains to the Firth River valley (Roseneau et al. 1974, Roseneau and Curatolo 1976). When caribou winter in the Arctic Village-Chandalar Lake area of Alaska, the Arctic Village-South Brooks Range route is used, which crosses the East Fork of the Chandalar River, Sheenjek and upper Coleen Rivers and follows the Firth River into Canada, joining there with the Old Crow route (Roseneau et al. 1974, Roseneau and Stern 1974, Roseneau and Curatolo 1976). In years of light snow cover, caribou wintering in the Arctic Village area have been observed crossing northern mountain passes and moving directly to the calving grounds (Roseneau et al. 1974). There is considerable annual variation within each migration route as to the exact route that is followed by caribou (Thompson 1978).

Spring migrations usually come in 2 separate movements, the first being predominately pregnant females, the second consisting mainly of juveniles and bulls (Kelsall 1968). Typically, the first movement of caribou traveling the Richardson Route reach the Blow River on the Arctic coast by mid-to-late May whereas the second movement is only beginning to cross the Peel River at this time (Thompson 1978). Similar time-space relationships occur during spring migration on the Old Crow and Arctic Village-South Brooks Range routes. During the spring migration caribou typically move in long, single-file lines, following wind-swept ridges and frozen lakes and rivers where the walking is usually less difficult and predators are more easily detected (Kelsall 1968, Thompson 1978).

Calving. The international calving grounds of the Porcupine caribou herd extend along the Arctic Foothills (up to 1,100 m elevation) and Arctic Coastal Plain from approximately the Babbage River in Canada to the Canning River in Alaska (Fig. 1). The calving grounds of most Alaskan caribou herds are relatively snowfree compared to surrounding areas at the time of calving (Lent and Lønø 1962, Skoog 1968). Lent (1980) confirmed this characteristic by analyzing snow melt patterns shown on satellite images, and documented an area of early snow-melt along the Arctic Foothills Province from Herschel Island to the Canning River. This area of early snow melt corresponds with the identified area of calving activity for the Porcupine herd. The Arctic Foothills Province of the calving grounds is wind-swept of snow and has little fog-cover in spring, which allows for an earlier melt-off than the frequently fog-covered coastal plain (Calef and Lortie 1973, Lent 1980). In addition,

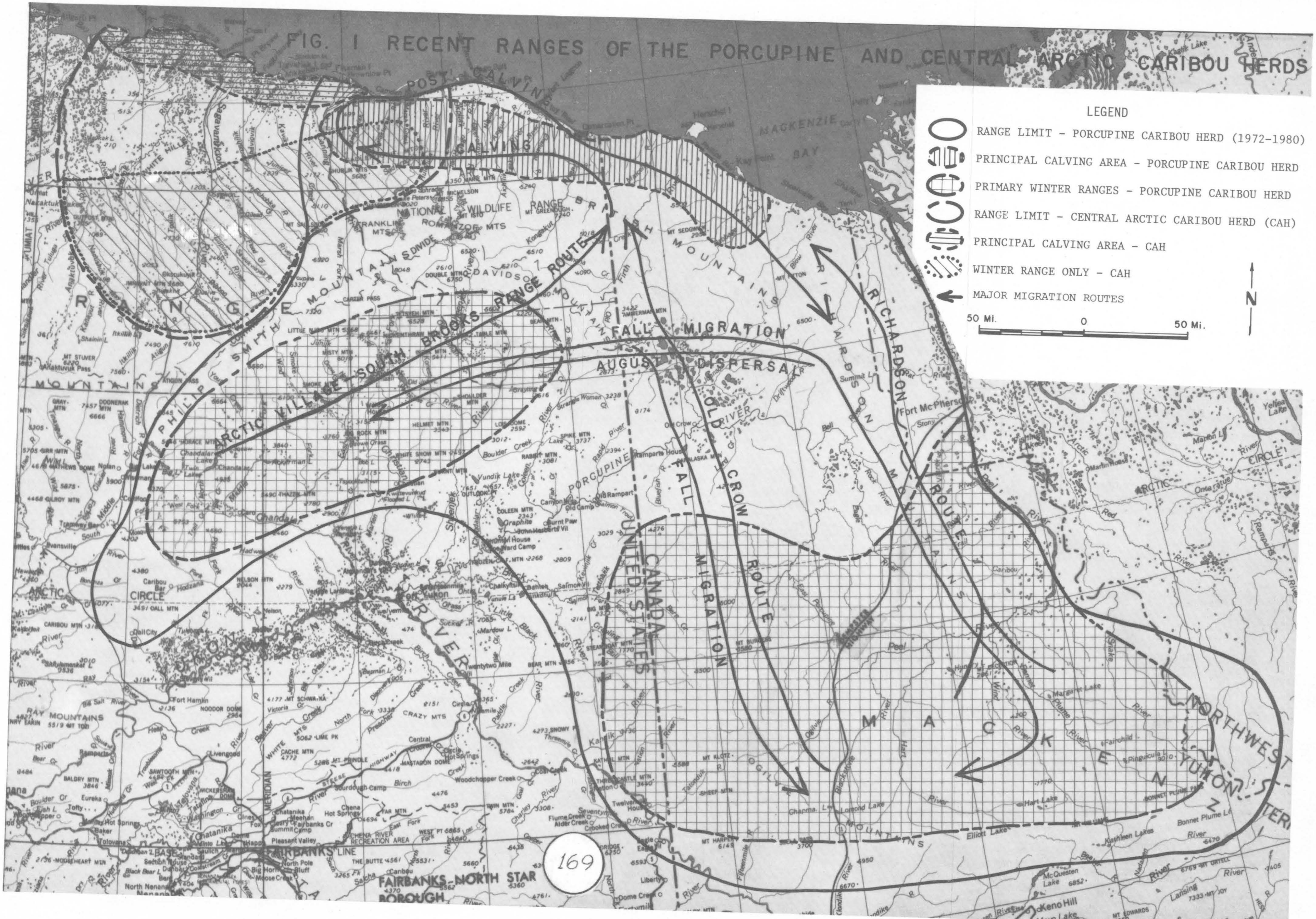


FIG. 1 RECENT RANGES OF THE PORCUPINE AND CENTRAL ARCTIC CARIBOU HERDS
LEGEND
RANGE LIMIT - PORCUPINE CARIBOU HERD (1972-1980)
PRINCIPAL CALVING AREA - PORCUPINE CARIBOU HERD
PRIMARY WINTER RANGES - PORCUPINE CARIBOU HERD
RANGE LIMIT - CENTRAL ARCTIC CARIBOU HERD (CAH)
PRINCIPAL CALVING AREA - CAH
WINTER RANGE ONLY - CAH
MAJOR MIGRATION ROUTES
50 Mi. 0 50 Mi.
N
POST CALVING
CALVING
FALL MIGRATION
AUGUST DISPERSAL
ARCTIC VILLAGE-SOUTH BROOKS RANGE ROUTE
OLD CROW ROUTE
FALL MIGRATION
RICHARDSON ROUTE
RICHARDSON MOUNTAINS
BRITISH MOUNTAINS
PHILIP SMITH MOUNTAINS
DAVIDSON MOUNTAINS
MACKENZIE BAY
UNITED STATES
CANADA
YUKON
NORTHWEST
MACKENZIE MOUNTAINS
YUKON RIVER
PORCUPINE RIVER
OLD CROW RIVER
ARCTIC CIRCLE
FAIRBANKS-NORTH STAR BOROUGH
Fort McPherson
Old Crow
Fort Yukon
Fairbanks

the tussock (Eriophorum sp.) communities which predominate in the foothills contribute to early melting and evaporation because of their micro-topography (Benson 1969 as cited by Lent 1980). Kuropat and Bryant (1980) described vegetative and nutrient phenology associated with calving and post-calving habitats which present distinct advantages for caribou. The proximity of calving grounds to insect relief habitat is an important advantage as well. Traditional calving grounds are additionally advantageous due to the relative low density of wolves found there (Calef and Lortie 1973, Roseneau and Curatolo 1976).

The date of arrival of cows on the calving grounds varies annually depending on the location of previous wintering areas and snow conditions encountered along the migration routes (Table 1). In years of difficult snow conditions calving can occur along the migration routes (Lent 1966). Some calving has occurred in the Old Crow Flats and upper Firth River areas when migrations were delayed because of deep snow (Roseneau et al. 1974). When calving occurs along migration routes, cows will continue to move northward and west toward the traditional calving areas as soon as the calves are able to travel (Hemming 1971).

Table 1. Date of first arrival of caribou on the Alaskan portion of the calving grounds of the Porcupine caribou herd (Curatolo and Roseneau 1977).

Winter	Arrival Date[1]	Snow Cover (estimated)	Wintering Area[2]
1970-71	30 May	heavy	Oligivie Mountains
1971-72	26 May	heavy	southern Richardson Mountains
1972-73	24 May	medium	central Richardson Mountains
1973-74	5 May	light	central-eastern Yukon coastal plain
1973-75	12 May	light	central-eastern Yukon coastal plain
1975-76	20 May	medium	central Richardson Mountains

[1]Date on which caribou crossed Alaska-Yukon Territory border.
[2]Area closest to calving grounds where significant numbers of wintering caribou were observed.

Snow cover on the traditional calving grounds at the time of arrival also seems to influence the location of major calving activity. Although calving occurs in a variety of habitats from wet tundra to dry ridges, most arriving cows seek out the dry, snow-free upland tussock (Eriophorum sp.) meadows of the foothills to give birth to their calves (Lent 1966, Skoog 1968, Calef 1974). Calving activity expands on to the coastal plain during the later part of the calving season as that area becomes snow free (Roseneau et al. 1974). Fig. 2 a-e illustrate annual variations in the location of calving activity over the past 10 years. In years such as 1975 when snow conditions along the migration routes were light and arriving cows found a relatively snow-free calving grounds, nearly all of the Porcupine herd calved on the extreme western portion of the traditional area (Roseneau and Curatolo 1976, Surrendi

FIG. 2-a A COMPARISON OF THE PORCUPINE CARIBOU HERD'S CALVING GROUNDS FROM 1972 — 1981. (From Curatolo and Roseneau, 1977; Roseneau, 1977 unpubl. repts.; Yukon Game Branch, unpubl. repts.)

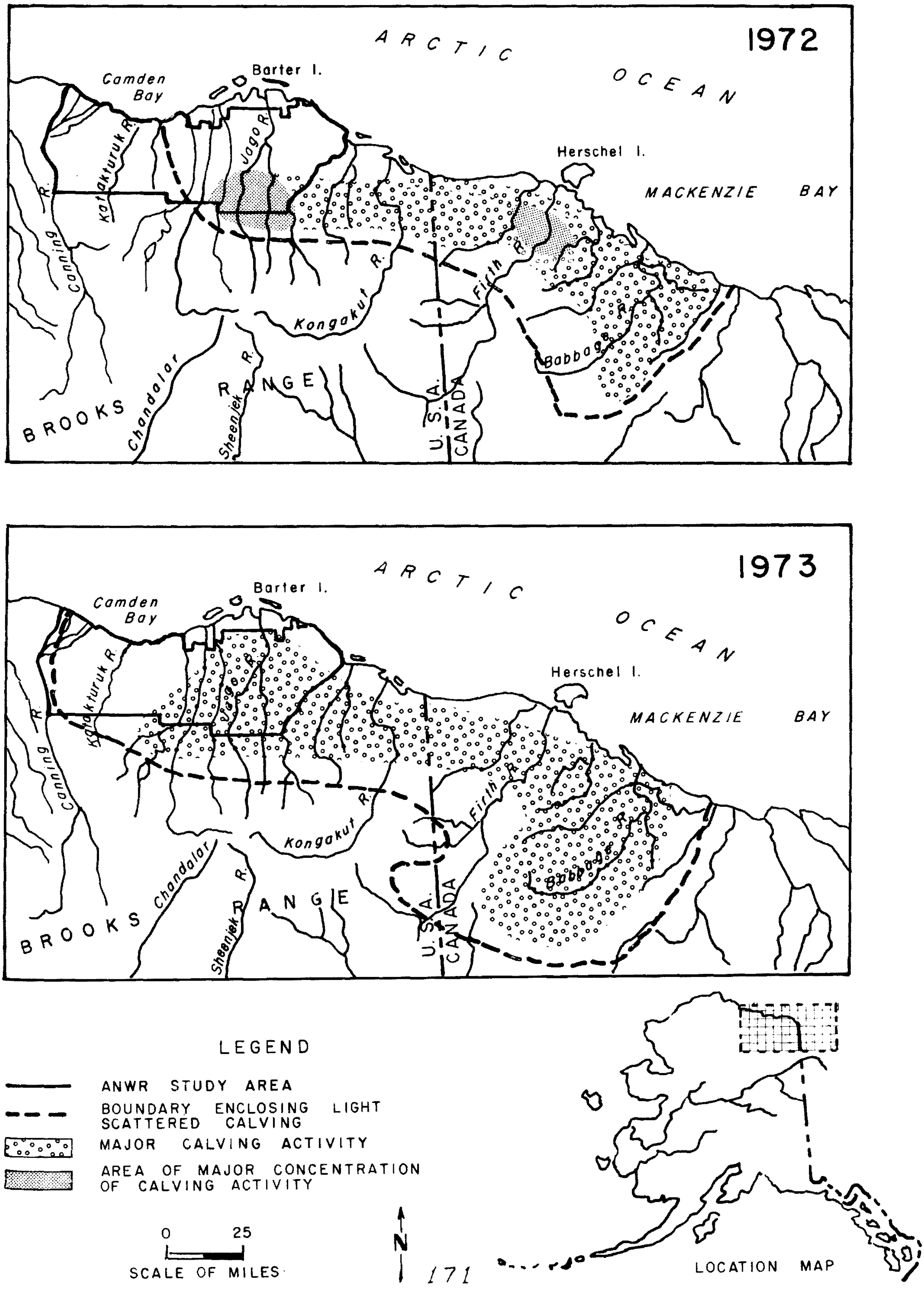


FIG. 2-b A COMPARISON OF THE PORCUPINE CARIBOU HERD'S CALVING GROUNDS FROM 1972 — 1981. (From Curatolo and Roseneau, 1977; Roseneau, 1977 unpubl. repts.; Yukon Game Branch, unpubl. repts.)

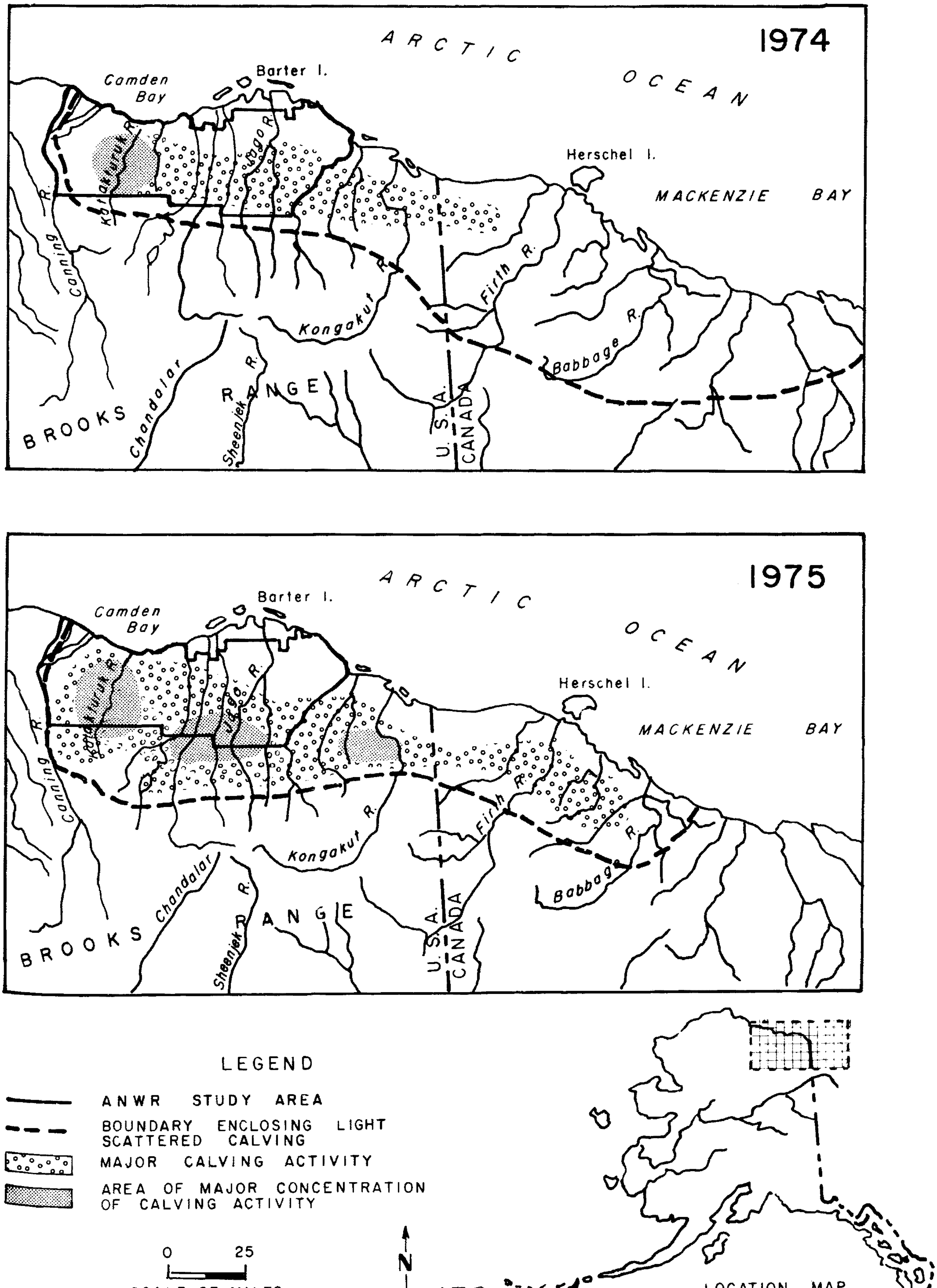


FIG. 2-c A COMPARISON OF THE PORCUPINE CARIBOU HERD'S CALVING GROUNDS FROM 1972 — 1981. (From Curatolo and Roseneau, 1977; Roseneau, 1977 unpubl. repts.; Yukon Game Branch, unpubl. repts.)

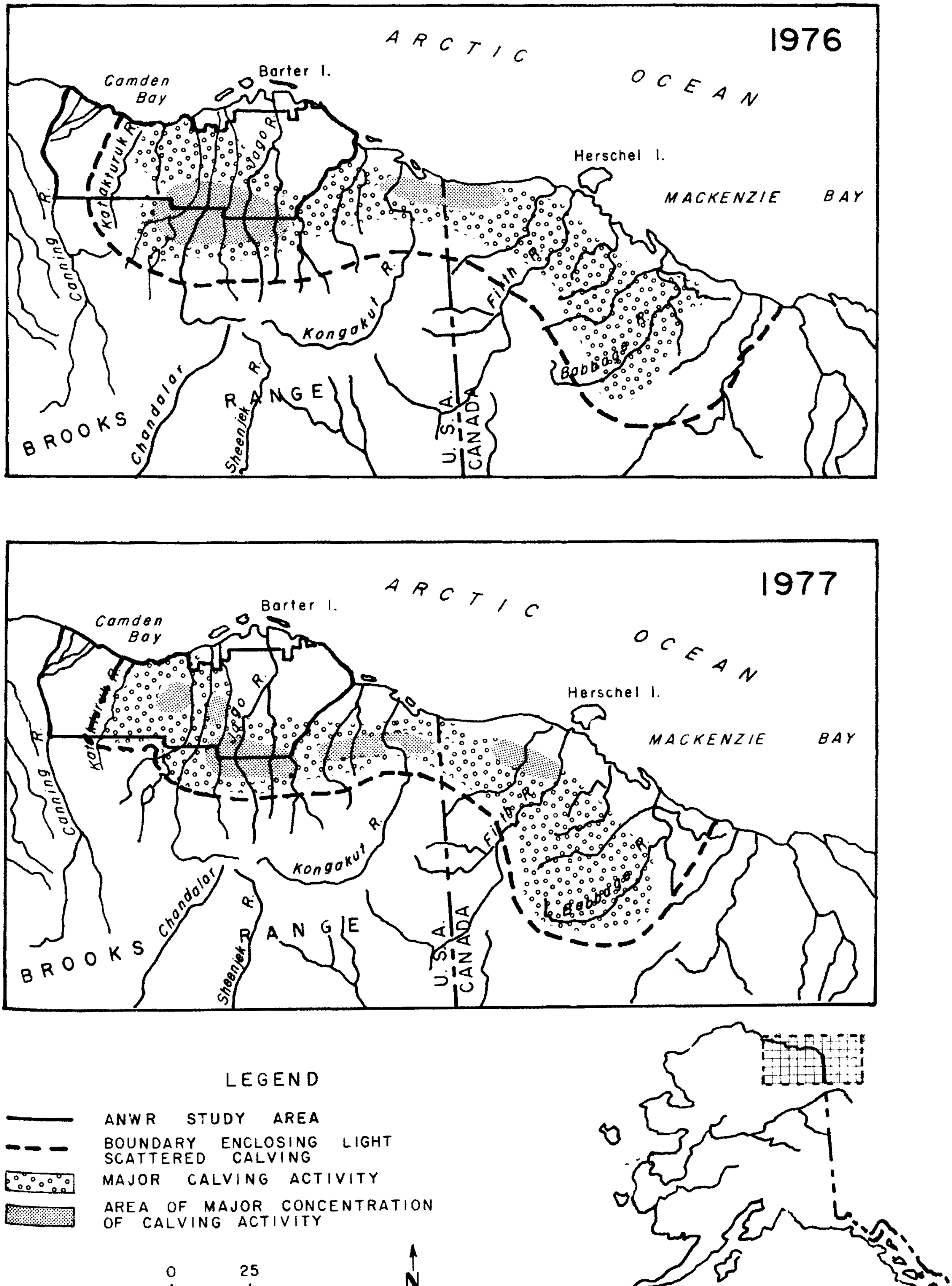


FIG. 2-d A COMPARISON OF THE PORCUPINE CARIBOU HERD'S CALVING GROUNDS FROM 1972 — 1981. (From Curatolo and Roseneau, 1977; Roseneau, 1977 unpubl. repts.; Yukon Game Branch, unpubl. repts.)

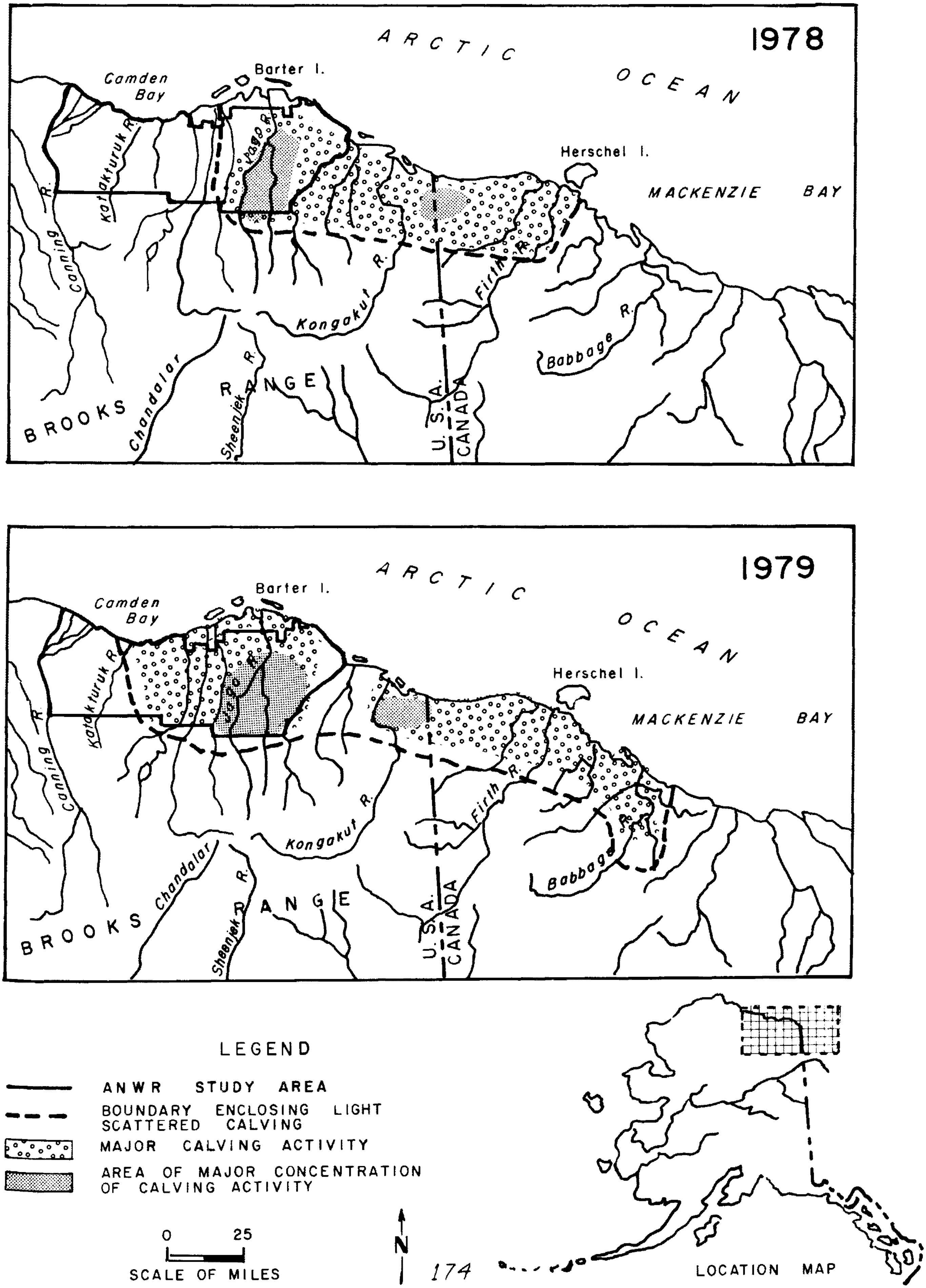
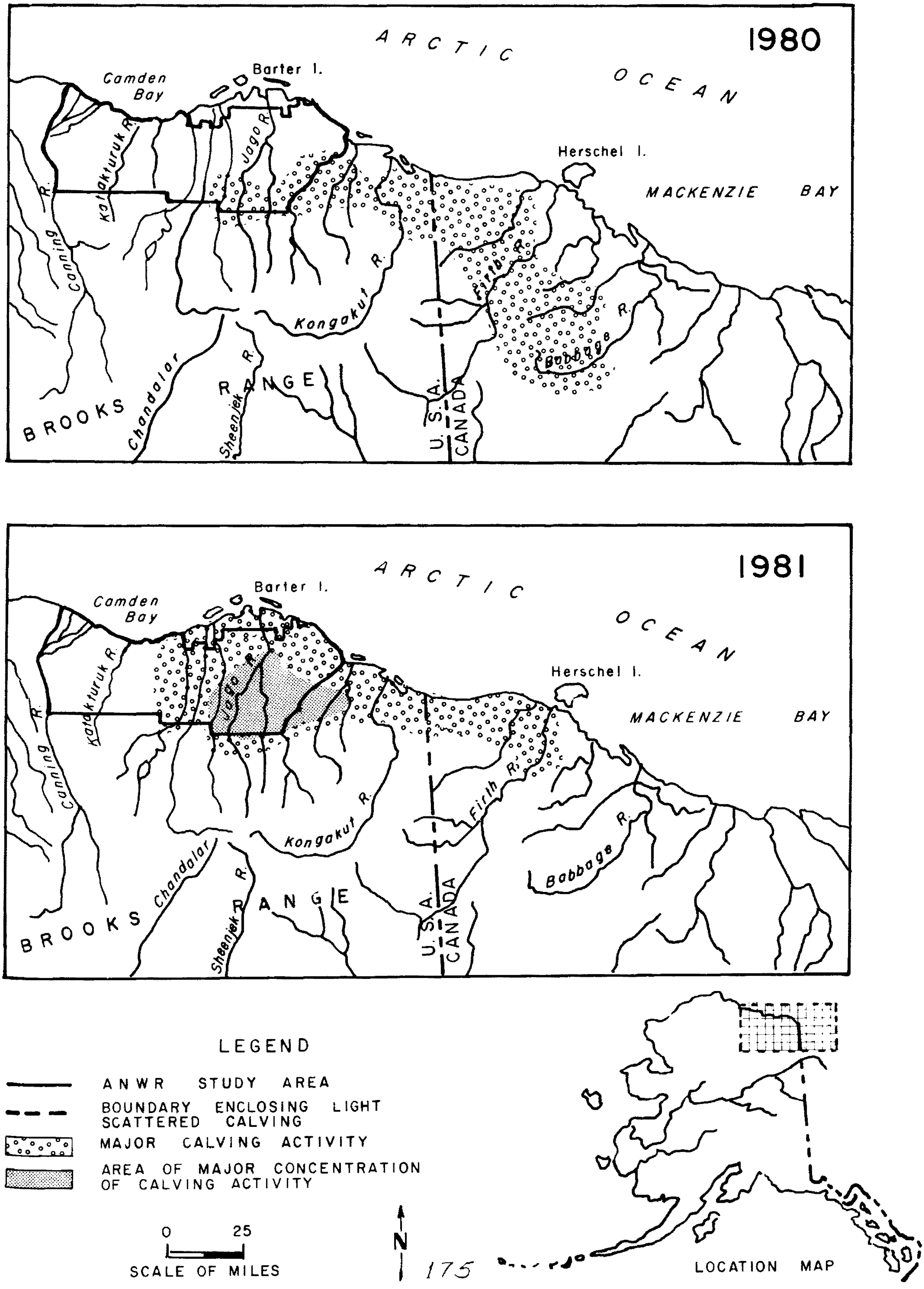


FIG. 2-e A COMPARISON OF THE PORCUPINE CARIBOU HERD'S CALVING GROUNDS FROM 1972 — 1981. (From Curatolo and Roseneau, 1977; Roseneau, 1977 unpubl. repts., Yukon Game Branch, unpubl. repts.)



and DeBock 1976). In 1972, a year of deep snow on the migration routes and limited snow-free areas on the western calving grounds, most calving activity occurred in the northern Yukon Territory and along the foothills from the international border to the Jago River area (Calef and Lortie 1973).

Major calving concentrations occurred in the ANWR study area in 1974, 1975 and 1977 between Camden Bay and the Sadlerochit Mountains (from the Tamayariak River on the west to the Sadlerochit River on the east, and in 1972, 1975-1979 and 1981 along the foothills from the Sadlerochit River to the Aichilik River. Scattered calving activity has occurred every year throughout much of the study area from the Canning River to the Aichilik River. Although there is considerable variation in where calving occurs, there is little difference from year to year as to when it occurs. The first calf of the season is usually observed in the last week of May. The peak of calving occurred between June 5 and 9 during the period of 1971-76 (Curatolo and Roseneau 1977). Calving is usually complete by June 18.

Caribou cows arrive on the calving grounds in small groups which are constantly changing in size and composition (Kelsall 1968). Cows are usually alone or near small groups at the time of birth. After the calf is born, the cow licks the calf and often eats or mouthes the after-birth (Calef and Lortie 1973). The cow and calf usually remain near the birth place for the first day (Skoog 1968). Caribou calves are very precocious, being able to stand and nurse within an hour or two after birth (Kelsall 1968, Curatolo and Roseneau 1977). After the third day the calf can walk well enough to follow its mother and can even run for considerable distances. By a week the calves can travel with swiftly moving caribou bands (Skoog 1968)

The cow-calf bond in caribou is relatively strong compared to other ungulates. Separations however, are common during the calving and post-calving seasons due to the migratory nature of caribou (Lent 1964, Skoog 1968, Calef and Lortie 1973). Calves may be particularly vulnerable during the bond-forming process. Lost calves have been observed to approach humans (Calef and Lortie 1973) and predators (Roseneau and Curatolo 1976) in their search for the maternal cow. After giving birth, cows with calves are frequently found in small "nursery bands". These bands move at a casual pace through the calving grounds, the cows grazing primarily on new-growth Eriophorum shoots. There is a continued movement to the west and north on to the coastal plain as the zone of snow melt advances towards the north (Calef and Lortie 1973, Curatolo and Roseneau 1977).

Post-calving. Barren ground caribou form large post-calving aggregations and at no other time are the caribou so concentrated. There is considerable annual variation in the chronology, location, movement, and group size of post-calving aggregations. Although this phenomenon is poorly understood, factors such as the location of calving concentrations, snow-melt patterns, vegetation phenology, temperature, wind and other climatic factors, as well as insect harassment contribute to the observed variations.

In some years, 1972-74 for example, large numbers of cows and calves gathered in the ANWR study area near the coast south of Camden Bay (from the Canning River to the Hulahula River) during late June (LeResche 1972, Calef and Lortie 1973, Roseneau et. al. 1974 and 1975, Roseneau and Curatolo 1976). In 1972 over 80,000 caribou were counted from aerial photos of 1 aggregated group south of Camden Bay (LeResche and Linderman 1975). By early July these large groups of caribou moved eastward in a broad front extending from the coastline to 30 km inland (LeResche and Linderman 1975). At times large numbers of caribou were observed in the coastal tidelands and even out on the shore-fast sea ice (Roseneau and Stern 1974). After crossing the Jago River near its mouth, caribou shift their movements to the southeast. At the Kongakut River caribou usually pass along the coast and the river delta, or move inland, crossing the river between the foothills and mountains where the river bends to the west. In most years a majority of the Porcupine herd passes into Canada between the first and second weeks of July. Caribou have remained in the ANWR throughout the summer. In 1972 about 10-12 thousand caribou spent the summer months ranging in the Katakturuk-Sadlerochit foothills and Peters-Schrader Lake area eastward to the Aichilik River (Roseneau and Stern 1974). Late migrating bulls and juveniles usually rendezvous with the rest of the herd in the Kongakut-Firth Rivers area. In northern Yukon Territory, the post-calving movement consisting of most of the Porcupine herd, continues southeastward along high ridges of the British, Barn, and Richardson Mountains. The large aggregations usually separate into smaller groups and then reform into larger ones several times during the post-calving march (probably as a response to mosquito harassment) (Curatolo pers. comm.). By late July-early August, the Porcupine herd reaches a staging area near Bonnett Lake in the Driftwood Hills of northern Yukon Territory. Fig. 3 illustrates this "typical" post-calving movement pattern for the Porcupine caribou herd. The traditionality of post-calving movements of the Porcupine herd has been confirmed by studies of caribou trail systems (LeResche and Linderman 1975).

In some years (e.g. 1976 and 1981), the Porcupine herd failed to form large aggregations (Curatolo and Roseneau 1977, Bartels pers. comm.). Fig. 4 shows the post-calving distributions and movements of 1981 in Alaska. In 1976 and 1981 caribou did not move in large numbers to the coast, instead they gathered into several loosely-formed groups farther inland, from the Sadlerochit to the Kongakut Rivers. In 1981 large numbers of caribou milled for several days between the Egaksarak and Kongakut Rivers prior to crossing the Kongakut and moving into Canada. By 30 June 1981 most of the herd was in Canada, considerably earlier than most years (Bartels pers. comm.).

The appearance of harassing insects, especially mosquitoes, partially contributes to the aggregation behavior of caribou (Kelsall 1968, Curatolo 1975). When mosquito harassment is particularly intense, caribou tend to gather into extremely dense, compact groups (Curatolo 1975). Stampedes can be triggered easily during this time and contribute to accidents, crippling, and separation of calves from the cows (Calef and Lortie 1973, Roseneau and Curatolo 1976). During the height of the insect harassment season (July - mid-August), caribou seek relief on windy ridges, along coastlines, on snow fields, and gravel bars. Movement of the herd is almost continuous and little time is spared for foraging and grazing. The insect season is apparently a time of extreme stress on caribou and contributes to a high mortality rate for calves (Calef and Lortie 1973, White et al. 1975). Additional disturbances during this time period could seriously increase mortality (Calef and Lortie 1973).

August Dispersal. Warble and nasal bot fly harassment is apparently responsible, in part, for the dispersal of caribou during mid-summer (Curatolo 1975). The Porcupine caribou herd disbands from the Bonnet Lake - Driftwood Hills staging area in early August, moving in widely scattered groups westward through the northern Old Crow Flats into Alaska (Roseneau et al. 1974,

FIG. 3 GENERALIZED MOVEMENTS BY POST-CALVING AGGREGATIONS — PORCUPINE CARIBOU HERD, 1972-74

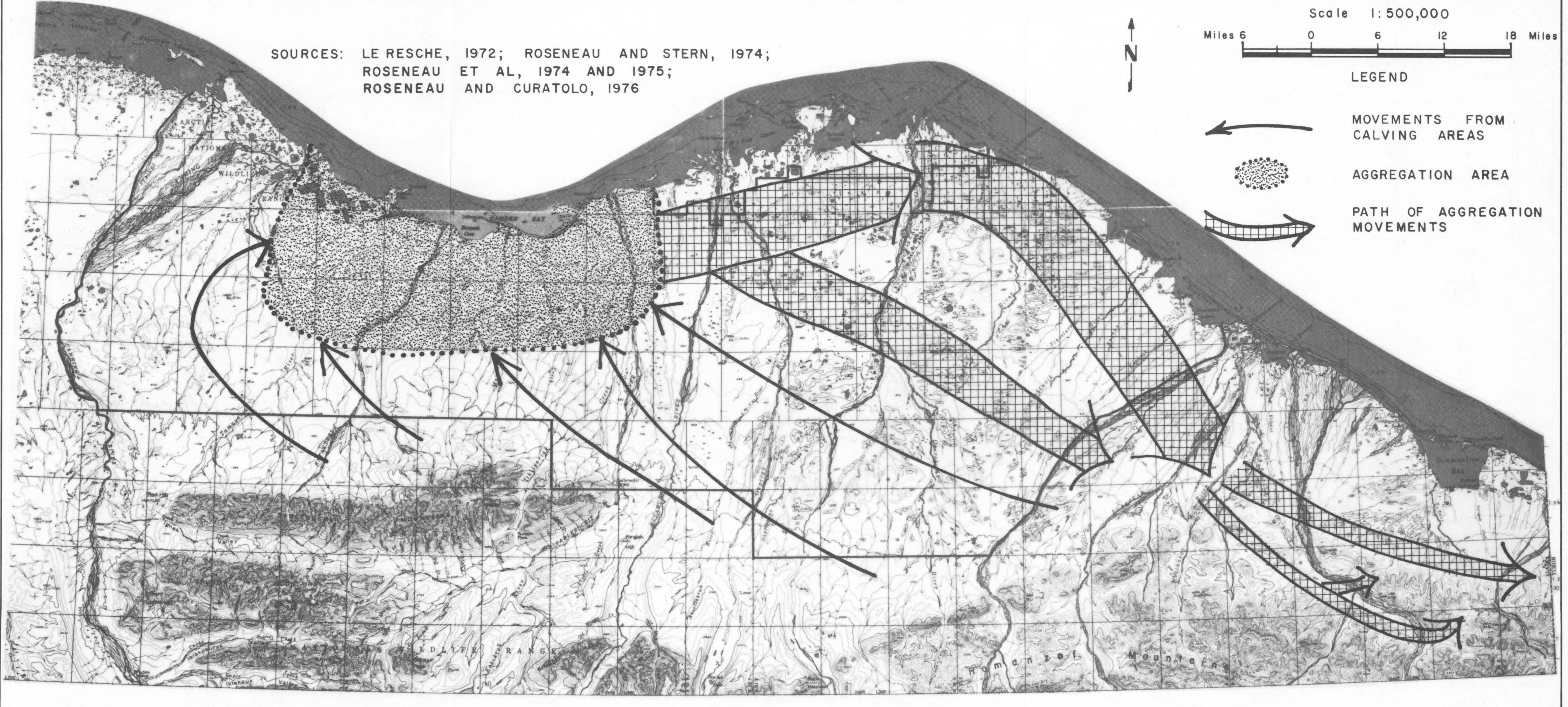
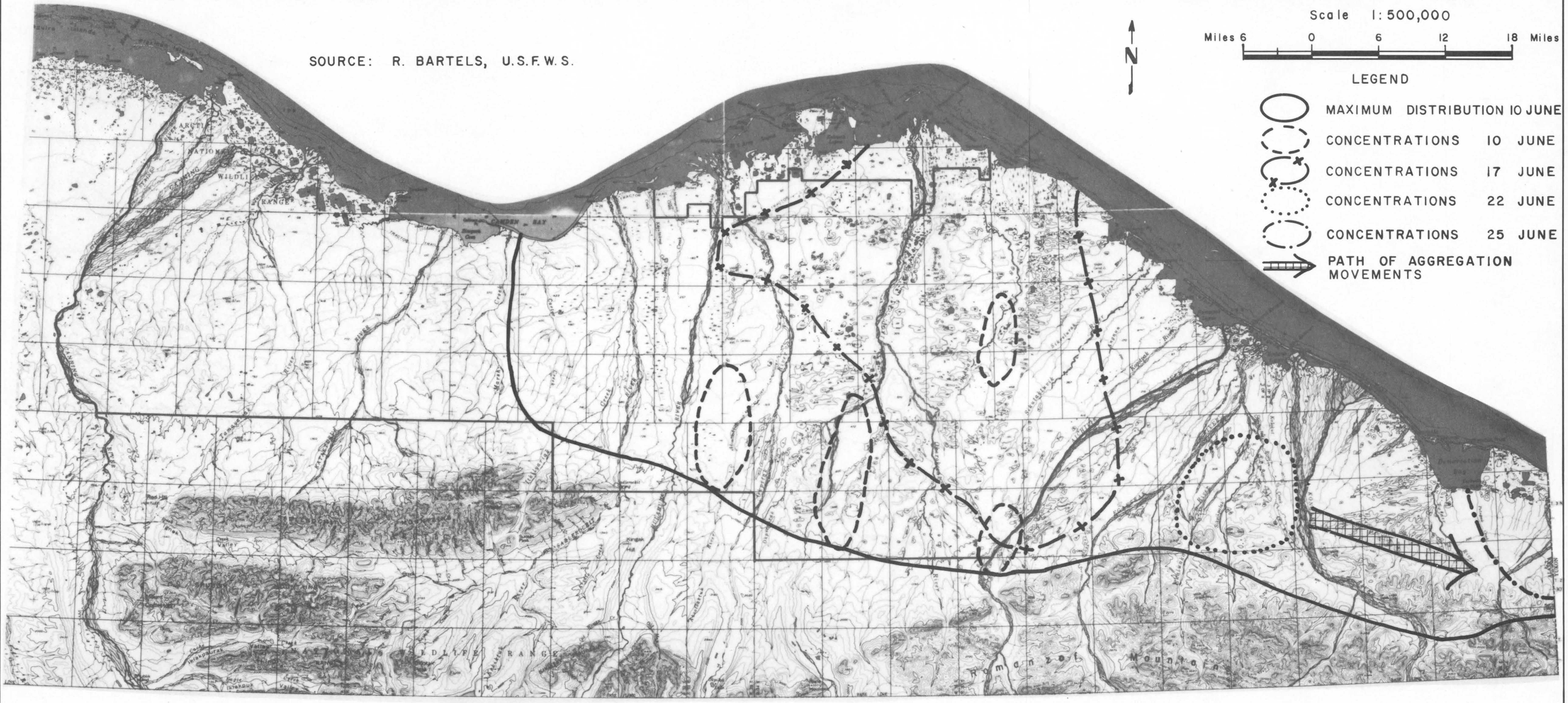


FIG. 4 POST-CALVING DISTRIBUTION AND MOVEMENTS — PORCUPINE CARIBOU HERD 1981



Surrendi and DeBock 1976). They continue moving along the southern foothills of the Brooks Range in the Upper Coleen and Sheenjek river drainages. During the period of mid-August to early-September, the Porcupine herd is widely dispersed from the broad-rolling hills south of Arctic Village to the Old Crows Flats (Surrendi and DeBock 1976).

Fall Migration. Usually by the second week of September a gradual eastward shift of caribou into Canada begins (Roseneau et al. 1974). Small groups of caribou begin to coalesce in the Old Crow Flats. Autumn snow storms sometimes accelerate the southward migrations and seem to influence directional movements towards the primary wintering areas (Lent 1966, Bergerud 1974b). Major crossing points on the Porcupine River are near Rampart House on the international border, up and downstream of the village of Old Crow, and near the mouth of the Bell river (Surrendi and DeBock 1976). The timing of river crossings varies considerably from year to year. In some years large numbers of caribou move to the northeastern slopes of the Richardson Mountains (Kevan 1970 as cited by Calef 1974). After crossing the Porcupine River, most of the herd moves into the Keele Mountains and proceeds southwestward as the rut begins (Calef 1974).

Rutting Season. The Porcupine herd breeds during the middle of October while enroute to the winter ranges (Calef 1974). In late August, bull caribou shed their antler velvet. By the time of rutting, the bulls have developed a thick layer of body fat which helps to sustain them during the breeding season. Throughout September the bulls become increasingly aggressive and begin brief sparring matches with other males. Large bulls are dominant and tend to fight mostly with other bulls of similar size. Usually the sparring matches are not particularily violent and last about 5 minutes (Skoog 1968). By the end of the rut, the bulls have lost a considerable amount of body fat depending on age, health, and breeding activity.

The rut lasts about 2 weeks and accounts for the short period in which the calves are born (Dauphine and McClure 1974). Cows can have several estrus cycles until conception takes place (Skoog 1968). The bulls usually mate with more than 1 cow. Most caribou are sexually mature at 2 years of age. The gestation period is about 210 days.

Several authors have noted an increased sensitivity of caribou to disturbance during the breeding season (Lent 1965, Surrendi and DeBock 1976). Caribou sex and age classes are quite evenly mixed during the rut. Harems are not formed as is done by some cervids (Lent 1965). Caribou are commonly in small heterogeneous groups during the breeding season.

Winter Activity. The 2 principal wintering areas for the Porcupine herd are located in the central portion of Yukon Territory and in the vicinity of Arctic Village in Alaska (Fig. 1). Wintering also takes place in the Richardson Mountains and along the lower Coleen River (Thompson and Roseneau 1978). Table 2 illustrates annual variations in the use of winter areas during 1970-1978. In the winter of 1972-1973 most of the herd was found in the Arctic Village area. In 1978-79 about half of the herd wintered in Alaska, spread from the Yukon River to the Brooks Range with the most concentration in the Coleen Valley (Whitten pers. comm.). In recent years the majority of caribou in the Porcupine herd have wintered in Canada, over 50% of these animals crossing to the east side of the Dempster Highway (Thompson and Roseneau 1978). Also recently an increasing number of caribou have wintered

Table 2. Annual variation in numbers of caribou of the Porcupine herd distributed on winter ranges.*

Winter range areas	Winter							
	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78
<u>In Canada:</u>								
Peel R. - Hungry Lakes, and Oglivie Mountains	23-30,000 15-40,000	40-62,000	12,000+	60,000	No. est.	Most of Pop.	Most of Pop.	Most of Pop.
Richardson Mountains	2-3,000	17-30,000	5,000+		10,000+	Very Few		
Arctic Coastal Plain			Few 100's	5,000	1,000	0	Few 100's	
Old Crow Area				5,000		Several 1000's		
Bell R. Drainage						1,000		
<u>In Alaska:</u>								
Chandalar-Sheenjek R. Drainages	1000	1400-2500	30-40,000		10-15,000		100	100-1000+
Coleen R. Drainage			1,000+	1,000+			200	1000-1500
Arctic Slope		2-400	Few 100's	1-2,000	ca. 200			
Hodzana R. headwaters		900	2-3,000					
Est. Total in Alaska	1000	2600-4000	50-60,000	13-14,000	10-15,000	3,000	300	2,400

* Estimates based on information in Doll et al. 1974, Roseneau and Stern 1974, Roseneau et al. 1974, Roseneau et al. 1975, Curatolo and Roseneau 1977, Thompson and Roseneau 1978.

in the vicinity of the international border on the upper Kandik and Tatonduk rivers (U.S. Dept. of State 1980). At the southern portions of the winter range interchange with other caribou herds (Forty-mile herd) has taken place in the past and probably will continue (Skoog 1968). In October of 1981 large numbers of caribou from the Porcupine herd crossed the Yukon River near Eagle. This event has probably not occurred in recent times (Whitten per. comm.).

Wintering groups of caribou do not remain on 1 feeding site for the entire winter (Henshaw 1968). Instead there are frequent short distance movements by wintering groups throughout the season. The condition of snow (depth and hardness) is an important factor determining where wintering animals are found (Pruitt 1959, Henshaw 1968). In a recent survey of the wintering Porcupine caribou herd, Thompson and Roseneau (1978) observed caribou "most often in broad rolling valley bottoms or slopes with moderate tree cover and continuous snow cover; or on windswept ridges with no tree cover." Because varying topography and vegetation alter wind speeds and thus influence snow conditions, the medium density black spruce stands of the taiga seem to provide favorable winter feeding sites for caribou (Bergerud 1974b, Thompson and Roseneau 1978). Open windswept ridges are also frequented by wintering caribou because of the ease in finding food and the good visibility which permits detection of predators (Thompson and Roseneau 1978).

Nearly every year several hundred to a thousand caribou winter within portions of the ANWR study area (Roseneau and Curatolo 1976). Information gained from radio-tracking studies indicates that these animals are probably part of the Central Arctic Caribou Herd (Cameron pers. comm.).

Population Characteristics

A review of basic population parameters indicates that the Porcupine herd has remained relatively stable over the past 10 years (Table 3).

Table 3. Porcupine caribou herd population estimates 1961-1979.

Year	Population Estimate	Method	Source
1961	110-117,000	calving grounds census	Skoog 1968
1964	140,000	calving grounds census	Skoog 1968
1972	101,000	"APDCE"[1]	LeResche 1972
1977	105,000	"APDCE"	Bente and Roseneau 1978
1979	110,000	"modified APDCE"	Whitten and Cameron 1980[a]

[1] APDCE = Aerial Photo-Direct Count Extrapolation

A population estimate was attempted in June, 1981, but was unsuccessful because the caribou failed to aggregate adequately for aerial censusing (Whitten per. comm.).

Sex and age composition data given in Tables 4 and 5 reflects general health and stability in the Porcupine caribou herd. The calf/cow ratio at post-calving has averaged 55% over the past 10 years. A re-examination of the 1979 census in light of 1980 age and sex compositions reveals that perhaps some 10,000 bulls were not counted (Whitten and Cameron 1980a). A revised 1979 population estimate for the Porcupine caribou herd of 120,000 animals is suggested by Farnell (1981).

Table 4. A 9 year comparison of sex and age composition of the Porcupine caribou herd post-calving aggregations during July 1-15.

Year	% Cows	% Calves	% Yearlings	% Bulls	Calf: Cow Ratio
1972[1]	53	26	9	12	48:100
1973[1]	58	27	6	10	47:100
1974[1]	55	37	3	5	66:100
1975[1]	52	27	9	12	51:100
1976[1]	55	32	10	2	59:100
1977[2]	61	24	11	4	39:100
1978[3]	46	31	8	14	67:100
1979[4]	47	26	8	19	55:100
1980[5]	39	26	11	23	66:100

Sources: [1]Curatolo and Roseneau 1977
[2]Bente and Roseneau 1978
[3]Whitten and Cameron 1980
[4]Whitten and Cameron 1980
[5]Farnell 1981

Table 5. Fall sex and age composition of the Porcupine caribou herd

Year	% Cows	% Calves	% Yearlings	% Bulls	Calf: Cow Ratio
1972	48.7	14.8	8.6	27.9	30.3:100
1977	39.0	18.5	12.2	30.3	47.5:100
1978	48.4	30.1	6.1	15.4	62.2:100
1980	42.8	23.2	8.0	25.9	54.0:100

Central Arctic Herd

Size, Range, Distribution, and Movement

The identity of a separate, discrete caribou herd occupying an area of the Arctic Slope between the ranges of the Western Arctic and Porcupine herds (Fig. 1) was confirmed by Cameron and Whitten (1976 and 1979a). Previous publications (Olson 1959, Skoog 1968, Gavin 1971, LeResche 1972, Child 1973, Roseneau et al. 1974, Roseneau and Stern 1974, Roseneau and Curatolo 1976, White et al. 1975) had also mentioned or described this caribou herd. Currently the Central Arctic herd is estimated at 7-9,000 individuals (Whitten pers. comm.). Its recent range lies north of the Brooks Range from the Colville River on the west and at least as far east as Camden Bay and the Sadlerochit Mountains (Whitten pers. comm.). The Prudhoe Bay oil field complex, Trans-Alaska Pipeline and the Dalton Highway transect the range of the Central Arctic herd.

The Central Arctic herd calves on the Arctic Coastal Plain from the Colville River to the Canning River delta. In years of late snow melt and flooding conditions on the coastal plain, the herd sometimes calves in dryer upland sites such as the Franklin Bluffs area (Whitten et al. 1981). Calving activity in the Prudhoe Bay area was reported earlier by Gavin (1971), Child (1973), and White et al. (1975) when the oil field was beginning to be developed. Later studies by Cameron and Whitten (1979a, 1980; Cameron et al. 1981) indicate an absence of calving near the coast at Prudhoe Bay possibly due to avoidance of the area by calving caribou. Two centers of concentrated calving activity were located in recent surveys (Whitten et al. 1981). One area, the Kuparuk, lies west of Prudhoe Bay in the vicinity of the newly developing oil field. The other area is east of Prudhoe Bay, primarily in the Canning River delta area within the ANWR. Calving activity in the Canning delta has been noted through radio-telemetry studies and has been partially quantified for the years 1978-1980 (Cameron pers. comm.). Surveys conducted in 1981 indicate that the Canning delta area is an important calving grounds for the Central Arctic herd and may have more calving caribou than the Kuparuk area (Whitten et al. 1981).

Following calving, portions of the Central Arctic herd usually move eastward along the coast in post-calving aggregations. Animals from the west often cross the Canning River delta and pass into the ANWR study area (Cameron and Whitten 1979b). These aggregations gradually disperse into smaller groups; some move back along the coast to the west, others remain in the Canning delta area. In mid-July, when insect harassment intensifies, bands of Central Arctic herd caribou can be found seeking relief on the coastal beaches, sand dunes, shorefast ice, and barrier islands of the Canning delta - Camden Bay area. In some years these caribou are hunted by villagers traveling by boat from Kaktovik (Bartels per. comm.).

A gradual southward movement of the Central Arctic herd occurs in late August and early September. This movement is usually accelerated by the first heavy snowfall. In years of "mild" weather, significant numbers of caribou have been found wintering on the coastal plain (Whitten per. comm.). The foothills are used more extensively in years of harsh weather and deep snow conditions. Scattered groups of caribou believed to be part of the Central Arctic herd also winter east of the Canning River. Radio-collared caribou of the Central Arctic herd have been located during the winter on the North Slope of the ANWR (Cameron pers. comm.).

In 1975 small numbers (200-300) of caribou were observed in the study area north of the Sadlerochit Mountains from the Canning River to Barter Island (Roseneau and Curatolo 1976). Eskimo hunters from Kaktovik commonly hunt caribou during the winter in the vicinity of Peters and Schrader Lakes, Hulahula River, Jago River, and Sadlerochit Mountains (Jacobson 1979). In some years, harvest of caribou from these wintering bands located in or near the study area is a significant part of the subsistence resources for Kaktovik.

Population Characteristics

Detailed studies of the Central Arctic herd were initiated by the Alaska Dept. of Fish and Game in 1974. The following year, the Department estimated that the herd numbered about 5,000 (Cameron and Whitten 1976). In 1978 the herd was estimated at 6,000. The current estimate of herd size for the Central Arctic herd is 7,000 to 9,000 (Whitten pers. comm.). The apparent herd increase over the past 6 years has been attributed to excellent early calf production and survival as well as relatively light hunting pressure (Whitten and Cameron 1981).

From 1978 to 1981, calf/cow ratios for the Central Arctic herd immediately after calving have ranged from 69/100 to 85/100, which indicates a high level of calf production (Whitten et al. 1981). The same ratio measured in October ranged from 53/100 to 65/100, indicating excellent calf survival (Whitten and Cameron 1981).

Extent, Location, and Carrying Capacity of Caribou Habitats

Preliminary calving ground habitat studies for the Porcupine herd have been conducted by personnel of the FWS, Denver Wildlife Research Center. Habitat and range studies currently underway in northern Yukon Territory are being conducted by the CWS. In spite of these efforts, a comprehensive vegetation map for the entire range of either herd has not been developed.

The Porcupine herd may spend up to 11 months of the year in mountainous terrain (Calef 1974). A wide variety of plant communitites, snow conditions, and insect densities are encountered as the herd makes altitudinal and latitudinal migrations through its range. Snow has been identified as an important feature throughout much of the caribou's annual cycle (spring migrations, calving, insect relief, fall migrations, and wintering areas). Some general observations have been made regarding the snow environment of the Porcupine herd (Roseneau et al. 1974, Roseneau and Curatolo 1976, Curatolo and Roseneau 1977, Thompson and Roseneau 1978), but more information is needed (Kelsall and Klein 1979).

Several recent studies have examined the relationships between plant phenology and the calving activities and summer movements of caribou (Klein and White 1978, Kuropat and Bryant 1980). A high degree of selection has been demonstrated by caribou for certain plant species during early growth stages of the plants. Selection of newly emerging tussock (Eriophorum sp.) on the calving grounds has already been discussed. Following calving, there is a general movement toward the lower coastal areas as snow melt progresses and vegetation green-up occurs. Later in summer and early fall, willow (Salix sp.) and sedges are the predominant food items (Kuropat and Bryant 1980).

Much discussion has taken place regarding caribou winter food requirements. Some researchers thought that lichens were required for the winter survival of caribou (Leopold and Darling 1953). But studies in the Canadian High Arctic (Klein 1980a) as well as on isolated caribou ranges in southern Canada (Bergerud 1974a) have determined that Rangifer spp. can survive throughout the winter without a lichen dominated diet.

Lichens on the other hand are the predominant winter forage for most of the North American caribou populations. Although lichens lack important nutritional elements such as nitrogen and phosphorus, they are relatively high in carbohydrates and apparently are important to caribou for their caloric value during the cold winter season (Kelsall 1968). Comprehensive studies of food habitats and seasonal forage selection patterns have not been conducted for the Porcupine herd.

Due to the nomadic nature of migratory barren ground caribou which range over vast areas, the concept of carry capacity as it is traditionally used for livestock is not applicable to caribou (Skoog 1968). Unlike other migratory species such as birds, which can fly from one important habitat to another, the caribou must move across the earth's surface from one area of advantage to another. An area of a herd's range may not be visited for a long time period, then as herd movements change, it again becomes an area of importance for caribou.

Numerous theoretical efforts to determine carrying capacities of caribou ranges have been made. Using basic range inventory techniques, such studies have identified much higher capacities than are exhibited by living populations (Calef 1974). Theoretical carrying capacities calculated for various caribou populations have ranged from 1.2 caribou/km^2 (Skoog 1956) to 3.7 caribou/km^2 (Porsild 1929, as cited by Calef 1974). Currently the Porcupine herd occupies its range at a density of 0.44 caribou/km^2. This corresponds closely with the overall average density of caribou populations in Alaska, Canada, and Taimyr (Calef 1974). Bergerud (1980) hypothesized that the discrepancy between theoretical carrying capacities and actual caribou range densities is primarily due to predation.

As caribou populations increase, there is a corresponding expansion of their range. Likewise as a population declines there is a corresponding shrinkage of range (Simmons et al. 1979). In cases where a caribou population increases rapidly and high densitites are achieved, there is a tendency for erratic movements, often leading to interchange with neighboring herds (Skoog 1968). The Porcupine herd has remained at a relatively high level for the past 20 years (Table 3). Skoog (1968) and Calef (1974) and others have described a close relationship between the Porcupine and Forty-mile caribou ranges and populations. Historically these have reported incidences of interchanges between these herds (Skoog 1968). The recent movement of Porcupine herd caribou south of the Yukon River may give biologists an opportunity to study the ramifications of herd interchange. The consequences of such exchange between caribou herds are not known. It has been hypothesized that exchanges may be essential for reversal of population declines and valuable for the exchange of genetic material which is crucial for long term viability of stocks (Haber and Walters 1980).

Effects of Human Activities

Interactions between man and caribou in northeastern Alaska dates back at least 27,000 years. Caribou fences, archeological sites and elements of Kutchin Indian and Inupiat Eskimo cultures attest to the early relationship of hunter and caribou in the region. There is no evidence that early man and his structures had significant impacts on the herd (Klein 1980b).

When Western man came to northeastern Alaska, firearms were introduced to indigenous people and the ease of killing caribou increased. Historical accounts indicate that fairly high harvests occurred during the late 1800's and early 1900's (Stone 1900, Leffingwell 1919). Considerable numbers of caribou were taken for food by overwintering whalers at Herschel Island at the turn of the century. Discovery of gold in the Klondike region of Yukon Territory brought a wave of miners into the southern range of the Porcupine herd. Records indicate that caribou was a popular food resource for these miners (Skoog 1968).

The next major influx of human activity in the range of the Porcupine caribou herd came in the 1950's, following World War II when the Distant Early Warning radar sites were constructed. During this time supply trails were used to carry equipment to the Arctic coast from Dawson (Y.T.) and Circle, Alaska. Efforts to locate oil and gas resources within the Porcupine herd's range began in Canada during the early 1960's in the Eagle River - Peel River plateau country. Both seismic exploration and exploratory drilling were conducted at this time. Construction of the Dempster Highway from Dawson to Inuvik was initiated in the 1960's and completed in 1978. The highway transects major winter ranges and migration at the Porcupine caribou herd (Fig. 1)

Other significant human events which influenced the Porcupine caribou herd directly or indirectly were the establishment of the Arctic National Wildlife Range in 1960, the introduction of snowmobiles as a new form of winter transportation (late 1960's), discovery of oil and gas at Prudhoe Bay and the Mackenzie delta in 1968, settlement of aboriginal land claims in Alaska in 1971, and passage of the Alaska National Interest Lands Conservation Act of 1980 which implemented geological and geophysical exploration in the ANWR study area and expanded the boundaries of ANWR.

The sport harvest of Porcupine herd caribou has remained relatively low in Alaska. State law currently allows for an annual bag limit of 5 caribou from the Porcupine herd's range. Two caribou/year may be transported out of the region (Game Management Units 25A, B and D and 26C). See Chapter 7 for discussion of subsistence harvest areas and activities related to the study area. Recent annual human harvest of Porcupine caribou herd has been estimated at less than 5,000 and has averaged 5% or less of the estimated total population (LeResche 1972, Surrendi and DeBock 1976, Davis 1980, Whitten and Cameron 1980a). Annual harvest rates of other major caribou herds in northern Canada range from less than 1% to 8.8% (Calef 1980, Davis 1980, Juniper 1980).

The annual harvest of the Porcupine herd has remained reasonably stable over recent years. The Central Arctic herd has a relatively low harvest level (Whitten and Cameron 1981). Bergerud (1974b) attribute drastic declines in caribou populations in North America to hunter harvest and predation.

Considerable concern has been raised by caribou biologists over potential harvest increases along the newly-opened Dempster Highway. High harvest levels of the Western Arctic herd (Davis et al. 1980) and the Kaminuriak herd (Simmons et al. 1979, Thomas 1981) have led to population declines. Bergerud (1980) predicts that if the annual harvest of caribou from the Porcupine herd increases by even a few thousand, a decline in the population will occur.

Other human interactions with the Porcupine caribou herd include contact by recreationists, air charter operators, trappers, geologists, biologists, other scientists and land administrators. Caution has been raised by a number of caribou biologists familiar with the Porcupine herd with regard to impacts from human disturbance on the calving grounds and post-calving areas (Calef and Lortie 1973). Specific mention has been made regarding potential conflicts from tourists on the Porcupine caribou herd especially during post-calving migrations at river crossings (Calef and Lortie 1973, Curatolo 1979).

Natural Processes

There are many naturally occurring events or factors which influence caribou populations. Extensive discussions of such factors are provided by Skoog (1968) and Kelsall (1968). Thompson 1973, Bergerud (1974[b]), Curatolo (1975), and Roby (1978) provided descriptions of the behaviorial responses of wild reindeer and caribou to external environmental factors. It is generally accepted that of the many natural processes, weather, insects, and predation usually exert the strongest influences on caribou populations. Other natural factors known to influence caribou include diseases, parasites, accidents and forest fires.

Weather. Climatic data for the study area are presented in Ch. 2. There is a lack of detailed information regarding the many facets of weather interactions with caribou in the study area. The following discussion provides some general insight into weather-caribou interactions and indicates relative significance to the study area.

Storms with high winds, low temperatures, and moisture have been associated with observed high calf mortality on calving grounds in northern Canada east of the Mackenzie River (Banfiled 1954, Kelsall 1968). Comparable instances of storm induced calf mortality have not been reported on calving grounds in the study area or elsewhere in Alaska. Skoog (1968) however, concluded that in Alaska "severe weather and chilling can result in high mortality among new-born claves during some years".

Much has been written regarding snow conditions and caribou (Pruitt 1959, Henshaw 1968, Lent 1964, Kelsall 1968, Skoog 1968, LaPerriere and Lent 1977, Thompson and Roseneau 1978, and Lent 1980). A serious weather condition for caribou occurs when ice-crusted snow prevents access to winter forage (Skoog 1968). Massive die-offs of Rangifer spp. have been associated with such conditions (Klein 1968, Skoog 1968). In Alaska ice-snow conditions are most prevalent in the western portion bordering the Bering Sea (Skoog 1968). Apparently ice-crusting is not a common problem for caribou herds associated with the study area.

Indirectly, the weather is responsible for a number of adverse conditions affecting caribou. Rapid warming trends in spring causing swollen rivers with ice floes can present difficulties for caribou during spring migrations. Calm, warm weather during the summer can facilitate extreme insect harassment conditions (Curatolo 1975).

Predation. Predation is considered to be a significant mortality factor for most caribou herds in North America (Kelsall 1968, Bergerud 1974b). The grizzly bear, black bear, polar bear, wolf, coyote, red fox, arctic fox, lynx, wolverine, golden eagle, bald eagle and raven have been listed as predators or potential predators of North American caribou (Skoog 1968). In the case of the Porcupine and Central Arctic herds, wolves, grizzly bears, and golden eagles tend to be the most important predators.

Wolves. For most large caribou herds in North America, the wolf is the most significant predator (Kelsall 1968, Skoog 1968). Bergerud (1974a, and b) suggests that the wolf has been a central factor in the evolution of behavioral characteristics of caribou. Adaptations such as: migrations to areas of low wolf density for calving, synchronized calving, gregariousness, the size, shape and clumping nature of groups, aggregations, alertness to moving stimuli, and shyness to ambush terrain (or sturctures resembling ambush features), have been suggested to be primarily responses to the selective forces of wolf predation (Bergerud 1974a and b, Dauphine and McClure 1974, Cummings 1975, Curatolo 1975, Roby 1978,).

The density of wolves in the study area and remainder of the arctic slope of the ANWR is considered to be relatively low. During intensive surveys of calving and post-calving activities of the Porcupine herd (1972-1975) the number of wolf observations recorded per year ranged from 1 to 6 (Calef and Lortie 1973, Roseneau and Curatolo 1975). This relative low density of wolves (as compared to other portions of the herd's range) is consistent with the calving grounds of other large Alaskan herds. There has been no comprehensive study of wolf predation conducted over the ranges of Porcupine or Central Arctic herds. Therefore the impact of this form of predation is not known.

Grizzly Bears, Grizzly bears are generally more numerous in or adjacent to the study area than are wolves and are considered to potentially be a more significant predator of caribou in the study area (Calef and Lortie 1973, Roseneau and Curatolo 1975). Grizzly bear populations and level of predation on caribou throughout the ranges of the Porcupine and Central Arctic herds are not known in sufficient detail to make assessments of impact to populations.

Golden Eagle. Several authors have noted relatively high numbers of golden eagles in and adjacent to the study area during the spring and summer (Calef and Lortie 1973, Roseneau and Curatolo 1974). During intensive surveys of calving and post-calving areas of the Porcupine herd in spring and summer, immature golden eagles were commonly observed. Several instances of golden eagles feeding on caribou calves were also observed (Roseneau and Curatolo 1976).

Diseases. A considerable number of diseases have been found in caribou. Brucellosis is considered by Skoog (1968) to be the most important diseases of caribou. It is a bacterial disease endemic to caribou and reindeer throughout the world (Dieterich 1980). In severe infections it can cause abortions, retained placentas, infection of male sex organs, weakened health of females, and lameness in both sexes (Dieterich 1980). A relatively high incidence of brucellosis has been detected in the Western Arctic herd (Skoog 1968). Dieterich (1980) reports that brucellosis is on the rise in reindeer herds in western Alaska. The status of brucellosis in the Procupine and Central Arctic herds is not known.

Insects. The 2 most important parasites of caribou are warble flys (*Oedemagena tarandi*) and nasal bot flys (*Cephenomyia trompe*) (Kelsall 1968, Skoog 1968). During July and August, adult warble flys lay eggs on the hair of caribou. Hatched larva bore through the skin and migrate to the back region, and remain there throughout the winter. In June, the larva emerge and drop to the ground. Serious infestations range from several hundred to as many as a thousand warble larvae (Dieterich 1980). Heavy warble fly infestations can contribute to impairment of the animal's health, cause local infections, and sometimes are responsible for death of the animal (Dieterich 1980).

Nasal bot flys torment caribou during the summer period (June-August) by depositing minute larvae in the nostrils which migrate to the retropharyngeal-pouch of the throat (Skoog 1968). The larvae emerge fully grown (30 mm long) in mid-May (Skoog 1968). Heavy infestations of bot fly larvae contribute to the general depletion of an animals' energy reserves but may not be a direct mortality factor.

Considerable study has been done on the effects of insect harassment on caribou. Mosquitoes usually occur from late June to late July. Following this period, oestrid flys (warble and nasal bot flys) emergence increases and harassment from these insects lasts beyond mid-August. White et al. (1975) reported that under extreme mosquito harassment, caribou at Prudhoe Bay, Alaska tended to move faster, form larger groups, and to seek refuge by moving nearer to the coast where the wind provided relief. Caribou of the Fortymile herd were observed by Curatolo (1975) to move to north facing slopes for relief from mosquitos. Calef and Lortie (1973) reported that Porcupine Herd caribou clumped into dense groups and sought relief from insects by standing and lying on snow drifts and wind swept ridges. Kelsall (1968) hypothesized that post-calving aggregations were partially a response to insect harassment.

Caribou harassed by oestrid flys elicit "aberrant running" behavior (Curatolo 1975) and "rigid standing" (Epsmark 1972). It has been hypothesized that August dispersal is a response to warble fly harassment (Curatolo 1975).

Accidents. Caribou are victims to a number of accidents during their long migrations. Many observed accidents have been reported in association with water crossings. In the barren lands of northern Canada considerable losses due to drowning have been reported where herds cross rivers in the vicinity of rapids (Clark 1940, Kelsall 1968). Caribou have been observed to drown after falling through thin ice of lakes and rivers (Skoog 1968). Others die from falls from cliffs (Skoog 1968). The incidence of crippled animals in large post-calving aggregations of the Porcupine herd varies from year to year (Roseneau and Curatolo 1976). The cause of such crippling is not known, however, trampling may be responsible (Calef and Lortie 1973, Roseneau and Curatolo 1976).

Forest Fires. Wildfire is common throughout the forested portions of winter range used by the Porcupine caribou herd (Calef 1974). Recent winter distribution of the Central Arctic Herd has been north of the Brooks Range -- a tundra area where fire is quite rare.

Forest fires are known to be destructive to lichens which are often important winter forage for caribou. A number of authors have suggested that forest fires on winter range have resulted in population declines in caribou herds (Palmer and Rouse 1945, Leopold and Darling 1953, Scotter 1967, as cited by Klein 1980c). The role of fire in northern forest ecology has been recently re-evaluated with respect to impact on caribou. Bergerud (1974b) analyzed various hypotheses regarding caribou population declines in North America and concluded that destruction of lichens by fire was probably not responsible because: 1) lichens are not necessarily essential for winter survival of caribou, 2) food supply has not been found to be a limiting factor in herd productivity in North America. Further studies have indicated the importance of forest fires in recycling of nutrients, habitat diversity and even for long term cycles of lichen abundance (Skuncke 1969, Viereck 1973). Recently, Miller (1980) demonstrated that caribou showed greater preference for medium aged lichen stands versus older stands. He also reported various caribou uses of recent burn areas. Klein (1980c) concludes that forest fires on a short term basis may destroy portions of available winter range for caribou, but that over the long term fire may be essential for assurring continued lichen growth and diversity of ecological systems.

Data Gaps

In spite of the large volume of information pertain to caribou, including the Central Arctic and Porcupine herds, further knowledge of individual herds and interactions between other herds, their environments, and man is needed. Because large caribou herds such as the Porcupine range over a vast area of many varying conditons, it is extremely difficult to collect the detailed information which is necessary to understand population ecology of the herd.

Ongoing management surveys and studies must be continued and refined. Improvement in the accurracy of caribou population estimates is needed. Methods have to be refined that will yield more representative herd composition data. Collection of reliable harvest data is difficult, especially for the Porcupine herd which is harvested by Eskimos, Indians, and non-Natives in both the U.S. and Canada. The status, distribution and movements of both the Porcupine and Central Arctic herds should be continued to be monitored. Special emphasis is needed to determine use patterns of the Central Arctic herd east of the Canning River as well as interactions and interchanges that may occur between the 2 herds.

Study of specific aspects of caribou biology are needed to anticipate and document the effects of possible oil and gas developments in the ANWR study area. At the present time there is insufficient information on mortality factors, herd productivity, behavioral patterns, habitat requirements, and the overall adaptive capability of the Central Arctic and Porcupine herds. Specifically there is need for calf mortality studies on the calving grounds and throughout the first year of life. Predator interactions with caribou must be determined throughout the ranges of both herds. Factors such as diseases, weather, and parasites need to be monitored. More detailed information is needed on snow conditions (accumulation patterns, density, hardness, and ablation patterns) on the winter grounds, spring migration routes, and calving areas. Comprehensive vegetative maps for the entire range of both herds should be developed and assessments should be made regarding seasonal forage selection patterns and habitat use by caribou. Long term studies of the effects of natural wildfire on caribou ranges are also needed. The physiological effects of disturbance-induced stress in caribou should be identified and studied. Related information on normal bioenergetic requirements would be valuable for evaluating the effects of disturbance, and obstructions on caribou populations. Baseline behavioral studies are needed to develop a valid behavior profile for the Porcupine herd. Particular focus of this effort should be on spring migration, calving, post-calving, insect season, fall migration, rutting and wintering activities.

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Muskoxen (*Ovibus moschatus*)

Muskoxen were formerly found throughout arctic Alaska. They were rapidly extirpated, however, when firearms were introduced in the mid-1800's (Bee and Hall 1956). During March and April 1969, 51 Nunivak Island muskoxen were released at Barter Island. In June 1970, 13 others were released at Kavik Camp about 80 air miles southwest of Barter Island. About 10 muskoxen died during or shortly after the transplant operation at Barter Island (Pegau pers. com. as cited by Roseneau and Stern 1974). Mortality among muskoxen released at Kavik Camp is unknown.

Despite this initial mortality, enough muskoxen survived to form the nucleus of a successful breeding population within ANWR. The first census of the transplanted muskoxen was by Roseneau and Stern in 1972 as part of the Arctic Gas Pipeline studies. Seven newborn calves were observed. This was the first documentation of reproduction among the transplanted muskoxen. They estimated the population to be a minimum of 29 and a maximum of 34 muskoxen. The population evidently grew steadily from the time of the transplant until 1978. Since 1978, the pre-calving population of muskox on the refuge has been annually censused by U.S. Fish and Wildlife Service (USFWS) biologists. Between 1978 and 1981 the population has approximately doubled in size. Muskoxen west of the Canning River, outside the refuge, have not been systematically censused. Scattered reports of muskox sightings between Prudhoe Bay and Canning River indicate that the muskoxen transplant at Kavik Camp was also successful.

Range and Distribution

There are 3 herds of muskoxen within the Refuge (Fig. 5). These herds have been designated the Canning, Sadlerochit Springs, and Jago/Okerokovik herds, and have been named for their affinity to a particular geographic region. Movements to date by these groups have tended to be north/south oriented along major drainages rather than east/west. Jingfors (1980) noted that feeding movements of the Sadlerochit herd were generally linear in riparian habitat as muskoxen moved along the river drainage.

Jingfors (1980) reported that the lowest daily movements for the Sadlerochit herd occurred during calving (average less than 0.5 km d^{-1}), reached a peak in mid-summer and declined again during the rut and early winter. In mid-summer the high movement rates may have resulted from the search for relief areas from mosquitoes. Feeding areas used during early and late winter overlapped between feeding areas used during parts of the summer. The seasonal distribution of the herd is related to snow conditions and forage availability and quality. Jingfors' (1980) study of the Sadlerochit herd supports the concensus from the literature that muskoxen are non-migratory and relatively sedentary. Wilkinson and Shank's (1974, as cited by Miller and Gunn 1979) study of muskoxen on Banks Island shows that they will remain in an area for days at a time but would also move several km to new foraging areas. Miller and Gunn (1979) reported general impressions that muskoxen on Prince of Wales and Russell Islands are mainly sedentary in summer with a relatively fixed size of range within which they move according to phenology of vegetation, drainage conditions, and possibly the size of the herd. Movement patterns of the other 2 muskox herds occupying the ANWR study area during different phases of their annual life cycle have not been studied.

The calving area for the Sadlerochit herd was observed and reported by Jingfors (1980) and used from 1978 through 1980 (Fig. 5). Calving areas for the other 2 herds on the ANWR study area have not been identified. The calving area for the Canning herd is suspected to exist just north of VABM TAM based on locations of the herd during pre-calving censuses from 1978 through 1981 (Fig. 5).

Within ANWR scattered groups of from 1 to 6 muskoxen, usually adult bulls, that have left the larger herds have been seen as far east as VABM Gordon near Demarcation Bay and as far west as the Canning River. Roseneau and Stern (1974) reported a muskox was killed by a local Indian hunter near Arctic Village, south of the Brooks Range. In the summer of 1981 Smith (pers comm.) reported the sighting of 2 muskoxen on the Hulahula River in the Brooks Range mountains by a hunting guide. Also in 1981, Spindler (pers. comm.) reported the sighting of 3 muskoxen at Kay Point, 70 miles east of the Refuge by a pilot flying along the Arctic coast of the Yukon. These muskoxen presumably dispersed from herds within ANWR. The appearance of lone bulls in an area has been suggested as a precursor to colonization (Pederson 1931 as cited by Hone 1934; Tener 1965 as cited by Jingfors 1980).

Population Size and Productivity

In a pre-calving population census in April 1981, 186 muskoxen were counted using a direct count of muskox both from the air and on the ground. [illegible] precalving population size of 186 muskox is considered a minimum number due to the high probability that some muskoxen were missed during the census, although it is probably not significantly larger, because muskoxen are highly visible against a snow covered background and are relatively sedentary within certain regions on the coastal plain of ANWR.

No direct census of the post-calving population of muskoxen on the Refuge was made in 1981. Calf production and overwinter survival of calves to yearling age has been good during previous years. The average annual population increase since 1978 has been about 20% which approximates the percentage of calves surviving to yearling age in the population (Table 6). Initial calf mortality is unknown but presumably low. Based on this figure the post-calving population of muskoxen in 1981 may have numbered slightly over 220 animals.

Table 6. Numbers of muskox in the Arctic National Wildlife Refuge, 1972 to 1981.

River Drainage	Canning River	Sadlerochit Springs	Jago/ Okerokovik	Sadlerochit River	Others	Total
1972[1]	10(2)[3]	14(3)	11(2)	5	1	36-41(7)
1973	11(1)	12(3)	13(4)	--	8[4]	44(8)
1974	14(5)	12(3)	10(3)	--	2	38(11)
1975	--	--	10(1)	5	--	10-15(1)
1976	24(4)	27(8)	15(3)	--	1	67(15)
1977	31(7)	35(8)	18(3)	5	1	90(18)

FIG. 5 MUSKOX DISTRIBUTION IN THE ARCTIC NATIONAL WILDLIFE REFUGE 1974 TO 1981

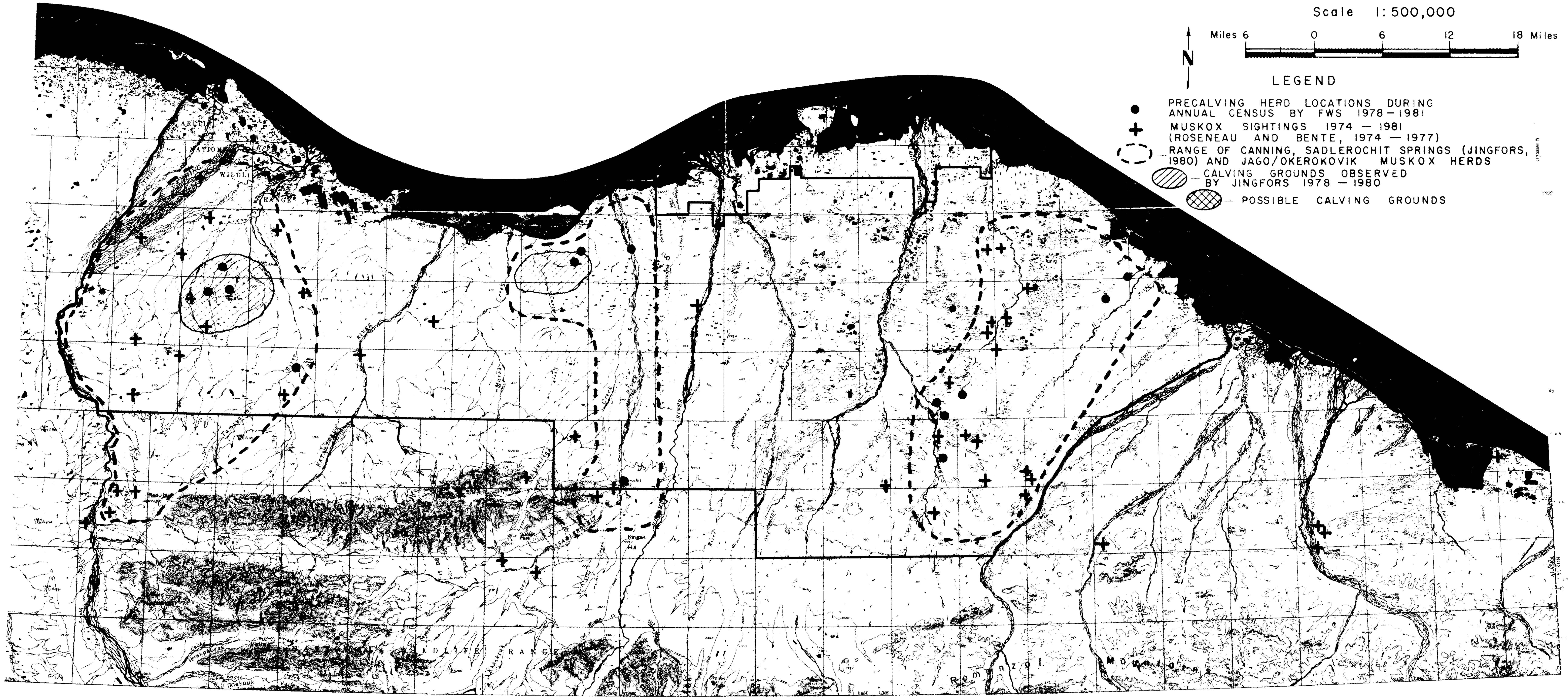

Table 6. Continued.

River Drainage	Canning River	Sadlerochit Springs	Jago/ Okerokovik	Sadlerochit River	Others	Total
1978[2]	32(7)	33(7)	14(3)	3	4	86(18)
1979	40(8)	42(12)	24(5)	--	6	112(25)
1980	48(9)	54(17)	27(6)	4	19	148(32)
1981	66(8)	74(12)	33(9)	4	13	186(29)[5]

1 1972 to 1977 unpublished data from Roseneau and Bente 1977.
2 1978 to 1981 unpublished data from ANWR files.
3 () Number of calves/yearlings included in number of muskox.
4 Includes a group of 7 in Yukon Territory that was not located again.
5 Number of calves/yearlings probably low due to greater percentage of unclassified mskox in the census count.

Highest productivity among the 3 muskox herds on the Refuge has been in the Sadlerochit herd. Jingfors (1980) reported observing a 2-year-old cow nursing a calf during studies of this herd.

Habitat Location, Extent and Carrying Capacity

`bus' (1981) study of forage use and Jingfors' (1980) study of habitat use are the only habitat studies of muskoxen on ANWR. Both studies dealt primarily, with the Sadlerochit herd. Robus (1981) found that riparian willows were a major food source for the Sadlerochit muskox herd partictularly in middle and late summer. Food habits of muskoxen from other areas in northern Alaska, mainland Canada, and Scandinavia show similar high use of willows (Robus 1981). Robus (1981) suggests that differences in forage preferences of muskoxen in different geographic areas is apparently explained by the availability of forage. A fecal analysis by Robus (1981) from muskoxen in the Tamayariak and Jago drainages had a lower percentage of willow and higher percentage of sedges. Willow is less abundant in these drainages and muskoxen are depending more on sedges and forbs where willows are not abundant (Robus 1981). Productivity in these groups has also been lower than the Sadlerochit herd. Robus (1981) concludes that muskoxen in the Sadlerochit herd are feeding on nutritious and abundant forage species which may explain the herd's high productivity.

Production of *Salix alaxensis,* a preferred muskoxen forage species peaked in early August at 82.4 gm^{-2} (Robus 1981). In contrast, Jingfors (1980), reported a peak biomass value for *Salix arctica* of 18.6 gm^{-2} on Bathurst Island in the Canadian High Arctic. Productivity of muskoxen (numbers of calves/cows) on Bathurst Island was lower compared to Sadlerochit muskoxen (Jingfors 1980).

The carrying capacity of the refuge for muskoxen is not known. Riparian willows, which appear to be optimal habitat for muskoxen, are limited to major stream drainages such as the Canning, Tamayariak, Katakturuk, Sadlerochit, Hulahula, Aichilik, and Kongakut Rivers. Robus (1981) believes that muskoxen would likely centralize in the few drainages that provide optimal habitat. Moderate to low numbers of muskoxen may use riparian areas and narrow creek drainages where willows grow in small thickets (Robus 1981). Large expanses of tundra isolated from riparian drainages will probably see little or no use by muskoxen (Robus 1981). Locations of muskoxen observed during spring pre-calving censuses tend to support these conclusions. During these censuses, muskoxen were located either in or quite near a riverine environment presumably where optimal habitat occurs (Fig. 5).

Rather than dispersing onto upland tundra of low productivity, muskoxen are more likely to emigrate south into the Brooks Range, east into Canada or west across the Canning River (Robus 1981). Dispersal of muskoxen, usually adult bulls from the 3 herds within ANWR has been observed. Whether this is due to habitat conditions or competitive social pressures within the herds is uncertain.

Impacts of Existing Processes and Activities

Wolves and brown bears, potentially the most significant predators on muskox, are uncommon on the coastal plain of ANWR. There have been no reported instances of direct mortality of muskox on the refuge due to wolf and bear predation. There is no sport or subsistence hunting season for muskox on the refuge at present. There are no data on natural mortality rates. Dead muskox have occasionally been found on the Refuge by residents of Kaktovik and others.

Jingfors (1980) observed that muskoxen react less to insect harassment than do caribou. During severe insect harassment, muskoxen decreased the proportion of time spent feeding while increasing movement rates (Jingfors 1980).

Caribou, moose, and brown bears, are potential competers with muskox on the ANWR for available forage. Robus (1981) observed that bears grazing on above ground portions of plants often leave root material which allows for regrowth. Brown bears are not numerous on the ANWR coastal plain and are absent in winter. They are not important competitors for food with muskoxen (Robus 1981).

Robus (1981) observed both caribou and muskox feeding on the same plant species. During early summer when food resources are abundant, the effects of potential competition are reduced (Miller 1967 as cited by Jingfors 1980). Caribou in large numbers are present for only a short period of the year on the ANWR coastal plain which further limits competition (Jingfors 1980). Jingfors (1980) observations of caribou/muskox interactions suggest a limited tolerance by muskoxen to approaching caribou.

In winter moose are concentrated in suitable riparian willow habitat. In the ANWR, the largest numbers of overwintering moose are found on the Cache/Eagle Creek tributaries of the Canning River. The 3 herds of muskox on the Refuge remain further north on the coastal plain. However, competition for riparian willow has been observed at Sadlerochit Springs by Robus (1981) where the ranges of moose and muskoxen overlap. Heavy browsing of willow by moose was observed but it was concluded that it did not limit forage availability for muskoxen (Robus 1981). As the population of muskoxen expands and disperses competition for willow may increase if areas of prime moose wintering habitat become occupied.

Data Gaps

Habitat and use patterns have been studied by Robus (1981), and habitat relationships and activity patterns have been studied by Jingfors (1980). Both of these studies focused on the Sadlerochit Springs muskox herd. Little is known about the range characterisitics, traditional use areas for calving, post-calving, rutting, and movement patterns for the other herds of muskoxen within ANWR. There are no data on calf production and natural mortality from the other herds. Interspecific competition between moose and muskoxen for forage may need further study if muskoxen move into traditional moose overwintering areas.

Miller and Gunn (1979) characterized knowledge gaps on the effects of man-induced harassment as falling into short and long term catagories. We do not know the energy budget cost of an individual's response to harassment nor are the long-term effects of harassment known. Baseline studies of muskox physiology are required to be able to interpret data regarding the physiological cost of harassment (Miller and Gunn 1979). The affinity of muskox to traditional ranges is not understood nor the level of harassment that might force range abandonment or the total consequences of such abandonments (Miller and Gunn 1979).

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Moose (Alces alces gigas)

Moose occur throughout Alaska and are considered the most widespread big game animal in the state (Chatelain 1952). Bee and Hall (1956) considered moose common in the riparian communities along major rivers on the North Slope of the Brooks Range. Distributional patterns of moose north of the Brooks Range vary seasonally, with animals being concentrated in the major river valleys in the mountains during the winter and occurring throughout the foothills, mountains, and coastal plain during the summer months (LeResche et al. 1974, Coady 1979). Densities of moose on the coastal plain of the North Slope are low and their occurrence there is considered infrequent (Chesemore 1968, Mould 1977), with speculation that use of tundra habitats may be an effort by moose to seek relief from insect harassment (Mould 1977).

The occurence of moose in northern Alaska and other northern environments has been considered a recent range extension into previously unoccupied areas (Anderson 1924, Leopold and Darling 1953, Peterson 1955, Barry 1961, Kelsall 1972). This view was disputed by Lutz (1960), who presented a historical record indicating that moose have long been present in these regions, and are subject to major movements and shifts in the use of available ranges. Causes for these shifts are poorly understood at the present time. However, habitat changes induced by fire (Leopold and Darling 1953, Kelsall 1972) and changing habitat conditions caused by a gradual holarctic warming trend have been proposed (Leopold and Darling 1953). Recent archaelogic evidence support Lutz's theory and indicate that moose have long been present in northern Alaska (Hall 1973).

Several major populations of moose occur on the North Slope of Alaska, with the largest populations associated with the Colville River (Mould 1977, NPRA Task Force 1978, NPR-A Work Group 3 1979), although Roseneau and Stern (1974) observed more moose along the Chandalar River than the Colville River in 1972. In northeastern Alaska, concentrations of moose occur along the Canning and Kongakut River drainages (Roseneau and Stern 1974, Lenarz et al. 1974), with sporadic occurrences along other river drainages between the 2 rivers.

In ANWR, moose range onto the coastal plain during the summer months and would be subject to peturbations from a summer seismic exploration program in the study area and any subsequent petroleum development that might occur. The yearly range of moose using the ANWR study area will be discussed to present the dynamics of seasonal population shifts and the relative importance of the coastal plain as a component of the habitat requirements of moose. The general biology of the species is discussed by Peterson (1955) and Franzman (1978).

Populations

There are 2 major moose populations north of the continental divide on ANWR (Fig. 6). The most stable population is associated with the Canning River on the northwestern portion of the refuge. Surveys have been conducted along the Canning River in 1972, 1973, 1974, 1975, 1977, 1978, and 1980. The second moose concentration area is the upper Kongakut River drainage in the northeastern part of the Refuge where surveys have been conducted in 1972, 1973, 1977, 1978, and 1980. Timing of these aerial surveys (March-April or September-October) and survey intensity have varied between years; therefore, direct comparison of the resultant data sets is difficult.

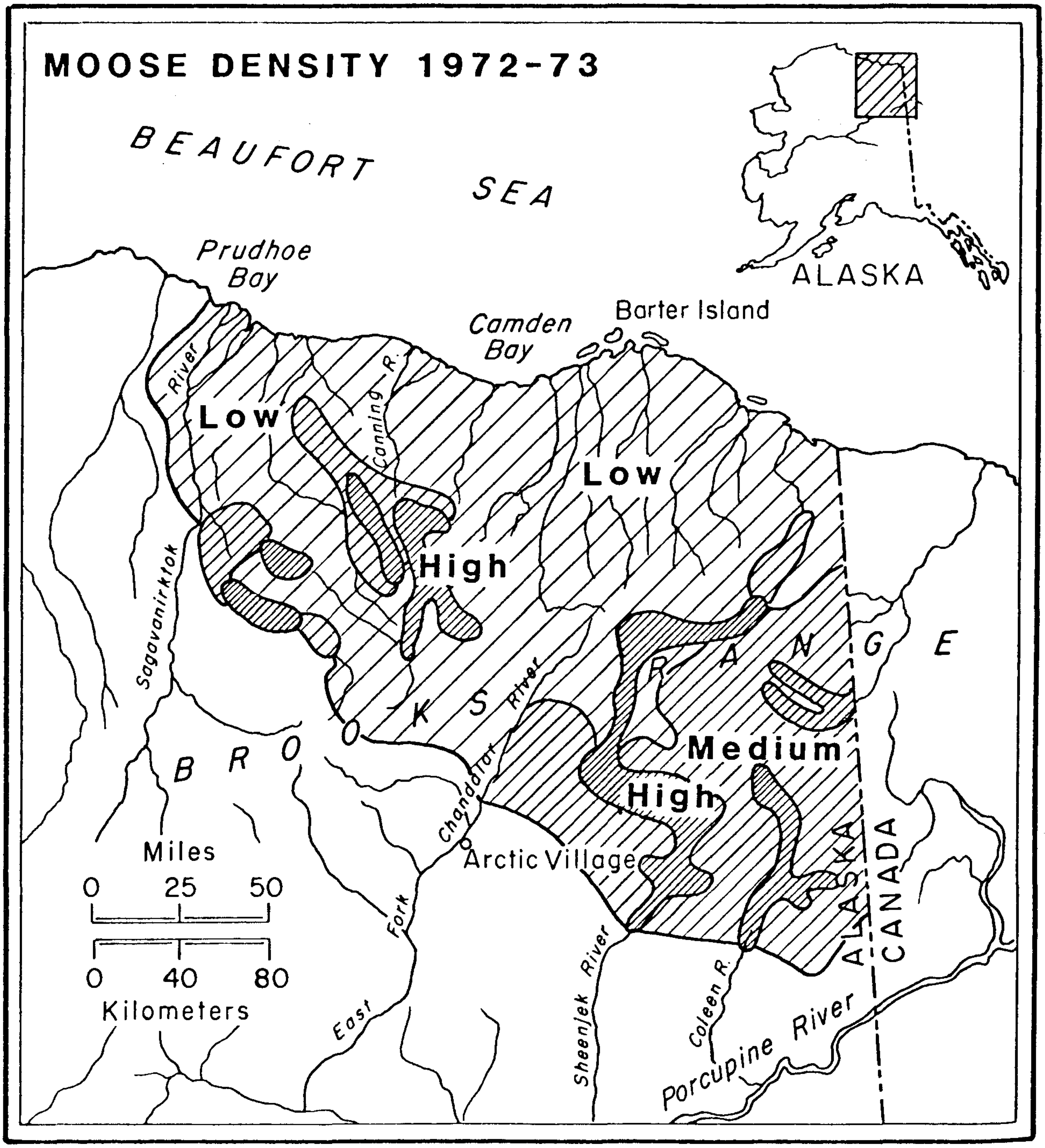

Figure 6. General areas of low, medium and high moose density, 1972-73. (Modified from Lenarz et al. 1974).

Canning River Population

The Canning River flows from the continental divide north to the Arctic Ocean and has 2 main branches in the Brooks Range. The Marsh Fork flows north from the Phillip Smith Mountains while the main branch of the Canning River flows north from the Franklin Mountains. The wildlife studies conducted by Renewable Resources Consulting Services Ltd. for Canadian Arctic Gas Study Limited (CAGSL) included surveys of the wildlife along the Canning River (Jakimchuk 1974a, 1974b). Moose occurring along the Kavik River were considered part of the Canning River moose population because of observed interchanges. A range map (Fig. 7) for this population was presented by Roseneau and Stern (1974).

The Canning River population was surveyed several times in 1972 (Roseneau and Stern 1974) and a maximum of 48 moose were recorded in March-April (Table 7). The Cache/Eagle Creek area was noted as an area important to concentrations of moose, especially in the extensive willow (Salix sp.) stands at the mouths of these 2 creeks. The river was surveyed again in 1973 and 1974, and a maximum total of 69 moose was noted in October 1973, with 64 of these animals in the Cache/Eagle Creek area (Lenarz et al. 1974). Subsequent surveys of the Canning River by ANWR staff recorded decreased numbers of moose in April of 1977 and 1978, while the late April survey in 1980 detected a large increase in the number of moose in the Canning River drainage.

Table 7. Total moose observed during aerial surveys of the Canning and Kongakut Rivers on the Arctic National Wildlife Refuge, 1972-1980.

	Drainage		
Month - year	Canning River (including Cache/Eagle Creeks)	Cache/Eagle Creeks	Kongakut River
March-April 1972[1]	48	--	21
September-October 1972[1]	7	16	8
March-April 1973[2]	64	--	--
May 1973[2]	45	--	--
October 1973[3]	69	65	68
March 1974[3]	42	--	--
September 1976[3]	--	42	--
April 1977[3]	48	--	54
April 1978[3]	43	--	58
April 1980[3]	147	111	123

1 Roseneau and Stern 1974
2 Lenarz et al. 1974
3 Arctic National Wildlife Refuge files

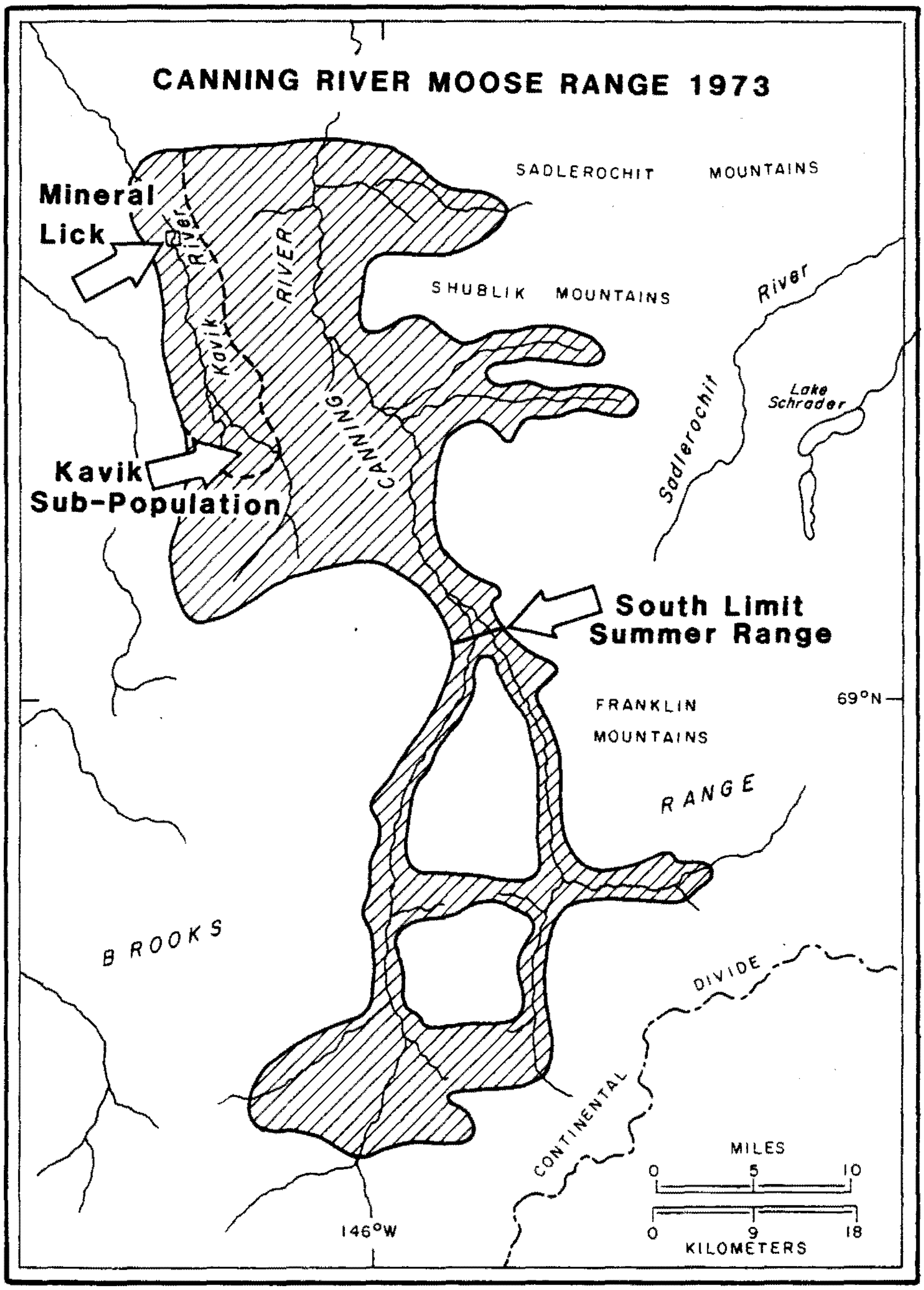

Figure 7. Approximate limits of the Canning River moose population, 1973. (Modified from Roseneau and Stern 1974).

Data on age/sex composition of the Canning River populations are limited, with the more detailed information available for the September-October surveys when moose are aggregated during the rut (Table 8). Sex ratios were relatively high in 1973 and 1974, ranging from 33 bulls/100 cows to 67 bulls/100 cows. On 13 October 1973, calves comprised 32.4% of the population, while only accounting for 9.5% of the population in March 1974. These data indicate that some over-winter calf mortality occurred; however, seasonal changes in distributional patterns of moose along the Canning River complicate interpretation of these data. Calf survival in 1976 and 1980 are comparable to the 1974 figures (9.5% of the population); however, calf survival in 1977 was considerably higher (27.1% of the population). Reasons for these observed differences are unknown, but may be an artifact of survey intensity or timing of the surveys in relation to the phenology of seasonal shifts by moose populations along the Canning River.

Kongakut River Population

The Kongakut River flows north from the continental divide to the Arctic Ocean in the northwest portion of the ANWR. Moose normally occur in the upper reaches of the river south of Whale Mountain. This population is much more variable than the Canning River population (Table 7) and is subject to emigrations and immigrations of moose in the Sheenjek River drainage and the Firth River/Mancha Creek drainages (Roseneau and Stern 1974). Surveys were conducted in the Kongakut River in 1972 and 1973 by Renewable Resources Consulting Service (Jakimchuk 1974a, 1974b). Additional surveys were conducted by ANWR staff in 1977, 1978 and 1980.

Populations varied from a low of 8 moose in 1973 to 123 moose in 1980 (Table 7). Composition data for 1973 indicated 89 bulls/100 cows, with a calf survival rate of 22.1% of the population. Calf survival rates in 1977 and 1980 were 16.7% and 20.3%, respectively (Table 8). These data indicate that calf survival rates in the Kongakut River are higher than those recorded for the Canning River.

Other Drainages

Moose populations in other drainages north of the Brooks Range within the ANWR were surveyed in 1972, 1973, and 1977. In March and April, 1972 Roseneau and Stern (1974) recorded 2 moose along the Hulahula River, 1 along the Jago River, 1 along the Aichilik River, and 2 along the Egaksrak River . Lenarz et al. (1974) recorded 2 moose along the Sadlerochit River, 6 along the Aichilik River, and 3 along the Egaksrak River in April 1973. An extensive survey of moose in April 1977 by refuge staff detected 10 moose along the Aichilik River, 7 along the Egaksrak River, and 1 along the Ekaluakat River. Moose were not sighted along the lower Kongakut River (north of Whale Mountain),

Table 8. Composition of moose observed during surveys along the Canning and Kongakut Rivers, 1973-1980.

Date	Location	Bulls	Cows	Yearlings	Calves	Unclassified Adults	Total
26 May 1973[1]	Canning River	7	21	14	3	--	45
6 October 1973[1]	Canning River	15	23	2	7	--	47
16 October 1973[1]	Canning River	20	37	--	12	--	69
17 October 1973[1]	Canning River	14	21	--	7	--	47
1 March 1974[1]	Canning River	--	--	--	4	38	42
21September 1976[2]	Cache/Eagle Creeks	14	24	--	4	--	42
11 April 1977[2]	Canning River	--	--	--	13	35	48
25 April 1980[2]	Canning River	--	--	--	14	133	147
25 April 1980[2]	Cache/Eagle Creeks	--	--	--	8	103	111
11 October 1973[1]	Kongakut River	25	28	--	15	--	68
13 April 1977[2]	Kongakut River	--	--	--	9	45	54
26-27 April 1980[2]	Kongakut River	--	--	--	25	98	123

[1] Data from Lenarz et al. (1974)

[2] Data from Arctic National Wildlife Refuge files

Okpilak River, Hulahula River, Sadlerochit River, Itkilyariak River, Ignek Creek, or the Peters/Schrader Lake area. These data indicate that moose distribution is sparse within the large area lying between the Canning River on the west and the Kongakut River on the east.

Mortality

Natural mortality factors affecting these moose populations are poorly documented. Brown bears (Ursus arctos) have been observed killing moose along the Canning River (Quimby and Snarski 1974). Wolves (Canis lupus) are known predators of moose and can affect moose populations when adverse snow conditions occur (Franzman 1978). Wolves have been observed feeding on moose carcasses in the area (ANWR files); however, it is unknown if the moose were killed or scavenged. The extent and effects of predations on these moose populations is unknown. The role of other natural mortality factors (disease, parasites, etc.) in the dynamics of moose populations in these North Slope river drainages is also unknown, but moose disease (Anderson 1964, 1972) does not occur in this area and the majority of diseases and parasites afflicting moose do not normally cause excessive mortality (Anderson and Lankester 1974, as cited by Franzman 1978).

Mortality due to hunting is considered to be minimal along the Canning River, with very little sport harvest. Natives from Kaktovik occasionally use moose for subsistence purposes, although it is not a preferred food (see Subsistence Section, Chapter 7). The 80 km distance between the village and Cache/Eagle Creek may also contribute to the low subsistence use (Lenarz et al. 1974). Sport harvest along the Kongakut is more common than on the Canning; however, the numbers taken each year are quite variable and dependent upon local moose population fluctuations (ANWR file data).

Habitat

Willow Communities

Willows comprise a major portion of the forage consumed by moose in Alaska (Milke 1969, Peek 1974, as cited by Franzman 1978). Use of individual willow species is evidently selective, with S. alexensis and S. planifolia being preferred species in interior Alaska (Milke 1969, Machida 1979). S. alexensis was also preferred by moose along the Colville River, with mountain alder (Alnus crispa) being an important winter food item (Mould 1977). In arctic regions, moose are restricted to the riparian communities along the major rivers during winter (LeResche et al. 1974, as cited by Lenarz et al. 1974), however, they do disperse into tundra areas during the summer months (Kistchinski 1974, as cited by Mould 1977). The long distances between the major rivers in this region may limit emigration or immigration (Lenarz et al. 1974), although the Kongakut River population seems to be subject to occasional shifts in range use patterns by moose (Roseneau and Stern 1974).

In 1973, willow stands along the Canning River drainage were mapped and examined qualitatively for evidence of browsing (Lenarz et al. 1974). Practically all willow stands showed evidence of moderate browsing, with heavy browsing occuring in the willow stands along Cache/Eagle Creeks and along the south fork of the Canning River. Again, S. alexensis was considered the major browse species in these willow stands. Balsam popular (Popular balsamifera) occurs in relatively discrete stands at several locations along the Canning

River; however, little browsing was noted for this species, except in the large stand along Cache Creek. The Cache Creek/Eagle Creek area is a major concentration area for moose and heavy utilization of willows and balsam popular was evident throughout the 2 drainages.

Riparian willow densities on the north side of the Brooks Range were estimated and mapped by refuge personnel in April 1977 to assess these areas as critical moose range (Hutson 1977). All rivers and streams between the Canadian border and the Canning River were surveyed and numbers of moose observed were recorded. Willows were most abundant along the Canning, Hulahula, Aichilik, and Kongakut Rivers, with the highest proportion of dense willow stands occuring along the Kongakut and Canning Rivers. Most of the moose occurred in the willow stands along the Kongakut and Canning Rivers (54 and 48 of 120 moose, respectively). Ten moose were observed along the Aichilik River and 8 were observed along the Egaksrak and Ekaluakat Rivers. Ground truth data for willow densities were not available for this study, therefore no conclusions were made about willow density as the single criterion for evaluating habitat quality for moose.

Species composition data for the riparian willow communities are limited; however, species occurring along Cache Creek and the Marsh Fork of the Canning River were recorded by Hettinger and Janz (1974). Principal willow species were S. alexensis and S. planifolia pulchra. Species occurring along the Sadlerochit River included the above 2 species and S. phlebophylla, S. arctica, S. glanca, and S. Brachyearpa (Jingfors 1980, Robus 1981).

Seasonal Habitat Use Patterns

Moose that occur in the northern Brooks Range, foothills, and coastal plain use the various habitat types in distinct seasonal patterns, dependent upon the particular environmental variables affecting each moose population.

Canning River Moose. The large willow and balsam poplar stands near the mouths of Cache and Eagle Creeks are the major concentration areas for the Canning River moose population in late May of each year (Valkenburg et al. 1972, Lenarz et al. 1974). Moose move north into this area in mid-May, and are aggregated into small widely dispersed groups along the lengths of Cache and Eagle Creeks. Calving occurs in late May and early June. Following calving, moose gradually disperse north along the Canning River and east along Cache and Eagle Creeks. Very few moose are present in the willow flats along the Canning River during late June and July (Valkenburg et al. 1972). Summer dispersal was believed to be limited to the drainages in the mountains (Lenarz et al. 1974), although a few moose were observed on the coastal plain as far north as the Arctic Ocean in 1972 (Roseneau and Stern 1974a, 1974b). However, recent observations of moose (cows with calves, single bulls, etc.) along the Sadlerochit River on the coastal plain (Magoun and Robus 1977, Magoun 1979 personal communication) and on to Okpilak delta (Spindler 1979) indicate that dispersal may be more widespread, with unknown numbers of moose moving onto the coastal plain for the summer.

Summer dispersal is relatively short-lived, and moose again begin to aggregate in the willow/poplar stands at the Cache/Eagle Creek confluence with the Canning River in late August (Lenarz et al. 1974). This aggregation is associated with the rut and tends to peak in October, when a majority of the Canning River population is located in the Cache/Eagle Creek area (see October

1973, Table 7). In years of relatively light snowfall, a majority of the Canning River moose winter in the Cache/Eagle Creek area (Lenarz et al. 1974). In normal or deep snowfall years, moose move south along the Canning River and winter in the valleys of the Marsh Fork, Main Fork, South Fork and East Fork of the Canning River, but, the Cache/Eagle Creek area is always used as a wintering area by at least a portion of the Canning River moose population (Lenarz et al. 1974), regardless of the snow conditions. A similar pattern of wintering along streams in mountainous terrain and moving north during the summer was noted for moose in northern Yukon Territory (Ruttan 1974). One characteristic of moose wintering north of the Brooks Range is a very high degree of local movements from 1 willow stand to the next (Roseneau and Stern 1974). Moose were often sighted in 1 willow stand along a drainage, and a few days later this stand would be devoid of moose. Reasons for these movements was undetermined, although they would tend to distribute browsing pressure across the available willow stands.

In April and early May, moose again move north along the Canning River and aggregate in the Cache/Eagle Creek area. Such seasonal movements can be considered a migration (Edwards and Ritchey 1956), although seasonal shifts in range use appears to be a more appropriate term for these movements.

Kongakut River Moose. Seasonal distribution of moose using the upper Kongakut River has not been well documented by repeated surveys at various times of the year, although limited survey data do give some evidence on the subject. This population is apparently subject to the influence of mass emigration and immigration of moose to and from adjacent drainages.

Roseneau and Stern (1974) documented an emigration in April 1972 of practically the entire moose population in the upper Kongakut River into the headwaters of the Firth River. These animals had moved approximately 25 km south over a pass and were located in the first 2 willow stands along the Firth River. This movement was in single file as evidenced by a narrow trail in the snow between the 2 locations. Other long distance movements (65-80 km) of moose have been detected by following tracks in snow (A. Thayer 1981, pers, comm.).

The Kongakut population in 1972 and 1973 ranged from a low of 8 moose in September-October 1972 to a high of 68 moose in October 1973 (Table 8). The low numbers were attributed to the aforementioned emigration into the Firth River, while the increase to 68 moose was attributed partially to moose moving north from the Sheenjek River across the continental divide into the Kongakut River drainage (Lenarz et al. 1974). The high numbers of moose observed along the upper Kongakut River in April 1980 (Table 8) may have been the result of a similar influx of wintering mooose from the upper Sheenjek River, but no evidence exists to support this contention.

Use of the Coastal Plain by Moose. Moose occur on the ANWR study area during the summer months; however the extent of this use and its importance to overall moose populations inhabiting the adjacent river drainages in the Brooks Range is not known. Moose have been considered occasional or accidental occupants of the coastal plain (Ruttan 1974, Roseneau and Stern 1974, Doll et al. 1974, Lenarz et al. 1974, Coady 1979), but recent data suggest that this use may be more extensive than previously suspected (Magoun and Robus 1977). Moose are most often observed along the river drainages and wetland complexes on the coastal plain (Magoun and Robus 1977, Spindler

1979). Carrying capacity of the coastal plain for moose cannot be determined from the available data.

Data Gaps

The ecology of moose north of the Brooks Range is poorly understood and quantitative data to assess the role and importance of the coastal plain as summer habitat for moose are not available. Baseline information needs include the numbers and distribution of moose using the coastal plain habitats, and an identification of those coastal plain habitat types used by moose. To comprehend the role of the coastal plain in ecology of moose north of the Brooks Range, extensive studies of population dynamics (productivity, mortality, age/sex ratios, etc.), movements, and seasonal food habits would be required for the entire moose population using the area.

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Marine mammals found in or adjacent to the ANWR study area are polar bears, ringed seals, bearded seals, bowhead and beluga whales, and occasionally spotted seals, walrus, and gray whales. The presence and location of marine mammals are related to the condition and location of the pack ice. The ice is used for resting, bearing young, molting, and as a feeding platform (Fay 1974). Ringed seals, bearded seals, and polar bears are year round residents in the Beaufort Sea (Lowry et al. 1979). Ringed seals are associated mainly with the landfast ice (that which is attached to the shore, also called shorefast) of the winter pack, while bearded seals can be found in the moving pack ice. Between the landfast ice and the moving pack, a flaw or lead zone occurs which contains some open water. Lead zones are important habitat for non-breeding ringed seals and bearded seals, as well as for the polar bears which prey upon them.

When the pack ice begins to break up in the Bering Sea in late March, bowheads and belugas begin their northward migration. In summer when the ice has retreated from the shore, animals may become pelagic, move inshore, or concentrate along the edge of the ice (Burns et al. 1980). Bowheads and belugas migrate south and west out of the Beaufort Sea before new ice begins to form along the shore in September or October.

Polar Bear (*Ursus maritimus*)

Distribution, Range and Size of Population

Polar bear distribution is circumpolar in the northern hemisphere. Polar bears range from as far as 88^{o} north on the polar ice pack and have been seen as far south as St. Matthew in the Pribilof Islands (DeMaster and Stirling 1981). Except for denning females, polar bears remain associated with the ice, traveling north and then eastward as the pack begins to melt in spring and spending summers at the edge of the ice, although they may occasionally range further into the pack. They are most abundant in the drifting pack ice zone where ringed seals, their primary food source, occur (Lentfer 1971).

At least 6 distinct populations are believed to exist and are centered in the following areas: Wrangel Island and Western Alaska, Northern Alaska, the Canadian Arctic Archipelago, Greenland, Svalbard-Franz Josef Land, and Central Siberia (DeMaster and Stirling 1981). Lentfer (1974b) advanced the theory of 2 discrete populations of Alaskan polar bears based on tag recoveries, differences in body and skull sizes, and levels of mercury in the tissues. Additional cranial measurements taken by Wilson (1976) also support this hypothesis. FWS Researchers in Alaska are presently collecting polar bear blood serum to conduct electrophoretic examination of blood proteins to further test for discreteness. Tegelstrom and Larsen (in press, as cited by Amstrup 1981) have shown that electrophoretic activities of certain blood proteins in polar bear blood differ according to geographic location and should identify different populations. A line northwest from Point Lay arbitrarily divides the hypothesized western and northern populations of Alaskan polar bears. Bears found within the ANWR study area would belong to the northern Alaska population. There is limited movement between these 2 Alaskan populations and also between Alaskan and Canadian bears (Lentfer 1974b; Stirling 1974).

Estimates of the world population of polar bears vary from 10,000 to 20,000 animals (DeMaster and Stirling 1981). Recent estimates of the total Alaskan population were 6,000 to 9,000 (D.G. Chapman pers. comm., cited in DeMaster and Stirling 1981), and 5,000 to 7,000 bears (Lentfer pers. comm. as cited by Seaman et al. 1981), although these numbers may include Wrangel Island and Chukchi Sea animals. Brooks (1978) estimated that there were 2500 to 3000 polar bears in the northern Alaska population. Mark and recapture studies are currently underway to define population limits more precisely, but at this time, mark and recapture estimates are unreliable because there are not enough data to estimate the statewide population with any confidence (Amstrup 1981).

Life History

In Alaska, pairing of males and females has been observed between 21 March and 10 May and estrus in females was evident throughout this period (Lentfer et al. 1980). Mating probably continues beyond 10 May but limited field work after May 10 yielded few observations. Lønø (1970) reported that breeding continues until about mid-July on Spitsbergen. Implantation is thought to be delayed until about September (Stirling et al. 1975a) and gestation takes from 195 to 265 days (DeMaster and Stirling 1981). The average age of first breeding for females is 5.4 years, but reproductively active females between the ages of 3 and 21 have been harvested or captured. Males are capable of breeding from a minimum age of 3 years to a maximum of at least 19 years (Lentfer et al. 1980).

Female polar bears return to land to den in October and November (Lentfer 1976b). The timing is thought to be dependent upon ice movement and the arrival of the ice pack to land in the fall (Lentfer and Hensel 1980). Dens are dug in snowdrifts on land or on the ice. One, 2 or occasionally 3 helpless cubs, about 25.4 cm long (Harington 1968) and weighing 0.6 kg (DeMaster and Stirling 1981) are born in December or January. Litter size in maternity dens is not known for Alaskan bears but the mean litter size for cubs captured in family groups was 1.58 (Lentfer et al. 1980). By the time cubs leave the den they weigh about 10 to 15 kg (DeMaster and Stirling 1981).

Polar bears emerge from dens in March or in April (Lentfer 1976b). Uspenski and Belikov (1976) believe that the emergence date is determined by weather conditions outside the den, especially air temperature and abatement of strong winds. Belikov (1976) reports that a female was observed to enter a den on 14 October and emerge on 14 April, for a total denning period of 183 days. The sow and cubs remain near the den and take short trips for 1 to 2 weeks while the cubs gain strength and become acclimated to the air temperatures outside the den (Lønø 1970, Lentfer 1976b). They then return to the ice to feed on seals. In Alaska, cubs remain with their mother for up to 28 months (Lentfer 1976b).

Food Habits

Ringed and bearded seals comprise the main diet of polar bears. Therefore bears must feed in areas where seals are either concentrated or accessible. Of 71 pinniped carcasses killed by polar bears and examined by Burns and Eley (1978), 92% were ringed seals, 7% were bearded seals, and 1% (1 animal) was a walrus (Odobenus rosmarus). Eighty % of the kills were on flaw zone ice or moving pack ice and 20% were on shorefast ice. Polar bears are not very successful in obtaining seals by excavating lairs (Stirling et al. 1975a). They usually capture seals by waiting at breathing holes. Polar bears are unable to capture seals in open water, and ringed and bearded seals rarely haul out on land, so when there are large areas of open water and seals have more places to breathe than just breathing holes, polar bear hunting success is lower (Stirling et al. 1975a). Bears feed predominately on the blubber and hide of the seal unless they are very hungry or are sharing the carcass with another bear.

Small amounts of other foods are occasionally eaten, such as sea birds, which bears capture by diving under the water and coming up beneath them (Stirling et al. 1975a), ptarmigan which they take from fox traps (Lønø 1970), and small amounts of seaweed. Females eat plants dug from under the snow both while constructing their dens (Belikov 1976) and when taking their cubs across the tundra to the sea ice (Uspenski and Kistchinski 1972). Since females do not feed for about 5 months during denning, it is important that a good food source is available during both the pre-denning and post-denning periods.

Habitat

Polar bears utilize a combination of sea ice and terrestrial habitats. The Beaufort Sea is completely ice covered for almost 10 months of the year. The open water begins to freeze in September or October and the nearshore ice does not melt until May or early June. With the exception of some denning females, polar bears inhabit the ice throughout the winter. The 3 basic types of sea ice present in winter are landfast ice, which is anchored to the shore, drifting pack ice, which is in motion between landfast ice and permanent polar pack ice, and the permanent polar pack ice (Lentfer 1972). The distribution of polar bears over the sea ice is influenced by the abundance and accessibility of their major prey species, ringed and bearded seals. In winter, seals may be concentrated in areas of drifting seasonal pack ice where open patches of water form and then refreeze into areas of thin ice in which the seals can maintain breathing holes when open water is not available (Lentfer 1971, Stirling et al. 1975a).

The shorefast ice is used as a substrate across which to travel, an area for feeding by females and cubs, and some denning also occurs there. Adult parturient females travel across this landfast ice in September or October to denning sites on land. Other members of the population use the landfast ice to reach areas on land or on barrier islands to which they are attracted by carrion of whales, seals, or walrus. Within the ANWR study area, polar bears are drawn to the carcasses of bowhead whales killed during the fall by Inupiat people in the village of Kaktovik on Barter Island. Preliminary results of the 1981 FWS research program which captured and tagged polar bears near the ANWR study area indicate that the autumn population near Barter Island is comprised largely of adult females, family groups, and subadults. Adult males were uncommon (Amstrup pers. comm.).

Female polar bears again traverse the shorefast ice in March or April when they lead their cubs from dens on land to the drifting pack ice. In transit, they hunt ringed seals and their pups which are found in subnivean lairs on the shorefast ice.

When the nearshore ice breaks up in spring, polar bears move with it and become most abundant at the southern edge of the pack ice, the position of which varies seasonally, but which usually occurs between 71° and 72° north latitude in Alaska. Sea ice provides polar bears with a hunting platform, shelter from weather, an avenue to feeding areas, and some denning sites. Polar bear denning has been documented on both shorefast ice and drifting sea ice (Lentfer 1975, Lentfer and Hensel 1980) but the extent to which the latter occurs is not known.

Tagging studies in both Alaska and Canada have shown that in successive winters bears often return to the same general area where they were captured (Stirling 1974). They seem to have the ability to navigate to specific areas during spring break-up even though winds, currents, and tides move the drifting pack ice elsewhere (Harington 1968, Lentfer 1972). In Alaska, terrestrial habitats are used only by denning females or by bears that have been attracted to carrion on land.

Denning Distribution and Habitat. Lentfer (1972, 1976b) and Lentfer and Hensel (1980) have summarized the results of studies of polar bear denning in Alaska. Only pregnant females go into winter dens for extended periods. They apparently do not concentrate for denning along the coast of Alaska as they do in "core" denning areas in other parts of their range. The Alaskan coastal zone is fairly flat, and snow of a suitable depth for denning occurs only along drainages, cut banks, and rough ice. Some factors which are thought to influence the choice of den location are distance inland from the coast, snow depth, snow density, and other topographic features which help to provide the best drifts, the least windchill, and the best insolation (Harington 1968). Dens have been found on land, offshore islands, shorefast ice, and drifting ice from 169 km offshore from the coast to 48 km inland. The area along the coast from the edge of the shorefast ice to about 40 km inland from the Colville delta to the Canadian border is thought to be a significant maternal denning area for the Beaufort Sea population of polar bears.

Of 35 maternity dens previously found in Alaska, 7 were found on land within the ANWR study area and 3 confirmed dens and 2 possible dens were found just north of it on the shorefast ice (Fig. 8, Table 9). A polar bear near what appeared to be a den was observed on the coastline midway between Pokok Bay and Pokok Lagoon by FWS personnel conducting mark and recapture studies of polar bears in October 1981. On 14 November 1981, a radio-collared female was tracked to a den about 12.9 km south of Demarcation Bay. Further surveys in the spring of 1982 will determine if these 2 dens are maternity dens. On the National Petroleum Reserve-Alaska, to the west of the study area, 13 of the previously mentioned 35 dens were found.

On 13 April 1980, Wilson Soplu of Kaktovik observed a sow and small cub near Itkilyariak Creek where it flows out of the north side of the Sadlerochit Mountains, 32 km straight-line distance from the coast. He said that the cub tired easily and had to stop often to rest (Jacobson 1980). On the ice north of the study area, Lentfer and Hensel (1980) have documented 3 sightings of cubs recently out of dens. Ave Thayer (pers. comm.), has observed many tracks of adult bears with cubs near Demarcation Bay in the wilderness area of the ANWR. In this area the mountains are relatively close to the coast, similar to the area north of the Sadlerochit Mountains. These areas have greater relief, which allows more snow accumulation than other locations within the ANWR study area. During polar bear den survey in the spring of 1981, Johnson

FIG. 8 POLAR BEAR MATERNITY DENS

Table 9. Polar Bear dens in or near the Arctic National Wildlife Refuge

Den Number and Location	Date	Source
1. 69 58'N 144 47'W Marsh Creek - .4 km. S VABM Maybell	1 April 1977	ANWR files
2. 69 56'N 144 28.2'W	3 April 1974	ANWR files
3. Between Carter Creek and Sadlerochit R. - 2 dens were 68.6 m apart	4 April 1974	
4. 69 49.5'N 144 35.0'W 16.1 km. S. of Camden Bay-Upper Carter Creek drainage.	4 April 1974	ANWR files
5. 69 50'N 144 08'W 24.2 km up Hulahula River.	Late Nov. 1968	FWS Den Log
6. No co-ordinates 2.4 km NW BM Penta	13 April 1976	ANWR files
7. No co-ordinates Niguanak R. 19.3 km inland SE of Barter Island.	26 March 1972	FWS Den Log
8. 69 32'N 141 25'W 12.9 km S of Demarcation Bay on fork of Turner River	14 November 1981	FWS
9. 70 10'N 143 40'W	March 1951	FWS Den Log
10. 7.2 km north of Barter Island airstrip.	19 March 1975	Moore, 1975
11. 6.4 km north of Barter Island airstrip.	19 March 1975	Moore, 1975
<u>Possible dens</u>		
12. 16 km west of Kaktovik and 6.5 km north of VABM Barbara.	21 March 1975	Moore, 1975
13. 14.5 km west of Kaktovik and 6.5 km north of the west end of Arey Island.	22 March 1975	Moore, 1975
14. On shoreline between Pokok Bay and Pokok Lagoon	October 1981	FWS

(1981) noted areas of potential denning habitat. In the study area, the following drainages had good to excellent potential denning habitat: Katakturuk R., Angun R., Okerokovik R., Jago, R., Carter Ck., and Marsh Ck.

Harington (1968), Lønø (1970), Uspenski and Kistchinski (1972), Moore and Quimby (1975), Larsen (1976) and Lentfer and Hensel (1980) have provided detailed descriptions of polar bear dens.

Impacts of existing processes and activities

Under the provisions of the Marine Mammal Protection Act of 1972, only Alaskan Natives are currently allowed to hunt polar bears in the state. There are presently no restrictions on number, sex, age, or method of taking, except that waste shall not occur. However, the Act does allow the state of Alaska to take over management of polar bears under certain conditions. Amendments to the Act allow rural Alaskan residents to harvest marine mammals for subsistence purposes once the state resumes management. An international agreement signed by Canada, Denmark, Norway, USSR, and the USA provides a High Seas sanctuary for polar bears which "...prohibits the taking of polar bears from aircraft or large motor vessels or in areas where they have not been taken by traditional means in the past," (Lentfer 1974a). For information on harvest and use of polar bears within the ANWR study area, see Ch. 7, Subsistence section.

Climate and sea ice conditions affect polar bear populations and their habitat. Warming and cooling trends of 50 to 100 year durations have been recorded in the Arctic (Vibe 1967 as cited by Lentfer 1971). Cooling trends could extend denning habitat further south while warming trends could result in fewer bears reaching favorable denning areas. In years when the landfast ice forms late on the coast, denning may be delayed or reduced, and cub production may be lowered (Harington 1968, Lønø 1970, Lentfer 1971, Uspenski and Belikov 1976). Den distribution also varies from year to year, depending on the ice condition of the previous autumn (Uspenski and Kistchinski 1972).

Natural mortality to polar bears can result from injuries and infections, starvation, cannibalism of young by older bears, and mechanical damage occurring in the moving ice (Harington 1968). Polar bears compete with man for their main prey item, the ringed seal. Any natural or man-induced reduction in ringed seals will affect the bears.

Lentfer (1976a) reported the results of baseline studies of environmental contaminants and parasites in polar bears. Effects of environmental contaminants on marine mammals are not well understood, but apparently lethal levels were not found in polar bears. About 60% of Alaskan polar bears are infected with *Trinchinella spiralis*, but whether or not this is life-threatening is not well documented.

Data Gaps

The FWS is continuing research which will provide a better understanding of population size, movements, and denning locations of polar bears.

Ringed Seal (*Phoca hispida*)

Distribution, Range, and Size of Population

Ringed seals are circumpolar in distribution and are the most abundant and widely distributed of the arctic seals. They inhabit the Beaufort Sea year around. In winter and spring, they are associated with the shorefast ice and the flaw zone, but move out to the pack ice edge during summer and fall. Brooks (1978) estimated that 250,000 to 1,500,000 ringed seals inhabit the seas bordering Alaska.

At lease 6 aerial censuses of ringed seals have been conducted within the ANWR study area (Table 10). In 1970, ringed seals were censused along the north coast of Alaska in order to establish a baseline of density and distribution (Burns and Harbo 1972). One of the census areas, Flaxman Island to Barter Island, was censused again in 1975, 1976, and 1977 by Outer Continental Shelf Environmental Assessment Program (OCSEAP) personnel. In addition, Moore (funded by Arctic Gas) used 2 methods to estimate ringed seal density in the Beaufort Sea from Camden Bay in the American Beaufort, to Shingle Point in the Canadian Beaufort Sea. All censuses were conducted during the second or third week of June when a maximum number of resident ringed seals would be hauled out on the shorefast ice to molt (Burns and Harbo 1972).

Table 10. A comparison of ringed seal densities obtained during surveys of the ANWR coast from 1970-1975 using different techniques.

Area	Year	Density (seals/km^2)	Source
Flaxman Island to Barter Island	1970	0.73	Burns and Harbo 1972
	1975	0.54	Burns and Harbo 1978
	1976	0.12	Burns and Harbo 1978
	1977	0.36	Burns and Harbo 1978
Camden Bay to Beaufort Lagoon	1975	0.26[1]	Moore 1976[2]
Camden Bay	1975	0.78	Moore 1976[3]
Barter Island	1975	0.83	Moore 1976[3]
Beaufort Lagoon	1975	0.91	Moore 1976[3]
ANWR coast[4]	1974(22 June)	0.82	ANWR file data
ANWR coast[4]	1974(16 July)	0.12	ANWR file data

1 Density extrapolated from segments 1 through 5 of the non-parallel flight line method.
2 Non-parallel flight line method.
3 Parallel flight line method.
4 Some bearded seals may be included in this count.

FWS personnel conducted aerial surveys along the ANWR coast on 22 June and 16 July 1974. Twenty-eight survey lines, perpendicular to the coast and approximately 16 km apart were flown. Ten were 19.3 km long and 18 were 8.0 km long. Observation width was 0.2 km on each side of the aircraft. The timing of the 22 June survey coincided with the peak of the molt, while the 16 July survey occurred after the peak of the molt and under conditions of poor visibility. Ringed seals and bearded seals were not differentiated, but low numbers of bearded seals utilize this area (Table 10). The average of the means of 0.44 seals/km^2 for the Flaxman Island to Barter Island sector is comparable to the overall observed density of ringed seals in the Beaufort Sea (including the Yukon Territory coast) of 0.40 seals/km^2 as derived by Frost and Lowry (1981), and to the density of 0.46 seals/km^2 for the Beaufort Sea from Camden Bay to Shingle Point as calculated by Moore for his non-parallel flight lines in 1975 (Table 10).

Moore's parallel flight line surveys found that the highest density of seals adjacent to the ANWR occurred near Beaufort Lagoon (Table 10). Ringed seal densities were higher to the east in Yukon Territory. With Moore's 1975 parallel flight line method, density was 1.56 seals/km^2 at Komakuk Beach (Y.T.), and with the non-parallel method, density was 1.19 seals/km^2 in the Herschel Island area (Y.T.) between the Firth and Babbage Rivers.

Ringed seal densities from west to east along the Beaufort Sea coast from 1970 to 1977 are presented in Table 11. West of the ANWR, the mean densities were higher between Barrow and Lonely but lower in other areas compared with densities in the ANWR.

Table 11. Ringed seal density estimates (number seals sighted/km^2) along various sectors of the Beaufort Sea coast (from Frost and Lowry 1981).

Year	Barrow to Lonely[1]	Lonely to Oliktok[1]	Oliktok to Flaxman I.[1]	Flaxman I. to Barter I.[1]	Yukon Coast[2]
1970	0.68	0.32	0.41	0.73	--
1974	--	--	--	--	0.52
1975	0.84	0.42	0.30	0.54	0.21
1976	0.42	0.33	0.42	0.12	--
1977	0.30	0.15	0.21	0.36	--

1 Burns and Harbo 1972, Burns and Eley 1978
2 Stirling et al. 1977

The density figures presented in Tables 10 and 11 may be used as indices of abundance but do not represent the actual numbers of seals in the population. In order to estimate the population, one must know what proportion of the population is hauled-out and therefore counted during surveys. The number of seals hauled-out varies with weather conditions (Finley 1979), and at any time may represent from 50 to 70 % of the population (Finley 1979, Frost and Lowry 1981). In addition, censuses were conducted over the fast ice in spring. When the ice breaks up there is a summer influx of ringed seals from the Bering and Chukchi Seas, and the ringed seal population increases (Burns and Harbo 1972, Lowry et al. 1979, Frost and Lowry 1981).

Life History

The age at which female ringed seals reach productive maturity ranges from 6 to 10 years, but most do so between 7 and 9 years of age. Males reach sexual maturity at age 7 and 8 (Burns and Eley 1977). Females are impregnated subsequent to pupping (between mid-and-late April) and implantation is delayed 3 1/2 months until mid-July or mid-August (Burns and Eley 1977). Single white-coated pups are born from mid-March through April in snow dens (subnivean lairs) excavated in packed snow on the lee or windward side of pressure ridges or ice hummocks. Pups remain in the dens for approximately 2 months, during which time they are dependent on the mother.

Longevity of ringed seals may approach 36-40 years, but few seals taken in subsistence harvests are more than 10-15 years old (Burns and Eley 1978).

Food Habits

Diets vary seasonally, presumably with the concentrations of prey species (Lowry et al. 1979), and may also vary somewhat with locality (Frost and Lowry 1981). Initially, food samples were collected primarily near Point Barrow and Prudhoe Bay, but during the summer of 1980 additional stomach contents were obtained from Pingok Island (west of Prudhoe Bay) and Beaufort Lagoon which is within the ANWR study area.

In general, ringed seals eat benthic crustaceans such as gammarid amphipods, mysids, shrimps, and isopods, in late winter and early spring (April-June), nektonic crustaceans, such as hyperiid amphipods and euphausiids in summer, (August-September), and arctic cod in winter (November-March) (Frost and Lowry 1981). The recent work at Pingok Island and Beaufort Lagoon, however, has shown that arctic cod may be a major summer prey item in areas where euphausiids or hyperiid amphipods may not be abundant. Arctic cod are present in summer, but are more dispersed; concentrations or aggregations of prey species, which occur in localized areas, enable seals to obtain large quantities of food more efficiently (Lowry et al. 1979). The use of actic cod in the winter diet may coincide with a nearshore spawning by arctic cod in the fall; this phenomenon has not been reported in Alaska but is documented for other areas of the world (Lowry et al. 1979). No data are available on foods used by ringed seals in the Alaskan Beaufort Sea during July or October (Frost and Lowry 1981).

Habitat

Ringed seals occur in both moving and landfast ice and are capable of maintaining breathing holes in ice as thick as 2 m by abrading the sea ice with the claws of their foreflippers. This adaption allows them to inhabit areas of extensive, thick, stable ice (Smith and Stirling 1975, Burns et al. 1980, Cowles 1981). Highest densities of seals along the northern Alaska coast occur in areas of very stable shorefast ice in late winter and early spring.

Preferred breeding habitat is landfast ice, and that is where breeding seals occur in the greatest density. However, ringed seals are known to use far offshore areas of shifting, but relatively stable ice (Smith and Stirling 1975). Moving ice may be marginal breeding habitat used by younger, more inexperienced seals, and may subject them to more polar bear predation (Burns and Eley 1977). The lairs, which function to protect ringed seal pups from predators (mainly polar bears (Ursus maritimus) and arctic foxes (Alopex lagopus) and from the cold, are located above breathing holes in the ice and may be complex structures (Smith and Stirling 1975).

Lagoons. Most of the lagoons within the ANWR study area are shallow and ice is usually anchored to the bottom in winter. Therefore they are not available to ringed seals as pupping habitat or winter feeding areas. Lagoons would have to be deeper than 2.5 -3.0 m and have an open connection to the ocean to provide suitable pupping habitat (L. Lowry, pers. comm.). Nuvagapak, Angun, and Jago lagoons are from 3.0 - 3.6 m deep in places, while Kaktovik lagoon reaches a depth of 3.9 m but does not connect directly to the ocean.

Ringed seals are occasionally seen in lagoons in very low numbers in summer and fall. Lowry (pers. comm.) reported seeing 1 or 2 seals on several occasions in Beaufort Lagoon in early September 1980. Between 9 June and 3 July 1980, Jim Levison saw 1 to 3 seals daily on the ice in the Nuvagapak portion of Beaufort Lagoon. The lagoon was 95% ice covered in June and only 25% ice covered by 3 July (ANWR files, unpubl. data). FWS biologists have seen seals in the lagoons within the refuge: B. Bartels (pers. comm.) has observed seals in Jago, Kaktovik, and Oruktalik lagoons in summer and fall, and M. Spindler (unpubl. data) saw one seal (sp.) in Tamayariak Lagoon on 3 August 1981. Seals are occasionally seen in Simpson Cove during the summer (ANWR files unpubl. data.). Although not a lagoon, it does lie within the study area. Spindler noted 2 seals (sp.) in Simpson Cove on 10 September 1981 and C. Meyers (pers. comm.) saw 2 seals on 11 August 1981 and 1 on 23 August 1981 in shallow water near shore.

Impacts of Existing Processes and Activities

Ringed seals are the smallest of the arctic seals and are the major prey of polar bears. Other predators are arctic and red foxes, dogs, wolves, and ravens. They are also an important subsistence resource for the Inupiat village of Kaktovik on Barter Island. (See Ch. 7, Subsistence section).

According to McLaren (1958) "The habit of pupping on the fast ice makes ice quantity and quality of primary importance in the reproductive ecology of this species." Heavily compacted ice in 1974, and limited snow cover in which seals could construct their lairs in 1974 and 1975 are believed to be the causes of a decline in the ringed seal population in the Eastern Beaufort Sea (Stirling et al. 1975b) and may have affected Alaskan populations of seals as well. This is supported by the Census data for Alaska (Table 10) tending to support this hypothesis; however the consistency of survey effort between years is unknown, and a definite statement in support the hypothesis is not possible.

Data Gaps

Ringed seal use of lagoon is not addressed in the literature. There is fragmentary evidence that some use does occur, and although the extent of such use is not well documented, it seems to be quite limited.

Bearded Seal (Erignathus barbatus)

Distribution, Range and Size of Population

Bearded seals are circumpolar in distribution in areas where seasonal ice covers water that is less than or equal to about 200m deep. The Bering-Chukchi population of the north Pacific extends into the Beaufort Sea where the seals are present year round in relatively low numbers (Burns and Frost 1979). The range of the bearded seal varies seasonally with ice conditions; most of the animals move south through the Bering Strait in the late fall-early winter, and spend winters in the Bering Sea. They move north as the ice breaks up in spring (mid-April to June).

Very little information is available regarding the numbers of bearded seals using the Beaufort Sea. Burns and Frost (1979) state that "...the region approaches being marginal habitat for these seals". Burns and Harbo (1972) noted that bearded seals occurred on moving pack ice in some of their survey areas in early June, but none were found in the Flaxman to Barter Island segment of the survey where extensive landfast ice was still present. In 7.9 hours of boat surveys at 2 locations north of the study area in August and September, 1977, no bearded seals were seen (Burns and Frost 1979).

J. Levison (unpubl. data ANWR files) noted from 2 to 6 bearded seals daily on the ice near Beaufort Lagoon during the first week of July 1980. Individuals were sighted on 31 July 1980 near Egaksrak Island and on 5 August 1980 on a floe between Beaufort Lagoon and Siku Entrance. A total of 24 were seen in leads near Icy Reef on 6 September 1980. Population studies were conducted in the Canadian Beaufort Sea in 1974 and 1975; the 1974 estimate of bearded seal was $2,759 \pm 729$, and was $1,197 \pm 235$ in 1975 (Stirling et al. 1975b).

Life History

Most bearded seal pups are born on the ice at the end of April, although pupping dates range from March through May. Pups are able to enter the water shortly after birth (Stirling et al. 1975b, Burns and Eley 1978). Pups nurse for only 12 to 18 days and gain about 45.4 kg (Burns 1967).

Breeding occurs mainly in May, with implantation approximately 2 months later. Males reach sexual maturity at 6 to 7 years and females at 4 to 7 years, although the mean for females is 6 years based on first pregnancy rather than first ovulation (Burns and Frost 1979).

Habitat

The preferred habitat of bearded seals is shallow water zones in areas of moving ice. They move seasonally with the drifting, disturbed sea ice as it advances and retreats north in spring and south each fall (Burns 1967). These seals can be associated with 4 types of winter pack ice: persistent flaw, polynyas, divergence zones, and the ice front (Burns et al. 1980). They are capable of maintaining breathing holes in thin ice (Burns and Frost 1979). Bearded seals are not found in areas of landfast ice until it begins to break up in June (Burns and Eley 1977).

Bearded seals are benthic feeders with a diving limit of about 100m, therefore floating or moving ice over shallow water provides optimum feeding habitat. The Beaufort Sea has a very narrow continental shelf, much of which is overlain by landfast ice during winter; therefore, feeding habitat for bearded seals is limited. In summer and autumn, the southern edge of the ice pack is generally over water which is too deep for feeding bearded seals, so in those seasons they are often associated with nearshore ice remnants. The Bering and Chukchi Seas, with their wide continental shelves, provide much more suitable habitat than the Beaufort Sea (Burns and Frost 1979). Based on data from 20 bearded seals collected in the Beaufort Sea (16 near Barrow), the most important food items were spider crabs (Hyas coarctatus), shrimp (Sabinea septemcarinata), and arctic cod (Boreogadus saida). Clams were important in August and fish were more important from November through February than at other times of the year. Other items consumed were hermit crabs, octopus, gammarid amphipods, and isopods (Burns and Frost 1979).

Impacts of Existing Processes and Activities

Predators of bearded seals include polar bears and man. For information on Eskimo harvest and use of bearded seals see Ch. 7, Subsistence section. In general, causes of natural mortality are unknown. These seals do harbor helminth parasites and have high heavy metal loads. Because of the high concentrations of cadmium in the liver and kidneys these organs should not be consumed by humans (Burns and Frost 1979).

Data Gaps

Numbers of bearded seals in the American Beaufort Sea are not well documented, especially in the central Beaufort north of the ANWR study area.

Bowhead Whale (Balaena mysticetus)

Distribution, Range and Size of Population

Bowhead whales are distributed in 4 principal areas of arctic and subarctic waters: Spitzbergen west to East Greenland; Davis Strait, Baffin Bay and Hudson Bay; the Bering, Chukchi, Beaufort, and East Siberian Seas; and the Okhotsk Sea. Bowheads that occupy the Bering, Chukchi, and Beaufort Seas are sometimes referred to as the western Arctic population (Tillman 1980).

The wintering area for the western Arctic bowheads is along the ice edge of the central and southwestern Bering Sea (Fraker et al. 1978; Naval Arctic Research Laboratory 1980). They undergo a spring migration which is correlated to ice movements (Marquette 1977, Brooks 1978). Leads, or areas of open water, begin to form in landfast ice in March, and the whales migrate from the Bering to the Chukchi and Beaufort Seas from March through June (Braham and Krogman 1977). Bowheads arrive in the Canadian Arctic (eastern

Beaufort Sea) in mid-May, June, and July, and remain in Amundsen Gulf during the late spring and summer. About mid-September they begin their westward migration back to the Bering Sea (Fraker et al. 1978, Fraker 1979).

Recent estimates of the western Arctic population were derived from counts of whales migrating past Point Barrow, Alaska, in spring. Marquette et al. (1981) felt that the 1978 estimate of 2,264 whales was the most reliable estimate obtained from 5 years of data. The International Whaling Commission, (IWC), however, quotes 1,300 animals as the best estimate of the bowhead population (Tillman 1980).

Life History

The life history of the bowhead whale is poorly understood. Marquette (1977) provides a summary and discussion of available data on growth and reproduction. Mating behavior has been observed during spring migration and probably occurs in summer as well. Calving is thought to occur between late winter and early summer; often during spring migration. The gestation period is about 12 months. Calves are weaned at approximately 5 to 6 months of age, but it is not known how long they remain with their mothers. Males reach sexual maturity at a length of 1158 cm and physical maturity at 1402 to 1468 cm. Females reach sexual maturity at 1220 cm and physical maturity at a length slightly greater than males. The age at which these lengths are reached has not been determined.

Food Habits

Bowhead whales feed by straining marine organisms through baleen plates that are suspended from their upper jaw (Marquette 1977, Fraker et al. 1978). It is not known whether whales feed during the winter. Those migrating in spring feed little or not at all, evidenced by the lack of food in the stomachs of whales harvested at Barrow. They do feed intensively in the Beaufort Sea during summer and fall, and whales harvested in autumn have contained substantial quantities of food in their stomachs (Lowry et al. 1978, Lowry and Burns 1980, Marquette et al. 1981).

There is little information available on food habits of bowhead whales in Alaskan Beaufort Sea, but Lowry and Burns (1980) collected data from 5 stomachs of whales taken 20 September and 11 October 1979 near Barter Island. They found that copepods (principally *Calanus hyperboreus*), and euphausiids (mainly *Thysanoessa raschii*) comprised about 97% of the food eaten. Copepods were dominant in 3 of 5 samples, and euphausiids in 2 samples. Small amounts of mysids, hyperiid and gammarid amphipods, and small fishes were also eaten. Whales taken at Barrow in September 1976, and May 1977, had eaten mainly euphausiids and copepods respectively (Lowry et al. 1978 as cited by Lowry and Burns 1980; Marquette 1979.).

Lowry and Burns (1980) state that "ringed seals and Arctic cod are probably the most significant trophic competitors of bowhead whales in the Beaufort Sea". Marquette et al. (1981) add that they do not know whether competition for food is affecting the recovery of this stock of bowheads.

Habitat

The winter habitat of bowhead whales varies with the seasonal distribution of the ice front. According to Frost and Lowry (1981) "All available information indicates a close association with the ice front from at least January through early April. Characteristics of the front provide an area where whales can reside among the ice while maintaining regular access to air between generally dispersed and mobile floes".

In late March or early April, a major flaw zone forms between the pack ice and shorefast ice creating a corridor of open water roughly parellel to shore through which the whales can migrate. These leads, which pass through the Bering Strait, are oriented in a southwest to northeast direction (Fay 1974) and pass close to Wales, Point Hope, and Barrow (Braham et al. 1980, Carroll and Smithhisler 1980). National Marine Fisheries Service (NMFS) personnel have conducted aerial surveys across the nearshore leads to determine the distribution of bowheads across them and found that most whales migrate within the first third of the lead closest to the shorefast ice (Marquette et al. 1981).

From Pt. Barrow eastward, bowheads are believed to cross the Beaufort Sea using far offshore leads in the pack ice which develop in a northeasterly direction towards Banks Island (Fig. 9). Satellite images have shown that these leads may extend as far north as 77° or 78° north latitude. The whales then follow the Banks Island lead, or the Tuktoyaktuk Peninsula lead south to Amundsen Gulf. As the ice becomes more fractured later in the season, bowheads probably use a more southerly route (Fraker 1979; Braham et al. 1980).

Bowhead whales summer in the eastern Beaufort Sea and Amundsen Gulf. Fraker and Bockstoce (1980) hypothesize that early in the open water season they are distributed primarily in Amundsen Gulf and the adjacent waters near Cape Bathurst. As the season progresses there is a gradual westward shift in distribution which may be related to the availability of food.

Since there is open water along the coast of Alaska in fall, bowheads are not dependent upon ice leads as corridors for travel, so they are able to remain closer to the coastline. Recent studies by the Naval Ocean Systems Center (NOSC) for the Bureau of Land Management (BLM) have added to the limited knowledge of the fall migration. Aerial surveys were conducted in August, September, and October, 1979, to study the behavior and movements of whales migrating through the Beaufort Sea. Whales were sighted primarily along the 10 fathom/20 m line.

The locations of whales sighted near the ANWR study area are shown in Figure 10a. On 24 September, 1979, 10 sightings of bowhead whales were made in a small area near Demarcation Bay. From 1 to 10 animals per sighting were noted for a total of 35 individuals. And, on 26 September, 14 sightings were made of 40 individuals (Fig. 10b). These groups seemed to be moving in a non-directional manner, suggesting that the whales may have been feeding in that area (Ljungblad et al. 1980). The presence of food in the stomachs of whales harvested in Kaktovik, just west of Demarcation Bay supports this hypothesis. Bowheads migrate more slowly in the fall than in the spring, feeding as they go.

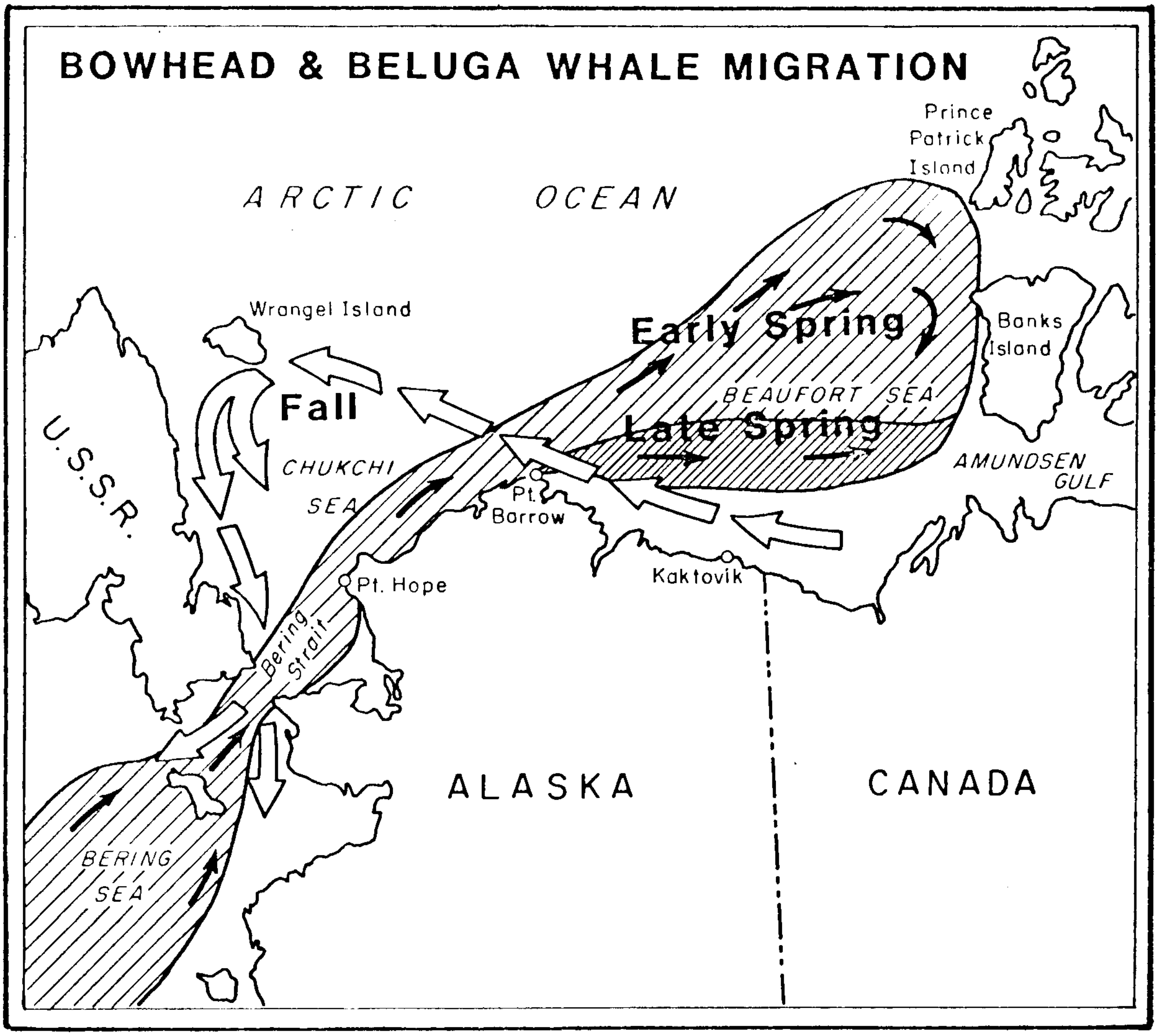

Figure 9. Generalized spring migration pattern of bowhead and belukha whales and fall migration route of bowhead whales. (After Richardson and Fraker 1981).

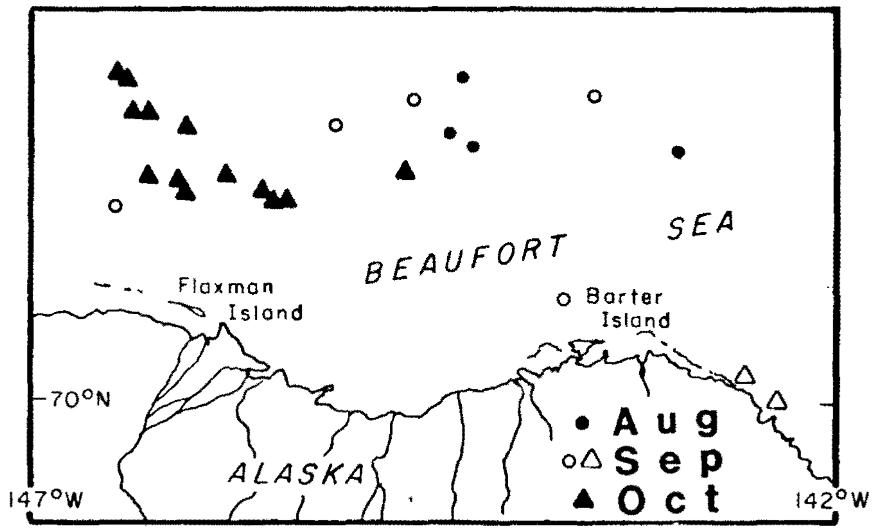

Figure 10a. Locations of bowhead whales sighted during aerial surveys conducted by NOSC, 1979. (Modified from NOSC TD 314).

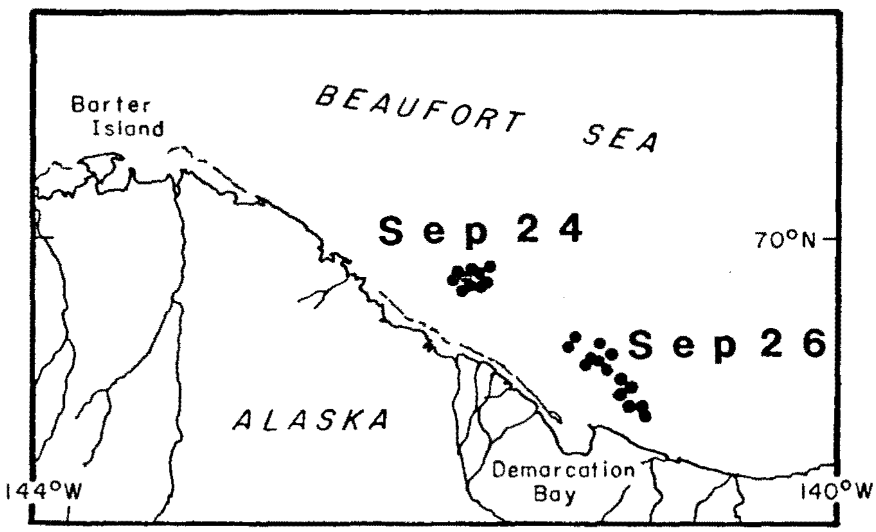

Figure 10b. September 1979 sightings of bowhead whales near Demarcation Bay. (Modified from NOSC TD 314).

Impacts of Existing Processes and Activities.

Bowhead whales have been harvested by Alaskan Eskimos for at least 2,000 years (Bockstoce 1978 as cited by Tillman 1980). In addition, Yankee whalers were active in the Arctic Ocean from 1848 to 1915 and killed approximately 8,852 whales (Bockstoce 1978 as cited by Tillman 1980). The International Whaling Commission (IWC) banned commercial whaling in 1947 and since then only hunting by aborigines has been allowed.

The bowhead whale is considered an endangered species. Mitchell (1977) estimated that the western Arctic population has been reduced to 7 to 11% of its original size. Under conditions of the Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972, continued harvest by Alaskan Eskimos for subsistence purposes was allowed providing that waste did not occur.

In 1972, the Scientific Committee of the IWC became concerned that the effect of Native hunting on the population was not known, so NMFS began a study in 1973 to determine the extent of the harvest and to gather data on population size, distribution, and abundance of whales. The results of the harvest study alarmed IWC members: In 1976, 48 bowhead whales were struck and landed and an additional 43 were struck and lost, for a total of 91 whales struck. They recommended that the whaling cease completely. In 1977, 111 bowhead whales were struck (29 landed) before action on the issue was taken by the U.S. Government. In December 1977, a compromise between the U.S. Government (with the assistance of the Alaska Eskimo Whaling Commission [AEWC]) and the IWC was affected, and a quota system on number of whales struck and number landed was instituted (Tillman 1980).

In March, 1981, the AEWC signed a cooperative agreement with the National Oceanic and Atmospheric Administration (NOAA) to aid NOAA in monitoring the bowhead whale hunt for the next 2 years (Tundra Times 1 April 1981). The quotas are set annually based on the most recent findings on population status by the scientific community and the needs of the Alaskan Eskimos. The quota for 1981 was 17 whales landed and 32 struck. The only whaling community near the ANWR study area is Kaktovik, whose residents hunt whales during their fall migration. Kaktovik hunters filled their quota of 3 whales in 1981. For more information on Eskimo whaling see Ch. 7, Subsistence section.

Natural impacts to whales may include suffocation from entrapment under the ice or starvation from lack of access to feeding areas (Eberhardt and Breiwick 1980, Ljungblad et al. 1981). Bowhead whales have few parasites and strandings are infrequent (Marquette 1977). The killer whale is the only suspected natural predator.

Data Gaps

Every aspect of the bowhead whale's biology, habitat, distribution, and population size need further study and clarification.

Beluga whales (Delphinaplerus leucas) and Incidental Species of Marine Mammals

Beluga whales utilize the waters of the Beaufort Sea north of the ANWR study area during their spring migration to feeding and calving grounds in the Amundsen Gulf and Mackenzie River delta, and the subsequent fall migration back to wintering grounds in the Bering and Chukchi Seas. The route and timing of the spring migraion is similar to that of the bowhead whales shown in Fig. 9 (Sergeant and Hoek 1974, Fraker 1979). The westward migration to the wintering grounds occurs in late August and September (Fraker et al. 1978). Although some beluga whales are present in the nearshore waters of the Beaufort Sea during their fall migration, most follow the edge of the ice pack (Seaman et al. 1981). Beluga whales are not actively hunted by Natives in Kaktovik, but are taken if they are encountered during the bowhead whale hunt (See Ch. 7, Subsistence section).

Gray whales (Eschrichtius robustus), spotted seals, (Phoca largha), and walrus (Odobenus rosmarus) are occasionally found in the portion of the Beaufort Sea north of the ANWR study area. Walrus are uncommon in spring, summer, and fall, and spotted seals are uncommon in summer (Burns et al. 1980). For information regarding the occurence of gray whales along the Alaskan coast, see Maher (1960), Marquette and Braham (1980), and Rugh and Fraker (1981). Since the central Beaufort Sea is on the fringe of the ranges of these species, they are not discussed in detail.

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Predators

Predators using the ANWR study area include brown bear, wolf, arctic fox, red fox, wolverine, ermine, and least weasel. The following materials present the current knowledge for the above species except for arctic and red foxes, ermine, and least weasel. Information on these 4 species is currently being synthesized and will be included in subsequent annual updates to this report.

Brown Bear (*Ursus arctos*)

Brown bear populations in North America have continually declined as human occupancy and development increased in brown bear habitat (Herrero 1972, Stebler 1972). These declines were not retreats from occupied habitat into more remote areas, but rather an extermination of brown bears in those areas being newly occupied by man (Jonkel 1970, as cited by Kucera 1974). Brown bears now exist in greatly reduced numbers and in restricted regions in the northwestern portions of the contiguous United States (Storer and Tevis 1955, Craighead and Craighead 1967, as cited by Reynolds 1979, Cowan 1972, Herrero 1972). Canadian populations are more common and widespread, with large areas in the western and northern territories being occupied (Kucera 1974, Pearson 1975). In Alaska, brown bears occur throughout the state and are managed as a big game species by the Alaska Department of Fish and Game (Quimby and Snarski 1974).

Two subspecies of brown bears occur in Alaska, with *U. a. Middendorffi* being restricted to Kodiak, Afognak, and Shuyak islands, and *U.a. horribilis* occurring throughout the remainder of the state (Rausch 1963). The distribution and abundance of brown bears in northern Alaska was investigated by Crook (1971) as a result of impending oil and gas development on the North Slope. Concern for the potential effects of this development upon northern brown bear populations and various gas pipeline routing proposals focused research efforts on these populations. No intensive research has been conducted to date that provides data specific to the ANWR study area; therefore, extrapolation of research data from adjacent or other northern areas is necessary. Research projects conducted for the Arctic Gas studies provide a majority of the information available for describing brown bear occurrence and use adjacent to the ANWR study area. Additional data are also available from studies of brown bear in National Petroleum Reserve - Alaska (NPR-A) in the northwestern Alaska.

Populations

Brown bears occurring north of the Brooks Range in Alaska are at the northern extent of the species range. These populations are characterized as having low reproductive potential, short periods of food availability, large individual home ranges, and habitats that provide little protective cover (Reynolds et al. 1976, Reynolds 1979).

Adult brown bears in the northern Yukon Territory and northern Alaska are comparable in size to those in the interior of southern Yukon Territory (Table 12). Adult males associated with the Canning River drainage in Alaska and the northern Yukon Territory were somewhat heavier than their counterparts in northwestern Alaska, although adult females averaged approximately the same weights in all 3 areas. Pearson (1976) noted that adult bears captured in September in the northern Yukon Territory were considerably heavier than adult bears captured 110 days earlier in May. He reported average weights for adult males captured in September as being 83 kg heavier than May captures, with adult females captured in September being 60 kg heavier than May captures. Curatolo and Moore (1975) recorded an average weight gain of 17% from spring to fall for 6 bears in northeastern Alaska. Weight gains varied from a low of 4% for a sow with 2 yearlings to a high of 41% for a solitary female. This seasonal weight increase was interpreted as an adaptation to survive the rigorous winter conditions.

Table 12. Average weights (kg) of adult brown bears in northern Alaska and Yukon Territory.

Sex	Sample Size	Average Weight	Weight Range	Location	Reference
Male	40	139	106-240	interior-southern Yukon Territory	Pearson 1975
Female	21	95	74-124	interior-southern Yukon Territory	Pearson 1975
Male	25	169	------	northern Yukon Territory	Pearson 1976
Female	31	111	------	northern Yukon Territory	Pearson 1976
Male	--	180	136-268	Canning River Drainage, northeast Alaska	Reynolds 1976
Female	18	109	88-141	Canning River Drainage, northeast Alaska	Reynolds 1976
Male	19	167	107-218	northwestern Alaska, NPR-A	Reynolds 1980
Female	24	111	84-177	northwestern Alaska, NPR-A	Reynolds 1980

Density, Home Range and Movements. Population densities of brown bears are low throughout their range, however, in northern Alaska, brown bear populations are especially sparse (Table 13). The wide range in densities of brown bear populations on the North Slope is attributed to several factors. The difficulty in censusing brown bears in northern Alaska is a major problem and was discussed by Crook (1971). A direct count method was used to census bears along the Canning River in northeast Alaska (Quimby 1974a, Quimby and Snarski 1974, Reynolds 1976) and in the southwestern portion of NPR-A in northwestern Alaska (Reynolds 1979, 1980). This technique provided the most reliable data, but was expensive, time consuming, and area specific. Reynolds (1979, 1980) used direct count data from these 2 areas for extrapolating a population estimate for the entire NPR-A (Table 13). Another factor influencing bear densities between areas on the North Slope is food availability and the seasonal variations in that availability. Reynolds (1979, 1980) attributed the relatively high density of bears in northwestern NPR-A to the high seasonal availability (early summer) of caribou in the form of both prey and carrion. Bears respond readily to newly available food sources and the timing of survey efforts can greatly influence the number of bears detected and subsequent density estimates.

Table 13. Summary of reported brown bear population densities in North America.

Estimated Density (km2 per bear)	Area	References
	Contiguous States:	
21.2	Montana, Glacier National Park	Martinka 1974
80-150	Wyoming, Yellowstone National Park	Craighead et al. 1974, as cited by Curatolo and Moore 1975
	Canada:	
22.7-27.1	southern Yukon Territory	Pearson 1972, 1975
28.5	British Columbia, Glacier National Park	Mundy and Flook 1973, as cited by Curatolo and Moore 1975
48	northern Yukon Territory	Pearson 1976
106-175	Richard Island, Northwest Territory	Harding 1976
	Alaska:	
1.5	Kodiak Island	Troyer and Hensel 1964
24.4-38.5	Mount McKinley National Park	Dean 1976
43	northern foothills, northwestern Brooks Range	Reynolds 1979, 1980
120-148	northeastern Alaska, Canning R. drainage	Quimby 1974, Quimby and Snarski 1974, Reynolds 1976
142	north slope of northeast Alaska	Curatolo and Moore 1975
228	central Brooks Range	Crook 1971
284.9	central Brooks Range	Crook 1972, as cited by Curatolo and Moore 1975
	north slope of Alaska:	Reynolds 1979, 1980
90	a. low foothills	
130	b. high foothills	
260	c. mountains	
780	d. coastal plain	

Densities of brown bear on the ANWR study area are believed to be low (Curatolo and Moore 1975) and are perhaps similiar to the estimate of 780 km^2 per bear for the coastal plain (Table 13) of NPR-A (Reynolds 1979, 1980). In actuality, little true coastal plain habitat occurs on the study area, with a majority being the low foothills type, where Reynolds (1979, 1980) detected a higher density of brown bears (Table 13). The drainages between the Canning River on the west and the Kongakut River on the east are believed to have lower densities than those reported for the Canning River (Quimby 1974a).

Brown bears have large cumulative home ranges with the largest occurring in northwestern Alaska (Table 14). Reynolds (1980) concluded that the large home range size of brown bears in northwestern Alaska was an indication of the relatively low quality and short period of food availability on the North Slope of the Brooks Range. Unlike home ranges reported in Yellowstone (Craighead 1976), most brown bear home ranges in northern Alaska were not made up of 2 distinct components (summer range, and fall/spring range which included the den site), connected by a migratory corridor. In northern Alaska, the majority of brown bear home ranges included the den site or the den site was immediately adjacent to the home range (Curatolo and Moore 1975, Reynolds 1980).

Table 14. Cumulative home range for brown bears in North America (adapted from Reynolds 1980).

Locality and Reference	Sex	Sample Size	Mean Cumulative Home Range Size (km^2)[a]
Yellowstone Park, Wyoming	M	6	161
(Craighead 1976)	F	14	73
western Montana	M	3	513
(Rockwell et al. 1978, as cited by Reynolds 1980)	F	1	104
southwestern Yukon	M	5	287
(Pearson 1975)	F	8	86
northern Yukon	M	9	414
(Pearson 1975)	F	12	73
northwestern Alaska	M	8	1350
(Reynolds 1980)	F	18	344

[a] cumulative home range size determinations were made using the minimum area method (Mohr 1947).

Yearly home ranges of brown bears along the Canning River in northeastern Alaska (Curatolo and Moore 1975) were larger than yearly ranges in northwestern Alaska (Reynolds 1979, 1980). Yearly range sizes were determined using Curatolo and Moore's (1975) modification of the exclusive boundary strip method described by Stickel (1954). This method of home range calculation is based upon the approximate size of daily movements and the resulting home ranges do not include large expanses of area in which no locations were recorded. Male bears in northeastern Alaska had an average yearly range of 702 km^2 (n=5), compared to males in northwestern Alaska with an average yearly range 510 km^2 (n=7). Female bears in northeastern Alaska had an average yearly range of 319 km^2 (n=8), compared to an average yearly range of 269 km^2 (n=16) for female bears in northwestern Alaska. Reynolds (1980) speculated that these differences in yearly home range sizes may reflect differences in topography. The northeastern Alaska study area was in more mountainous terrain than the northwestern Alaska study area. Another factor that may have influenced home range size was the availability of caribou as a food source in the northwestern Alaska study area. Caribou are normally not available in large numbers in the northwestern Alaska study area, and bears would have to depend upon other more widely dispersed food sources.

Reproductive status of bears influenced yearly home range size (minimum area method) in northwestern Alaska (Reynolds 1980). Average yearly home ranges in order of decreasing size were: breeding males (872 km^2, range 231-1776 km^2), breeding females (290 km^2, range 98-546 km^2), subadult females (194 km^2, range 88-316 km^2), and females with offspring (181 km^2, range 39-479 km^2). Similar trends were noted for daily movements of brown bears in northeastern Alaska. Brown bears may move long distances during short periods of time, ranging from 163 km for adult males to 18 km for subadult females (Reynolds 1980); however, normal daily movements are relatively small, with 6 males averaging 6 km and 11 females averaging 4 km (Reynolds 1980).

Detailed studies of brown bears that seasonally occupy the ANWR study area have not been conducted. Observations of brown bears on the study area were recorded in 1970 by Crook (1971); in 1971 by Jakimchuk et al. (1974) and Schweinsburg (1974); in 1972 by Valkenburg et al. (1972), Quimby and Snarski (1974), Ruttan (1974), and Magoun (1976); in 1973 by Doll et al. (1974); and in 1977 by Magoun and Robus (1977). During surveys of the Porcupine Caribou herd's calving grounds, personnel from the Yukon Wildlife Branch routinely recorded all brown bear observation in late May and early June of 1978, 1979, and 1981. ANWR personnel also recorded brown bear observations during post-calving surveys in June 1981. In general, brown bears appeared on the coastal plain in late May or early June, with the majority of sightings occuring during June and July. Bear sightings are common in the foothills habitat extending from south of Barter Island west into Canada. The highest number of bear observations has usually been the area lying between the Aichilik River on the west and the Canadian border on the east. The above generalities are based upon the existing recorded observation, however, these observations have occurred over a number of years, and may not be representive of true habitat use patterns by bears. Of special note, is the observation of a brown bear on Barter Island on 25 July 1981 (Bartels 1981, pers. comm.). This bear swam across the lagoon to the island and was harassed back into the lagoon and onto the mainland.

Productivity. Sex ratios reported by by Reynolds 1974, 1976, and Curatolo and Moore (1975) for northeastern Alaska brown bears was approxiamtely 50:50 for both adults (ages 5 years or older) and young (ages 1-4 years). Reynolds (1980) recorded sex ratios that slightly favored females in both age categories (45% males and 55% females for young bears; 43% males and 57% females for adults). The northeastern populations are subject to sport hunting mortality, which normally is heaviest on males (72% of hunter killed bears in Game Management Unit 26 were males between 1962-1976, Reynolds 1980).

Age ratio data presented by Reynolds (1976) for northeastern Alaska indicated a low percentages of cubs (7.9%) and 3-4 year old bears (5.0%). Adult bears comprised 65.3% of the population. In contrast, Reynolds (1980) detected 13.0% cubs, 10.7% 3-4 year olds, and 51.9% adult bears in the population in northwestern Alaska. Based on these data, Reynolds (1980) concluded that the northeastern Alaskan brown bear populations was declining, while the status of the northwestern population was uncertain. Maximum age of northeast Alaska bears was 28 years for 23 males and 22 years for 24 females (Curatolo and Moore 1975). In northwest Alaska, maximum age was 20.5 years for 23 adult males and 7.5 years for 30 adult females (Reynolds 1980).

Sexual maturity of female brown bears on Kodiak Island and the Alaska Peninsula occurs between 3 and 6 years of age (Hensel et al. 1969), while brown bears in northeast Alaska do not successfully produce offspring until 6 to 12 years of age (Reynolds 1976). Breeding season normally extends from May through July, implantation is delayed and cubs are presumably born in January or early February in the winter den (Hensel et al. 1969). Female brown bears in northern Alaska are long-lived, with a potential for being reproductively active for 19 years in northwestern Alaska (Reynolds 1980) and 15 to 16 years in northeastern Alaska (Curatolo and Moore 1975, Reynolds 1976).

The reproductive interval (time between breeding and weaning of offspring) was 4.03 years in northwest Alaska (Reynolds 1980) and at least 4 and possibly 5 years in northeast Alaska (Curatolo and Moore 1975). Pearson (1972, 1975) recorded a 3-4 year reproductive interval for brown bears in the southern interior of the Yukon Territory, while a 4 year reproductive interval was reported for brown bears in the northern Yukon Territory (Pearson 1976).

Litter size for brown bears ranges between 1.58 and 2.34 cubs per litter (Table 15) with litter sizes in northeast Alaska being lower than most other localities in North America. When low litter size, longer reproductive interval, older age at sexual maturity, and shorter potential reproductive period are combined, the overall low productivity of brown bears in northeast Alaska is apparent.

Table 15. Reported litter sizes for brown bears in North America (Adapted from Curatolo and Moore 1975).

Litter Size	Location	Reference
2.34-2.08	Yellowstone National Park, Wyoming	Craighead et al. 1974
2.3	Southcentral Alaska	Glenn and Miller 1970
2.25	Kodiak Island, Alaska	Troyer and Hensel 1964
2.23	Kodiak Island and Alaska Peninsula	Hensel et al. 1969
2.1-1.8	central Brooks Range, Alaska	Crook 1972
2.03	northwest Alaska, NPR-A	Reynolds 1980
2.00	Glacier National Park, British Columbia	Mundy and Flook 1973
1.81	Mount McKinley National Park, Alaska	Dean 1976
1.8	Arctic Mountain, Northern Yukon Territory	Pearson 1976
1.8	northeastern Alaska, Canning River	Curatolo and Moore 1975, and Reynolds 1976
1.7	Glacier National Park, Montana	Martinka 1974
1.63	Canning River drainage, Alaska (mountainous portion)	Quimby 1974
1.60-1.58	southern Yukon Territory	Pearson 1972, 1975

Mortality. Pearson (1976) indicated that normal mortality factors such as disease, parasites, and malnutrition have little impact on brown bears. Most mortality factors that have been identified are either intraspecific mortality or man-induced mortality. Numerous researchers have documented that intraspecific mortality occurs in brown bears (Troyer and Hensel 1962, Mundy and Flook 1973, Reynolds 1974, Curatolo and Moore 1975, Pearson 1975, Glenn et al. 1976, Pearson 1976, Reynolds 1976, 1980). The extent of this mortality is unknown, however intraspecific mortality could be contributing to the high mortality rates in young bears in northeast Alaska (Curatolo and Moore 1975). Some over-winter mortality has been recorded, but causes of this mortality are unknown (Pearson 1972). Human-induced mortality occurs as the result of subsistence and sport hunting. Brown bears using the ANWR study area are subject to both sport and subsistence hunting. Present state regulations limit the sport hunt to 7 permits in the fall and 3 permits in the spring. These drawing permit hunts are for the Brooks Range north of the continental divide in ANWR. The portion of the harvest occurring on the ANWR study area is unknown. Subsistence hunting does occur, but brown bear are not a staple of Kaktovik subsistence hunters (see Chapter 7).

Habitat

Bears are opportunistic ominvores and their habitat use patterns are a reflection of this foraging strategy (Hetchel 1978, included in Reynolds 1980). Those habitats with abundant food resources are used on an as available basis and bears readily shift their areas of use when new food sources become available. Habitat use patterns are seasonal and begin each year when bears emerge from the winter dens.

Den emergence on the North Slope of Alaska and Canada begins in mid-April when adult males become active. Females with new cubs are not common until mid-May (Quimby 1974a, Ruttan 1974, Harding 1976). This pattern of earlier emergence by adult males is similar to brown bears in other areas, although the timing of emergence is usually earlier in more southern latitudes (March and April in Yellowstone Park, Craighead and Craighead 1972). Quimby (1974a) noted that bears on the south slope of the Brooks Range emerged several weeks later than North Slope bears, but offered no explanation for this difference. Post-denning movements were usually from the den site into the major river drainages and downstream (Ruttan 1974). Quimby (1974a) noted that carrion was an important food source at this time and that bears traveling down the Canning River valley in April and May where primarily using carrion and exposed vegetation. Linderman (1974) noted that caribou and moose carrion was especially important to a bear he ground tracked along the Canning River between 10 May and 30 June 1974. Bears also used root materials of Astragalus spp., Oxytropis spp., and Hedysarum spp. in May and early June (Quimby 1974a, Reynolds 1979, 1980), while overwintering bearberries (Arctostaphylos alpina) were used heavily by the ground tracked bear (Linderman 1974).

During the summer months, bears appeared to move from the major river valleys (Curatolo and Moore 1975), dispersity to higher elevations to feed upon Equisetum spp. (Linderman 1974, Quimby 1974a, Reynolds 1979, 1980). In and adjacent to caribou calving grounds, bears use caribou both as prey and carrion. Bears kill both adults and calves (Lent 1964, Skoog 1968, Doll et al. 1974, Reynolds 1979, 1980). Brown bear densities in the vicinity of the Western Arctic caribou herd's calving grounds in NPR-A were estimated as approximately 6 times higher than estimated densities throughout the remainder of the North Slope of the Brooks Range. This bear population was also more productive than bear populations studied along the Canning River drainage in northeastern Alaska. Reynolds (1980) concluded that the high density and increased productivity was probably due to the availability of caribou as carrion and prey.

Bears did not extend their normal home ranges to take advantage of caribou calving in NPR-A. Rather, bears were more dependent upon the cariou being within or moving through the bear's established home range (Reynolds 1980). Pearson (1976) also did not detect a shift in home ranges of bears to take advantage of migrating caribou in the Barn Mountains of the Yukon Territory. Bears in the Barn Mountains did move north along drainages in the spring and onto the coastal plain. Observations of brown bears in the ANWR study area also indicate a general northward movement in the late spring and early summer (see previous discussion). However, reasons for this movement are uncertain although bears have been routinely observed during survey flights of the Porcupine caribou herd during calving.

During August and September, bears move back into the river valleys and move upstream to denning areas (Quimby and Snarski 1974, Ruttan 1974, Pearson 1976). Food habits during this period consisted primarily of soapberries (Shepherdia canadensis) along the Canning River (Quimby 1974a, Reynolds 1974, Curatolo and Moore 1975). Excavations of arctic ground squirrels was also more intensive during this period, although colonies of these rodents are exploited by bears throughout the summer (Quimby 1974a, Hechtel 1978 included in Reynolds 1980).

Brown bears in the Arctic normally enter dens during the first 2 weks in October, however denning has been recorded as early as 29 September (Quimby 1974a, Quimby and Snarski 1974, Curatolo and Moore 1975, Reynolds et al. 1976, Reynolds 1979, 1980). Contrary to brown bears in Yellowstone Park (Craighead and Craighead 1972), dens were dug 2 or 3 days prior to entering them for the winter. In Yellowstone, bears often dug dens 4 to 6 weeks before entering them for the winter. Inclement weather, especially snow storms, is considered a major factor in stimulating denning activity (Craighead and Craighead 1972, Reynolds 1980).

In the Arctic, continuous permafrost is the rule, and bear dens are dug into coarse textured soils that are seasonally free of permafrost to a depth of at least 1.5 m (Reynolds et al. 1976, Reynolds 1980). This soil texture causes excavations to collapse unless the top 10 cm of soil are frozen. Therefore, bears in the Arctic cannot dig dens until air tempertures of -10^0C or less have frozen the upper layer of the soil (Pearson 1976, Reynolds 1980). Unlike dens described for bears in Yellowstone National Park (Craighead and Craighead 1972), Alaska peninsula (Lentfer et al. 1972), south slopes of mountains in the Yukon Territory (Jakimchuk et al. 1974, Ruttan 1974), southern Yukon Territory (Pearson 1975), Richards Island in the Northwest Territories (Harding 1976), and Alberta (Vroom et al. 1980), Arctic dens did not have shrubby or woody vegetation surrounding the densite and providing structural support for the den chamber (Canning River and northeast Alaska - Quimby 1974a, Quimby and Snarski 1974, Curatolo and Moore 1975, Reynolds et al. 1976; Barn Mountain in Yukon Territory - Pearson 1976; NPR-A in northwest Alaska - Reynolds 1979, 1980). Most dens in the Arctic collapse after the top layer of soil thaws in the spring, therefore little reuse of dug dens occurs (Reynolds et al. 1976, Reynolds 1980)

Dens are dug into slopes of foothills and mountans. In NPR-A, no preference for slope orientation was detected (Reynolds 1979, 1980), however, in northeast Alaska, 90% of the located dens were on south-facing slopes (Reynolds et al. 1976). In most instances, dens were located in areas that accumulated thick layers of snow over the den. In the Arctic, this factor is largely determined by prevailing winds, however, in other areas, the shrubby or woody vegetation assists in accumlating snow over the den. One den located in the foothills north of the Sadlerochit Mountains in 1973 may have been in the ANWR study area (Quimby 1974a).

Several snow dens have been recorded for brown bears on the Alaska peninsula (Lentfer et al. 1972), the Yukon Territory (Ruttan 1974), and the Norhwest Territories (Harding 1976). Although bears apparently over wintered in these dens, snow is not considered "normal" denning habitat. In northeast Alaska, bears apparently use rock caves as winter dens (Quimby 1974a, Quimby and Snarski 1974, Reynolds et al. 1976). Of 52 active and inactive dens located during these studies, 13 were in rock caves. All the rock caves den sites had vegetation either at or near the cave opening and bears used this naterial to form a nest-like bed (Reynolds et al. 1976). Only 1 of the 13 rock cave dens was located north of the continental divide in the Brooks Range (Quimby 1974a).

Jakimchuk et al. (1974) postulated that lack of adequate den sites may limit northern Yukon brown bear populations. Other researchers (Quimby 1974a, Quimby and Snarski 1974, Curatolo and Moore 1975, Reynolds et al. 1976) did not believe denning habitat was a limiting factor on bear populations in northeastern Alaska.

Data Gaps

Brown bears use the ANWR study area during the summer months, but the nature of this use is poorly understood. The role that predation and scavanging on caribou plays in brown bear ecology on the ANWR study area is unknown. Bears may den on the ANWR study area, but the location and extent of denning is unknown. Pearson (1976) thought that brown bears denned in the foothills adjacent to the coastal plain in the Yukon Territory, but was unable to verify that use. In the Northwest Territories, bears denned in the foothills immediately adjacent to the coastal plain in the Mackenzie River delta.

Wolf (*Canis lupus*)

Distribution, Range and Population Size

Wolves are found throughout most of the remote regions of the Northern Hemisphere which remain relatively undeveloped by humans (Mech 1970). In North America wolves once occupied nearly the entire continent. Today they can be found in most of Canada and Alaska, parts of northern Minnesota and Montana and certain regions of Mexico (Cahalane 1964, as cited by Mech 1970). Most taxonomists recognize 32 subspecies of wolves, of which 24 occur in North America (Mech 1970). Wolves inhabiting the ANWR study area have been identified as *C. l. tundarum*, the Alaskan tundra wolf (Hall and Kelson 1959, as cited by Mech 1970).

Examination of recent reported sightings of wolves in or adjacent to the ANWR study area (Table 16) indicate that wolves have been sighted more often in the foothills and mountain valleys to the south of the study area. Biological consultants working for Arctic Gas Ltd. in 1972 recorded 56 wolf sightings north of the continental divide in northeastern Alaska, only 6 of which were in the AWNR study area (Quimby and Snarski 1974).

During the past 10 years, active wolf dens have been found in mountainous terrain of the Hulahula, Canning and Kongakut drainages. Although wolves are known to den on the coastal plain to the west of the refuge (Stephenson 1975), no dens have been found in the ANWR study area. In 1973, Quimby (1974b) identified 4 wolf packs and their corresponding home ranges in the Canning River drainage south of the ANWR study area. Wolf tracks and trail systems observed in the snow indicate that members of a wolf pack ranging in the Cache-Eagle Creeks area may occasionally travel across southern portions of the ANWR study area in the vicinity of the Sadlerochit Mountains (Thayer pers. comm.). It is generally believed that wolves range primarily in the arctic foothills and mountains of the Brooks Range and are more abundant there because prey species such as Dall sheep and moose are also more abundant in these areas on a year-round basis (Thayer pers. comm., Stephenson pers. comm.). Wolves tend to be less abundant on the coastal plain of the refuge because prey is less abundant on a year-round basis (Stephenson per. comm.). When caribou are abundant in the ANWR study area (May and June) most wolves are occupied with denning activities in the mountains to the south. The hunting range of denning wolves is usually limited to about a 32 km radius from the den site (Stephenson per. comm.). Thus, wolf predation on caribou in the ANWR study area during calving and post-calving is probably low. Current numbers, movement patterns, and requirements of wolves which occasionally use the ANWR study area are not known.

Life History

Wolves are the largest wild members of the dog family (Canidae). Adult males from most areas average 43 to 45 kg., while adult females tend to range from 36 to 39 kg. (Mech 1970). Their pelage ranges in color from white, to gray, brown, and black. Wolves have evolved to become one of the most widely distributed and proficient predators (Mech 1970).

Wolves are gregarious animals with a highly developed social behavior which is primarily manifested in the social unit or pack. Wolf packs are loosely associated groups of animals, often family members (Mech 1970). A hierarchy system usually limits breeding activity to only the top female and male of the pack. Breeding in Alaska occurs in the late winter from late February through March (Rausch 1967). Dens are prepared or visited by the pregnant female as much as 4-5 weeks prior to parturition (Chapman 1977). The pups are usually born in mid-May to early June in arctic areas (Chapman 1977). The average litter size for wolves is 4.0 to 6.5, but may vary somewhat due to many factors (Mech 1970). Within 11 to 15 days the pup's eyes open and in about 3 weeks the pups begin to emerge from the den opening (Chapman 1977). Whelping dens are used for varying lengths of time. In the arctic, dens are usually abandoned in July, however some may be occupied as late as August (Chapman

Table 16. Some recent wolf sightings in or adjacent to the ANWR study area.

Date	Location	Number/color	Activity	Source
30 Mar. 1969	coastal plain S. Barter Island	2/gray	------	Griffin 1969
9 Apr. 1970	Snow Creek	1/gray	standing	Thayer 1970
10 Apr. 1970	Canning R. w. of Mt. Capleston	1/gray 2/black	feeding on moose	Thayer 1970
10 Apr. 1970	Hulahula R. S. of Kikitak Mts.	2/gray	running	Thayer 1970
29 May 1972	Aichillik R. (foothills)	2/N.A.	moving north	Blackhall 1972
14 July 1972	Aichillik R. (foothills)	1/gray 1/black	running	Doll et al. 1972.
1972	lower Aichillik R. (10 mi. from coast	1/black	N.A.	Quimby and Snarski 1974
1972	10 mi. S.E. of Barter Island	1/black	N.A.	Quimby and Snarski 1974
1972	15 mi. S. of Barter Island	1/black 1/gray	N.A.	Quimby and Snarski 1974.
1972	Itkilyariak Creek near Sadlerochit Mtns.	1/black	N.A.	Quimby and Snarski 1974
1972	Jago R. (foothills)	1/gray	N.A.	Quimby and Snarski 1974
1972	Canning R. (10 mi. N. of Ignek Creek	1/black	N.A.	Quimby and Snarski 1974.
1972	Sadlerochit Mtns. (5 mi. E of Katakturak R.)	2/black	N.A.	Quimby and Snarski 1974
1972	Upper Sadlerochit River	2/black 1/gray	N.A.	Qimby and Snarski 1974
1972	Canning River (Cache and Eagle Creeks)	Numerous sightings	N.A.	Quimby and Snarski 1974 Magoun 1976
25 June 1977	Marsh Creek (12 mi. from coast)	3/N.A.	resting	Magoun and Robus 1977
30 July 1977	Konganavik Pt.	1/gray	trotting	Magoun and Robus 1977
July 1981	Jago R. (coastal plain)	1/gray	N.A.	Ross pers. comm.
4 March 1982	Canning R. (near Eagle Creek)	2/gray 5/black	feeding on kill	Ross pers. comm.

1977). Rendevous sites are used during the summer where the pups are left while the adults are hunting. Both parents, as well as other members of the pack hunt and care for the young.

Summer food items of wolves in the north-central Brooks Range (determined by analysis of scats) are predominantly large ungulates (caribou, Dall sheep and moose) (Stephenson 1975). Significant quantities of microtine rodents, ground squirrels, birds, eggs, and insects are also utilized during summer by wolves in arctic Alaska (Stephenson and Johnson 1972). During the remainder of the year, large ungulates are often utilized even more exclusively. In some locations such as the Northwest Territories in Canada (Kuyt 1972) and northwestern Alaska (Stephenson 1979), wolves tend to shift their ranges in correspondence with seasonal caribou migrations. Similar shifts may not be as prevalent in the northcentral and northeastern Brooks Range due to a greater abundance of less migratory prey (Dall sheep and moose).

Habitat, Location, Extent and Carrying Capacity

Judging from the locations of reported sightings it is apparent that wolves roam throughout the ANWR study area and probably utilize most habitats of the area. Information is insufficient to determine if certain habitats or portions of the ANWR study area are preferred by wolves. Wolf den sites in arctic Alaska usually are found on moderately steep southern exposures where the soil is well drained and unfrozen (Stephenson 1974). Land forms such as cut banks, escarpments, dunes, kames and moraines are often associated with wolf dens (Stephenson 1974). Although no wolf dens have been found within the ANWR study area, the basic habitat requirements for denning appear to be present.

Wolves were relatively abundant prior to aerial wolf hunting and predator control activities which began in earnest on the North Slope of Alaska in the mid-1950's (Stephenson per. comm.). By 1962 it was recognized that wolf numbers on the North Slope were depressed and an annual bag limit of 2 wolves was imposed (Stephenson and Johnson 1972). In 1970 aerial hunting of wolves on the North slope was banned. Wolf populations on the North Slope have remained low, however, due in part to continued illegal aerial hunting and persistent harvest with the use of snow mobiles (Stephenson per. comm.). Wolf population density estimates for the north-central Brooks Range in 1971-1972 ranged from 1/320 km^2 to 1/194 km^2 (Stephenson 1975). Following surveys and studies of wolves in the NPR-A, wolf densities of 1/520 km^2 (coastal plain) and 1/130 km^2 (foothills and mountains) were estimated (Stephenson 1979). In the Canning River area, Quimby (1974b) reported a 1973 density of 1/596 km^2 in the spring and a fall density of 1/181 km^2. The determination of carrying capacity of wolf habitat is a complex problem and is poorly understood. Apparently the density of wolves in a given range is influenced by many factors such as prey abundance, social dynamics of packs, human disturbance and harvest levels, diseases, and many other ecological relationships.

Natural Processes and Human Activities

There are numerous naturally occurring processes which influence mortality and population numbers. Pre-birth mortality (in utero) has been reported by Rausch (1967). The causes of such mortality, however, remain undetermined. Following birth, there are numerous mortality factors such as canine distemper, rabies, malnutrition, parasites, cannibalism, predators (golden eagles, grizzly bears), porcupine quill infection, and accidents (Murie 1944, Kuyt 1972, Stephenson and Johnson 1972, Chapman 1977, 1978). In analyzing reported data from 22 wolf litters in a variety of locations in North America, Chapman (1977) found an average summer survival rate of 85% for wolf pups. High mortality rates of wolf litters has been reported in cases where food supply is limited, or declines (Kuyt 1972, Mech 1977). It is believed that certain social mechanisms such as stress, competition and subordination may also function to control wolf populations (Mech 1970).

In the ANWR study area, prey abundance seems to influence general distribution of wolves in the region. In the summer of 1977 rabies killed all known members of a wolf pack on the Hulahula River (Chapman 1978). Little is known about other natural factors which may affect wolves in the ANWR study area.

In the past, human activity has often had negative consequences for wolves. The extirpation of wolves from extensive areas of North America and Eurasia has been directly associated with human settlement activities. Predator control and bounty programs using guns, traps, and poison effectively removed the wolf from major agricultural areas of the U.S. and Canada. In Alaska, Government sponsored aerial hunting and poisoning of wolves during the 1940's and 1950's greatly reduced wolf populations in some areas of the State (Rausch and Hinman 1977). It should be noted that in arctic Alaska where wolves are particularly vulnerable to hunting from airplanes and snow mobiles, wolf numbers remain low (Stephenson per. comm.). The current harvest of wolves from the study area is unknown.

Wolverine (<u>Gulo gulo luscus</u>)

<u>Distribution, Range and Population Size</u>

Wolverines are circumpolar in distribution, inhabiting the remote northern coniferous forest and tundra regions of North America and Eurasia. In North America the wolverine is found throughout most of Alaska, the Yukon and Northwest Territories, British Columbia, the Rocky Mountains of Canada and northern U.S., the northern portions of the Prairie Provinces of Canada, and the remote regions of Ontario, Quebec and Labrador (Rausch and Pearson 1972, van Zyll de Jong 1975,). Throughout it's global distribution, the wolverine is noted for its avoidance of humans, solitary-wide ranging nature, and sparse densities. These characteristics have made it difficult for biologists to study the wolverine and obtain detailed knowledge about this species.

Little is known about wolverines in the ANWR study area. Field observations incidental to other activities and limited harvest reports have documented that wolverines inhabit the study area (Table 17).

Table 17. Some recent wolverine sightings in or adjacent to the ANWR study area.

Date	Location	Number of wolverines	Activity	Source
Mid-August 1980	Pingokraluk Pt. (near Demarcation Bay)	1	feeding on caribou carcass	Levison, unpubl. data 1980.
23 June 1979	Mouth of Itkilyariak Creek	1	hunting	Robus unpubl. field notes, 1979.
28 June 1979	1/2 mi. s. of mouth of Itkilyariak Creek	1	feeding on caribou calf	Robus unpubl. field notes, 1979.
24 May 1972	Aichillik R. (foot-hills)	2	seen by tent	Blackhall, 1972
1972	coast of Canning delta	1	N.A.	Quimby and Snarski 1974.
18 May 1972	VABM Gwen (lower Kongakut drainage).	1	traveling	LaPerriere, unpubl. note, 1972

During extensive studies in the early 1970's, biological consultants working for Arctic Gas Ltd. recorded a total of 26 wolverine sightings in northeastern Alaska (Quimby 1974b). Ten sightings (out of 26) were located north of the continental divide, and only 1 of which occurred within the ANWR study area (Quimby and Snarski 1974). Most wolverines that were seen north of the continental divide were in the mountain valleys of the Canning River drainage, particularly Cache and Eagle Creek (Quimby and Snarski 1974). Recent reported wolverine harvest from the study area has averaged about 1 animal per year. The actual annual harvest may be higher due to incomplete reporting. In general it appears that very few wolverines are present in the study area (Quimby 1974b). Although comprehensive data on wolverine densities and population size in the Alaskan Arctic are lacking, it is generally believed that in at least some select locations to the west, wolverine densities are higher than in the ANWR study area (Magoun In prep.). In an intensive life history study of wolverines in northwestern Alaska, Magoun (In prep.) recorded an over-all density of 1/70 km^2 (includes resident adults of both sexes, subadults and kits of the year). Since there has been no specific study of wolverines in the ANWR study area, essentially nothing is known about the actual population size, range, habitat use, food habits, and other ecological aspects of the species.

Life History

The wolverine is the largest terrestrial member of the weasel family (Mustelidae). Adult males weigh up to 20 kg. (average weight for males is about 13 kg.), while females average about 9.5 kg. (Rausch and Pearson 1972). Wolverines are noted for their stocky body build and powerful musculature. Tooth structure and composition indicate that the wolverine has evolved primarily as a scavenger, although it functions as a predator as well.

Adult wolverines usually breed in late spring and early summer (Rausch and Pearson 1972). Magoun (In prep.) observed adult wolverines breeding in early June in northwest Alaska. Rausch and Pearson (1972) reported that some female wolverines mature at about 1 year and produce their first litters when they are 2 years old. In northwest Alaska, Magoun (In prep.) observed a young female wolverine (17 or 29 months old) breeding in early August, however, no young were produced. Following breeding, the embryos are not implanted until during winter. The average litter size (based on fetuses recovered from carcasses) for 54 Alaskan and Yukon wolverines was 3.5 (Rausch and Pearson 1972) Only 1.8 young/litter (based on 4 observations of 2-3 month old kits with maternal females) were recorded by Magoun (In prep.) in northwest Alaska.

Young wolverines are born in late winter (early March in northwest Alaska, Magoun 1972) in snow dens. They grow rapidly and usually are able to move out of the den within a month (Magoun In prep.). By fall the young wolverines are nearly full-grown. Based on a limited number of relocations of radio-collared animals in northwest Alaska, it appears that young wolverines disperse from their mothers during the period of January-May (Magoun In prep.).

The food habits of the wolverine reflect an opportunistic feeding behaviour. Wolverines have been reported killing large ungulates such as dall sheep, caribou, and moose (Burkholder 1962, Haglund 1974, Gill 1978). It is generally thought, however, that in Alaska the wolverine is more often a scavenger than a predator of the large ungulates (Rausch and Pearson 1972). Magoun (In prep.) found that food items in the wolverine's diet in northwest Alaska varied with season. Arctic ground squirrels were an important food item throughout most of the year. Caribou were utilized in May and June when large numbers were in the area studied. During June and July, wolverines also prey on birds and nests. An important winter food for wolverines in the tundra environment appears to be ground squirrels that are cached from the fall or excavated from their hibernacula (Magoun In prep.).

Habitat

Based on observations and tracks noted during studies in the early 1970's, it is apparent that wolverines frequent all types of terrain within the ANWR study area (Quimby and Snarski 1974). Features such as rivers and mountains do not inhibit wolverine movements (Magoun 1979). Magoun (In prep.) found that adult female wolverines with young were territorial and occupied considerably smaller home ranges than adult males. Snow drifts are important habitat for wolverine den sites (Pulliamen 1968). In the tundra environment, remnant snow drifts in small drainages with associated meltwater caverns were found to be an important rearing habitat used by maternal females and their offspring (Magoun In prep.). In northwest Alaska, females with young inhabited 3 general habitat types (Tussock meadows, vegetated upland tundra, and bare hilltops) 70% of the time. The amount each type was used seemed to depend on the specific setting of each individual territory and the season of the year (Magoun In prep.).

Impacts to Natural Processes and Human Activities

Little is known about how wolverine populations respond to the influences of natural processes. Some observations have been reported of wolves killing wolverines (Boles 1976), however, the significance of such mortality is not understood. Several authors indicate that food availability may be a factor in wolverine mortality, and abundance (van Zyll de Jong 1975, Hornocker and Hash 1981).

Circumstantial evidence indicates that wolverine abundance throughout much of eastern and central Canada declined as a result of human exploitation (van Zyll de Jong 1975). Hornocker and Hash (1981) reported that 15 out of 18 wolverine mortalities noted during an intensive study in northwestern Montana, were human caused. In tundra areas such as the ANWR study area wolverines are especially vulnerable to human harvest due to the high visibility of the animals or their tracks from airplanes and snow mobiles. Currently an average adult wolverine pelt is worth about $175.00 to $225.00 (Anderson 1981). Wolverine pelts are highly prized by Inupiat Eskimos for parka ruffs. Prices paid for wolverine pelts in Eskimo villages is often considerably higher than quoted fur prices. Due to the lack of detailed information regarding the status of wolverines in the ANWR study area, the impact of present human harvest can not be adequately evaluated.

Data Gaps

Very little is known about wolverines which inhabit the ANWR study area. In order to make definitive statements regarding the consequences of oil and gas exploration (seismic as well as exploratory drilling), and development and production, information is needed on relative abundance and distribution of wolverines, as well as investigate population dynamics, movements, food habits, and other ecological characteristics. In addition, studies of wolverine behaviour may be needed to attempt to determine tolerances to human disturbance and habitat loss.

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Rodents

Rodent species occurring on the ANWR study area include arctic ground squirrel, northern red-backed vole, tundra vole, brown lemming, and collared lemming. The following materials present current knowledge for the arctic ground squirrel. Information on the remaining species and other small mammals (shrews) is currently being synthesized and will be included in subsequent annual updates of this report.

Arctic Ground Squirrels (Spermophilus parryii)

Arctic ground squirrels are distributed across most of northern Alaska (Nodler and Hoffman 1977, Batzli and Sobaski 1980). Specific studies dealing with ground squirrels have been conducted only on areas south and east of Barrow (Mayer 1953), near Cape Thompson (Carl 1971), and near Atkasook (Batzli and Sobaski 1981). Arctic ground squirrels are found throughout the ANWR study area, but no studies have dealt specifically with this population.

Arctic ground squirrels are found in colonies restricted to well-drained soils, which are free of permafrost (Mayer and Roche 1934, Melchior 1964). Such areas are found along ridges, river sand banks, hillocks, and other raised areas in sandy soils (Mayer 1934).

The home range of the arctic ground squirrel is large when compared to other rodents in the same genus. Mayer (1953) recorded instances of individuals foraging over 1370 m from their burrows. However, most foraging occurred within 30 m of the burrow (Batzli and Sobaski 1980). Batzli and Sobaski (1980) calculated home ranges of 4.3 ha for adult males and 3.2 ha for adult females. These home ranges varied in colonies located in different habitats, as well as throughout the summer season. Generally poorer habitat requires a larger home range. Densities of 1.3 to 1.7 animals/ha were found near Atkasook. This figure is 4 to 5 times lower than populations at more southern latitude (Batzli and Sobaski 1980).

Batzli and Sobaski (1980) found herbaceous dicotyledons comprise 25%-75% of the diet of the ground squirrels near Atkasook. This plant material included over 40 species of forbs and shrubs. Evergreen shrubs, lichens, and insects comprised a very small percentage of the diet. Mayer (1953) cites examples of arctic ground squirrels eating meat and even being cannibalistic.

Arctic ground squirrels are subjected to severe climatic stresses, and hibernate in winter. Mayer and Roche (1954) state: "In their habitat on the wet, flat, treeless, arctic tundra the ground squirrels are exposed to extreme cold during the months from October to May. Although certain rodents such as lemmings of the genera Lemmus and Dicrostonyx are active throughout the winter period, the ground squirrel resorts to hibernation to avoid the rigors of the environment. During a maximum activity period of five months adults must gain back not only weight lost during the previous winter's hibernation but also that lost in the demanding post-emergent breeding season."

Hibernation is entered in September and emergence occurs before the land is snow free in May (Mayer and Roche 1954). Upon emergence in May, ground squirrels feed on vegetation stored from the previous season. They also eat dead and frozen vegetation that can be dug through the snow (Mayer and Roche 1954).

Arctic ground squirrels mate in May. After a gestation period of 25 days, average litters of about 8 young are produced (Mayer and Roche 1954). The young squirrels then undergo rapid growth and development. Mayer and Roche (1954) summarized: "In three months of above ground foraging the young of the year must attain sufficient size and weight to allow them to enter hibernation in the fall and to emerge in the spring in breeding condition."

Ground squirrels are occasionally utilized as a subsistence food source by Kaktovik residents (See Chapter 7). However, their greatest importance probably lies in the role of a prey item in the arctic food web. The arctic ground squirrel is preyed upon by raptors, such as snowy owls and rough legged hawks. Gulls and jaegers are known to feed on them (Pruitt 1966). A large portion of the diet of foxes and grizzly bears is ground squirrels (Pruitt 1966). Banfield (1958) felt that the central Canadian arctic population of grizzly bears could not survive in areas devoid of ground squirrels. The extent of ground squirrel use by grizzly bears on the ANWR coastal plain is not known. However, many ground squirrel colonies were noted to have been excavated by grizzly bears during the summer of 1981 (R. Bartels pers. comm.)

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Chapter 6

FISH

This chapter presents information relevant to fishery resources on the ANWR study area. Habitat description and data are presented first and are followed by species descriptions of those species for which data and literature are available. The final section of this chapter describes the major data gaps concerning fishery resources within the ANWR study area.

Habitat Description

Overwintering areas are perhaps the greatest limiting factor for arctic anadromous and freshwater fish populations because severe winter conditions in the Arctic drastically reduce available water supplies. Many sections of river channels and coastal lakes (less than 3 m in depth) freeze solid. Winter flow is generally immeasurable (Murphy and Greenwood 1971, Arnborg et al. 1972, McCart et al. 1972). During this period water sources are limited to spring areas, deep isolated pools, deeper lakes and brackish river delta areas (Wilson et al. 1977). Known and potential overwintering areas are depicted in Fig. 1.

Springs provide the major source of water to downstream overwintering areas (Childers et al. 1973, Craig and Poulin 1974). The importance of springs for overwintering and spawning for arctic fish populations has been well documented (Yoshihara 1972 and 1973, McCart and Craig 1973, Craig and McCart 1974, Furniss 1974 and 1975, Alt and Furniss 1976, Craig 1977b,). All stages of char life history are present in spring areas (Glova and McCart 1974, Craig 1977c). McCart et al. (1972) found that the abundance and diversity of macroinvertebrates in springs and spring fed sections of the channel was much greater than in other arctic lotic habitats.

Several springs have been identified on and adjacent to the ANWR study area (Fig. 2). The cumulative discharge of springs on the Canning River drainage is one of the largest on the North Slope (Childers et al. 1977) The largest on the Canning River is Shublik Springs located on the southwest end of Coplestone Mountain. The discharge from this spring remains fairly constant throughout the year at about 24 cfs (Table 1). Sadlerochit Spring, the largest known spring on the North Slope that issues from a single bedrock source, is within the ANWR study area. This spring is located on the east end of the Sadlerochit Mountains and has a fairly constant discharge of about 37 cfs (Childers et al. 1977). Red Hill Spring, one of the few known hot springs on the North Slope, is located on the west end of the Sadlerochit Mountains. Childers et al. (1977) reported water temperature at Red Hill Spring in April, 1975, to be 32.8°C with discharge at 0.85 cfs. Red Hill Spring drains into the Tamayariak River.

Large sheets of ice, or aufeis, that may measure several kilometers in width and several meters thick are formed below springs during winter. These icings have been reported up to 50 km^2 on the lower Kongakut River (Childers et al. 1977). The area, thickness and location of these icings are primarily dependent on the volume of water supplied by the spring and to a less extent on the water temperature, air temperature and topography of the ice accumulation area. Icings are slower to melt than snow cover and some persist

Table 1. Selected chemical and physical characteristics for springs on the North Slope, ANWR (Adapted from Childers et al. 1977).

Station Name	Latitude	Longitude	Date	Discharge (cfs)	Specific Conductance (micromhos/cm at 25°C)	pH	Water Temperature (°C)	Turbidity (JTU)	Dissolved Oxygen (mg/l)
Shublik Spring	69°28'20"	146°11'50"	05-10-73	24	275	8.0	5.5	--	--
			04-28-75	24	270	7.9	5.5	1	9.8
Red Hill Spring	69°37'37"	146°01'38"	04-28-75	0.85	1000	7.0	33.0	2.0	0.4
			08-12-75	--	950	8.2	29.0	--	--
Katakturuk River Trib. Spring	69°41'42"	145°06'33"	04-28-75	4.28	245	8.2	1.0	1	11.4
Sadlerochit Spring	69°39'23"	144°23'37"	04-27-75	35	410	7.9	13.0	1	7.0
			08-07-75	37.4	400	7.9	13.0	--	6.2
			11-16-75	38.7	360	7.3	--	--	--
Hulahula River Spring	69°45'39"	144°09'15"	04-28-75	7.3	240	8.0	1.0	1	13.6
			11-26-75	4.6	225	7.2	1.0	--	--
Okerokivik River Spring	69°43'06"	143°14'25"	11-24-75	26	300	7.3	1.0	--	--
Aichilik River Spring	69°31'06"	143°02'00"	04-27-75	1.5	338	8.0	3.6	2	12.4

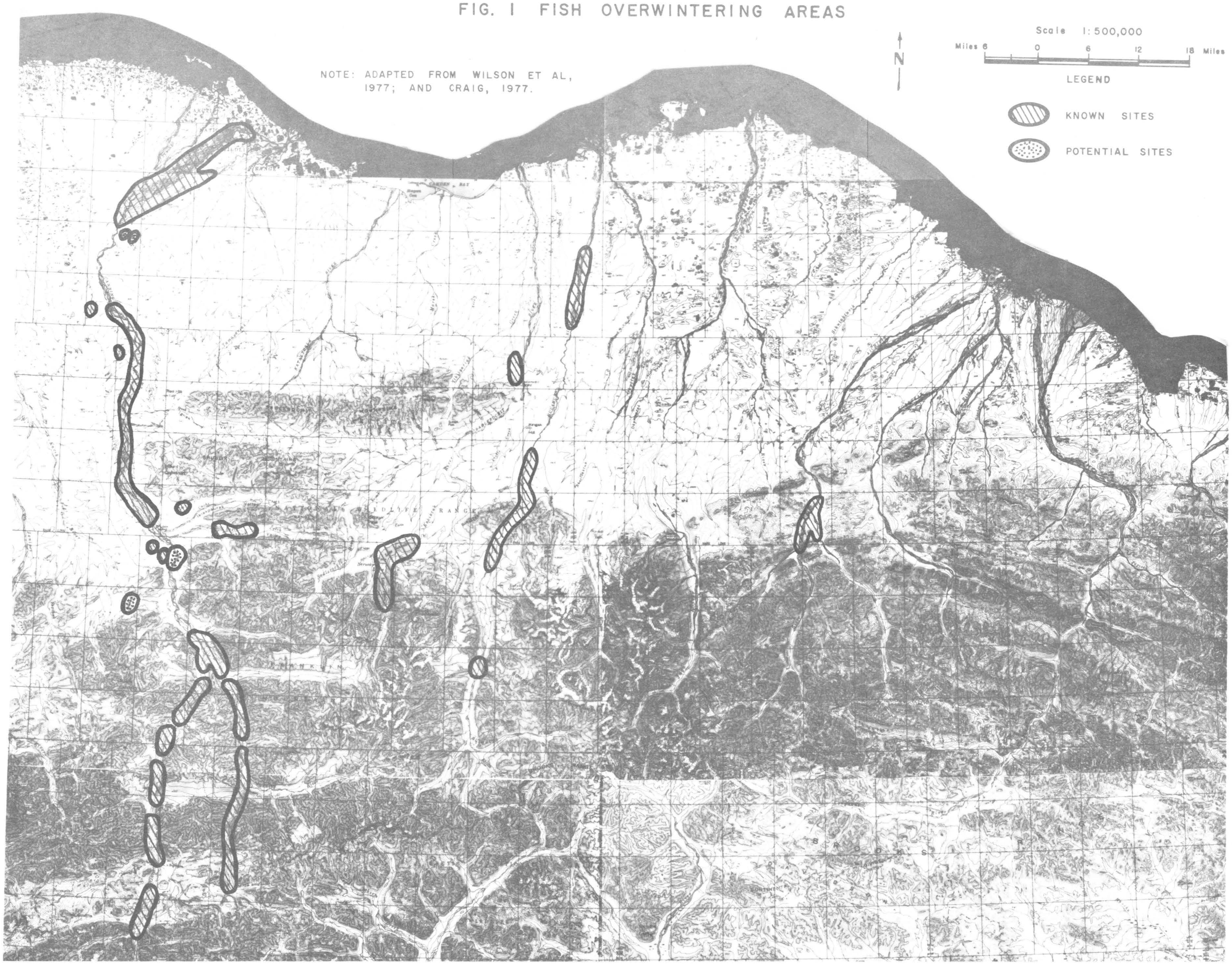


FIG. 1 FISH OVERWINTERING AREAS
NOTE: ADAPTED FROM WILSON ET AL, 1977; AND CRAIG, 1977.
N
Scale 1:500,000
Miles 6 0 6 12 18 Miles
LEGEND
KNOWN SITES
POTENTIAL SITES

FIG. 2 LOCATION OF SPRINGS AND ICINGS

throughout the year. One icing on the Echooka River was 4.9 m thick in July (Childers et al. 1977). These icings can have a major effect on stream channel configuration and on riparian vegetation in the area in which they are formed. On the Canning River, icings are extensive and are almost continuous by late winter from the upper Marsh Fork throughout the entire length of the main channel. One of the largest icings in the study area occurs in the Canning River delta. Icings are common on many of the drainages on the ANWR study area (Fig. 2).

Deep river pools may also provide overwintering habitat for arctic fishes. Furniss (1975) stated that arctic rivers generally range from 1.8 to 3.6 m in depth, but freezing can reduce available habitat to 0.3 to 0.4 m. Mann (1975) stated that fish may not be able to overwinter in water less than 0.5 m in depth. Some surveys indicate that arctic fishes inhabit pools generally deeper than 2 m (Yoshihara 1972, Furniss 1974 and 1975), but Alt and Furniss (1976) found pools in the Sagavanirktok River with depths less than 2 m, harboring overwintering populations of fish. Deep pools on some drainages of the ANWR appear to be relatively scarce. On the Canning River during August, pools were measured by Smith (unpublished data) utilizing a recording fathometer. No pools were recorded over 2.7 m deep from the confluence of Eagle Creek and the Canning River to the Staines River. Similar conditions were observed on the Sadlerochit and lower Hulahula Rivers. Spring and groundwater areas are probably utilized extensively for overwintering on these and other streams in or adjacent to the ANWR study area.

Several parameters are intimately involved with the suitability of river pools for overwintering. These ultimately effect dissolved oxygen concentration and include: density of organisms in the pool area, species physiological tolerances, volume of the pool, temperature, organic matter, and spring influence. Dissolved oxygen concentrations in river pools range from 1.2 to 15 mg/l (Yoshihara 1972, Shallock and Lotspeich 1974, Alt and Furniss 1976, Bendock 1976). Physical and chemical characteristics of drainages on or adjacent to the ANWR study area are presented in Table 2. Spring flooding during break up dramatically increases discharge rates from these drainages (Table 3).

Overwintering of fishes in river delta areas and coastal waters influenced by freshwater dilution has not been sufficiently documented. Marine nearshore waters have been shown to be important spawning and overwintering areas for many marine fishes such as arctic cod, fourhorn sculpin, saffron cod and snailfish (Craig and Haldorson 1980). The importance of river deltas as overwintering areas for freshwater and marine fishes had been examined by Kogl and Schnell (1975). Percy (1975) documented fish overwintering in the Mackenzie River delta. Arctic and least cisco have shown a preference for habitats with brackish water during the ice free period and this trend continues during winter when they move into brackish waters of the Colville Delta (Craig and Haldorson 1980). Suitability of delta overwintering areas depends on the salinity and tolerances of species using the area. Arctic char might overwinter in delta areas that are not hypersaline (Alaskan Arctic Gas Study Company 1974).

Arctic lakes have been classified by 3 geographic areas: coastal plain, foothill, and mountain. Coastal plain lakes are generally less than 5 m in depth (Carson and Hussey 1962, Prescott 1963, Kaliff 1968, McCart et al. 1972). Glacial foothill lakes and mountain lakes generally exceed 5 m in

Table 2. Selected chemical and physical characteristics for streams on the North Slope, ANWR (Adapted from Childers et al. 1977).

Station Name	Latitude	Longitude	Date	Discharge (cfs)	Specific Conductance (micromhos/cm at 25°C)	pH	Water Temperature (°C)	Turbidity (JTU)	Dissolved Oxygen mg/l
Canning River	69°48'29"	146°23'25"	11-08-75	228	--	7.7	--	--	--
Canning River	69°50'38"	146°42'10"	08-12-75	2500*	240	7.7	9.0	1.3	11.8
Canning River delta, E. channel	70°04'38"	145°42'35"	11-30-75	0	--	6.7	0.0	--	--
Katakturuk River	69°52'25"	145°12'00"	08-10-75	400*	250	7.8	3.0	20	13.2
Marsh Creek	69°47'33"	144°49'00"	08-10-75	15*	425	7.5	3.5	2	12.2
Sadlerochit River	69°39'13"	144°22'56"	08-07-75	--	155	7.1	7.0	0.25	11.6
Hulahula River	69°41'47"	144°12'10"	08-07-75	739	210	7.5	4.0	2	12.9
Jago River	69°50'38"	146°27'10"	08-08-75	267	193	7.7	4.5	1	12.9
Okerkovik River	69°42'07"	143°14'23"	08-08-75	85.2	275	7.5	8.0	0.0	11.6
Aichilik River	69°35'23"	142°58'03"	08-11-75	800*	235	7.5	3.5	1	12.9
Aichilik River	69°40'30"	142°46'52"	11-25-75	0	370	7.2	0.0	--	--
Aichilik River	69°48'50"	142°10'00"	11-23-75	0	700	7.2	0.0	--	--

* Estimated values.

Table 3. Flood characteristerics on selected rivers in the ANWR. (Adapted from Childers et al. 1977)

Stream site	Bankfull Channel						Maximum Evident Flood			Flood Characteristics	
	Streambed material	Slope (%)	Width (m)	Mean depth (m)	Max depth (m)	Discharge (cfs)	Width (m)	Discharge (cfs)	Unit runoff (cfs/km^2)	Q_2(cfs)	Q_{50}(cfs)
Canning River 69°50'38" 146°27'10"	large cobble	0.12	292	2.1	4.3	31,000	351	53,000	10.9	4,400	13,500
Katakturuk River 69°52'25" 145°27'10"	coarse gravel	0.64	207	1.1	2.1	17,000	204	10,000	16.9	660	2,800
Marsh Creek 69°47'32" 144°49'00"	coarse gravel	1.48	171	1.0	1.8	14,000	85	500	0.7	750	3,100
Sadlerochit River 69°39'13" 144°12'10"	boulders	0.62	85	1.4	2.1	11,000	85	11,000	8.0	1,400	5,200
Hulahula River 69°41'47" 144°12'10"	coarse gravel	0.50	76	2.2	2.7	23,000	73	10,000	5.7	1,800	6,300
Jago River 69°37'02" 143°41'06"	boulders	1.32	55	1.8	2.1	14,000	55	14,000	16.8	1,000	3,600
Okerokovik River 69°42'07" 143°14'23"	coarse gravel	0.33	180	1.0	2.1	10,000	110	2,300	5.3	650	2,600
Aichilik River 69°35'23" 142°58'03"	coarse gravel	0.54	250	1.7	2.4	33,000	249	27,000	18.5	1,900	6,300

depth (Kaliff 1968). The numerous, shallow coastal plain lakes generally offer unsuitable habitat in winter. Many, with maximum depths less than 3 m, freeze solid; others, exhibit high ionic concentrations and low dissolved oxygen (Wilson et al. 1972). Lake overwintering suitability generally increases going from the coastal to the mountainous regions. Walker (1960) noted that arctic lakes that drain into streams often have open water near the outlet with concentrations of fish being found in these areas.

Although overwintering habitat is of primary importance to arctic fishes, those areas that are unsuitable may play an important role as feeding, rearing, spawning and migration passages during ice free periods. Ward and Craig (1974) stated that some coastal lakes may serve only as feeding areas. DeBruyn and McCart (1974) found that grayling spawn primarily in tundra and foothill streams that freeze solid in winter.

Species Description

Twenty-nine species of fish are known to inhabit arctic marine, estuarine, and fresh-water environments on or adjacent to the ANWR study area (Table 4, Fig. 3). There is a great amount of variation in habitat preference and life history requirements between these species and within particular species. Some species such as the arctic and starry flounders occupy strictly marine-estuarine habitats. Other species occupy only freshwater habitats. Anadromous species, such as some of the arctic char, may occupy all 3 types of habitat. As a result, the various life history requirements (spawning, over-wintering, rearing, feeding, etc.) are distributed throughout a wide range of habitat areas. Wilson et al. (1977) presents an extensive literature review of arctic fisheries information. Current knowledge on arctic fishes is limited to primarily char, grayling and whitefish species. The following materials are summaries of available literature and data on those species of fish.

Arctic char This species has a circumpolar distribution. It is a common species along the Beaufort Sea coastline and occurs in many North Slope rivers and lakes. Both anadromous and freshwater forms are known to occur in the ANWR study area in the following drainages: Canning, Sadlerochit, Hulahula, Okpilak and the Aichilik Rivers. Lake resident char have also been reported from Peters/Schrader Lakes (Wilson et al. 1977) and from lakes in the Canning River drainage (Craig 1977a). Proper taxonomic classification of the North Slope Arctic char has been complicated recently by Morrow (1980) who classifies the stream dwelling char in this region as Dolly Varden (Salvelinus malma). This classification has not been widely accepted and most authors still consider this fish an arctic char.

Four life history patterns have been reported for arctic char in the Canning River (Craig 1977a). These include stream-dwelling anadromous, stream dwelling non-anadromous males, spring resident (non-andromous, self perpetuating) and lake resident. Some or all of these life history patterns presumably occur in other locations in the ANWR study area.

Arctic char size vary considerably depending on location and life history pattern. Anadromous char from the Canning River are generally smaller than some other North Slope drainages. Craig (1977a) found sea-run char length to range between 183-620 mm. The largest char caught by Smith (unpubl. data) in

Table 4. Species of fish which inhabit Arctic marine, estuarine, or fresh waters (Adapted from Wilson et al. 1977 and Craig and Haldorson 1980)

Common name	Scientific name
Arctic char*	Salvelinus alpinus
Arctic grayling*	Thymallus arcticus
Arctic cisco*	Coregonus autumnalis
Least cisco*	Coregonus sardinella
Bering cisco	Coregonus laurettae
Broad whitefish*	Coregonus nasus
Humpback (lake) whitefish	Coregonus pidschian
Round whitefish*	Prosopium cylindraceum
Lake trout*	Salvelinus namaycush
Pink salmon	Onchorynchus gorbuscha
Chum salmon*	Onchorynchus keta
Arctic lamprey	Lampetra japonica
Burbot*	Lota lota
Alaska blackfish	Dallia pectoralis
Boreal smelt	Osmerus eperlanus
Northern pike	Esoc lucius
Longnose sucker	Catostomus catostomus
Ninespine stickleback*	Pungitius pungitius
Slimy sculpin	Cotus cognatus
Fourhorn (deepwater) sculpin	Myoxocephalus quadricornis
Arctic flounder	Liopsetta glacialis
Starry flounder	Platichthys stellatus
Three spine stickleback	Gasterosteus aculeatus
Arctic cod	Boreogadus saida
Saffron cod	Eleginus gracilis
Capelin	Mallotus villosus
Pacific herring	Clupa harengus
Snailfish	Liparus sp.
Pacific sand lance	Ammodytes hexapterus

* Species reported from lakes and drainages of the North Slope of the Arctic National Wildlife Refuge.

1981 from the Canning had a 655 mm fork length, and weighed 2700 gm. The Sagavanirktok drainage to the west has produced char up to 773 mm while the largest from the Kongakut has been reported at 740 mm and weighed 3200 gm (Furniss 1975).

Typically freshwater resident char are substantially smaller than sea-run char although some overlap in size occurs. Resident char (including pre-smolts) from the Canning River ranged from 55 to 331 mm (Craig 1977a). Maximum size char caught in Peters/Schrader Lakes by Fischer (unpublished) had a total length of 408 mm and weighed 690 gm. Char in three headwater lakes in the Canning River drainage showed large variability in growth rate and maximum age (Craig 1977a). In Big Lake, char attained an older age (13) but were considerably smaller (190 mm) than char of the same age from the 2 other lakes. In the other two lakes char were measured up to 430 and 482 mm at ages 10 and 12 respectively. The slow growth rate of char in Big Lake is among the slowest recorded in literature (Craig 1977a). The most common age classes in the Canning River sea-run char population appear to be 7 through 9 with the range from 2 to 11 (Craig 1977a).

Mature sea-run char begin moving into the Canning River in the last part of July. The peak movement into the river system occurred in the first 10 days of August during 1981 (Smith unpublished data). The annual migration appears to be temporally separated by reproductive condition. Mature spawners enter first, followed by mature non-spawners, and then immatures, although considerable overlap does occur. On August 29, 1981 sea run immature and non-spawners were still entering the Canning River system (Smith unpublished data). Progress upstream is not well documented. In September 1972, 2000-3000 spawners were counted in the vicinity of a spring in the upper region of the Canning River. Approximately half of these fish had completed spawning and moved downstream by November 5 (Craig 1979a). Upstream progress of 2 radio tagged char during August 1981 were from 0 to 8 km per 24 hour period (Smith unpublished data). When these fish were located twice daily, all movements were between the period 19:00 hr. and 09:00 hr., indicating a nocturnal pattern to their movements. Much more verification is necessary to substantiate this indication.

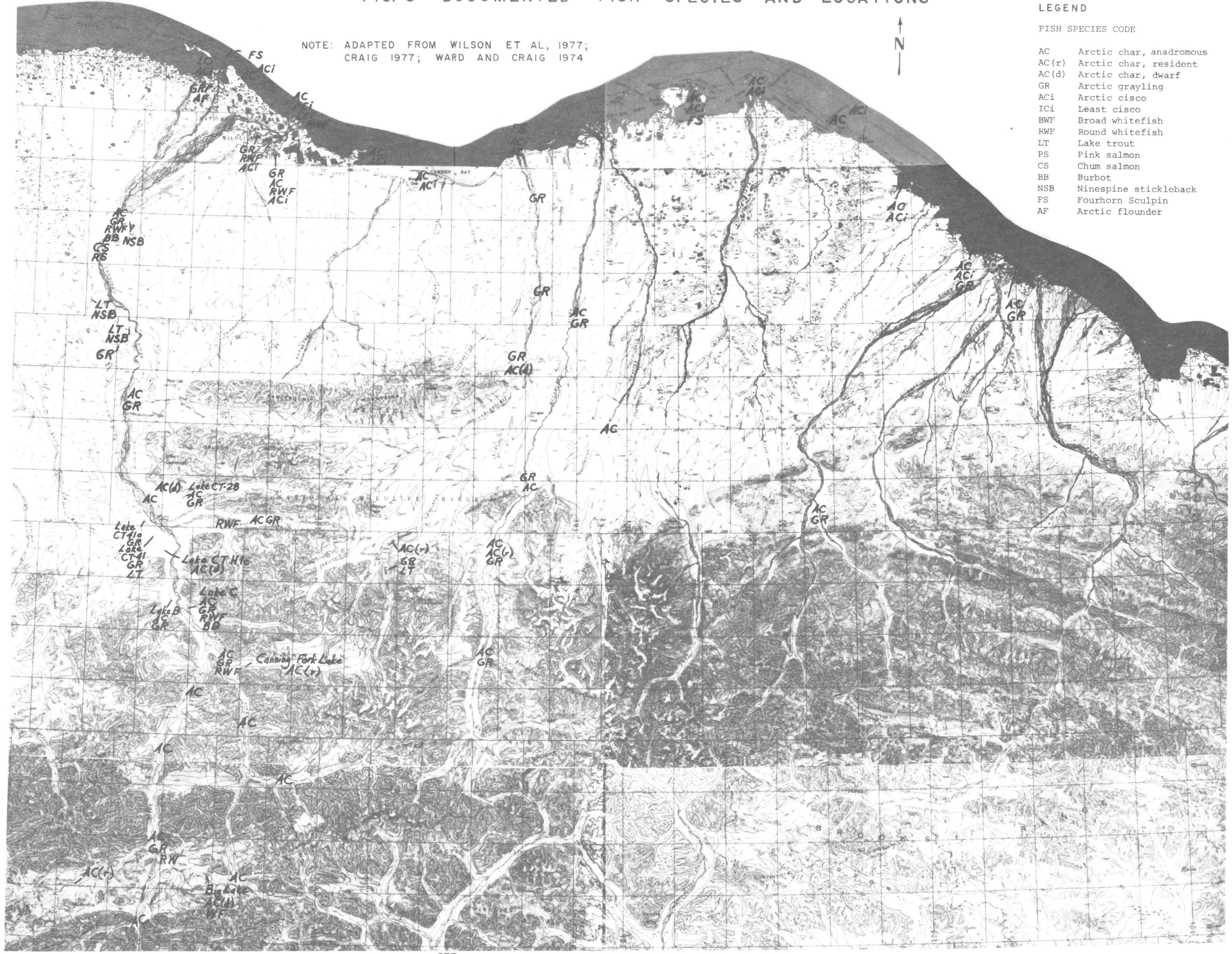
Several locations on the Canning River have been identified by Craig (1977a) as spawning sites for arctic char. All known spawning sites for anadromous char on the North Slope are associated with springs or ground water seeps that insure an adequate winter water supply for egg and fry survival. Some anadromous populations may utilize lakes for spawning but none have been documented. Length of time for incubation of char eggs has been estimated at 7 to 9 months in the Sagavanirktok River (McCart et al. 1972). Craig (1977a) estimated the same incubation time requirements for Canning River char although he speculated that fry in perennial springs might emerge sooner. In studies on a Canning River spring by Craig (1977a), peak emergence occurred during the last few days of May and the first part of June.

The age at which North Slope char make their first seaward migration is variable. Craig (1977a) found most char smolting around ages 4 or 5, but occurring as early as age 2. Smolting generally occurred during or shortly after river breakup in the spring.

Scale 1:500,000

Miles 6 0 6 12 18 Miles

FIG. 3 DOCUMENTED FISH SPECIES AND LOCATIONS



LEGEND

FISH SPECIES CODE

AC	Arctic char, anadromous
AC(r)	Arctic char, resident
AC(d)	Arctic char, dwarf
GR	Arctic grayling
ACi	Arctic cisco
lCi	Least cisco
BWF	Broad whitefish
RWF	Round whitefish
LT	Lake trout
PS	Pink salmon
CS	Chum salmon
BB	Burbot
NSB	Ninespine stickleback
FS	Fourhorn Sculpin
AF	Arctic flounder

Char overwintering locations in the ANWR are not well documented. Craig (1977a) lists possible overwintering locations on the Canning River; however these areas represent distribution of char at freeze up. It is not known whether these fish remain in these locations through the winter. It is likely that the majority of anadromous char in the ANWR overwinter near springs or seeps. The amount of overwintering in intermittent pools in rivers is unknown but may be minimal because of the scarcity of deep pools. Most common food items of resident char include dipteran larvae, plecopteran nymphs, and trichopteran larvae. Anadromous char greatly decrease or cease feeding upon entering freshwater. In coastal waters char feed mainly on crustaceans (amphipods and mysids) and fish (primarily Arctic cod) (Craig and Haldorson 1980).

Arctic Cisco. The Arctic cisco is one of the most abundant and widely distributed fish along the Beaufort Sea coast. It is found in northern coastal waters and lower rivers in Europe, Asia and western North America. In Alaska it ranges from Demarcation Point to Point Barrow. It has been reported from along the ANWR in lagoons and river mouths by Roguski and Komarek (1972) and from the lower Canning River (Craig 1977a). Craig and Mann (1974) found Arctic cisco distribution restricted to marine or brackish water in the Beaufort Sea. It has been proposed by several researches that the Colville and Mackenzie Rivers are the source of most of the Arctic cisco stocks found off the ANWR coast. Mature Arctic cisco in spawning condition, however, have seldom been documented from the Colville River.

Spawning movements and timing is not well known for the Beaufort Sea Arctic cisco. The Siberian population is anadromous and makes an upstream spawning migration beginning in July (Scott and Crossman 1973). Craig and Haldorson (1980) reported that most Arctic cisco had moved out of Simpson Lagoon in 1978 by mid-September. It was speculated that most spawners return to the Colville by early July followed by sea-run immatures and non-spawners after mid-September.

No spawning locations have been documented in the Colville River and no Alaskan stream to the east of the Colville has been found to support anadromous runs of Arctic cisco. Mature Arctic cisco which would spawn in the year of capture have been reported off the ANWR coast. Craig and Mann (1974) reported 2 fish (6%) from a sample of 33 near the Canning River were mature spawners. Another study with a larger sample size of 169 fish from along the entire coast of the ANWR found 74 fish (44%) to be spawners of the year (Roguski and Komarek 1971).

Spawning generally takes place over gravel beds in fast flowing water (Scott and Crossman 1973). Eggs are broadcast and abandoned. Eggs presumably hatch in the spring. Smolting can occur as early as the first year and age 1 fish were the most abundant age class caught by Craig and Haldorson (1980) in the fyke nets in Simpson Lagoon. Age 1 fish were also observed in Prudhoe Bay by Bendock (1977). Roguski and Komarek (1972) captured only one age 1 Arctic cisco in nearshore waters of the ANWR even though the area was widely sampled with small mesh gill nets from June until September 1970. These investigators stated that it was unlikely any significant number of small Arctic cisco were present in their sampling area which extended from the Canadian border to the Canning River.

Overwintering locations of Arctic cisco are not well documented. Craig and Haldorson (1980) found a large non-spawning segment of the Arctic cisco population overwintering in brackish (18-32 ppt) water of the Colville River delta and speculated that more overwintering was probably occurring in brackish river deltas and nearshore than previously thought.

The most common prey of Arctic cisco in Simpson Lagoon especially in summer had been reported as mysids, Mysis litoralis and M relicta (Craig and Haldorson 1980). Amphipods were also important and became the major food eaten in winter. Griffiths et al. (1975) found the feeding habits to vary seasonably in Arctic cisco near Herschel Island. Predominant food items in the spring included chironomids (18.6%), amphipods (17.5%) and small epibenthic isopods (17.8%). Mysids were the most common food (24.5%) in the summer while copepods (50.8%) and amphipods (15.7%) were abundant in the fall diet.

Least Cisco This species is found along coastal waters and in certain inland lakes and streams in northern Europe, Asia and North America. In the Beaufort Sea, least cisco have been reported to be abundant from Barrow to Prudhoe and near the Mackenzie River but relatively scarce in between (Craig and Haldorson 1980). Least cisco have been documented in the Canning River delta (Craig 1977a) and Ward and Craig (1974) found them offshore near the Canning River. Roguski and Komarek (1972) sampled along the entire coast of the ANWR during the summer of 1970 and did not catch any least cisco. It is doubtful that this species ever occurs in large numbers in nearshore waters of the ANWR, but where they do occur, they are much more common inland of the barrier islands (Bendock 1977).

Least cisco in the Beaufort Sea have been reported up to 414 mm (Craig and Haldorson 1980) and Bendock (1977) found the mean length of least cisco in Prudhoe Bay to be 272 mm with maximum length 364 mm. Age range of these fish was 1 to 12 with the majority between age 7 and 10. Age at maturity for Simpson Lagoon cisco was found to be 6 to 7 for males and 7 to 10 for females (Craig and Haldorson 1980).

The spawning behavior of least cisco is complicated by the existence of freshwater and anadromous life history patterns. Spawning generally takes place in the fall over sand or gravel in shallows of rivers or along lake shores (Scott and Crossman 1973). Kogl (1972) reported mature least cisco in the Colville delta in July that were potential spawners. Ripe and spawned out least cisco have been caught in the commercial fishery on the Colville River. Mature potential spawners were also found in the main Colville River and in nearby coastal lakes (Craig and Haldorson 1980). It is likely that some spawning occurs in both lakes and stream drainages along the Beaufort Sea coast, however, spawning in or near the ANWR study area is probably minimal.

Overwintering locations are unknown along the ANWR coast. Least cisco are thought to overwinter in both freshwater and brackish water of the Colville River delta in similar habitat utilized by Arctic cisco (Craig and Haldorson 1980). Mann (1975) has found overwintering least cisco in the lower Mackenzie River delta.

Food habits are similar to Arctic cisco. Craig and Haldorson (1980) reported mysids support 60-66% of the summer diet while amphipods were the major prey in the Colville River overwintering population.

Broad whitefish. The broad whitefish in Alaska is widely distributed throughout the interior, western and northern regions of the state from the Alaska Range north. It is frequently caught in nearshore waters of the Beaufort Sea and anadromous runs occur in the Colville and Sagavanirktok Rivers. Broad whitefish have been reported in the lower Canning River and they could utilize other drainages to the east although none have been reported. Roguski and Komarek (1972) did not catch broad whitefish in 1970 off the coast of the ANWR although a wide scale sampling program was conducted.

Sizes of broad whitefish from Simpson Lagoon to the west of the ANWR ranged from 66-548 mm however, this range was bimodal with no fish in the 200-260 mm range (Craig and Haldorson 1980). Bendock (1977) found ages of Prudhoe Bay fish to range from young-of-the-year to 15 but ages 4 to 7 were not represented. The maximum age reported by Craig and Haldorson (1980) for fish from Simpson Lagoon was 22 years. He thought sexual maturity was reached between the ages 9-14 but only a small percentage (13) of fish caught in coastal waters were mature spawners.

No broad whitefish have been documented spawning in ANWR coastal rivers however, spawning generally takes place in the fall in the lower reaches of other North Slope rivers. Bendock (1977) stated that adult broad whitefish entered the Sagavanirktok River in late August and spawned in deep pools throughout the lower delta. Ripe broad whitefish were captured in the Sagavanirktok River during the last week of September, 1976. Spawning time in the Colville River was reported as mid-September through mid-October (Hablett 1979) and in the Mackenzie River in October (Jessop et al. 1974, as cited by Craig and Haldorson 1980). Egg and fry developement is largely unknown but young-of-the-year fish have been documented in coastal waters (Bendock 1977, Craig and Haldorson 1980) indicating early movement away from spawning areas.

Overwintering locations have been reported in pools from the lower Sagavirktok River (Bendock 1977) and from the Colville River in the vicinity of Umiat (Bendock 1980). Stomach contents from Colville River whitefish included diptera larva, sand and organic debris (Hablett 1979). In Prudhoe Bay 41% of the broad whitefish captured contained food which included primarily chironomid larva and amphipods (Bendock 1977). All spawning broad whitefish captured in this study had empty stomachs.

Arctic Grayling. Grayling are one of the widest distributed fishes in Alaska occurring in most freshwater drainages throughout the state except in southeast. On the Arctic coast most of the freshwater drainages that have been surveyed have contained grayling. Within the ANWR study area grayling have been reported from the following drainages: Canning, Tamayariak, Sadlerochit, Hulahula and the Aichilik Rivers (Ward and Craig 1974). Grayling were caught by Roguski and Komarek (1972) in coastal areas on the ANWR in June in locations where salinities did not exceed 1 ppt. No grayling were captured in these same locations after July 8.

The length of grayling caught in coastal waters by Roguski and Komarek (1972) ranged from 225 to 410 mm. Age classes in this study ranged from 4 to 11 years. The largest grayling caught on the Canning River during July and August 1981 was 475 mm long and weighed 925 gm. This individual fish was unusually large; most grayling were less than 400 mm in length (Smith unpublished). Grayling taken from the Colville River near Umiat ranged in length from 34-389 mm and in age from young-of-year to 10 (Kogl 1972). Sexual maturity was reached at ages 7 and 8 for these grayling.

Grayling are typically spring and early summer spawners. On Weir Creek, a tributary to the Kavik River, grayling spawned from June 11 to 18 (Craig and Poulin 1974). Similar timing for spawning would be expected for coastal streams across the ANWR study area. Grayling movements to spawning locations are associated with spring thawing and higher flows in late May and early June. Preferred spawning habitat consists of small gravel or rock bottom tributaries to the larger rivers, but spawning can occur in gravelly areas on the main rivers (Scott and Crossman 1973). There appears to be some variation on length of time the adults spend in the spawning stream depending on the size of the stream. Data obtained by Craig and Poulin (1974) indicated that adults depart the smaller tributaries immediately after spawning and return to the main river. In other locations some have been reported to stay until midsummer or autumn (Reed 1964; Tripp and McCart 1974 as referenced in Craig and Poulin 1974).

Generally juvenile grayling and fry remain in smaller streams longer than adults. Warmer water temperatures, more abundant food, and reduced competition for food in smaller streams provide favorable conditions for growth of these smaller fish. Most fry and juveniles move out of the smaller streams by October and presumably move to deeper pools on the main rivers for overwintering. Craig and Poulin (1974) report that in northern streams most movement of fry downstream occurs during September.

Grayling overwintering locations in the ANWR study area are not well known. Deeper lakes with outlets such as Peters/Schrader provide some overwintering habitat. Intermittent pools have been shown to contain wintering grayling in the middle reaches of the Colville River (Bendock 1980). Pools in the Canning and Sadlerochit Rivers coastal plain are relatively scarce and most overwintering probably occurs in the vicinity of springs or seeps.

Food habits of grayling have received much study in Alaska. On the Colville River during the summer grayling were found to utilize the following in descending order of abundance: caddis fly larvae, chironomid larvae, terrestrial and aqautic bettles, aerial insects, snails, bivalves, amphipods, and ninespine sticklebacks (Hablett 1979). Scott and Crossman (1973) report the food of young grayling to be composed mostly of zooplankton with a gradual shift to immature insects as size of the fish increases.

Round Whitefish This species is distributed widely throughout northern North America and into northeastern Asia. They are found throughout northern Alaska in inland lakes and streams and may be found in lakes and streams in the ANWR study area. This species has been documented only from the Canning River drainage.

Round whitefish from the Colville River have been reported up to 422 mm in length and weighing 800 gm. (Hablett 1979). They averaged 266 mm in length from several locations on the Colville. The largest round whitefish reported from the Canning River has been one measuring 449 mm and 710 gms (Smith unpublished). Furniss (1975) found round whitefish in the Ivishak River up to 14 years old. Over 81 percent of his sample were in the age classes 9 to 11 and were between 323-410 mm in length.

Spawning generally takes place in the fall in the shallow water of lakes or streams over a gravel substrate (Scott and Crossman 1973). Preliminary information on Colville River round whitefish from the Colville River indicated an instream migration to spawning areas from mid-August to mid-September with spawning occurring from mid-September through the first week of October (Hablett 1979). Characteristic of whitefish, the eggs are broadcast and receive no parental care. Time of egg development is not well known for Alaska round whitefish, but has been reported as 140 days at 2.2 C for New Hampshire fish (Morrow 1980).

Overwintering locations on the ANWR study area have not been documented. Round whitefish have been reported in late winter in deeper pools on the Colville River (Bendock 1980) and in pools on the lower Kuparuk and Sagavanirktok Rivers (Bendock 1977).

Food of round whitefish from the Colville River has been reported by Hablett (1979) included snails, bivalves, aerial insects, chironomid larvae, caddis fly larvae and phytoplankton.

Burbot This species is widely distributed throughout the Northern Hemisphere from about 40 N to the Arctic Ocean. They are found throughout Alaska in freshwater lakes and streams. Within the ANWR study area they have been documented only from the Canning River (Craig 1977a, Smith unpublished data).

Burbot age and length data are not available for fish from the ANWR study area. Hablett (1979) reported Colville River burbot up to 915 mm in length and weighing 4,000 gm, with average length and weights of 658 mm and 1724 gm. Burbot seldom live longer than 15 years according to Morrow (1980).

Spawning generally takes place in winter, probably in January and February. Burbot caught in March in the Colville had completed spawning (Bendock 1980). Burbot spawning habitat is described by Scott and Crossman (1973) as 1-4 feet of water over sand in streams or in gravel shoals 5-10 feet deep in lakes. Eggs take around 30 days to hatch at 6°C (Scott and Crossman 1973) and should take longer on the North Slope where temperatures are near 0 C during egg development.

Burbot utilize some of the same overwintering locations as other freshwater species. Bendock (1980; 1977) documented burbot in intermittent pools from the Colville River and the lower Sagavanirktok and Kuparuk Rivers.

Adult burbot are considered piscivorous. The summer diet of burbot on the Colville River contained, in descending order of abundance: slimy sculpin, ninespine stickleback, round whitefish, grayling, caddis fly larvae and snails (Hablett 1979).

Salmon Small runs of pink and chum salmon occur in the Colville and Mackenzie Rivers. These salmon also occasionally enter other North Slope drainages such as the Sagavanirktok River. Three chum salmon were caught in the Canning River during August of 1981 (Smith unpublished data). A small run of pink salmon passed through Simpson Lagoon during the first part of August 1978 heading eastward (Craig and Haldorson 1980). One of these fish was caught in September, 250 km to the east off the shore of the ANWR in a subsistence net. Craig and Haldorson (1980) also reported chinook salmon and one sockeye salmon from Simpson Lagoon. Sockeye salmon are extremely rare in the Beaufort Sea but stragglers have been reported from Bathurst Inlet (Scott and Crossman 1973). One sockeye salmon in spawning condition was documented in the Canning River in August 1981 (Smith unpublished data).

Pink salmon caught in Simpson Lagoon by Craig and Halderson (1980) ranged in size from 388 to 540 mm in length and the 2 chum salmon caught measured 600 and 622 mm. Pink salmon from the Colville River averaged 503 mm in length and 1,975 gm in weight (Hablett 1979).

Spawning locations of salmon are unknown from the ANWR study area. The 3 chum and one sockeye caught on the Canning River in August were in spawning condition (Smith unpublished). Pink and chum salmon taken on the Colville River between the Itkillik River and Umiat during August 1978, were also in spawning conditon (Hablett 1979). If spawning does occur in drainages of the ANWR it would probably be in the vicinity of springs or seepages that would insure adequate water flow for egg development during winter.

Adult spawning salmon do not normally feed during their upstream migrations. Information regarding fry development and length of time spent in fresh water prior to smolting is unknown for North Slope salmon populations.

Lake Trout. Lake trout are widely distributed across the North Slope where suitable habitat exists. They are found in rivers such as the Colville and deeper coastal lakes such as Teshekpuk west of the ANWR. Within the North Slope of the ANWR they are known from coastal plain lakes near the Canning River drainage (Craig 1977a) and from Peters and Schrader Lakes. Suitable habitat such as deep lakes are limited on the coastal plain of the ANWR and lake trout are not expected to be very abundant in the study area.

Lake trout up to 890 mm and weighing 6400 gms have been reported from Peters/Schrader Lakes (Fisher unpublished). Lake trout from Teshekpuk and other nearby lakes ranged in length from 419 to 850 mm and weights ranged from 548 to 6,980 gm (Hablett 1979). These fish ranged in age from 3 to 10 years.

Spawning generally occurs in the fall over a large boulder or rubble bottom in inland lakes at depths less than 13 m (Scott and Crossman 1973). Incubation and hatching vary depending on habitat conditions but usually requires 4 to 5 months.

Lake trout overwintering on the North Slope occur in deep lakes and in rivers. Bendock (1980) found a lake trout in the Colville River in a pool 2.4 m deep with dissolved oxygen of 2.4 ppm. Overwintering locations on the North Slope of the ANWR other than Peters/Schrader Lakes are unknown.

Hablett (1979) reports that of the lake trout captured during summer in the western Arctic only 49% had food in their stomachs which consisted of the following in descending order of frequency: least cisco, snails, aerial insects, round whitefish, slimy sculpin and voles.

Other Species. Slimy sculpin, *Cottus cognatus*, are common in drainages in the western Arctic but have not been reported from the ANWR. Humpback whitefish, *Coregonus pidschian*, are also common to the west but apparently are absent from the ANWR.

Ninespine stickleback, Pungitius pungitius are common in many lakes and drainages in the ANWR study area. Little information is available on the life history of this species. It apparently spawns in the summer in streams and lakes and can grow up to 6.4 cm or more. It is an important prey for many other species of fish (Scott and Crossman 1973).

Boreal smelt, Osmerus eperlanus, have been reported in subsistence catches in coastal waters of the ANWR. This fish is typically anadromous moving to freshwater in the spring to spawn. Smelt average 18-20mm in length (Scott and Crossman 1973) and have been reported up to 15 years old (Craig and Haldorson 1980).

Boreal smelt were found to be a minor component of the nearshore fish community during summer in Simpson Lagoon, but one of the most abundant in winter (Craig and Haldorson 1980). Smelt apparently concentrate near some river mouths such as the Colville during winter presumably to migrate up the river in the spring to spawn.

Marine species that are expected to be commonly found along the ANWR coast include fourhorn sculpin, Myoxocephalus quadricornis and arctic cod Boreogachis saida.

Fourhorn sculpins are among the most widespread and numerous of all the marine fishes found along the Beaufort Sea coast. They ranged in length from 18-265 mm in Simpson Lagoon (Craig and Haldorsen 1980). These fish apparently spawn during winter between November and February in coastal waters. Overwintering sculpin have been observed in brackish river deltas and in coastal areas indicating a wide salinity tolerance for this species. Fourhorn sculpins have very limited commercial or subsistence value.

Arctic cod are widely distributed along the Beaufort Sea coast and have been described as a key species in the arctic ocean ecosystem because of their abundance and importance in the diets of marine mammals, birds and other fish (Craig and Holdorsen 1980, Bendock 1977). Craig and Haldorson (1980) found Arctic cod around Simpson Lagoon to range in size from 6 to 257 mm and in age from young-of-year to 6. Arctic cod spawn near shore under the ice during January and February (Bendock 1977). Specific information on Arctic cod distribution and life history along the ANWR coast is scarce, but they are an important food item for Kaktovik residents and their dogs especially during early winter.

Impacts of Existing Human Activities

One source of mortality to fishes of the coastal plain and nearshore waters of the ANWR is human fishing pressure. No commercial fishery exists in this region at present. The only continuing commercial fishery on the North Slope is located on the Colville River delta. This fishery which operates from October to December has reported an average annual harvest from 1964 to 1976 of 65,230 fish. Sixty five % of this catch has been arctic cisco and 29% least cisco. Broad and humpback whitefish compose the remaining 6% (Craig and Haldorson 1980).

A subsistence fishery exists in nearshore waters and river deltas in summer and at traditional fishing locations on rivers and lakes during winter. The main species constituting this fishery are Arctic cisco and Arctic char during summer and char and grayling during winter (see Chapter 7, Subsistence section). Very little is known of the numbers of fish taken annually by this fishery. Furniss (1975) reports that on a traditional hole on the Hulahula River, 4 persons caught 18 char ranging in size from 122 to 331 mm and 2 grayling during 4 days of fishing in April 1974.

Some limited sport fishing also occurs by summer recreationists visiting the area. It is doubtful that the current amount of fishing pressure is having a significant effect on the fishery resources of the area.

Data Gaps

Of those biological resources occurring on the ANWR study area, fisheries resources are perhaps the least known. The remoteness and severe environmental conditions of the area have limited the amount and quality of aquatic studies. A better understanding of freshwater and nearshore fisheries and aquatic habitat requirements is necessary if fishery resources are to receive adequate consideration in future decisions concerning oil and gas development on the refuge.

Fish distribution in lakes and streams east of the Canning River is relatively unknown . With the exception of the Canning River, there have been only 2 fish species, grayling and arctic char, that have been documented in freshwater on the ANWR study area. The few surveys that have been conducted have been brief and superficial. Other drainages need to be surveyed more intensively to determine the range and distribution of all fish species on the ANWR study area.

One of the most essential habitat requirements of arctic freshwater and anadromous fish is suitable overwintering areas. Potential conflicts resulting from petroleum exploration and development could be especially critical during winter when minimal or no flow, low dissolved oxygen levels, and other water quality problems may reduce the amount of suitable winter habitat. Additional stress from water withdrawals or increased sedimentation from construction activities could exceed fish tolerance limits and impact large numbers of fish that are concentrated in these overwintering areas. At present, the locations, amount and quality of overwintering areas on the ANWR study area are mostly conjecture. These areas need to be located and evaluated as to their quality and overall importance to the fishery prior to developmental activities that may have long term impact.

Several springs have been identified on or in the vicinity of the study area. These springs have also been mentioned as a possible winter water source. Springs are usually the only source of flowing water on the North Slope during winter and are essential to several fish species for such life history requirements as spawning, rearing, egg development, and overwintering. It is not known what effects the withdrawal of water during winter would have on the available aquatic habitat below these springs. The minimum flow necessary to sustain the relatively large and diverse concentration of aquatic flora and fauna normally found at these springs through winter needs to be assessed before determining if any water can be withdrawn.

Although arctic char have been documented in several drainages on the ANWR study area, their movement patterns and life history requirements are relatively unknown. Studies should be directed at obtaining the location of spawning areas, population estimates by drainage, and timing of spawning runs. This information is essential in supplying location and timing recommendations on such developmental activities as water withdrawals, materials extraction, and road and pad construction.

Species composition and distribution of the nearshore and lagoon fishery is another unknown. Large discrepancies exist in the species composition between those fish found from the Prudhoe Bay area to those fish reported offshore of the ANWR. This area needs to be surveyed to determine species present and the relative importance of different areas.

Human fishing pressure is another factor that needs to be quantified. With a limited and relatively fragile resource such as the ANWR fishery, all sources of mortality will need to be determined and monitored more intensively in the future as pressures on that resource increase.

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CHAPTER 7

HUMAN CULTURE AND LIFESTYLE

This chapter discusses the historical and present day human uses of the ANWR study area and adjacent areas. The archaeology and history of the area is presented first, followed by historic and present day subsistence use patterns of Kaktovik and other affected villages outside the study area. Recreational use of the area is presented next and is followed by a discussion of wilderness values and natural landmarks proposed within the ANWR study area. Data gaps are discussed within the text of each section.

Early History and Archaeology

The Eskimo

The Inupiat Eskimo of northern Alaska are descendents of proto-Mongoloid peoples who migrated across the Bering Land Bridge at the close of the Pleistocene Epoch. The Inupiat are composed of 2 distinct, but interacting ethnological groups: the Nunamiut and the Tagiugmiut. The Nunamiut were nomadic, and ranged over the northern slopes and foothills of the Brooks Range following the migrating caribou upon which they subsisted. The Tagiugmiut occupied small villages along the coast from which they hunted marine mammals, principally bowhead whales and seals. Although the 2 groups of Inupiat depended primarily upon distinct resources, there was significant overlap of resource utilization and considerable cultural interaction (Gubser 1965, Schneider and Libbey 1979). The Tagiugmiut regularly traveled inland along the major river drainages to take fish, caribou and other furbearers. Likewise, the Nunamiut journeyed along the same rivers to the coast, where they traded caribou meat and hides for food and materials produced by the coastal people from their marine resources.

Prior to 1885, the inland Nunamiut are thought to have been more numerous than the coastal Tagiugmiut, reaching a peak of more than 1,000 in scattered bands of 50-150 people in the river valleys of the arctic mountains and foothills (Gubser 1965). However, as the effects of an expanding white culture increased, their numbers dwindled. By 1920, the lure of employment in whaling and trapping, and the effects of disease and declining caribou herds had reduced the Nunamiut population to less than 20, and these soon moved to the coast. In the late 1930's, several Nunamiut families returned inland to settle at Anaktuvuk Pass in the central Brooks Range. At present, this village is the sole remaining Nunamiut settlement. The coastal Tagiugmiut faced similar problems during this period and are now concentrated in a few larger villages, principally Point Hope, Wainwright, Barrow, and Kaktovik.

Historical Perspective

Written history of the ANWR study area begins with Captain John Franklin's report of exploration in the year of 1826 (Franklin 1828). The Royal British Navy sent Franklin on an overland expedition intended to map the Arctic seacoast in connection with their effort to find the northwest passage between the Atlantic and Pacific Oceans. Franklin traveled from the Mackenzie River west along the Beaufort Sea coast intending to rendezvous with Captain F.W. Beechey, who was sailing east towards Pt. Barrow. While members of Beechey's crew did reach Pt. Barrow, Franklin was forced to turn back after reaching the

Return Islands near Prudhoe Bay (Franklin 1828). He spent the months of July and August on the Arctic coast between the mouth of the Mackenzie River and Foggy Island. He named the Clarence River, Demarcation Point, the British and Romanzoff mountains, Mt. Copleston, the Canning River, and many other geologic features. He reported visiting a trade fair located on what he called Barter Island. Since that time, however, this location has become known as Arey Island (Leffingwell 1919).

Franklin returned to England at the end of this his second expedition, but disappeared on his next journey into the north. However, his work and that of those who followed him investigating his disappearance led to the completion of the basic mapping of the Arctic coast of Canada and, to a lesser extent, Alaska. Franklin's journal provides much information about the country between the Mackenzie and Foggy Island as well as the first descriptions of the natives who inhabited that part of the coast.

The next expedition to enter the study area was commissioned by the Hudson's Bay Company and led by Dease and Simpson in 1836 (Dease and Simpson 1837). Exploring the northern coast and closing the gap between the maps of Franklin and Beechey was their purpose. They named the Franklin Mountains after John Franklin and reported a native village at Demarcation Bay, but much of their information has been regarded as inaccurate or unreliable by later investigators (Leffingwell 1919).

This expedition was followed by several others sent in search of information about the disappearance of Franklin. Reports of these trips were written by several junior military officers (see Leffingwell for bibliographic references). Of special interest is the journey of the Enterprise (Collinson 1855), the first vessel to overwinter in the study area when the ship was frozen in at Flaxman Island not far from the mouth of the Canning River. Collinson attempted to travel from Flaxman Island to Barter Island but turned back due to bad weather. He did report several possible Native village sites between the 2 islands. The observations of Collinson during his 3 winters (1851-1854) in the arctic had far-reaching effects. Although he found no sign of Franklin, his information on anchorages and the abundance of bowhead whales in the Beaufort Sea, together with similar reports from other investigators, spurred the expansion of American and European whaling efforts into the Arctic Ocean east of Pt. Barrow (Leffingwell 1919).

Collinson's work encouraged others to sail eastward from Barrow and soon whalers started advancing a little further to the east each year and eventually reached Herschel Island. Seven ships were reported overwinting there during 1849-95. Hunting parties from these ships traveled as far west as the Aichilik River in the study area. More importantly, the concentration of these ships required that large quantities of meat be provided. While these needs were met partly by the efforts of the ships crews, they also relied heavily on the native population to provide meat and other goods in return for trade items. The presence of these goods, including guns, acted as a magnet to draw Eskimos from as far as Anaktavuk Pass. Along with these goods, the natives encountered for the first time alcohol and a variety of diseases carried by the whalers. In 1865 there was a measle epidemic among the Mackenzie Eskimo which substantially reduced the size of the population.

The growth of the arctic whaling industry had profound economic and social effects on the Native inhabitants of the area. Opportunities for employment on whaling ships and the introduction of trade goods altered the economic base of the coastal Inupiat, while the introduction of disease and alcohol had significant social and cultural consequences. The use of firearms acquired from white traders and whalers permitted the Eskimo to take increasingly large numbers of caribou, thus seriously depleting the herd. This, together with the sudden increase in whale harvests, in many instances led to starvation (Spencer et al. 1979) or migration east to Canada.

Contact between Natives and Whites became more intense during the late 1860's with relatively major demographic changes occurring. From that point on, pre-contact subsistence patterns were constantly under pressure to change and the following quote summarizes the occurrances of the next 40 years:

> After the appearance of the American whaling fleet along the Mackenzie Delta coast in 1889, and with the increasing association between the indigenous population and the whalers wintering at Herschel Island and elsewhere, the effects of epidemic disease and the disruption of aboriginal social patterns accelerated rapidly...At the same time as Eskimos were being decimated by disease, local aboriginal culture was being submerged beneath a wave of American and Alaskan Eskimo introductions...The latter were either brought to the area as caribou hunters by the whaling ships, or had moved in on their own in search of new hunting and trapping grounds after the North Alaskan caribou herds had been killed off to supply the excess demands of the whaling fleet...Aborginal Mackenzie Eskimo culture could probably be considered to have become extinct between 1900 and 1910 (McGhee 1974).

Very little was known of the Mackenzie Eskimo before they all but disappeared. They are mentioned only infrequently in the literature of the explorers and little or no effort was made to learn their customs and history. Just as the Mackenzie people were disappearing, the first scientific expedition whose specific purpose was to study the northern Eskimos arrived in the area. This expedition, which arrived in 1908, was led by Vilhgalmur Stefansson and Robert Anderson under the auspices of the American Museum of Natural History. Anderson spent a winter living with the natives in the Hulahula River and provided much ethnographic information (Anderson 1919). These people were apparently mostly western Eskimo that had moved from Barrow and the Anaktuvuk Pass areas.

Stefansson was able to reconstruct some information about the Mackenzie people from 2 informants (Stefansson 1919). He indicated that there were 5 distinct groups scattered from about 100 miles east of the Mackenzie River to the Demarcation Point or Icy Reef area. The group was called the Kigisktarugmiut which were named for the main village of Kiguklayuk on Herschel Island. They occupied the area from Shingle Point east of Herschel Island to Demarcation Bay according to Stefansson. However, based on work completed later it appears that these people's territory may have extended as far west as Barter Island (McGhee 1974).

Stefansson and Anderson led the Canadian Arctic Expedition back to the north shortly after their first visit. Stefansson lost his ship the Karluk to the ice although he was not on board at the time. Anderson's ship made it to Camden Bay where it overwintered at Collinson Point. The crew included Diamond Jenness who conducted the first scientific archaeological excavations at Barter Island. These excavations were brief but established the fact that the spit running east from Barter Island, where the modern landing strip is now located, was a large archaeological site. The arctifacts he recovered resembled those found in the Barrow area that have been assigned to an early Eskimo tradition named the Thule. The significance of this find is discussed later.

At about the same time as Anderson entered the country, Ned Arey, S.J. Marsh, and F.G. Carter arrived to prospect for gold. Arey spent 11 years in the study area and was the first white man to enter the headwaters of the Canning, Hulahula, Okpilak and Jago Rivers. He was also the only full time non-Native resident in the area. Carter and Marsh wintered at Camden Bay in 1901 and spent most of the following 2 years prospecting the Canning River as far south as Cache Creek. Their lack of success led them back to interior Alaska via the upper Canning and Chandalar Rivers. Many geographic features along this route were first named by or after Carter and Marsh (Leffingwell 1919).

Other scientific parties were also starting to enter the area. In 1890 Turner discoverd the Firth River. He was followed by Funston in 1894 and Peters and Schrader in 1901 who were mostly interested in the geography and geology of the area. In addition, a surveying team of the United States Government established the border between the United States and Canada (Leffingwell 1919).

The most extensive early survey of northeast Alaska was conducted by E.deK. Leffingwell, a geologist with the U.S. Geological Survey who established a permanent camp on Flaxman Island between 1907 and 1912. During this period he collected data on the geology and geomorphology of the Canning River area and explored the drainages of the Okpilak and Hulahula Rivers (Leffingwell 1919). His original camp on Flaxman Island was placed on the National Register of Historic Places in 1972. He first entered the north in 1906 as a co-leader of the Mikkelson-Leffingwell expedition which was less than successful, because their ship was trapped in the ice and crushed leading to the departure of Mikkelson. Leffingwell stayed on and during the next decade spent 9 summers and 6 winters in the study area. Leffingwell prepared the first accurate chart of the north Alaskan coast, a detailed study of ground ice, a detailed discussion of physiography including past and present glaciation, and an analysis of the processes of erosion and deposition under polar conditions. In addition to this scientific data he provides excellent discussions of techniques for living and working in a harsh and unyeilding environment. His description of the process he used in mapping the coast and some of the interior mountains is an example of accurate and complete documentation setting a standard for that type of work. In naming many features on his maps he used Native names when he could. This contradicted the traditional policy of naming geographic features for patrons, teachers, government agents, or previous explorers and explains the large number of features bearing native names that appear on modern maps of the area.

Early Oil Exploration

The presence of oil seeps on the Arctic Coastal Plain had long been known to the native inhabitants of the region, and this information was duly noted in early geological surveys (Leffingwell 1919). This information, together with an increasing demand for oil to fuel the Navy's ships, led President Warren G. Harding to issue an executive order on 27 February 1923 withdrawing 9,315,000 ha north of the Brooks Range and west of the Colville River as Naval Petroleum Reserve No. 4. There was little activity in NPR-4 until after the Department of the Interior issued Public Land Order 82, which closed NPR-4 and an additional 10,125,000 ha to the west and east (including the present area of ANWR) to appropriation under any public land laws and reserved mineral rights for use by the Secretary of the Interior in the "the prosecution of the war". Between 1944 and 1953, the Navy and then a civilian contractor (ARCON) conducted exploration for oil and gas on lands set aside by PLO 82. Although several minor and a few larger discoveries were made, the high potential costs of development and transportation led the Secretary of the Navy to discontinue the exploration program in 1953 (U.S. Navy 1977). Apparently, no seismic exploration or drilling was carried out within the present ANWR area, although between 1947 and 1953 geologic mapping was conducted on the Canning River, Marsh and Carter Creeks, the upper Katakturuk and Tamayariak drainages, the Sadlerochit Mountains, and the Kongakut and upper Firth Rivers (Reed 1958). Naval oil exploration also prompted initiation of scientific investigations to begin in the Alaskan arctic. The Arctic Research Lab (ARL) began operations in Barrow in 1947. An ARL field station was established at Peters and Schrader Lakes to provide support for geologists and biologists working in the eastern arctic (Ritchie and Childers 1976).

Post-War Military Development

World War II and early oil exploration activity seems to have had little effect upon the northeastern Alaskan arctic and its inhabitants. However, during the military defense buildup which followed the war, a Distant Early Warning (DEW Line) system was constructed at intervals along 4827 km of Alaskan and Canadian arctic coastline. Barrow was the main supply base during construction, and Barter Island was selected as a site for 1 of the larger DEW Line installations.

Construction and support of the DEW Line stations had a significant effect upon both the arctic coastal environment and its people. Specifically, establishment of the 1822 ha DEW Line site on Barter Island resulted in 3 relocations of the village of Kaktovik between 1947 and 1964 to accomodate changes in the layout of the installation (Wentworth 1979). DEW Line construction and operation brought social and economic changes to the native residents of the arctic coast on a scale not experienced since the decline of the whaling industry. Increased job opportunities once again caused immigration and concentration of the nomadic native populations in villages such as Kaktovik (Wentworth 1979).

The effect of DEW Line construction and operation on the Beaufort Sea coastal environment was also significant. Between the Canning River delta and Demarcation Point, 1 principal DEW Line station (Barter Island) and 2 intermediate stations (at Camden Bay and Beaufort Lagoon) were constructed, as well as lesser structures at Brownlow and Demarcation Points. Only the Barter Island installation remains active today. Abandoned materials include numerous rusting steel fuel drums located primarily at Camden Bay and Beaufort Lagoon, but also scattered along the coast and inland within the boundaries of ANWR (Thayer 1979).

Establishment of the Arctic National Wildlife Refuge

In 1949, the National Park Service began a survey of Alaska's recreational potential. The survey was directed by George L. Collins, Chief of the State and Territorial Recreation Division for Region 4 of the NPS. In 1954, following aerial surveys, field verification and consultation with prominent conservationists such as Olaus Murie and A. Starker Leopold, Collins recommended to the National Park Service that the northeast corner of Alaska be preserved for its wildlife, wilderness, recreational, scientific and cultural values. Collins also recommended that the area be an international park, to include contiguous lands between the Alaska-Canada border and the Mackenzie Delta (Ritchie and Childers 1976, Spencer et al. 1979).

On 20 November 1957, Secretary of the Interior Fred A. Seaton announced plans to repeal Public Land Order 82 of 1943. The action would leave NPR-4 and neighboring areas open for development, but specified that approximately 3.6 million ha of Alaska's northeastern arctic be considered for establishment of a national wildlife range. In January 1961 Secretary Seaton signed PLO 2214 that created the Arctic National Wildlife Range. On 2 December 1980 President Carter signed into law the Alaska National Interest Lands Conservation Act (ANILCA). The ACILCA legislation created the 7.2 million ha Arctic National Wildlife Refuge which encompassed the existing 3.6 million ha Arctic National Wildlife Range and an additional 3.6 million ha of adjoining lands west to the Trans-Alaska Pipeline and south to the Yukon Flats. An area of approximately 3.1 million ha, comprising most of the original Arctic National Wildlife Range, was designated wilderness, while approximately 0.5 million ha of coastal plain within the refuge was opened to seismic exploration for oil and gas.

Archaeological Indications of Prehistory Use of the ANWR Study Area

The first archaeological survey to be conducted in the ANWR study area covered the sea-coast from Flaxman Island at the mouth of the Canning to Barter Island (Giddings 1954). This survey located only 1 small prehistoric mound and an unreported number of historic sites. Giddings did not provide an exact location for the prehistoric site, but stated it was "on the eastern shore of Camden Bay, a few miles south of Anderson Point" (Giddings 1954:97). The site was described as a single half-underground house with a shallow midden surrounding it, partially eroded into the sea. According to Giddings, the styles of bow frames, arrow stems of antler, sealing darts, and other artifacts present indicated the site may be earlier than Ekseavik which he dated to the late 14th and early 15th centuries based on dendrochronology (Giddings 1952). Unfortuantely, Giddings' 1954 article was not a report of survey, and no information about other sites or photographs of artifacts from the reported site were included.

The divide between Kongakut and Firth River drainages, Mancha Creek, a tributary of the Firth River, and 64 km of the upper Kongakut River were superficially covered by survey in 1953 (Ricciardelli 1954). Several caves located 122 to 244 m above the valley floor in difficult to reach locations were examined and found to be sterile of cultural evidence. Creek banks, old terraces, weathered ridges, willow patches, confluences of tributary streams, and other favorable spots were examined for prehistoric sites with the same results. Several sites associated with gold mining were located, but no details were given. Vague reference was made to "cultural material...of the post-contact period" (Ricciardelli 1954).

During the summer of 1961 a survey was conducted in the vicinity of Peters and Schrader Lakes and the adjacent foothills and valleys of the Shublik and Sadlerochit Mountains. The major objective of this project "was to explore the unglaciated treeless tundra in this narrow constricted zone between the mountains and the sea. It was desired to test the hypothesis that this was a natural route for prehistoric man through this part of the northland. The region selected for investigation seemed to offer a logical unimpeded low-level route for early man into North America" (Solecki et al. 1973). Solecki (1951) had hypothesized that this area held a high potential for early sites in North America (Solecki 1951). Although they were far from definitive, the results of this survey did very little to support the hypothesis.

A total of 12 sites that were considered to be prehistoric were located. Four are termed multicomponent, but none were stratified. Rather, components were identified by extracting artifacts that appeared to fit into traditions that had been previously defined based on work done elsewhere. One of these sites contained British Mountain, Denbigh Flint Complex, and Eskimo components. One consisted of British Mountain and Eskimo components, while another contained Denbigh and Eskimo artifact groups. One of the Denbigh sites had an unidentified component with it. The remaining prehistoric sites either yielded single components or were not identified; 2 were Eskimo, 4 were Denbigh, and 3 were unidentifiable. Seven historic tent rings were also located and mapped (Solecki et al. 1973).

Some of these sites were termed settlement types (Solecki et al. 1973), however, the criteria for these types were not discussed. It appears that sites located on good vantage points for spotting game and having few artifacts were called hunting sites, while sites containing larger numbers of artifacts or those in more sheltered areas were defined as habitation sites. One site was designated as a hunting site that was also a workshop. Many of these sites were either multi-component or were located very close to each other, and this fact was attributed to similar adaptations to similar environments. This assumption was based on scattered results from fragmentary glacial geology studies that seem to indicate that the last glaciation did not effect much of the foothill/coastal plain area.

The FWS has conducted archaeological investigations on ANWR for several years (Wilson undated). The results of these investigations are incomplete, but some preliminary conclusions will be presented. The investigations conducted included survey and limited testing of selected areas of the upper Hulahula River, the foothills around the Kongakut and Canning Rivers, and along the coast in the Demarcation Bay and Barter Island areas. These investigations have resulted in the identification of more than 40 archaeological and historic sites which in aggregate represent the last 6000 years. Unfortunately, those sites that may represent an early occupation have not yielded quality or types of artifacts to provide secure dating. These possible early sites are exclusively small lithic scatters, with no "type specimens" present and without charcoal or other material dateable by the C-14 method.

At least 2 and possibly 3 Thule village sites have been identified in and adjacent to the study area. These sites are scattered along the coast with 1 located at Barter Island, 1 at Arey Island, and 1 at Icy Reef in the Demarcation Bay area. Only the site at Barter Island has been dated and this was through comparison, by Jenness (1928) and Whistler (1916), to collections from Barrow. Unfortunately, little remains of this site because it was almost totally destroyed by the construction of the airport on the island. Only a few scattered remains can be identified, and occasionally an isolated artifact will erode from the runway. A brief visit was made to the site on Arey Island and placing it in the Thule period is not well substantiated only on the feeling of the observer that it is "old" Eskimo. The site at Icy Reef is also not dated with any confidence because it also was only visited briefly. Several of the sites located in the foothills may result from older Eskimo occupation, but, again, not enough material was collected to place these sites in a cultural tradition with any degree of confidence.

Most of the sites found during this survey were occupied at one time or another during the last 200 years. They range in size and importance from a large semi-permanent caribou hunting village with several associated burials, to concentrations of several tent rings or sod houses some which have 1 or 2 associated burials, to caribou fences and single tent rings.

The most important of these sites is the Turner River Overlook, located in the northern foothills of the Brooks Range. In addition to providing a view of the Turner River and its tributaries, Demarcation Bay and the arctic coast, it provides an excellent location at which to await the spring and fall migrations of the Porcupine caribou herd. Limited testing at the site provided evidence of an intensive occupation over an extended period of time. At least 3 living floors have been identified as having several firepits. Resting on these floors are structural remains such as medium sized wood structrual members that are usually associated with semi-permanent dwellings. The remains of what appeared to be sod also were identified. Many artifacts made from wood, bone, metal and lithics have been recovered along with the partial remains of at least 18 people . Thousands of fragmented caribou bones have also been identified.

Artifacts that are smiliar in material and construction to those found at Turner River have been found at 2 fences usually associated with caribou hunting and at tent rings in the Demarcation Bay area. It is possible that these sites were used by 1 group of people in exploiting a variety of resources in the area.

Although the artifacts present in these sites suggest that they were occupied sometime during the middle to late 1800's, there is no memory of them in the traditions of the people, most of whom are Western Eskimo, presently living in Kaktovik. This fact and the report of Stefansson that the Mackenzie Eskimos were almost extinct by the beginning of this century, indicate that these sites may represent that last occupation by Mackenzie Eskimos of what is now northeastern Alaska. Other sites found during the survey represent the remains of the Native and White communities that have moved into the area in the last 80 years (see subsistence section and Appendix II).

Summarizing these reports of archaeological investigations, it is reasonable to say that thus far little is known of the archaeology and early history of the study area and those areas immediately adjacent to it. All surveys were conducted over very limited areas and were extensive rather than intensive in nature in that they were intended to learn as much as possible about broad areas rather than concentrate on small regions and survey them completely. All surveys focused on locations where archaeologists expected to find sites based on previous experience and none of the efforts spent much time looking for sites in areas suspected of having low probabilities for yeilding sites.

Data Gaps

The limited amount of work done thus far in and adjacent to the ANWR study area leaves many questions to be answered about the cultural remains of the area. The questions involve the chronology of the cultural sequence, the processes that produced this chronology and the behavioral significance of the cultural remains present. In order to make the limitations of this knowledge clear it is necessary to provide a general discussion of what is known or suspected about the cultural remains of the northern area of Alaska and northwestern Canada so that they can be compared to those of the study area. Comparing the 2 will verify the limited nature of the knowledge of the study area and result in a list of archaeological questions that need to be answered for the study area. As will become clear during the following discussion, the general history is incompletely understood and some of the questions developed for the study area will have relevance at this general level.

Table 1 presents Hall's provisional outline of North Alaskan Culture history (Hall 1981). It represents the only attempt at synthesizing information available in the literature of the area. When Hall proposed this outline of cultural history he explained that any attempt to establish a chronology for this area must include a set of compromises. The lack of scientific archaeological investigations in northern Alaska has led to a situation where there are areas of disagreement between archaeologists about some of the criteria used to place assemblages into groups. For example. there are disagreements about which sites should be included in Ipiutak and about the relationship to the modern Inupiat of the cultures that make up the Arctic Small Tool Tradition. Some archaeologists see a continuum from the ASTT to modern Eskimo while others suggest they may only be related in some indirect way that is not well understood. In addition, the relationships between Norton, Charis and Denbigh is confusing at best. Finally, there are dicrepancies in radio-carbon dating that have not been adequately addressed.

These discrepancies of chronology are only part of the problem reflected in the limited scientific archaeology that has been done in Northren Alaska. The goal of archaeology is more than collecting and cataloging archaeological specimens; it is understanding the human behavior associated with the specimens and their distribution. It also seeks answers to questions besides those directly reflected in tool use and distribution such as the size of the groups involved and the structure of social relations both within and between small groups. Most of these behavioral questions have yet to be addressed in any meaningful way by the archaeological community working in northern Alaska. Without answers to some of these questions, the names assigned to "cultural tradition" are little more than names of collections of similar artifacts that have only limited behavioral significance. However, rather

TABLE 1. Provisional Outline Of North Alaska Culture History.

TRADITION	CULTURE	DATE	RADIOCARBON DATES[1]	REPRESENTATIVE SITES
Eskimo	Historical Inupiat	1838-present	---	Turner River Overlook. Prudhoe Bay #1, Barrow sites, Sisraruq, Tukuto Lake, Anaktuvuk Pass sites, Anigarnigurak, and many others.
Eskimo	Late prehistoric Inupiat (Western Thule)	A.D. 900-1838 on coast; ca. 1300-1838 in interior.	Walakpa: 840+90 B.P.=A.D. 1110. Some radiocarbon dates from Alyeska Pipeline corridor may date sites occupied during this period.	Nuwuk and other sites around Barrow, Walakpa, Nunagiak, Agergognat, Liberato Lake, Swayback Lakes, Tukuto Lake, Lake Betty, Kinyiksukvik, Etivluk Lake and others.
Athapaskan	Kavik (Kutchi)	A.D. 1450-1850	Atigun: 115+140 B.P.=A.D. 1835; 360+100 B.P.=A.D. 1519; 310+140 B.P.=A.D. 1640; 168+34 B.P.=A.D. 1782, etc.	Kavik, Atigun.
Eskimo	Punuk	ca. A.D. 900	---	Nunagiak
	Birnirk	A.D. 500-900 on coast; interior apparently not	Anderson Point: 1130+200 B.P.= A.D. 820; 1160+240 B.P.=A.D. 797; 1090+300 = 867 A.D. Kugusugaruk: 1430+90=A.D. 527; 1146 +95=A.D. 811; 1430+190=A.D. 520; 1146+95A.D. 804. South Meade #1: 1260+65 B.P.=A.D. 690; 1340+55 B.P.=A.D. 610; 1420+110 B.P.=A.D. 530.	Anderson Point, Birnirk and other sites in Barrow area, Walakpa, South Meade #1.
	Old Bering Sea	ca. A.D. 500	---	Birnirk and other sites in Barrow area.
Arctic Small Tool	Ipiutak	A.D.O. - A.D.700; may have co-existed with Birnirk for some time.	Five dates on material from the Feniak Lake site, in the Noatak drainage, which is comparable to Anaktuvuk Pass Ipiautak, average A.D. 500.	Anaktuvuk Pass, Itkillik Lake.
	Norton	1500B.C.-A.D. or slightly later	Gallagher Flint Station: (Hearth 1 2920+155 B.P.=970 B.C.; (loc. 1A) 2620+175 B.P.=670 B.C.; (Loc. 5) 1975+125 B.P.=25 B.C.; 2540+185 B.P.=590 B.C.; (Loc. 7) 1735+150 B.P.=A.D. 215; 2640+180 B.P.=690 B.C. and others.	Sites in Barrow area, BAR-095, Walakpa, Sisraruq, Avak Point, Tukuto Lake, Kayuk and Avingak in Anaktuvuk Pass, numerous sites along Alyeska Pipeline corridor including Gallagher Flint Station.
	Choris		Other radiocarbon dates from Alyeska Pipeline corridor may date sites occupied during this period. Dates on the brief Avingak occupation at Anaktuvuk Pass range from 1500 to 3000 years ago.	
	Walakpa	ca. 1500 B.C.	Walkpa: 3400+520 B.P.=1450 B.C.	Walakpa and Coffin.
	Denbigh	?2300 B.C.-500B.C.?	Punyik Point: 3660+150 B.P.= 1710 B.C.; another date of 650 B.C. was discarded as being too late. No Name Knob: 3440+160 = 1490 B.C.; 3855+155 = 1905 B.C. Blip: 3480+180 = 1530 B.C. Mosquito Lake: 5 dates ranging from A.D. 20-40+150 to 880-900+165 B.C.; a sixth date (2040 + 170 B.C.0 believed to be culturally invalid.	Tukuto Lake, Kurupa Lake, Etivluk Lake (Punyik Point), Anaktuvuk Pass Mosquito Lake and other sites along the Alyeska Pipeline Corridor.
Northern Archiac	Tuktu	? 4500 B.C.-? area may have been unihabited for a period before Denbigh times.	Tuktu: seven dates range from 4500 B.C.- 200 B.C., but earlier dates believed correct on basis of dated sites outside Northern Alaska	Tunalik, Tuktu, Lisburne, sites along Alyeska Pipeline corridor (Cook 1970).
Paleo-Amerind	Lanceolate Point	6000-5000 B.C.	Mesa: 7620+ 95= B.C.	Kahurok, Mesa, Naiyuk (Anaktuvuk Pass Lisburne, Bedwell (Putu site).
	Fluted Point	ca. 6500 B.C.	Putu: 6090+150 B.P.; 4140 B.C. 8454+130 B.P.; 11,470+500 B.P.= 9520 B.C.	Utokok River sites, Lisburne, Putu scattered finds elsewhere?
American Paleo	---	ca. 8500 B.C.-6500 B.C.	Gallagher Flint Station: 10,540+ 150 = 8590 B.C.	Tunalik, Lisburne, Gallagher Flint Station, scattered finds elsewhere.

[1] Many of the radiocarbon dates presented are uncorrected and therefore may be slightly inaccurate (After Hall 1981).

than rejecting Hall's chronology as inadequate the practical alternative is to use it as the best one available while keeping its limitations in mind, and to hope that future research in the north and in the ANWR study area in particular will help to eliminate some of these limitations.

Two omissions from the outline should be mentioned; these are the British Mountain Tradition and certain finds from the Old Crow Basin. The British Mountain tradition was originally identified in a site located on the northern Firth River, Yukon Terrritory. MacNeish (1956) thought it to be quite old. Later work in Canada provided a secure date of 5400 B.P. (Gordon 1971) which was more recent than originally thought. Salwin et al. identified this tradition as occuring in the foothills of the Brooks Range just south of the study area. However, some scholars doubt the existence of the tradition (Dekin 1978). For the purposes of this discussion, the possibility that the Tradition does exist will not be rejected but the 5400 B.P. date rather than an earlier one will be used. Rather than try to place the tradition in Hall's chronology, it will be considered separately and, its existence and possible relationship to Hall's Paleo-Amerind is a potential research question.

The problem of the Old Crow finds also requires discussion because there is a relatively widely accepted date of 27,000 B.P. for a caribou bone flesher from that area (Irving and Harrington 1978). Those who accept this date tend to disregard the facts that the flesher was secondarily deposited and that it very much resembles tools seen in modern Athapasckan camps during the historic period. Even if these facts are ignored, it is difficult to discuss these finds further because the archaeological evidence is so limited and confusing that there are no other locations where convincing supporting finds have been made. Other data such as paleogeography, climatic history and vegetation that could help clarify the situation are also incomplete. While these finds can not be totally disregarded and should be added to Hall's chronology, the likelihood of encountering them in the study area is not very high.

Review of the table shows that other locations in northern Alaska have been occupied much longer than has the ANWR study area . Whether this is due simply to the limited amount of investigation completed thus far, or to the fact that the bearers of the American Paleo-Arctic, Paleo-Amerind and Northern Archnic Traditions never occupied the ANWR study area is not clear. There is, however, no reason to reject the possibility that they may have been present in the area, and this possibility should be investigated in future work.

The status of the Arctic Small Tool Tradition in the study area is even more unclear than it is for northern Alaskan in general. While the relationships between the cultures of the tradition are vague in the larger area, it has at least been possible to make tentative distinctions between them. The few sites thus far indentified in and near the ANWR study area have not yielded collections large enough to even be positive that they represent the tradition itself. Certainly, it has not been possible to assign these sites to specific cultures. Here again, it is reasonable to believe that future work, particularly if it covers a wider geographic area, will yield sites containing inventories adequate for the purposes of assigning them to a specific culture.

It is presently difficult to describe the specific relationship of the older sites at Barter and Arey Islands to the Birnirk sites to the west (Table 1). As was mentioned earlier, Jenness thought the collection from Barter Island was similar to collections from Barrow, however this work is almost 70 years old and additional comparisons are appropriate. Because the site at Barter Island has been almost totally destroyed, the best way to make this comparison would be to conduct excavations at Arey Island and compare the collections recovered to those from Birnirk sites to the west. It is also possible that this would also result in some tentative conclusions about whether Old Bering Sea and Punuk peoples ever got as far east as Barter Island. Excavation at Arey Island would also provide very valuable information about what a trading site looked like from an archaeological perspective.

Those sites Hall includes in his Athaspaskan Tradition are all in the Brooks Range and because the ANWR study area does not extend that far south, it is not very probable that future work will find sites from this tradition. However, Stefansson (1914) indicates that Indians from the Arctic Village area used the Hulahula River as a travel route when attending the trade fair at Arey Island, which Franklin may have observed, and it may be possible that surveys on this river will identify Indian sites.

There have been many Eskimo sites dating to within the last 200 years identified in and near the study area. Of these the most interesting due to its size and complexity is Turner River Overlook which is outside the study area. However, there is no reason to believe that the site is unique in that it was seemingly located primarily to effeciently exploit caribou. The possibility that there may be more sites of this kind should be investigated during future work. These sites hold a tremendous potential for providing data about a wide range of archaeological questions based on the theories of cultural ecology. There are also definite possibilities that other caribou fences and tent rings representing early modern Eskimo will be identified and questions about their structure and function and how they are related to the larger sites in the area may be addressed.

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Subsistence

This section documents land use patterns and the use by Native people of fish and wildlife species present or adjacent to the ANWR Study area. It presents detailed information from the village of Kaktovik, an Inupiat Eskimo community located immediately adjacent to the ANWR study area. It also discusses subsistence use by villages outside the study area which is affected by wildlife populations found in or near the study area. Discussion of villages other than Kaktovik is limited to uses of the Porcupine caribou herd, polar bears and beluga whales as these migratory species may be affected by activities in the ANWR study area. Information for these villages was gathered solely from existing literature and information. Information on the village of Kaktovik was accumulated over a 4 year period, from 1977 to 1981. Few published references are cited as most of the information was gathered from local residents. Formal interviews, informal conversations, and actual field observation and participation were employed as research methods. Mike "Jake" Jacobson, former Assistant Manager of the ANWR travelled and camped with local people, and employed some in refuge projects. Through observation and conversation, information was gathered on fish and wildlife species, land use and historic knowledge. During summer of 1978, Cynthia Wentworth Jacobson collected information on the subsistence land use for many fish and wildlife species through formal interviews and land use mapping with 13 hunters, representing 1/4 to 1/3 of Kaktovik's households. This was done as part of a larger study and mapping effort of subsistence land use on Alaska's North Slope (Pedersen 1979). Since that time, more extensive knowledge has been accumulated on subsistence land use, including past and present use of historic sites, through more conversations with local people and more actual participation in their activities.

Traditional Land Use Inventory Sites

The North Slope Borough, under the direction of Flossie Hopson, prepared and published a "Traditional Land Use Inventory" (TLUI) of historic and cultural sites in the Beaufort Sea coastal area (Nielson 1977a). This inventory has been used as the basis for compiling additional documentation on sites used and having special significance to the people of Kaktovik and to people residing in places such as Barrow, Nuiqsut, and Anaktuvak Pass in Alaska; and Inuvik, Aklavik, and Tuktoyaktuk in Canada. These sites date to about 1910, which is considered the beginning of the historic period in this area. The information presented is not a comprehensive compilation of use for these sites nor is it a complete listing of all TLUI's important to the people of Kaktovik. Historic (TLUI) sites are referred to throughout this section. TLUI sites are underlined in the text. Inupiaq place name spellings in use today are often different from those appearing on USGS maps. The correct Inupiaq spelling and the USGS name are given in those instances. For example, <u>Kanigniivik</u> historic site is in the same general location as Kongánevik Point on the USGS map.

TLUI sites identified in and near the ANWR study area are listed in Table 2 and their locations are presented in Fig. 1. Detailed descriptions of these sites are located in Appendix II.

Table 2. Traditional Land Use Inventory Sites found on or near the ANWR study area.

Inupiaq Name	English Name
Qikiqtaq	-------------
Sirak	Flaxman Island
Kugruak	--------------
Agliguagruk	Brownlow Point
Tigutaaq	--------------
Kayutak	--------------
Kanigniivik	Konganevik Point
Katakturak	Katakturuk
Nuvugaq	Point Collinson
Kunagrak	---------------
Aanallaq	Anderson Point
----------	Sadlerochit Springs
Sanniqsaaluk	---------------
Patkotak	---------------
Sivugaq	---------------
----------	First Fish Hole
----------	Second Fish Hole
Katak	Third Fish Hole
Kanich	---------------
Uqpillam Paana	---------------
Naalagiagvik	Arey Island
Iglukpaluk	---------------
----------	Tikluk-Akootchook housesite
Qaaktugvik	Kaktovik (first location)
Qaaktugvik	Kaktovik (second location)
Qaaktugvik	Kaktovik (present location)
Pipsuk	Pipsuk Point
Qikiktaq	Manning Point ("Drum Island")
Tapkak	Bernard Spit
Tapqauraq	Martin Point and Tapkaurak Spit
Uqsruqtalik	Griffin Point
Pukak	-----------------
Imaignaurak	Humphrey Point
Iglugruatchiat	-----------------
Angun	-----------------
Nuvagapak	Nuvagapak Point
Atchilik	-----------------
Siku	Icy Reef
Piyuqsraluk	-----------------
-----------	Demarcation Bay - west side
Kuvluuraq	-----------------
----------	Old Man Store
Kanigluaqpiat	-----------------
Pattaktuq	Gordon

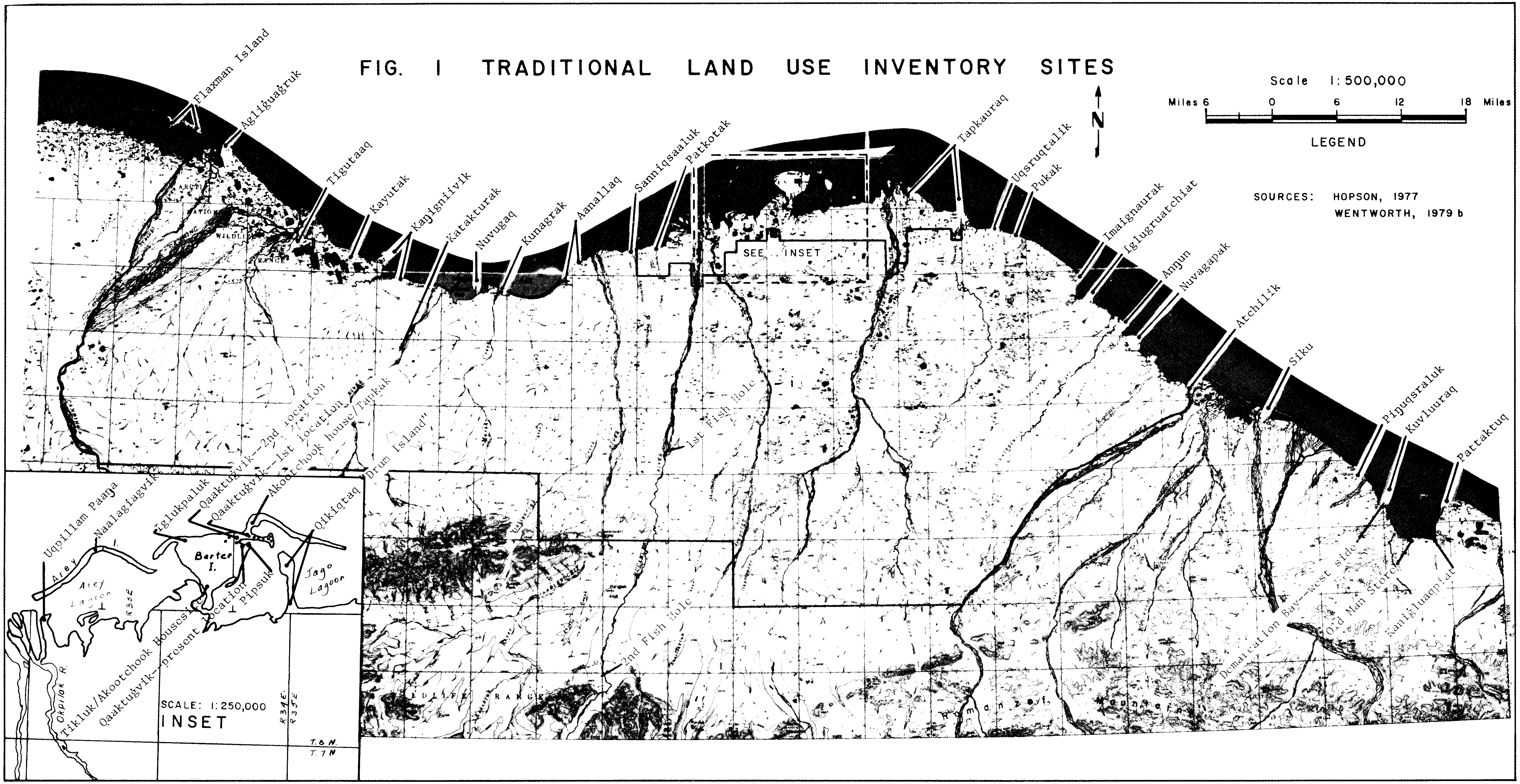

FIG. 1 TRADITIONAL LAND USE INVENTORY SITES

Historical sites located west of the ANWR between the Canning and the Colville Rivers are designated as mid-Beaufort Sea TLUI sites (North Slope Borough 1980). These TLUI sites are identified by their mid-Beaufort site number in the text of this section. Two Canning River delta sites at Flaxman Island and Agliguagruk (Brownlow Pt.) are included in this list and have been described in the North Slope Borough's mid-Beaufort Sea designation (North Slope Borough 1980). Agliguagruk (Brownlow Pt.) is also within the boundaries of the ANWR study area, and Flaxman Island is in close proximity. In addition to the Borough's TLUI for these sites, the Borough has done a special study of the cultural resources at these 2 places, which together form the focus of a Borough designated cultural resource subsistence zone (Libbey 1981). This consolidated discussion of the sites at the 2 places not only includes much of the previously documented information (Wentworth 1979, North Slope Borough 1980) but is based on actual site visits which took place during summer 1980. The documentation team visiting the sites included former residents of the sites as well as a Borough archeologist and ethnohistorian, other Borough officials, and a representative of the ADF&G's Subsistence Section. Although other archeological studies have been done on the ANWR (see Archeology section), this is the only on the ground study of historic (TLUI) sites that has been completed. It is also the only study which combines historical and archeological expertise.

Kaktovik

Location and History

Kaktovik is the easternmost village in the North Slope Borough. Most of its 175 residents are Inupiat Eskimos who are part of the broader cultural group of Inuit peoples stretching from Siberia to Greenland. Their language is North Slope Inupiaq. Kaktovik is located on Barter Island, in the Beaufort Sea. In contrast to the Chukchi Sea, where offshore leads are likely to remain open all winter, the Beaufort Sea coast may be ice bound by shorefast ice for 10 months or more each year. Because of these conditions, winter populations of marine mammals are smaller in the Beaufort than in the Chukchi Sea (Arctic Environmental Information and Data Center (AEIDC 1979). Some species common in the Chukchi Sea, such as walrus, are rarely found far east of Barrow even in summer. As a result of the differing resource levels, the Chukchi Sea coast has supported a larger Native population than the coast of the Beaufort Sea (AEIDC 1979).

Most of Kaktovik's present subsistence land use is within ANWR, and extends as far south as the headwaters of the Hulahula River. The coastal area west of ANWR may also be used during summer, often to Bullen Point and occasionally as far as Foggy Island. Some present day Kaktovik people grew up in this mid-Beaufort sea coastal area between the Canning and Colville Rivers, and they still have strong associations with this area even though it is no longer the main subsistence area (Wentworth 1979b). Some Kaktovik people also once lived and hunted extensively east of the ANWR, in Canada.

Because subsistence and trapping activities determined where people lived, historic sites (Table 2) used by Kaktovik people are found within their former and present subsistence land use area. The sites span an area from Oliktuk Point (Uuliktuq) at the Colville River mouth, to the Canadian border and beyond. Most of the historic sites that people use now are within the ANWR and are associated with present subsistence land uses (Fig.1).

Barter Island, as its name implies, has been an important trading center. Canadian Inuit people met here to trade with Barrow area residents, sometimes while travelling to another trading center at Niglik at the mouth of the Colville. Inland people also came down from the mountains to trade, and even Indians from south of the Brooks Range visited here occasionally (Nielson 1977b as cited by Wentworth 1979a).

A large prehistoric village once existed on the island. The Canadian explorer Diamond Jenness counted between 30 to 40 old house sites there in 1914 (Leffingwell 1919). Before the present airport was built atop this site, many whalebones could be found among the sod house ruins, suggesting that the people were whalers (Kaveolook 1977). Cora Ungarook's father Nasunguluk of Barrow wintered there in 1916 and used some of these whalebones for fishnet weights. One legend says these prehistoric people, the Qanmaliurat, were driven east to the Canadian side by other Inupiat through fighting. The Qanmaliurat killed one couple's only son, which is why after that there were no more people living at Barter Island. The couple fished their son's body out of the water with a seining net...hence the name Qaaktugvik (Kaktovik) which means "seining place" (Kaveolook 1977, Okakok 1981). Another legend states that the body fished out of the water was that of Pipsuk, who drowned in the lagoon while fishing from a kayak (See Pipsuk Point site, Appendix II). Although Barter Island was not a permanent village, it remained a seasonal home for some of the nomadic ancestors of present-day Kaktovik residents, who travelled around in pursuit of caribou, sheep, marine mammals, fish, and birds.

Barter Island was also an important stop for commercial whalers during the 1890's and early 1900's (Nielson 1977b as cited by Wentworth 1979a). In 1917, the whaler and trader Charles Brower sent his associate Tom Gordon from Barrow to Demarcation Point to establish a fur trading outpost for the H.B. Liebes Company of San Francisco. After several years at Demarcation Point, Andrew Akootchook helped Gordon establish a trading post at Barter Island in 1923 (Kaveolook 1977). The trading post provided a market for local furs, and was the beginning of Kaktovik as the permanent settlement of today (Nielson 1977b, as cited by Wentworth 1979a).

Although people living in the vicinity of Barter Island congregated at the fur trading post on holidays and other occasions, most of the time they lived dispersed along the coast. They were semi-nomadic, following the animals on which their hunting, fishing and trapping economy depended. The arctic fox was a source of cash income, and they supplemented it with game (Kaveolook 1977). Some of the families also herded reindeer, keeping them at places such as Nuvugaq and Aanallaq at Camden Bay, Barter Island and Demarcation Point, and taking them to the foothills of the Brooks Range during winter months.

The Scottish botanist Isobel Hutchinson (1937) described life with the Gordon family at Iglukpaluk on Barter Island in 1933. In his published diary of a trip taken in April 1937, Fred Klerekoper (1937) described his stay with the Ologak family near the mouth of the Sadlerochit River (Aanallaq), and with the Akootchook family just east of Barter Island at Bernard Spit (Tapkak). Almost all of Kaktovik's present Inupiat population of 175 is closely related by blood or marriage to these 3 interrelated families.

The fall of the fur price for fox in the late 1930's caused most of the Alaskan trading posts to close by the early 1940's. Tom Gordon died of a stroke in 1938 and no one took over the Barter Island post. The trader at Imaignaurak died in 1942, and the trader at Agliguagruk left in 1943. Reindeer herding also ended in the late 1930's. People had to go to Aklavik in Canada to trade. Several Kaktovik families moved to Herschel Island, Canada. Others built houses at Barter Island. The early 1940's was a hard time for most Kaktovik people. The small amount of "tannik" or white man's food that they received each summer on the yearly supply ship was not enough to last through the winter,and then they were exclusively reliant on the area's fish and wildlife for survival.

World War II had little effect on Kaktovik residents, but the postwar military build-up caused major changes. In 1945 the U.S. Coast and Geodetic Survey began mapping the Beaufort seacoast. Over the next few years at least 3 Kaktovik people were hired to help with this project. Barter Island was chosen as a radar site for the Distant Early Warning (Dewline) system, which extended across the Alaskan and Canadian Arctic. This development provided jobs for area residents, and caused several physical alterations to the community. In 1947 the Air Force built an airport runway and hangar facility on the prehistoric village site, where several houses were located. In 1951, the entire area around Kaktovik (1,823 ha) was made a military reserve. In 1964 the village moved a third time, and received title to the present site, although not to the old cemetery (Nielson 1977b, as cited by Wentworth 1979a).

The availability of jobs resulting from U.S. Coast and Geodetic Survey work and DEW Line construction, and the consequent establishment of a school, caused the Barter Island population to increase rapidly. The U.S. Census counted 46 people in 1950, but by August 1951 when the BIA school opened at Kaktovik, there were 8 families with 86 adults and children. People moved in from the surrounding area and 5 of the 6 families living at Herschel Island moved to Barter Island. By the spring of 1953 the population was 140-145 (Kaveolook 1977). The population remained relatively stable until the late 1970's when more employment opportunities and better housing caused some former Barter Island area residents living in Barrow to move back with their families.

Land Use Patterns

Present day land use patterns in Kaktovik are a function of tradition and history. Families have a tendency to return to those places where parents lived or camped during their youth. The changes in living patterns of Kaktovik residents are largely a result of changes in the type of cash economy which has supported them. Although they have lived in a part-subsistence, part-cash economy since the late 1800's, only since the late 1940's has it been the type of cash economy which required them to stay in one place. Before that time, Barter Island area residents earned cash through the land-based activities of fur trapping and reindeer herding. Their pursuits, as well as the traditional hunting and fishing activities, required that they live dispersed along the coast and be somewhat nomadic.

The establishment of a permanent village and the arrival of modern technology and its amenities, including hunting and fishing technology, have increased people's need or desire for cash. This has, in turn, made it necessary that they stay in the village to earn it. Those who have permanent jobs arrange their subsistence activities around their jobs by hunting on weekends and during leavetime. Those who have seasonal or intermittent jobs are free to be full-time subsistence hunters the remainder of the time. It is rare, however, for people to leave the village for more than a few weeks at a time. The advent of snow machines means that travel is much faster. For example, it used to take 2 days by dog team to get to the second Fish Hole on the Hulahula River, but now it takes only 4 hours. Therefore, it is now possible to go to the Hulahula River for the weekend, although almost everyone who goes stays a week or two. The expense of gas and the work involved in hauling supplies makes a stay of more than two or three days desirable (Wentworth 1979a).

Several different individual illustrations of Kaktovik people's land use patterns over time have been compiled (North Slope Borough 1980, Jacobson and Wentworth 1981).

Resource Utilization Patterns

Kaktovik residents depend primarily on caribou, sheep, bowhead whales, fish, waterfowl and other birds for their subsistence. Seals, polar bear, and furbearers are also taken. Grizzly bears may be taken occasionally, but they are not hunted actively. Sometimes a walrus is taken, but these animals are uncommon in the Beaufort Sea. A few people pick berries, wild rhubarb, and roots to round out the subsistence diet. Driftwood is gathered along the beach and used as a supplementary heating source by some families. Table 3 lists species utilized by Kaktovik residents and identifies their common and Inupiaq names.

Fig. 2 summarizes the annual cycle of use for subsistence resources by the people of Kaktovik. Subsistence patterns and activities are determined largely by whether snow is present, permitting travel by snow machine, or if open water is present allowing for boat travel. During the snow-free months (usually mid-June through September), overland travel by snowmachine is not possible. However, by early July the sea ice has melted enough to make the coastal areas accessible by outboard-powered boats. Thus the entire coast from Foggy Island to Demarcation Bay is what might be called the "summer subsistence area". Motorboat access to inland areas by means of the rivers is normally not possible because of shallow water.

The snow season (from October through May), greatly expands the amount of land used for subsistence. Snow cover permits travel across the tundra of the coastal plain, and access to the camps along the Hulahula and Sadlerochit River drainages of the Brooks Range. During the snow season "the mountains" are the single most important place for subsistence activities. April and May are considered the best months for travelling overland by snowmachine because snow cover is adequate and there are many hours of daylight.

Marine Mammals

Bowhead Whale (Agviq): Beluga Whale (Qilalugaq): According to older residents, Kaktovik was a prehistoric whaling site with whale bones used for a walkway to the beach (Kaveolook 1977, Okakok 1981). In historic times, however, no whaling occurred at Kaktovik prior to 1964. As men from other parts of the North Slope have married Kaktovik women, they have brought their whaling

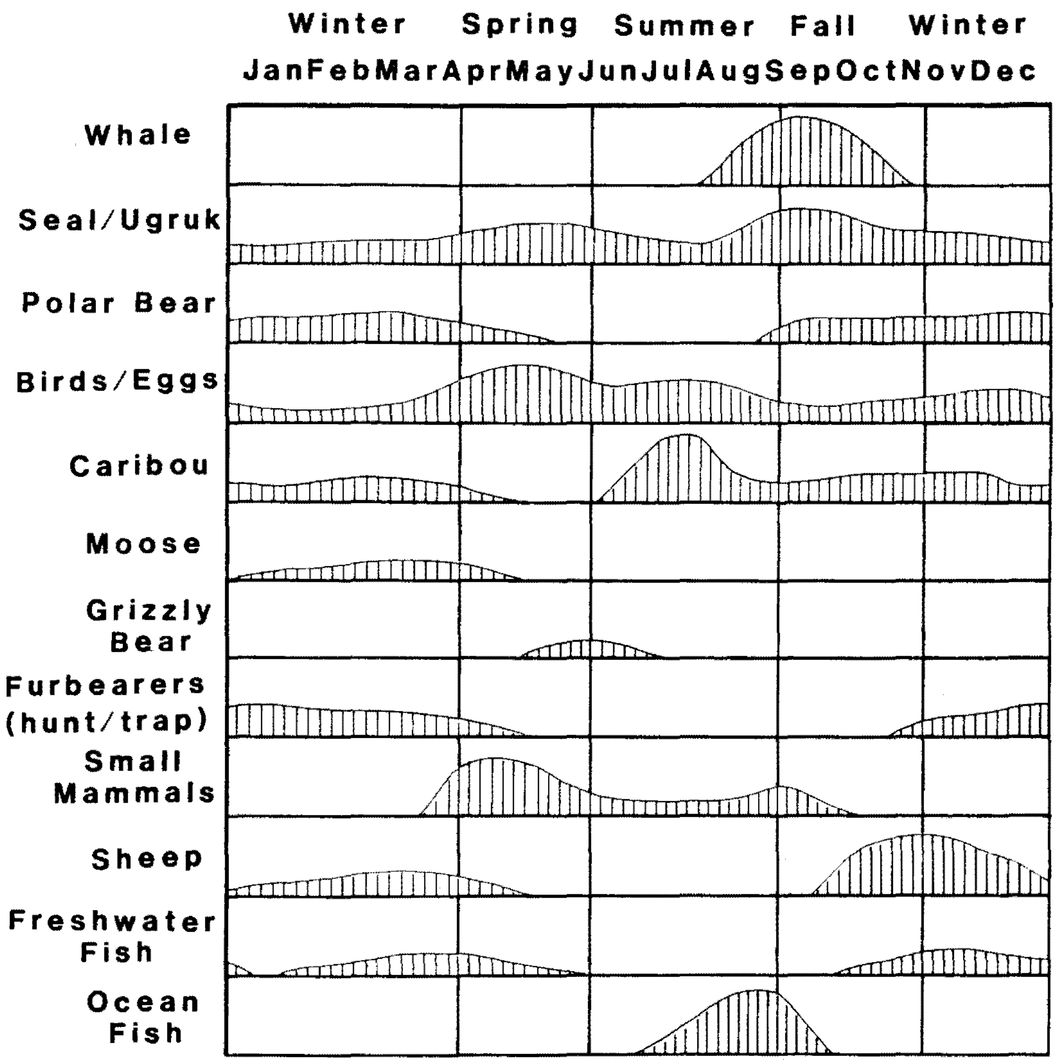

Figure 2. Yearly cycle of subsistence use at Kaktovik, Alaska. Patterns indicate desired periods for pursuit of each species based upon the relationship between abundance, hunter access, seasonal needs and desirability.

Table 3. Species used by Kaktovik residents for subsistence purposes.

English Name	Inupiaq Name
Marine Mammals	
Polar bear	Nanuq
Bearded seal	Ugruk
Ringed seal	Natchiq
Spotted seal	Qasigiaq
Walrus	Aiviq
Beluga whale	Qilalugaq
Bowhead whale	Agviq
Birds	
Common eider	Amauligruaq
King eider	Qinalik
Black brant	Niglingaq
Snow goose	Kanuq
Canada goose	Iqsragutilik
Pintail	Kurugaq
Oldsquaw duck	Aaqhaaliq
Ptarmigan	Aqargik
Willow ptarmigan	Akrigivik
Rock ptarmigan	Niksaaqtuniq
Snowy owl	Ukpik
Birds' eggs	Mannik
Large Mammals	
Caribou	Tuttu
Dall Sheep	Imnaiq
Moose	Tuttuvak
Brown Bear	Aklaq
Furbearers/Small Mammals	
Arctic fox	Tigiganniaq
Red fox	Kayuqtuq
Wolf	Amaguq
Wolverine	Qavvik
Mink	Itigiaqpak
Weasel	Itigiaq
Arctic ground squirrel	Siksrik
Hoary marmot	Siksrikpak
Fish	
Arctic char	Iqaluk Iqalukpik
Whitefish	
Arctic cisco	Qaaktaq
Least cisco	Iqalusaaq
Broad whitefish	Aanaakliq
Round whitefish	Savigunaq
Ling cod	Tittaaliq

Table 3. (Continued).

English Name	Inupiaq Name
Grayling	Sulukpaugaq
Chum salmon	Iqalugruaq
Pink salmon	Amaqtuq
Arctic flounder	Nataagnaq
Fourhorned sculpin	Kanayuq
Lake trout	Iqaluakpak
Pike	Paigluk
Arctic cod ("tomcod")	Uugaq
Smelt	Ilhuagniq
Blackfish ("old man fish")	Anayukararuak
Berries	
Blueberry	Asiaq
Cloudberry	Aqpik
Cranberry	Kimminnaq
Greens/Roots	
Wild potato	Masu
Wild Rhubarb	Qunulliq
Forest/Vegetation	
Driftwood	Qiruk
Brush, willow	Uqpik

skills and equipment with them and helped reestablish whaling in Kaktovik. Kaktovik people have always eaten maktak, which they obtained from other villages before they began whaling at Kaktovik. The whaling season occurs during the westward migration of bowheads off the Beaufort seacoast, from late August until early October. There is no spring whaling season at Kaktovik because the open leads are too far from shore. Whale hunting generally occurs within 16 km of land but sometimes as much as 32 km offshore.

A total of 22 whales have been taken by the villagers of Kaktovik since 1964 (Table 4). Over the past few years up to 7 crews with about 5 members each have participated in the hunt. The crews use small outboard-powered boats (4.3 - 6.7 m in length). They communicate by citizens band radio. When a whale is struck, the other crews help to kill and tow the whale to Kaktovik. During the whaling seasons of 1979 and 1980, hunters from the village of Nuiqsut joined the Kaktovik whalers because of unfavorable conditions in their area.

Whaling normally occurs between Aanallaq on the west and Uqsruqtalik on the east. Crews may occasionally go as far east as Humphrey Point, staying closer to shore when they go this far. Many days are not good for whaling, as the seas must be relatively calm and the visibility favorable. Often, the fog rolls in or sudden storms come up, forcing the whaling crews to return to shore. Whaling does not take place far from Barter Island, because when a whale is taken, it must be towed to Kaktovik. Towing a 30 to 50 ton whale, even with 6 or 8

Table 4. Whales taken by the village of Kaktovik between 1964 and 1981.

Number of Crews	Number Taken	Date	Approximate Length	Sex	Approximate Location
--	2	1964	----	--	1.6 km NW Bernard Spit and 1 found dead off Humphrey Pt. (Imaignaurak)
--	3	1973	9.1-12.2 m	--	One 1.6 km N Bernard Spit. Two between Jago Spit and Griffin Point (Ugsruqtalik).
2	2	10-24 Sept. 1974[a]	----	--	------
2		1975[b]	----	--	------
7	2	20 Sept 1976[c]	13.7 m	M	3.2 km NE Jago Spit .
		27 Sept 1976[c]	9.1 m	--	Barter Island's Arey Spit, N of Iglukpaluk.
5	2	28 Sept. 1977[d]	16.8 m	M	3-7 km N Barter Island.
		1 Oct. 1977[d]	9.1 m	F	3-7 km N Barter Island.
5	2	21 Sept. 1978[e]	11.1 m	M	Barter Island; washed up at Camden Bay.
		26 Sept. 1978[e]	13.3 m	M	16-24 km N Griffin Pt.
7	5	20 Sept. 1979[f]	12.7 m	M	5-8 km NE Griffin Pt.
		6 Oct. 1979[f]	10.7 m	F	Shallow water 1 km N-NE Barter Island.
		8 Oct. 1979[f]	10.3 m	M	------
		10 Oct. 1979[f]	10.8 m	M	------
		11 Oct. 1979[f]	10.8 m	M	Shallow water Arey Island Pt.
5	1	14 Sept. 1980[g]	9.2-10.7 m.	M	Pukak
5	3	8 Sept. 1981	17.1 m	F	8-9 km NW Jago Spit.
		11 Sept. 1981	14.3 m	M	N Tapkaurak Spit.
		22 Sept. 1981	16.2 m	F	11 km NE Jago Spit.

[a]Fiscus and Marquette 1975
[b]Marquette 1976
[c]Marquette 1978
[d]Marquette 1979
[e]Braham et al. 1980
[f]Johnson et al. 1981
[g]Marquette et al. 1981

outboard powered boats, may take several hours under the best of conditions. When the weather is stormy or visibility is poor, towing time can take one or more days. The farther the whale has to be towed, the greater the chance that the meat will spoil. The thick layer of blubber does not allow the carcass to cool, even when air temperature is cold. Therefore, The time spent in towing the whale to Barter Island and butchering it is a prime consideration.

The earliest date that Kaktovik hunters have sighted a whale is 21 August. Whale sitings can vary considerably from day to day. Some days whalers may see few or no whales. Other days they may see 15 or 20. The last stage of migration is when large females and their calves pass Barter Island.

When crews are out whaling, people in the village may keep a vigil, climbing on rooftops and watching for returning boats with binoculars. If a whale is taken, a boat bearing a raised flag will return with the news, or the village is informed by radio. The villagers help the crews land the whale and pull it up on shore, using large pulleys and heavy equipment. Women erect a wall tent on the beach, and fix hot coffee and tea for the crews and workers. Older men and others gather the butchering tools and sharpen the knives. Women cook fresh maktak and the intestines if they are not spoiled and children pass them out. Everyone in the village is involved in one way or another.

After a whale is butchered, the meat and maktak are divided among the captain, crews, and the rest of the village. The captain saves "the captain's share", that portion from the "belly button" to the tail, and then distributes it at Thanksgiving and Christmas, and Nalukatuq feasts the next summer. The shares for the crews and for each village household are divided into equal portions. There is also a portion for the Presbyterian church in Fairbanks, and some families send part of their shares to relatives in Anaktuvak Pass, Barrow, Inuvik, or other villages. In 1981, over half of the meat and maktak went to places outside Kaktovik, with a whole plane load being sent to Nuiqsut.

Whaling is perhaps Kaktovik's most important community activity. It stresses the cultural values of group cooperation and sharing of resources, and is a way of passing these values to the younger generation. Almost every able-bodied man is on a whaling crew; a few women also go whaling. Older men serve as teachers, telling others how to butcher and divide the whale. School is closed for the event, the store closes, and all other community activities cease as people busy themselves with butchering the whale.

According to older residents, Kaktovik was a prehistoric whaling site with whale bones used for a walkway to the beach (Kaveolook 1977, Okakok 1981). In historic times, however, no whaling occurred at Kaktovik prior to 1964.

Kaktovik villagers occasionally take beluga whales incidental to the hunt for bowhead whales in the fall. In late August 1978, 2 beluga whales were taken from a large school near Pukak. Beluga whales were seen close to Barter Island in late August or early September 1980, and between 6 and 20 were taken. A few belugas were also taken at Uqsruqtalik in 1980, however, no beluga whales were taken at Kaktovik in 1981.

Seals. Kaktovik people hunt bearded seal (Ugruk), ringed seal (Natchiq), and spotted seal (Qasigiaq) for the oil, meat, and skins. Seal oil is a necessary element in the Inupiat diet and is also used for storing and preserving food. (Wentworth 1979a). Seals are hunted throughout the year although few are taken. Most seal hunting occurs by boat from July into September all along the coast, both inside and outside the barrier islands. With open water and long days, seal hunters can cover large areas. At other seasons, hunters sometimes travel considerable distances on the sea ice by snowmachine searching for seals along open leads.

The most intensely used summer seal hunting area extends from Pokok Bay on the east to Nuvugaq and Simpson Cove on the west. The Canning River delta and around Flaxman Island to the southeast of Brownlow Point are also important. Hunting on sea ice may extend as far east as Pokok Lagoon and as far west as Brownlow Pt. Two traditional spring seal hunting camps are at Naalagiagvik on Arey Island, and on Tapkauraq Spit, but many of the other traditional sites along the coast may also be used for seal hunting.

Ringed seals and bearded seals are taken more commonly than spotted seals. Ringed seals are the most numerous seal and occur year around. Bearded seals are more dispersed, however they are highly prized and are probably hunted more actively than ringed seals. Spotted seals are the least common species, with Aanallaq (Anderson Point) to the Hulahula-Okpilak delta and Demarcation Bay to the Canadian border being identified as important spotted seal hunting areas.

Seasonal preferences for seal hunting varies depending on whether or not the hunt is for the hide. Spring is considered the most favorable time for sealing, when days are long and the animals are often seen lying on the ice. However, ringed seals are molting at this time (May) and their hides are not in prime condition until August or September. June was considered an excellent time for seal hunting when dog teams were used for transportation, however, with the shift to the heavier snow machines, this period of seal hunting is no longer used.

A typical August seal hunt will usually take hunters 8 to 16 km offshore, but sometimes up to 32 km depending on the boating conditions and distribution of the ice. They travel among the floes of drifting ice, searching mainly for bearded seals. Bearded seals seem to prefer big ice floes, often several ha in size, particularly the floes with gradual sloping sides rather than a steep edge that is more difficult to climb upon.

Seal oil and meat remain an essential part of the Kaktovik diet, however, few seals are taken compared to former times. Dog teams had practically disappeared by the late 1960's, with the last dog team in Kaktovik disappearing in 1971 or 1972. The need for gas to feed snowmachines replaced the need for seals to feed dogs.

Walrus (Aiviq) are not often seen at Kaktovik. Over the past 20 years only 5 or 6 walrus have been taken by Kaktovik hunters. In the mid-1950's, 3 Kaktovik teenagers took the first walrus that had been seen in several years. During July 1978 a young walrus was taken 1 km from Barter Island, and in August 1981 a walrus was taken close to Bernard Spit. In 1975 or 1976 a few walrus were seen during the fall whaling season, but were not harvested. A small number of walrus were seen during the whaling season in 1981.

Polar bear (Nanuq) are actively hunted on the ice, seaward of the barrier islands. The main hunting area extends from the Hulahula-Okpilak River delta on the west, to Pokok Lagoon on the east. Hunters may go as far as 16 or more km offshore after polar bear.

Polar bear may be killed opportunistically when people are out camping or looking for other game. One was shot at Agliguagruk (Brownlow Point) in 1968. In 1975, a polar bear was shot at Uqsruqtalik (Griffin Point). Polar bears have occasionally been seen inland several km, sometimes even in the mountains. One was killed in the mountains of Canada in 1946, while another was chased using a dog team up the Okpilak River. In November 1977, polar bear tracks were seen along the Hulahula River, about 32 km from the coast. In April 1980 a polar bear sow and cub were seen on the northeast edge of the Sadlerochit Mountains near Itkilyariak Creek.

In recent years, polar bear have almost always been taken in the vicinity of Kaktovik, occasionally within a few m of a person's house. Fall and the dark months of winter are times when polar bear may be frequent visitors to the village. They are often attracted to the Barter Island dump, or to a whale carcass on the beach. Bears which enter the village are considered dangerous, especially the "skinny ones". Not all polar bears seen around the village are shot. In most years, mothers with cubs are left alone. Occasionally bears will appear during summer months; these are usually ignored or chased away from the village.

Since passage of the Marine Mammal Protection Act in December 1972, it has been illegal to sell unprocessed polar bear hides to non-Natives. There is probably less incentive now to hunt the bears actively; however, hides are very valuable if made into articles of Native clothing such as boots, mittens, or coats. Polar bear mittens are important cold-weather gear for village people.

Although polar bear hunters are interested mainly in the hides, the meat is usually eaten if the bear has enough fat on it. According to village elders, "skinny bears will make you sick". Fresh polar bear meat is considered an important side benefit although a few villagers prefer not to eat it saying it is too rich. When a hunter kills a bear the news travels fast and the meat is shared with others in the village.

The number of polar bears taken varies considerably from year to year, and is related to ice conditions and the number of bears attracted to the village during fall and winter. In 1977, 5 were taken, all between 20 October and 23 November. In 1978, 1 was taken, in November. In October and early December 1980, approximately 28 polar bears were taken when they were present in the Barter Island area. Virtually every family in the village shot at least 1, some took several. People at Barter Island have taken large numbers of polar bear in other years. In 1941, 11 polar bears were taken by one family alone.

Into the 1940's and 1950's, when present day Kaktovik people lived at other coastal locations, polar bear were hunted at other places off the Beaufort seacoast. One hunter went polar bear hunting by dog team each year out on the ice due north of Demarcation Bay, sometimes about 48 km out. Late April was the best time for these hunting trips. He also often hunted polar bear between Angun Point and the Kongakut River delta, 3-5 km beyond the barrier islands. Another former polar bear hunting area was Flaxman Island on the western part of the island, and off of Agliguagruk in the fall. One of the

Inupiaq names for Flaxman Island is Sigak, (commonly spelled Sirak) which means "place where polar bears go to get covered up with snow and have their cubs."

Birds

Waterfowl are hunted mostly in the spring, from May through early June, although less intensive hunting continues into September. Because arrival coincides with the end of school, waterfowl hunting is a family activity. Stays at the camps range from a few days to over a month, but are most commonly 1 to 2 weeks.

Black brant (Niglingaq) are the main species hunted in the spring and are prized for their freshness and flavor. People also commonly hunt pacific eider (Amauligruaq), king eider (Qinalik), snow geese (Kanuq), Canada geese (Iqsragutilik), pintail duck (Kurugaq) and oldsquaw (Aaqhaaliq). Oldsquaw are the most numerous waterfowl. Although more oldsquaw are taken than any other species, they are not highly prized and are usually taken incidental to other forms of hunting or when fishing nets are checked.

One popular place to hunt waterfowl in the spring is Nuvugaq, the spit on the east side of Simpson Cove in Camden Bay. The campsite is at the base of the spit, west of March Creek and on the shores of Simpson Cove. People hunt in a wide area around the spit and coastline, dependent on flight patterns of the birds. Sometimes families camp at Aanallaq on the eastern shores of Camden Bay, and hunt waterfowl in nearby coastal areas. On the western side of Camden Bay, Kanigniivik (Konganevik Point) and the small bay directly to the south are good hunting sites for brant.

Uqsruqtalik (Griffin Point), located 40 km east of Barter Island, is another popular waterfowl hunting camp. Hunting occurs from Oruktalik Lagoon to Tapkaurak Point and all around the narrow spit and coastline from Griffin Point to Pokok Lagoon. One family hunts waterfowl every year at Pukak, setting up a tent in late May. They usually return to Kaktovik in mid-June, then get their tent when they go back to the area by boat in July. People emphasized they use this area for brant, snow geese, and eider ducks.

At Barter Island, waterfowl hunting and camping areas vary according to flight patterns of the migrating flocks. The most commonly used hunting site during recent years has been the south end of Qikiqtaq or Manning Point, about 6 km from Kaktovik (Manning Point is also locally referred to as "Drum Island", because of the many discarded fuel drums in the vicinity). Brant are taken at Qikiqtaq in late May and early June. If birds pass farther out from the mainland, Naalagiagvik on Arey Island is a popular camping spot. The lakes southwest of Barter Island are also hunted, and sometimes waterfowl hunting camps are set up along the banks of the Okpilak and Hulahula Rivers just south of the delta.

The camps near Barter Island are used for shorter periods of time with more frequent travel to and from the village. Some people make day trips to the western or southern sides of Barter Island or to Bernard Spit when the ducks and geese are flying, and may go as far as the lakes south of the Jago Delta. Later in the summer, after the sea ice goes out, waterfowl are hunted using boats in Arey, Kaktovik, and Jago Lagoons.

Although the sites and areas described above are those most commonly used for waterfowl hunting, people may hunt ducks and geese along the entire coastline from Flaxman Island to Demarcation Bay. Travel to the more distant areas is usually by boat in July after the ice goes out, and is often in combination with fishing or caribou hunting. Two families emphasized they use Agliguagruk (Brownlow Point) and the spit directly southeast for waterfowl hunting. Flaxman Island is occasionally hunted and is remembered as a hunting area for brant and eider ducks by those who used to live there. In the fall, one family usually hunts geese in the lake system south of the Tamayariak River.

During summer boating trips, some people hunt waterfowl in Pokok Bay and Angun Lagoon and on the seaward side of these spits. One person emphasized that good waterfowl hunting areas exist at Beaufort Lagoon from Angun Point to Nuvagapak Lagoon, and Siku Lagoon from Siku entrance to the eastern mouth of the Kongakut River. This person also hunts ducks and geese in Demarcation Bay and outside Demarcation spit to the Canadian border.

Small numbers of bird eggs are collected each spring and are considered a delicacy. Eider and less commonly, glaucous gull and oldsquaw eggs, seem to be most commonly collected, usually from Arey Island or Tapkauraq Spit. The barrier islands from Flaxman Island west, including the Maguire, Stockton, and especially the McClure Island groups, are remembered by older people as having many eider duck eggs.

Willow ptarmigan (akrigivik) and Rock ptarmigan (niksaaqtuniq) are hunted throughout Kaktovik's land use area. Although ptarmigan may be hunted all year, most hunting occurs during April and May due to availability of the birds, long hours or daylight and easy accessibility to the mountains. In April and May the birds congregate in large flocks, making them easier to hunt. The last trips to the mountains for the spring season are often made to get squirrel and ptarmigan; ptarmigan are shot or caught in snares hidden among willow branches.

Large Mammals

Caribou (Tuttu) is the staple food item and most preferred land mammal in Kaktovik's subsistence diet. It can be a source of fresh meat throughout the year, meat which provides high levels of protein, vitamins and minerals. It is also eaten frozen and dried, and is a important part of the holiday feasts. Caribou hides may be used for garments, boot soles, and for blankets. Caribou mittens are worn during cold weather, and mukluks made from the skin of caribou legs are common. Hides are often used to sit or sleep on when people are camped away from the village (Jacobson 1979). Caribou bulls are preferred during summer, fall, and spring when they are fattest. Hides from caribou taken in July and August are used for garments and boot soles, while those taken in late October through November are used for blankets and mukluks.

Number of caribou taken by Kaktovik villagers is a function of the movements of the herd, environmental conditions, time available for hunting, and success of other hunting pursuits. No exact figures on yearly harvests are available, but village leaders have estimated that the average yearly take is 100 animals (Aishanna 1973, as cited by U.S. Dept. of Interior 1974, A.K. Brower 1979 pers. comm.). Estimated yearly takes for recent years are: 1977 - 100; 1978 - 90; 1979 - 40; 1980 - 80 (Jacobson and Wentworth 1981, Pederson and Caulfield 1981a). Fewer caribou are harvested now that dogs have been replaced by snow machines.

Caribou hunting opportunities for the residents of Kaktovik are usually greatest from early July to late August, but can fluctuate widely depending on the sea ice conditions and movements of the herd. In July when open water is present, people travel by boats along the coast in search of caribou. Hunters usually cannot go inland by boat because the rivers are too shallow, except for the lower 9-11 km of the Canning River. Other main caribou hunting periods are from late October to late November when there is sufficient snow cover for overland travel by snow machine and the days are not yet too short, and from late February through March and April when there are longer daylight hours and better weather conditions.

While travelling along the coast, hunters commonly go ashore to scan the surrounding terrain for caribou. Hunters may maneuver their boats closer to the animals and then pursue them on foot. Sometimes caribou are shot from the boat. Dead caribou are carried or dragged back to shore and butchered at the camp. Caribou are often spotted from camp.

The coastal area directly south of Barter Island and eastward to the Jago River delta is one of Kaktovik's most intensely used summer hunting areas. In May and June small numbers of caribou are taken here in conjunction with spring waterfowl hunting, though access may be limited due to break-up conditions and lack of snow. People hunt here mostly in July after the ice has gone out of the lagoon. The mainland southwest of Barter Island along Arey Lagoon is also quite important. Farther east of Barter Island the coastal area from Tapqaurak Point to Pokok Bay is heavily used for summer caribou hunting. Within this area, Uqsruqtalik is probably the most popular campsite. People go to Uqsruqtalik in July, and may spend several weeks there fishing and hunting.

Tapkauraq and Pukak are also popular places to camp. Present caribou hunting extends beyond Pukak to the Kogotpak River mouth and Nuvagapak Lagoon. People may also hunt caribou at Demarcation Bay if very few caribou have been seen closer to Barter Island, or if people are on their way to or from visiting relatives in Canada.

West of Barter Island, Aanallaq and Sanniqsaaluk may be used as bases for caribou hunting in July and August. Although the entire coast is used, the area from Nataroarok Creek to the eastern shore of Camden Bay appears to be important. Nuvugaq in Camden Bay is another well used caribou hunting location, where people often camp.

In some years the post-calving aggregations of the Porcupine caribou herd are not accessible to Kaktovik hunters. During the summers of 1978, 1979, 1980, and 1981, the Porcupine caribou herd passed to areas east of Barter Island and into the Yukon Territory before Kaktovik people were able to do any travelling. This situation occurred in late June and early July at a time when ice still covered much of the Beaufort seacoast, thus boat travel was impossible or extremely limited. Later in July, when boating did become possible, it appeared that the Porcupine caribou herd had left the area. In 1979 no caribou were reported taken by Kaktovik hunters during the entire month of July.

In August, scattered groups of caribou often appear near the coast in the areas of Kanigniivik and the Canning River delta. These caribou are probably members of the Central Arctic herd. This area has been a particularly important hunting area over the past few years, when few Porcupine herd caribou were available. Almost everyone in Kaktovik hunts at Kanigniivik, and several people hunt from Kanigniivik to the delta of the Canning River's main channel, up the channel as far as it is navigable, and from this area up to Agilguagruk (Brownlow Point). While most of this hunting is in August, people hunt at Kanigniivik throughout the year, particularly in the fall and winter. Caribou tend to congregate on the sandbars and delta of the Canning and nearby sandspits (Cameron, R. and K. Whitten 1979 pers. comm.). According to Kaktovik hunters, caribou often go to Flaxman Island during the spring and summer. They are sometimes hunted there, as well as along the coast from Agilguagruk to beyond the Staines River and around Bullen Point.

Caribou hunting in September and early October is greatly reduced because this is the time of subsistence whaling. Virtually the entire energies of the village are devoted to the pursuit of whales.

During October, after enough snow has accumulated, the inland caribou hunting areas become accessible. Most winter caribou hunting occurs in the mountains along river valleys. But people occasionally hunt caribou on the coastal plain, especially at favored locations like Kanigniivik (Konganevik Point). The Hulahula River's 2nd Fish Hole is one of the most intensely used areas for winter caribou hunting. Hunters radiate out from this winter camp in every direction, looking for the animals. Many people hunt the Hulahula drainage area between 2nd and 1st Fish Hole, and from 2nd Fish Hole upriver to Kolotuk Creek. The area between this stretch of the Hulahula and the Sadlerochit River drainage is also intensively hunted. People normally hunt as far south as Katak Creek, Karen Creek and the Kekiktuk River, along the north side of Lake Schrader, and west to the upper Sadlerochit River, the Fire Creek drainage, and north to the southern slopes of the Sadlerochit Mountains. They often camp along the Sadlerochit River, and hunt across the foothill country to the Hulahula River.

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

The Okpilak River drainage is another winter caribou hunting area, especially from about as far south as the Hulahula River's 1st Fish Hole inland to Okpilak Lake. People also hunt the Okpirourak Creek drainage. They may travel from Barter Island and follow the course of the Okpilak River or they may come over to the Okpilak from 2nd Fish Hole, travelling in a northeasterly direction. The foothill area from 2nd Fish Hole to Kingak Hill near the Hulahula, and across to the Okpilak and Okpirourak drainages is another important winter caribou hunting area.

Some winter caribou hunting occurs on the Jago River drainage, as far inland as Marie Mountain. East of the Jago, 2 important winter caribou hunting areas are in the Niguanak Hills between the Jago and the John River, and the Niguanak Ridge area just to the south.

In spring, caribou hunting continues in the Hulahula, Sadlerochit, Okpilak and Jago River winter use areas. More hunting occurs on the coastal plain and in the foothills and mountain valleys due to increased daylight and slightly warmer temperatures. The most territory is covered at this time of year. Occasional trips are made up the Okerokavik River and to the foothill country of the Aichilik River. Until the 1940's, when people were living at Uqsruqtalik and other coastal locations, they often found caribou in an area surrounding the Okerokavik River and its branches, due west of the Angun River headwaters.

By May (occasionally earlier) rivers are flowing and most snow has disappeared at lower elevations, so access to any caribou is limited and remain so until early to mid-July, when open water again allows for boat travel.

Moose (Tuttuvak) are taken by the village of Kaktovik at a rate of 1 or 2 per year. Moose are not specifically hunted; they are taken on an opportunistic basis. Moose are most often taken in the Sadlerochit Valley, and in the foothills along Old Man Creek, Okpilak River, and Okpirourak River. They are more commonly seen along the Sadlerochit River than along the Hulahula River. They are also seen along the Kekiktuk River and on the Sadlerochit side of Kikiktat Mountain. Moose often congregate in the Ignek, Ikiakpaurak and Ikiakpuk Valleys, and along the Canning River, between these valleys. People sometimes make hunting trips to this area in the spring. They also take moose occasionally on the other side of the Canning River along the Kavik River and in the foothills near its headwaters.

Moose are relatively recent arrivals to this part of the North Slope, therefore there is not a strong cultural tradition for hunting them as there is for other species. However, it is the nature of the subsistence hunter to adapt to whatever is available. Most people prefer caribou to moose, and a few do not like moose. It is shared widely in the village among those who do like it. In 1979, moose soup was served at the Thanksgiving feast.

Brown bear (Aklaq) are occasionally taken by Kaktovik people. In recent years the village has taken about 2 bears per year. Brown bears are generally taken inland during April or early May while there is still sufficient snow and ice for travel by snow machine, and also during July when as occasional bear may be seen close to the coast. Brown bears are taken strictly on an opportunistic basis (Jacobson 1980).

The Sadlerochit River drainage is reported to have many brown bears. Every spring they are seen in the Sadlerochit River valley. One was taken near the Neruokpuk Lakes in May of 1978, and 1 atop of one of the hills near the Kekiktuk River in late April 1979. Kaktovik people occasionally have trouble with nuisance bears. In 1975 or 1976, 3 were shot at a summer camp at Qikiqtaq (Manning Point). In April 1980, a brown bear was shot at a vacant tent at 2nd Fish Hole on the Hulahula River. In late July 1981, a brown bear tore up a new tent left at a Canning River delta camp.

Dall Sheep (Imnaiq) are traditionally hunted from mid-October until mid-December. The sport hunting season is from August to early September when the animals are not accessible by snow machine to Kaktovik hunters. In 1979 a special Dall sheep hunting season was created to meet local subsistence needs. Some sheep hunting has also occurred from January to March when people were short of meat.

The upper Hulahula River is the most intensely used sheep hunting area. Hunting begins at the entrance to the mountains near the 2nd Fsh Hole and continues to the headwaters, called Kanich. The hunting area includes most of the tributary creeks. The TLUI sites Katak (or 3rd Fish Hole) and Kanich are chiefly associated with sheep hunting. A nearby stream is known locally as "200 sheep creek".

People hunt sheep in the Sadlerochit mountains beginning a few km south of Sadlerochit Springs. There is an important sheep camping area near Sadlerochit Springs. The upper Sadlerochit River in the Franklin Mountains, the creeks along the eastern side of the Shublik Mountains and Third Range, and the Whistler Creek area at Neruokpuk Lakes are other locations where sheep are occasionally hunted.

In 1978, most hunters interviewed stressed the upper Hulahula drainage as their most important sheep hunting area. However, during recent years there has been increased hunting in the upper Okpilak, Jago, and especially the Aichilik River drainages. Hunting on the Okpilak begins at about Okpilak Lake, and on the Jago drainage near Marie Mountain. On the Aichilik River, people begin hunting near the 1st Fish Hole.

Number of sheep taken by Kaktovik hunters has fluctuated greatly, with only a few killed in some years to as many as 50 in other years. From 1977 through 1979 the average take was about 36 animals. The harvest varies depending on the success of the whaling season, the number of caribou available, snow cover, weather, and travelling conditions in the mountains. The sheep harvest is a mixture of both ewes and rams. All of the sheep is eaten, including parts of the intestines and the feet. Meat from the head is considered a delicacy.

Sheep hunting is more of a village than an individual activity. Most of the sheep are taken by 4 families, who then share the meat with the rest of the village. Sheep meat and sheep soup are an important part of the communal feasts at Thanksgiving and Christmas. Sheep horns are sometimes used to make jewelry, fishing lures, and other items.

Furbearers

The winter months are important for trapping and hunting furbearers. Arctic foxes are taken on the coastal plain while red and cross foxes, wolves and wolverines are taken in the mountains. Furs are used locally in making parkas and ruffs, or are sold to the village corporation or directly to a fur buyer.

The Arctic or white fox, (Tigigganniaq), is trapped mainly along the coast and on the coastal plain. In recent years, most people have set their traps on Barter Island, and on the barrier islands, lagoon ice, and coastal area between the Sadlerochit River and Uqsruqtalik (Griffin Point). Arctic fox traplines are usually within 16-24 km of the coast, but Arctic fox are occasionally taken further inland or in the mountains. In March 1978, an Arctic fox was taken at the Hulahula River's First Fish Hole and another in the Sadlerochit Valley. Arctic foxes have been seen as far inland as Kanich, the headwaters of the Hulahula River.

When people lived a nomadic lifestyle, Arctic fox were trapped all along the coast, one trapline went from Beechey Point to Foggy Island. Another trapline went from Bullen Point to the Canning River delta, on Flaxman Island and up the Staines River. (North Slope Borough 1980: 145-147). Two Kaktovik men were partners in a trapline that extended from Barter Island to the Canadian border along the coastline. One trapline went from Demarcation Bay to the Aichilik River, and included a large area near the coast to several km inland between the Aichilik and Sikrelurak River.

The Arctic fox population can fluctuate widely from year to year. During the winter of 1976-77, over 100 fox were taken, while during 1977-78 only 2 were taken. Most people did not see tracks that winter. The next year the numbers were up again, and fox harvests have remained over 100 each year through 1981.

People are cautious around animals, especially foxes, that they suspect may have rabies. In 1976 nearly every dog on Barter Island had to be destroyed after contracting rabies from an arctic fox. An entire family also had to undergo rabies vaccinations.

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

Formerly, red and cross foxes were taken inland on the Kongakut River, often from a base camp at the Pungautilik tributary. They were also taken inland on the Canning People generally take fewer red and cross foxes than arctic foxes. Each year, 4 or 5 trappers may each get 3 or 4 of these animals.

Most wolves (Amaguq) and wolverines (Qavvik) are trapped or shot in the foothills of the Brooks Range. The Hulahula, Sadlerochit, and Okpilak River drainages are most commonly hunted. A particularly good area for finding these animals in winter is the Hulahula and Sadlerochit River drainages and from about the Sadlerochit Spring on the north to Kikiktat Mountain and the Neruokpuk Lakes on the south. This terrain is characterized by gentle slopes and open country where one can see long distances; yet it is protected from the strong winds of the coastal plain by the Sadlerochit Mountains and foothills of the Hulahula and Okpilak Rivers. Wolves and wolverines are often first seen low in the drainages where willows are abundant. Wolves are also encountered in the upper Hulahula River area during fall when people enter the mountains to hunt sheep. Occasionally a wolf is trapped on the coast. Wolf and wolverine ruffs are a sign of a good hunter, or that one comes from a family of a good hunter.

During the winter of 1980-81, a total of 5 wolves and 7 wolverines were taken. Several wolverines were seen along the coast. Four or 5 were trapped on Barter Island, and another was seen at the freshwater lake near the village.

Although rare, mink have been seen on the north side of the Brooks Range, especially during recent years. In the fall of 1977, a mink was trapped at 2nd Fish Hole on the Hulahula River. A few others were taken at the same location during the winter of 1978-79. In November 1980 two or more mink were seen at the Aichilik River in the area of 1st Fish Hole. One long-time Kaktovik resident captured a mink at Demarcation Point in the 1940's. It was the first mink he had seen.

Other species taken include a small number of least weasel (Naulayuq) that were trapped in mountain valleys incidental to other species. A few river otters (Pamiuqtuuq), were seen in the upper Hulahula River during fall of 1977. Tracks of otters have been observed along the Canning River. Porcupine (Qinaglud) are sometimes seen in the upper portion of the Hulahula River, though none are known to have been taken in recent years. Lynx (Niutuiyiq) have been observed from time to time on the north side of the Brooks Range. The impression is that lynx used to be more common than they are now. In 1964, a lynx was seen on the Hulahula River between 1st and 2nd Fish Holes. A few other lynx were also seen on the coastline in summer. During the winter of 1971 or 1972 a lynx was observed between 1st and 2nd Fish Holes (NW of Kingak Hill) on the Hulahula River.

Small mammals

Rodents. Arctic ground squirrels (Siksrik) emerge from their winter dens in March and April and are hunted along the banks and sandy mounds of the deltas and lower 8-24 km of the major rivers, especially the Jago, Okpilak, Hulahula and Sadlerochit. Two of the most intensely used areas are the Jago River delta and the Hulahula -Okpilak River delta, from the coast to several km inland. People also take squirrels from the entire drainages of the Jago and the Okpilak. People also hunt ground squirrels along the Hulahula from the coast up to 2nd Fish Hole where the mountains begin, and along the Old Man and Old Woman Creek tributaries near 2nd Fish Hole. Hunting is concentrated in the vicinities of 1st and 2nd Fish Hole. Traps and small caliber rifles are used for taking squirrels. The entire Sadlerochit River drainage is hunted, up to and including the Kekiktuk River tributary over to Neruokpuk Lakes, but the Springs area up to 16 km north of the Springs seems to be most heavily hunted.

Ground squirrels are hunted along the banks and lowland areas around Neruokpuk Lakes and the lowlands between Neruokpuk Lakes and the upper Sadlerochit River south of Okiotak Peak. East at the Jago River, squirrels are hunted over most of the Niguanak and Sikrelurak River drainages, including the Niguanak Hills, and occasionally along the Aichilik and Egaksrak River. Formerly squirrels were hunted along the Kongakut River, especially in the area where the river makes the big bend.

West of the Sadlerochit River, some squirrel hunting occurs near the mouths of Marsh and Carter (Iqalugliurak) Creek, and inland 6 or 8 km from Camden Bay. On the Canning River, squirrels may be hunted in conjunction with spring fishing trips. Squirrels are taken near the warm springs close to Ignek and

Nanook Creeks and several km farther inland. During the summer, squirrels may be hunted in the large mound areas near the main channel of the Canning River delta.

Marmots (Siksrikpak) are hunted each spring along Itkilyariak Creek after they emerge from their winter dens in May. The edge of the mountains between Itkilyariak Creek and the Sadlerochit Springs are the main hunting areas. Marmots also occur in some of the rocky areas at Neruokpuk Lakes. They emerge from winter dens later (May) than ground squirrels.

Fish

Arctic char (Iqalukpik) are the most extensively used fish species. In summer, sea-run char are caught all along the coast, around the barrier islands, and in the navigable portions of the river deltas. Char are the first fish caught in the nets after ice out in early July, and are caught through late August. Freshwater resident arctic char are taken through holes in the ice in inland rivers during winter. A smaller variety than the sea-run char, they are sometimes called iqalukpiayat because of their small size (13 - 46 cm).

Arctic cisco (Qaaktaq) are the most common whitefish species and are taken in the ocean by netting or seining. They begin appearing in the nets about the first of August, usually after the arctic char run peaks. The arctic cisco run is at its peak between August and early September. An arctic cisco tagged west of Prudhoe Bay (Kavearak Point) in August 1978 was caught one year later 274 km east at Uqsruqtalik (Griffin Point). Another tagged at Prudhoe Bay in July 1981 was caught at Uqsruqtalik in August 1981.

Least cisco (Iqalusaaq), a whitefish species similar to arctic cisco, is taken in the lagoons, river deltas, and particularly the small lakes and streams of the river drainages. It is much less common than arctic cisco A least cisco tagged at the Prudhoe Bay dock on 25 July 1977 was caught at Uqsruqtalik on 14 August.

Broad whitefish (Aanaakliq) is a species of whitefish found in the Canning River drainage. It is usually taken in the deeper lakes and channels of the Canning River delta during July through September. Occasionally it is taken in the winter at fishing holes farther inland on the Canning.

Round Whitefish (Savigunaq) is much less common than the broad whitefish, and is found in the same areas of the Canning. Formerly, Kaktovik people caught both broad and round whitefish in the Sagavanirktok River.

Ling cod or burbot (Tittaaliq) may be taken in small numbers inland on the Canning River during the snow season. Formerly, they were taken during fall and winter on the Kuparuk River and some of the other larger rivers. It appears that they have been taken only in the inland portions of rivers, at least 16 km from the coast.

Grayling (Sulukpaugaq) is a major subsistence species taken in many of the area's rivers and river deltas. Grayling are taken in late summer after freeze-up, and again in spring.

Pink salmon (Amaqtuq), and Chum salmon (Iqalugruaq) are occasionally taken in nets in July and August, especially near Barter Island. Pink salmon were taken in large numbers all along the Beaufort seacoast in 1978. This was a very unusual event and many villagers had never seen pink salmon before.

Arctic flounder (Nataagnaq), and Fourhorn sculpin (Kanayuq) 2 appear occasionally in the nets during summer ocean fishing. Kaktovik people catch Arctic flounder off Qikiqtaq (Manning point or Drum Island), Arey Spit, and in Kaktovik Lagoon between Qikiqtaq and the mainland.

Sculpin are usually not eaten because they are too boney.

Lake trout (Iqaluakpak) are caught during the winter in the Neruokpuk Lakes of the Brooks Range by fishing through the ice with hook and line. The fish are often 60-90 cm long and are the large fish species taken but Kaktovik villagers.

Paigluk, which Kaktovik people believe to be pike, are occasionally taken in the Hulahula River, mainly at 1st Fish Hole. They are also caught in other rivers. This species has not been positively identified. It is described as "sort of an ugly fish", having a large lower jaw, white meat, and pink stripes.

Arctic Cod or Tomcod (Uugaq) and Smelt (Ilhuganiq) are small fish that may be caught with nets in summer and with hook and line in winter along the Beaufort coast. In summer they are sometimes taken near the spits off Barter Island. In October and November, people fish through the ocean ice for them at Iglukpaluk and north of Barter Island.

Blackfish (Ayukararuak) are also called "old man fish" by the local people. They are small fish (up to 30 cm in length) that may be taken along rivers through the ice in winter and spring. Rivers where they have been taken include the Canning, Hulahula, and especially the Aichilik.

Summer subsistence fishing occurs in the coastal waters, river deltas, and from the barrier island during the ice-free months of July, August, and September. People usually set gill nets, although rods and reels are sometimes used near the village and at the fish camps. People presently fish as far west as Foggy Island and as far east as Demarcation Bay. They set up fish camps at places such as Koganak Inaat (Koganak's camp - MB 35), Agliguagruk (Brownlow Point), Nuvugaq (Collinson Point) and Uqsruqtalik (Griffin Point) where they may remain for several weeks. Fishing activity is most concentrated off the coast and around the spits of Barter Island, around Bernard Spit and Arey Island, and in Oruktalik Lagoon off Griffin Point. People may camp at Iglukpaluk, Naalagiagvik (Arey Island), or Uqsruqtalik (Griffin Point) while they fish, or they may simply go out by boat each day to check their nets. This area is very good for arctic char beginning in early July and for arctic cisco beginning in August. People often find 20 or more fish each time they check their nets. and it is not uncommon to catch 50 fish in a day. In 1978, one woman had 300 char by July 28.

A popular summer fishing camp is Uqsruqtalik, where people may dry large quantities of fish for winter use. They fish in Tapkaurak Lagoon, Oruktalik Lagoon, Pokok Lagoon, and on either side of the long and narrow barrier islands which form Angun Lagoon. Formerly, many small arctic char were taken in the summer in the delta of the Kongakut River's western branch, near Siku. People also fished in summer all along the spit known as Pattaktuq (Demarcation Point), and occasionally do so today when travelling in this region. The spit used to extend further into Demarcation Bay, but DEW line operatons in the early 1950's removed a great quantity of gravel from it, causing a channel to be formed. Fishing has not been as good in the Bay since that time.

West of Barter Island, Nuvugaq spit in Camden Bay and the eastern part of Camden Bay near the traditional site Aanallaq, are other summer fishing places for arctic char and arctic cisco. Carter Creek is known for its arctic cisco and arctic char. The Inupiaq name for this river is Iqalugliurak, which means "Little river with lots of fish". The best time for netting these fish is in June, after the river opens up (North Slope Borough 1980: 185)

During summer and early fall the Canning River delta is one of the more important fishing areas. Almost everyone in the village has fished here at one time or another during the summer, particularly on the main channel of the Canning from near the mouth to 16 - 24 km upriver. This stretch of river is especially noted for its grayling taken in early fall, and broad whitefish taken in summer. The latter are also caught in the largest lake south of the main channel (between the main channel and the Tamayariak river) and in the Tamayariak River and the system of small lakes to the south. People catch arctic cisco in this area also. The larger lakes to the east of the Tamayariak River (south of VABM "Walker" and north of VABM "Noon" on the USGS map) are too shallow for fishing.

Agliguagruk (Brownlow Point) at the northern tip of the Canning River delta is another important fishing area. Several families may camp here during the summer. Nets are set in the ocean north-northwest of the Point, and in the lagoon inside the spit, just to the east of the Point. Arctic cisco is the main species taken, followed by char. Arctic flounder and sculpin are caught occasionally in the nets here too. Summer fishing for char also occurs along the coast southeast of Agilguagruk, as far as the main mouth of the Canning River.

Summer fishing for char and arctic cisco takes place in several places off Flaxman Island. People have noted the inland sides of both eastern and western ends of the island, especially the area west of the Panningona cabin and Leffingwell historic site.

Moving further west, Kaktovik people sometimes fish for char and arctic cisco in the vicinities of Pt. Hopson, Pt. Gordon, and Savagvik (Bullen Point). The large triangular shaped bay between Pt. Gordon and Savagvik, and the river emptying into it, are known for good summer fishing.

Some families may travel to the Shaviovik River delta and as far as Foggy Island for summer fishing, camping at traditional sites such as Koganak Inaat and Ekoolook Inaat. These are usually the people who lived in this area in their youth. At the Shaviovik River delta they fish for char, arctic cisco, and least cisco (iqalusaaq). During summer 1981 many grayling and some char were taken at the Shaviovik River.

Formerly, Kaktovik people caught 3 whitefish species in the Sagavanirktok River delta: broad whitefish, round whitefish and arctic cisco. People were especially dependent on the fish in this area in 1941, when they lived at Kaniqluq at Prudhoe Bay. The area was particularly good for arctic cisco, which was caught around Siklaqtitaq Pt. McIntyre and Pt. Storkerson.

After freeze-up and all through the snow season, people travel inland up the Hulahula and other rivers, where they fish through holes in the ice. They camp near the deep pools and open water springs where the fish overwinter. In the springtime, especially, they fish through the ice of the Neruokpuk and Okpilak Lakes in the Brooks Range. Usually a simple hook and line is used, attached to a willow stick. The common fishing method is referred to as "hooking". Presently, winter fishing may take place as far west as the Canning (Kuugruaq) River and as far east as the Kongakut River. Until the mid-1940's, present-day Kaktovik people also relied extensively on fish in the rivers west of the Canning, especially the Shaviovik and the Kuparuk River.

The Hulahula River is the most important winter fishing river to Kaktovik residents. After freeze-up, people travel to 1st Fish Hole and to 2nd Fish Hole where they set up camp. Almost everybody in the village fishes at one or both of these locations during the year. When travel conditions permit, most people also go up to Katak or 3rd Fish Hole, beyond Kolotuk Creek. They catch mostly arctic char and some grayling at 1st and 2nd Fish Holes, and char at Katak. The area around 1st Fish Hole is especially good for char in the fall, from about 8 km north of the camp to 3 km south.

The Sadlerochit and Okpilak Rivers are less important for snow-season fishing than the Hulahula, but they both contain grayling. One fishing place for grayling is the area downriver from Sadlerochit Springs, where the water stays open much of the year. Grayling are also caught in Okpilak Lake and the other lakes to the north.

Neruokpuk Lakes is where people go if they want to catch lake trout. The best chance to catch them is during the dark winter months. Holes several feet deep may be chiseled or drilled through the ice.

The Canning River drainage provides winter as well as summer fishing, inland from the delta. Important areas seem to be along the braided sections and at the warm springs near Ignek and Nanook Creeks. There are "lots of fish holes" in the braided area south of the Staines confluence with the Canning. Also, the braided area for about 16 km downriver from Shublik Island is noted for char, grayling, and ling cod.

Formerly when Kaktovik people were living at the traditional sites along the coast, they would make fishing trips up the Canning River in the fall and at any time during the snow season , staying several weeks or longer. Now, however, trips as far as the Canning are usually made in the spring when there are long daylight hours for travelling. A group may travel the coastal route from Barter Island to the Canning River delta, then follow the river inland. Or they may travel inland along the Sadlerochit or Hulahula Rivers and cut over along the north side of the Sadlerochit mountains, to the Canning. Most people do not make this trip every year chiefly because of the distance. But they are familiar with the variety of fish species found in the Canning.

People now living at Kaktovik used to fish through the ice of the Shaviovik, Kavik, Sagavanirktok and Kuparuk Rivers during the snow season. They caught char, grayling, arctic cisco, and black fish at the confluence of the Kavik and Shaviovik Rivers, and at warm springs called Sigsinak at about the 122 m contour line along both these rivers. In the Kuparuk River they caught "big tittaaliq (ling cod)" and grayling. The Kuparuk River from 10 to 40 km inland was a particularly important winter fishing area for these species. The grayling caught in the Kuparuk "were lifesavers" during the winter of 1941, when some Kaktovik people wintering at Kaniqluq in the Prudhoe Bay area were very short of food.

According to Kaktovik people, the Jago River has "no fish whatsoever". There are some smelt in the summertime in the Jago River delta, but they are very hard to get because the water is so shallow.

The Aichilik and Kongakut are both good fishing rivers. Kaktovik people often fished in these rivers until the mid-1940's, when they lived at traditional sites such as Uqsruqtalik , Pinuqsraluk, and at Pattaktuq near the Canadian border. Now that people have congregated at Kaktovik, they have not used these rivers often. The Aichilik River is said to be one of the better rivers for catching grayling. When people were living at Uqsruqtalik and other coastal locations, they went up the Aichilik regularly for grayling and char. "First Fish Hole" on the Aichilik is located at the 305 m contour line just before entering the mountains. A second fish hole, known especially for grayling, is several km further inland near the large tributary which enters from the west. On the Kongakut River, one important fishing area for char was where the Pungautilik River empties into the Kongakut. Another was on the Pagilak tributary. Char and grayling were caught in the large bend in the river near the 710 m contour line. This area was known for its many willows, which provided fishing rods as well as firewood. It was an important winter camping area. Nearer the coast, the stretch of river about 9 to 16 km inland on the east branch of the Kongakut was another winter fishing area.

Subsistence Economic System

The Inupiat Eskimo have always sustained themselves by living off the meat, fish, and fowl taken directly from the land and sea. Their culture is based on this close economic relationship with the land, and is after described as a "subsistence economic system". The contemporary Kaktovik economy is a merging of subsistence and monetary elements, operating within the Inupiat cultural context (Wentworth 1979a).

The North Slope Inupiat have been living in a combined subsistence and cash economy since the late 1800's. Some of the ancestors of Kaktovik residents, both Native and White, were commercial whalers working out of Barrow and Herschel Island. Commercial whaling declined by about 1910, and fur trapping took its place as the main source of cash income. Kaktovik people combined subsistence with trapping and reindeer herding as they moved seasonally from place to place.

Kaktovik people began working for wages in the late 1940's. This increased their economic security by adding to the subsistence economy and providing an alternative to the less stable cash economy of trapping and reindeer herding. Despite these and many other changes, subsistence has remained the main provider of protein, and the source of some Arctic cold-weather clothing. It is also the basis their for the relationship with the land, group activity, and sharing of resources that is central to the Inupiat culture (Wentworth 1979a).

Until the 1970's, the Barter Island DEW-Line site and related construction were the main sources of local wage employment. Although full-time as well as temporary seasonal jobs were available at the site, the rigid 9 hour day, 6 day a week schedule left little time for subsistence activities except during vacations. Cross-cultural problems also made work at the site less desirable. As a result, many local people chose not to take advantage of these jobs. By 1981, only 3 Kaktovik Inupiat were working at the site.

Since the 1950's, a few jobs were available in the village at the post office, store, and school. More village jobs became available after passage of the Alaska Native Claims Settlement Act (ANCSA) in 1971, and creation of the North Slope Borough in 1972. By the late 1970's, people were working for the North Slope Borough, the village corporation organized under ANCSA, and in Borough funded construction of village housing and public building.

The new village housing and associated costs have greatly increased people's needs for cash. They now must make house payments, and pay rising electricity and fuel bills (Table 5). Fuel oil and gasoline are almost twice as high in Kaktovik as in Fairbanks, and propane is 3 to 6 times as high depending on freight method. This in turn, has made it necessary for them to work longer hours. However, the North Slope Borough jobs are generally more flexible than the DEW-Line jobs allowing more time off for subsistence activities.

Table 5. Kaktovik fuel prices, 1977-1981.

	Stove oil (55 gal.)	Gasoline (55 gal.)	White Gas (5 gal.)	2 Cycle Oil (1 qt.)	Propane (100 lb. bottle)
Price	$45.10	$68.75	$15.00	$1.56	$67.50
Date	7/77	9/77	10/77	7/77	7/77
Price	104.50	68.75	-----	2.00	88.00
Date	5/78	5/78	-----	5/78	6/78
Price	64.90	69.30	16.50	------	------
Date	11/78	11/78	11/78	------	------
Price	64.30	69.40	-----	-----	78.00
Date	6/79	6/79	-----	-----	6/79
Price	-----	120.00	-----	-----	------
Date	-----	2/81	-----	-----	------
Price	95.70	102.85	-----	-----	91.00
Date	8/81	8/81	-----	-----	8/81
Price	109.45	123.75	28.75	2.16	170.00
Date	10/81	10/81	10/81	10/81	10/81

The increase in the number of local jobs in the late 1970's brought more money into the village than had been present before. Other changes have also taken place in a short time span. In addition to the new housing, a high school, gymnasium with a swimming pool, and public safety building have been built. A fire hall and new community center-medical clinic are scheduled to be built under the North Slope Borough's capital improvement program. Villagers now have satellite television and telephones in every home.

The many outward changes, however, have not brought a similar inward change in socio-cultural values. Although the village corporation operates as a profit-making business, ideas of sharing money and other resources take precedence over making money for the future. The economic system operates through strong kinship ties and alliances of the extended family, as everyone in Kaktovik is related. Sharing is especially prevalent with Native food but also with store bought goods. For example, families go camping together and think nothing of sharing hundreds of dollars worth of store-bought food with everyone in camp. Kaktovik people do not operate private businesses, except for limited arts and crafts production using local fish and wildlife resources. The only real entrepreneurs in the village are 2 non-Natives.

In Kaktovik, as in other North Slope Inupiat villages, people's decisions about earning and spending money, and what is important often differ from the outsider's viewpoint. In any society, the amount a person wants to earn is influenced by what he wants to spend it on; but in any society, earning and spending patterns are, at least in part, culturally determined. In Kaktovik, an important reason for earning and spending money is to buy better subsistence equipment such as snowmachines, outboard motors, and rifles to be a more successful hunter. A person's standing within the community is directly related to success as a food gatherer. Similarly, people use their cash incomes to support relatives or to buy goods to share with them, just as subsistence harvests are shared (Wentworth 1980). Much money is also spent on plane tickets to visit relatives in other villages, or to have them visit Kaktovik. In this sense the airplane has replaced the dog team in carrying on the cultural tradition of travelling great distances to visit - a tradition that existed before the Inupiat of this area lived in permanent villages.

Some North Slope employers operating in Kaktovik become disillusioned with hiring local Inupiat people because "they won't stay at jobs" even when offered very high wages. This is an illustration of how differing cultural values influence economic choices about wage work. Cross-cultural problems arise when non-Native employers apply their own cultural standards in an attempt to understand Inupiat behavior. In any society, a person will work only up to the point at which the costs of working, in terms of time given up, equal the benefits. When the costs of giving up this time begin to exceed the benefits, measured in money, the person quits. For the Inupiat, this point is often reached earlier than in the non-Native society, because the value to him of what he could buy with that extra money is not worth giving up the extra time. Put simply, giving up that extra time is just not worth the price.

Furthermore, after a certain point, the "price" of time spent working may be very high to the Inupiat because it is time away from subsistence activities (Wentworth 1980). Although cash incomes and the needs for them are increasing, one thing that cash income cannot buy is Native food (nikipiaq). Of course, spending money on better hunting equipment and spending time maintaining it is an indirect way of buying Native food. But the food itself cannot be purchased directly; it must be worked for or earned by hunting. In the American society, a large component of any family's budget is for food. But in Kaktovik, the need for Native food can't be met with the cash budget; therefore, beyond a certain point, people would rather spend their time hunting than earning the cash. The price of food in the local store, its inconsistent availability, and the lack of locally available fresh meat and produce at any price add an additional incentive to subsistence hunting (Table 6). In October 1981 Kaktovik food costs were 87% higher than Fairbanks, which is already 33% higher than the national average. This difference between Kaktovik and Fairbanks food prices has been widening rapidly. In 1978 and 1979, Kaktovik food prices were only about 35% higher than Fairbanks. This widening price difference is typical of what is happening between urban and rural Alaska generally as energy prices and transportation costs to "the bush" rise (Table 6, Cooperative Extension Service 1974-1980).

In addition, irregular air freight service due to Arctic weather conditions, associated time delays, and lack of economies of scale keep the Kaktovik store from being able to stock fresh milk, produce, and many other items. The nutritional importance of subsistence in such an environment is obvious. While much of the modern Inupiat diet comes from store-bought foods, these tend to be foods of low nutritional quality. Even the frozen beef, chicken and pork, which is more popular in Kaktovik than canned or frozen vegetarian items, is not as nutritious as Native foods. Subsistence harvested meats and birds are high in protein and low in fat. They contain some essential vitamins and minerals not found in domestic meat and poultry. Caribou and seal have twice the protein as an equivalent amount of beef. Marine animals have many times more Vitamin A and 10 times as much iron than beef, and ptarmigan has twice the thiamine as chicken. Seal and whale oil, which is 100% energy, is polyunsaturated and does not predispose one to heart disease (Cooperative Extension Service 1974, Hurwile 1977, Nobman 1978, Milan 1979, Worl 1979).

The time conflict between wage work and subsistence is reconciled in a variety of ways. Some people are employed only seasonally, while in some families, the wife works leaving the husband free to hunt. If the husband is working, the wife may go hunting with her sons or other relatives (Worl 1979). People who work at the DEW-Line site schedule their annual 2 month vacation around the hunting activities most important to them. One man retired from the DEW-Line site after 25 years and now hunts year-round for younger members of his extended family. The more flexible work schedules of the North Slope Borough jobs allow people time off for subsistence activities.

Because subsistence is an extended family and group activity and because subsistence harvests are shared, the time conflict between work and subsistence exists more at the individual level than at the group or village level. Still, however, the high wages paid in Kaktovik not only reflect higher living costs, but are also a reflection of the "price" people pay to give up a measure of freedom inherent in the lifestyle they have been used to.

Another way culture influences economic decisions and earning patterns has to do with what might be termed "cultural skills". An Inupiat working for wages may be very skilled at his work. But chances are, it's not the area in which he is most skilled. His best skills are not necessarily obvious in the village, but become apparent on the land and sea.

Table 6. Kaktovik staple food prices - 18 items

Food item	Unit	Fairbanks[a] 6/13/78	Kaktovik[b] 6/16/78	Fairbanks[a] 7/6/79	Kaktovik[b] 7/3/79	Fairbanks[a] 10/12/81	Kaktovik[b] 10/3/81
Round steak[c]	1 lb.	$3.22	none ($4.08)	$4.21	$4.20	$3.04	none ($4.30)
Hamburger[c]	1 lb.	1.79	none (2.03)	2.52	2.25	1.59	none (2.57)
Pork chops[c]	1 lb.	2.84	none (3.57	2.49	none (3.34)	2.52	none (4.37)
Chicken[c]	1 lb.	.79	none (1.68)	.79	1.50	.85	none (1.69)
Tuna Fish	6.5 oz.	1.03	none (1.39)	1.07	none (1.39)[d]	1.49	2.13
Spam	12 oz.	1.73	none (1.96)	1.54	2.29	2.15	none (2.20)
Pink salmon (canned)	15.5 oz.	2.40	none (3.00)	2.21	none (3.00)[d]	3.09	4.82[e]
Butter	1 lb.	1.65	none (2.83)	1.84	2.51	2.14	5.35
Evap. milk	14.5 oz.	.50	.72	.56	.72	.70	1.31
Flour	10 lb.	2.90	4.48	3.40	4.69	4.01	8.06
Sugar	10 lb.	3.24	4.84	3.47	5.10	4.77	12.96
Eggs	1 doz.	.94	none (1.61)	.90	1.72	1.20	1.85
Rice	28 oz.	1.17	1.68	1.25	1.60[e]	1.69	3.28
Tomato soup	10.5 oz.	.31	none (.52)[d]	.37	.54	(.44 not used in total)	none (price not a
Grapefruit juice	46 oz.	1.22	none (1.95)[d]	1.34	1.99	1.95	3.57
Coffee	3 lb.	10.80	15.34[e]	10.44	15.37[e]	8.26	16.63[e]
Loose tea	1 lb.	4.24	4.85	4.31	5.00	(5.19 not used in total)	none (price not a
Pilot bread	2 lb.	2.07	2.66	2.29	2.89	2.67	3.67
Totals		$42.84	$59.19	$45.00	$60.10	$42.12	$78.75
Kaktovik prices as % of Fairbank's prices			138%		134%		187%

a average for 2 stores

b Prices in parenthesis are what the item would have sold for if available. Kaktovik got meat in their store 6 October 1981, after 2 months without any spoilage due to problems in shipment.

c Fairbanks prices are for fresh meat except for frozen chicken; Kaktovik prices for frozen meat.

d Previous year's price.

e Price extrapolated to fit size of container.

Several attempts have been made to place an imputed dollar value on the subsistence resources that rural Alaskans depend on, to estimate the loss in dollar terms if they could no longer secure food by hunting and fishing (U.S. Department of Interior 1974). Assuming that each Kaktovik person consumed 500 pounds of subsistence harvested meat and fish each year (USDI 1974) at an imputed average price of $4.00 per pound (T-bone steak was over $7.00 per pound in October 1981) the gross dollar amount of subsistence for each man, woman, and child would be $2000 per year. For the village of 175, it would be $350,000 per year. However, if the government were to pay for losses of Native food by giving people store bought substitutes, this would likely insult and anger the people, as it would be regarded as an affront to their culture and a form of welfare that took away their ability to lead productive lives (Association of Village Council Presidents 1978, Adams 1981). In the words of one resident:

> Several years ago, the government came to Kaktovik with free handouts of beef roasts and chicken because they thought we were short of caribou. This didn't consider the people's feelings. It's sad when Eskimos move to town and try to make duck soup out of chicken, and caribou stew out of beef. It's sad because it's just not the same. When I'm in town and can't get any Native food, I can't really get used to it because I never feel filled up. My body is still craving something, it isn't satisfied.

The incorporation of store-bought foods in the diet means that subsistence is no longer necessary for physical survival, but the amount of change which has already occurred has not been without a price in human health. The partial move away from hunting and gathering food has been accompanied by increases in dental cavities, anemia, diabetes and heart disease (Nobman 1978). Average death rates among young North Slope Inupiat appear to be more than 4 times higher than the national average, probably due to increased accidents and suicides in recent years (Kruse et al. 1980: 19, Table 3-3). While Alaska's 70,000 Natives make up only 15% of its population, they account for 43% of all suicides, 38% of all homicides, and 60% of all alcoholism related deaths (Lenz 1980). In this context, traditional food gathering activities contribute to mental health by providing necessary stability and cultural identity. Subsistence activities strengthen the family unit, provide meaningful work, and fulfill needs for personal self-reliance, self-esteem, and self-fulfillment (Hurwitz 1977).

Kaktovik's Mayor Archie Brower (1979) has stated that "The Brooks Range all the way to the ocean is our garden. We feed on that - the sheep, caribou, fish, seals, and whales". The essence of the economic importance of the fish and wildlife to Kaktovik people lies not only in their needs and preferences for subsistence foods, but in their ability to provide their own food from the area in which they live.

Villages Outside Study Area

Villages outside the ANWR study area utilize wildlife species which may spend part of their life cycle in or adjacent to the study area. The Porcupine caribou herd is of particular significance. Archaeological evidence (Irving and Harington 1973, as cited by U.S. Dept. of State 1980) show that man has been using caribou for at least 27,000 years, apparently extending back before the last glaciation in northern Alaska and Canada. Work done at sites occupied up to 1500 years ago near Old Crow, Yukon Territory, reveals a subsistence economy centered primarily on the interception of spring and fall migrations of caribou (Morlan 1972 and 1973, Cinq-Mars 1974). Morlan's investigations (1972, 1973) of the Cadzow Lake site and the Klo-kut site show signs of the importance of caribou by the high percentage of caribou bones in faunal remains, and in the continuity of caribou evidence over many years through changes in accompanying material goods from stone axes to bullets.

The Athabascan people, specifically the Vunta Kutchin of the Old Crow area and the Netsit Kutchin of the Chandalar area in Alaska, were traditionally nomadic groups whose life cycle basically centered around the hunting of big game animals. The seasonal migration of caribou was the most important natural phenomenon which influenced the way of life (Stager 1974). Caribou were the most important game species and until the early 1900's, were often hunted using surrounds or enclosures (Balikci 1961, McKennan 1965). Corral areas with long wing fences were constructed and groups of caribou drifted or were driven into them. Warbelow et al. (1975) studied and recorded many of these surrounds in Alaska and Canada. These surrounds show the large amounts of communal effort expended in obtaining caribou. The use of surrounds declined after the introduction of the rifle to the Kutchin people, and hunters changed from the traditional group hunting strategies to single hunter strategies; however, one surround north of Old Crow was used into the 1950's (Balikci 1961). Another indication of the Athapascan people's dependence on caribou during pre-contact and early contact times were the periods of starvation that ensued in years when caribou were unavailable to them.

Caribou from the Porcupine caribou herd are vitally important to people in rural villages of Alaska and the Yukon Territory today. Two of the villages most dependent on the caribou resource are Old Crow, Yukon Territory, and Arctic Village, Alaska, as they are inland villages with little of no access to marine resources. Other villages that hunt Porcupine caribou are Kaktovik, Venetie, Fort Yukon, Chalkyitsik, Beaver, and Stevens Village in Alaska, and Fort McPherson, Inuvik, Aklavik, Arctic Red River and Tuktoyaktuk in the Northwest Territories. The use of caribou in these villages depends on the availability of animals near the village. In some years caribou migration routes or wintering areas may not bring caribou near enough to the village to make caribou hunting feasible. Thus the caribou harvest can vary greatly from year to year. Despite a general shift during the 1900's from a dependence on subsistence resources to an increased dependence on imported foods, the subsistence use of game resources has clearly remained strongest in small isolated villages (U.S. Department of State 1980). Most of the Inupiat and Athapascan villages within the range of the Porcupine caribou herd fall into that category. Emphasis will be given here to current uses of caribou in Arctic Village and Old Crow, as available information indicates that these 2 villages still rely most heavily on the caribou resource.

Arctic Village, Alaska, is located on the south side of the Brooks Range at 145^{o} west longitude, 68^{o} north latitude, in the valley of the East Fork of the Chandalar River. The village is at the northern limits of the boreal forest. The present population is approximately 125 people (Pederson and Caulfield 1981b). Work done by McKennan (1965) and Hadleigh-West (1963) provides baseline information on lifestyle and culture of the Netsit Kutchin of the present Arctic Village area, and provides early documentation of subsistence use of resources. Annual activities in Arctic Village are still closely tied to the harvest of fish and wildlife resources. Caribou is the most important source of food, with moose, fish, Dall sheep, waterfowl and small mammals also important.

Caribou are often available near Arctic Village from August to April, although, as previously mentioned, there are years when changes in migration routes or wintering areas may bring few caribou near the village. Fall hunting is usually conducted near the village from hunting camps on Old John Lake. Winter hunting usually includes the use of snowmachines which gives the people an opportunity to hunt farther from the village. When caribou are not available, moose, fish, and Dall sheep may be taken in larger numbers (Pederson and Caulfield 1981b).

Old Crow, Yukon Territory, is located on the north bank of the Porcupine River at 139° west longitude and 67° north latitude. The present population is about 206 including white residents (Stager 1974). Work by Stager (1974) in 1973 showed that 55% of the food needed by Old Crow people in 1973 came from the land. Most of the game meat consumed was caribou flesh. Of this food, caribou was the most important. The major hunt for caribou is in the fall. In September large numbers of caribou pass through the Old Crow flats and cross the Porcupine River heading for their wintering areas. At this time they can be taken on land or by riverboat. Most males older than 11 years joins in the caribou hunt (Berger 1977). There is some hunting of caribou in winter and in spring depending on the year (Stager 1974). In addition to caribou, people harvest fish during the summer, moose, muskrats and waterfowl during spring, and rabbits and ptarmigan when available.

Of the other Canadian villages utilizing caribou from the Porcupine herd, Aklavik and Fort McPherson are most important. Because they are geographically located on the edge of the Porcupine herd's range, the Northwest Territory villages have a varied take of caribou in different years. The same is true of the other interior Alaskan villages that may take Porcupine caribou from year to year. Villages such as Chalkyitsik no longer focus great effort on caribou hunting but will take them when available (U.S. Dept. of State 1980). Venetie and Fort Yukon also take animals when they are available. It must be emphasized, however, that a great deal of sharing and trading of resources occurs between villages. If caribou are not available in Fort Yukon, they may trade salmon to someone in Arctic Village for caribou. An elaborate network of exchange exists for "country produce" so that those who are unable to provide subsistence resources for themselves are able to receive it from their friends or relatives (Berger 1977). In early 1981, a number of people from Venetie, Fort Yukon, Chalkyitisk, Beaver, and Birch Creek visited their relatives and friends in Arctic Village, and since caribou were generally accessible within 8 km of the village, used their visit as an opportunity to take caribou (R. Caulfield, pers. comm.).

Caribou harvest information is most villages utilizing the Porcupine herd is lacking. Harvest estimates that are available are based on interviews conducted in the villages or through various voluntary reporting systems. A recently established program in Kaktovik and Arctic Village by the ADF&G Subsistence Division will attempt to fill some of these data gaps and preliminary information should be available in the spring of 1982 (Pederson and Caulfield 1981b).

Estimates of the harvest of caribou in various villages varies between years (Table 7). These data do not include information on rural residents living outside of villages who harvest caribou on an opportunistic basis. The total annual harvest of caribou by Natives in Alaska and Canada is estimated to be between 3000 and 5000 animals (LeBlond 1979).

Table 7. Caribou harvest estimates in the 1970's for selected Alaskan and Canadian villages.

Year	Village	Number	Source
1972-1973[a]	Arctic Village	1000	(LeBlond 1979)
	Venetie, Chalkyitsik, Fort Yukon	100	
	Aklavik, Inuvik, Fort McPherson, Arctic Red River	2000	
	Old Crow	600	
1975-1976	Arctic Village	800-1200	(ADF&G 1978 as cited by U.S. Dept. of State 1980).
	Canada	1500-3000	
1977-1978	Arctic Village	200-300	(LeBlond 1979)
	Old Crow	470	
	Fort McPherson	350	
	Aklavik	114	
	Inuvik, Arctic Red River	100	
1979-1980	Arctic Village	3	(P. Car. Tech. Comm. 1981)
	Venetie, Chalkyitsik, Fort Yukon	0	
	Old Crow	800	
	N.W. Territories	No. infor available	
1980-1981	Arctic Village	500-600	(Pedersen and Caulfield 1981a)
	Venetie	200-300	
	Fort Yukon	80-100	
	Chalkyitsik	0	

[a] When a 2-year period is indicated, it is generally 1 July of one year to 30 June of the following year.

The importance of caribou in the diet of rural residents is not well documented and needs further research and documentation. A 1973 survey in Arctic Village revealed that about half of the per capita village consumption of protein came from caribou (U.S. Dept. of Interior 1974). In 1977-1978, 50% of survey respondents in the village harvested caribou, in a year when caribou harvest was below average (Alves and Kruse 1978). Estimated annual per capita caribou harvest in Arctic Village has ranged from 2 to 5 in the past 10 years (U.S. Dept. of State 1980).

Steger (1974) reported that an estimated 66,000 kg of flesh were consumed in the village in 1973, 46,500 kg of which were game. Outside of Arctic Village in Alaska, the role of caribou in diets appears to be much less significant.

Alves and Kruse (1978) found that only 9% of the survey respondents in the Yukon-Porcupine Region reported harvesting caribou in 1977-1978. It must be noted that this is a one year survey, and other years may show very different subsistence patterns.

The use of marine mammals in Canadian coastal villages is important to the economy and lifestyle of the residents. Communities of the Mackenzie River delta (Inuvik, Aklavik and Tuktoyaktuk) and the "Rim" (Sachs Harbour, Holman, and Paulatak), are partially dependent on subsistence uses of beluga whale and polar bear. Beluga whales are harvested in the Mackenzie portion of the Beaufort Sea. Whales enter warmer waters of the bays near the Mackenzie River delta during early July and remain until the middle of August. Hunting may occur throughout this period (Brackel 1977). Whaling for beluga whales is not regulated and approximately 120 whales are utilized per year (Brackel 1977). Whale products are used primarily domestically although some products such as maktak are occasionally sold. Sharing of whale meat and maktak is common; beluga maktak is often shared with relatives in Kaktovik and other Alaskan and Canadian villages. The importance of beluga whales to the economy and diet of Mackenzie villages may be more a matter of preference than economic necessity; a variation in diet, and the sport and recreation of the hunt with opportunities for socialization are all important factors in whaling (Brackel 1977).

Polar bears represent a substantial component of the cultural and economic base of the Inuit people of the Canadian western Arctic (Stirling et al. 1975). Polar bear hides have direct economic value, and in recent years the principal motivation for polar bear hunting has been the sale of hides (Stirling et al. 1975). Fur exports are an important source of cash in the economies of Mackenzie and "Rim" villages. According to Brackel (1977), marine furs (white fox, polar bear, and ringed seal) provided 5% of the earned income in the Mackenzie economy with Tuktoyaktuk having the largest percentage, and 19% of the Rim economy with Paulatuk having the largest percentage. Brackel (1977) also states: "Polar bears warrant special attention because their value and socio-economic importance overshadow other marine furs....Polar bear exports, worth $17,000, make a sizeable contribution to marine fur income in the Mackenzie economy". Polar bears are the least abundant of the marine fur species but the individual hides have the most value. The average price received by hunters was $1000 in 1974 (Brackel 1977).

Data Gaps

The TLUI sites are not all inclusive as there may be other sites which are not known. A recommendation for further work on the ANWR study area would be to complete on-site studies for the remaining historic (TLUI) sites within the refuge. Studies are needed to determine exact locations and other relevant archeological and historical documentation information. This need for on the ground identification and documentation of historic sites is the most important data gap existing in this subsistence-cultural resource.

As with most subsistence and resource use information, data are scanty on the domestic use of natural resources. Additional research is needed in Canadian communities as well as Alaska on the subsistence utilization patterns of caribou. Some information is available for Venetie, but long term data are necessary to evaluate the role of caribou in the inland subsistence economies.

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Recreation, Wilderness and Natural Landmarks

Recreation

"When Alaska Recreation is viewed from a national standpoint, it becomes at once obvious that the highest value lies in the pioneer conditions yet prevailing throughout most of the Territory... In Alaska alone can the emotional values of the frontier be preserved... Alaska is unique among all recreational areas belonging to the United States because Alaska is yet a wilderness" (Marshall 1938:213).

This discussion of recreation excludes subsistence use by local rural residents. Recreational uses of Arctic NWR are varied and related to wildlife or wilderness values. Recreationists are attracted to Arctic NWR because these values are not easily found elsewhere, especially in the lower 48 states. Recreationists usually choose a recreational experience in the refuge because of its wilderness characteristics, opportunities to explore remote, untamed areas, opportunities to view wildlife, and a chance to experience solitude and tranquility. Solitude and tranquility are considered important parts of a wilderness experience by most visitors (Hendee et al. 1968, Rossman and Ulehla 1977). Esthetically, Arctic NWR offers opportunity to experience pristine arctic and subarctic habitats. Lucas (1980) indicated that some wilderness visitors placed priority on recreational opportunities while others placed priority on finding a natural ecosystem.

The most common form of recreation in the refuge is hunting, followed by backpacking/hiking, and floating rivers. Hunters, both guided and non-guided, seek Dall sheep, moose, caribou and brown bear. Other recreational pursuits on the Refuge include wildlife observation, photography, mountain climbing, cross-country skiing, fishing, and nature study. In connection with subsistence activities, or solely for recreation, local residents also engage in snowmobiling.

Available data on recreational uses of ANWR are very limited. Two surveys were conducted during the 1970's constitute the information on recreational use. Annual surveys are not conducted on the refuge. A 1975 survey (Ritchie and Childers 1976) estimated that 281 sampled visitors (exclusive of industry, research personnel, native community residents, and DEW-line site employees) accounted for 75% to 90% of the total visitation. Most people visited the refuge between 1 June and 15 September. Warren (1980) estimated 435 visitors in 1977, exclusive of subsistence users. Visitation in the 1970's was increased over the 1960's. Use by recreationists, particularly hunters, increased rapidly in the early 1970's, and have leveled off to a more steady increase after 1974 (Refuge files). The above mentioned studies were completed within the boundaries of the pre-ANILCA Arctic "Range"; with the addition of 3.6 million ha to the refuge, new visitor use estimates are being made. The best estimates of yearly visitation to the entire refuge, exclusive of subsistence users, is 900-1000 (J. Liedberg, pers. comm.). Visitation to this area is low because of cost, access, and limited facilities.

Visitors to the refuge come mostly from Alaska and the contiguous Pacific Coast states and most are between the ages of 25 and 45 years old (Warren 1980). The average stay was 10.6 days for hunters and 13.4 days for non-hunters. These visitors sought a recreational experience with many different goals -- hunting, experiencing the wilderness, photography, etc. (Warren 1980). Not all goals require a true wilderness setting; some recreational experiences are available in non-wilderness settings. Management goals for ANWR have been to preserve the option of a true wilderness experience for those types of recreationists who require it for their recreational experience.

It is difficult to isolate recreational uses of the ANWR study area from the remainder of the refuge, especially the contiguous Brooks Range. Many recreational experiences rely on a continuous trip from the mountains, across the coastal plain to the coast, or vice versa. Every year, visitors hike from Barter Island to Arctic Village, or from drop-off points in the Brooks Range to Barter Island. The esthetic values of such trips have not been measured.

Recreation on the study area is based on the natural features and natural resources of the area including vegetation, wildlife resources, and scenic and esthetic resources which are difficult to quantify. The potential for high-impact recreational uses such as snowmobiling in the study area is not great. A low use, high quality level of primitive recreational experience is appropriate.

No recreational facilities exist on the study area, and none are planned. The abandoned DEW-line sites at Camden Bay and Beaufort Lagoon may occasionally be used by recreationists.

Present recreational use on the ANWR study area is light, but Warren (1980) states that 4.1% of the hunters and 17.9% of the non-hunters visited the northwestern part of the Refuge, and 4.1% of the hunters and 26.3% of the non-hunters visited the northeastern part of the refuge (Fig. 3). This would indicate approximately 90-110 annual visitors to the ANWR study area.

Visitors usually arrive on the study area via commercial air service to Kaktovik or Prudhoe Bay and by aircraft charter from these locations to their destination. Other visitors may arrive by foot, hiking from drop-off points in the Brooks Range or from Arctic Village. Visitors floating rivers begin trips on rivers within the Brooks Range and float north to pick-up points on the coast or on the coastal plain. Some kayak groups float to the coast and then paddle through the coastal lagoons to Barter Island. The river corridors are especially important to most visitors because they serve as navigational aids and they provide easy hiking routes across otherwise difficult terrain.

Recreational activities conducted on the ANWR study area include nearly the same activities as those already mentioned for the entire refuge. The highest use of this area is probably by backpackers/hikers, and, secondarily, by boaters. Hiking is good along the coast and along the river courses in the coastal plain. Cross country hiking is difficult because of wet, tussocky terrain. Most hikers are probably enroute from the mountains to the coast when traversing the study area. Boaters utilize rafts or kayaks to navigate the river courses. The more popular floating rivers are the Canning, Hulahula and the Jago. Canoes are not a practical craft on the rocky, shallow north slope rivers. Hunting is not as popular on the coastal plain as it is in the mountains because there is no Dall sheep habitat. However, one hunting guide does operate in this area, and has applied to the state for an exclusive guide area. Hunts are guided for caribou and brown bear. Other recreational activities include wilderness enjoyment, nature study, photography, fishing, and wildlife observation. These activities may be the major purpose for the trip, but are usually done in conjunction with other recreation such as hunting or backpacking (Fig. 4). The residents of Kaktovik occasionally engage in snowmobiling and cross country skiing.

Specific numbers of participants engaging in these activities are difficult to obtain. Some information is available from air charter operators, but not all visitors utilize charter services. There is a definite need to more accurately and routinely obtain visitor information for the entire refuge area.

Wilderness Values

The Wilderness Act of 1964 listed 6 characteristics to be considered in a wilderness evaluation. The following discussion addressed the wilderness values of the ANWR study area for each of these 6 characteristics.

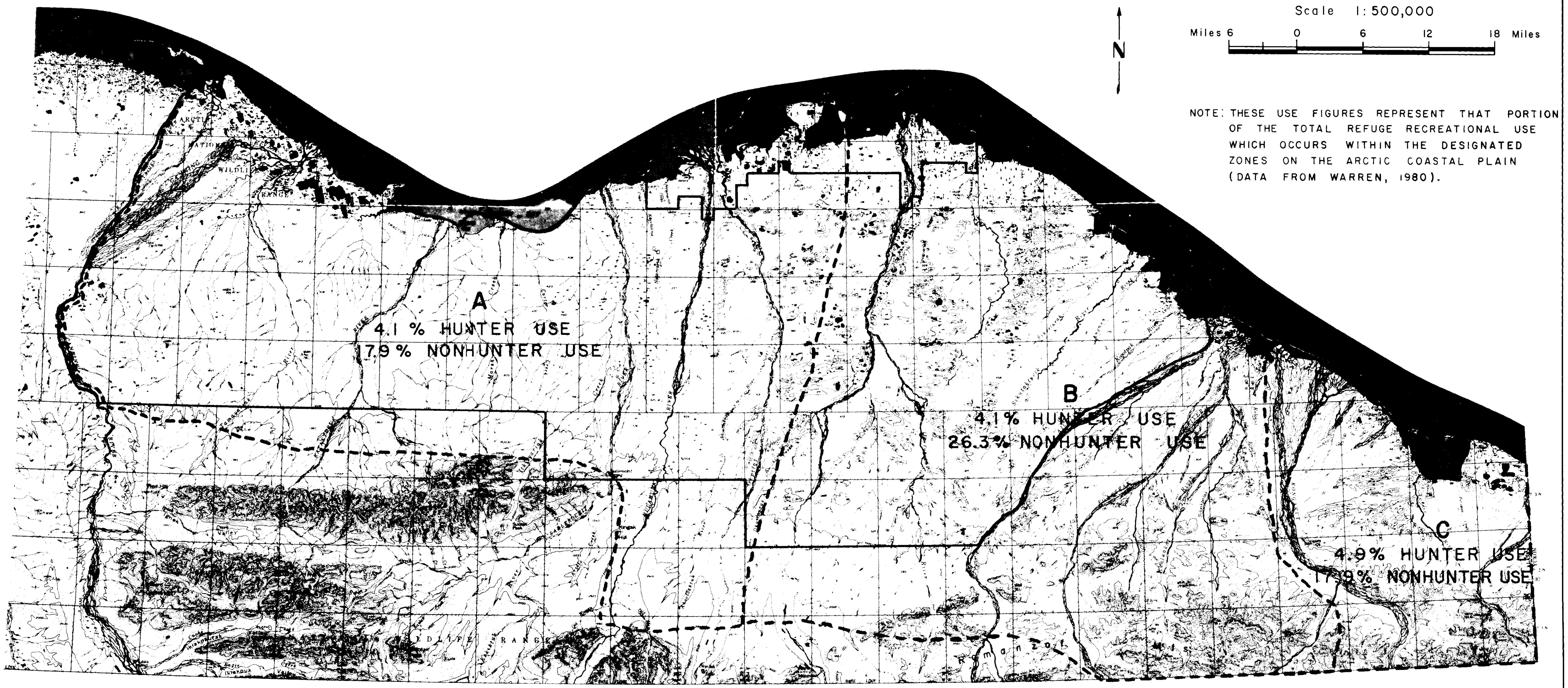
1. Size: The study area meets the designated size criteria i.e., the unit exceeds 2,000 ha and is of sufficient size as to make practical its preservation and use in an unimpaired condition.

2. Naturalness: With few exceptions the entire study area is primeval. Exceptions are the 3 military reservations on the coast and some lands on Barter Island. Throughout the remainder of the area, the works of man are substantially unnoticeable. Some tractor tread marks are visible near the coast. On some maps these tracks are incorrectly noted as a tractor trail. The tracks are the result of some random travel approximately 25 years ago. The tracks are substantially unnoticeable at this time.

3. Opportunities for solitude: The ANWR study area is primeval land and offers excellent opportunity for solitude, further enhanced by the wilderness status of the land immediately south and east. To the West of the study area, land is used primarily by the oil and gas industry. A

FIG. 4 RECREATIONAL USE MAP

FIG. 3 DISTRIBUTION OF RECREATIONAL USE BY HUNTERS AND NONHUNTERS



minimal amount of recreational use comes across the border. The Arctic Ocean lies north of the area. There are no designated trails for wilderness travelers, but most travel occurs along river courses. However, even in close proximity to another party, the meandering shape of stream valleys provides adequate opportunity for seclusion.

4. Opportunity for primitive and unconfined type of recreation: The characteristics that provide opportunity for solitude, already mentioned above, also provide the situation for primitive and unconfined recreation, especially hiking, skiing, photography, wildlife observation and wilderness enjoyment. A special feature of the unit is the openness and unconfinement. The land is an undulated plain carpeted with very short vegetation. The vegetion, except for some willow thickets on stream bottoms, is less than 30 cm in height. The visitor and the wildlife alike are conspicuous on this open plain. To the north the view is to the Arctic Ocean with its ice flows. To the south the view is up to the highest mountains in the Brooks Range. East and west the flowered plain extends in undulating waves further than the viewer can see.

   The shallow valleys of the numerous streams that flow north across the unit to the Arctic Ocean provide good camping sites. Gravel outcrops on the plain above provide a camp site with very broad views. The streams in the area are not navigable by conventional power boat and most are not handily navigable by canoe. Rafts or kayaks provide the best crafts for river running.

   The Arctic Ocean beach reef system is composed of sand and small gravel. The beach, with the Arctic Ocean to the north and the broad coastal plain on the south and the general absence of man's work offers extensive primitive and unconfined camping and wilderness enjoyment opportunities.

5. Ecological, geological, scientific, educational, and historic values: The ecological, geological, scientific, and educational values are the interdependent values that constitute wild lands. The geologic formations of beach gravel and sand formed by the Arctic Ocean are used as nesting and resting sites for marine and other wild birds. Bearded seals and harbor seals rest on the ocean spits and gravel reefs. During early winter polar bears excavate their dens in the snow drifts that form where creeks, especially Marsh and Carter Creek, have worn declivities into the earth. Where streams become slower as they reach the ocean they form deltas with many small ponds and marshes that are nesting sites for waterfowl and shore birds that feed in the ocean and along the beaches. Caribou, grizzly bear, wolves, fox, and muskoxen inhabit the unit. The area is an important calving area for the Porcupine caribou herd.

   Many historic sites are located within the unit, primarily along the coast. Historic sites and traditional land use sites are often considered one and the same.

   This stretch of Arctic Coastal Plain is the last such area in Alaska that has not been committed to man's development activities. As such, it has extremely high values as a remaining example of the natural coastal arctic ecosystem. Its ecological, scientific and educational values as such an example are almost incomparable.

6. Possibility of returning to natural conditions: The military reservations at Camden Bay and Beaufort Lagoon are slowly returning to natural condition through the process of beach erosion, thermokarsting and frost tilling. The FWS is slowly removing some of the man-made objects from the sites. If all man-made objects are removed the sites will assume a natural condition in less than 200 years.

Natural landmarks

Two sites within or immediately adjacent to the study area have been recommended for inclusion in special recognition systems (Fig. 4). Bliss and Gustafson (1981) note that Sadlerochit Mountains and Warm Springs have been nominated for inclusion as a National Natural Landmark site. The goal of the National Natural Landmarks Program, established in 1963, is to inventory and characterize sites that best illustrate the diversity of our nation's natural heritage. The approximate size of the site is 93,313 ha. The Sadlerochit Mountains themselves lie outside of the study area; the Sadlerochit Springs lies on the boundary of the area. This nomination was made because it contains the most northern population of Dall sheep in North America and because of the warm water aquifer and lush vegetation (Bliss and Gustafson 1981).

An additional site has been nominated for consideration for inclusion in a statewide system of Ecological Reserves. The Jago River drainage, according to Stenmark and Schoder (1974:50) contains "a complete array of tundra and flood plain vegetative and animal types typical of the North Slope." The complete river drainage from headwaters to mouth is included in the proposal; much of the proposal is included in the study area (Fig. 4).

Data Gaps

The characteristics, timing, length of stay, activities, etc. of recreationists using the study area needs to be quantified. The esthetic values of the walking and floating trips access the study area also needs to be assessed. The wilderness values of the study area will be assessed in the review of the area for potential inclusion in the Wilderness Preservation System.

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Chapter 8

POTENTIAL IMPACTS OF GEOPHYSICAL EXPLORATION

This chapter describes the potential impacts which may occur to the fish, wildlife, and cultural resources of the ANWR study area due to the geophysical exploration program mandated by ANILCA. Previous chapters presented a synthesis of existing information about the biological and cultural resources of the study area. That information and the same general organization of the previous chapters will be followed in discussing potential impacts of the exploration program (eg. vegetation, birds, mammals, fish, human culture). This discussion is followed by a summary of seasonal impacts to selected resources or the study area and a set of seasonal sensitivity maps. A comprehensive impact matrix is presented which summarizes the potential impacts of the various exploration program components to the fish, wildlife and cultural resources of the study area. Data gaps in knowledge about the impacts of exploration are discussed at the end of the chapter.

Few studies have been conducted regarding the impacts of a specific seismic exploration program. Although extensive information is available regarding the effects of various construction and development related activities, that information is often patchy and of questionable value. For example, a study of the information available about the effects of pipeline construction on Alaskan mammals showed that many data gaps existed and that much available information is qualitative and anecdotal (Douglas et al. 1980). This chapter reviews the available literature on related activities and impacts studied in Alaska, Canada and other northern environments and applies that information to the resources and conditions found in the ANWR study area. Studies will be conducted in the future to clarify and ascertain the potential impacts as they relate specifically to the ANWR study area (see Chapter 1).

Exploration Techniques

Section 1002 of ANILCA authorizes only "surface geological exploration or seismic exploration, or both" for the inventory of oil and gas resources on the ANWR study area. Exploratory well drilling is prohibited. The details of which technique(s) will be used, the timing and the extent of the exploration which will actually take place on the study area are not known at this time. The following techniques are those that have been considered in this chapter to describe the potential impacts to the fish, wildlife and cultural resources of the study area. These techniques are ones that are commonly used on the North Slope, or potentially could be used. The information was derived from FWS employees experienced in monitoring seismic operations and from available literature.

Exploration programs may be conducted on either reconnaissance or intensive levels. The same techniques can be used for either level by varying the spacing of the source points. For example, the conventional technique described below may have a reconnaissance survey grid 4.8 by 9.7 or 9.7 by 9.7 km square, or an intensive survey grid 1.6 by 1.6 or 1.6 by 4.8 km square. In addition, the same vehicles (eg. flexible tracked surface vehicles, airplanes, or helicopters) can be used to support different techniques. Vehicle impacts may vary according to the type of vehicle and intensity of use of the vehicles.

Three non-seismic exploration techniques can be used in reconnaisance level investigations. These are surface geology, aeromagnetic, and gravimetric surveys. Surface geologic investigations generally are conducted during the summer using helicopter support. Geologists visually examine geologic structures, and may collect and chemically test small samples. Since few rock outcrops exist in the study area, relatively little geologic investigation would be expected. Aeromagnetic surveys are used to detect large basement anomolies, and can be conducted with an aircraft flying at an altitude of 457 m or more. Gravity surveys can be conducted along with a surface seismic operation or can be conducted independently, using either helicopters or airplanes.

Seismic exploration generally is conducted using one of 3 techniques: conventional drilled shotholes, vibrating systems (Vibroseis*), or air shots (Pouldier**). Occasionally both vibrating and conventional techniques are used during the same survey, for verification of data. It is also possible that both the Pouldier and conventional techniques would be used on the same survey, for the same reason.

With the conventional technique, shot holes 18 to 23 m deep and 9 to 13 cm in diameter are drilled 0.4 to 0.8 km apart. Charges of 23 to 45 kg are placed in the holes and the cuttings are replaced. The shots are usually exploded individually rather than in unison.

The vibrating technique uses 3 or 4 vehicles equipped with large weighted pads. The pads are lowered on to the ground 12 to 15 m apart from the source point and the weight of the vehicle is applied to the pad. The the pads are activated in unison for 7 to 15 seconds during which a range of frequencies is used. Next the vibrators move forward in tandem 5.5 to 7.3 m and are activated again. At each source point the process is repeated 10 to 13 times, and source points may be located 0.2 to 0.4 km apart. Vibrations can also be produced by dropping a weight onto the ground (thumper).

The air shooting technique involves placing small charges in an array on the ground or on stakes 0.6 to 1.5 m high around the source point. The individual charges used are generally less than 4.5 kg, and the array is detonated simultaneously, totalling up to 27 kg.

Ship based seismic exploration is possible during the summer in marine and lagoon waters. Impulses can be generated by compressed air or spark ignited explosions of gases, usually propane and oxygen.

All of the above techniques (except ship based) have several features in common. A surveying crew is necessary to mark the source points, geophone locations and seismic traverses ahead of the operation. Geophones must be laid out, and sections are transported forward ahead of the existing spread. A recording instrument shelter and vehicle is needed. The conventional technique specifically requires 4 to 5 drilling machines, shooter vehicle and an explosives storage trailer. The vibration technique requires a vibrator tender vehicle rather than a shooting vehicle.

* "Vibroseis" is the trademark of Continental Oil Company.
** This term is also spelled "Poulter", "Poulder".

The above techniques may be used either in summer or winter. Generally the conventional and vibrating methods are conducted during the winter using surface vehicles and accompanied by a mobile camp (cat train) which supports up to 50 personnel. However, a modified conventional technique can be conducted using helicopter support. A helicopter supported air shot operation was conducted for the first time on Alaska's North Slope during the summer of 1981, in the National Petroleum Reserve-Alaska, where it was proven feasible during that season. In subarctic areas in Alaska, helicopter supported seismic operations are conducted both in summer and winter, but helicopter winter operations have not yet been conducted on the North Slope.

Living quarters for the crew must be supplied. In winter this is normally accomplished by using up to 20 trailer units mounted on sleighs or flexible tracks. Usually 5 trailers are pulled in a train by a D-7 tractor and move daily or every other day near the seismic crews. During the summer, tent camps can be used. They would be relocated by helicopter every 30 days or so. If a winter helicopter program were conducted, shelter units might be used if they could be transported by helicopter.

All of the above techniques require logistical support of varying degrees. Personnel, food, fuel, explosives, and water must be supplied, but each operation will vary in the intensity of supply flights. From 2 to 5 flights a week are common, but 2 to 3 a day may occur. During the winter, temporary airstrips can be established on large lakes or long gravel bars. During the summer, long broad gravel bars can be used, but helicopter support is often necessary. A base supply camp is necessary, but may be located as far away as Prudhoe Bay or Umiat. Fuel and explosives caches in the study area may also be required.

A variety of vehicles may be used to carry out the exploration program. Surface vehicles generally are of 2 types: tracked or wheeled. Tracked vehicles can include snowmobiles, Bombadier personnel carriers, larger Nodwells, tractors of the D-7 Caterpillar size, and support units for living trailers. The larger vehicles range between 40,000 to 60,000 pounds gross weight and between 5 to 6 pounds per square inch (psi) surface pressure. Wheeled vehicles generally are of the Rolligon type with oversized low pressure tires in the 4 to 5 psi range. Aircraft generally will be of the light, single or twin engine type with short take off and landing capabilities. Possibly larger freight airplanes such as the Hercules C-130 would be used where large established airports are available. Helicopters could be either the smaller 3 to 5 passenger size (eg. Bell 206) or a larger transport size. It is possible, but not probable, that air cushion vehicles would be used.

In summary, the most commonly used seismic techiques on the North Slope are the conventional drilled shothole or vibration type conducted during the winter. Helicopter supported summer air shots or modified conventional methods have been proven feasible. Helicopter supported techniques may be possible during the fall, winter, or spring, but have not been attempted during those periods on the North Slope. It is unknown at this time if the vibrator method could be adapted for helicopter use. Seismic exploration of the lagoons is possible by ship in the summer or by other surface methods in the winter on ice.

Impacts on Vegetation and Surface Stability

The potential impacts of geophysical exploration on vegetation and surface stability can be expected to vary according to the types of vehicles utilized for transport of personnel and equipment, the seismic techniques employed, and the possibility of accidental impacts due to spills, fires, etc. The degree of impact of any of these factors is in turn dependent upon the time of year in which operations are carried out. The susceptibility of arctic tundra to disturbance has been discussed by Bliss et al. (1970), Ives (1970), Bliss and Wein (1972a), Billings (1973), Dunbar (1973), Webber and Ives (1978), Brown and Graves (1979), and others. The following discussion reviews the relative impacts of the above components of an exploration program on arctic tundra and permafrost terrain.

Vehicular Impacts

Tracked or Wheeled Vehicles

Studies of vehicle damage to tundra surfaces (Hok 1969, 1971, Rickard and Brown 1974, Walker et al. 1977, Lawson et al. 1978, Brown and Grave 1979) have recognized that vegetation and permafrost disturbance may be related to several factors:

1. The number of passes of tracked or wheeled vehicles over the same trail,
2. The degree of surface pressure exerted,
3. Certain patterns on treads or tracks that are more likely to break plant parts and gouge surface soils,
4. Passage of vehicles over highly unstable soils, slopes, or where subsequent drainage results in erosion,
5. Use of sharp turns in trails causing lateral displacement of surface materials.

The impact of vehicles also varies according to vegetation type, soil moisture, microtopography, and time of year. Walker et al. (1980) rated the sensitivity of several vegetation-microsite categories at Prudhoe Bay based on a single pass of a Rolligon during the summer. They found 3 high sensitivity categories: dry frost-boil barren, wet graminoid meadow low centers or flat areas, and wet graminoid meadow troughs. Categories of moderate sensitivity included moist graminoid meadow rims, wet graminoid meadow low centers or flat areas, and moist graminoid meadow rims or hummocks.

Winter traffic can be expected to cause significantly less damage than summer traffic, although some disturbance may occur. The Navy (1977) stated that "... the potential surface impact from overland travel is compaction and possible tearup of the tundra surface, which can result in 'greentrails', ponding water, and minor erosion in summer months". Reynolds (1981) studied the effects of different vehicle types travelling across 4 arctic vegetation types. Little damage occurred to all types of vegetation from a single pass of low pressure vehicles while the greatest impact resulted after passage of tractor trains. Natural recovery of disturbed areas occurred within 16 months, although recovery of damaged riparian willow stands was expected to take several years. It appeared that sleigh mounted units bog down more easily in deep snow than other vehicles, with corresponding surface damage incurred during efforts to free the mired equipment.

Although snow cover and frost depth were not measured by Reynolds (1981) these are important parameters in determining the impact of surface travel. Exploration regulations usually require snow cover of at least 15.3 cm and frost depth of at least 30.5 cm before vehicles are permitted to travel on arctic tundra (USGS/BLM 1979, BLM 1980). In a report which reassessed winter precipitation data on Alaska's North Slope, Benson (1981) concluded that Barter Island received more snow than Barrow, but a zone of reduced precipitation existed near the Jago River. In addition, wind measurement data comparisons between Barrow and Barter Island show that winds in excess of 7 m per second which are most important in transporting snow, occur about 9% more frequently at Barter Island than at Barrow (Benson 1981). These findings may be due to influences brought about by the relative proximity of the Brooks Range to the Beaufort Sea in northeastern Alaska. Due to a greater diversity of topographic features and more frequent strong winds, snow cover tends to be more variable in the ANWR study area than on most of the coastal plain to the west. In general, snow accumulates in the numerous drainage features and other depressions in the study area (Benson 1981), leaving ridges and elevated land surfaces exposed or with only a thin covering of snow in certain areas (Everett 1981). Heavy surface vehicles travelling in winter can become stuck in snow filled drainages and may require plowing of trails and other removal measures which could increase the potential for surface damages. Travel by such vehicles across exposed tundra areas can result in damage to unprotected vegetative cover.

When disturbance does occur, the ultimate impacts on vegetation and surface stability vary. In extreme cases where the vegetation mat is completely removed, thermokarst erosion can lead to depressions and gullies which do not recover for many years. Aggravated erosion can occur along coastlines, lake shores, and river banks. Moderate disturbance of vegetation can cause localized slumping and boggy depressions, increased frost heaving, and crack formation. Tussocks may be destroyed and polygon ridges broken. Drainage patterns may be altered. Disturbance of minimal impact can cause minor tussock damage, brown trails, or green trails. The brown or green trails indicate minor disturbance to the vegetation and little or no alteration of the active layer. They can be an aesthetic problem, however, because the trails are visible, primarily from the air and occasionally on the ground. Although the total area of disturbance would be small in an exploration program, its significance to the wilderness values of the refuge could be great (see Wilderness and National Landmarks section later in this chapter).

One indirect impact of vehicle use is the necessity of snow removal in some instances to facilitate movement and siting of equipment. Blading of snow by caterpillar tractors reduces its insulative value and, where the ground is uneven (i.e., tussocks or polygon ridges), or blading is too deep, may result in removal of organic material.

Hovercraft

To date, only a few studies have shown a correlation between hovercraft operation and habitat degradation (Rickard and Brown 1974, Abele 1976, Abele and Brown 1976). The primary limitation of air cushion vehicles is not their potential damage to the surface, but rather technical limitations such as maneuvering over inclines or bluffs. If these technical problems are overcome, use of air cushion vehicles may increase, and further studies of their effects on vegetation and terrain may be needed.

Aircraft

Aircraft generally have no direct effect on vegetation, since ice on lakes and rivers, or gravel bars are usually used for airstrips. The potential effects of blading airstrips on ice are discussed in the Fisheries section of this chapter. Aspects of aircraft disturbance to animals will be discussed in the wildlife section of this chapter.

Impacts of Seismic Techniques

The potential for disturbance of vegetation and permafrost will vary according to the particular seismic technique used, as well as the time of year during which exploration is carried out. It should be remembered that the effects of a particular seismic technique will be compounded by the impacts of vehicle use (see above) and that all of the methods described will require several thousand sample points throughout the ANWR study area.

The seismic techniques considered here include 2 explosive (conventional and Pouldier) and 1 non-explosive (Vibroseis) methods. Few systematic data have been gathered on the effects of these techniques on vegetation and permafrost; much of what is known or assumed is based on scant observational information and should be supplemented by detailed, long-term studies.

Conventional

Conventional seismic technique require drilling one to several shot holes and loading them with charges of 50 to 150 lbs. At the surface, the result is a small diameter hole (up to 15 cm) surrounded by a mound of cuttings which are usually swept back into the hole, leaving a small amount of loose dirt. The impacts of shot holes are minor, although they are visible on the ground (Reynolds 1978). Removal of snow cover through placement and ignition of charges can also be expected to have a minor effect.

Pouldier

This technique, also known as air shooting, is a modified method which requires placing a series of small charges on 1 m wooden stakes, with the energy being transmitted into the ground by the stake and air blast. When used during the summer months, this method can cause a brown patch effect by dislodging and scattering dead plant material (Reynolds 1981, pers. comm.). The nitrogen in the explosives may further affect the vegetation through fertilization and development of a temporary green patch of more luxuriant growth. It is likely that with adequate snow cover, winter use of the Pouldier method would have little or no effect on surface conditions.

Vibroseis

This method utilizes a non-explosive energy source transmitted from the surface by a hydraulically operated vibrator pad attached to the underside of a tracked vehicle. The vibrator pad exerts considerably more pressure on the surface than do tracked or wheeled vehicles (10 psi vs. 5-6 psi), and 4 vibrator units are activated simultaneously 10 to 13 times around each sample point. The resulting compression and removal of snow could be significant, causing physical damage to vegetation through breakage or freezing.

It may also be necessary for drilling and detonating units to accompany the vibrator survey to provide supplemental geophysical measurements. These accessory units would add the impacts of drilling and conventional explosive methods.

Miscellaneous Impacts

Spills

Spills of refined fuel and other toxic substances are another potential impact of the exploration program. Ground vehicles and aircraft require fuel to operate, and most vehicles and machinery also use fuel, oil, lubricants, hydraulic fluid, and other materials which may damage vegetation. The effects of small scale spills of less toxic substances are likely to be local and minor.

Spills of refined fuels, however, could cause moderate to heavy impacts depending on their size and location. Terrestrial spills are likely to have minor impacts if they remain localized; if they contaminate lakes, rivers, or coastal waters, however, the impacts would be greater. Chronic fuel spills could have greater long term impacts than a single occurrence.

Numerous studies have been conducted on the effect of spilled crude oil on vegetation and soil systems (McCown et al. 1972, Deneke et al. 1975, Everett 1978, Linkins et al. 1978, Sextone et al. 1978, Walker et al. 1978, Brown and Berg 1980). Some of these studies have been conducted using refined fuels (Deneke et al. 1975, Sextone et al. 1978, Walker et al. 1978). Walker et al. (1978) found that plant sensitivity to spilled oil varied by species and soil moisture. Lichens, mosses and most dicots showed little recovery while sedges and willows were quite resilient. Dry sites were most sensitive and wet sites were the least sensitive. Diesel fuel produced more damage than crude oil. Bergman et al. (1977) reported that all aquatic plant life was destroyed in a contaminated pond at Storkersen Point. While the impacts of crude and refined oil spillage upon arctic vegetation are not fully understood, effects observed by the above investigators and others include:

1. Disruption of surface albedo, or heat absorption (depending on season), with a resultant change in energy transfer to soil and permafrost layers and an increase in the depth of the active layer.
2. Greater disturbance resulting from spills during nonwinter periods of the year.
3. Significant decreases in primary production, particularly in aquatic systems.
4. Differential responses by plant species to spills of crude versus refined petroleum products.
5. Potential long range effects due to persistence of contaminants.

Because the vegetation in the study area is generally drier than that to the west and there are fewer lakes, ponds and wet tundra areas which are important to waterbirds, the effects of a fuel spill on the ANWR study area may be greater than in the Prudhoe Bay area.

Fire

Wildfires are uncommon events on arctic tundra; the combination of saturated soils, a lack of combustible, dead woody fuel and the absence of large, erect woody species inhibit the initiation and spread of fire (Bliss and Wein 1972b). Wildfires do occur occasionally, however, and their effects have been studied in the Canadian Arctic by Cochrane and Rowe (1969), McKay (1970), and Bliss and Wein (1972b). The effects of wildfire on Alaskan arctic tundra have been examined by Barney and Comiskey (1973), Hall et al. (1978), McKendrick and Mitchell (1978), Melchior (1979), and Racine (1979, 1980). The principle adverse effects of fire on arctic tundra are the destruction of vegetation and the potential for thermal or wind erosion. In severe situations this may result in a loss of wildlife habitat. However, in most cases, the affected area is small and vegetative recovery is relatively rapid (a few to several growing seasons). If seismic exploration is carried out during the summer months, there is a risk of fire due to the use of explosives, aircraft or vehicle accidents, or ignition of spilled fuels.

Waste Water Disposal

Kitchen waste water and washwater (gray water) are generally filtered and then discharged onto the snow or land surface. Waste water disposal is not expected to produce significant impacts on vegetation and surface stability, since the quantity and duration of the discharge are likely to be limited. However, prolonged or repeated discharge of warm wastewater may lead to thawing of the active layer, or have artificial affects (fertilization) on vegetation growth.

Impacts to Landcover and Landform Types

The following discussions of potential impacts of an exploration program to landcover and landform types is derived from the soils and vegetation studies conducted on the study area during the summer of 1981. The 12 landcover and 5 landform types are those described in Chapter 3. Two provisional impact matrices are also presented. The reader should note that the impact scales used in these matrices are not the same due to the different study techniques used. Information in these matrices will be updated after further studies are conducted in 1982.

Visual Impact of Seismic Lines to Landcover Types

This assessment of visual impact is based primarily on observations of seismic lines and off-road vehicle operations at Prudhoe Bay (Walker et al. 1977, 1978), at Lonely (Abele et al. 1977), and in NPR-A (Everett 1981, Reynolds 1981). Assessments of impacts and terrain types not covered in those reports are more speculative. This evaluation assumes 12 - 15 passes by seismic vehicles that have from 5-10 p.s.i. ground pressure. These assessments are applied to each of the land-cover categories describing the land-cover units and terrain types on the preliminary Landsat classification of the study area. Predicted impacts to soils, landforms, and vegetation are used in the evaluation of estimated visual impact at the end of 1 and 5 growing seasons (Table 1). The assessments do not include any aesthetic factors. The visual impacts do, however, imply various functional changes such as physical alteration and/or habitat conversion. Table 1 does not include evaluations of camps, runways, and storage areas.

Table 1. Provisional visual impact matrix for seismic surveys within the Arctic National Wildlife Refuge. Impacts are rated for summer (S) and winter (W) operations. Fractions denote visual impact after 1 summer (numerators) and after 5 summers (denominators). Ratings are as follows: 0=no visual impact, 1=slight visual impact, 2=moderate visual impact, 3=severe visual impact. Columns 1-8 are impacts related chiefly to soils and landforms; columns 7-12 are related to vegetation. Totals (Column 12) are used to estimate visibility of tracks at end of first and fifth growing seasons (Columns 13 and 14).

Landcover Categories	1. Compression of organic mat		2. Shearing of surface mat		3. Destruction of surface pattern or soil profile		4. Hydraulic erosion including siltation		5. Thermal erosion		6. Spontaneous liquifaction (mass movement)		7. Processed hydrocarbon spills		8. Sewage		9. Breakage of vegetative parts		10. Compression of erect dead plant material		11. Displacement of tussocks and/or mosses	
	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W
I Water	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
IIa. Pond Complex	3/2	1/0	3/2	1/1	1/1	0/0	0/0	0/0	1/3	0/0	0/0	0/0	1/1	1/1	2/1	1/1	2/2	0/0	2/1	0/0	2/2	0/0
IIb. Aquatic Tundra	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/1	1/1	1/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0
IIIa. Wet Sedge Tundra (non-complex)	2/1	0/0	1/0	0/0	0/0	0/0	0/0	0/0	1/3	0/0	0/0	0/0	1/1	1/1	2/1	1/0	2/0	1/0	3/0	1/0	3/2	1/1
IIIb. Wet Sedge Tundra (very wet complexes)	3/2	1/0	3/2	1/1	1/1	0/0	0/0	0/0	1/3	0/0	0/0	0/0	1/1	1/1	2/1	1/0	2/0	1/0	3/0	1/0	3/2	2/2
IIIc. Wet Sedge Tundra (moist complexes)	2/1	0/0	2/1	1/0	1/1	0/0	0/0	0/0	1/3	0/0	0/0	0/0	1/1	1/1	2/1	1/0	2/0	1/0	2/0	1/0	2/0	1/1
IIId. Wet Sedge Tundra (saline)	1/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/1	1/1	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0
IVa. Moist/Wet Sedge Tundra Complex	2/1	0/0	1/0	0/0	1/1	0/0	0/0	0/0	1/3	0/0	0/0	0/0	2/1	1/1	2/1	1/0	2/0	1/0	3/0	1/0	3/2	2/2
IVb. Dry Prostrate Shrub-Forb Tundra (Dryas River Terraces)	1/0	0/0	3/2	2/2	2/2	1/1	0/0	0/0	0/0	0/0	0/0	0/0	3/2	3/2	1/0	1/0	2/1	2/1	1/0	1/0	1/1	1/1
Va. Moist Sedge-Prostrate Shrub Tundra	2/1	1/0	1/0	0/0	1/1	0/0	1/2	0/0	1/2	0/0	0/0	0/0	3/2	3/2	1/0	1/0	2/1	1/0	2/0	1/0	2/1	1/0
Vb. Moist Sedge/Barren Tundra Complex (Frost boil Complex)	2/2	1/0	1/0	0/0	2/2	1/0	0/0	0/0	1/2	0/0	0/0	0/0	3/2	3/2	1/1	1/0	2/1	1/0	2/0	1/0	2/1	1/0
VI Moist Tussock Sedge-Dwarf Shrub Tundra	2/2	1/0	2/1	1/0	1/0	0/0	1/2	0/0	1/3	0/0	0/0	0/0	2/1	2/1	1/1	1/0	2/2	2/1	2/0	1/0	2/2	2/1
VIIa. Moist Dwarf Shrub-Tussock Sedge Tundra (uplands)	2/2	1/0	2/1	1/0	1/0	0/0	1/2	0/0	1/3	0/0	0/0	0/0	2/1	2/1	1/1	1/0	3/2	2/1	2/0	1/0	3/2	2/1
VIIb. Moist Dwarf Shrub-Tussock Sedge Tundra (birch tundra)	2/2	1/0	2/1	1/0	1/0	0/0	1/2	0/0	1/3	0/0	0/0	0/0	3/2	3/2	1/1	1/0	3/2	2/1	2/0	1/0	2/1	1/0
VIIc. Moist Tussock Sedge-Dwarf Shrub/ Wet Dwarf Shrub Complex (water track complex)	2/2	1/0	2/1	1/0	1/0	0/0	2/2	0/0	1/3	0/0	0/0	0/0	2/1	2/1	1/1	1/0	3/2	2/1	2/0	1/0	3/2	2/1
VIII Shrub Tundra	1/0	0/0	1/1	0/0	1/0	0/0	2/3	1/2	0/0	0/0	3/3	0/0	2/1	2/1	1/0	1/0	3/2	3/2	2/1	2/1	1/0	0/0
IXa. Partially vegetated - River bars	0/0	0/0	1/0	1/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	2/0	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0
IXb. Partially vegetated - Alpine tundra	1/0	0/0	1/0	0/0	1/0	0/0	1/2	0/0	0/0	0/0	0/0	0/0	2/1	2/1	1/1	1/0	2/1	1/0	2/0	1/0	2/1	1/0
IXc. Partially vegetated - Sorted stone nets	0/0	0/0	0/0	0/0	2/2	1/1	0/0	0/0	0/0	0/0	0/0	0/0	1/1	1/1	0/0	0/0	1/1	0/0	0/0	0/0	0/0	0/0
IXd. Partially vegetated - Beaches	0/0	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	2/0	2/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0
IXe. Partially vegetated - Sand dunes	0/0	0/0	0/0	0/0	3/2	2/1	0/0	0/0	0/0	0/0	0/0	0/0	2/0	2/0	0/0	0/0	2/1	0/0	0/0	0/0	0/0	0/0
X Barren gravels or rock	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
XI Barren mud or wet gravel	1/0	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
XII Ice	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0

The 4-point rating scale for estimates of visual impact is based on the following criteria:

1. No visual impact (0) assumes no detectable changes in plant composition or alteration of soil or landforms, either visible on the ground or from the air.

2. Slight visual impact (1) assumes that there are some detectable changes to the composition or structure of the vegetation, soils or landform. These are of a minor, non-extensive nature.

3. Moderate visual impact (2) assumes that alterations of the geobotanical aspects of the terrain are more severe than with a (1) rating, but that in most cases the original vegetation, soil, and landforms can still be discerned.

4. Severe visual impact (3) assumes that in some areas the vegetation, soils, and/or landforms will be completely altered. These may be of a local nature such as in the case of diesel spills or the formation of thermokarst pits.

Various impact categories contribute to the overall visual impact of vehicle trails. Several of the more important ones are listed below with short explanations.

1. Compression of the organic mat. This category concerns primarily the non-elastic compression of the organic vascular and moss vegetation mat.

2. Shearing of surface mat. This category denotes the breakage of the organic vegetation mat and the exposure of mineral soil or lower organic layers. This often results in increased thaw, which in turn, could lead to thermokarst erosion.

3. Destruction of surface pattern or soil profile. This category relates to changes in soil profiles such as the elimination of a thin O or A horizon and/or alteration of microscale features, such as the flattening of hummocks, polygon rims, or frost boils.

4. Hydraulic erosion. This category relates to flowing water and soil erosion. Vehicle tracks on the slopes are often channels of erosion. Siltation of streams and lakes are often related to this factor.

5. Thermal erosions. This category relates to increased thaw of the permafrost table, resulting in subsidence of the surface. This is often caused by a decrease in the surface albedo due to such factors as removal of the vegetation mat, flattening of the erect dead vegetation or ponding of water.

6. Spontaneous liquifaction. This category refers to the mass movement of saturated soils on steeper slopes. This can be triggered by machine vibrations.

7. Processed hydrocarbons. This category refers mainly to diesel and gasoline spills. This impact will be of minor extent but damage is likely to be locally severe.

8. Sewage. This impact may not be much of a problem if all sewage is incinerated, treated or backhauled. However, accidental spills may result from ruptured or overfilled sewage tanks.

9. Breakage of vegetative parts. This category refers to damage to plants. The damage will be most severe in areas with woody vegetation.

10. Compression of erect dead plant material. This category relates to the non-prostrate dead component of the vegetation cover, which is composed mainly of dead herbaceous leaves and stems that have high reflectivity to solar radiation. Vehicles tend to compress this component to the soil surface, causing a darker vehicle track with decreased albedo, leading eventually to increazed thaw and a deepening of the vehicle track. The "greening" of vehicle trails is in part due to this effect plus the increased availability of nutrients that are associated with most tundra disturbances.

11. Displacement of tussocks and/or mosses. This category relates to the overturning and displacement of vegetation adjacent to vehicle tracks. In some cases this can result in piles of material adjacent to the tracks and the smothering of covered plants.

Some of these effects are likely to be more extensive and hence more important in the overall ratings. For example, displacement of tussocks and/or mosses, (11) would certainly be a more common occurrence than Number 6, impact from processed hydrocarbon spills (6). However, weighting was not utilized in determining overall impacts.

Each landcover category is rated for expected impacts from summer and winter seismic operations (Table 1). Scores are given for impacts after one growing season and after 5 growing seasons. The scores are totaled for both the rows (landcover categories) and columns (types of impact).

Several important facts regarding impact can be inferred from Table 1:

1. Snow cover and/or frozen ground greatly reduce the impact in all categories except fuel spills and sewage spills. This is particularly true for thermal and hydraulic erosion, compression or shearing of the surface mat, and movement or destruction of the vegetation canopy.

2. For summer seismic operations, damage from processed hydrocarbon spills, breakage of plant parts, compression of standing dead vegetation, and displacement of tussocks and/or mosses are the most noticeable types of impact after 1 growing season. After 5 growing seasons, thermal erosion in vehicle tracks is likely to be by far the most noticeable impact, but impacts from diesel spills and compression of the organic mat and displacement of tussocks will still be noticeable in many land cover types. The most significant impact categories are hydraulic and thermal erosion where there is likely to be progressive deterioration of the terrain.

3. For winter activities, hydrocarbon spills, breakage of plant parts (particulary woody shrubs), and tussock displacement are likely to be the most noticeable types of impact after 1 growing season. These same events are also likely to be noticeable after 5 summers, although with somewhat reduced visual impact.

4. Summer seismic operations are likely to create heavy damage in all well-vegetated tundra types. The landcover types that are likely to incur the most damage from summer activities are: 1) water track complexes, 2) wet sedge tundra (very wet complexes), 3) all tussock sedge-dwarf shrub tundra types, 4) pond complexes, 5) moist/wet tundra complex, and 6) shrub tundra. The impacts are likely to be evident in most areas 5 years after seismic operations.

5. With winter operations, impacts will be much reduced except in areas with low snow cover or medium height to tall shrubs. Most well-vegetated tundra types are likely to have some visual impact after 1 growing season, but most of these areas should have nearly complete recovery after 5 years. Exceptions will be *Dryas* river terraces, exposed pingos, and river bluffs with shallow snow cover. In these areas, tracks and wheel treads are likely to rip the vegetation mat and recovery will be slow. In shrub vegetation, woody plant parts will be broken and are not likely to recover completely within 5 years, although eventually these areas should recover completely. Travel across tussocky terrain will result in some damage to tussocks and shrubs. It is not known if recovery will be complete after 5 years. In some cases the tracks may still be visible from the air, particularly on steeper slopes.

6. The relative moisture of the landcover categories is quite important. Aquatic environments are least susceptible to summer and winter impacts. Moist to wet types are most likely to be affected by summer impacts, and the impact will often persist beyond 5 years. Dry sites show the most inconsistent response to impact.

7. Areas with complex terrain are likely to experience more severe impact due to irregular micro-relief.

It is currently not possible to predict the specific geographic locations where the impacts are likely to be the greatest. This would be possible with accurate maps depicting snow cover, slope, landform, and vegetation types.

Impacts of Seismic lines to landform types

This assessment of potential impacts to landform types combines information from both the landcover and the soils investigations, as well as information on habitat use by animals. Impacts are rated in a matrix (Table 2) by persistence, as follows:

Low: Impact persists for 1 year or less.
Moderate: Impact persists for 1 to 3 years.
High: Impact persists longer than 3 years.

Table 2. Provisional Impact Matrix For Summer And Winter Seismic Surveys Within The Arctic National Wildlife Range

	Riverine			Thaw Lake Plain			Foothills				Rolling Coastal Plain						Alpine				
	Terrace	River Is. Complex	Bluff and Bluff Edge	Thaw Lake Complex	Drained Lake Basin	Flat	Crest/ Interfluve	Slope > 2%	Stream Complex	Flat	Crest/ Interfluve	Slope > 2%	Thaw Lake Complex	Pond Complex	Drained Lake Basin	Flat	Crest	Slope >10%	Flat	Beaches Spits & Bars	Dunes
Inelastic compression of organic map	M (L)	L (L)	L (L)	M (L)	L (−)	M (L)	M (L)	M (L)	M (L)	M (L)	M (L)	M (L)	H (L)	L (−)	L (−)	L (−)	− (−)	M (−)	M (−)	− (−)	− (−)
Surface shear resistance	M (H)	M (H)	L (M)	M (H)	H (H)	M (H)	M (H)	M (M)	M (H)	M (M)	M (H)	L (M)	M (H)	M (H)	H (−)	H (−)	M (H)	L (M)	H (−)	M (M)	L (L)
Significant destruction of surface pattern and/or soil profile	M (L)	L (L)	H (M)	L (−)	L (−)	L (−)	L (−)	M (L)	L (−)	L (−)	L (−)	M (L)	L (L)	L (L)	L (−)	L (−)	H (H)	L (L)	L (−)	L (−)	M (M)
Hydraulic erosion	L (−)	− (−)	H (−)	L (−)	L (−)	L (−)	− (−)	M (−)	L (−)	− (−)	L (−)	H (−)	L (−)	L (−)	L (−)	L (−)	L (−)	H (−)	L (−)	− (−)	− (−)
Thermal erosion	L (−)	− (−)	M (−)	M (−)	L (−)	H (−)	H (−)	H (−)	− (−)	H (−)	H (−)	H (−)	M (−)	L (−)	− (−)	H (−)	L (−)	L (−)	L (−)	− (−)	− (−)
Altered surface hydrology	L (−)	− (−)	H (−)	M (−)	L (−)	M (−)	L (−)	M (−)	H (−)	L (−)	L (−)	M (−)	L (−)	L (−)	− (−)	L (−)	L (−)	H (−)	L (−)	− (−)	− (−)
Siltation	− (−)	− (−)	H (−)	− (−)	− (−)	− (−)	− (−)	H (−)	L (−)	− (−)	L (−)	H (−)	− (−)	− (−)	− (−)	− (−)	L (−)	H (−)	− (−)	L (−)	− (−)
Spontaneous liquification	− (−)	− (−)	L (−)	− (−)	− (−)	− (−)	− (−)	H (−)	− (−)	− (−)	L (−)	H (−)	− (−)	− (−)	− (−)	− (−)	− (−)	L (−)	− (−)	− (−)	− (−)
Processed hydrocarbon pollution	M (M)	L (−)	M (−)	M (L)	M (L)	M (L)	M (M)	M (L)	L (−)	M (M)	M (M)	M (M)	L (−)	L (−)	L (−)	M (M)	H (H)	H (M)	H (M)	H (H)	H (H)
Sewage dispersal	M (L)	L (−)	− (−)	M (L)	L (L)	M (L)	M (M)	M (L)	L (−)	M (M)	M (L)	M (L)	L (L)	L (L)	L (L)	M (L)	H (H)	H (M)	H (L)	H (H)	H (H)
Visual	M (L)	L (L)	H (M)	M (L)	M (L)	M (L)	H (M)	H (L)	M (L)	H (M)	H (M)	H (M)	H (L)	M (L)	L (L)	H (M)	H (H)	H (M)	H (M)	H (H)	H (H)

Legend
Potential
- no impact

L impact < 1 year
M impact > 1 < 3 years
H impact > 3 years
(W) in winter

Flat Thaw Lake Plains

Typical coastal plain topography with large oriented thaw lakes, drained lake basins, and expanses of low-centered ice-wedge polygons is found in only a few small areas of the ANWR study area, covering only about 3% of the region. The wet tundra areas of the coastal plains are sensitive to impact (Table 2) for 3 principal reasons (Walker 1981). First, the wetness of the landscape can cause numerous problems during the summer. The soils are easily compressed and displaced, resulting in ponding and consequent major changes in plant habitat. The extensive networks of vehicle tracks visible from the air in all areas of the North Slope outside ANWR attest to this (Hok 1969). At Prudhoe Bay, despite efforts to utilize low ground pressure off-road vehicles, tracks continue to proliferate. Second, thaw lake plains and coastal marshes are particularly valuable habitat for waterfowl. Bergman et al. (1977) classified the coastal vegetation into 8 wetland categories based on basin morphometry, vegetation, salinity of water, and water movement. They emphasize the need to minimize oil or gas related activities near their following habitat types: Class III - Shallow-Arctophila (pendant grass); Class IV - deep-Arctophila; Class VI - Basin complex (i.e. areas with numerous ponds and tundra types mixed in complex arrays); and Class VIII - Coastal (i.e. saline) wetlands (see Appendix I, Table 9, crosswalk to purposes). Spindler and Knudston (1978) report that flooded tundra areas are the most important habitat to nesting birds on the Arctic Coastal Plain.

Third, the harsh summer climate near the coast affects a number of limiting factors for plant growth. This is particularly important within the "littoral tundra" zone described in Chapter 3. Plants and animals that can survive the cold summer temperatures have special adaptations for the broad temperature variability that occurs between years. For example, most coastal plants begin senescing several weeks earlier than the air temperatures seem to dictate (Tieszen 1972). Myers and Pitelka (1979) view this as a possible mechanism to ensure that the photosynthetic gains made during the summer are transferred to below-ground biomass, in the form of roots, rhizomes and bulbs, well within the time margin allotted by yearly variations. Few woody plants occur near the coast because there is little surplus production available for woody support tissues. Therefore, many pioneering species are not available for recolonization or are not particularly effective under this harsh climatic regime. Also, the amount of recovery that can take place in a single growing season is limited. This fact is clearly evident when comparing natural 30-year recovery at old drill sites on the coast (e.g. Cape Simpson) versus sites further inland (e.g. Oumalik in NPR-A) (J. Ebersole and V. Komarkova 1980 pers. comm.).

Rolling Coastal Plain

This land form type is a complex region of very gently undulating tussock tundra, thaw lake plains, and pond complexes which extend inland between the Hulahula and Jago Rivers from the flat thaw lake plain to the foothills. Impacts to this type would be a combination of those possible in the thaw lake plain type plus those associated with the foothills type, such as crushing or abrading of tussocks on slope areas (Table 2).

Drier areas within the wetlands are few and often of special interest as wildlife habitat. For example, dunes, pingos, and the margins of many small tundra streams are relatively dry areas where dens for foxes, lemmings, and ground squirrels are concentrated. Grizzly bears use the dry sites for hunting lemmings and squirrels; caribou find relief from mosquitoes near the coast, particularly in dunes and elevated sites; muskox are nearly restricted to the braided drainages of the larger rivers (Robus 1981); numerous birds such as snowy owls, jaegars and gulls use these for observation posts; and numerous other bird species for breeding grounds (e.g. buff-breasted sandpipers). These areas are also botanically important. Pingos often act as dry islands in a sea of wet tundra and contain numerous unique plant communities that are similar to those found in high alpine areas (Murray 1979, Walker 1981). These small unique habitats are also often areas that are likely to be impacted by activities such as vehicle traffic, or as relatively elevated sites for seismic camps or radio antennae.

Foothills

Impacts to foothills vegetation may vary considerably (Table 2), depending mostly on the steepness of the terrain, the amount of ground ice, and the amount of snow cover. Areas where solifluction forms (e.g. discoutinuous strips of frost scars or lobes) are common and where slope breaks exceed 7-10%, are quite susceptible to vehicular impacts because of relatively great microrelief and high moisture content. Because of the exposed nature of inter water-track areas (which may develop up to 65-80% active frost scars), snow cover can be thin or absent and disturbance to vegetation may be severe.

Alpine

Impacts to alpine areas (Table 2)are unlikely to occur because of the small areal extent within the ANWR study area and the inaccesibility of the steep slopes. However, these areas are naturally unstable and the vegetation communities are complex, making them of great interest.

Riverine

The riverine landform presents another complex of vegetation and soil types. Unvegetated islands of gravel, gravelly sand, or silt (in the deltas) are probably inundated at least sporadically in most years. Vehicular impacts to these areas are expected to be minor because of the natural reworking that occurs (Table 2). Partially vegetated islands and bars are among the most floristically rich sites in the region. Willows are common on partially vegetated areas, and may form fairly extensive thickets which are important habitat areas for mammals and birds. However, the recent Landsat land cover classification shows less than 0.2% cover of willow shrub thickets and 1.7% cover of partially vegetated areas. Any destruction of this limited supply of riverine willows would constitute a significant negative impact to several wildlife species. Because of their exposed position, crests of river bluffs are commonly snow free during winter and are susceptible to damage by vehicles, which can then lead to increased wind abrasion and erosion.

Impacts to Wildlife and Fish

Birds

The potential impacts of summer seismic operations on migratory birds include:

1) disturbance due to increased human activities, including air traffic,
2) locally increased predation due to animal attraction to camps,
3) direct effects due to oil (refined fuel and lubricant) spills, and
4) habitat alterations

The amount of information available on short term disturbance effects and other impacts is large. However, some of the studies present conflicting results. In general, disturbance to birds can cause a number of short term impacts:

1) lower nesting density,
2) lower hatching success,
3) nest abandonment,
4) increased stress during molting,
5) increased predation on eggs or chicks.
6) increased energetic stress during staging and migration

The effects of long term disturbance have not been determined. The experimental disturbance studies conducted on the Yukon North Slope, 1972-1975, documented short term (day-long to several weeks-long) effects on nesting, molting, and staging birds, but could only speculate on long term effects and recommend further long term disturbance research (Schweinsburg 1974; Patterson 1974, Wiseley 1974; Davis and Wisely 1974; Gollop and Davis 1974; Salter and Davis 1974; Gollop et al. 1974 a, b, c, and d; Schweinsburg et al. 1974; Platt and Tull 1977)

Impacts to Birds of Tundra Habitats

Birds nesting and molting on uplands or tundra lakes could be affected by disturbances. Barry and Spencer (1976) concluded that helicopters flying at low levels were the most disturbing factor to nesting and molting birds within a 2.5 km radius at a drill rig at the Mackenzie Delta, N.W.T. Hatching success of nests was lower in the area surrounding the drill rig as compared to an undisturbed control area.

In experimental disturbances Barry and Spencer (1976) found that:

(1) Whistling swans left their nest when a helicopter hovered over it at an altitude of 10 m.
(2) Whistling swans left their nest when a human walked within 1500 m of it (Typically on ANWR they leave if one approaches to within 300 m, Spindler unpubl. data).
(3) Molting swans and white-fronted geese sat tight and did not fly when a helicopter flew overhead.
(4) Helicopter flights at 90 m flushed flocks of Canada geese and flushed sandhill cranes off their nests.
(5) Whistling swans, arctic and red-throated loons, white-winged scoters, and oldsquaw were flushed from the river channel by a passing transport barge.

Schmidt (1970) witnessed the desertion of a whistling swan nest that was discovered with no eggs on 14 June 1970: "On 15 June a helicopter from an oil company landed on the strip to support geologists camping at Nuvagapak Point. The pair of swans seemed extremely frightened and flew off to the east. These birds did not return to their nest and they were not seen in the area again. Two pintail pairs and 1 green-winged teal pair left the pond area adjacent to the strip after several helicopter landings on the strip".

Overall whistling swan densities on the coastal plain of ANWR are lower than areas surveyed farther west, but within the ANWR concentration areas, densities are as high as or higher than elsewhere on the North Slope. Disturbance in the form of aircraft overflights, human pedestrian and vehicular traffic and habitat alteration could reduce the ANWR swan population (Timm 1979, Martin and Moitoret 1981, T. Rothe unpubl. data, Sarvis pers. comm.). However, if such disturbances are excluded from the swan concentration areas during late-May to mid-September, the period when swans are present, populations most likely would not be affected.

Snow geese are more sensitive than most other waterfowl species, to disturbances, including aircraft overflights at most altitudes below 3050 m and especially below 55 m (Wiseley 1974, Davis and Wiseley 1974, Salter and Davis 1974, Barry and Spencer 1976). During a close overflight (within 2-3 km and up to 3050 m altitude), snow goose flocks will take off and fly 2-5 km before landing again (Davis and Wiseley 1974, Salter and Davis 1974). If disturbances continue and are frequent it is likely that the birds will expend unnecessary energy to escape the disturbances, hence preventing them from accumulating the fat reserves usually acquired before the fall migration (Patterson 1974). Juvenile snow geese staging on the Yukon North Slope in 1973 increased their fat reserves by an amount equal to the fat accumulated prior to the arrival on the North Slope (Patterson 1974). Snow geese on the Yukon North Slope were found to spend 57% of their time feeding during staging. In experimental trials and modelling, 0.5 fixed-wing aircraft overflights per hour would cause a reduction of 20.4% in the amount of energy juvenile snow geese store; similar rates of helicopter overflights would cause a 9.5% reduction (Davis and Wiseley 1974). Snow geese probably do not habituate to aerial disturbances since they react to aircraft overflights on the wintering grounds, many areas of which have had frequent aircraft traffic for decades (Spindler pers. comm.). Wiseley (1974) found that snow goose feeding flocks rarely approached closer than 800 m of ground-based and noise simulation. There is also documentation of snow geese abandoning the Howe Island nesting colony on the Sagavanirktok Delta for the remainder of one nesting season following frequent helicopter overflights (Gavin 1980, Welling et al. 1981).

Canada geese breeding on the arctic coastal plain of ANWR were noted to be easily disturbed early in incubation (Spindler 1978) and when forced off their nest by human presence were noted to be slow in returning to the nest, hence exposing it to egg-eating predators (Martin and Moitoret 1981).

Wright and Fancy (1980) detected subtle differences in nest density of a few bird species (Lapland longspur, semipalmated sandpiper, Baird's sandpiper, pectoral sandpiper, and snow bunting) between an area adjacent to an active drilling pad and a nearby control area in the vicinity of Pt. Thompson. Small scale habitat differences between the 2 areas, and inherent spatial variation in abundance for some species were thought to be the causal factors in the different nesting densities of the 2 areas. Helicopters servicing the drill rig were observed to flush many birds from their nest, but a reduction in nest density underneath the regular helicopter flight path was not observed.

Although Wright and Fancy (1980) concluded that there were similar species diversity and species equitibility values between the drilling area and control area, suggesting similar community structure, there were lower overall populations of total birds and numbers of bird species in the drilling area as compared to the control site.

Gollop et al. (1974b) stated that with respect to small terrestrial birds:

> "statistically significant differences were noted in the reproductive success of Lapland longspurs on control, human and aircraft disturbance sites."

At Pt. Thomson there were no statistically significant differences in nesting success between the area near the drill rig and the control area (Wright and Fancy 1980). They also did not find any pattern of increased nest failure in close proximity to pedestrian traffic. Those findings are in contrast with those of Spindler (1978), Martin and Moitoret (1981), Timm (1979), Olson and Marshall (1952), and Barry and Spencer (1976), who noted that various species (notably arctic and red-throated loon, Canada goose, brant, common and King eiders, and whistling swans) are susceptible to nest failure induced by the adults being flushed from their nests frequently, hence exposing them to predators and abandonment.

A 60% decrease in waterfowl usage of a small North Slope lake resulted from 4 days of repeated floatplane landings (Schweinsburg 1974). Following the initial 4 days of disturbance on the small lake, populations stabilized at the reduced level. Schweinsburg et al. (1974) noted that repeated disturbance of a Mackenzie Valley lake caused a low density waterfowl population to become tolerant of floatplane overflights and landings. However, they added that "longer term effects of disturbance, such as higher mortality of young or desertion of molting areas by adults, are an additional possibility." Sterling and Dzubin (1967) determined that Canada geese deserted traditional molting grounds when subjected to harassment. Wiseley (1974) found that white-fronted, Canada and snow geese, and whistling swans turned back or diverted away from noises resembling gas compressors.

Derksen et al. (1979) reported that overflights of single engine aircraft at 1500 m agl caused escape responses 9 times out of 10 by molting brant and Canada geese. Single engine airplanes elicited maximum reaction at altitudes less than 600 m. Multiengine aircraft at flight altitudes between 750-1800 m caused "escape to water". An example of extreme disturbance was apparently caused by a helicopter 10 km away from a flock of brant. Part of the flock swam 4.5 km in 42 min. before arriving at a far shore.

The effects of disturbance on nesting gyrfalcons was studied by Platt and Tull (1977). They reported: "There was no significant difference in the productivities of successful Gyrfalcon nests between those nests that were disturbed by helicopter overflights and those that were not disturbed." However, they noted that disturbed birds did not reoccupy nest sites the following year, possibly chosing a new nest site or not nesting at all. Helicopters "invariably" disturbed gyrfalcons by passing at an altitude of 150

m. Significantly less disturbance occurred at 300 m and none at 600 m. Gyrfalcons became habituated to human approach on foot over a several day period.

No impacts to peregrine falcons are expected from the exploration program because there are no known active or historical peregrine nest sites in the ANWR study area. Although nest sites have been observed in other portions of the refuge, none were reported active during a 1980 study (Roseneau and Bente 1980). Peregrines are seen hunting and apparently migrating to the east along the coast in summer and fall. However, little impact to peregrines is expected at those times because of their scattered occurrence and relatively low sensitivity to disturbance. If studies reveal peregrines nesting in the study area, or activities are proposed which may affect peregrines outside of the study area, the FWS will undergo Section 7 consultation pursuant to the Endangered Species Act of 1973 (as amended).

The increase in avian predators (ravens, jaegers, and gulls) near drilling sites and camps has been reported (Barry and Spencer 1976, Eberhardt 1977, Brink 1978). However, Wright and Fancy (1980) did not note the expected increase. Barry and Spencer (1976) found that gulls and jaegers took advantage of exposed eggs in snow goose nests when the adults were flushed by a helicopter.

Winter surface travel may have a minor effect on bird habitat. Damage to lake shores can lead to erosion of the shoreline and subsequent draining of the lake (Derksen pers. comm.). Because of the low number of lakes in the study area, the drainage of a lake could have a significant negative impact on the amount of wetland habitat available to waterbirds.

Impacts to Birds of Shoreline and Barrier Island Habitats

Aircraft disturbance to barrier island and shoreline colonial nesting birds is of concern because aircraft traffic tends to follow the coastline when ceilings and visibility are low. Gollop et al. (1974b) found that helicopters were more disturbing to nesting brant, common eiders, glaucous gulls, and arctic terns than fixed wing aircraft on the Yukon coast. Of those species, brant and arctic terns were most susceptible. Human presence in nesting colonies was found to be more disturbing (by interrupting incubation and exposing eggs to avian predators) than aircraft overflights. They provided several recommendations to alleviate shoreline nesting colony disturbance.

Bird species associated with shoreline habitats differ in their susceptibility to littoral zone disturbances such as fuel and oil spills, or habitat alteration (Table 3). The species most susceptible to perturbations are those which most actively use the water, wade in the water, or forage closest to the water's edge, such as red and northern phalaropes, sanderling, and ruddy turnstone. In view of the high turnover rate of shorebirds using littoral habitats near Barrow, large numbers of birds moving through an area, each individual stopping for a few days, increases the significance of a localized disturbance (Connors and Risebrough 1977).

> "During open-water periods of August and September, oil carried to nearshore areas would probably cause extremely high mortality to juvenile Red and Northern Phalaropes and other swimming birds, including gulls, waterfowl, and alcids. Immediate

effects might be almost as severe on other species of shorebirds feeding in affected habitats. Any drastic reduction in prey densities of plankton or infaunal invertebrates in areas where these shorebirds feed might reduce the foraging efficiency and survival of all these species" (Connors and Risebrough 1977).

A tenative ranking of various shoreline habitat types according to their importance to birds is given in Table 4.

Table 3. Relative susceptibility of common Arctic shorebirds to littoral zone disturbances (adapted from Connors et al. 1979).

High	Moderate	Low
red phalarope northern phalarope sanderling	semipalmated sandpiper western sandpiper	golden plover pectoral sandpiper Baird's sandpiper
ruddy turnstone	dunlin long-billed dowitcher black-bellied plover	

Table 4. Tentative ranking of ANWR shoreline habitat types according to levels of bird use (sources: Connors and Risebrough 1977, Martin and Moitoret 1981).

High	Moderate	Low
Gravel spits Gravel barrier islands Outer lagoon shores Wet saline tundra	Mudflats Brackish Pools	Inner lagoon shores Coastal Bluffs River shores

Impacts to Birds of Coastal Lagoons

The use of ANWR coastal lagoons by migratory birds has been discussed under the "Bird Use of Lagoons and Offshore Habitats" and various annotated species accounts (in Chapter 3). Potential impacts of summer seismic activities on these birds include disturbance, possible introducton of pollutants, and habitat alteration.

In addition to resident waterfowl, it is probable that many waterfowl molting in ANWR coastal lagoons have traveled up to several hundred km to these areas. Such molt migrations have been documented by Hochbaum (1956), and Oring (1964), Salomonsen (1968). The energy required for premolt movements coupled with the high energy demands of molting place the waterfowl utilizing the lagoons in a stressful physiological position (Jacobsen 1974). Sterling and Dzubin (1967) felt that continued long-term harassment could cause ducks to abandon sheltered molting areas for less desirable, but undisturbed areas. This could adversely affect survival of molting waterfowl. Disturbance induced energy expenditures during the post-nuptial molt could increase stress enough to increase mortality and reduce the probability of a successful fall migration (Jacobsen 1974). Oldsquaws molting in a lagoon near a Pt. Thompson drilling rig possibly had habituated to continued helicopter traffic since they were not as easily disturbed by overflights as were oldsquaw in a relatively undisturbed control area (Wright and Fancy 1980). Complicating that conclusion, however, was the differing bird group sizes and coastline configuration of the drilling and control areas. S.R. Johnson (unpubl. data) reported that the normal 24 hour feed-rest cycle completely disappeared in groups of molting Oldsquaw at Thetis Island when helicopters and small boats arrived to work in the lagoon waters in August 1980. Gollop et al. (1974c) observed helicopter disturbance of molting oldsquaw and scoters at Herschel Island in the Canadian Beaufort Sea. They observed that the molting waterfowl were driven from resting areas on land into the sea, and then rafted into large flocks. This information was summarized by Jacobsen (1974):

> "Behavioral modifications (e.g. increased flocking under stress) that reduce feeding efficiency, decrease resting opportunities on land, or increase energy depletion may contribute to increased mortality."

Oil and fuel spills could directly affect large numbers of molting waterfowl. Since the birds are flightless during the molt period, they would be incapable of avoiding introduction of such pollutants. Direct oiling of waterfowl can cause a decrease or total loss of the insulating value of their feathers, and result in death. Illness or death can result from ingesting oil pollutants while preening (Biderman and Drury 1980).

Any habitat alterations which changes drainage patterns could alter the fresh-salt water regime of lagoons or increase siltation. These changes would adversely affect the food-chain complex of the lagoons, and reduce or eliminate the invertebrate fauna. These invertebrates are a critical food to molting ducks (Jacobsen 1974).

Winter Seismic Exploration

Winter seismic operations would affect a limited number of birds species. Status of birds wintering on the coastal plain is discussed under "Bird Use of Tundra Habitats - Winter" in Chapter 3. Gyrfalcons most likely remain within 20 km of their eyrie sites if prey availability permits (references in Annotated Species section, Chapter 3). Disturbance in the form of aircraft or vehicles could drive gyrfalcons from their eyries, placing them in a physiologically stressful situation in the harsh winter climate.

Dippers must winter in the only open water available near Sadlerochit and Shubelik springs. Reduction of water flow at the springs, or any other activity that would cause the open water to ice-over, would probably extirpate dippers from the particular spring/stream system. The dippers that winter at Sadlerochit Springs are the farthest north known population in Alaska.

Caribou

Winter/Surface Access Seismic Programs

Porcupine Caribou Herd Review of historical records indicates that large numbers of caribou, presumably the Porcupine herd, may have wintered on the Arctic Coastal Plain and Foothills during the late 1800's (Skoog 1968). The only recent references of Porcupine herd animals wintering in the study area is that of Roseneau et al. (1974) and Roseneau and Curatolo (1976). More recent evidence obtained from radio telemetry studies and other observations indicates that these wintering caribou were most likely members of the Central Arctic Herd (Curatolo and Roseneau 1977, Jacobson 1979, Cameron per. comm.).

The earliest that large numbers of caribou of the Porcupine herd have been reported in the vicinity of study area was mid-May in 1975 (Roseneau and Curatolo 1976). In other years the arrival date in the study area has varied between mid-to late-May (Roseneau and Curatolo 1976). A majority of the herd usually leaves the study area by mid to late July. Assuming that any winter surface seismic program authorized on the study area would be limited to when there is adequate snow and ground frost conditions (approximately from November to early May) such operations will have minimal direct contact with the Porcupine caribou herd.

In connection with previous exploration and development programs elsewhere in the Arctic there have been several cases reported of caribou becoming entangled in abandoned wires, some of which may have been left by seismic crews (K. Whitten pers. comm.). The extent of injuries and mortality to caribou from entanglement with seismic wire has not been quantified. Because materials such as wire deteriorate slowly in the arctic, continued littering of wire constitutes an increasing cumulative problem which will have negative effects on caribou for a long time.

If the Porcupine herd continues to follow its current use patterns in the study area, the effects of a winter surface seismic program will be limited primarily to influences on vegetative habitat. Of the entire array of seismic techniques evaluated in this study the surface access methods can cause the most damage to vegetation. Tussock communities are one of the most vulnerable vegetative types found in the study area. Studies on impacts to vegetation caused by contemporary seismic operations elsewhere in the Arctic indicate that with appropriate equipment, adequate snow conditions, well scouted travel routes, and effective monitoring by surface protection specialists the potential for significant disturbance of vegetation can be reduced considerably (Reynolds pers. comm.). In considering the overall extent of tussock communities of the study area and the remainder of calving and post-calving range of the Porcupine caribou herd, the losses of vegetative resources resulting from a properly conducted seismic program will not significantly influence the forage resources of caribou.

Central Arctic Caribou Herd. A conventional winter/surface access program in the study area may come in direct contact with caribou of the Central Arctic Herd. Scattered groups of caribou totaling up to a thousand or more, believed to be members of the Central Arctic Herd have been observed during the winter either in or near the study area (Roseneau and Curatolo 1976, Jacobson 1979). Detailed information on the numbers, distribution, movements, and overall status of these caribou in the study area is lacking . On-going radio-telemetry studies to obtain further data on the status of the Central Arctic Herd in the study area as well as throughout its general range are being conducted on a cooperative basis between the ADF&G and ANWR personnel. Until better information is available, statements regarding the potential effects of seismic exploration programs on these caribou must be general in nature and based on comparable situations elsewhere rather than on actual, first-hand knowledge.

The potential effects of disturbance created by a winter surface seismic program on the Central Arctic caribou herd can be divided into 2 broad categories: aircraft disturbance and surface disturbance. It is expected that supply flights to seismic crews will orginate from centers such as Deadhorse, Umiat, Barter Island, and possibly from temporary supply sites at Kavik, Camden Bay DEW Line site, and Beaufort Lagoon DEW Line site. Temporary landing fields will be constructed on frozen lakes within reasonable distance of an operating crew. Supply flights are expected at least bi-weekly, with additional flights as necessary. Landing sites will change as a crew progresses over the study area. Thus the potential aircraft disturbance to caribou will not be a constant factor nor will it be located at a fixed location throughout the exploration program.

The actual impact that will occur to caribou from aircraft supply flights will depend on the location of landing sites and flight lines with respect to where caribou may be at the time of a supply flight. If caribou are near a landing site and directly under an approach or take-off route they could be disturbed by approaching or departing aircraft. Aircraft disturbance of caribou could also occur along the flight path to the landing site, expecially if low level flights are made. There is also the chance of purposeful harassment which is difficult to control. Although wintering caribou can be encountered nearly anywhere in the study area, the overall density is low. Due to the isolated and transient nature of seismic operations, only scattered, local disturbances of short duration are expected to occur to caribou. The effect of aircraft disturbance on caribou is difficult to determine due to the uncertainty of when, where, and how it may occur.

Local disturbance of caribou during a winter surface seismic program in the study area may occur as a result of encounters with snow mobiles, heavy equipment, humans on foot, and with trails, berms and tracks left in the snow by seismic operations. If caribou are chased or harassed by surface vehicles the negative affect of the disturbance will be greatly increased. Studies of winter seismic activities in the Canadian Arctic indicate that caribou reactions to such activities are variable. In a study on Banks Island, Russell (1977) reported that all caribou groups encountered by seismic vehicles at less than 0.8 km reacted by moving (usually walking) away at right angles. At distances greater than 1.2 km, Russell (1977) found that caribou remained in the area and were generally non-reactive to the activity. Urquhart (1973) found that the distance at which caribou would react to seismic craws varied according to terrain. In rolling country seismic crews were able to get nearer to caribou than on flat areas. However, the intensity of reaction by caribou in rolling terrain was greater, possibly due to the "surprise" of a moving object suddenly appearing over a rise (Urquhart 1973, as cited in Carruthers 1976). Russell (1977) reported that caribou reoccupied habitat within 0.8 km of a seismic line within 2 to 4 days after the disturbance ceased. In a study of seismic activities near wintering groups of the Porcupine herd on the northeastern slope of the Richardson Mountains. Hoffman (1974) reported that a group of caribou were displaced from selected ranges and that disturbance from seismic crews apparently stimulated an early spring migration by the group.

Numerous studies and observations have been made with respect to caribou encounters with obstructions (Klein 1980). Movement of wintering caribou in the study area may be impeded to some degree by seismic lines. Urquhart (1973) found that caribou encountering seismic lines would often turn and move parallel to the line. No overall affect on caribou migration movements was observed. The barrier effect created by bulldozed lines was greater than on lines with no bulldozing (Urquhart 1973). Old, drifted-in seismic lines seem to present less of a barrier than new lines (Urquhart 1973). Wintering caribou tend to shift about in response to weather (especially storms), snow conditions, and disturbances from predators and humans. The consequences of impairment of the caribou's natural movements by seismic lines in the study area are not known. Entanglement in abandoned seismic wires may occur but the extent of injuries or mortality resulting from this is not known. The potential effect of forage destruction on the Central Arctic Herd cannot be assessed because nothing is known about what vegetative types are used by caribou wintering in the study area. However, because of the relatively insignificant quantity of losses of vegetative resources that are expected to occur under a properly managed seismic program, it is reasonable to assume that no significant impact to Central Arctic Herd caribou forage will occur.

Helicopter Transported Seismic Surveys

Porcupine Caribou Herd. Potential effects of a helicopter transported seismic program on the Porcupine caribou herd will vary greatly depending on the season of the year that this technique is employed. The most potentially adverse time would be during the period of May through mid-to-late July (depending on annual variation of caribou use of the study area). It is during this period that large numbers of the Porcupine caribou herd use the study area for calving and post-calving activities. Caribou are more sensitive to disturbance during calving and post-calving than any other time (Lent 1964, Calef and Lortie 1973, Calef and Lent 1976). Disturbance of the type resulting from a helicopter seismic program could interfere with caribou use of critical calving and post-calving areas. Displacement from preferred habitats could contribute to reduced productivity (Calef and Lent 1976). Disturbance on the calving grounds can also interfere or prevent the establishment of cow-calf bond which is essential to the calf's survival. If proper bonds are not formed and separation occurs, calf mortality is greatly increased (Calef and Lortie 1973). In addition, caribou (especially parturient females) may be at the lowest ebb of the annual physiological cycle during May through July and their energy budget may be critical at this time (Dauphine 1976, White et al. 1981). Disturbance of nursery bands and post-calving aggregations by helicopters could stimulate stampedes causing adults and calves to be trampled and injured. Stampedes would also increase the number of separations between cows and calves and cause significant levels of mortality to occur. Above-ground detonations at this time may also cause a disturbance.

To prevent undue disturbance of caribou during critical spring migration, calving and post-calving periods, land management authorities have commonly placed restrictions on certain industrial and other human activities. Such restrictions usually prohibit potentially disturbing activities from occuring within critical areas during sensitive time periods or require precautionary procedures such as limitations on low level aircraft flights (Darby 1978). In a review of several studies of aircraft disturbance on caribou, Davis and Valkenburg (1979) concluded that during calving and post-calving periods a minimum elevation of 660 m AGL should be maintained during overflights to prevent mortality of young caribou. They also concluded that operation of helicopters at low levels (below 100 m) caused greater disturbance to caribou than light fixed wing aircraft and were generally a greater harassment to caribou. Helicopter seismic programs conducted throughout the remainder of the year (excluding May-late July) may have the least effect of all techniques on the Porcupine caribou herd. Use of this technique may result in less disturbance of vegetation used by caribou.

Central Arctic Caribou Herd. A helicopter supported seismic program in the study area would also effect this herd in varying ways depending on the season of use. Disturbance related impacts described for the calving and post-calving seasons of the Porcupine herd would also apply to the Central Arctic Herd on its calving grounds in the vicinity of the Canning River delta. Post calving aggregations of the Central Arctic Herd also occur in the Canning delta-Camden Bay coastal area. Helicopter disturbance in this area during May-late July could be significant.

A limited number of Central Arctic Herd caribou remain in the study area after calving and the post-calving aggregations. Up to 1000 or more caribou could be affected by a helicopter seismic program. This number would vary from year to year. If helicopter seismic programs were conducted during times of the year other than May-late July, the impacts to Central Arctic Herd caribou could vary greatly. Because little is known about specific use of the study area by Central Arctic Herd animals other than for calving and post-calving it is difficult to predict potential effects. Disturbance from aircraft (helicopters) may be greater than surface transported seismic crews. This concern must be weighed against potential impacts resulting from surface operations.

Surface Geology Programs

It is expected that surface geology programs may also be conducted in conjunction with seismic exploration. The traditional method of access for such activities is by helicopter during the late summer.

Porcupine Caribou Herd. Provided that helicopter supported surface geology studies are conducted during the period of August-1 May, little if any direct impact is expected to occur to the Porcupine Caribou Herd.

Central Arctic Caribou Herd. Portions of this herd are usually present in the study area year round. Of critical concern is the Canning River delta calving grounds, post-calving area, and insect relief areas along the coast of Camden Bay and the Canning River delta. Like the Porcupine herd, the period of August-1 May would be the time of least impact to Central Arctic Herd caribou.

Muskox

Muskoxen may be susceptible to disturbance from aircraft and ground parties during geophysical exploration on the refuge. The most detailed observations available on the responses of muskoxen to helicopters are from Miller and Gunn (1979). They concluded that there is an inverse relationship between the intensity and strength of response and the altitude of the aircraft. At 200 m AGL, a greater percentage of helicopter overflights cause disturbance to muskoxen than 400 m AGL (Miller and Gunn 1979).

Muskoxen typically react to harassment by assuming a group defense formation. Miller and Gunn (1979) observed that the distance muskoxen moved after taking up a group formation after a helicopter overflight varied, but in only 1 instance was it more than 200 m. They did not observe any traumatic injuries as a result of helicopter overflights. It should be pointed out that this is the only condition that could be visually detected and the energy cost of the responses to the animal and the population over a period of time is unknown (Miller and Gunn 1979). Muskoxen may be subjected to harassment during exploration activities if individual animals or herds are purposely chased from the air. This harassment could have severe consequences for the animals affected, resulting in traumatic injuries or direct mortality. Observations of muskoxen approached on the ground suggest that they move greater distances than when disturbed by a helicopter alone (Miller and Gunn 1979). They noted that few herds remained in place in a group formation when a helicopter landed nearby. Reaction of groups in these instances was to drift apart and forage or move away. Urquhart (1973) noted similar reactions to a helicopter landing near a herd of muskoxen on Banks Island. The herd initially stampeded, stopped and faced the helicopter, then continued running for about 0.4 km.

Urquhart (1973) observed no injuries or abandonment of calves during 2 experimental overflights with helicopters but felt that under certain conditions muskoxen may be disturbed by geophysical exploration activities. In one instance, a herd of muskoxen ran out of sight when approached by overland seismic vehicles. In another instance on Banks Island a calf was reported abandoned when men driving Nodwell vehicles met a herd of muskoxen in a valley (Urquhart 1973).

On Nunivak Island, muskoxen did not always take up a defensive formation in response to disturbance, particularly when such disturbance involves loud noise such as that associated with snowmachines, airplanes, and helicopters (Lent 1976). Very frequently, but not always, they would run considerable distances (up to several km) following such disturbance. Young calves may be separated from the group during such disturbance. Since this in not a normal, natural behavior, the mothers are much less likely to recover their calves than in the case of caribou. Avoidance of seismic operations may cause muskoxen to abandon their normal prime winter range, at least while the equipment is present for 1 or 2 days. This can affect pregnant cows or individuals in poor condition since they would be displaced to less optimal habitat (Urquhart 1973).

Limited loss of favorable muskoxen habitat and riparian willows may occur along overland seismic lines that cross stream channels. This may be of limited extent or may become a moderate impact if cumulative destruction occurs.

Moose

Moose using the ANWR study area in summer may be subject to disturbances by low flying aircraft, if helicopter supported seismic or surface geology programs are conducted during the summer months. McCourt et al. (1974) reported that moose reacted to a fixed-wing aircraft flying at altitudes less than 180 m. The degree of reaction was also dependent upon altitude, with few strong reactions to the aircraft flying at altitudes between 60 m and 180 m (1 of 24 cases). Strong reactions to aircraft flying at altitudes 60 m were more common (2 of 15 cases); however, in nearly half of these cases (7 of 16 cases), moose showed no reaction to aircraft flying at altitudes below 60 m. Moose did not react to aircraft flying at altitude above 180 m. The type of aircraft will also affect the degree of reactivity to overflights, with helicopters being much more disturbing than fixed-wing aircraft (Klein 1973). Data are not available that quantifies this expected difference in reactivity by moose to overflights by helicopters versus fixed-wing aircraft.

Reactions by moose to overflights are also dependent upon habitat type. Mould (1977) reported that moose on open tundra reacted more frequently to passing aircraft than when they were located in wood cover types. He also noted that flight distances of moose in open tundra reacting to people on foot were sometimes over 700 m, whereas flight distances when moose were in shrubby areas were less than 100 m.

Reproductive state of moose can also have an effect upon the reaction of moose to aircraft. Agonistic reactions to helicopters were reported for moose in the Yukon Territory, Canada (Ruttan 1974). A cow with a 10 month old calf charged a helicopter that attempted to land on a knoll near the pair. On other occasions, bull moose reared and struck at helicopters that closely approached them during the rut (15 to 30 m). When the helicopter remained 60 to 90 m distant from the rutting bulls, the bull usually fled the area.

The ultimate effect of these types of disturbances upon moose populations using the study area is unknown. Displacement of moose from riparian or other habitat types as a result of a summer seismic exploration program would probably be short term in nature, and moose would be expected to reoccupy these sites once the disturbing agent left the area. Also, the effects of increased energy expenditures by moose as a result of disturbance are unknown, although abundant forage resources available in the summer would suggest little overall impact.

Moose are usually not present in the study area during the winter, and would not be directly impacted by activities at that time.

Wolf

Numerous conflicts resulting from the attraction and habituation of wolves at industrial work camps in Alaska have been described by Follman et al. (1980). Problems associated with wolf-human interactions at permanent facilities in the Arctic are reported in Grace (1976). During construction of the Trans-Alaska Pipeline, wolves were attracted to construction camps where food was often readily available at improperly managed garbage dumps and as a result of feeding by humans. Problems such as biting of humans, health threats (rabies), property damage/economic loss and increased garbage cleanup and maintenance because of wolves was reported on 65 occasions between 1971-79 (Follman et al. 1980). The ultimate effect of such interactions on wolves has not been entirely documented, however, there is a tendency towards increased mortality resulting from animal control measures (shooting), enhanced vulnerability to hunting, and vehicle collisions (Stephenson pers. comm.). Ecological and nutritional aspects of wolf habituation at industrial camps has not been investigated.

Human disturbance of wolves at den sites and during the rearing season was analyzed by Chapman (1977). Reported findings indicate that wolf dens within 1.0 km of established centers of human activity were permanently abandoned by wolves (Chapman 1977). The consequences of forced abandonment of wolf dens is not entirely understood, however, nutrition of the pups may be the most serious effect (Chapman 1977).

Wolverines

Since little is known about current wolverine populations inhabiting the ANWR study area, it is difficult to assess the potential impact of seismic exploration activities on them. Thus far, there have been no published observations of impacts of seismic exploration elsewhere in the Alaskan arctic on wolverines. Apparently wolverines are shy animals and are not as vulnerable to problems related to human feeding as are other carnivores such as wolves, bears and arctic foxes. It is not known if seismic activities could pose a serious disturbance to maternal denning activity of wolverines. Perhaps the greatest potential for negative impacts to wolverines in the ANWR study area could come from hunting and trapping by members of seismic crews.

Fish

The potential impacts of geophysical exploration to fish and their habitats may be in the low to moderate range. Several characteristics of arctic fish populations make them highly sensitive to disturbance. They exhibit slow growth, poor recruitment, and late maturity. High concentrations of some species during spawning and in overwintering areas make them especially vulnerable.

Use of explosives in seismic exploratory programs may impact fish. The effects of underwater explosions on fish have been documented by Falk (1973). Results from this study showed maximum lethal ranges of 15 to 150 m varying with the explosive charge, depth of charge and underlying substrates. Information on the effects of explosions adjacent to lakes and streams is not available. It is conceivable that impacts may arise where explosives are in close proximity to critical habitat areas (i.e. overwintering habitat). It is thought that the Vibroseis technique does little harm to fish.

Impacts of water withdrawal may produce long-term irreversible effects. All life stages of a particular species may be located in a single isolated pool or spring. Potential impacts would be upon the entire genetic population. Ward and Peterson (1976) reported that overwintering pools located in the Sagavanirktok, Canning, and Hulahula Rivers become completely isolated (without recharge) when sections of the river freeze solid. Effects of water withdrawal on fish populations include: direct mortality; indirect mortality from waste concentration; and dewatering marginal gravels containing developing fish embryos and fry. Bendock (1976) reported masses of grayling fry and insects at the surface of one dewatered hole. Impacts of dewatering pools or springs may also cause fish to change overwintering areas and therefore impact subsistence fisheries.

Alternative winter water sources, where minimal impact would occur, are not abundant. Tundra lakes are generally of poor quality and must be treated to be potable, or they are so shallow that they freeze solid (Schallock 1976). Other deep lakes may contain fish populations. Although potential water use during the exploration program will be small, the potential for affecting overwintering pools or springs is significant.

Another potential impact to overwintering fish populations is the increased depth of freezing of pools or lakes due to removal or compaction of the insulating snow layer. Clearing of large lakes for airstrips is a common practice. If lakes of marginal overwintering capacity are cleared and allowed to freeze, the entire fish population could be eliminated. Likewise, compaction of snow over river pools can cause freeze-down and fish mortality.

Environmental contamination from sewage wastes, fuel, and oil spills are potentially threatening to arctic fish populations. Domestic wastes entering arctic aquatic ecosystems may cause severe dissolved oxygen depletions particularly during the low water winter conditions when the assimilative capacity is much reduced. Dissolved oxygen depletion can cause direct mortalities and long-term damage to the food structure of arctic waters (Craig and McCart 1974, Schallock 1976).

Increased fishing pressures, if generated by exploration crews could have an impact on the fisheries. Use by the citizens of Kaktovik of fish in several inland springs is common, and additive pressure could harm the population. Craig and McCart (1975) stated that selection in the fisheries for the larger spawning population would disproportionately harvest females thereby reducing the reproductive segment of the populations.

Polar Bears

Geophysical exploration activities on the ANWR study area may have greater impact on polar bears than on any other marine mammal. An especially critical period in the bears' life cycle is denning (Lentfer 1974a). Polar bears may be present in the study area during denning, which begins during late October to early November. At this time, pregnant females travel to the coastal areas where denning habitat may be found on the fast ice, offshore islands, or on the mainland up to 48km inland. Cubs are born in midwinter, and the sow and cubs break out of the dens in March and April (Lentfer and Hensel 1980). During the winter, most non-denning bears remain offshore, and during the summer nearly all bears are far offshore at the edge of the ice pack. Impacts to non-denning bears are generally expected to be minimal. However, occasionally large numbers of bears congregate locally to scavenge on whale carcasses in the fall. Preliminary results of a recent FWS study indicate that adult females, family groups and juveniles are the primary bear groups using nearshore areas in the fall (Amstrup pers. comm.).

Responses of denning female polar bears to disturbance vary. Several bears deserted newly formed dens in October and November due to the presence of scientific investigators and it was thought that the impact during that time was significant (Belikov 1976). In early March, a female and an extremely small cub were sighted northeast of Prudhoe Bay, indicating an early exit from the maternal den (Lentfer 1974b). An incident of disturbance to a family group of a female with 2 cubs by a seismic charge caused the group to leave their den and travel north (Moore and Quimby 1974). One study on grizzly bears indicated that a radio collared female in the den showed some movement immediately after seismic explosions but did not desert her den (Reynolds 1979). On the other hand, Belikov (1976) reported observing female polar bears with cubs in dens without apparent disturbance, and a female with 2 cubs at a den in Prudhoe Bay were observed by oil company personnel for several weeks (Lentfer 1974a).

The factors which influence polar bear reactions to disturbance may include the frequency and level of disturbance, distance from the den to the disturbance, and the stage of denning during which the disturbance occurs. Explosives used for seismic exploration may cause disturbance, as might numerous vehicles driving by or aircraft landing nearby (Lentfer 1974b). The effect of the Vibroseis technique is unknown at this time.

The impacts of disturbance to denning female polar bears may be 2-fold. If the pregnant female is disturbed while searching for a den, she may retreat to the pack ice to den, where the substrate is less stable and food supply is less abundant. Denning success and productivity could be significantly reduced. Disturbance of females with cubs may cause neglect or abandonment of the cubs, leading to their death and lower recruitment to the population (Lentfer and Hensel 1980).

Preservation of undisturbed denning habitat may be important for polar bears. Although the number of bears returning each year varies according to ice, snow and weather conditions, it is thought that they show fidelity to birth sites and try to reach the area previously used for denning (Lentfer and Hensel 1980). Denning habitats include areas which accumulate drifting snow, such as rivers, lake banks, and coastal bluffs. These drifted areas could be rendered physically unuseable by heavy machinery traversing or plowing through them, or the areas could be rendered unuseable due to human activity scaring bears away. However, the percentage of potential habitat actually used is not known, and the impact of disturbing a portion of potential habitat cannot be determined.

Other possible impacts to polar bears include attraction to waste disposal sites or camps, and reduction in prey (ringed seal) availability locally. Polar bears are attracted to camps and waste disposal sites, where they become nuisances or a danger to personnel (Lentfer and Hensel 1980, Woolridge and Belton 1980). Camps located near the coastline would be the most likely sites for such problems, since the coast is a natural concentration zone for bears (U.S. Fish and Wildlife Service 1976). Although scare techniques are available (Woolridge and Belton 1980), nuisance bears are usually relocated or eventually shot.

Reduction in the ringed seal populations is a potential problem. Pre- and post-denning food supplies are important to female polar bears because of the 5-month long denning period during which they do not eat. An immediately available food supply may be critical to survival of the female and cubs (Lentfer 1974b). However, the low population of ringed seals found in the study area may not contribute significantly to polar bear nutrition when compared to areas further offshore.

Ringed Seals

Geophysical exploration on the ANWR study area may cause minor impacts to ringed seals. Few ringed seals inhabit or use the lagoons within the study area. Their primary winter habitat is the shorefast ice beyond the 3 fathom isobath and the flaw zone. Summer habitat for seals is primarily along the pack ice edge but some may also be found among the bergy bits in open water. It is possible that seismic exploration in the lagoons or barrier islands within the study area could affect a few seals locally by causing temporary displacement of pregnant females, abandonment of pups, or disruption of summer feeding. Traffic, either surface or aerial, along the offshore area could cause limited disturbance to seals.

Ringed seals are most sensitive to disturbance during the denning and pupping period which extends from mid-March to mid-May. Distrubance can cause pregnant females to be displaced to less desireable denning areas, or can cause females to abandon their pups (McLaren 1958). Although a correlation between seismic lines and low ringed seal densities has been shown (Burns et al. 1980), exploration on the ANWR study area is not expected to cause similar problems because of the lack of seal use of the study area during pupping.

Another period of sensitivity of ringed seals may be during summer. Summer feeding may be important for sustaining seals through the winter, especially pregnant females (Burns et al. 1980). However, only a small number of seals have been seen feeding in lagoons in the study area. These few seals could be disturbed by summer exploration in the lagoons, and boats gaining access to the lagoons from deeper waters offshore may cause some disturbance to seals feeding offshore. These impacts are expected to be minor.

Bowhead Whales

Geophysical exploration in the ANWR study area is likely to produce only indirect impacts to bowhead whales rather than direct impacts. Seismic techniques which are boat-based or use above ground explosives (Pouldier), boat or aircraft traffic, and activities at shoreline facilities may all cause disturbance to bowheads during the time they are adjacent to the study area. Bowheads are not known to use the lagoon systems along the study area, but are seen offshore during their westward migration in late summer and fall (Lowry et al. 1981, Richardson and Fraker 1981). Intensive feeding also occurs in nearshore waters during this time (Lowry and Burns 1980, Richardson and Fraker 1981). Disturbance during this period may cause some disruption of feeding or variation in the migration path. Even though these impacts are expected to be minor or non-existent due to the localized nature of the exploration activities, they are discussed because of the status of the bowhead as an endangered species and because of the dependence on whales for subsistence by residents of Kaktovik. Section 7 consultation pursuant to the Endangered Species Act of 1973 (as amended) may be required.

Early whale studies included observations of disturbance but those observations are contradictory. Within the past 2 years, detailed studies of the effects of disturbance to bowheads have been initiated (Fraker et al. 1981). However, very little is presently known about the short- or long-term effects of disturbance to bowhead whales, and the following discussion presents only a qualitative description of potential impacts.

The potential sources of disturbance to bowheads due to exploration activities can be classified into 3 major categories:

1. Sounds produced by exploration or facilities
2. Approaching air-or watercraft
3. Toxic substances

Underwater sound can directly or indirectly affect whales. Direct effects include masking of communication, echolocation, or reception of other environmental sounds. Underwater sound reaching whales can be generated by both underwater and above ground sources. The primary source for the exploration program would be boat based seismic exploration, which produces the sonic impulses using air guns or spark-ignited gas explosions. One whale study recorded sounds produced by a seismic ship in the Beaufort Sea (Ljungblad et al. 1980), but was not able to study the reaction of whales, as there were no whales nearby. Another study observed a group of bowheads within 13 km of a seismic ship and saw no obvious signs of disturbance. However, as it was not a controlled experiment, the authors wre hesitant to draw conclusions from the one observation (Fraker et al. 1981). The use of above-ground explosives, known as the Pouldier technique, may also produce sound detectable in the water.

Aircraft overflights of bowheads may cause disturbance. Some studies have shown that bowheads will dive if overflown, but the reported altitude causing disturbance varies, up to 305 m above sea level (ASL) (Fraker et al. 1981). One observer reported no disturbance down to 150m ASL (Koski pers. comm., as cited by Fraker et al. 1981). Another study reported immediate reactions in the spring and little reaction in the fall (Ljungblad et al. 1980). Fraker et al. (1981) indicated that bowheads may be more sensitive to disturbance by aircraft than other whale species.

Bowheads react to boats approaching nearby by both moving away and spending more time submerged. Moderate boat distances (900 m or less) cause orientation away from the boat. Even idling of boat engines at a distance of 3.7 km caused an alteration in the time that whales spent at the surface between dives. However, there is no information to indicate that bowheads completely leave the area after a disturbance episode (Fraker et al. 1981).

The effects of toxic substances to whales is unknown. It is possible that foreign substances might disrupt a whale's ability to locate food by masking its chemoreception. Damage to active epidermal cells is also possible (Fraker et al. 1981). Another potentail impact is the chance that oil would foul the baleen of bowheads, making them less efficient in feeding, or causing the whales to stop feeding (Fraker et al. 1978). However, since exploratory activities will be localized during the time that bowheads are present near the study area, little impact to whales is expected from toxic substances.

Other Marine Mammals

Beluga whales and bearded seals are found only occasionally near the study area. Impacts of exploration activities to these animals are expected to be negligable.

Impacts to Human Culture and Lifestyle

Archaeology

Potential impacts of exploratory activities on archaeological resources could be caused by the operation of surface vehicles, construction and occupation of campsites, use of explosives, collection of artifacts by crew members, or fuel spills and subsequent clean up activities. The possibility of an archaeological site sustaining damage from any activity is much higher during summer than winter. Even during winter there is some possibility of damage to sites located in unfrozen areas and to sites that are not covered by snow. However, only a limited amount of archaeological reconnaissance has been conducted on the ANWR study area. Site specific surveys will be needed to determine if any archaeological sites would actually be affected by exploration.

The possible types of damage to archaeological sites that can occur from ground vehicles during seismic testing (Table 5). The amount of damage that could occur would depend on factors such as the type of vehicle involved, what part of it contacts the ground, ground pressure (psi), driver skill, etc. Damage to archaeological sites from surface travel can include: direct breakage of cultural objects; damage to vegetation and thermal regime leading to erosion and subsequent deterioration of organic artifacts and shifting and mixing of components; and loss of association between cultural objects.

If seismic activities rely on helicopter support for placement of testing implements, potential impact to cultural resources would be reduced substantially. However, because the use of explosives can damage archaeological sites, helicopter supported conventional seismic exploration could have some impact. The above ground explosives technique (Pouldier) probably would do little harm because of the small charges involved and lack of drilled shotholes.

Campsites can cause impacts to archaeological resources not only because of the vehicles used around the camp, but also because of the associated pedestrian traffic. Summer camps, such as those used for surface geologic exploration, would have the greatest impact if large numbers of people are housed for an extended period of time. The impacts would be similar to those of surface vehicle use, although less severe. Fuel spills can have an indirect yet serious impact on archaeological sites by contaminating the organic material. This would eliminate the possibility of using C^{14} dating methods. Clean up activities could also inadvertently damage cultural resources. Members of exploration crews may also affect archaeological sites during the summer by rummaging through the site and collecting artifacts.

Table 5. Possible damages to archaeological sites as a result of ground vehicle travel (from Hall 1980)[1].

Conditions at Archaeological Site	Extent of Possible Damage	Nature of Possible Damage
Summer		
Any subsurface, with or without ground cover; any ground cover.	Moderate to Extreme	Breaking of cultural objects, loss of association between cultural objects, mixing of components in stratified site, erosion and complete loss of cultural objects, and lowering of permafrost table and subsequent deterioration of organic artifacts, etc.
Winter		
Bedrock or consolidated sand/gravel with no sod cover or with thin sod cover with/without denuded areas.		
Frozen ground and substantial snow cover	Probably none.	---
Frozen ground and relatively little snow cover.	None to slight.	Some breakage and/or slight lateral displacement of objects.
Unfrozen ground and substantial snow cover.	None to slight.	Some breakage and/or slight lateral/ vertical displacement of objects.
Unfrozen ground and relatively little snow.	Moderate to extreme, depending on whether vehicle runs in a straight line or turns.	Breakage, lateral and vertical displacement; possible subsequent vehicle erosion with adverse effects.
Wet tundra or other unconsolidated ground; upland tundra;		
Frozen ground and substantial ground cover.	Probably none.	---

Table 5. (Continued).

Conditions at Archaeological Site	Extent of Possible Damage	Nature of Possible Damage
Frozen ground and relatively little snow cover.	Slight to moderate.	Damage to tundra can change thermal regime and cause subsequent erosion.
Unfrozen ground and substantial snow cover.	Slight to moderate.	As above.
Unfrozen ground and relatively little snow cover.	Moderate to extreme.	As above; potential for extreme erosion.
All seasons		
Any condition	Serious.	Injection of fossil hydrocarbons into ground water because of leakage or spillage can cause contamination of organic material and eliminate the possibility of C^{14} dating.[2]

[1] This table is intended only as a general summary; experimental field studies would be necessary for a more detailed analysis. These data are based upon travel by heavily loaded, tracked vehicles, or vehicles pulling heavy loads on skids, as associated with the seismic program.

[2] Potentially this is the most serious problem connected with ground vehicle travel in the study area. Studies of the Old Fish Creek Wellsite, where drilling took place 30 years ago, indicate that the effects of oil spills are pervasive and long term; soil samples from a depth of 40 cm still retain a strong smell of diesel fuel and thaw in some cases reached 70 cm, nearly twice the thaw depth in adjacent unaffected areas (K. Everett personal communication).

Subsistence and Other Socio-Economic Features

The abundance of wildlife resources is tied directly to the level of sustainable subsistence harvest. While positive impacts of an exploration program such as a stimulated local cash economy could benefit local people, loss of wildlife resources would negatively affect residents dependent upon it.

> "The Inupiat culture and lifestyle are currently under stress. Survival of the Inupiat culture as a unique and distinct entity depends upon the viability of its socio-economic subsistence complex and its direct relationship and dependence on the arctic environment" (USGS 1979).

Geophysical exploration activities on the ANWR study area could further exacerbate stress and increase existing social and cultural problems, as well as erode the subsistence resource base. Socio-economic impacts are often underestimated, possibly because it is erroneously believed that social problems can be easily overcome.

This section is divided into 2 parts. Because Kaktovik would be the most heavily impacted of all the villages, it has been addressed separately. Other affected villages are addressed in the second section.

Kaktovik. The socio-economic impacts of oil related activities on the people of Kaktovik are essentially cultural impacts. These impacts can be divided into 2 broad categories. The first is the physical impact on the resource base: the historic sites, and the fish and wildlife resources and habitat that are the base of Inupiat subsistence dependence. The second is the impact on the subsistence activities, and on the village and villagers themselves.

Impacts on the fish and wildlife or associated habitats of the ANWR study area resulting from seismic exploration may impact subsistence use of the species involved. For example, if fish in a particular drainage are reduced in number due to impacts at their overwintering area, or if foxes are attracted to a seismic camp and are trapped or shot, this reduces the numbers of fish or foxes available for subsistence use. This in turn could reduce people's food supply or their income from trapping. If caribou became less available to people of Kaktovik, this would reduce availability of the primary source of protein which is essential to their health and culture (North Slope Borough Assembly 1978).

If seismic crews are allowed to hunt, fish or trap, this would increase competition for the wildlife resources. Especially significant impacts could occur from increased fishing in the overwintering areas of rivers and lakes, as these areas may already be fished to their limit by the local population.

Seismic activity may also have a physical impact on the historic (Traditional Land Use Inventory) sites of the ANWR study area, many of which have present-use value as subsistence sites (Jacobson and Wentworth 1981). These sites may or may not have tangible remains, and in many cases their boundaries cannot be easily delimited.

The following quotation is helpful in understanding why historic sites, even without physical remains, have so much value in Inupiat culture:

> Members of the Inupiat and Western cultures operate from distinctly different sets of premises, and the level of mutual understanding may be limited. This difference in values is exemplified in the ways in which westerners and Inupiat regard land. The Western notion usually derives from some economic or recreational base. On the other hand, to the Inupiat, a landscape contains thousands of sites that are significant in a variety of ways. The meaning of each site is expanded and deepened through oral traditions and historical knowledge. Each person may have lifetime of subsistence or social and cultural experiences at many sites, and the experiences and uses are passes from generation to generation. Old occupation sites and landmarks may also have supernatural associations that affect modern Inupiat use. Much of the value of a site may be invisible to a non-Inupiat. Nevertheless, alteration of sites constitutes a defacing of history and even may entail a threat of supernatural retribution. As a result of the multiplicity of types of sites and emotional associations, the Inupiat consider a whole array of values that may be unfamiliar to planners or developers (USGS 1979:45).

Seismic exploration may affect not only the fish and wildlife used for subsistence, but also people's subsistence activities and their daily life in the village. Seismic work may interfere with people's subsistence activities in a variety of ways. For example, work in a particular area where people are used to hunting or fishing could cause the wildlife to temporarily leave that area, making them unavailable for subsistence at the time of year people normally hunt them. Or, if the seismic crews are in a particular area at a time of year when people usually hunt there, people may feel they cannot go there because 1) they would feel too uncomfortable or self-conscious under the circumstances, 2) the hunting experience would not be aesthetically pleasing or enjoyable, 3) their chances of hunting success would be reduced due to noise or other interference, or 4) their cultural group activity and privacy would be disrupted. Alternatively, the people might encounter the seismic activities while hunting and feel angered or annoyed for any of the above reasons. For example, if seismic boats were running back and forth in the Beaufort Sea north of Barter Island in September, they might alter the migration path of the whales, or other interference such as aircraft might scare whales. Both of these situations would make the whales more difficult to hunt. If a seismic crew established a camp at Camden Bay in May, Kaktovik people might feel too self-conscious to make their annual trip there for spring waterfowl hunting. Or, if a helicopter was flying low along the coast in July and passed over a herd of caribou, this might cause the caribou to scatter and move inland, making them unavailable to hunters using boats for access.

Of greater long term importance than temporary loss of hunting opportunity or conflicts between seismic crews and subsistence users, however, may be the location of the base camp for seismic exploration. If located at Barter Island, social impacts could be great. Locating a base camp at Camden Bay or outside the ANWR would minimize social impact because local people would interact with it only seasonally or not at all. In the case of seismic activity conflicts with subsistence users, Kaktovik people would have the option of going somewhere else that year. However, maintaining a base at

Barter Island would be more permanent and could affect the daily life, culture, and social structure of the entire village.

To understand the nature of this impact, it must be emphasized that on Alaska's North Slope there are 2 very different cultures with very different values (USGS 1979). The degree to which the Inupiat culture, social system and values have remained intact has been a function of their degree of isolation. Although outside contact has brought many material and other benefits, the amount of cultural stress and accompanying social problems over the past several years has been directly related to the increased amount of western influence and the rapid changes involved (Wentworth 1980). Stationing a base camp at Barter Island could alter the cultural character of the village.

In Kaktovik, a degree of socio-cultural stability has existed despite outside influences, keeping those influences from becoming overwhelming. Non-Native visitors often remark on the friendliness of Kaktovik compared to Barrow, and on the absence of the overt racial tension sometimes exhibited in Barrow. This may be related not only to Kaktovik's smaller size, but to its relative isolation and the greater degree of socio-cultural stability Kaktovik people have. The few non-Natives that the people deal with on a daily basis are usually known entities, not strangers, and the Inupiat have always been clearly in the majority. Establishing a base camp at Barter Island could alter this balance, possibly making non-Inupiat the majority for the first time. The degree of impact would depend on where the camp was located on Barter Island, the degree to which it was self-contained and independent from the village, and the rules and regulations that were made and enforced concerning interaction with the village. Impacts would also vary depending on the degree to which the local Kaktovik government was involved in planning for the facility.

Existing outside influences at Kaktovik include the Barter Island DEW Line Site and airport, which have been present for over 30 years. Up to 70 employees live at the Site. While the Site has had considerable physical, social, and economic impact on the village over the years (Nielson 1977, Jacobson and Wentworth 1981), methods of controlling the impact have evolved which now keep this influence at a minimum. The Site is located about 1.6 km from the village, and workers there do not mingle with the village except in a very controlled fashion, such as an occasional sports event. This is both a matter of choice and a matter of policy. Similarly, Kaktovik people do not visit the Site unless they are employed there or are an official guest of a DEW-Line employee. Several resident non-Natives who work at the Site have lived in Kaktovik many years.

Problems between the Site and the village have been many. Much of the erosion of traditional cultural values at Kaktovik can probably be traced to influences from the Site or its personnel. Lingering hostility exists over the village relocations necessitated by the Site (see Chapter 7). A recent cause of DEW-Line village friction concerns the closure of the DEW-Line airport terminal to use by the village. Aside from these factors, however, peaceful coexistence between the Site and village is usually maintained.

Other permanent non-Native influences present at Kaktovik are the school with 8 teachers (most of whom came from outside of Alaska); 3 or 4 maintenance and physical plant employees; 4 or 5 construction workers employed by the North Slope Borough's Capital Improvements Program, and 3 families working for the

Borough's Public Safety Dept., the U.S. Post Office, and the U.S. Fish and Wildlife Service.

In summertime, the number of non-Natives at Kaktovik temporarily swells as more construction workers, geophysicists, Fish and Wildlife Service employees, researchers, hikers and hunters visit the village. Although Kaktovik is a friendly village, attitudes towards non-Inupiat outsiders are noticably cooler during the summer than during the winter when there are fewer visitors. Stationing a seismic crew at Barter Island would likely increase this coolness, and could perhaps for the first time even cause overt racial tensions in Kaktovik. Depending on the degree to which the seismic personnel interacted with the village, the already serious local problems of alcohol and drug abuse could intensify (USGS 1979).

Other affected villages. Impacts on the communities which are heavily or partially dependent on the Porcupine caribou herd as a subsistence resource will depend on the impacts of seismic exploration on the herd itself. If the herd is not affected by oil and gas exploration (i.e. if the numbers of animals available for hunting remains constant or increases, if migration patterns, temporally or spatially, are not altered, and if bag limits and seasons do not change drastically), the impacts on subsistence use will not be felt in these villages. However, if the impact of exploration on the Porcupine herd is a negative one, then the subsistence use and the lifestyle of rural residents would also be negatively impacted. The same would hold true for coastal villages which take beluga whales or polar bears -- if the distribution or abundance of these mammals declined, the level of sustainable subsistence and commercial harvest may be reduced.

If caribou are less available to people of Arctic Village and Old Crow, and other villages, the largest impact will be in reducing the availability of a source of protein. The ramifications of this lack of food may lead to an increased dependence on welfare or other assistance programs for food. Another result may be a change in emphasis to hunting less abundant species such as moose or Dall sheep, altering their populations to a point of less abundance, and in Alaska, possibly invoking the subsistence preference for harvesting game in the Arctic Village area.

Hearings held in Old Crow during the Mackenzie Pipeline Inquiry (Berger 1977) revealed that people there fear that white people may destroy their caribou, and if the caribou are threatened, the people themselves are threatened. They see the caribou as the essential link between their past and their future, and the preservation and maintenance of the Porcupine caribou herd as of fundamental importance to their survival.

The social and cultural fabric of Old Crow and Arctic Village may also be affected by a reduced number of caribou available for hunting. Cultural bases and social structures which are dependent on hunting prowess and hunter status may change, causing social unrest or confusion in the village.

Effects on the economy of the affected villages are difficult to predict. A possible increase in dependence on outside social programs may change cash flow or cash dependency within the village. More people may have to seek cash employment for greater periods of time creating increased competition for the few available paying jobs or necessitating leaving the village for employment.

Arctic Village may be affected in one additional way from oil and gas exploration on the coastal plain. Increased air traffic to and from Kaktovik or other base camp locations may increase the number of planes landing in Arctic Village. This may increase the supply and diversity of goods coming into the community and may increase use of the lodging facilities in the village. Furthermore, local people could be employed on seismic crews, increasing employment opportunities.

The impact of a reduced caribou harvest in some of the other previously mentioned villages that utilize animals from the Porcupine herd may not be as severe as in Arctic Village or Old Crow since the caribou are not often as large a component in the subsistence harvest. The lack of data for most of the other villages, especially Venetie, makes it difficult to assess these impacts accurately. The lack of caribou in the diet or for trade may be more of an inconvenience or discomfort rather than a critical shortage. However, in certain years when other resources such as marine mammals or fish are not as available in these other villages, the lack of caribou could be more critical.

The ramifications of oil and gas exploration are not limited to Alaska. Since beluga whales also migrate from Alaskan waters eastward to Canadian waters (see "Marine Mammals" Section), impacts on the whale population could impact subsistence use of that population in the Mackenzie villages of the Northwest Territories. Whaling is traditional for coastal Eskimos; if whaling as an activity is lost or reduced it will have cultural ramifications in Aklavik, Inuvik, and Tuktoyaktuk. The social, recreational, and cultural aspects of whaling would be lost as well as the subsistence food the whales provide.

A limited amount of polar bear movement between Alaska and Canada has also been reported (Stirling et al. 1975). Since polar bear hides play an important part in the economy of the "Rim" villages of Sachs Harbour, Paulatuk and Holman, and a more minor role in the Mackenzie villages, impacts which decrease polar bear populations may negatively affect the economy and livelihood of Canadians. If oil and gas exploration activities tend to move polar bear populations to the east, the economies of the Canadian villages could benefit to the detriment of the polar bear population. Another impact could involve arctic fox populations which are important as furbearers in the "Rim" and to a lesser degree, in the Mackenzie economies. Fox tend to follow polar bears on the pack ice where they scavange the remains of seals killed by bears. If polar bear populations were to decline, arctic fox populations may decline, and therefor the economy of the villages may be adversely affected. A baseline study of arctic fox population dynamics and the relative importance of its seasonal food sources would provide a better understanding of bear-fox interrelationships and the subsequent effects on the economic base in arctic villages (Stirling et al. 1975)

Recreation

The following section describes possible effects of an oil and gas exploration program. There have been no specific studies on impacts of exploration activities on recreationists using the north slope or elsewhere. The overall effects of an oil and gas exploration program on recreational opportunities on the coastal plain study area can be expected to be mainly psychological effects on the recreationists themselves. With the exception of above ground explosions, there are probably no aspects of the exploration program that would physically restrain recreationists from participating in their chosen activity. However, the psychological impacts of carrying on a wilderness-based recreational pursuit with a backgound of cat trains, helicopter overflights, or seismic booms would likely decrease recreational activities on the coastal plain of the Arctic NWR. Visitors are normally expecting some form of a wilderness experience, and seeing any or all of the effects of an exploration program on the environment will especially affect that percentage of visitors to whom wilderness qualities are essential for their experience.

The impacts resulting from seismic exploration will differ somewhat with varying techniques, but will basically be detrimental to the types of recreational activities now on-going if there is seismic or exploratory activity during the period from June 1-September 15. Any change in the esthetic qualities of the wilderness character of the coastal plain will detract from the quality of the wilderness experience.

Equipment and logistical support required for any type of seismic activity, except for an ocean boat-based method, would cause disturbance factors in an otherwise wilderness environment. Although wilderness is not essential to some forms of recreation, such as hunting, visitors to this particular area expect to have a wilderness experience. Most visitors support maintaining the wilderness in a pure state (Warren 1980) and disruption of the wilderness character will likely negatively affect the recreational experience even though the recreational activity itself is not curtailed or prevented. Direct disturbance factors can include such things as noise from explosives, helicopter and light aircraft flights, visual intrusions from the presence of machines, mobile camps and their associated solid waste, and possibly air pollution from diesel engines or generators causing foreign odors in otherwise pristine air. There has not been any research to identify which, if any, of the above disturbances are most annoying or acceptable to recreationists, how far noise levels carry across the tundra, etc., but attitudes of wilderness users do not allow for man-made disturbances to occur without a change in the quality of their experience. Solitude and tranquility, both important components of a wilderness experience (Hendee et al. 1968, Rossman and Ulehla 1977), will no longer be available. By directly affecting the esthetics of the wilderness area, exploration will indirectly serve to reduce recreational use of the study area.

One component of exploration that is particularly annoying to wilderness visitors is helicopter flights (J. Liedberg, pers. comm.). Helicopters seem to detract from a primitive recreational experience more than single engine "bush" aircraft. The impact of helicopter flights will be felt in all on-going recreational activities.

Hikers crossing the coastal plain and encountering tracks from vehicles or other permanent scars from man's activities, would probably be negatively affected. The impact of any recent evidence of man's presence in the pristine environment would have detrimental effects on the wilderness user's experience. Another effect of exploraton that may adversely affect wilderness users is the effect that increased activities may have on wildlife populations. Wildlife observation is an important part of most visitors' experiences (Warren 1980). If wildlife are frightened away or become exceedingly wary and difficult to view, this will lower the quality of experience that visitors receive. It may negatively affect hunter's trips if they are unable to have a successful hunt, and may also negatively affect the hunting guide operations in this area.

Most fixed camp facilities, especially if located off-refuge or at one of the already disturbed DEW-line sites, will probably not greatly impact recreation directly. The largest indirect impact would probably be from visual interference. On the flat tundra of the coastal plain it is possible to see objects for long distances, and seeing a camp with associated facilities in an otherwise pristine setting would impact the scenic resource and the esthetics of the view.

Use of power boats or airboats in the lagoons and on rivers may negatively affect the experience of a kayaker or river floater, but since the level of this recreational use is quite low on the coastal plain, the impacts would probably be minimal.

Winter seismic activities would have essentially no impact on recreation unless permanent scars or facilities were left in the area. A very limited amount of cross-country skiing may occur in March and April, and skiers would likely be disturbed in the same ways as backpackers and others would be during summer months.

Wilderness and Natural Landmarks

Any permanent scars on the landscape will contribute to the ineligibility of the ANWR study area for inclusion in the Wilderness System. Temporary intrusions of vehicle trains, helicopter flights or tent camps will not impact eligibility of the area. Natural landmark eligibility at the 2 nominated sites would probably also be jeopardized by permanent damage or permanent evidence of man's activities.

Consideration of the ANWR study area for Wilderness designation is a concern. Section 1317 of ANILCA requires that the Secretary review all National Wildlife Refuge lands that were not designated Wilderness for suitability for designation and that the President must make recommendations to Congress regarding formal designation. Of all the Alaskan North Slope, presently only a small area in the northeast corner of the state, that area within the Arctic National Wildlife Refuge, has been formally designated as Wilderness. In addition to the study area, only one other federal land holding, the Central Arctic Management Area, managed by the Bureau of Land Management, is under consideration for potential Wilderness designation. Certain lands within the National Petroleum Reserve in Alaska (NPR-A) may constitute "de facto" wilderness, but there is no existing or proposed legal designation for those areas. In fact, much of NPR-A may be leased for oil and gas development in the future. Most state land north of the Brooks Range has been leased and explored for oil and gas, or is proposed for leasing (see Fig. 1, Chapter 9). Native land holdings in the Alaskan arctic may or may not be opened for development; their future use is unknown. In summary, retention of wilderness characteristics of the study area is an important aspect in the discussion of impacts which could potentially occur due to the exploration program. Some impacts which may be acceptable in terms of fish and wildlife habitat loss or population level declines could be unacceptable for protection of wilderness values and characteristics necessary to qualify for Wilderness designation.

Comprehensive Impact Matrix

The following matrix (Table 6) summarizes the potential impacts expected from the exploration program. Exploration activities are subdivided into component parts which include technique, transportation, services, and general items. Affected resources are subdivided by species, species group, or general type. The potential impacts are rated by season and in the following categories:

1. Magnitude
   a) unknown
   b) none
   c) low - affects small area or low number of animals
   d) moderate - affects significant area or number of animals
   e) high - affects large area or large number of animals

2. Duration
   a) short - up to one year
   b) moderate - one to 10 years
   c) long - over 10 years

Summary of Potential Impacts by Season

In order to consolidate the preceding information into a useful form, this section summarizes fish and wildlife use of the study area and potential impacts of the exploration program by season. Seasonal designations for this presentation are spring (May-June), summer (July-August), fall (September-October), and winter (November-April). These periods approximate such physical characteristics of the area as snow and ice cover (Fig. 1). A set of sensitivity maps depict in a general sense the areas in and adjacent to the study area which have concentrations of fish and wildlife susceptible to disturbance by the exploration program. Only a few species are discussed and they were selected based upon the characteristics of relatively large concentrations of the animals and/or relatively great sensitivity to disturbance. Reference is made to the preceeding chapters which discuss animal movements, numbers, and sensitivity to impacts in more detail. These maps are not intended to depict all animal species but only those which are relatively concentrated during a particular season. These maps show only areas of known use by animals rather than areas of potential use. Future studies may identify other important habitat areas or other species which exhibit relatively great sensitivity to disturbance. Existing subsistence uses of animals is discussed in the following narrative, but the areas of use are not shown on these maps.

Spring (May-June)

Increasing day length and warmer temperatures combine to initiate spring breakup in May. River water begins flowing over the ice and onto deltas and lagoons. Snow melt begins during the first half of May and adds meltwater to river flows. Ice breakup and peak river flows occur during late May to early June. Lakes begin thawing in May and shallow ponds may be ice-free by the end of June. Large deep lakes will have open water along the edges, but may contain ice remnants into July. Lagoons become flooded on top of the ice by river overflow in May, and by the end June lagoons will be nearly ice free. Soil materials begin thawing and new plant growth emerges. The surface of the ground becomes vulnerable to disturbance by ground vehicles at this time.

Table 6. Preliminary matrix, impacts of seismic exploration.[1]

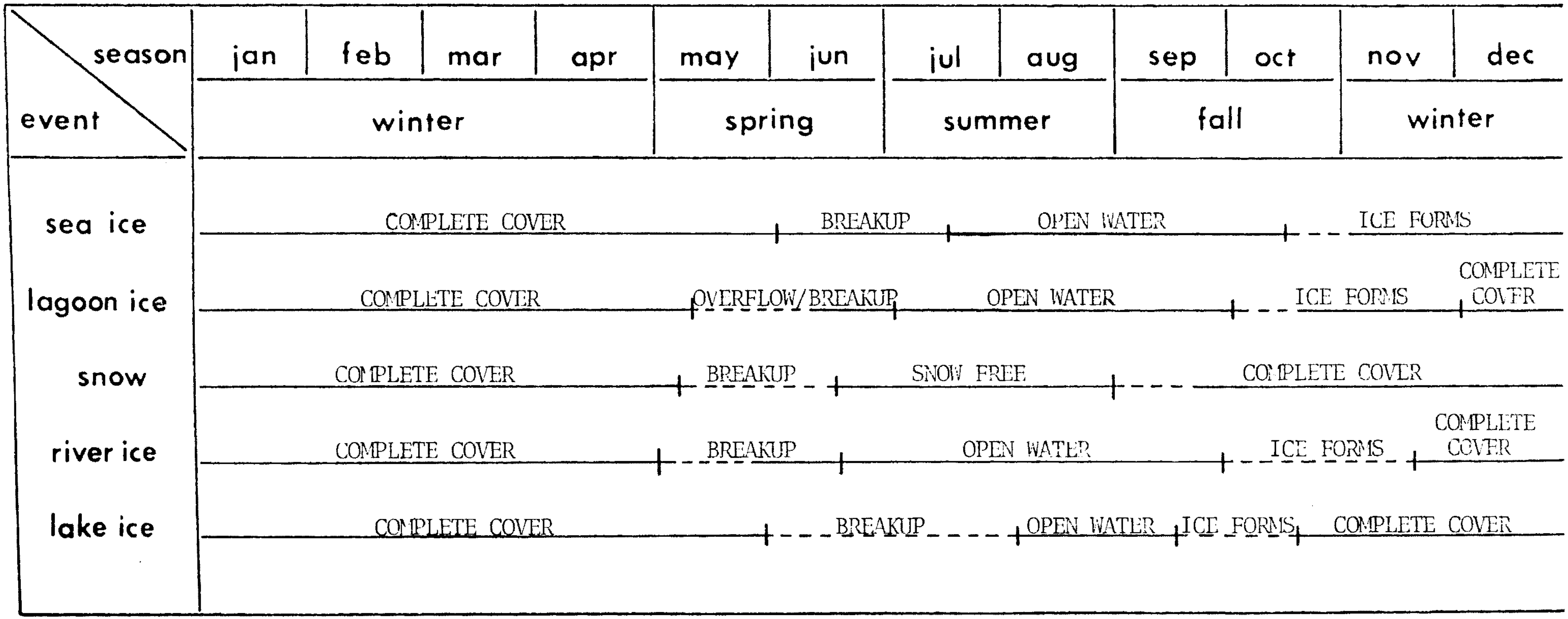
Resource Season	Technique: Conventional	Pouldier	Vibroseis	Transportation: Surface Vehicle	Airplane	Helicopter	Ship	Services: Fuel Spill	Water Use	Wastewater disposal	Solid waste	Camp-site	General: Noise	Increased activity
Fish														
Spring	2S	1S	0	0	0	0	0	3S	3S	3S	0	0	0	0
Summer	2S	1S	0	0	0	0	0	3S	0	0	0	0	0	0
Fall	2S	1S	0	0	0	0	0	3S	0	0	0	0	0	0
Winter	2S	1S	0	0	0	0	0	3S	3S	3S	0	0	0	0
Birds														
Swans														
Spring	2S	3S	x	x	3S	3S	x	2S	0	0	0	2S	2S	2S
Summer	2S	3S	x	x	3S	3S	0	2S	0	0	0	2S	2S	2S
Fall	1S	2S	x	x	2S	2S	0	2S	0	0	0	1S	1S	1S
Winter	0	0	0	0	0	0	x	0	0	0	0	0	0	0
Oldsquaw														
Spring	0	0	x	x	0	0	x	0	0	0	0	0	0	0
Summer	2S	2S	x	x	2S	2S	2S	2S	0	0	0	1S	2S	2S
Fall	2S	2S	x	x	2S	2S	2S	2S	0	0	0	1S	2S	2S
Winter	0	0	0	0	0	0	x	0	0	0	0	0	0	0
Snow geese														
Spring	0	0	x	x	0	0	x	0	0	0	0	0	0	0
Summer	3S	3S	x	x	2S	3S	0	1S	0	0	0	2S	2S	2S
Fall	3S	3S	x	x	2S	3S	0	1S	0	0	0	2S	2S	2S
Winter	0	0	0	0	0	0	x	0	0	0	0	0	0	0
Shorebirds														
Spring	1S	1S	x	x	1S	1S	x	2S	0	0	0	1S	1S	1S
Summer	1S	2S	x	x	1S	1S	0	0	0	0	0	1S	2S	2S
Fall	1S	2S	x	x	2S	2S	0	2S	0	0	0	1S	2S	2S
Winter	0	0	0	0	0	0	x	0	0	0	0	0	0	0
Raptors														
Spring	2S	2S	x	x	2S	3S	x	0	0	0	0	2S	2S	2S
Summer	1S	1S	x	x	1S	1S	0	0	0	0	0	1S	1S	1S
Fall	0	0	x	x	0	0	0	0	0	0	0	0	0	0
Winter	1S	1S	1S	1S	1S	1S	x	0	0	0	0	1S	1S	1S
Upland birds														
Spring	1S	1S	x	x	1S	1S	x	1S	0	0	0	1S	1S	1S
Summer	1S	1S	x	x	1S	1S	0	1S	0	0	0	1S	1S	1S
Fall	1S	1S	x	x	1S	1S	0	1S	0	0	0	1S	1S	1S
Winter	0	0	0	0	0	0	x	0	0	0	0	0	0	0

Table 6. Continued.

Resource Season	Technique			Transportation				Services					General	
	Conventional	Pouldier	Vibroseis	Surface Vehicle	Airplane	Helicopter	Ship	Fuel Spill	Water Use	Wastewater disposal	Solid waste	Camp-site	Noise	Increased activity
Mammals														
Caribou (Porcupine Herd)														
Spring	2S	3S	x	x	2S	3S	x	0	0	0	1L	2S	3S	3S
Summer	2S	2S	x	x	2S	2S	0	0	0	0	1L	2S	2S	3S
Fall	0	0	x	x	0	0	0	0	0	0	1L	0	0	0
Winter	0	0	0	0	0	0	x	0	0	0	1L	0	0	0
Caribou (Central Arctic Herd)														
Spring	2S	3S	x	x	2S	3S	x	0	0	0	1L	2S	2S	2S
Summer	2S	2S	x	x	2S	2S	0	0	0	0	1L	2S	2S	2S
Fall	1S	1S	x	x	2S	2S	0	0	0	0	1L	1S	1S	1S
Winter	1S	1S	1S	1S	1S	1S	x	0	0	0	1L	1S	1S	1S
Muskox														
Spring	3S	3S	x	x	3S	3S	x	0	0	0	0	3S	3S	3S
Summer	2S	2S	x	x	2S	2S	0	0	0	0	0	1S	2S	2S
Fall	1S	2S	x	x	2S	2S	0	0	0	0	0	1S	2S	2S
Winter	2S	3S	2S	2S	3S	3S	x	0	0	0	0	2S	2S	2S
Moose														
Spring	0	0	x	x	0	0	x	0	0	0	0	0	0	0
Summer	1S	1S	x	x	1S	1S	0	0	0	0	0	0	1S	1S
Fall	0	0	x	x	0	0	0	0	0	0	0	0	0	0
Winter	0	0	0	0	0	0	x	0	0	0	0	0	0	0
Polar Bears														
Spring	2S	2S	x	x	1S	1S	x	0	0	0	1S	2S	2S	2S
Summer	0	0	x	x	0	0	0	0	0	0	0	0	0	0
Fall	2S	2S	x	x	1S	1S	0	1S	0	0	1S	2S	2S	2S
Winter	2S	2S	2S	1S	0	0	x	0	0	0	1S	2S	2S	2S
Ringed Seals														
Spring	0	1S	x	x	0	0	x	1S	0	0	0	0	0	0
Summer	0	0	x	x	0	0	0	1S	0	0	0	0	0	0
Fall	0	0	x	x	0	0	0	1S	0	0	0	0	0	0
Winter	0	1S	0	0	0	0	x	1S	0	0	0	0	0	0
Bowhead Whales														
Spring	0	0	x	x	0	0	0	0	0	0	0	0	0	0
Summer	1S	1S	x	x	1S	1S	2S	2S	0	0	0	0	1S	2S
Fall	1S	1S	x	x	1S	1S	2S	2S	0	0	0	0	1S	2S
Winter	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Code meanings are as follows: Magnitude: 0 = none; 1 = low; 2 = moderate; 3 = high. Duration: S = short; M = moderate; L = Long; x = not applicable

Fig. 1. Seasonal cycle of physical events.



Birds generally begin arriving in the study area in early May. Raptors begin nesting along bluffs and cliffs as early as April. Raptors are especially sensitive to disturbance during this period. Raptor nesting habitat is shown as small circles near the foothills in Fig. 2. Waterfowl and shorebirds begin arriving in the study area in May. They initially use river delta areas which are blown free of snow, and both deltas and lagoons which have overflow water, for staging prior to nesting. Waterbird nesting can begin as early as mid-May, but most occurs in June. Disturbance to birds during nesting can be serious, leading to lower nesting density, nest desertions, and lower hatching success. Waterfowl nesting areas are shown in Fig. 2 mainly as a large band along the coast, but extending inland in areas of good habitat.

Large numbers of caribou cows of the Porcupine and Central Arctic herds often use the study area during mid-to-late May through 20 June for calving. Caribou of both herds commonly form into large post-calving aggregations in the study area during late June to mid-July. Caribou are particularily sensitive to disturbance during calving and post-calving activities. The mammal use area shown in Fig. 2 encompasses the area of caribou use.

Muskox calving occurs in early to mid-May and they are quite vulnerable to disturbance during this time. The calving areas are not shown separately in Fig. 2, but are presented in Chapter 5.

Grayling migration to spawning areas occurs in late May and early June, and spawning can occur from mid-to-late June. Blocking of the spawning migration or disturbance to spawning activities or habitat could have a detrimental impact on grayling populations. Rivers which are known to support grayling populations are shown in Fig. 2.

Subsistence use of wildlife resources in the spring includes hunting and trapping of ground squirrels, marmots, and ptarmigan in the mountains while the snow cover lasts. Waterfowl hunting also occurs along the coast, although by early June it is centered near Barter Island due to the difficulty of travelling.

Summer (July-August)

Snow and ice are essentially gone from the study area during summer. The exceptions are ice remnants in deep lakes, aufeis fields, and ocean ice. Plants are well into the growing season, and the soil active layer continues to thaw, making summer a period of high sensitivity to disturbance by surface vehicles. Plant senescence can begin in late August, and snow flurries can occur then. However, snow does not begin to accumulate until September.

For most birds, brood rearing and chick fledging are the important components of this period. Most raptor fledging is complete by the end of August. Swans with young may depart the study area as late as mid-September. Both of these species are vulnerable to disturbance during this period, although less so than during nesting. Oldsquaw molt migration along the coast can begin as early as mid-July and extend into mid-September. Disturbance of feeding activities during this period could have a detrimental impact on oldsquaw. Snow goose staging begins shortly after mid-August, and geese may remain until the onset of freezing weather, sometimes as late as mid-October. Disturbance to snow geese during staging may disrupt feeding activities which are important for the success of their fall migration. Fig. 3 shows a combination of raptor nesting habitat, waterfowl nesting areas, and oldsquaw and snow goose staging areas.

Post-calving aggregations of the Porcupine caribou herd generally begin moving eastward from their calving areas during the end of June and usually pass into Canada during the first half of July. However, this movement is variable, and it is not uncommon for portions of the herd to remain in the study area throughout the summer. Caribou of the Central Arctic herd may remain in the study area after calving primarily in the Canning River delta and Camden Bay area. These areas are important insect relief habitat for the Central Arctic herd. Disturbance of caribou during the post-calving period could produce a significant impact due to stampedes which can injure calves and cause separation of cows from their calves.

Muskox and moose are present in the study area during the summer, and both would be sensitive to disturbance during this time because of the vulnerability of the calves. However, muskox are more sensitive than moose and moose density is very low. Fig. 3 combines the ranges of caribou, muskox, and moose. See individual sections in Chapter 5 for more detail.

Beluga and bowhead whales may begin their westward migrations as early as August, but the peak normally occurs during September. Disturbance to whales may be minor at this time, however this is the only time of year that whales are near the ANWR study area. Bowheads are an endangered species and important for subsistence use by villagers, therefore any disturbance to them is of concern. The whale migration path is shown in Fig. 4.

Arctic char migration and spawning begins in late July and can continue into September. Egg incubation time is about 7 to 9 months. Grayling adults move from spawning streams into the main river channels in mid-summer, while juveniles and fry move into the main river channels during September. Char will be susceptible to blockage of migration or disturbance to spawning or egg development. Grayling fry would be susceptible to disturbance in their rearing streams as well. Fig. 3 shows rivers which support grayling and char spawning as well as nearshore areas along which char migrate.

Subsistence use of wildlife resources in the summer consists of caribou hunting which starts 1 July, and fishing for arctic char and arctic cisco along the coast. Some waterfowl hunting continues during the summer. Ringed and bearded seals are hunted also. Bowhead whaling may begin in late August, but occurs primarily in September. Beluga whaling occurs primarily in August.

Fall (September-October)

The snow season begins in September and shallow ponds begin to freeze. However, larger lakes and the ocean do not freeze until early October. Vegetation becomes covered with snow and the soil active layer begins refreezing. This can be a sensitive period for surface travel until the frost and snow cover are sufficient to protect the tundra.

Most birds begin their migration south by September. However, oldsquaw molting continues into September and snow goose staging also may continue until the end of September or possibly later, depending on weather conditions. Fig. 4 shows snow goose and oldsquaw staging areas.

FIG. 2 GENERALIZED SPRING (MAY — JUNE) SENSITIVITY AREAS

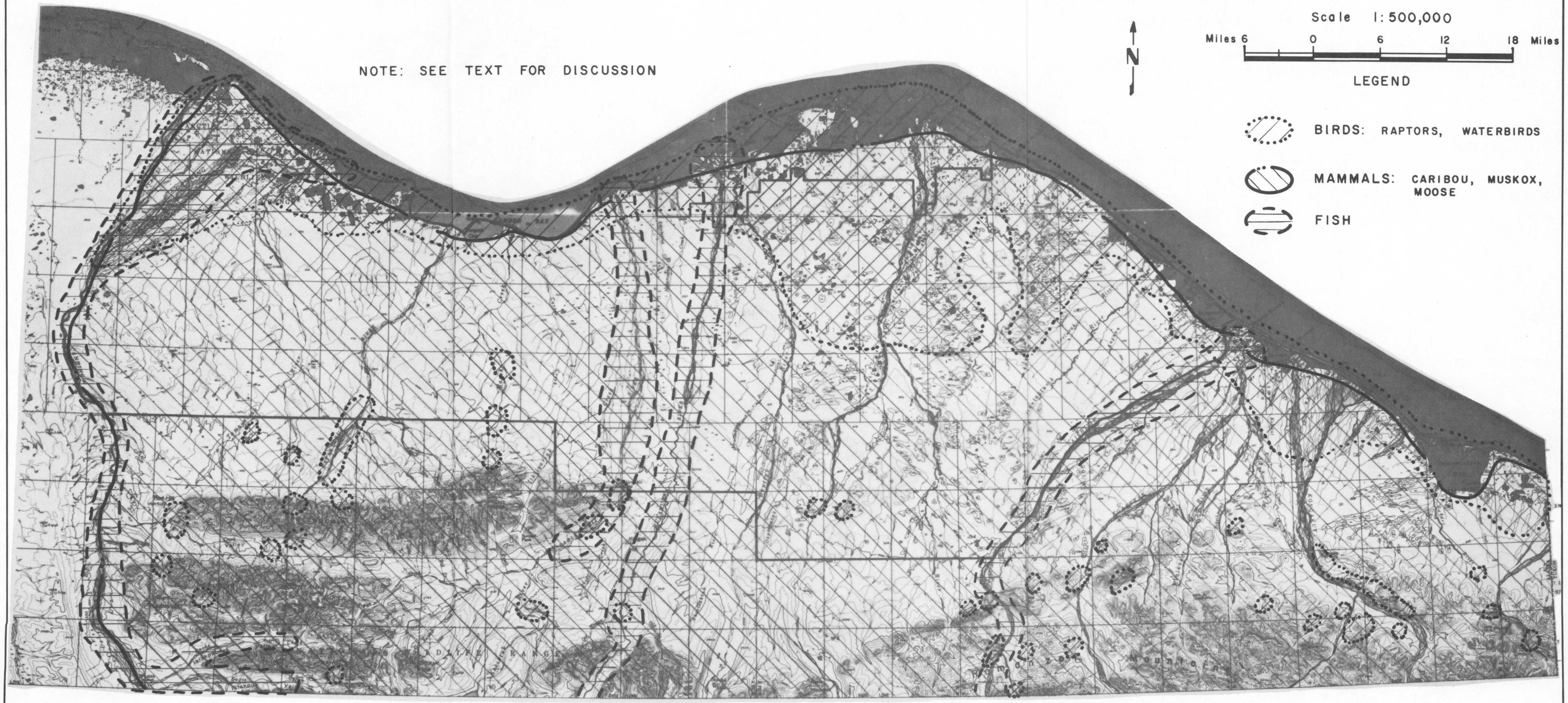


FIG. 3 GENERALIZED SUMMER (JULY – AUGUST) SENSITIVITY AREAS

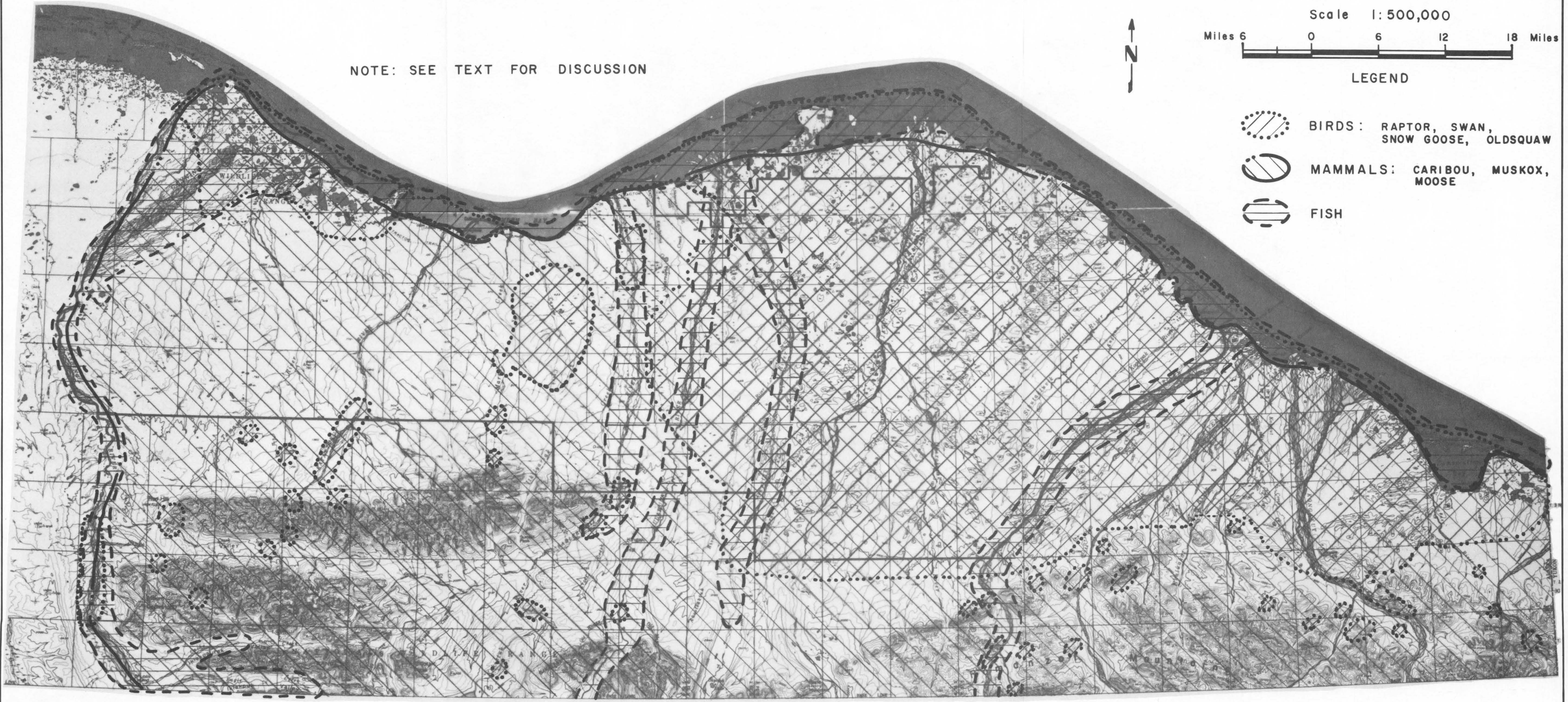


FIG. 4 GENERALIZED FALL (OCTOBER — NOVEMBER) SENSITIVITY AREAS

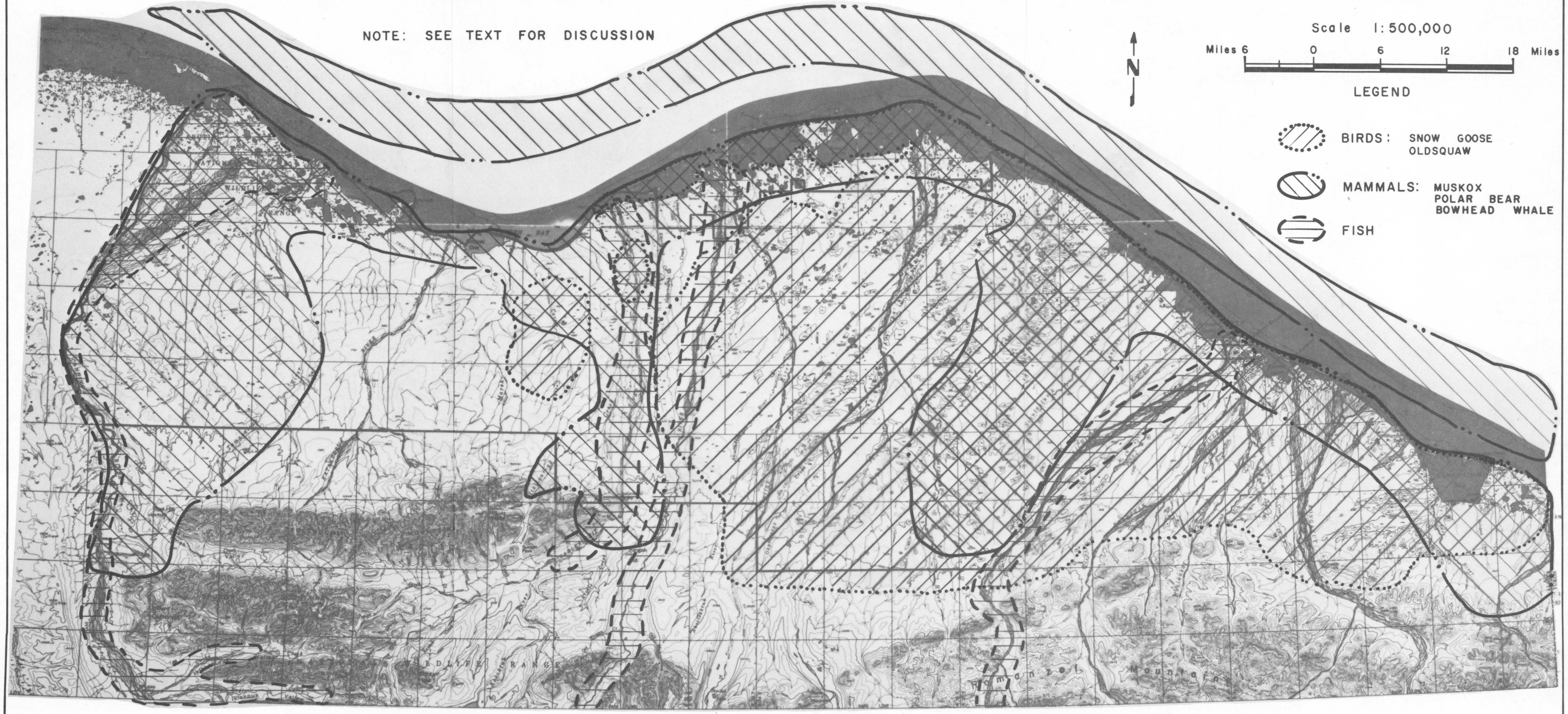
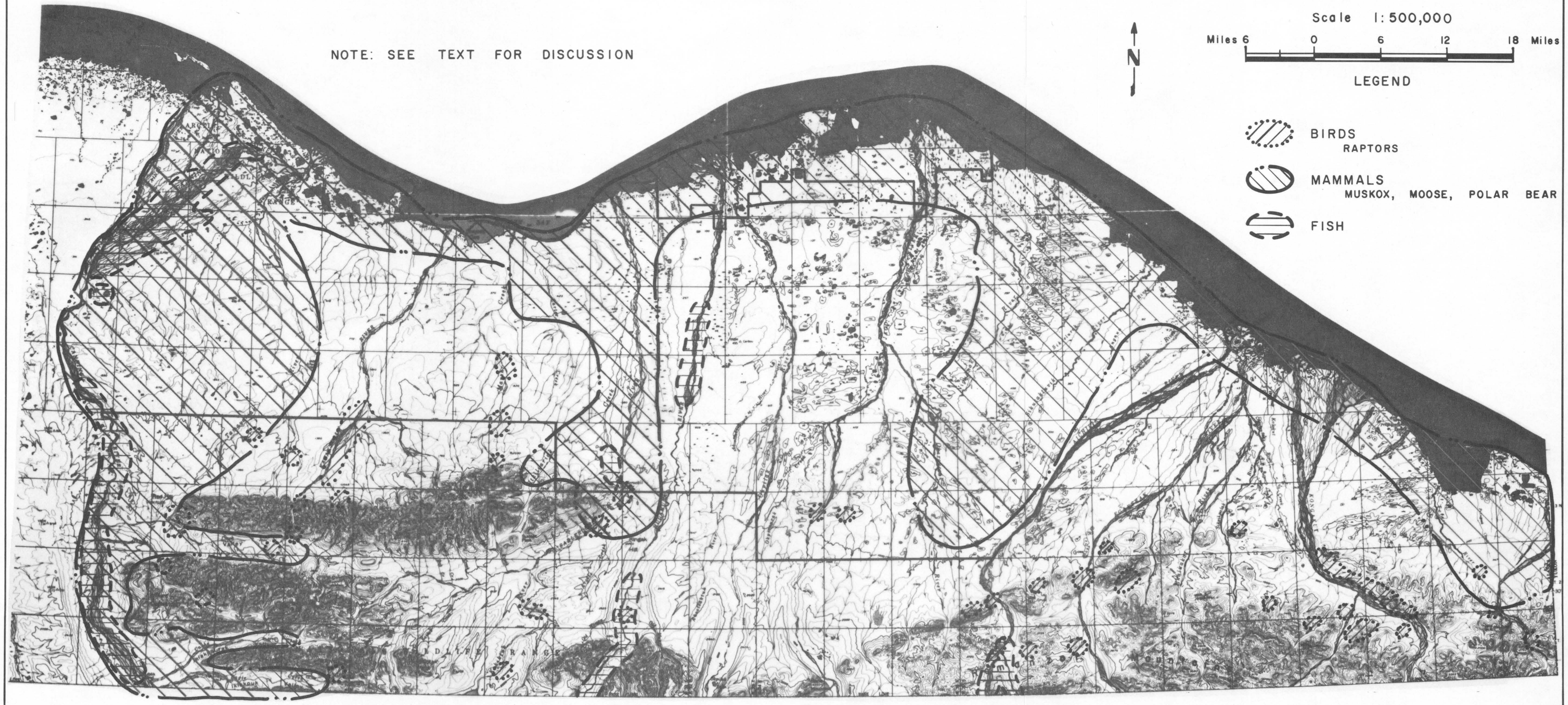


FIG. 5 GENERALIZED WINTER (NOVEMBER — APRIL) SENSITIVITY AREAS



Caribou of the Porcupine herd are generally absent from the study area in the fall. Some members of the Central Arctic herd may be found in the study area and south into the foothills during the fall. The potential for disturbance of caribou in the study area during this period is relatively low due to their low density and scattered nature, therefore Fig. 4 does not include caribou use areas.

Muskox are present in the study area in the fall. Breeding occurs in August, so muskox may be less sensitive to disturbance in fall than at any other time. However, Fig. 4 does show muskox herd locations because muskox are relatively more sensitive to disturbance than other animals. Moose generally will not be present in the study area in October and November.

Polar bears begin to move to the coast from offshore in late October and November. Adult females, family groups, and juveniles may be attracted to carrion on shore, primarily whale carcasses. Pregnant females are headed for onshore maternity dens. All are susceptible to disturbance at this time, but the denning females are especially so. Fig. 4 shows polar bear use areas as a band along the coast and rivers inland where dens or sows with cubs have been observed. However, polar bears and dens can occur in other areas.

Bowhead and beluga whales can be found offshore of the ANWR study area in the fall, primarily during September. They would be vulnerable to disturbance at this time, which could cause alteration of their migration path. This disturbance may affect subsistence use of the whales as well as affecting the whales directly. A broad band offshore shows the primary migration path of bowheads. However, whales may also occur closer to shore.

Arctic char spawning continues into September in the vicinity of active springs. The eggs of arctic char are susceptible to siltation or dewatering until hatched, which occurs during May and June. Most grayling will have moved into the main river channels during this time.

Fall subsistence activities are highlighted by bowhead whale hunting. Fishing may also continue. Caribou and sheep hunting in the mountains becomes important after whaling ends. Polar bears also are hunted during this period.

Winter (November-April)

Cold weather and few daylight hours mark the central winter period, although day length in March and April increases significantly. Snow and ice blanket the landscape, but snow cover may very according to topography. Strong winds tend to blow ridges bare of snow and pile it into deep drifts along river bluffs. This causes some areas of vegetation to be susceptible to disturbance from surface travel.

Few birds are present in the ANWR study area during winter. Dippers, ravens, snowy owls, and gyrfalcons can be found as winter residents. Gyrfalcons begin nesting in April and are sensitive to disturbance during that period. Raptor nesting habitat is shown in Fig. 5. Dippers exist at the northern extension of ther range in springs in the study area.

Varying numbers of caribou (possibly up to 1000) may be present in the study area during the winter. Central Arctic Herd animals sometimes winter along the Canning River and in the foothills. Animals of the Procupine herd occasionally may winter north of the Brooks Range. However, because of the scattered nature of their winter occurence, they are not noted on Fig. 5.

Muskox are winter residents in the study area, primarily using riparian zones. Just prior to calving in the first week of May, muskox may move to windswept south facing hillsides. Throughout the winter muskox are susceptible to disturbance because of the increased physiological stress of the period. Herd locations are shown in Fig. 5.

Female polar bears may be present in maternity dens in the ANWR study area during the winter. Sows with cubs emerge from dens in March and April. At this time they are vulnerable to disturbance because of the small size of the cubs because and the sow has not eaten for approximately 6 months. Polar bear sensitivity areas are shown as a band along the coast and inland along river drainages in which dens or sows with cubs were observed.

Fish such as grayling and arctic char can be found in the ANWR study area during the winter. Their primary habitats are unfrozen spring areas, deep river pools, or deep lakes. Fish are especially susceptible during this time to any decrease in habitat quantity because winter conditions are marginal. Fish sensitivity areas are shown in Fig. 5 as known open water areas or deep pools.

Subsistence activities in the study area are many and varied during the winter. Caribou and sheep are hunted in early winter and again in late winter. Ice fishing also occurs during these times. Trapping is conducted throughout the winter. In April, hunting begins for ground squirrels and ptarmigan.

Data Gaps

No disturbance studies have been conducted on the ANWR study area to date. Rather, results of studies in other areas have been applied to the ANWR study area for this report. It will be necessary in the future to refine our knowledge of the effects of oil and gas exploration elsewhere to the specific resources on the ANWR study area. Impact studies will be conducted in coordination with the biological studies described in Ch. 1, where possible, because biological parameters must be understood in order to determine the impacts of "outside" activites. A discussion of those studies will not be repeated here.

Vegetation and Surface Stability

Further information on the impacts of seismic techniques and associated transportation modes are needed. Specifically, quantification of impacts of the Vibroseis and Pouldier techniques are needed, as are knowledge of impacts of surface vehicle operations and subsequent vegetation recovery in the habitats types found on the ANWR study area. Related to this would be more detailed information on snow fall, wind, and snow cover characteristics because of the relationship between snow cover and degree of impacts of exploration activities. Inquiry into new exploration techniques or modifications of existing techniques would also be of value.

Birds

More data regarding disturbance to nesting, staging, and molting birds are needed. Raptors and dippers are of special interest in the study area during the early spring period, and swans, oldsquaw, and snow geese are of interest in the fall. Existing data on the effects of summer disturbance on nesting success are contradictory and further studies may be needed to clarify the topic.

Mammals

All aspects of the effects of disturbance to caribou need further study, especially regarding vehicular disturbance and the effects of winter trails. The potential long-term effects of disturbance during both winter and summer and are not well understood. Studies being conducted in Canada may supply portions of this information.

Muskox are present throughout the year and appear to be especially sensitive to disturbance. In addition, the ANWR study area is the only Alaskan North Slope area where muskox exist in numbers. It is important therefore, that more detailed and accurate information on the effects of exploration in the study area be obtained and related to similar Canadian studies.

FWS investigations of polar bear distribution and denning habits should continue with an effort toward obtaining more information on characterization of good denning habitat and the effects of disturbance to denning females and fall family group congregations.

Studied conducted for the Outer Continental Shelf Environmental Assessment Program on bowhead and beluga whales should provide adequate information on impacts to whales of activities on the ANWR study area.

Fish

More information on the effects of seismic techniques on overwintering fish and eggs, as well as the importance of and effects of disturbance to overwintering habitat is needed.

Human Culture and Lifestyle

Location of archaeological sites is probably the main area of information lacking related to archaeology. More information on socioeconomics and subsistence are needed to further define the socioeconomic and subsistence characteristics which presently exist and the impacts which may occur due to the exploration program. Kaktovik would be the center of interest, but other villages which rely on the Porcupine Caribou herd are also of importance. Some of this information may be obtained through the ongoing studies by the Subsistence Division of the Alaska Department of Fish and Game.

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Chapter 9

IMPACTS OF FURTHER EXPLORATION, DEVELOPMENT AND PRODUCTION OF OIL AND GAS RESOURCES

Subpart D of Section 1002 (c) of ANILCA requires the baseline study report to address the impacts of both exploration and development of oil and gas to the fish and wildlife resources of the Arctic Coastal Plain Study Area. The potential impacts of exploration were discussed in Chapter 8. In this chapter, the effects of oil and gas development on the North Slope of Alaska are discussed in a general manner based upon what is presently known. It is not possible at this time to predict whether or not oil or gas will be found in the study area, where the reservoir(s) might be located, or whether or not it would be economical to develop a field. And, finally, the methods and timeframes for development are far beyond the realm of prediction. Nonetheless, the matter must be addressed, not only because of the aforementioned legal requirement, but also because an initial analysis of available information must be conducted before study plans can be designed to fulfill the long-term requirements of the baseline study.

Examples of exploration, development, production, and transportation of petroleum are found in nearby oil fields on the North Slope of Alaska (Fig. 1). Currently in production are the well-known Prudhoe Bay unit and the Kuparuk River unit. The Milne Point unit, located between and slightly north of the previous 2 units, is scheduled to go into production by 1985. To the east and north of the Prudhoe Bay unit is the Duck Island unit which will begin production in 1987. Several areas are currently being explored. The Pt. Thomson unit is just west of the ANWR study area, along the coast. The Mikkelson Bay unit is between Prudhoe Bay and the Pt. Thomson unit. Further west, the outlying parts of the Kuparuk River unit are still being delineated. The Colville River delta also contains leased lands and exploration is beginning there. A large block of federal land, the National Petroleum Reserve in Alaska (NPRA), extending from the Colville River west to the Chukchi Sea, has been explored under the direction of the U.S. Geological Survey. Portions of NPRA were leased in December of 1981 and possibly in later sales. Other tracts which are scheduled for lease, both onshore & offshore are indicated in Fig. 1. Oil exploration is also being conducted off the Mackenzie River delta in Canada, with development expected to begin within the next 10 years.

A general discussion of an oil development scenario was presented by USGS (1979). Activities are generally conducted in a standard sequence leading to production of an oil field. Geophysical exploration, including seismic techniques, occurs first. After several years, exploratory drilling may begin where prospective areas have been found. Another several years of exploration drilling may occur before either a field is delineated or is considered a non-producer (BLM 1981). The non-producing area would subsequently be rehabilitated and abandoned. A producible field may be developed immediately or at a later date depending on the world and national economic situation. A transport system for oil and gas is another factor in the overall picture. The oil from Prudhoe Bay and associated fields is transported through a combination of pipeline and tanker ships. Other schemes for transportation of oil and gas include ice breaking tankers or submarine tankers. Ocean transport of oil and gas from the ANWR study area would require docking and loading facilities and would increase the size of the area which may potentially be impacted. Refining of crude oil in situ has not been considered for the North Slope. The final phase of shutdown and abandonment logically would follow the end of production, but has not yet occurred on the North Slope (Hanley et al. 1980).

Leasing of federal lands for oil and gas development is generally carried out under the provisions of the Mineral Leasing Act of 1920, although several other federal laws and regulations may also apply. On "Alaska wildlife lands" (eg. National Wildlife Refuges in Alaska) leasing is conducted through the provisions of 43 CFR 3101.3. A discussion of oil and gas development on federal lands in Alaska is contained in a report by Hanley et al. (1980). While development on a National Wildlife Refuge may come under different regulations than on other federal, state or private lands, the general scenario of the development would be the same (Hanley et al. 1980).

Many of the impacts of exploration which were discussed in Chapter 8 may also occur during development, although they may be of greater magnitude and duration. Additional impacts which will occur are related to the intensity of the field development, such as spacing and number of well pads, size of the field, amount and kind of support services required, and the type of petroleum transportation system used. See Hanley et al. (1980) for a discussion of petroleum industry field practices. Several other volumes have discussed potential impacts of development (USDI 1976, USGS 1979, BLM 1981, Starr et al. 1981). The Berger Report (Berger 1977) discussed potential impacts of construction of an oil pipeline in the Canadian Arctic. The remainder of this chapter will discuss the potential effects of hydrocarbon development on the vegetation, birds, mammals, fish, and cultural resources of the ANWR study area.

Impacts to Vegetation and Surface Stability

Impacts to vegetation and surface resources during exploratory drilling, development, production and transportation phases of oil and gas production will be much greater than during the geophysical exploration program. Drilling of exploratory wells poses less potential for impact than development drilling. The reasons for this are the relatively small number and wide spacing of exploratory pads, and the relatively standardized practice of winter-season only drilling which allows use of ice roads rather than gravel roads and also reduces disturbance to wildlife. Ice roads minimize damage to vegetation, although some damage may occur. The paths of ice roads may be seen from the air for several years. Everett (1981) documented a significant increase in the depth of thaw along the Inigok ice road in NPR-A, and cautioned against using ice roads widely until more is known about long term recovery. In addition, water and snow necessary for construction of ice roads may be in short supply in the ANWR study area. There are very few lakes deep enough to supply water during the winter (see Chapter 6). Discussions of snow availability for snow road construction for an arctic oil pipeline (Berger 1977) pointed out potential problems in obtaining adequate quantities of snow near the road route which included the ANWR study area. Exploratory well pads

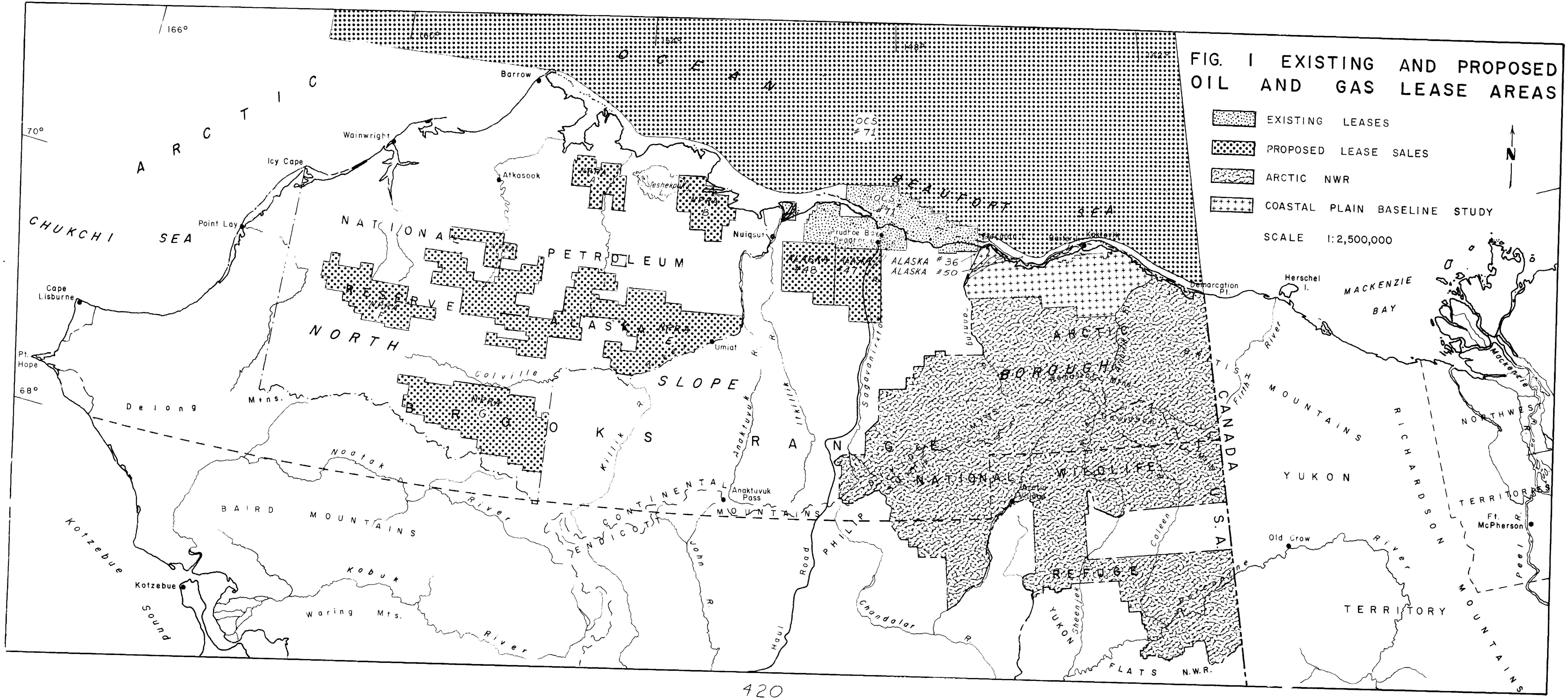

FIG. 1 EXISTING AND PROPOSED OIL AND GAS LEASE AREAS

are usually 5-6 ha in size, and may be constructed of gravel, sand, silt, snow, or ice. Pads of sand or silt are more easily revegetated than those of gravel. Ice or snow pads allow for eventual recovery of the natural vegetation underneath, although disturbance to vegetation can be noticeable for several years. Other potential impacts during exploratory drilling include oil spills and mud spills.

The proliferation of facilities during the production phase of oil development has a large impact on surface resources. Walker et al. (1980) documented a 30-year period from before exploration through development in 3 areas in the Prudhoe Bay field, focusing on the progressive development of the road system. Although roads cover less than 1% of the total land surface, a much larger area is directly impacted. Roads, pipeline access pads, and other linear facilities may affect wetlands by altering the natural water flow regime. This may cause flooding "upstream" and drying "downstream" of the road, thus altering the vegetation and thermal stability (U.S. Army Corps of Engineers 1980). Other indirect impacts of roads include dust shadows, leaching of dust control or de-icing material, and littering of roadsides with gravel due to grading.

Production well pads are as much as 3 times larger than exploratory pads and are usually constructed of gravel. All-season gravel roads, air fields, docks, camp facilities, processing sites, and other service facilities are also necessary for a production area, and usually are constructed of gravel. The number, location, and size of these facilities will affect the amount of impact that development of an oil field would have in the ANWR study area. For example the Kuparuk field will require more wells, well pads, and associated facilities than the Prudhoe Bay field due to geologic and reservoir characteristics (U.S. Geological Survey 1981).

Potential effects of production drilling operations include blowouts, chronic petroleum spillage, and mud spillage or leaching. Blowouts are more common in exploratory wells than in development wells. In addition to potential well blowouts, other potential sources of spilled petroleum are pipeline leaks or breaks, marine tankers, tanker terminals, onshore storage facilities, and highway tank truck spills. The impact of oil spills on vegetation was discussed in Chapter 8. The long term effects of chronic spills of crude oil or refined products are unknown.

A recent study (LGL 1981) rated the sensitivity of coastal areas of the Beaufort Sea to the impact of a major marine oil spill and subsequent cleanup activities. As part of this study, a preliminary oil spill retention index of coastal features was developed (Table 1). This index rates various coastal landforms in terms of oil retention, which is based on shoreline morphology and sediments, potential of oil degradation due to degree or intensity of energy available, and degree of flushing based on the efficiency of retaining factors.

Table 1. Preliminary oilspill retention potential index (from LGL 1981).

Environment	Retention Index	Level of Mechanical Degradation	Efficiency of Retaining Factors
Steep cliffs	Low	Very high	Low
Unprotected tundra bluffs, exposed non-vegetated barriers	Moderate	High	Moderate
Low vegetated barriers, generally protected shoreline, lagoon-facing mainland shores	High	Moderate	High
Low tundra along bluffless shorelines, low drained-lakes protected estuaries	Very High	Low	Very High

Mud pits (also known as reserve pits) are constructed to hold used muds and cuttings from the well. The constituents of mud may vary, but the main ingredients are barite and bentonite, both inert materials. Additives used to alter pH, kill bacteria, etc., may be toxic. Toxicity will vary according to concentration and the sensitivity of affected animal species. Used muds are generally stored in mud pits which are either excavated or constructed of gravel fill, or both. The gravel berms or walls may break, allowing drilling fluids to escape (French and Smith 1980). Chronic leaching may occur through unprotected walls. Occasionally mud pits may overflow in spring due to excessive spring snowmelt water (Stroebele pers. comm.). The effect of spilled mud is usually localized. Impacts from either toxicity or smothering can cause the death of plants and invertebrates (Vander Valk et al. 1980).

Extraction of gravel and other materials may cause the greatest impact to surface and aquatic resources (Pamplin 1979). Gravel may be extracted from river bars, terraces, or upland sites. Large pits may later be used as water reservoirs, and if constructed properly, can cause less harm than shallow, scraped sites (Morehouse et al. 1978, Woodward-Clyde Consultants 1980).

Impacts to Landform Types

This discussion of the potential effects of oil and gas production, development, and transportation to landform types of the ANWR study area is derived from the vegetation and soils studies described in Chapter 3. Impacts of seismic exploration were discussed in Chapter 8 and will not be reiterated here.

Flat Thaw Lake Plains. Gravel roads and pads create special problems in this landform type. The distribution of water on the tundra surface can be easily changed by road and pad construction, which dams the natural runoff of water in some areas and creates excessive and erosive flows in others. Large flooded areas are particularly evident in the Prudhoe Bay region and are likely to occur wherever roads and pads are built on flat thaw lake terrain. Ponded water, because it acts as a black body for heat, causes degradation of the permafrost table, resulting in thermokarst and the gradual enlargement of the flooded area, similar to the processes involved in thaw-lake formation. Because of the relatively small extent of this landform type in the study area and its relative importance to waterfowl, it is particularly sensitive to impact.

Rolling Coastal Plain. This complex landform type may also be affected by changes in water distribution caused by roads and pads. Drier areas would be affected because they are relatively few and of special interest as wildlife habitat.

Foothills. The greater topographic relief found in this landform type may affect the degree of impact caused by oil and gas development. Many areas in the foothills have numerous small drainage tracks, termed water tracks, on the sides of hills. Roads traversing these areas may alter drainage patterns along the water tracks. The amount of gravel fill necessary to construct roads and pads in this area will be greater than in coastal terrain because of the greater relief.

Alpine. Impacts to alpine terrain are unlikely to occur because of the small areal extent within the ANWR study area.

Riverine. Floodplains are likely to be the most heavily impacted landform in the study area because of the difficulty of avoiding these areas. They are obvious transportation corridors, many would be crossed by a coastal transportation route and they are often sources of gravel for construction. Hydrologic changes due to road construction or gravel removal may also cause changes in vegetation communities within the floodplain. Near Prudhoe Bay, floodplains are the areas most likely to contain rare disjunct plant species, such as the endangered plant *Thlaspi arcticum* (Walker 1981).

Habitat Rehabilitation

Consideration of impacts on vegetation and surface conditions should include the feasibility of restoration or revegetation in arctic Alaska. Restoration and revegetation needs are intensified by the potential for rapid thermokarst erosion of surface material. Obstacles to re-establishment and stabilization of vegetation and soils in ice-rich areas, particularly on slopes, may exceed the natural regenerative capacity of arctic tundra vegetation. In recent years there has been a significant increase in available information on restoration and revegetation of Alaska's arctic tundra (Mitchell 1970, McGrogan et al. 1971, Van Cleve 1977, Lawson et al. 1978, Johnson 1981). However, restoration techniques are still in developmental stages and success on a large scale has not been reported. Much work needs to be done before successful rehabilitation becomes a common occurrence.

Impacts to Wildlife and Fish

Birds

The potential impacts of oil and gas development to birds include direct loss of habitat or prey base; disturbance due to activities such as road traffic, aircraft, or industrial noise; and degredation of habitat and prey base due to alteration of drainage patterns and contamination by road dust, gravel, petroleum products, drilling muds, formation waters, or other materials. The potential effects of disturbance due to industrial noise, traffic, and oil spills were discussed in Chapter 8.

The results of 2 studies regarding the impacts of oil and gas development in the Prudhoe Bay field have not yet been published. A 2-year study was conducted by the U.S. Fish and Wildlife Service (Rothe pers. comm.) and a long-term study was begun in 1981 under contract to ARCO (Wolfe pers. comm.). These 2 studies will provide much needed information on effects of development on birds.

Brink (1978) found that contamination of vegetation, water, and soil by petroleum products was common along the trans-Alaska pipeline, and that all contaminated sites showed signs of habitat deterioration. Dusting of vegetation by road dust occurred during dry periods in spring and summer. Dust deposited during the winter promoted early melting of snow adjacent to the road in spring. The effect of the early melt area was to concentrate migrating birds in a narrow corridor where disturbance due to road and aircraft traffic was high. This area would also be more hazardous to birds due to the previously mentioned oil contamination.

Flooding of habitat areas due to improper drainage structures may have a great impact on birds. Although some birds use shallow ponds for feeding or resting, the areas which would be covered by water due to the improper road construction are usually much more productive habitat, such as drained lake basins (Bergman et al. 1977).

Oil spills caused by well blowouts, pipeline breaks, or tanker accidents may also have a major impact on bird populations, either due to direct oiling of birds or indirect contamination of prey. Truett (1980) stated that because coastal and marine birds and their prey are highly mobile, contaminated areas could be quickly repopulated and that uncontaminated birds could avoid areas of depleted food supply by moving into uncontaminated areas. However, he does note that low-level chronic effects will persist for a long period of time after a marine oil spill.

Caribou

The development of permanent oil and gas production facilities within the ANWR study area could have profound effects on caribou. Exploratory drilling programs would have varied influences on caribou depending on location, timing, number of wells, operation methods, and seasonal restrictions imposed. It is highly speculative at this time as to where, when and how oil and gas production and transportation facilities may be constructed and operated in the study area. Therefore, predicted consequences of these activities on caribou can only be general in nature, and must be drawn from the results of studies that have been conducted elsewhere and applied within the context of known caribou behavior and ecology on the study area.

Major elements of concern that have been identified in recent studies are: the effects of physical barriers on caribou movements; disturbance of caribou by aircraft, road traffic, or human presence; and the effect of sound, smell and visual stimuli. Concern has also been expressed regarding the physiological and bioenergetic effects of disturbance on caribou. The effects of aircraft disturbance were discussed in Chapter 8.

Physical barriers. The presence of ancient structures built by early hunters to deflect migratory caribou to ambush sites indicates an intrinsic vulnerability of caribou to physical obstructions. In spite of a long exposure to artifical barriers, caribou have not demonstrated a high degree of adaptability to this form of disturbance. On the other hand, caribou fences and associated early hunting activities apparently did not impact caribou significantly (Klein 1980). The orientation of caribou fences in northeastern Alaska and northern Yukon coincide with current caribou migration routes (Warbelow et al. 1975). In an effort to obtain comparative information on the reactions of *Rangifer* sp. to obstructions, Klein (1971) analyzed the experiences of Scandanavian reindeer with highways, railroads, and hydroelectric developments. In general, Klein (1971) found that considerable numbers of reindeer were killed each year from collisions with trains and cars. The development of a railroad and highway corridor near Trondheim, Norway apparently restricted the movements of a wild reindeer herd which ultimately resulted in overgrazing of ranges and herd reduction (Klein 1971). In an update to his 1971 paper, Klein (1980) reported numerous cases of railroads, highways, hydroelectric projects, pipelines, industrial developments, and disturbances which apparently caused obstruction, deflection, delays, and disturbance to caribou and reindeer populations in the Soviet Union, Canada, and Scandanavia as well as in Alaska. Jakimchuk (1980) reviewed many of the same case histories that Klein (1980) addressed and concluded that other factors may have been responsible for observed population declines that had been associated with man-made obstructions.

Experimental studies of physical barriers and caribou began in Alaska in 1971 at Prudhoe Bay (Child 1973). Using simulated pipelines, initial study results showed that a majority (78-85%) of the caribou encountering the simulation reacted by turning back or moving parallel to it until they could pass around it. It was also learned that the reaction of caribou to simulated pipelines depended upon age, sex, group size and composition, insect harassment, and previous experience. An important observation made by Child (1973) was that gravel overpass facilities functioned considerably better (18% vs. 5%

successful crossings) than an elevated "pipeline" in accomodating caribou movements. During periods of mosquito harassment, caribou were less reluctant to cross artifical barriers.

Studies initiated by the Alaska Department of Fish and Game in 1974 of caribou reactions to construction of the Trans-Alaska Pipeline found that cows and calves exhibited an avoidance reaction to the oil field, haul road and associated construction activity during spring and summer (Cameron and Whitten 1979, Cameron et al. 1979, Cameron and Whitten 1980). The spring of 1981 marked the 6th consecutive year that this avoidance behavior of cows and calves was documented at Prudhoe Bay (Whitten et al. 1981). Bull caribou on the other hand seem to be less sensitive (Roby 1978). In addition, the pipeline and road are apparently influencing east-west movements of caribou to some degree.

Caribou responses to the Dempster Highway in the central Yukon which transects winter ranges and migration routes of the Porcupine Caribou herd have been a subject of study. Surrendi and DeBock (1976) found that caribou responded differently depending on the type of habitat setting. In open tundra areas caribou appeared less inhibited, whereas in timbered areas they were more apprehensive when approaching the road. It was also found that high steep road embankments tended to deflect caribou, as did deep snow banks left by snow plows. During early studies when traffic rates were low, the Dempster Highway did not prove to be an insurmountable barrier to caribou. However, if vehicular traffic and human activities significantly increase, it is thought that a serious barrier to caribou movements may develop (Surrendi and DeBock 1976).

Surface Vehicle Disturbance. Disturbance reactions of caribou to road traffic has been studied by several authors (Klein 1971, Bergerud 1974, Villmo 1975, Surrendi and DeBock 1976, Johnson and Todd 1977, Roby 1978, Horeijsi 1981). It is clear that heavy or frequent traffic constitutes a more serious impact to caribou than the road structure (Klein 1971, Bergerud 1974, Villmo 1975), and can result in blocking or deflecting movements. Fast moving vehicles with clouds of snow or dust cause more disturbance to caribou than slow moving vehicles (Roby 1978, Horeisi 1981). Cows and calves seem to be more sensitive to vehicular disturbance than any other group of caribou (Roby 1978). Cameron and Whitten (1980) attributed observed avoidance of the trans-Alaska pipeline corridor by cow and calf caribou to vehicular disturbance as well as other cumulative factors. During winter, caribou seem to be attracted to roads where the snow is compacted, making them potentially vulnerable to collisions with vehicles (Calef 1974, McCourt et al. 1974).

Human Presence. The presence of humans is often a disturbing factor, especially if caribou associate potential harm such as hunting with human encounters (Calef 1974). Intensive hunting activites at caribou crossing points on the Taylor and Richardson Highways in Alaska caused delays in crossing (Skoog 1968, Curatolo 1975). A significant factor in caribou avoidance of an active oil drilling site was attributed to the workers attempting to approach and photograph caribou (Wright and Fancy 1980). The presence of man in concentrated calving areas can contribute to separation of cows and calves (Lent 1964). Post-calving aggregations at river crossings (Calef and Lortie 1973) are particularly vulnerable to disruption by the presence of humans which could result in stampedes, trampling, drowning, injuries and separation of cows and calves (Calef and Lortie 1973, Curatolo pers. comm.).

Sound, smell and visual stimuli. Gas compressor noise simulation studies found that during spring migration, calving, and fly-season movements, caribou did not respond when the sound source was beyond 270 m (McCourt et al. 1974). Calving caribou were reluctant to approach within 200 m of the sound (Calef 1974). Reactions of reindeer to sonic booms were characterized by Epsmark (1972) as moderate and did not include lasting behavioral changes.

Smell is believed to be the caribou's most sensitive sense (Kelsall 1968). Caribou have been known to detect the scent of humans at approximately 1.6 km. (Banfield 1954, as cited in Kelsall 1968). When caribou encounter a strange scent they often investigate to visually confirm the source (Bergerud 1974). There is a paucity of data regarding the effect of foreign odors on caribou.

Visual stimuli are associated with most other forms of human disturbance of caribou. It is believed that part of the influence of physical barriers is due to visual factors (Curatolo pers. comm.). Part of the reluctance to cross berms, roads, and other barriers may be due to a perceived danger of predators being associated with such structures (Roby 1978). It is not known if such associations are acquired as a result of predation or if it is an inherited characteristic. During intense insect harassment, caribou seem to overcome this fear of visual barriers (Child 1973). In general, caribou seem to be more sensitive to visual stimuli when sounds or smells are also present (Bergerud 1974, Tracy 1977, Roby 1978).

Impacts of Exploratory Drilling. The potential effects of exploratory drilling activities on caribou may vary. The timing of drilling related activities and location of drill sites are perhaps the most important factors in determining potential impacts to caribou. The period which has the greatest potential for conflict with the Porcupine herd is from mid-May to mid-July. In most years, large numbers of cow caribou of the Porcupine herd return to the study area for calving. Following calving (about June 20), cows and calves tend to move northward and sometimes westward in small "nursery bands" over the study area. In late June caribou usually begin to assemble into large aggregations. Most frequently these aggregations have been observed forming in the rolling terrain immediately south of Camden Bay. Usually there is a movement of the post-calving aggregations towards the east, either along the coast or on a more inland course (this varies from year to year). Usually by mid-July a majority of caribou of the Porcupine herd has left the study area. The period of mid-May to mid-July also coincides with the calving and post-calving activities of a portion of the Central Arctic herd in the vicinity of the Canning River delta. The sensitive period for the Central Arctic herd within the study area continues through mid-August when insect harassment declines.

Activities associated with exploratory drilling (site reconnaissance, site preparation, construction, drilling operations, maintenance, and termination activities) during mid-May to mid-July could directly intefere with calving and post-calving activities of the Porcupine and Central Arctic caribou herds. Cows and cows with calves exhibit a high sensitivity to disturbance during this period of their annual cycle (Lent 1964). Disturbance of caribou in the study area at this time could lead to local avoidance of calving and post-calving habitat in the vincinity of drill sites, during the period of human activity. Avoidance by caribou of the area adjacent to an active drilling site was observed by Wright and Fancy (1980) during the period of 9 June to 17 August. Potential consequences in addition to avoidance of drill site areas, would be increased cow-calf separations, injury due to trampling (especially calves), and increased energy expenditure leading to increased calf mortality, as a result of disturbance from aircraft associated with drilling activities. The consequences of distrubance of calving and post-calving activities in drill site areas on a population level are not known.

Caribou of the Central Arctic herd remain in the study area after mid-July, seeking relief from insects by frequenting the coastal areas of the Canning River delta and Camden Bay. Activities associated with drilling in this area during mid-May to mid-August could disturb caribou. During the remainder of the year, varying numbers of the Central Arctic herd are found scattered throughout western portions of the study area. In the winter season, Central Arctic herd caribou frequent the southern uplands in and adjacent to the study area (along the Sadlerochit Mountains and east to the Jago and Aichilik Rivers). Drilling activities in the study area could affect these caribou during the winter months. It is expected that caribou would be locally displaced from the immediate drill site area during period of human activity. The consequences of such displacement, however, are not known.

If gravel pads are used to construct drill sites, some vegetative habitat for caribou will be destroyed. The extent of such losses are dependent on how many wells are developed and where they are located. Judging from exploratory drilling programs elsewhere to date, the loss of habitat from gravel pads does not appear to be a significant factor for caribou.

Impacts of Oil and Gas Development and Production. Of all the activities described in this report the development of oil and gas production and transportation facilities in the study area constitutes the greatest potential for long term negative impact to caribou. Because of the demonstrated sensitivity of cows and cows with calves to disturbance, it is expected that those components of the Porcupine and Central Arctic herds may avoid oilfield development in the study area. The potential consequences of displacement from traditional or preferred calving grounds, disturbance of post-calving aggregations, and interference with insect harassment movements were described in the preceding section. The calving and post-calving grounds of a caribou herd are the one place at which most of the herd can be found together every year and any development such as a permanent oil field facility could be encountered annually by the herd. In the case of the Porcupine herd, the calving grounds are a narrow area of Arctic Coastal Plains and foothills restricted by the Arctic Ocean and the Brooks Range. The calving grounds of other herds in arctic Alaska are not as restricted physically and may have more alternative displacement habitats. The calving and post-calving activities in this limited environment are thought to be the most sensitive and vulnuerable events in the annual cycle of the Porcupine herd. The new born calves are susceptible to a variety of environmental factors and have the highest mortality rate of any cohort in the population. Disturbance or displacement from preferred habitats could contribute to increased calf mortality and potentially influence herd numbers.

Pipelines, roads and other linear structures associated with oilfield development and production of petroleum resources from the study area could impede the natural movements of caribou in the study area. The results of such restrictions could lead to abandonment of traditional ranges, as well as reduced, fractured herds which are less migratory and collectively number less than the original herds (Klein 1980, Lent pers. comm.).

Comparisons between the Prudhoe Bay-Central Arctic herd situation may be of limited value in predicting the effect of an oilfield development in the study area. The Porcupine herd may have different behavioural characteristics from the Central Arctic herd (Klein 1980). It has been demonstrated that caribou tend to habituate to obstructions if the caribou are resident in the area of the obstruction (Klein 1980). This may be somewhat the case with the Central Arctic herd at Prudhoe Bay. The Central Arctic herd does not migrate great distances from the Arctic Coastal Plain and in many years they are year round residents. The Porcupine Herd, on the other hand migrates over much longer distances and normally uses the study area seasonally. Thus habituation to oilfield obstructions and disturbance by the Porcupine Herd may require a longer time than that of the Central Arctic herd which is generally more resident to the vicinity.

With regard to the Central Arctic herd, an oilfield development and production operation in the study area may, in conjunction with the existing oilfield at Prudhoe Bay, exert additional influence on the herd. If Central Arctic herd animals are displaced from their calving habitat on the Canning River delta, as well as from the Kuparuk calving area where oilfield development is currently occurring, in additon to the present displacement from the Prudhoe Bay area, there may be few suitable alternative calving areas left for that herd.

It is difficult to predict with accuracy what effect oil field development and production would have on the long-term survival of a caribou herd. At the present time it is not known how important a particular portion of traditional or preferred calving habitat may be to long term productivity of the herd. The ability of a caribou population to adjust to productivity losses or increased mortality through other mechanisms is not known. The importance of post-calving aggregation in terms of long term stability of a herd also is not understood. And, it is not known whether cows and calves will habituate to oilfield disturbance over time. Thus far, cows and calves of the Central Arctic herd have avoided the Prudhoe Bay oilfield for about 6 years and there has been no observed reversal of earlier trends.

Muskox

Muskoxen are year around residents on the study area. It is difficult to predict, with any certainty, where drilling might begin or the extent of possible subsequent development on the study area. We do know from exploration that has already taken place elsewhere and from developments in and surrounding Prudhoe Bay that there will be a need for water and gravel in large quantities. Millions of cubic yards of gravel and thousands of gallons of water are required for a Prudhoe Bay scale development. Gravel used for oil development on the north slope of Alaska has come principally from braided river channels. It is also along river channels that favorable habitat for muskoxen. Gravel removal from river beds may result in the outright destruction of favorable muskoxen habitat or alter stream hydrology to indirectly result in habitat loss.

Drilling pads, mud pits, sewage lagoons, and associated airstrips also deny the use of potential habitat through outright alteration. The zone of habitat loss around occupied man-made structures would likely be larger than just the area occupied by the physical structures due to the effects of disturbance. The extent of this loss cannot be predicted but would exist for the time the stimulus was present.

With commencement of drilling activity in the study area, the level of disturbance/harassment to the muskoxen population will increase. Increased noise from nearby oil rig machinery, and from both fixed wing and rotor wing aircraft can be expected around drilling rigs and camps. Since exploratory drilling is most frequently a winter activity on the north slope the stress level on muskoxen will be increased at a time when the population is already under maximum stress from natural environmental factors. Miller and Gunn (1979) predict that almost any interference with the distributions of muskox by foreign activities which drive them from their preferred ranges will have a marked effect on the segment of the population concerned.

The long term effects on the muskoxen population from oil exploration and development are uncertain. The impact on the population will depend on such factors as magnitude and location of development, amount of habitat lost through alteration, and the level of disturbance to which the population is unable to habituate.

Moose

If oil and gas development and production facilities were limited to the coastal plain (i.e. drill rigs, pads, roads, pipelines, etc.) the potential impacts described in Chapter 8 would still apply. In addition to those impacts, moose using the coastal plain would be subject to human habitation of the area. Moose are normally very tolerant of most human activities (Kucera 1974). However, elevated pipelines may impede movements through a given area (Hinman 1974). Use of the coastal plain by moose appears to be a wandering type of use and the effect of an elevated pipeline on those segments of moose populations using the coastal plain is unknown.

Habitat alterations on a relatively small percentage of the coastal plain would also occur as a result of development, but summer use by moose would be only slightly affected. However, if development activities were to take place in the more critical wintering habitats along the Canning and Kongakut Rivers, then impacts to moose population could be expected, dependent upon the type of development. Again, the overall effect of development on moose populations is unknown.

Wolverines

Intensive oil and gas development activities within the ANWR study area will most likely displace wolverines from such areas. The frequency of wolverines sightings near human development sites in the Alaskan arctic have been noted to decline as human activity intensified (Quimby 1974). Since little is known about the location of wolverine home ranges in the ANWR study area and sites of possible future intensive oil and gas activities are yet to be identified, an accurate assessment of the consequences of further development cannot be made.

Polar Bears

The effects of oil and gas development and transportation on polar bears may include direct habitat loss, undirect habitat loss or degredation, impacts to food supply, or problems associated with oil spills.

Denning Bears. A large development facility might be located in an area used for denning by pregnant female polar bears. Because polar bears are thought to show fidelity to birth sites and try to reach the area previously used for denning (Lentfer and Hensel 1980), a large facility could deflect a bear from a preferred onshore den site. It is unknown how important traditional sites are and specifically what effect such a deflection would have, although it is thought that denning success is much lower on the pack ice (Lentfer 1974).

Noise and activity associated with an oilfield facility or road, or the presence of a pipeline, may deflect female bears from traveling to denning sites onshore. A road parallel to the coast which has heavy use could cause bears to avoid inland denning sites along the length of the road. Roads perpendicular to the coast would have a much smaller impact (Lentfer and Hensel 1980), although a road within a floodplain where potential denning habitat exists could have an impact on denning female bears and cubs and emerging females and cubs as described in Chapter 8.

Non-denning Bears. The impacts of oil and gas development to non-denning segments of polar bear populations are not well known. This segment of the population generally inhabits the pack ice throughout the year, although in the fall a number of animals, primarily family groups composed of females and juveniles, are seen along the coast (Amstrup pers. comm.). The potential direct impacts to bears inhabiting the pack ice would be disturbance due to oil tankers or an accidental oil spill from an oil tanker or loading facility. Simple disturbance is not likely to have a great effect on non-denning bears. Direct effects of oil contamination are not well known. Initial results of a study conducted in Canada (Hurst et al. 1981) indicate that bears forced to enter an oil slick and then subjected to cold temperatures and wind are likely to die. However that study did not determine if polar bears will enter an oil slick of their own accord.

Family groups of bears which scavenge on whale carcasses along the coast may be affected by oil and gas development in the ANWR study area if they are attracted by garbage or curiosity to a populated area. Because bears are attracted to the Barter Island area due to whale remains, an oil and gas facility located nearby may have a higher occurence of nuisance bears than other existing facilities presently report.

Polar bears may be affected indirectly through their primary prey, ringed seals. Local reductions in ringed seal populations may cause bears to desert an area in search of prey. Lack of an immediately available food supply may be critical to survival of females and cubs just emerging from the den (Lentfer 1974). Such a reduction in ringed seal numbers may be caused by ice breaking tankers as described below.

Ringed Seals

The impacts of development of oil and gas resources to ringed seals are likely to be similar to, but more intense than, the impacts of exploration. The sensitivities of ringed seals to disturbance were discussed in a previous section on exploration impacts and will only be summarized here. Further seismic exploration would likely be required before development begins. The impacts to ringed seals discussed in the previous section may become somewhat more acute because of the extended period of exploration. Those potential impacts are disruption of feeding or food supplies, but would probably remain minor in magnitude because the ANWR study area contains relatively poor seal habitat.

Development, production and transportation of oil and gas resources could affect ringed seals primarily in 2 ways: an oil spill caused by a well blowout or tanker crash, or chronic pollution from small scale fuel or oil spills or other chemicals kept at shore based facilities (Burns et al. 1980). A catastrophic oil spill may cause either local short term or extended long term impacts. If the spill were to occur within a lagoon system, it is likely that oil would remain mostly in the lagoon, and impacts to seals would be minor. Also, if a spill were to occur during the summer, it could be cleaned up fairly easily, thereby keeping impacts to a minimum. However, if the spill were to occur offshore and during the winter or early spring, the impacts would be major. Adult seals could experience severe eye damage, affecting their feeding. Young seals could be oiled and die. Prey species such as arctic cod could experience egg, larval, or adult mortality. Nektonic invertebrate populations could also be affected. However, the severity of these impacts depends on many variables and no quantitative description of them is possible (Burns et al. 1980).

Chronic pollution of waters inhabited by seals may be a greater long term problem than an oil spill. However, because the effects of low level contamination of waters to seals or their prey is not known, it is not possible to quantify these impacts. Further studies on these questions are necessary.

One other possible source of impact to ringed seal populations from transportation of oil and gas resources lies in the possibility that ice breaking tankers would be used to carry the oil to market. If the tankers travel through ice areas that are used by seals for denning and pupping, there is the possibility that a large area of seal habitat would be destroyed. The extent of impact depends on the timing and amount of tanker traffic, and the location of the routes.

Bowhead Whales

Development and production of oil and gas resources in the ANWR study area could have much greater impact on bowhead whales than exploration. Potential impacts to whales are related to shore based facilities, ocean freight traffic, and ocean going oil tankers or submarines.

Shore based facilities may disturb bowheads due to noise generation or contamination by fuel or oil spills. Supply shipping can disturb whales due to noise, while tankers pose the additional risk of oil spill. The effects of noise disturbance were discussed in Chapter 8. It is possible that heavy boat traffic could cause bowheads to desert areas near the coast which they normally use (Fraker et al. 1981). The long-term impact of such disturbance is not known, although the effect on subsistence hunting of the whales by residents of Kaktovik could be significant.

The effects of toxic substances to whales are unknown. It is possible that foreign substances might disrupt a whale's ability to locate food by masking its chemoreception. Damage to active epidermal cells is also possible (Fraker et al. 1981). Another potential impact is the chance that oil would foul the baleen of bowheads, making them less efficient in feeding, or causing the whales to stop feeding (Fraker et al. 1978).

Other Marine Mammals

Beluga whales and bearded seals are found only occasionally near the study area. Impacts of oil and gas development and transportation to these animals are expected to be negligible.

Fish

Major problems potentially threatening fishery resources in the arctic during oil development include; water and gravel demands, construction impacts, environmental contamination, and increased population demands on the fisheries. Water and gravel demands pose the most significant problems. Water is required in all phases of oil development. These uses include water for: potable and other domestic uses, drilling operations, make-up water for cement and slurry sand, dust control, ice road and airstrip construction, truck and car washing, coolant for power generators and vehicles and for secondary oil recovery operations. Wilson et al. (1977) summarized water use demands related to oil development at Prudhoe Bay. Camp requirements for geophysical exploration rarely exceed 100 gallons per day (gpd). Exploratory drilling required an average of 40,000 gpd per drill site. Average water usage projected for 7 of Husky's Oil Company's exploratory wells was 1,037,000 gallons per well drilled. Potable water demands for Atlantic Richfield's camp facilities at Prudhoe Bay for 1977 were reported between 200,000 to 240,000 gpd. Water used for ARCO's development drilling was estimated at 50,000 gpd per rig. Service camps at Deadhorse use an estimated 120,000 gpd. Table 2 (Wilson et al. 1977) shows total projected water use for the Prudhoe Bay development, winter 1976-77. One of the greatest future demands for arctic water supplies may ensue from secondary oil recovery operations. During recovery operations water is used to restore subsurface pressures to facilitate further oil extraction. Wilson et al. (1977) estimated that this would take 84 to 126 million gpd.

Table 2 Total projected water use, Prudhoe Bay development, winter, 1976-77

User	Daily Consumption (gpd) Minimum Drilling[1]	Maximum Drilling[2]
Atlantic Richfield		
Camps	200,000	200,000
Drilling	160,000	240,000
BP Alaska		
Camps	96,000	96,000
Drilling	51,000	102,000
Service Companies		
Deadhorse Camps	120,000	120,000
Totals	627,000[1]	758,000[2]

1 Assumes 6 rigs operating
2 Assumes 10 rigs operating.

The amount of water needed for oil development contrasted with its lack of availability poses serious threats to fishery resources, particularly during severe winter weather conditions. Impacts of water withdrawal may produce long-term irreversible effects. All life stages of a particular species may be located in a single isolated pool where potential impact would be upon the entire genetic population. Ward and Peterson (1976) reported that overwintering pools located in the Sagavanirktok, Canning, and Hulahula Rivers become completely isolated (without recharge) when sections of the river freeze solid. Effects of water withdrawal on fish populations includes: direct mortality, indirect mortality from waste concentration, and dewatering marginal gravels containing developing fish embryos and fry. Bendock (1976) reported masses of grayling fry and insects at the surface of one dewatered hole. Impacts of dewatering may also cause fish to change overwintering areas and therefore impact subsistence fisheries.

Alternative winter water sources, where minimal impact would occur, are not abundant. Tundra lakes are generally of poor quality and must be treated to be potable, or they are so shallow that they freeze solid (Schallock 1976). Other deep lakes may contain fish populations. Wells may ultimately take water from overwintering sites.

Gravel demands for oil development in the ANWR study area may require thousands of cubic m of material and consequently presents a significant threat to arctic fish communitites. Gravel will be required for road and airstrip constuction, for drill pads in both exploratory and production phases of oil development, and in pads for storage areas, living quarters, waste treatment facilities, flow stations and other construction activities.

The affects of gravel removal on fisheries and aquatic habitat in arctic floodplains was documented by Woodward-Clyde Consultants (1980). They identified 5 major categories of effects on the aquatic habitat: increased channel braiding, removal of bank and instream cover, migration blockages, entrapment areas, and siltation. Increased channel braiding was evident where flow increases inudated mined areas along rivers and where gravel deposits were scraped to below the waterline. Consequently, depth and velocity were reduced, with a resulting decrease in the diversity of the fish community. This alteration also increased the probability of aufeis formation. The presence of aufeis prolongs recovery of the site, as the channel and substrate remain unstable. Siltation persists through the melt-off period and water stored in the aufeis field becomes unavailable for downstream overwintering areas.

Densities of char and grayling were lower in areas where portions of undercut banks were removed to access underlying gravel deposits (Woodward-Clyde 1980). Other investigators have reported that reductions of bank and instream cover adversely affects fish populations (Hobbs 1947, Boussu 1954, Hunt 1968, Haines and Butler 1969). Increased wetted perimeter and decreased depth resulting from gravel mining operations could lead to fish passage blockage. Extensive backwater areas created by mining operations can entrap fish during low flows and cause mortalities by increasing vulnerability to predators and by subjecting fish to suboptimal temperatures and dissolved oxygen concentrations. Siltation becomes an immediate problem during gravel removal operations. Indirect effects arise from erosion of inudated mined areas. Primary affects of siltation are on spawning and feeding areas. The effects of siltation on fish populations has been documented by Cordone and Kelly (1961), Hollis et al. (1964), and Everhart and Duchrow (1970).

Activities related to road construction adjacent to rivers and river crossings may considerably impact fish populations. Debris associated with stream crossings could cause jams creating a barrier to fish migration. Barriers could also result from improperly designed and/or positioned culverts, creating high water velocities (USFWS 1970). Spawning grounds could be affected by siltation and erosion from road construction activities. Direct mortality of eggs and fry could arise from movement of heavy equipment over spawning areas.

Environmental contamination from sewage wastes, and fuel and oil spills are potentially threatening to arctic fish populations. Domestic wastes entering arctic aquatic ecosystems may cause severe dissolved oxygen depletions particularly during low water, winter conditions when the assimilative capacity is much reduced. Dissolved oxygen depletion can cause direct mortalities and long-term damage to the food structure of arctic waters (Craig and McCart 1974, Schallock 1976).

Large amounts of fuel are required for arctic oil development. Impacts of fuel or oil spills would be greatest to spawning or overwintering areas by causing either direct mortality to all life history phases or indirect degredation of spawning and feeding areas.

Increased population density in the arctic arising from oil development will increase fishing pressure. Several characteristics of arctic fish populations make them highly vulnerable to overharvest. They exhibit slow growth, poor recruitment, and late maturity. High concentrations of some species, during spawning and in overwintering areas make them much more vulnerable to exploitation. Craig and McCart (1975) stated that selection in the fisheries for the larger spawning population would disproportionately harvest females therefore reducing the reproductive capacity of the populations. A summary of impacts related to exploratory drilling, production and development are listed in Table 3.

Table 3. Summary of exploratory drilling, oil development and production impacts on Arctic fish.

Operational Requirements	Possible Impacts	Effects
<u>Water Demands</u> Drilling operation Domestic supplies Road and airstrip construction Secondary oil recovery operations Miscellaneous uses	Dewatering overwintering and spawning areas	Direct mortality of all stages of species life history. Reduced water quality stressing fish populations and organisms. Fish movement out of traditional wintering areas effecting subsistence fisheries. May lead to destruction of whole genetic populations.
<u>Gravel Demands</u> Road and airstrip construction Drill pad construction Camp and living quarters Miscellaneous uses	Inudation of stream channels, erosion and siltation, increased channel braiding. Increased aufeis formation - limiting flow to overwintering areas. Reduction of bank and instream cover. Physical destruction of spawning and overwintering areas. Creation of fish entrapment areas. Creation of migration barriers.	Direct mortality of fish eggs and fry. Reduced water quality. Reduced carrying capacity. Alteration of migration routes and destruction of spawning areas. Stress/mortality of winter concentrations of fish. Degradation of food organism's habitat.
<u>Road Construction Activity</u>	Inudation of stream channel, erosion siltation, fish passage blockage.	Direct mortality of eggs and fry. Degradation of feeding and spawning areas. Alteration of migration routes. Stress - Reduced water quality. General reduction in fish density.

Table 3. (Continued)

Operational Requirements	Possible Impact	Effects
Domestic Waste Disposal	Discharge into rivers and lakes	Decrease dissolved oxygen. Direct mortality of fish, eggs and fry. Alteration of food structure. Fish movement out of traditional wintering areas - impacting subsistence fisheries.
Fuel and Oil	Spills into aquatic environment.	Direct mortality and/or stress upon all life history phases. Degradation of spawning and feeding areas.
Population Increases	Fishing pressure increase	fish overharvest. Alteration of reproductive capacity by selection of the larger sized spawning females.

Impacts to Human Culture and Lifestyle

Archaeology

Development and transportation of oil and gas resources on the ANWR study area have the potential of negatively affecting cultural resources. Direct impacts may include burial by gravel for well pads, roads, or airstrips; destruction of sites by vehicle traffic or other construction activities; and use of sites for gravel or rock material.

Construction of either seasonal or permanent well pads, roads, airstrips, pipeline access pads, docks, or other facilities may bury archaeological sites within the construction zone. The extensive network of roads and facilities found in a developed oil field has a greater potential impact than do a few exploratory wells due simply to the amount of construction per unit of land surface. A special problem may be encountered in the ANWR study area if an oil reservoir is along the coastline or nearshore, as appears to be the case in the Pt. Thomson Unit. In that case, well pads would be concentrated along the shoreline, which is an area in which archaeological sites are concentrated.

It is possible that construction activities taking place without benefit of roads or construction access pads could affect archaeological resources. Some examples of this are bridge abutments, pilings and pipelines, either buried or above ground, constructed using ice pads.

Cultural resource work done during previous construction activity in Alaska has indicated that knobs favored as gravel sources also were favored as activity areas by previous occupants of the area (Cook 1977).

It is also possible that there may be indirect or secondary impacts from oil development related activities. This could occur due to roadways altering the hydrological regime of a river causing bank erosion; docks, causeway or gravel borrow accelerating beach erosion; ponding behind improperly culverted roads leading to thermokarsting; or humane destruction or looting of archaeological sites.

Subsistence and Other Socio-Economic Features

The socio-economic impacts of petroleum development and production would be similar to those described for seismic exploration, only many times the magnitude. Impacts would depend on the size of development, its location and location of support facilities, transportation modes and corridors, and many other factors not discernible at this time.

The first category of socio-economic impacts are those which would affect the land and the resource base. Those impacts are outlined in the wildlife resources sections. Impacts on historic (TLUI) sites and subsistence areas could occur both from development itself and from the influx of people from outside the area, whether associated with development or increased access. Damage to or disturbance of traditionally used sites and areas may direct subsistence use from formerly productive areas to less familiar areas, resulting in longer and costlier journies and uncertain harvests. Impacts on TLUI sites and subsistence areas, both terrestial and marine, may also engender feelings of anxiety or hostility on the part of Inupiat residents.

Subsistence-related impacts could also occur from increased competition for fish and wildlife, making subsistence hunting and hunter success more difficult (USGS 1979).

The second category of socio-economic impacts are those that could interfere with subsistence activitites or socially impact the village and the region. If people could no longer hunt successfully due to development-related impacts on the wildlife resources, the traditional bases of esteem and leadership in the village may erode as the outstanding hunters lost status. This would impact the social fabric of the village. The boredom and loss of identity resulting from the loss of meaningful activity could increase alcohol and drug abuse, crime, and other health problems (USGS 1979).

Oil development in the ANWR study area could affect the growth and composition of both the local and the regional population by bringing in workers from other areas of the state and nation. Better access could increase tourists and recreational visitors. The influx of people resulting from development and improved access could impact Kaktovik's social structure, which revolves around family and kinlike alliances. The village power base could switch from Native to non-Native, making Inupiat residents feel like political step-children. The resulting loss of self-esteen, together with the increased amount of money available from the increased number of jobs, could intensify the already serious problems of alcohol and drug abuse, crime, and other health problems (USGS 1979). The degree of impact would depend largely on the mode of access. An overland transportation corridor, for example, connecting the Dalton Highway with Kaktovik, would probably have the greatest amount of social impact if it were open to the public. Increased air and barge transportation, on the other hand, would cause less social impact (Wentworth 1980).

Petroleum development and production could increase the number of jobs in the region and opportunities for small business, thereby increasing local economic stability. Tax revenues might also increase, making more money and jobs available to the North Slope Borough and villages. Development in the region could increase investment opportunitites for the Arctic Slope Regional Corporation. It could further increase the area's salaries, cost of living, and regional inflation. Increased pressure on local housing and infrastructure would also occur (USGS 1979).

Impacts to other villages from production of oil and gas in the ANWR study area would be similar to those for oil and gas exploration, only many times the magnitude. As stated previously, impacts on wildlife populations would have effects on subsistence uses of those populations and subsequently on local economic and cultural patterns. For villages outside of the immediate production zone, direct impacts would be minor. Arctic Village may see a greater increase in aircraft flights and helicopter operations than in an exploration phase, which may affect the economy.

Recreation

The effects of oil development on recreational activities in the study area would be similar to the effects of oil exploration. Development activities will largely destroy wilderness values and alter or destroy scenic values on a year-round basis. A change in the wilderness qualities would discourage wilderness oriented recreation due to destruction of esthetic values. However, some developments, such as roads and airstrips, have the potential to increase access for recreational users for whom a wilderness experience is not necessary.

Impacts on recreation will be closely linked with facility development and human activity. The overall effect may be to bring about a change in the type of recreationists who visit the area. This type of recreationist may not need wilderness as much as those people presently attracted to the area; those recreationists needing true wilderness to satisfy their recreational needs will be displaced to other areas where wilderness characteristics are still available. This phenomena of social succession has been noted by Hendee and Stanky (1973).

Facilities such as drilling pads, pipelines, pump stations, treatment stations, camps, and power plants would likely physically prohibit recreational activities from taking place, through regulation. The development, even though limited to a relatively small area, would have far reaching impacts on the scenic resource. It would be difficult to hide such development on the treeless and essentially flat coastal plain. The visual impact of such development would have a negative impact on scenic resources, an important wilderness component.

Odors generated by machines or waste materials will negatively impact esthetic qualities of the area, and therefore recreational uses. The overall increase in activities and disturbance would remove the opportunity for experiencing the solitude and serenity which are characteristics of wilderness.

Roads and trails, especially if opened to the public, would have high impact on recreational activities. Roads and trails would provide improved access for recreationists. With increased access recreation use may increase. If access is complete enough, for example, if the Dalton Highway is opened to the public to Prudhoe Bay and a spur road to Camden Bay or Kaktovik is also opened, the potential for overuse, at least in local areas, will exist.

Water consumption or siltation caused by construction may adversely affect float-boating or fishing opportunities in the affected rivers. If too much water is removed from the river, recreational fishing may be negatively affected. Gravel mining could cause increased channel braiding and shallower water which would inhibit river trips.

Increased aircraft flights will decrease the quality of the wilderness experience far from the development sites. The number of aircraft seen during a 1 week trip in the Arctic NWR greatly affects the quality of trip experienced by visitors (Warren 1980). Warren reported that more aircraft sightings contributed to a lower quality of experience. Airstrips or runways could have beneficial or adverse effects on recreationists. More airstrips would mean improved access for recreational uses of a given area, but a permanent or heavily used airstrip would reduce the wilderness qualities of an area. Increased access may also cause overharvesting of game by sport hunters, which may impact subsistence lifestyles or cause game population declines.

If an increase in recreational use is the result of oil related development, it is possible that there will be a demand for facilities on ANWR that are not now available. The construction of facilities such as visitor centers and public use cabins would further alter the wilderness characteristics which now exist in the refuge.

Wilderness and Natural Landmarks

With the decision to develop the oil and gas potential of the ANWR study area, the decision against wilderness classification will essentially have been made. The development of drilling pads, pipelines, permanent camps, airstrips and the general increase in air and ground activity would render the area ineligible for wilderness classification. The possibility exists for restoration when and if oil activity ceases; however, to return the area to its present wilderness condition would be an extremely slow process. In addition, the impact of the loss of the wilderness status of the study area would have far reaching impacts on people who will never visit the area, but derive satisfaction merely from knowing that it is there.

Natural landmark eligibility will be negated in an area with permanent oil development. With complete clean-up and restoration, there is the possibility that these sites would again be eligible in the future.

Data Gaps

A major area of information lacking for this chapter's discussion of the potential impacts of further exploration, development, and production of oil and gas in the ANWR study area is the potential location, size, and extent of the petroleum reservoir. Most impacts which could occur to the vegetation, soils, fish, wildlife and human resources of the study area vary according to site-specific factors. Thus, determination of the presence and location of a petroleum reservoir is necessary. This information will be obtained during the exploration program which may begin after 2 December 1982.

Vegetation and Surface Resources

More detailed information on the vegetation and soils of the study area is needed. Verification of the vegetation classification obtained through Landsat imagery analysis is important. Mapping of selected habitats at a smaller scale would also be helpful.

Studies of the impacts of construction activities and facilities associated with oilfield development to vegetation which have not yet been published (Fish and Wildlife Service and ARCO Alaska Inc.) are expected to provide an adequate basis for the Report to Congress, regarding the impacts to vegetation, *per se*. However, the effects of vegetation alteration or degredation to wildlife need further study. Also, study of methods to minimize construction impacts to vegetation is needed, primarily regarding placement of adequate culverting to pass sheetflow water in wet tundra areas to prevent ponding. More study is needed concerning ice/snow road construction, use, and impact. The availability of adequate quantities of snow and water is quetionable (Berger 1977). Further, use of ice/snow roads may have a greater affect on vegetation and soils than previously thought (Everett 1981).

Additional investigations on the causes of reserve pit failure and effects of spilled drilling muds on terrestrial systems, both long and short term, are needed. These may be conducted by the FWS in the Prudhoe Bay area beginning in 1982 (Stroebele pers. comm.) and may be continued in Canada (French and Smith 1980). Rehabilitation and revegetation techniques need to be studied further, but in addition, several past studies, such as those in NPR-A also should be reported to be a value.

Wildlife and Fish

The bird studies proposed by the Outer Continental Shelf Environmental Assessment Program and the continuation of studies being conducted for ARCO Alaska Inc. in Prudhoe Bay and the Kuparuk River field, will both fill in gaps in information needed regarding impacts of oil development on birds. Other studies needed for baseline information on bird populations in the ANWR study area, such as swans, snow geese, oldsquaw, and tundra nesting birds are planned (see Chapter 1).

Continuation of studies within the Prudhoe Bay and Kuparuk fields is needed to better delineate the effects of disturbance and human activity on caribou. Specific studies of the eastern segment of the central Arctic Herd and of the Porcupine herd should also continue, with emphasis on migration, calving, post-calving, and effects of predators. Habitat utilization investigations are also needed for the Porcupine herd. These studies are planned by the FWS and the Alaska Department of Fish and Game.

Further studies of muskox calving areas, productivity, and habitat use are needed. Clarification of both short term and long term impacts of disturbance is also necessary, although some information may be furnished by Canadian studies. Monitoring of use of the ANWR study area by moose is the primary information needed regarding moose. Investigation of the population and habitat use of wolverines are needed.

Further information on the location and behavior of denning polar bears is currently being conducted by the FWS. Studies suggested in Chapter 8 regarding impacts of exploration will also be of value related to development impacts. Studies of other marine mammals by the OCS Program should be most useful.

The primary information needed regarding fish and the impacts of oil development is the investigation of the locations of fish spawning and overwintering areas in the ANWR study area. Implementation of a study on springs and their support of overwintering fish populations may also be necessary.

Human Culture and Lifestyle

More detailed studies of the potential economic and social impact of a nearby oil development to the village of Kaktovik and the North Slope Borough are needed.

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APPENDIX I.

CLASSIFICATION OF VEGETATION AND LAND COVER
IN THE ARCTIC NATIONAL WILDLIFE REFUGE
USING LANDSAT DIGITAL DATA

Three Landsat scenes were selected for analysis. The eastern two-thirds of the region were covered by scene 22008-20420 (22 July 1980) acquired from the Canada Centre for Remote Sensing after a check of the data base showed that it was unavailable from U.S. ground stations. Most of the remainder of the region was covered by scene 21633-20531 (13 July 1979), while a small wedge in the extreme southwest was picked up on scene 2570-20462 (14 August 1976). Differences in spectral response from scene to scene and in phenological changes in vegetation from year to year owing chiefly to different moisture regimes, necessitated that each scene be treated separately in the analysis process.

Four test sites had been visited in the field during the summer of 1981. Vegetation of these sites had been delimited on 1:60,000 scale color infrared photographs based on the field data. These sites were identified in the Landsat scene, and spectral clusters were obtained for each. These clusters describe in statistical terms (means and covariances) the spectral properties of Landsat pixels. Clustering sorts the Landsat data into classes whereby pixels within each class are as similar to each other as possible, and whereby pixels from different classes are as different from each other as possible.

After clustering, an analyst assigned vegetation class labels to each based on the ground data. Additional spectral classes were defined for specific vegetation types by finding those types in the Landsat scene, delimiting boundaries of each, and then submitting those pixels to another clustering. General spectral classes were defined by clustering large samples of the Landsat scenes being used.

The clusters were examined for each scene, and an analyst made decisions concerning which clusters to keep, delete, or merge before using them in the classification process. These decisions wee made on the basis of an analysis of the spectral statistics, especially measurements of cluster spearability. In general, an attempt was made to utilize clusters that described well-defined vegetation types with a minimum of conflict among the various clusters in terms of spectral overlap.

Once a set of statistics was defined for each scene, maximum likelihood classifications were run for each. In this process calculations are run for each pixel indicating the closeness of fit of the spectral properties of each to every one of the pattern clusters. Classification is to the cluster most likely the same as the pixel in question. In this way all pixels were classified into spectral classes defined by the clusters.

Results were viewed on a color digital image display. Using the display, the analyst was able to view selected portions of the Landsat scene and give each spectral class a distinctive color while he tried to identify the vegetative characteristics of it from field notes and higher resolution serial photography. This interpretation step was most important and was aided immensely by the fact that one of the analyst-interpreters was expert in classifying vegetation in the field in Arctic Alaska.

Each of the clusters was interpreted and identified. Land cover types describing vegetation took shape as minor variations and fluctations in spectral clusters were amalgamated into larger units. Care was taken in looking for and resolving conflicts between Landsat scenes in developing the final 12 land cover classes.

Control points, features identifiable on a map and in the Landsat data, were selected to compile parameters needed for geometric correction of the data. About thirty, well-distributed points were selected for each scene based on the 1:63,360 scale topographic maps and gray scale prints from the Landsat data produced on a lineprinter at approximately 1:24,000 scale. Using these parameters each scene was corrected to a UTM production (Zone 6) and resampled so that resulting pixels were 50 meters on a side. Once the data had been corrected to a common base, they were digitally mosaicked into one data set.

Meanwhile, a special base map was compiled from a mosaicking of four USGS 1:250,000 scale quadrangles. A tape of the mosaicked Landsat data was used to drive a large format laser plotter to generate three color separation plates at 1:250,000 scale. These were registered to the base map for printing the final map, USGS Map I-1443.

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Table 1. Land cover classes and assigned map colors for Landsat Scene 20420, Barter Island, Alaska (22 July, 1980).

Dominant Land Cover	Dicomed Color	Spectral Category
Water, turbid.	dark blue	1, 2, 3, 4, 5, 6
Pond complex, aquatic vegetation. *Carex aquatilis*, *Arctophila fulva*, up to 50% tundra.	aqua	7
Wet sedge tundra. Wet/moist sedge tundra. Wet/moist complex.	dark green	15, 17, 19
Moist sedge tundra. Moist/wet sedge tundra. Frostscar tundra*.(20420)	light green	20, 22
Moist sedge tundra. Moist sedge prostrate shrub. Frostscar tundra*.(20531)	sand	21, 23, 25
Tussock dwarf shrub tundra. Tussock prostrate shrub tundra. Moist sedge tundra with tussocks.	tan	26, 27
Dwarf shrub tussock tundra. Complex of tussock dwarf shrub tundra with water tracks.	dark brown	28, 29
Shrub tundra in high density water tracks and on south facing slopes.	red	30, 31
Partially vegetated areas (river bars, lichen-covered mountain barrens, lichen-covered sorted stone nets). *Dryas integrifolia*-forb tundra sand dune community. Sedge prostrate shrub tundra along stream. Prostrate shrub lichen-covered frostboil areas.	violet	9, 18
Bright gravel and bare rock barrens. Gravel barrens on ridge tops. Prostrate shrub lichen tundra barrens.	black	10, 12, 14, 24
Wet muds and silts forming deltas. Wet river gravels.	dark grey	8
Ice white	11, 13, 16	
Background	black	32

*Identification on single scene only

Fig. 1. 85.0% CONCENTRATION ELLIPSES FOR BANDS 3 AND 2
ANWR SCENE 22008-20420 SPECTRAL PLOT 31 CLUSTERS

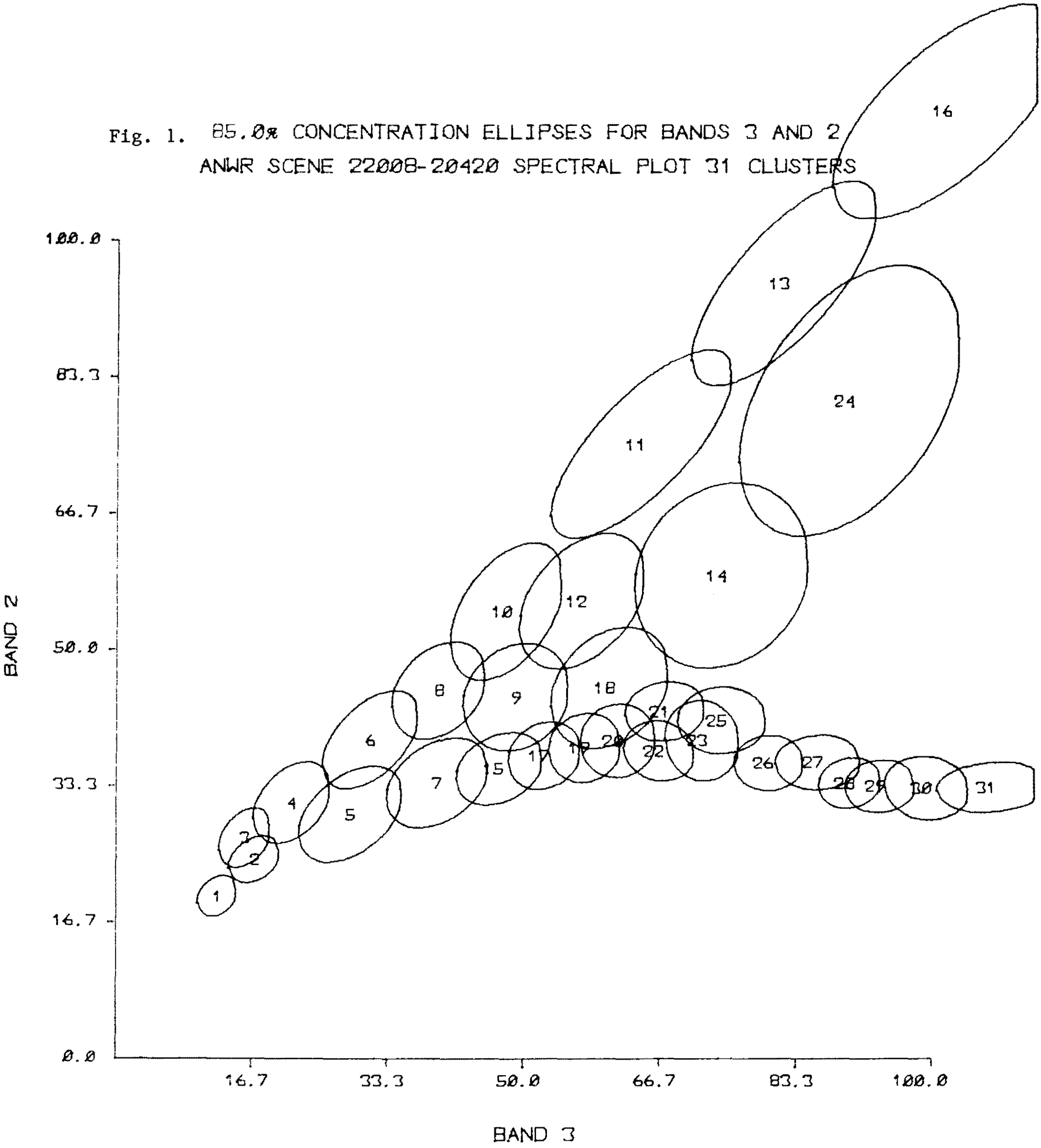

Table 2. Surface areas for cover categories in LANDSAT Scene 20420, Barter Island, Alaska (22 July, 1980).

Grouped Categories	Pixels*	Acres	Hectares
Water (1-6)	133,091	148,092	59,931
Pond complex (7).	8,538	9,500	3,845
Wet sedge tundra (15,17,19).	141,241	157,161	63,601
Moist sedge tundra (20,22).	182,752	203,350	82,293
Moist sedge-prostrate shrub tundra (21, 23, 25).	217,172	241,650	97,793
Tussock-dwarf shrub tundra (26, 27).	153,939	171,290	69,319
Dwarf shrub tundra (28, 29).	9,898	11,014	4,457
Shrub tundra in water tracks and on south facing slopes (30,31).	304	338	137
Partially vegetated (9, 18).	15,254	16,973	6,869
Bright barrens (10, 12, 14, 24).	15,218	16,933	6,853
Wet mud and silts (8).	9,789	10,892	4,408
Ice (11, 13, 16)	17,261	19,207	7,773
Background (32)	0	0	0
Totals:	904,457	1,006,400	407,279

*pixel = 79m x 57m
= $4503 m^2$
= 1.11 acres
= .4503 ha

Table 3. Land cover classes and assigned map colors for Landsat Scene 20531, Flaxman Island, Alaska (13 July, 1979).

Dominant Land Cover	Dicomed Color	Spectral Category
Water, turbid.	dark blue	1, 2, 5
Pond complex, aquatic vegetation. *Carex aquatilis*, *Arctophila fulva*, up to 50% tundra.	aqua	6
Wet sedge tundra. Wet/moist sedge tundra. Wet/moist complex.	dark green	7, 8, 11
Moist sedge tundra. Moist/wet sedge tundra. Frostscar tundra* (20420).	light green	12
Moist sedge tundra. Moist sedge-prostrate shrub. Frostscar tundra*.(20531)	sand	13, 14
Tussock-dwarf shrub tundra. Tussock-prostrate shrub tundra. Moist sedge tundra with tussocks.	tan	15, 16
Dwarf shrub-tussock tundra. Complex of tussock dwarf shrub. tundra with water tracks.	dark brown	17
Shrub tundra in high density. water tracks and on south-facing slopes.	red	18, 19
Partially vegetated areas (river bars, lichen-covered mountain barrens, lichen-covered sorted stone nets). *Dryas integrifolia*-forb tundra sand dune community. Sedge prostrate shrub tundra along stream. Prostrate shrub/lichen-covered frostboil areas.	violet	22
Bright gravel and bare rock barrens. Gravel barrens on ridge tops. Prostrate shrub-lichen tundra barrens.	black	9, 10
Wet muds and silts forming deltas. Wet river gravels.	dark grey	3, 4, 20, 21
Ice	white	23 - 35
Background	black	36

*Identification on single scene only

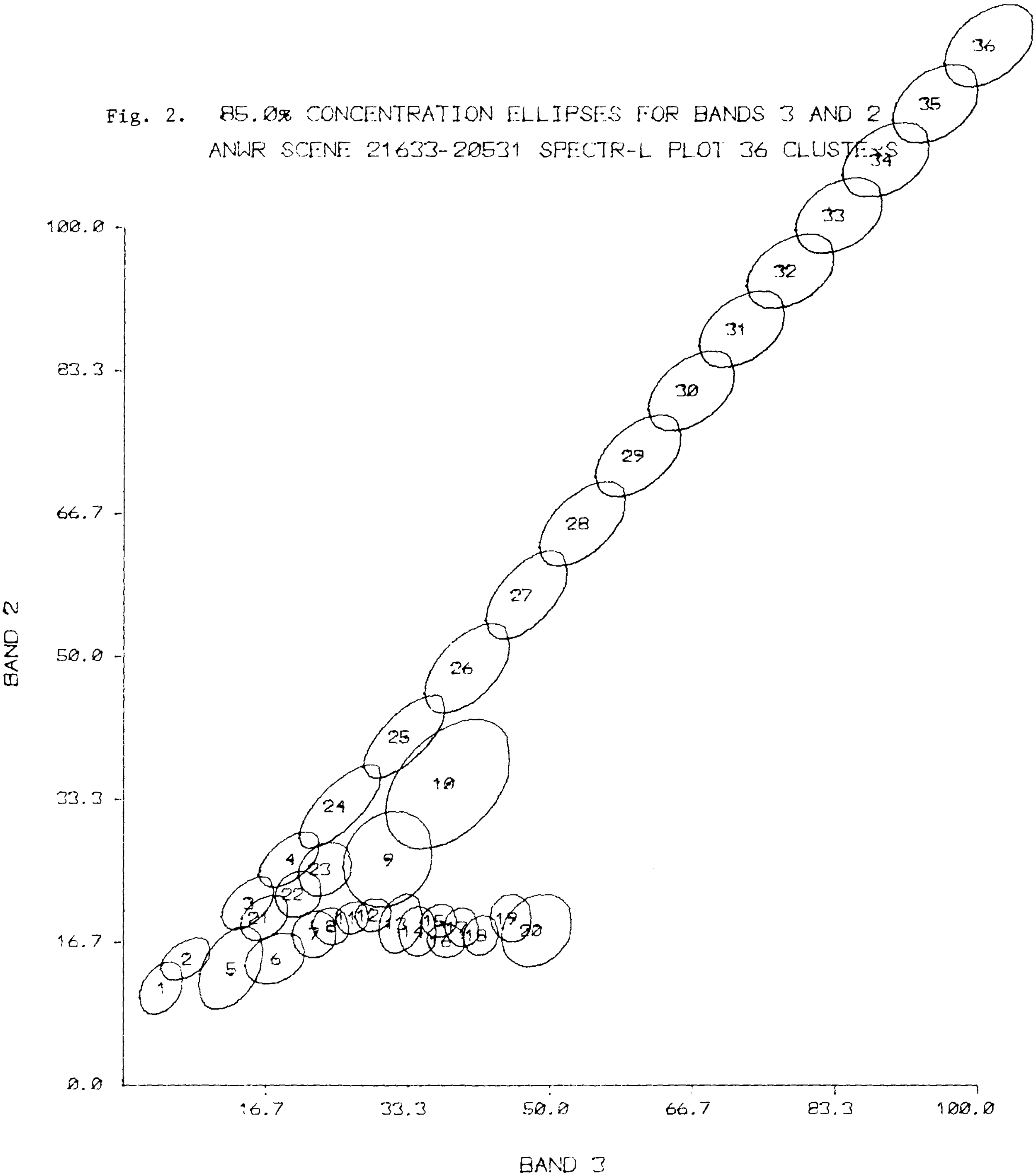

Fig. 2. 85.0% CONCENTRATION ELLIPSES FOR BANDS 3 AND 2
ANWR SCENE 21633-20531 SPECTR-L PLOT 36 CLUSTERS

Table 4. Surface areas for cover categories in LANDSAT Scene 20531, Flaxman Island, Alaska (13 July, 1979).

Grouped Categories	Acres	Hectares	Pixels*
Water (1, 2, 5)	113,896	46,083	141,838
Pond complex (6).	7,760	3,140	9,664
Wet sedge tundra (7, 8, 11).	107,536	43,510	133,918
Moist sedge tundra (12).	58,553	23,691	72,918
Moist sedge-prostrate shrub tundra (13, 14).	174,380	70,556	217,161
Tussock-dwarf shrub tundra (15, 16).	196,117	79,350	244,230
Dwarf shrub tundra (17).	48,874	19,775	60,864
Shrub tundra in water tracks and on south facing slopes (18, 19).	3,544	1,434	4,413
Partially vegetated (22).	5,484	2,219	6,830
Bright barrens (9, 10).	14,016	5,671	17,455
Wet mud and silts (3, 4, 20, 21)	31,144	12,601	38,785
Ice (23 - 35)	26,786	10,838	33,358
Background (36)	0	0	0
Totals:	788,091	318,868	981,434

*1 pixel = 57m x 57m
= $3249 m^2$
= .803 acres
= .3249 ha

Table 5. Land cover classes and assigned map colors for Landsat Scene 20462, Flaxman Island, Alaska (14 August, 1976).

Dominant Land Cover	Dicomed Color	Spectral Category
Water, wet mud and gravel. Water, very wet tundra, wet tundra. Pond complex, wet mud and gravel.	dark blue	1, 2
Wet sedge tundra, wet/moist tundra.	dark green	3
Moist/wet tundra, moist sedge tundra.	light green	5
Frostscar tundra (better breakout than 20531). River barrens and frostscar tundra. Moist tundra in stream channels.	sand	6, 17, 18
Tussock dwarf shrub tundra.	tan	16
Dwarf shrub-tussock tundra.	dark brown	19
Shrub tundra.	red	15, 20
Bright gravel barrens. Mountain barrens.	black	7, 8, 11
River barrens, wet muds and silts, partially vegetated areas.	dark grey	4
Ice, clouds.	white	9, 10, 12, 13, 14
Background	black	21

Fig. 3. 85.0% CONCENTRATION ELLIPSES FOR BANDS 3 AND 2
ANWR SCENE 2570-20462 SPECTRAL PLOT 20 CLUSTERS

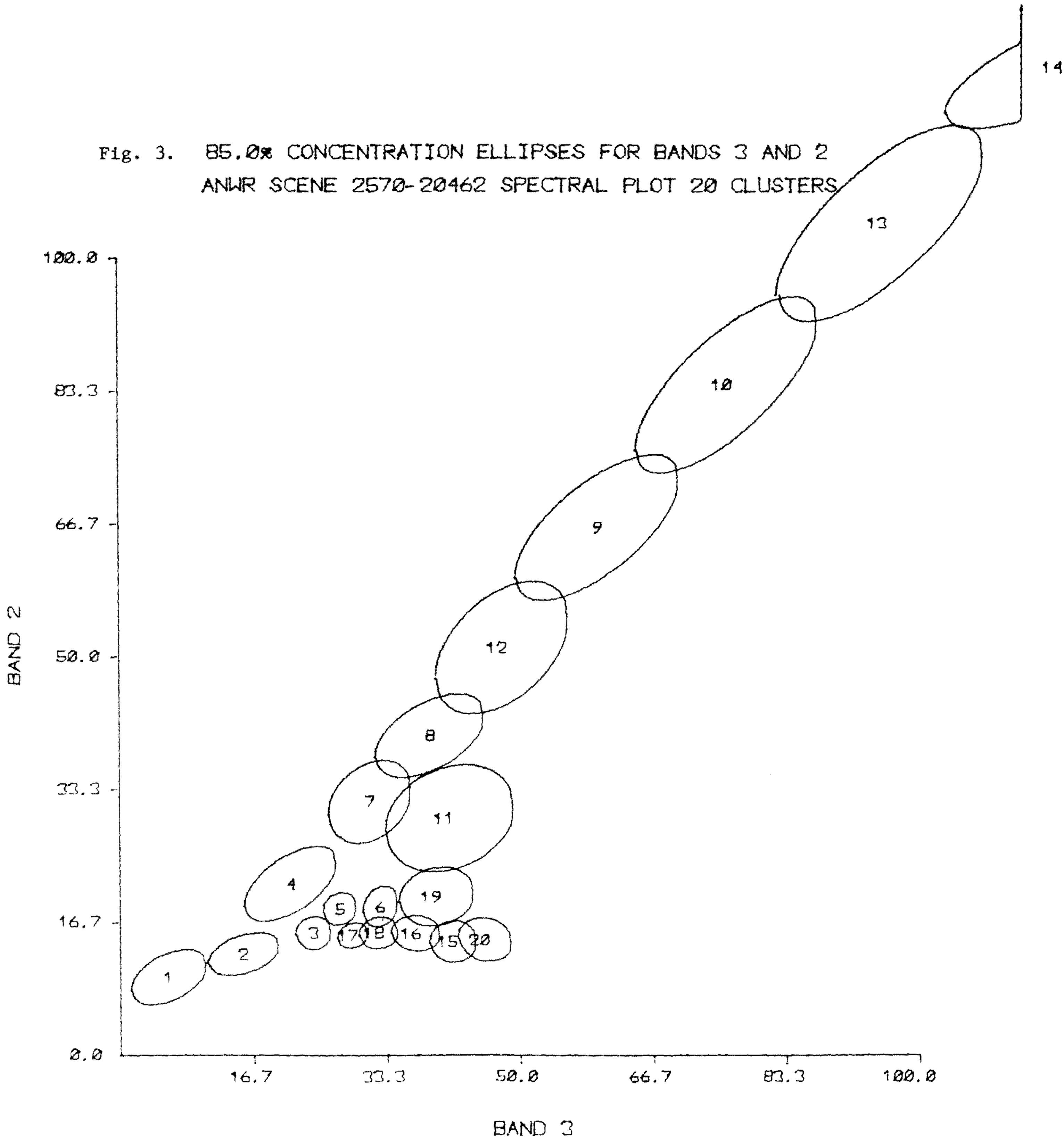

Table 6. Surface areas for cover categories in LANDSAT Scene 20462, Flaxman Island, Alaska (14 August, 1976).

Grouped Categories	Acres	Hectares	Pixels*
Water, wet mud and gravel (1,2).	961	389	864
Wet sedge tundra (3).	2,342	948	2,105
Moist/wet tundra (5).	1,104	447	992
Frostscar tundra (6, 17, 18.)	27,501	11,129	24,715
Tussock-dwarf shrub tundra (16).	30,541	12,359	27,447
Dwarf shrub-tussock tundra (19).	1,000	405	899
Shrub tundra (15, 20).	431	174	387
Bright barrens (7, 8, 11).	110	46	99
River barrens, wet mud and silts, partially vegetated areas (4).	2,557	1,035	2,298
Ice, clouds (9, 10, 12, 13, 14).	0	0	0
Background (21)	0	0	0
Totals:	66,547	26,932	59,806

*1 pixel = 79m x 57m
= $4503 m^2$
= 1.11 acres
= .4503 ha

Table 7. Preliminary descriptions of LANDSAT land cover categories for the ANWR study area

1. Water

Water bodies greater than 1 acre in size; including ocean, lakes and rivers.

2. Pond Complex or Aquatic Tundra

a. Pond Complex

Very wet tundra with numerous small bodies of water such as drained lake basins with small ponds, polygon troughs and centers, and strangmoor. Relatively well-drained tundra may cover up to 50% of the unit.

b. Aquatic Tundra

Emergent communities covering more than 1 acre. Arctophila fulva is the dominant taxon in water up to 1 m deep. In shallow water (less than 30 cm) the main taxa are Carex aquatilis and Eriophorum scheuchzeri.

3. Wet Sedge Tundra

a. Wet Sedge Tundra (non-complex)

Relatively wet tundra with little or no standing water and a few well-drained microsites associated with polygon rims, strangmoor, hummocks, etc. Usually flooded after breakup and remains saturated throughout the summer. Relatively large areas of non-complex wet tundra occur on the deltas of the larger rivers, in drained lake basins and along some river channels. The primary taxa are numerous sedges, including Carex aquatilis, Eriophorum angustifolium, E. russeolum, Carex rotundata and C. saxatilis. Herbs include Pedicularis sudetica ssp. albolabiata, Saxifraga hirculis, Melandrium apetalum, Caltha palustris and Potentilla palustris. Mosses include Drepanocladus spp., Scorpidium scorpioides, Campylium stellatum, Calliergon spp. and Sphagnum spp.

b. Wet Sedge Tundra (very wet complexes)

Complexes of wet tundra with up to 50% water or emergent vegetation. Low-centered polygon complexes, areas with extensive thermokarst pits, or complex thermokarst areas in the foothills are included in this vegetation subunit. Non-aquatic portions of the complex include moist shrub tundra (5a), moist tussock-dwarf shrub tundra (6), dry sedge-crustose lichen tundra (see 5a), and wet saline tundra (3d).

c. Wet Sedge Tundra (moist complexes)

Complexes of wet tundra with up to 40% moist tundra of varying character. Low-centered polygon complexes with well-developed polygon rims, and string-bogs with closely spaced strangs are common areas with this vegetation sub-unit.

d. Wet Sedge Tundra (saline facies)

Areas near the coast periodically inundated with salt water. The primary taxa are Carex subspathaceae, Puccinella phryganodes, Carex ursina, Stellaria humifusa, and Cochlearia officinalis. Some saline areas have numerous ponds and are likely to be classed as Pond Complex (2).

4. Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub - Forb Tundra

a. Moist/Wet Sedge Tundra Complex

Moist sedge tundra mixed with up to 60% wet sedge tundra. Flat areas with low or flat-centered polygon complexes (common in drained lake basins) or strangmoor (more common on river deltas and gentle slopes) usually have a large percentage cover of wet tundra in the polygon troughs, basins, thermokarst pits and inter-strang areas. The spectral signature of these areas are likely to vary according to season and summer rainfall. Moist areas may have Eriophorum tussocks, depending on proximity to the coast. Common taxa in moist tundra areas include the sedges Eriophorum triste, E. vaginatum, Carex bigelowii, C. membranacea. Prostrate shrubs include Dryas integrifolia, Salix reticulata, S. arctica, S. pulchra and S. lanata. Forbs include Pedicularis lanata, Polygonum bistorta, Stellaria laeta and Senecio atropurpureus ssp. frigidus. Common mosses include Tomenthypnum nitens, Hylocomnium splendens, Ptilideum ciliare, Orthothecium chryseum, and Ditrichum flexicaule. Common lichens are Thamnolia subuliformis, Cetraria spp., Dactylina arctica, Cladonia spp. and Cladina spp.

b. Dry Prostrate Shrub-Forb Tundra (Dryas river terraces)

River terraces that have a dense prostrate mat of Dryas integrifolia with numerous forbs and prostrate shrubs. This unit is quite dark on aerial photography and LANDSAT data and has a spectral signature similar to Wet Sedge Tundra (3) and Moist/Wet Sedge Tundra (4a), although this unit is physiognomically distinct from these. It may be possible to distinguish these terraces in some other phenological stage on LANDSAT scenes taken later in the summer. The primary taxa are the prostrate shrubs Dryas integrifolia, Salix reticulata, S. rotundifolia, and Salix ovalifolia. Herbs include Astragalus alpinus, Oxytropis nigrescens, Equisetum arvense, Artemisia arctica, Silene acaulis, Chrysanthemum integrifolium, Saxifraga oppositifolia, Carex membranacea, and Eriophorum triste. Common mosses are Distichum capillaceum and Ditrichum flexicaule

5. Moist Sedge-Prostrate Shrub Tundra or Moist Sedge/Barren Tundra Complex

a. Moist-Sedge-Prostrate Shrub Tundra

Moderately well-drained areas, located primarily along the northern the foothills. Principle taxa are similar to those of the Moist/Wet Sedge Tundra Complex (4a). These areas may have up to 20% cover of Eriophorum tussocks. Wetter facies near streams are likely to have no tussocks and have high percentages of prostrate shrubs including Salix arctica and S. pulchra, and herbs such as Petasites frigidus, Saxifraga punctata, Carex aquatilis, Saxifraga hirculis and Valeriana capitata. On slightly elevated microsites near the coast moist tundra is likely to include components of prostrate shrub communities, including Dryas integrifolia, Salix pulchra, Carex bigelowii, S. phlebophylla, Luzula arctica. Ground cover consists of small hummocks with the moss Dicranum elongatum covered by white crustose lichens, (mainly Ochrolechia frigida and Lecanora epibryon).

b. Moist Sedge/Barren Tundra Complex (frost-scar tundra)

Primarily well-drained areas with as much as 90% of the surface covered by frost-boils or frost-rings. Vegetation on the frost scars is generally sparse and includes such taxa as Juncus biglumis, Arctagrostis latifolia, Petasites frigidus, Dryas integrifolia, Chrysanthemum integrifolium and Saxifraga oppositifolia. Mosses include Rhacomitrium lanuginosum, Bryum spp., Distichum capillaceum and Drepanocladus uncinatus. Frost scar areas near the coast are usually Moist Sedge Tundra (Va) dominated by Carex bigelowii, Dryas integrifolia, Arctagrostis latifolia, and the moss Tomenthypnum nitens. In the foothills frost-scar tundra occurs mainly on slopes and ridge tops and is likely to have scattered low (10 to 40 cm tall) Salix lanata or S. glauca. This unit is difficult to separate on the LANDSAT data. On the Flaxman scene it is most often classified as Unit 5 while on the Canadian scene, it often appears as Unit 4.

6. Moist Sedge Tussock-Dwarf Shrub Tundra

a. Moist Sedge Tussock-Dwarf Shrub Tundra (upland tussock tundra) (acidic facies)

Relatively well-drained upland tussock tundra sites primarily in the foothills with high percentage cover of Eriophorum tussocks and dwarf or prostrate shrubs. In this unit the tussocks are usually dominant with about 20 to 70% cover. On acidic soils the dwarf shrubs include Salix pulchra, Betula nana, Ledum decumbens, Vaccinium uliginosum, V. vitis-idaea, Empetrum nigrum, Arctostaphylos rubra and Cassiope tetragona.
Mosses include Hylocomnium splendens, Sphagnum spp. Aulacomnium palustre, and Ptilidium ciliare. Lichens are dominated by Cladonia spp. and Cladina spp.

b. Moist Sedge Tussock-Dwarf Shrub Tundra (alkaline facies)

On more neutral or basic soils, important taxa include Dryas integrifolia, Carex bigelowii, Salix arctica, S. reticulata and S. lanata. The chief moss species is Tomenthypnum nitens, while the lichens are primarily Cetraria spp. The alkaline soils are most often a result of frost-stirring of basic parent materials, and barren frost-scars can cover a large percentage of this unit.

Note: Both 6a and 6b may have up to 30% coverage of other vegetation types, mainly Moist Sedge-Prostrate Shrub Tundra (4a) or Wet Sedge Tundra (3).

7. Moist Dwarf Shrub-Sedge Tussock Tundra or Moist Tussock Sedge-Dwarf Shrub/Wet Dwarf Shrub Tundra Complex.

a. Moist Dwarf Shrub - Sedge Tussock Tundra (upland dwarf shrub-tussock tundra)

This unit is similar to 6 except that the shrubs, mainly Salix pulchra and Betula nana, are dominant and may reach 50 cm. in height.

b. Moist Dwarf Shrub-Sedge Tussock Tundra (dwarf tundra)

High-centered polygons and palsas with dwarf shrub communities dominated by Betula nana and Eriophorum vaginatum. These areas often occur in low thermokarst drainage areas in the foothills. In some communities birch is completely dominant and Eriophorum is absent. Other taxa typical of these sites are Rubus chamaemorus, Ledum decumbens, Pedicularis labradorica and Vaccinium vitis-idaea. Sphagnum spp., Cladonia spp.and Cladina spp. dominate the ground cover.

c. Moist Sedge Tussock-Dwarf Shrub/Wet Dwarf Shrub Tundra Complex (water track complex)

Slopes in the foothills with water tracks are included in this unit. In these areas tussock-dwarf shrub tundra forms a complex with more pure shrub communities in the water-tracks. Height and density of the water-track shrubs vary, but the dominant taxon is usually Salix pulchra. Other important taxa in water tracks include Salix arctica, Betula nana, Carex aquatilis, Eriophorum angustifolium and other taxa typically found in Wet Sedge Tundra (3a).

8. Shrub Tundra

a. Shrub Tundra (non-complex)

South-facing slopes in the foothills dominated by dwarf and medium-height (up to 2 m) willows, birch and/or alders. These sites are relatively warm and often rocky with a variety of microsites which contribute to species diversity. Typical taxa are Salix spp., Betula glandulosa, Alnus crispa. Lupinus arcticus, Artemisia tilesii, A. arctica, Aconitum delphinifolium, Delphinium brachycentrum, Potentilla fruticosa, Bromus pumpellianus, Equisetum arvense, Festuca altaica, Senecio lugens, Castilleja caudata, Carex microchaeta, Arnica frigida, A. alpina, Petasites frigidus, Saxifraga tricuspidata, Vaccinium uliginosum, V. vitis-idaea, Aster sibiricus, Ledum decumbens and Empetrum nigrum.

b. Shrub Tundra (water track complex)

This unit is very similar to 8a, except here the water track shrub communities dominate.

9. Partially Vegetated Areas

a. River Bars

Partially vegetated river bars have a high diversity of taxa, including Epilobium latifolium, Artemisia spp., Salix spp., Castilleja caudata, Hedysarum alpinum, H. mackenzii, Arctostaphylos rubra, Oxytropis campestris, Anemone parviflora, Equisetum arvense, Trisetum spicatum, Deschampsia caespitosa and Astragalus alpinus.

b. Alpine Tundra

Many alpine tundra areas appear partially vegetated because of the large amount of bare talus and rocks. The character of alpine tundra varies, but the more completely vegetated areas have extensive moss mats (mainly Hylocomnium splendens) with numerous prostrate shrubs, such as Dryas octopetala, Salix rotundifolia, Salix phlebophylla and S. Chamissonis. Herbs include Carex microchaeta, Geum glaciale, Saxifraga bronchialis, S. davurica, S. tricuspidata, and S. serpyllifolia. Lichens include Cladina spp., Cladonia spp., Nephroma expallidum, Cetraria spp., Dactylina arctica and Sphaerophorus globosus.

c. Sorted Stone-Nets

Some extensive sorted polygons occur in the Jago and Okpilak drainages. These contain rocks covered by lichens such as Umbilicaria spp., Lecanora spp., Lecidea spp., Rhizocarpon spp. and Alectoria minuscula.

d. Beaches

Some coastal beaches and mud flats are sparsely vegetated with Carex subspathacea, Puccinellia phryganodes and other taxa typical of Wet Saline Tundra (3d).

e. Sand dunes

Dune communities occur on the delta of the Canning River. Species are similar to those occurring on river bars (9a). The most sparsely vegetated dunes are dominated by Elymus arenarius.

More stable dunes have communities similar to the *Dryas* river terrace community (4b).

10. Barren Gravel or Rock

Light-colored barren gravel or rock includes bare river gravels, gravel and sand spits, alpine barrens (particularly dolomite), and cultural barrens such as the runway and roads on Barter Island. Some gravelly ridge tops in the foothills are classed in this unit. These areas have a rich but sparse flora that includes *Potentilla biflora*, *Dryas octopetala*, *Artemisia arctica*, *Castilleja caudata*, *Pedicularis verticillata*, *Polemonium boreale* and other taxa typical of gravel river bars (9a).

11. Barren Mud or Wet Gravel

This unit has a somewhat darker spectral signature than the Barren Gravel category (10). It includes extensive barren mud in rivers deltas and wet gravels on the rivers and beaches. Some dark-colored rocks in the mountains are also classed in this unit.

12. Ice

River icings (aufeis) occur in the braided stream channels of most of the larger rivers.

Table 8. Preliminary descriptions of soils within the LANDSAT land cover categories for the Arctic National Wildlife Refuge study area.

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1. Water

No soil identified.

2. Pond Complex or Aquatic Tundra

a. Pond Complex

Principal landforms of the pond complex are numerous shallow ponds 1 hectare, low centered ploygons, often with standing water in their centers and string bogs (strangmoor). The very wet elements of the unit have in order of abundance, Histic Pergelic Cryaquepts usually with 20 cm or more of fibrous organic material over gleyed (reduced) mineral soil. Pergelic Cryaquepts with less than 20 cm of fibrous organic over gleyed mineral material or Cryofibrists/Cryohemists with 40 cm of fibrous organic over gleyed mineral soil. Positive microrelief elements, especialy well developed (> 20 cm) rims of the low centered polygons have Pergelic Cryaquolls, occasionally Pergelic Cryaquepts with 5 to 10 cm of highly decomposed organic matter overlying gleyed mineral soil. Pergelic Cryosaprists are rare and are the organically oxidized extensions of the Cryofibrists or Cryohemists.

b. Aquatic Tundra

Normally soils have not been described in areas where Arctophila fulva is mapped. The substrate in such environments consists commonly of a suspension of detrital organic materials often with a significant component of mineral materials held in a matrix of plant roots. Underlying mineral soils may a uniformly gleyed or on occasion show mottles, the result of oxidation around aerenchymus roots. Such soils are placed provisionally with the Pergelic Cryaquepts. Similar soils with increasing amounts of fibrous biomass occur within the shallower (< 30 cm) water depths.

3. Wet Sedge Tundra

a. Wet Sedge Tundra (non-complex)

These areas have seasonal standing water (after snow melt) but by mid-summer the thickening active layer together with evapotranspiration removes the standing water leaving a saturated soil - free water is encountered within a very few centimeters of the surface. Patterned ground features are poorly developed and consist of large disjunct polygons, hummocks and strangmoor - the strangs are often coexitensive with the low polygon rims. All in all there is not much positive microrelief. The soils, like the surface are wet predominantly Pergelic Cryaquepts or Histic Pergelic Cryaquepts both of which have fibrous organic horizons. In certain cases where organic and neutral to alkaline mineral substrate is present Histic Pergelic Cryaquolls occur.

b. Wet Sedge Tundra (very wet complexes)

In contrast to 3a are areas with more strongly expressed surface patterns and microrelief but with significant amounts of standing water in the form of thermokarst pools or the centers of low centered polygons. Such areas are typical of broad crests in the Foothills regions and portions or the Rolling Coastal Plain. Moist tussock and tussock frost scar slopes in this subregion have Pergelic Cryaquolls and/or Ruptic-Entic Cryaquolls. Pergelic Cryaquolls commonly form associations with Pergelic and Histic Pergelic Cryaquepts where low centered polygons are well expressed. Histic Pergelic Cryaquolls are the principal soils of low flat centered ploygons, a form common to Unit 3b. Complexes of Pergelic Cryaquepts Pergelic and Histic Pergelic Cryaquepts characterize the unit generally.

c. Wet Sedge Tundra (Moist Complexes)

This subunit differs from the others principally in terms is better drained aspect. More extensive areas of well developed (near microrelief) low-centered polygons and areas of string bogs in which the strangs are more closely spaced reflecting a more clearly defined hydraulic gradient. Pergelic and Histic Pergelic Cryaquepts are common in the strangs. Complexes and associations of Pergelic Cryaquolls and Pergelic and Histic Pergelic Cryaquepts are common to the rest of the subunit.

d. Wet Sedge Tundra (saline facies)

These near coast areas may display any of the landform subunits of Classes 2 or 3 except 3b. The soils in recently flooded areas are morphologically little different than those of the unflooded parts. Chemically however they may have conductivities that range from 12000 to 18000 mohs/cm and shold probably be considered as Halic Pergelic Cryaquepts, S. Rieger (in manuscript). Where saline conditions have prevailed for a protracted period of time and salt tolerant plants such as Puccenellia phryganodes and Carex subspathacea are established on the dead Carex aquatilis there is a pronounced change in the texture of the accumulating organic matter.

4. Moist/Wet Sedge Tundra Complex or Dry Prostrate Shrub-Forb Tundra

a. Moist/Wet Sedge Tundra Complex

This occurs on flat upland areas or in old drained lake basins where flat centered polygons form complexes with thermokarst pits or with strangmoor. Wet areas may comprise up to 60% of any given area. The moist/wet sedge tundra is also common to gentle slopes with flat centered polygons. The 4a subunit is most extensive east of the Hulahula River. Soils of the moist areas (polygon centers especially) are Pergelic Cryaquolls. Those of the wet sites are Histic Pergelic Cryaquolls or Histic Pergelic Cryaquepts. In areas where frost scars are common to the moist sites the soil complex is best described as consisting of Ruptic-Entic Pergelic Cryaquolls.

b. Dry Prostrate Shrub-Forb Tundra of river terraces.

These terraces are generally components of the Riverine complex. Except under unusual circumstances they are not flooded being a meter or more above the active terraces or river island complex. Surfaces of these terraces still display the river island and channel features. The former commonly displays polygonal cracks and has soils resembling Cryofluvents with from 15 to 50 cm of interlayered silts, sands and organic materials overlying river wash sands and gravels. Permafrost is 1 m and no water table occurs. Former channels are wet to moist and have Pergelic Cryaquepts soils.

5. Moist Sedge Prostrate Shrub Tundra or Moist Sedge/Barren Tundra Complex

This cover class is mostly in the northern or rolling foothills of the wildlife refuge and is commonly difficult to separate from cover category unit 4a in that it occupies broad sloping interfluves with flat centered polygons. The soils are Pergelic Cryaquolls with a small percentage of Pergelic Cryaquepts. Portions of the slopes have a very high percentage of frost scars - in some cases 80-90%. These areas are especially common on crests with bedrock outcrops at or close to the surface and areas low on the slopes near drainages. Soils of the frost scars are Pergelic Cryaquepts (or Entisols) more stable areas between the frost scars (10-50% of the surface) are Pergelic Cryaquolls. Active layer thickness ranges near a meter in the scars to between 40 to 60 cm beneath the Cryaquolls. Portions of the long low slopes are characterized by Tussock-water track tundra (Cover class unit 7c).

6. Moist Sedge Tussock Dwarf Shrub Tundra

a. Moist Sedge Tussock - Dwarf Shrub Tundra

Two facies acid and alkaline are recognized in this Foothills unit. Landforms are principally long slopes dominated by cottongrass tussocks that obscure flat centered polygons. The acidic facies of this unit occur in association with sandy and gravel conglomerate units of the underlying Cretaceous and/or Tertiary bedrock and are particularly common in the area west of the Katakturuk River. The soils are Pergelic Cryaquepts and form a complex with numerous frost scars (Ruptic-Entic Pergelic Cryaquepts). Histic Pergelic Cryaquepts are common where water track units occur. Alkaline facies of this cover class are most common west of the Katakturuk River and the soil complex is Ruptic-Entic Pergelic Cryaquolls. Water tables are generally absent in the moist portions of both facies except in water tracks and near the foot and crest of the slope. Pergelic Cryochrepts are present on the few well drained areas within this unit.

7. Moist Dwarf Shrub - Sedge Tussock Tundra or Moist Tussock Sedge Dwarf Shrub/Wet Dwarf Shrub Tundra Complex

a. Moist Dwarf Shrub - Sedge Tussock Tundra

This unit is generally similar to unit 6 in terms of soils.

b. Moist Dwarf Shrub-Sedge Tussock Tundra (dwarf tundra)

This sub-unit occurs principally in the head water areas of many small, often beaded, drainages in the Foothills area. In such areas thermal erosion combines with natural thermokarst to produce by way of topographic reversal high centered polygons which may have a meter or more microrelief. Soils, that in uneroded portions of the head water basins are Histic Pergelic Cryaquepts or Pergelic Cryohemists are converted to (Sapric) HIstic Pergelic Cryaquolls or Pergelic Cryosaprists by virtue of the better drainage afforded by the microrelief difference. A feature of head water basins and some broad interfluves (unit 3b) especially in the southern part of the Foothills area are Birch covered peat plateaus (Palsas generally) that stand 0.5 to 1.0 m above the surrounding wet sedge tundra. The soils of these features are fibrous, Histic Pergelic Cryaquepts in which large volumes of segregation ice occur. Ice volumes increase with depth and individual layers may be a meter or more thick.

c. Moist Sedge Tussock - Dwarf Shrub/Wet Dwarf Shrub Tundra Complex (water track)

This differs from unit 6a, b, primarily because of the increased importance of water tracks, up to 30% of some slopes. These wet drainage lines run generally normal to the slope curving toward small streams. Wet sedge tundra with fibrous Histic Pergelic Cryaquepts occurs between short strangs (commonly curving down slope) that have a dwarf shrub vegetation - microrelief (drainage) contrasts are seldom sufficient to change the soil designation on the strangs. A shallow water table is always present in contrast to the adjacent sedge tussock (Pergelic Cryaquoll) tundra. Active layer thickness in the water tracks is greater than in the adjacent areas.

8. Shrub Tundra

Shrub Tundra is common to steep (25 to 65%) slopes in the southern part of the Foothills and vegetation covered slope in the alpine areas of the Wildlife Refuge. Such slopes are characterized by one or more forms of mass wasting, most commonly solifluction. Non-soil and different kinds of soil are often juxtaposed forming a mosaic composed of Pergelic Cryorthents, Pergelic Histic Pergelic Cryaquolls (Pergelic and Histic Pergelic Cryaquepts where acid bedrock types are near the surface) and in some cases Pergelic Cryosaprists.

9. Partially Vegetated Areas

a. River bars

River bars are included in the River Island Complex. Those that lack vegetation or lack soils are treated as river wash deposits. Some bars or river island, although subject to seasonal flooding and scouring receive mostly silts and sands. Those that are partly vegetated have soils similar to those of unit 4b and are Pergelic Cryorthents. The principal difference is that the silt and/or sand upper horizon is generally 10 cm thick and lacks zones of organic materials.

b. Alpine areas

Alpine areas above the solifluction slopes (unit 6) are composed of partially vegetated steep ($<$ 50%) talus slopes, and narrow crests, the flatter ones have sorted and unsorted stone nets and/or frost scars. The stable areas which support most of the vegetation have Pergelic Cryorthent soils and if sufficient fines are present Pergelic Cryochrepts. The soil pattern is Ruptic-Entic Pergelic Cryporthents and/or Cryochrepts both with a Sapric organic surface horizon up to 5 cm thick. Other areas have large block bordered polygons (9c) are noted in the southern parts of the Jago and Okpilok drainages. In some cases Ruptic-Entic Pergelic Cryochrepts and/or Cryaquepts are developed in the finer textured materials in the center of the polygons. Beaches (9d) generally do not have sufficient stability to develop soils. In the few cases when they are developed under sedges they are Cryorthents.

e. Sand dunes

Sand dunes are not abundant in the Wildlife Refuge, occurring mostly in the delta regions of the Canning and Jago Rivers where sufficient vegetation exists to stabilize or partially stabilize them. The soils are Pergelic Cryopsamments. Permafrost is 1 m. Wet sandy materials between the dunes have Pergelic Cryaquept soils. No soil is recognized on dunes lacking vegetation.

10. Barren Gravels or Rock

Barren gravel areas are mostly included in the River Island Complex and do not have soils (river wash deposits sub-unit 4b). Water tables reflect river water level and permafrost is deep or absent. Some gravel barrens and rock outcrop areas especially occur on uplands. Here a water table is absent and ice rich permafrost if present at all lies at depths 1 m.

11. Barren Mud or Wet Gravel

These areas are within the Riverine system and occur mostly in the delta areas although wet gravels may occasionally be formed on flat uplands and beaches. In most cases shallow water tables and a thick active layer occur. No soils are recognized.

12. Ice.

Table 9. Approximate equivalent units in several systems of vegetation classification used in northern Alaska.

1981 Preliminary ANWR Landsat classification	ANWR Landsat classification Nodler and LaPierriere (1977)	Prudhoe Bay Stand Types Walker (1981)	Pt. Storkerson Wetlands Bergman et al. (1977)	National Wetland Inventory Cowardin et al. (1977)*	Alaska Viereck et al. (1981) Level IV where possible	International UNESCO (1973)
1. Water	II. Water, Shadows	W1, W2, W3	V. Deep Open	M1OWL, L1OWH, R3OWH E1OWL, R1OWH POWH, R2OWH	None	None
2a. Pond Complex	II. Water, Shadows VI. Shallow water communities	Complex of W1, E1, E2, M4 and others	VI. Basin-Complex	$P\frac{EM5}{OW}H$	None	None
2b. Aquatic Tundra	VI.A) Shallow Water Communities	E1, E2	IV. Deep <u>Arctophila</u> or III. Shallow <u>Arctophila</u> or II. Shallow <u>Carex</u>	PEM3H**, L2EM3H PEM5F**	3.C(3)b. Fresh grass marsh	V.E.16. rooted fresh water communities & higher alt. forb forms.
3a. Wet Sedge Tundra (non-complex)	V.A West Sedge Meadows includes smooth wet sedge meadows, low-center polygon wet sedge meadows, and string bogs.	M1, M2, M3, M4, M8	I. Flooded Tundra	PEM5E	3.C.(1) a. Wet sedge meadow tundra 3.C.(1)b. Wet sedge-grass meadow tundra.	V.C.8b. Graminoid sod-form tundra.
3b. Wet Sedge Tundra (very wet complexes)	VI.8) Flooded Sedge Meadow	Complex of M4 or E1 with U3 or U4	Complex of II. or IIb and Uplands	$P\frac{SS1}{EM5}H$, $P\frac{EM5}{OW}H$	Complexes dominated by 3.C.(1)a.	V.C.8b. Graminoid Sod-form tundra IV.E.2b. String bog.
3c. Wet Sedge Tundra (moist complexes)	V.A Wet Sedge Meadows	Complex of M1 and M2 with U3 or U4	Mostly Uplands	$P\frac{SS1}{EM5}F$, $P\frac{SS1}{EM5}C$	Complexes dominated by 3.C.(1)a.	V.C.8b. Graminoid sod-form tundra.
3d. Wet Sedge Tundra (saline facies)	V.B) Salt Grass Meadows	M9	VIII Coastal Wetlands	E2EM5P	3.C.(4)e. Halophytic sedge wet meadow	V.C.8b. Graminoid sod-form tundra.
4a. Moist/Wet Sedge Tundra Complex	VII Intermediate Wet Moist Tundra	Complex of U3 or U4 with M2	Complex of I. and uplands	$P\frac{SS1}{EM5}C$, $P\frac{SS1}{EM5}B$ $P\frac{SS1}{EM5}E$	Complexes dominated by 3.C(1)g. sedge-willow tundra, or 3.C.(1)I. Sedge-dryas tundra.	V.C.8b. Graminoid sod-form tundra
4b. Dry Prostrate Shrub-Forb (<u>Dryas</u> river terraces)	VIII Dryas Terrace Community	B6	None	Upland, PSS1A, PSS1B	2.C.(1)c. Dryas herb tundra 2.C.(1)h. Prostrate shrubs and herbs on flood plains.	IV.B.3b. Cold deciduous creeping or matted thicket

Table 9. (continued)

1981 Preliminary ANWR Landsat classification	ANWR Landsat classification Nodler and LaPierriere (1977)	Prudhoe Bay Stand Types Walker (1981)	Pt. Storkerson Wetlands Bergman et al. (1977)	National Wetland Inventory Cowardin et al. (1977)*	Alaska Viereck et al. (1981) Level IV where possible	International UNESCO (1973)
5a. Moist Sedge-Prostrate Shrub	VIII.A) Upland Sedge Meadow	U3 or U4	None	Upland, $P\frac{SS1}{EM5}B$	3.C.(1)g. Sedge-Willow tundra or 3.C.(1).1. Sedge-dryas tundra.	V.C.8b. Graminoid sod-form tundra
5b. Moist Sedge/Barren Tundra Complex(frost-scar tundra)	XI. Hummocky frost-heaved	Complex of U4 or U3 with B3	None	Upland, $P\frac{SS1}{EM5}B$	Complex of 3.C.(1)g. or 3.C.(1)i. and barrens	V.C.8b. Graminoid sod-form tundra.
6a. Moist Tussock Sedge-Dwarf Shrub Tundra (acidic facies)	IX.B) Tussock Meadow	None	None	Upland, $P\frac{SS1}{EM5}B$	3.C.(2)d. Sedge tussock-mixed shrub	V.C.8a. Graminoid bunch-form tundra
6b. Moist Tussock Sedge-Dwarf Shrub tundra (alkaline facies)	IV.B) Tussock Meadow	U2	None	Upland, $P\frac{SS1}{EM5}B$	3.C.(2)d. Sedge tussock-mixed shrub 3.C.(2)b. Sedge tussock-willow	V.C.8a. Graminoid bunch-form tundra
7a. Moist Dwarf Shrub-Tussock Sedge Tundra (Upland Dwarf Shrub-Tussock Sedge Tundra)	IV.B) Tussock Meadow	None	None	Upland, $P\frac{SS1}{EM5}B$	3.C.(2)d. Sedge tussock-mixed shrub	V.C.8a. Graminoid bunch-form tundra
7b. Moist Dwarf Shrub-Tussock Sedge Tundra (Dwarf Tundra)	IV.B) Tussock Meadow	None	None	Upland, $P\frac{SS1}{EM5}B$	2.B.(3)h. Dwarf birch-ericaceous shrub-sphagnum bog	IV.E. Mossy bog formations with dwarf shrub IV.D.1a. Caespitose dwarf-shrub moss tundra.
7c. Moist Tussock Sedge-Dwarf/Wet Dwarf Shrub Tundra Complex (water track complex)	IV.B) Tussock Meadow	None	None	Complex of Uplands with $P\frac{SS1}{EM5}B$	Complex of 3.C.(2)d. Sedge-Tussock-mixed shrub and 2.B.(3)n. Willow-sedge fen or 2.B.(2)a. low willow	V.C.8a. Graminoid bunch-form tundra
8. Shrub Tundra	None	None	None	Upland	2.B.(2) Closed low shrub	III.B.3b. Sub-alpine or sub-polar deciduous thicket

Table 9. (continued)

1981 Preliminary ANWR Landsat classification	ANWR Landsat classification Nodler and LaPierriere (1977)	Prudhoe Bay Stand Types Walker (1981)	Pt. Storkerson Wetlands Bergman et al. (1977)	National Wetland Inventory Cowardin et al. (1977)*	Alaska Viereck et al. (1981) Level IV where possible	International UNESCO (1973)
9. Paritally vegetated areas: a. River Bars	IV. Partially vegetated ground	B4	None	R45B, R2FL, R3FL R2BB, R3BB	Several types including: 3.D.(1)a. Seral herbs 2.C.(1)h. Prostrate shrubs and herbs on floodplains 2.B.(3)b. Low willow	V.D.2b(3) Episodical forb communities III.B.3b. Subalpine or subpolar deciduous thicket.
9b Alpine Tundra	IV. Partially vegetated ground	None	None	Upland	Several types including: 3.D.(1)c. Alpine herbs 3.D.(1)b. Alpine herb-sedge (snowbed) 2.C.(1)i. Mat and cushion-sedge tundra 2.C.(1)k. Dryas tundra 3.E.(2)a. Crustose lichens	V.C.7b. Alpine and subalpine meadows of higher latitudes
9c. Sorted Stone nets	IV. Partially vegetated ground	None	None	Upland	3.E.(2)a. Crustose lichens 2.C.(1)g. Open lichens	None
9d. Beaches	IV. Partially vegetated ground	B8	None	M2BBP, M2FLN, E2FLN	3.d.(3)d. Halophytic wet meadow	None
10. Barren Gravel or rock	III. Barrens	B4, B8, B9, B10 B11, B13	None	Upland or R4SB, R2FL R3FL, R2BB, R3BB	None	None
11. Wet gravel or mud	III. Barrens	None	None	Upland, R4SB, E2FL R2FL, R3FL, R2BB, R3BB	None	None
12. Ice	I. Ice, snow, aufeis	None	None	None	None	None

* These codes are based on the 1977 Operational Draft of the U.S. Fish and Wildlife Services' Classification of Wetlands and Aquatic Habitats of the U.S. (Cowardin et al.) Mapping based on the final 1979 version will use slightly modified codes.

Item A

Taxonomy of soils on the ANWR study area

Of the 10 soil orders recognized in Soil Taxonomy (Soil Survey Staff, 1975) 4 are found in ANWR. Soils belonging to the order Mollisols are probably most extensive, occurring in all terrain types, but especially in the Foothills and Rolling Coastal Plain. Mollisols are dark colored mineral soils. The color reflects included organic material (2.5% organic carbon) in the upper 18 cm of the profile. In addition to the dark color Mollisols have a base saturation > 50% i.e., Mollisols are neutral or slightly alkaline in reaction (pH). Wet Mollisols are classified as Aquolls (aqu indicating an aquic (reducing) moisture regime and oll indicating the soil order Mollisols). The prefix Cry appears at the Great Group level of classification for all soils found in ANWR and indicates a mean annual temperature of $8^{\circ}C$. The term Pergelic (perminantly frozen) appears at the subgroup level of all ANWR soils. Thus Pergelic Cryaquoll defines a cold, wet dark colored, base and organic rich mineral soil underlain by permanently frozen material. Pergelic Cryaquolls in very wet areas may have a surface horizon >20 but <40 cm of organic material. These soils are designated as Histic (fibers) Pergelic Cryaquolls. Mollisols on well drained sites are termed Pergelic Cryoborolls.

The next most extensive soil order represented in ANWR includes the Inceptisols. These are mineral soils that have only weakly differentiated soil horizons. This is due primarily to ineffectiveness of the leaching process in the cold wet tundra. Organic carbon in the Inceptisols is not evenly distributed in a distinct mollic epipedon (surface horizon) as in the Mollisols. The wet Inceptisols (Aquepts - the same principals of name formation apply here as with the Mollisols) commonly show some degree of mottling (iron oxidation) in the mineral soil below the organic surface horizon. Mineral soil colors generally are grey reflecting a saturated, reducing environment. In some cases an organic surface horizon > 20 cm thick forms the epipedon and the soils are termed Histic Pergelic Cryaquepts. Those soils lacking such an epipedon are simply termed Pergelic Cryaquepts. Most Cryaquepts. Most Cryaquepts show some quantity of organic matter enmixed in the sub-surface horizons, presumably due to frost action. It is also common for these soils to have organic concentrations at or near the seasonal permafrost table. Many Cryaquepts developed in silt-silt loam or fine sandy loam display thixotropic like characteristics upon vibration.

Cryaquepts may have any pH and are common components in soil complexes and associations with Mollisols particularly where they occur with frost scars. In such cases the complex is termed Ruptic-(interupted) Entic (Entisol) Cryaquepts.

Relatively well drained and stable sites especially on crest areas have Pergelic Cryumbrepts - Inceptisols with a dark colored (due to organic matter) surface horizon (epipedon) underlain by an acid (base poor) sub-horizon. Similar soils lacking the Umbric (dark colored) surface horizon are usually designated Cryochrepts.

Soils that show no profile differentiation or have (for the most part) only an organic surface horizon above a mineral substrate coarser than loamy fine sand belong to the soil order Entisols. In ANWR Entisols, primarily Pergelic Cryorthents are found most commonly in Alpine and Riverine terrain types where site instability or the short time span since sediment deposition has presented profile differentiation.

Perhaps the least extensive and least predictable of occurrence are organic soils (Histolsols). These soils have a surface horizon composed of 40 cm of organic materials generally $>$ 60% organic matter overlying grey, sometimes mottled, fine textured mineral materials. Normally these soils are very wet - to the degree that organic materials are buoyant or partially so. They occur on flat areas - either crest or low land.

Three taxa of cold Histosols are recognized - Pergelic Cryofibrists (fibrous low density organic matter), Pergelic Cryosaprists (non-fibrous, highly decomposed and dense organic matter) and Cryohemists (intermediate organic matter characteristics). Histosols may have any pH although in ANWR most are near neutral in reaction.

Appendix II

Traditional Land Use Inventory Sites in and adjacent to the Arctic National Wildlife Refuge Study Area.

FLAXMAN ISLAND: Mid-Beaufort TLUI Site 20

Location: In the Canning River Delta region, north of the Staines River.

Meaning: Flaxman Island has 3 Inupiaq names. Qikiqtaq means "big island". Kugruak means "Canning River". Sirak means "place where polar bears come in to cover themselves up with snow and have their cubs". The English name was given by Sir John Franklin during his 1826 expedition, for the English sculptor and artist John Flaxman.

(For site description, see North Slope Borough 1980, Libbey 1981).

AGLIGUAGRUK - BROWNLOW POINT: Mid-Beaufort TLUI Site 46

Location: Northern tip of the Canning River delta.

Meaning: "A person's jaw, which the point of land resembles."

U.S. Census 1939: 27 people (listed as "Brownlow Point")

(For site description, see North Slope Borough 1980, Libbey 1981).

TIGUTAAQ: TLUI Site

Location: Canning River delta, by the Tamayariak River where it joins the Canning.

Meaning: Tigutaaq was a well-known man who had a house at this site.

House ruins belonging to Tigutaaq and others are at this site. A grave marker is also at this site or nearby.

Tigutaaq lived both in this area and in the Barter Island area. He lived and trapped at Barter Island in the early part of this century, before it became a settlement. He was the husband of Julie Nasugiluuk, Mary S. Akootchook's mother's sister. His grandson, Pipsuk, is associated with a legend of how Kaktovik got its name (See Pipsuk Point).

Tigutaaq was on the crew of Gus Masik's trading boat Hazel when the botanist Isobel Hutchinson made her trip from Barrow to Martin Pt. in 1933. When they reached Flaxman Island, he remained there and his grown son took over until they got to Martin Pt. Hutchinson refers to him as "Old Tigutaak", and Mary S. Akootchook has verified that he was already an old man in the 1920's, when she was small (Hutchinson 1937).

Village source: Mary S. Akootchook

KAYUTAK: TLUI Site

Location: On the coast near the Canning (Kuugruaq) River delta, and about 3-5 km west of Kanigniivik.

Meaning: Kayutak is the name of the family who lived here.

An old house ruin is here, and old utensils, etc. have been found. The house belonged to Paul and Mae Suapak Kayutak, parents of Annie Soplu of Kaktovik.

Other indicators of this site are a large log half-buried in the sand, and several large rocks. According to village people, this is the only place along the Alaskan Beaufort coast where one must be careful of rocks when travelling in a boat. Kaktovik people have questioned whether there may not be another boulder patch in this area.

Village sources: Danny Gordon, Herman Rexford, Mary Sims, Johnny Anderson, Olive Gordon Anderson.

KANIGNIIVIK - KONGANEVIK POINT: TLUI Site

Location: East of the Canning (Kuugruaq) River delta, on the west side of Camden Bay. Cabins were located both on the tip of the point itself, and on the mainland near the small spit and lake, directly south-southeast of the point.

Meaning: "reindeer pond" (Orth 1967) - Long ago, Eskimos were driven to this point by the Indians so the Indians could starve them and kill them all. But the Eskimos hunted seal and fish and lived, while the Indians watched at the narrow part of the point. The Eskimos lived, and the Indians had to leave when they ran out of food.

U.S. Census 1939: 24 people.

The area is known for its caribou hunting, both in the past and presently. In the old days, people would catch caribou here in the summer by driving them out on the point, blocking the path between the caribou and the mainland. Now, Kanigniivik is one of Kaktovik's most important caribou hunting areas, in both summer and winter. In 1978 and 1979, Kaktovik people hunted here during November and January as well as July, August, September.

The cabin by the small lake on the mainland belonged to Richmond and Annie Ologak and their family. Richmond's brother Paul Patkotak also lived here.

Richmond and Annie's daughter Pearl had a son, Adam Pingo, who died and is buried here. Pearl now lives at Tuktoyaktuk, N.W.T., Canada.

Charlie Kupak used to have a house near Kanigniivik. His 2 children are buried here: one was named Benjamin Silamiok. Charlie went off to Canada, where he died.

Village sources: Ruby Okpik Linn, Maggie Linn, Tommy O. Gordon, Danny Gordon, Wilson, Soplu, Archie Brower.

KATAKTURAK: TLUI Site

Location: On the west side of the Katakturak River, about 9 km due south from the coast.

Meaning: Named after the Katakturak River; "Kataktu" means "you can see a long way".

This is where the moviemaker Charlie Kimrod is buried. Kimrod, a moviemaker for Captain Louis Lane, was in Alaska helping to make the first white man's picture of walrus. He had been on a Brooks Range sheep hunting trip with Henry Chamberlain (see TLUI Mid Beaufort Site Brownlow Pt.) and Captain Larson. They were returning to the coast by dog team, when they hit a storm and Kimrod froze to death. Larson assumed that Kimrod was lost and died out on the ocean. But 2 reindeer herders, Apayauk and Wilson, discovered the body here at this spot and buried it here. Levi Griest, now of Barrow, thinks the government should mark this grave and put it on the record (North Slope Borough 1980).

Village sources: Levi Griest (Barrow), Archie Brower.

NUVUGAQ - POINT COLLINSON (POW "D"): TLUI Site

Location: The point and spit in Camden Bay, just east of Simpson Cove and west of Marsh Creek

Meaning: "a point of land which juts out into the ocean"

Point Collinson was named for Captain Richard Collinson of the H. M. S. Enterprise who explored along the north coast of Alaska in 1851 and in 1853-54 (Orth 1967: 231).

Nuvugaq, an old village site, is now an important campsite and waterfowl hunting area for Kaktovik residents. The explorer Ejner Mikkelson found numerous abandoned Eskimo houses here in 1908, and felt it must have been a large village at one time (Nielson 1977a: 38). George Agiak, whose family used to have a house at Nuvugaq in the 1920's stated that he remembers seeing an old house at this site that belonged to Captain Roald Amundsen.

Nuvugaq was also tried as a site for a trading post, but was apparently never successful. Stefansson, in his book My Life with the Eskimo, describes visiting the trader E.B. "Duffy" O'Connor here in May 1912. O'Connor had come here from Nome with his store of trade goods the summer before, but had not had a successful trading year. According to Stefansson, the country was not rich in foxes, and besides, the explorer Leffingwell already had a trading establishment at Flaxman Island, only

96 km to the west. Stefansson came here and put up a store for Captain C.T. Pederson. It was located across, "on the other side" from where the old DEW Line facility is. Jack Smith dynamited out a hole for the house. However, he apparently did not remain too long at this location, returning instead to his post at Foggy Island (Mid Beaufort Site 12).

During 1913-14, 2 ships of the Canadian Expedition wintered here. In the spring of 1914, the Expedition consumed about 20 ptarmigan daily for 2-3 months. Most of these ptarmigan were secured within 24 km of their camp (Leffingwell 1919: 65).

George Agiak's family and the Ologak family both lived at Nuvugaq off and on during the 1920's. Agiak's mother Tuuluk and Richmond Ologak were brother and sister, and their mother Eve Kignak also lived with them here at this site.

Levi Griest and his family (Kunagraks) moved here in late 1924 and built an iglu. Levi lived here off and on until 1935. They also had some ice cellars here. Levi thinks there are still some remains of their house at this site, and when interviewed in March 1979, he wanted to get a "skidoo" so he could go inspect it (North Slope Borough 1980).

The Air Force DEW Line Station known as "POW D" was built here in the 1950's and some Kaktovik people worked here. However, the military buildings are now abandoned.

Nuvugaq continues to be an important campsite for waterfowl hunting, especially in May and early June. Several of the Kaktovik families go there for a few days to a week or more, and hunt seals and ugruk as well as brant, pintails, and oldsquaws. This site is used later in the summer for fishing, and at various times throughout the year for caribou hunting. Arctic fox are trapped here during winter months.

Village sources: George Agiak, Wilson Soplu, Levi Griest, Mildred Sikatuak Rexford, Jane Akootchook Thompson.

KUNAGRAK: TLUI Site

Location: Camden Bay, at the mouth of Marsh Creek, on the east side. For exact location, see the spot marked "cabin" on the U.S.G.S. map, Mt. Michelson (D-2) quadrangle, Scale 1:63,360.

Meaning: "Kunagrak" is the name of the family that lived here.

John Kunagrak built a large ice house here, and used it for a trapping cabin for quite awhile. His son Levi in Barrow has told Wilson Soplu of Kaktovik that John used to store all his tools, including his siklaq (ice pick) and shovel, down inside this ice house, and leave them here while he was gone. Alfred Linn Sr. of Kaktovik also lived here for a year, and trapped foxes. There are no graves at this site, as far as Wilson Soplu knows.

About 3 km east of this site is Carter (Iqalugliurak) Creek, an especially good one for fishing. The word iqaluk means fish, and Iqalugliurak means "little creek with lots of fish". Iqalugliurak Creek is especially good for fishing during the month of June. Arctic char and arctic cisco are caught around here.

Village sources: Wilson Soplu, Mary S. Akootchook.

AANALLAQ - ANDERSON POINT: TLUI Site

Location: Anderson Pt. itself is just to the east of Camden Bay, between the Bay and the mouth of the Sadlerochit River. However, the place referred to as Aanallaq extends from Anderson Pt. to about 3 km southwest of Anderson Pt., to the spot marked "Koganak" on the USGS map.

Meaning: "At the head of the bay".

The Ologak family, now of Kaktovik, lived and herded reindeer here for many years. Their daughter Masak (Evelyn Gordon) was born here on 9 June, 1925. The family had a house near the spit marked "Koganak" on the USGS map, on the east side of the small lake (see Mt. Michelson A-1 Quad, Scale 1:63,360). Kunagrak, Patoktak, and Annik and their families also had cabins here on the west side of the lake and herded reindeer.

This area was especially good for keeping reindeer because the land here is high - almost like a low hill - which made it relatively easy to see the deer and keep track of them. Every spring, Ologaks would take their reindeer herd from here up the Sadlerochit River to the mountain valley behind Sadlerochit Springs, for calving. Then when summer came, they would return here with the calves.

Qaggualuk (Levi Griest), son of John Kunagruk, first lived here with his family during 1924. He found many sheep on the Hulahula, so they had enough provisions for the winter. He also had a trapline that started here and went inland west of the Kadlerochilik River. The ocean area around Aanallaq was very good for catching seal. It was not good for setting up a fish net in winter. But it did have tomcod (uugaq) which could be pulled out right at the edge of the icebergs. That summer Qaggualuk and his family caught some 500 molting brant (nilingat) along towards the Canning River and hauled them to Aanallaq for the winter (North Slope Borough 1980, Okakok 1981: 607).

Fred Klerekoper and Roy Ahmaogak visited Ologaks here at Aanallaq on 15 April 1937, and again on 22 April on their return journey to Barrow. They had coffee here, and Ologak told Klerekoper that there were sheep in the mountains (Klerekoper 1937).

Phillip Tikluk of Kaktovik remembers living at Aanallaq when he was about 6 years old (1943). He was the son of Ellis Tikluk and of Ologak's daughter Faith who died when he was very young. One of his memories is of his grandfather Richmond Ologak erecting a long pole here at Aanallaq, which he used as a lookout tower for spotting caribou. Ologak saw the big piece of driftwood floating by in the ocean, went out with his new rowboat, tied a rope around it and towed it to shore. Then he dug a big hole in the dirt, "just like you would for a grave," and put it in. This pole is still here.

Paul Patoktak's son Brian was born at Aanallaq while the family was living here. Patkotak was a brother of Richmond Ologak.

Several graves are located at Aanallaq. Adam Alisuarak, grandfather and great-grandfather to many Kaktovik residents, died here about 1923 or 1924 while he was living with his daughter Tuuluk and her husband Annik (see above). He is buried somewhere along the little river flowing into the small lake where the families lived. Other people buried in the area of Aanallaq are Paul Patkotak's daughter Mary, Charlie Kupak's daughter Rosie, and Alice Napageak's daughter.

Now, Aanallaq is an important spring camping place and migratory waterfowl hunting area for Kaktovik people. A common practice is to make a base camp at Aanallaq in late May - in 1978 tents were set up at the spot marked "Koganak" on the USGS map - and then make overnight trips to the mountains to hunt squirrel and marmot.

The hills near Aanallaq are said to be excellent for picking berries. Annis Ologak, who died in 1980, was very knowledgeable about this.

Village sources: Mildred Sikatuak Rexford, Mary Sirak Akootchook, Wilson Soplu, Levi Griest, George Patkotak, Ruby Linn, Alfred Linn Sr., Phillip Tikluk.

SADLEROCHIT SPRINGS: TLUI Site

Location: Near the Sadlerochit River where the mountains begin, at the 305 m contour line.

Meaning: "Away from the mountains" or "area beyond the mountains".

In the 1920's and 1930's, Kaktovik people brought reindeer herds to the Sadlerochit Springs area each spring for calving. Arriving in March, the first calves were usually born in early April. In June the herd was taken back to the coast.

Sadlerochit Springs is an important snow season camping area. In the spring, it is not unusual for 30-40 village people to be camped here together. They often hunt squirrels and hunt and snare ptarmigan.

Grayling (sulukpaugak) are in the creek here which flows into the Sadlerochit. One woman has fished for them from a rubber boat, and her husband has set short nets for them.

SANNIQSAALUK: TLUI Site

Location: On the east side of the mouth of Kajutakrok Creek, between the Sadlerochit and Hulahula Rivers. For exact location, see the spot marked "cabin" on the USGS map, Flaxman Island (A-1), Scale 1:63,360.

Meaning: "The place where there are cabins built of logs all running in the same direction".

Phillip Tikluk Sr. of Kaktovik was born here in a tent on 25 January 1937, when it was "really blowing" outside. He is the son of Ellis Tikluk and of Ologaks' daughter, Faith, who both died when he was very young.

The remains of one of the log cabins here were visible on 21 May 1978, during a snowmachine trip along this part of the coast.

Sanniqsaaluk is presently used as a camping area and as a base for caribou hunting. In spring of 1977, 2 Kaktovik families stayed here in a tent and hunted caribou nearby. Another got a caribou here in July 1981.

Village sources: Daniel Akootchook, George Akootchook, Phillip Tikluk, Mildred Sikatuak Rexford.

PATKOTAK: TLUI Site

Location: At the mouth the Nataroaruk Creek, between the Sadlerochit and Hulahula Rivers.

Meaning: Patkotak was a brother of Richmond Ologak, Susie Akootchook, and Tuuluk, all direct ancestors of present-day Kaktovik residents, and this site is named after him.

This is one of the places where Paul Patkotak and his family had a house.

Village sources: Isaac Akootchook

SIVUGAQ: TLUI Site

Location: On the Hulahula River, about 16 km from the coast.

Meaning: "Long, high bluff area."

Sivugaq is where the main trail from Barter Island joins the Hulahula River. The bluffs here are a landmark and resting place on trips to and from the mountains, as they provide some wind protection. They are also a favorite sliding area for children. Unidentified ruins are at this site (Hopson 1977,as cited by Nielson 1977a).

FIRST FISH HOLE: TLUI Site

Location: About 32 km inland on the Hulahula River.

Meaning: This site is known by the English name, First Fish Hole.

This is one of Kaktovik's most popular fall, winter, and spring fishing areas, and an important traditional stopover and camping place on trips to the mountains. People fish here for whitefish (iqalukpik) and grayling (sulukpaugaq); fishing for whitefish is especially good here in the fall. The site is also good for "pike" (paigluk), a fish species that has not been positively identified.

No old ruins exist at this site but people now living in Kaktovik have been using it since the 1920's.

Around April 1940, the Presbyterian minister Fred Klerekoper came by airplane from Barrow to Barter Island. Finding no one there, he followed the Hulahula River inland. He found the Kaktovik people all camped at First Fish Hole, and landed his plane. Klerekoper served holy communion inside a tent. It was so cold the grape juice froze in the glasses before the people had a chance to drink it.

Village sources: Danny Gordon, Mildred Rexford, Archie Brower, Olive Anderson, Perry Akootchook.

SECOND FISH HOLE: TLUI Site

Location: About 64 km inland on the Hulahula River, just south of the mouths of Old Woman and Old Man Creeks.

Meaning: This site is known by the English name, Second Fish Hole.

This is one of Kaktovik's most popular fall, winter and spring camping and fishing areas. In some years, many whitefish may be caught here, as well as grayling. Some families leave a tent up all winter at this location, from October through April. They may spend several weeks at a time here, using it as a base camp for hunting caribou, sheep, and small game. It is not uncommon for 30 or more people to be camped here at one time.

In the 1920's and 1930's, Fred and Dorothy Panikpak Gordon and Tom and Agiak Gordon would bring their entire families here in the spring, by dog team, a 2 day trip from Barter Island. They would stay until the river started breaking up. The return trip to Kaktovik was often difficult due to lots of water and so little snow: everybody including children had to help pull the sled.

Thomas Napageak's mother Ikiakpuk used to walk from Sadlerochit Springs to Second Fish Hole in 1 day and go fishing, all with a baby on her back.

Village sources: Danny Gordon, Olive Anderson, Wilson Soplu, Tommy Uinniq Gordon.

KATAK - THIRD FISH HOLE: TLUI Site

Location: Inland on the upper reaches of the Hulahula River, a few km south of Kolotuk Creek.

Meaning: "To fall down, or fall off".

The remains of a house belonging to Fred Gordon are located here. He was the father and grandfather of many Kaktovik people, and used to take his entire family here. It is an important present day fishing spot and camping place and serves as a base for sheep and caribou hunting. Lack of sufficient snow cover or too much river overflow sometimes prevents people from reaching this site.

Village sources: Betty Brower, Archie Brower.

KANICH: TLUI Site

Location: At the headwaters of the Hulahula River.

Meaning: "sources of the river".

This is Kaktovik's main winter base camp for sheep hunting. The Agiak family lived here off and on during the winter for several years, beginning in the late 1930's (North Slope Borough 1980: 96). The river branch to the right is an important source of firewood.

Village sources: Archie Brower, Betty Brower, Nora Agiak.

UPILLAM PAANA: TLUI Site

Location: At the Okpilak River delta, just to the east of the Hulahula River delta.

Meaning: "Mouth of the river, without willows".

The whaler Ned Arey and his family had a house around here. The explorer Ernest de Koven Leffingwell talks of visiting here in May 1907 right before he, Ned, and Ned's son Edward Gallagher explored the Okpilak River up as far as the west fork. They returned to the coast on 11 July, and Leffingwell was here with the Areys until 1 August (Leffingwell 1919). For more information on the Areys, see Tommy Uinniq Gordon interview (North Slope Borough 1980:136-139).

The Hopson family used to live here, and this is probably where they were living when Olive Gordon Anderson and her mother Agiak Gordon used to visit them. Olive remembers spending the night at Hopson's with her mother, and using a sleeping bag from which her feet stuck out. Eben

Hopson would tease her, telling her that the mice were going to come eat her feet in the night.

Village sources: Olive Gordon Anderson, Archie Brower.

NAALAGIAGVIK - AREY ISLAND: TLUI Site 19

Location: In the middle of Arey Island, about 8 km west of Barter Island.

Meaning: Naalagiagvik means "where you go to listen". Arey Island is named after the commercial whaler and explorer Ned Arey, grandfather of Annie Soplu of Kaktovik.

Arey Island is a prehistoric and historic village site. In 1914, the ethnologist Diamond Jenness of the Canadian Expedition was employed to examine this site. He thought there may have been 30 to 40 old house ruins here (Leffingwell 1919: 67). Several old sod and log structural remains were visible at this site during an inspection in August 1978.

The Akootchook family sometimes lived on Arey Island. Isaac Akootchook was born here on 31 March 1922, and Roy Akootchook on 7 January 1926. The family had a reindeer herd from 1922 until 1936, and they often kept them at this site.

Agiak Gordon, wife of Scottish trader Tom Gordon, used to go there to hunt and trap and to look for artifacts. The story goes that she used to be able to communicate with the birds. She would tell a bird in the Inupiaq language that she wanted to be shown where the artifacts were. The bird would answer back by alighting on the place, calling out and flapping its wing. Then she would go to that place and start digging, and sure enough she would find artifacts.

Today Naalagiagvik is a key migratory bird hunting camp in late May and early June. It is also a traditional seal hunting camp in spring and summer. Fish nets are set around the island in July and August, and Arctic char, Arctic cisco and pink salmon may be taken.

Village sources: Olive Gordon Anderson, Isaac Akootchook, Jane Akootchook Thompson, Tommy Uinniq Gordon, Mildred Sikatuak Rexford, Georgianna Tikluk.

IGLUKPALUK: TLUI Site

Location: Iglukpaluk in on the western end of the northern coast of Barter Island. On the USGS map as "Elupak (Site)" it is mislocated on both the USGS map and the original TLUI map. It is not at the base of the spit as shown, but is actually about 1 km to the east, on the coast which faces north. It is not the last high point of land before the land slopes downward to the lakes and the spit.

Meaning: "A big house seen from far away". The site is named for Scottish trader Tom Gordon's big house, which was built at this location in 1923.

In April 1918 Hudson Stuck and his party visited Stefansson's base camp at Barter Island, but it is unknown whether this camp was right at the Iglukpaluk site or farther to the east. It was an extensive building, half underground. Stuck did not meet Stefannson, who was away at the time. "We were hospitably received by Captain Hadley, who was in charge, with 2 other white men and several Eskimo women and children and a great deal of stuff. The schooner Polar Bear, belonging to the expedition, lay in the ice" (Stuck 1920: 304).

Tom Gordon established his trading post here in 1923, and his family began living here. Over a period of years they moved their trade goods from Demarcation Bay to here at Iglukpaluk (North Slope Borough 1980: 136). Former Kaktovik school teacher Harold Kaveolook (1977:2) describes this in his History of Kaktovik and its Schools.

Levi Griest, now of Barrow, may have been one of the first Inupiat to visit the new trading post. He made a trip here to get flour the year it opened in 1923 (North Slope Borough 1980: 140).

In the early years of the post, Indians would occasionally visit. But the visits were sometimes surreptitious. One time Tom's wife, Agiak Gordon got an order to make a pair of sealskin and caribou hide mukluks. When they were finished, she took them out on the tundra and left them for the Indian to pick up. Sure enough, the next day they had been taken. Another time, an Indian stole a parka from the trading post. But he brought it back because it was too small!

Isobel Hutchinson, (1937: 166-168) provides a glimpse of what life was like at Iglukpaluk in 1933.

Hutchinson made 2 mistakes in her descriptions of the Gordon family. The native wife that she refers to (Agiak Gordon) was actually the mother of all the Gordon children except Mickey and Dan, who drowned. And Olive was almost 11 years old at the time of the visit, rather than 9 years old.

The Gordon family used to have a reindeer herd there at Iglukpaluk. Joe Arey worked for them as their herder. Hutchinson describes him taking the deer from Iglukpaluk to Martin Pt. in late October, and selling one to Gus. The reindeer skins for her parka and leggings made by Mrs. Arey also came from this herd.

The Presbyterian Elder Ninuk and his family used to come to Iglukpaluk from their home in the mountains every October, after a snowcover made dog team travel possible. Olive Gordon (Anderson) used to look forward to this visit because Niniuk's children Jonas Ningeok and Mamie Matumeak always brought her spruce gum, which she used for chewing gum. Jonas Ningeok now lives in Kaktovik, and Mamie visits often from Barrow.

Gordons used to have a very large ice cellar at this site. Here they would put up fish, especially Arctic cisco which they caught from the spit. These would be stacked in long rows, in layers. Now, the only visible remains at Iglukpaluk is an old ice cellar. Most of the area was plowed over and the physical appearance altered at the time of DEW Line construction.

Tom Gordon's big white house was moved several times and divided in half. Now both houses are still in use at Kaktovik's present townsite: one as a residence and the other as the village store.

Today Iglukpaluk is a very popular summer fishing area. Whitefish, Arctic cisco, and flounder are taken by hook and line and in nets.

Village sources: Olive Gordon Anderson, Mildred Sikatuak Rexford, Tommy Uinniq Gordon, Herman Aishanna, Nora Agiak.

TIKLUK - AKOOTCHOOK HOUSE SITE: TLUI Site

Location: Southwestern part of Barter Island.

This site was the first place on Barter Island where the Andrew Akootchook family lived. They built a house here about 1919-1920, and spent about 2 years here before moving to Arey Island. Fenton Tigalook, Andrew Akootchook's older brother, also lived here with his wife Elsie Iqarina and children Vern, Ellis and Prisilla. Ukumailak's family's house is also here. Kaktovik resident Wilson Soplu described the area in the North Slope Borough description of mid-Beaufort Sea TLUI sites (1980:194).

QAAKTUGVIK - KAKTOVIK (first location): TLUI Site 15

Note: The North Slope Borough's publication Kaktovik, Alaska: An Overview of Relocations (Nielson 1977b) includes a detailed map of Kaktovik's various locations.

Location: Northeast part of Barter Island, on the spit just where the airport hangar and runway are now located.

Meaning: "seining place".

This is a prehistoric village site. In 1914 Diamond Jenness of the Canadian expedition counted between 30 and 40 old house sites on the spit running east from Barter Island (Leffingwell 1919). Former Kaktovik schoolteacher Harold Kaveolook (1977:1-2) also documents this in his History of Kaktovik and its Schools.

This was the location of Kaktovik until 1947 when the U.S. Air Force decided to build an airport on this site and the village had to move. Present-day Kaktovik people built houses here in the 1930's and early 1940's and possibly earlier. Herman and Mildred Rexford built their house here in 1940, in the middle of where the airport runway is now. Georgianna Tikluk, daughter of Fred and Dorothy Panikpak Gordon, was born "right under the airport hangar" on 15 March 1946. So was Isaac and Mary S. Akootchook's son Benny, on 14 May 1947.

The North Slope Borough's publication Kaktovik, Alaska: An Overview of Relocations describes the move from this site (Nielson 1977b:3-4).

Mildred Sikatuak Rexford has stated that they moved their house from this site in 1947, after the white people (taniks) came. She remembers that the first military ship came on 10 August 1947. Mildred's 2 younger brothers, George and Daniel, who were age 15 and 14 at the time, would hide every time these taniks came around, as this was the first time they'd ever seen strange white people.

Many artifacts and small items from the old village site are buried under the airport hangar and the gravel runway.

Village sources: Mildred Sikatuak Rexford, Georgianna Tikluk

QAAKTUGVIK - KAKTOVIK (second location): TLUI Site

Note: The North Slope Borough's publication Kaktovik, Alaska: An Overview of Relocations (Nielson 1977b) includes a detailed map of Kaktovik's various locations.

Location: Northeast part of Barter Island, on the north coast where the spit joins the main part of the Island.

Meaning: "seining place".

The Akootchook family's house, and what is now referred to as the "old" cemetery, were at this site before there was any village here. The Akootchooks were living here in October 1933 when the Scottish botanist Isobel Hutchinson visited them. Hutchinson writes: " At this house of Andrew (Tom Gordon's brother-in-law, a native licensed by the Presbyterian Church at Barrow as a preacher, and a faithful adherent of that church) we stopped for a cup of hot tea, and made the acquaintance of his wife and family. The house was the usual Eskimo dwelling of driftwood, but contained a sewing machine beside the stove and bunks, and the walls were decorated with pictures and texts." (Hutchinson 1937: 166).

Fred Klerekoper and Roy Ahmaogak also visited Akootchooks here, in April 1937. They spent the night on their return trip to Barrow, after going to Demarcation Point. Klerekoper's diary, which includes a picture of Andrew Akootchook, describes the visit (Klerekoper 1937:10).

The village of Kaktovik was moved to this site by the Air Force in 1947. (See Kaktovik, first location). When Harold Kaveolook came to teach at Barter Island in August 1951, there were about 8 houses and 8 families living at this site, with 86 adults and children). Then in the spring of 1952 and the spring of 1953, several families moved back to Barter Island from Herschel Island, Canada, swelling the population to 140-145 (Kaveolook 1977).

The North Slope Borough publication: Kaktovik, Alaska: An Overview of Relocations, states:

> The new village was along a slowly eroding section of beach and in the landing pattern of the airfield. Houses were rebuilt and new cellars dug and, fortunately, the village cemetery, located on the plateau behind the new site was not then in danger and left undisturbed.
>
> The village was relocated again in 1953 because of changes in the DEW Line layout and new road construction. This move was accomplished in the same manner as the previous one, with the new site located further to the west and a little further back from the beach. This site was near where the main installation is now located and within a quarter-mile of the old cemetery (Nielson 1977b: 4-5).

(Note: The 1953 relocation was so close to the 1947 relocation, that they are considered the same site.)

Other than the cemetery, an old ice cellar is virtually the only remains that can be seen at this old village site. However the area has been used so much by the DEW Line installation for storing equipment and supplies, etc., that it can't be expected that much in the way of village evidence could remain here.

The cemetery is located on Air Force DEW Line property, and is surrounded by the DEW Line installation and paraphenalia. There are 12 unmarked graves here, and the following marked ones:

Leffingwell Nipik Born 23 December 1908 Died 9 July 1929	(very old, worn sign, barely readable; this may have been the son of Olokomayuk).
John Apayauk Born 20 August 1935 Died 3 April 1954.	(Grandson of the famed whaler of Barrow, Apayauk).
Edward T. Akootchook Born 8 April 1953 Died 3 January 1954	(son of Isaac and Mary S. Akootchook).
Candace M. Brower Born 31 October 1957 Died 29 August 1958	(daughter of Archie and Betty Brower)
Leonard Gordon Born 3 December 1956 Died 31 July 1959).	(son of Danny and Ethel Gordon)

Village sources: Flossie Lampe, Nora Agiak, Harold Kaveolook, Perry Akootchook.

QAAKTUGVIK -KATOVIK (Present location): TLUI Site

Note: The North Slope Borough's publication, Kaktovik, Alaska: An Overview of Relocations (Nielson, 1977b) includes a map of Kaktovik's various locations. It also contains more detailed information concerning acquisition of this present townsite.

Location: Northeast part of Barter Island, inside the small lagoon across from the airport.

Meaning: "seining place"

Kaktovik has been at this location since 1964, when it was moved for health reasons and so that the Air Force could expand its facility onto the earlier site. As the result of at least 4 years of negotiations instigated by Kaktovik Village Council President Herman Rexford, Kaktovik teacher Harold Kaveolook, and Utkeagvik Presbyterian Church missionary John R. Chambers, the village was able this time to get title to their village townsite. The village townsite plan was approved 14 July 1964. The village townsite was completed in August 1964, and officially filed in the Fairbanks District Land Office on 14 November 1966. However, the Air Force did not deed over the cemetery, which is still on Air Force land (see Kaktovik second location) (Kaveolook 1977, Nielson 1977b).

Kaktovik, Alaska: An Overview of Relocations, states on page 7:

> The new village site was located on the East shore of the island facing Kaktovik Lagoon on 280.29 acres. The official name of "Kaktovik" was adopted and placed on the U.S. Post Office trailer. Again, the Air Force lent its equipment and, under the supervision of the BIA, the village was uprooted for the third time in less than twenty years and moved to its new site overlooking the lagoon, the airport and the Beaufort Sea beyond (Nielson, 1977b).

Harold Kaveolook, (1977:15) Inupiat teacher at Kaktovik for 18 years, also describes this final village move.

A new cemetery is located just to the southeast of the village, on the village townsite. At least 4 unmarked graves are located here, including the grave of Fred Gordon, who died in March 1977. The 3 marked graves are:

Forrest Linn (youngest son of Alfred Linn Sr. and Ruby Okpik Linn)
Born 1 December 1961
Died 7 September 1974

Dorothy Panipak Gordon
Born 16 Sept. 1909
Died 1 February 1973

Riley Tikluk
Born 29 May 1935
Died 17 October 1976

Village sources: Harold Kaveolook, Flossie Lampe

PIPSUK - PIPSUK POINT: TLUI Site

Location: Northeast part of Barter Island, on the point across from the airport and just southeast of the present village site.

Meaning: Named after Pipsuk, grandson of Tigutaaq, a former longtime resident of this area (Hopson 1977)

Pipsuk's grave is located here. According to one legend, Pipsuk drowned here in the lagoon while fishing from a kayak. His body was retrieved with a seining net, hence the name Qaaktugvik (Kaktovik), which means "seining place".

Pipsuk reportedly worked for the surveyor Leffingwell, and was the grandson of Tigutaaq, who used to live both in this area and in the Canning River delta area. Tigutaaq was the husband of Mary S. Akootchook's mother's sister, Julie Nasugilook. He was on the crew of the trading boat Hazel in 1933, when the botanist Isobel Hutchison made her trip from Pt. Barrow to Martin Point (Hutchison 1937:139).

Pipsuk's grave is marked with an old wooden cross, the horizontal part of which bore the capital letters: PIPSUK. However, part of this cross has been broken off so that only the SUK remains.

Around 1940, 2 Kaktovik girls about 12 years old dug up Pipsuk's grave. Working during the summer night of 24 hour daylight, after their parents were asleep, it took them 3 nights to get it dug up. When they finally got the lid open, they saw what looked like a lady with very long hair and with beads around her neck. They were so scared that they immediately closed the lid and recovered the coffin with sod.

Village sources: Mary S. Akootchook, Perry Akootchook, Anonymous

QIKIQTAQ - MANNING POINT - "Drum Island": TLUI Site

Location: Just east of Barter Island, between Kaktovik Lagoon and Jago Lagoon.

Meaning: "Big Island"

This is a heavily used spring and summer camping area. Its main use is for migratory bird hunting from mid-May to mid-June. Caribou are also hunted from here in late spring and summer. People camp both on the point and on the mainland opposite.

One summer in the late 1940's, a large group of caribou was herded into the water at Oikiqtaq where they could be killed from waiting boats. Some women and children were standing on "Drum Island" as the men drove the caribou onto it from the mainland. At one point the herd was coming right at the women. One woman took off her jacket and swung it round and round over her head, which luckily caused the caribou to veer off into the water.

Village sources: Georgianna Tikluk, Archie Brower, Mary Ann Warden

TAPKAK - Bernard Spit: TLUI Site

Location: Bernard Spit is actually a barrier island just northeast of Barter Island.

Meaning: "Spit"

The Andrew and Susie Akootchook family had a house on the western part of Bernard Spit, due north of what is now the Barter Island landing strip. They lived here off and on between the mid 1920's and the mid 1940's. Their daughter Elizabeth Akootchook Frantz was born here on 22 October 1929.

Village sources: Mildred Sikatuak Rexford, Perry Akootchook

TAPQAURAQ - MARTIN POINT and TAPKAURAK SPIT: TLUI Site

Location: East of the Jago River delta, about 10 miles east of Barter Island. Tapkaurak Spit extends from Martin pt. southeast almost to Griffin Pt. Ruins are on the point across from Taqkaurak Entrance, and on the widest portion of the spit.

Meaning: "little narrow spit"

U.S. Census 1939: 18 people.

The small island (denoted by the word "ruins" on USGS maps) in Tapqauraq Lagoon just east of Martin Point is the site of the late Dan Gordon's old house. He was one of the sons of Tom and Agiak Gordon and brother and uncle to many Kaktovik residents (Hopson 1977, as cited by Nielson 1977a). This island has been a good location for finding waterfowl and gull eggs. The water in this area is too shallow for boating except quite close to the island.

When Kaktovik people talk about Tapqauraq today, they are generally referring to the house ruins on the Tapqauraq Spit (Fig. 1 Chapter 7)

On Tapqauraq Spit are the ruins of a cabin that belonged to the trader Gus Masik, and a driftwood and sod house that was the home of Bruce and Jenny Nukaparuk. Much insight into the life at Tapqauraq Spit in the 1930's is given by Isobel Hutchinson (1973). Hutchinson spent 6 weeks here at Tapqauraq in the fall of 1933. As a guest at the trader Gus Masik's cabin, she was able to observe first-hand the lives of the Inupiat in the region. Her recorded observations about these ancestors of present day Kaktovik residents reinforce their own oral accounts of their lifestyles during the 1930's.

Tommy Uinniq Gordon is very familiar with the area of Tapqauraq, and refers to Gus Masik's place as Tapqauraq. When he was a boy, he and his family lived in Gus's house here for a year, while Gus was away.

Fred Klereloper, in his published diary, also mentions stopping here at Gus Masik's place on 21 April 1937.

Village sources: Tommy Uinniq Gordon, Frances Lampe, Archie K. Brower

UQSRUQTALIK -GRIFFIN POINT: TLUI Site

Location: On the east side of Oruktalik Lagoon, between the Jago and Aichilik Rivers, about 32 km east of Barter Island.

Meaning: "Place where there is oil on top of the ground."

Uqsruqtalik is one of Kaktovik's main and most popular summer camps. It is the site of an old village, which was in existence in 1918 when Hudson Stuck and his party stopped here. Stuck mentions stopping briefly at this village and shaking hands, before travelling on to Annun for the night.

John Olsen's trading post was originally here at Uqsruqtalik. He was a Norwegian trapper who later became a good friend of Tommy Uinniq Gordon's. He had also been a partner with Gus Masik on several expeditions (Hutchinson 1937).

Isobel Hutchinson visited Olsen here on 17 October 1933, on her way back from visiting Mrs. Arey at Pukak. She was served coffee, and canned peaches and cheese from his store. Near the end of October, Olsen came to Tapqauraq and accompanied Hutchinson and Charlie Gordon to Iglukpaluk. (Hutchinson 1937)

Hutchinson also mentions that John Olsen was planning to take his dog team to the hills when the trapping season began on 15 November.

Sometime between 1933 and 1937, Olsen moved his post over to Imaignauraq. This was about when Fred Gordon, son of Tom and Agiak Gordon, started living at Uqsruqtalik full time. Before this, Fred had used Uqsruqtalik for a fish camp. He used to walk to Barter Island in the summer, to buy flour and other supplies. Fred got his house at Uqsruqtalik from Irving Singatuk, who had moved to Pukak. Fred lived at Uqsruqtalik with his wife Dorothy Panikpak for many years and they raised their family here. Two of their children were born here: Frances Lampe on 15 April 1940 and Thomas K. Gordon on 27 September 1943. Fred and Dorothy continued to return to their house here into the 1970's, even though they moved to Barter Island in the mid-1940's. Fred and Dorothy's children and grandchildren and other Kaktovik people go to Uqsruqtalik during July and August. They camp across the lagoon from Fred and Dorothy's house. Their stays may last for up to 2 months, returning to Kaktovik only long enough to get mail, etc. Some permanent tent frames have been built out of lumber and driftwood, so only the canvas needs to be put up and taken down each summer. In addition, Fred and Dorothy's house is still used as a shelter cabin.

At Uqsruqtalik, people fish for whitefish and arctic cisco , and hunt seal, ugruk, caribou, and brown bear. Occasionally, a polar bear may be taken. The area south of Uqsruqtalik, around the Niguanak River, Niguanak Hills, and Jago River is an important caribou and squirrel hunting area. The word Niguanak means "place where one waits for some animals to come".

Village sources: Georgianna Tikluk, Frances Lampe, Danny Gordon, Tommy Uinniq Gordon, Archie Brower.

PUKAK: TLUI Site

Location: Pukak is the area around Pokok Lagoon and Pokok Creek (the latter are USGS map spellings), on the coast a few km to the east of Uqsruqtalik or Griffin Pt. The site Pukak should not be confused with Pokok Bay on the USGS maps, which is farther east and is actually Humphrey Bay.

Meaning: Pukak was the name of a village once located on the east end of Pukak Lagoon.

This present day spring and summer camp used by Kaktovik people is near the site of an historic, and perhaps prehistoric, Eskimo village. "The Eskimo name 'Pokang' is shown in this area on John Simpson's native map, 1853, as the farthest point seen by the Point Barrow natives" (Orth 1967).

Irving and Martha Singatuk and family used to live at Pukak. Their daughter Hope is the wife of Alec Gordon of Inuvik, N.W.T., the brother and uncle of Kaktovik residents. Their son Leffingwell lives at the Bar 1 DEWLine Site in Canada.

The Areys also used to live at Pukak. Mrs. Arey, or Ekayauk, came down to her house here from her tent in the mountains so she could make a reindeer skin parka for Isobel Hutchinson. Hutchinson visited here twice in late October to have the parka fitted, and Martha Singatuk helped make the parka hood. Leffingwell Singatuk was off hunting in the mountains at the time. In addition to making the parka, Ekayauk gave Hutchinson a silver lemming skin, and "2 brant geese for the pot"...The children also brought her "the body of a small brown bird (perhaps a 'kinglet') with a blood-red crest, found frozen by the door - a little explorer from Yukon forests evidently blown far out of its course by the blizzard, to perish in the frozen north. The natives said they had not seen such a bird before..." (Hutchinson 1937:164).

Paul Kayutak and family moved here to Pukak from Pinuqsraluk in about 1934, and built a house. Kayutak's wife Mae Suakpuk was the daughter of Mrs. Ned Arey. Kayutak's daughter Annie Soplu lives in Kaktovik; their daughter, Teva Gordon, lives in Inuvik.

Now people travel to Pukak every spring to camp and hunt waterfowl. Eider ducks and snow geese are the main species taken. Parka squirrels and an occasional seal may also be hunted. Commonly, people may leave a tent set up at Pukak when they return to Barter Island by snowmachine in the late spring. Then they return to Pukak by boat in early July, after the ice has gone out. This is often a prime time for caribou, seal hunting, as well as Arctic char fishing. In the summertime, the caribou come out on the sandpits by Pukak, to escape the bugs. In late August 1978, 2 beluga whales were taken at Pukak, and a whole school of them could be seen.

Village sources: Herman Aishanna, Danny Gordon, Tommy Uinniq Gordon, Annie Soplu

IMAIGNAURAK - HUMPHREY POINT: TLUI Site

Location: At the base of the small spit on the west side of what is labelled Pukak Bay, at the location marked "cabin" on the USGS map.

Meaning: "Place of new sod houses"

U.S. Census 1939: 24 people.

Two mistakes were made when the U.S. Coast and Geodetic Survey mapped this area about 1950. What appears on the map as "Pukak Bay" should actually be "Humphrey Bay". "Humphrey Point" is actually here at Imaignaurak rather than on the east side of the bay.

The trader Jack Smith spent the winter of 1923-24 here after successfully trying to go over to Canada to buy furs.

This is where John Olsen, a Norwegian trader, had his trading post after he moved it from Griffin Pt. In June after the ice broke up, Tommy Uinniq Gordon would fish with John at Pukak Bay and they'd put up the fish in the ice cellar at this site.

John ran a "business" of buying fish and seal from people, storing it, and then selling it back to them at the same price he paid them for it. He did this to help people out. For example, in the summer he would buy 5 gallons of seal blubber from Uinniq for $2.50, and fish for 5¢ a piece. Then Uinniq would buy it back in the winter, for the same price. Uinniq also sold and bought seal meat from him in the same manner. The only things John made money on were the white fox that he bought and sold, and the fish that he caught himself.

Fred Klerekoper and Roy Ahmaogak apparently visited this site in April 1937. Klerekoper mentions spending the night at John Olsen's trading post in his published diary. A picture of John Olsen with his fox skins and a polar bear hide, is on page 16 of the diary (Klerekoper 1937:11,16). The polar bear hide shown is probably from a bear shot by Tommy Uinniq. Uinniq used to sell his polar bear hides for about 10 dollars a foot.

John Olsen died here of pneumonia in the fall of 1942. He had gone to Barrow that year and bought a boat, and died not too long after his return. He was probably around 60 years old when he died.

The Fred and Dorothy Gordon family have a long history of use of this site, and it is still a hunting, fishing, and stopover place for Kaktovik people. Emanunaruk is the name of the dry lake just south of this site.

Village sources: Levi Griest, Tommy Uinniq Gordon, Betty Brower, Archie Brower, Danny Gordon

IGLUGRUATCHIAT: TLUI Site

Location: On the coast between the Jago and Aichillik Rivers, on the point between Pukak (Humphrey) Bay and Annun Lagoon.

This point of land, called the Inupiat, is incorrectly labelled "Humphrey Pt." on the USGS map. Humphrey Pt. is actually on the west side of Pukak (Humphrey) Bay. See notes for Imaignaurak. This area has been used extensively for waterfowl, ugruk, and caribou hunting. It is also an important fishing area.

Village sources: Betty Gordon Brower, Archie Brower.

ANNUN: TLUI Site

Location: On the coast between the Jago and Aichilik Rivers, between Annun Lagoon and Beaufort Lagoon.

Meaning: "Oil seep"

Hudson Stuck (1920:308) described his stay one night at the Native village of Annun, in April 1918.

Annun Point is best known to Kaktovik people as the site of an oil seepage, which they call pitch. The oil was formerly used as heating fuel, because all the wood around this site was wet. In the winter this "pitch" is brittle and can be chipped off; but in summer it is soft, some areas are like quicksand. In fact, caribou and birds have gotten caught in it, getting sucked in and never coming out again. Both Tommy Uinniq Gordon, who lived at Demarcation Bay, and Betty Gordon Brower, who lived at Griffin Pt., used to come and get this fuel to burn in their stoves. However, it was extremely sooty and had a strong odor. According to Uinniq, it would be impractical as a fuel source today because one would have to be constantly washing one's floor, and the outside of one's house would turn black. They used to be able to smell the smoke from this fuel 16 km away.

Annun Point had a shelter cabin where Tommy Uinniq would spend the second night on the 3-day, 96 km trip from Demarcation Bay to Barter Island.

Village sources: Tommy Uinniq Gordon, Betty Gordon Brower

NUVAGAPAK - Nuvagapak Point: TLUI Site

Location: This point was mislabelled on the USGS map as being at the VABM site and airport. Actually Nuvagapak is the larger point of land to the northwest, between the VABM site and Annun (Angun Pt.)

Meaning: "Big point"

Unidentified house ruins are at this site.

Village sources: Archie Brower

ATCHILIK: TLUI Site 7

Location: On the west side of the delta of the Aichilik River, near the lake.

Old ruins are at this site. It is a former and present camping and fishing area for Kaktovik residents. Some consider it the best river for grayling within their present land use area.

In November 1933, when Isobel Hutchinson was travelling by dog team with Gus Masik from Martin Pt. to Herschel Island, they stopped here at the "cluster of ruined houses". They spent the night here in a cabin which had been occupied by Gus Masik's former trading partner, Harry Knudson (Hutchinson 1937:174-175).

Village sources: Danny Gordon, George and Nora Agiak

SIKU - ICY REEF: TLUI Site 6

Location: On the reef, near the delta of the western mouth of the Kongakut River.

Meaning: "ice"

This is an old and probably prehistoric village site. In August 1849, the explorer N.A. Hooper observed 2 boats and several huts here (Nielson 1977a:29).

The former commercial whaler, Ned Arey, was living here in his cabin with his family when Hudson Stuck and his party stopped for lunch in April 1918. He is the maternal grandfather of Annie Soplu of Kaktovik. Stuck (1920) described Arey's life at Siku.

Siku is the birthplace of Tommy Uinniq Gordon, son of Mickey and Rosie Piyuulak Gordon, and a present-day Kaktovik resident. He was born here in April 1921. The site still has a marker (which looks like a small telephone pole) and 2 old houses, including 1 that belonged to Uinniq's father Mickey. Uinniq used to camp here on the first night of the 3 day, 96 km trip from Demarcation Bay to Barter Island.

Residents at Siku during the 1930's included Taktuk and his family, and Paul Kayutak and his family, who were living here in April 1937 when Fred Klerekoper (1937) and Roy Ahmaogak visited. A picture of these residents at Siku is in Klerekoper's diary, at the top of page 14. (The caption under the picture is incorrect; the captions on page 14 and 15 should be reversed.). Taktuk, the father of Neil Allen, now of Nuiqsut, is at the extreme left. Mae Titus, Neil Allen's sister, is third from left. She is the hunchbacked girl that Klerekoper refers to. She lived with Paul Kayutak and his family, and now lives in Anchorage. Paul Kayutak was the father of Annie Soplu, now of Kaktovik, and Teva Gordon, now of Inuvik, N.W.T.

The small delta of the Kongakut River just south of Siku is an important fishing area for arctic char. Historically, the Kongakut River was one of the main travel routes into the mountains for hunting sheep, caribou, and small game, and for trapping and fishing.

Village sources: Tommy Uinniq Gordon

PINUQSRALUK: TLUI Site 5

Location: On the coast just to the northwest of Demarcation Bay, on the west side of the large creek. Between "Pingokraluk Lagoon" and "Pingokraluk Pt." on the USGS map.

Meaning: "Place where there are mounds and sand dunes by the rivers and river deltas."

In 1929, Tommy Uinniq Gordon's father Mickey bought a house at Pinuqsraluk for $200, plus $50 for the things inside. He bought it from Joe Arey, son of the whaler Ned Arey. They lived there until 1933. The house was originally built by a white man named "Old Man Store". There is another old house at Pinuqsraluk that belonged to Ed Arey, the half brother of Joe Arey. He gave his house to Tommy Uinniq Gordon when he (Ed) moved to Herschel Island in 1941. Joe Arey's grave is located at Pinuqsraluk.

Putugook moved here from Kanigluaqpiat, in about 1931. Then about 2 years later he moved to Siku. Isobel Hutchinson stopped at a group of cabins here in November 1933, when the trader Gus Masik was taking her by dog team from Martin Pt. to Herschel Island. Among those living here were the Mickey Gordon family and the Kayutak family. (Mac Suakpuk Kayutak was a sister of Joe and Ed Arey). Hutchinson and Masik visited at Mickey Gordon's home and family welcomed them. Mickey was at Barter Island visiting at the time. They offered them some of the reindeer stew that was simmering in a pot on the stove, but Hutchinson and Masik declined. Hutchinson wrote: "The laws of Eskimo hospitality give the stranger access to his house and larder even should there be scarcely enough to feed the host's own family" (Hutchinson 1937:176).

Fred Klerekoper and Roy Ahmaogak stopped at Ed Arey's house at Pinuqsraluk twice in April 1937. On the trip east, a boy put a small seal on their sled for dog feed. On the trip west, Klerekoper baptized 2 of Ed's children (Klerekoper 1937:11,15)

The remains of several structures are still visible at Pinuqsraluk: 3 houses are still standing. Tommy Uinniq's house is the 1 that is leaning due to beach erosion.

A small graveyard is south of the houses. Although letters are barely visible on the woodern markers, the following names and dates could be made out:

Hit Arey Alonik,
Died 2 Jan. 1922

Annie 1918;

Joe Arey
Died 15 May 1936
Joe Arey starved to death in the mountains and was brought here and buried (Jacobson and Wentworth 1981).

Both the names Alonik and Annie are written with reverse n's. Lawrence Malegana is also buried here.

Village sources: Tommy Uinniq Gordon

KUVLUURAQ: TLUI Site

Location: On the end of Icy Reef, on the spit on the west side of Demarcation Bay. Marked on the USGS map as "Kuluruak (Site)"

Meaning: "A small thumb located in the spit."

Loren Apayauk had a house here. He built the house in the summertime, and then went off to get some caribou. But when he came back, the spit the house was on had turned into an island and he couldn't get to his house. So he built another one at Demarcation Bay West-Side. Apayuak was one of the reindeer herders present at Barter Island when Frank Daugherty, the Local Reindeer Superintendent from Barrow, visited there on 17 April 1937 (Bureau of Indian Affairs 1938).

Lawerence Malegana built a house here at Kuvluuraq because there was a good supply of wood here...he was tired of hauling wood so far to his mainland house (See Demarcation Bay - West Side). However, he died just before freeze-up and never did live in this new house. His grave is at Pinuqsraluk.

It is felt this may have been a poor site for a house because of the lack of freshwater.

Village sources: Tommy Uinniq Gordon

DEMARCATION POINT - WEST SIDE: TLUI Site

Location: On the west side of Demarcation Bay, at the head of the Bay.

The grave of Loren Apayauk may be here. He built a house here after he was unable to reach his house at Kuvluuraq (see Kuvluuraq). He was 1 of the reindeer herders present at Barter Island when Frank Daugherty, the Local Reindeer Superintendent from Barrow, visited there on 17 April 1937 (Bureau of Indian Affairs 1938).

Paul Kayutak used to live at this site, and Lawrence Malegana had a house here. He had a wife and 4 or 5 children (including Johnny, Rebecca, Dorcas, and Leah). He could read and write for local reindeer herders.
He

also would draw the different marks for reindeer ears that were used to show ownership.

Village sources: Tommy Uinniq Gordon, George Agiak

OLD MAN STORE: TLUI Site

Location: On Demarction Bay, about 3 km east of the mouth of the Turner River.

This is where Old Man Store's cabin was located. It was probably built in 1916 (Hopson 1977, as cited by Nielson 1977a). An acquaintance of Tommy Uinniq Gordon, Old Man Store was a white man who was never known by any other name. He used to feed Uinniq boiled caribou meat. He may have been a whaler from Herschel Island. He died at this location in 1928 or 1929. Sometime after he died, Uinniq cleaned up his ice house and began using it as his own.

Village sources: Tommy Uinniq Gordon

KANIGLUAPIAT: TLUI Site

Location: Demarcation Bay, by the small lake where Kagiluak Creek flows into the Bay.

Meaning: "The group of people way over at the farthest place" (i.e. over towards the Canadian border)

This is where Putugook lived, until about 1931. The creek near here is named for him on the USGS map. Putugook (his name means "Big Toe") was a fine trapper, he was especially good at getting wolves. He could howl like a wolf and knew how to attract them. He went to Barrow about 1943, and died the following year of influenza after a severe windstorm. His daughter, Alice Makalik (Putugook) used to live at Kaktovik and was well-known to Kaktovik people. She died in Fairbanks in the spring of 1979.

Village sources: Tommy Uinniq Gordon

PATTAKTUQ - GORDON: TLUI Site

Location: On the east side of Demarcation Bay, at the base of the spit.

Meaning: Pattaktuq means "where the waves splash, hitting again and again." Gordon is named after the Scottish whaler and trader Tom Gordon, who established a trading post here in 1917.

U.S. Census 1939: 25 people

Tom Gordon established a trading post here in the summer of 1917, with the help of his brother-in-law Andrew Akootchook. They built a log house and warehouse, an outpost for the H. Liebes and Company of San Francisco. The Akootchook family lived here with the Gordon family for about a year before the Akootchooks moved to Barter Island.

Nora Agiak, daughter of Tom and Agiak Gordon, was about 6 years old when they first moved to Demarcation from Barrow. She remembers that between 1918 and 1922, Indians used to visit them here at Demarcation. They always used to talk about Ft. Yukon, but she's not sure if that's where they were from. Nora's family would know when the Indians were approaching, because they would shoot 3 times as a warning. Then the Gordons would answer back with 3 shots, signalling that it was all right for them to come. They visited once in January and February, and another time in August, when they came to meet the fur trading ship. When they came in August, Nora remembers them walking around in the water with their moccasins, and then trading their moccasins for sealskin mukluks. They would always try to trade their wolverine skins and their dry meat. Their dry meat was very good as it was made from fat caribou. These Indians already knew the older Eskimos that were living around Demarcation Pt. They were friendly, and didn't try to steal anything or hurt anyone.

Episcopal Archdeacon Hudson Stuck (1920:310-313) and his party visited the trading post here the year after it was established. Stuck's Inupiaq guide George Leavitt helped give a religious service at the Tom Gordon family's home.

Tom and Agiak Gordon's youngest child, Olive, was born here on 28 December 1922. The next year, 1923, the family moved to Barter Island and Tom started the trading post at Iglukpaluk.

After Tom left, he gave the Demarcation Bay establishment to his son Mickey. Mickey continued to run it as a trading post until the late 1920's. He and his family lived here off and on until the early 1940's, and when Mickey died in 1943 ownership of the house passed to Mickey's son Tommy Uinniq.

When Isobel Hutchinson and Gus Masik passed by Pattaktuq on their journey to Herschel Island in November 1933, the trading post building was deserted, as the Mickey Gordon family was living at Pinuqsraluk. Hutchinson also mentions 2 other empty houses here. One belonged to a native named Frank, and this is where her party spent the night (Hutchinson 1937).

Other families who lived at or near here in the 1920's and 1930's were the Ikpiaruks, the Mukaparuks, and the Kayutaks, Niel Allen's father, and a white man named Charlie Lou. Lou is remembered by Tommy Uinniq Gordon as "living off the country." Uinniq never knew Charlie Lou, but he remembers being carried to Charlie Lou's house on his mother's back.

In the 1940's, while Uinniq was living at Herschel Island, some surveyors moved into his house at Pattaktuq without his permission. They installed an oil stove, and they took some of his valuable things - a piece of mastodon tusk which he had there, as well as the spears and arrowheads which he had found (North Slope Borough 1980: 136-139).

In the 1950's, DEW Line Construction began in the Demarcation area. Uinniq lost the old trading post house at Pattaktuq because the DEW Line hauled too much gravel from the spit, causing the house to be washed away.

As evidenced by the number of sites, Demarcation Bay was and is a good fishing and hunting area. People hunted ducks in and around the Bay, especially oldsquaw (aqhaaliqs). They hunted caribou around the bay and several km inland. They also fished all along the spit extending out from Pattaktuq. They hunted polar bear by going due north from Pattaktuq and sheep by going south up the Kongakut River. Demarcation Bay is still used as a camping, hunting and fishing area, and as a stopover place when Kaktovik people are making boat trips to and from Canada.

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Fig. 3. Land-cover categories of ANWR. From Walker, Webber and Acevedo.