

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

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Alaska National Interest Lands Conservation Act



U.S. Department of the Interior
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Region 7
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**ARCTIC NATIONAL WILDLIFE REFUGE COASTAL PLAIN
RESOURCE ASSESSMENT**

**FINAL REPORT
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OF THE FISH, WILDLIFE, AND
THEIR HABITATS**

**Section 1002C
Alaska National Interest Lands Conservation Act**

**Edited by
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**U.S. Department of the Interior
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CONVERSION TABLE

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

<u>Multiply Metric S(1) Units</u>	<u>By</u>	<u>To obtain American Units</u>
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	35.7143	Cubic feet per second
Degrees Celsius (°C)	(°C x 1.8) + 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 Assessment). The following materials are the complete text of Section 1002(c) of ANILCA which mandated the baseline study program.

(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.

The initial report for the baseline study (U.S. Fish and Wildlife Service 1982) presented the status of the study as of mid-December 1981. The baseline study continued from 1982 through 1985, and the following guidelines were established to define the scope of studies and reports:

1. The baseline reports were intended to provide the current state of knowledge concerning the fish, wildlife and their habitats, and the cultural resources on the ANWR study area.
2. The baseline study reports were not decision making documents, nor were they documents that stated U.S. Fish and Wildlife Service (USFWS) policies or positions on oil and gas exploration issues. The Regulations and accompanying Environmental Impact Statement (U.S. Fish and Wildlife Service 1983) required by Section 1002(d) of ANILCA served that function.

3. The baseline study reports were not a planning process or document.
4. The baseline study reports presented factual information that described the surface resources of the area, and analyzed the impacts of the seismic exploration program and potential impacts of further exploration, development, and production of petroleum resources on those surface resources.

In addition to the initial baseline report (U.S. Fish and Wildlife Service 1982), baseline update reports have been prepared on an annual basis (Garner and Reynolds 1983, Garner and Reynolds 1984, Garner and Reynolds 1985, Garner and Reynolds 1986). These reports detailed progress on the individual projects and included an overall summary that presented new information, changes, and additions to the initial report.

This volume constitutes the final report for the ANWR baseline study of fish, wildlife and their habitats, and cultural and subsistence resources required under Section 1002(c) of ANILCA. Information was derived from the field studies conducted from 1981 through 1985 on the ANWR study area and a synthesis of available information from other sources, including published sources, unpublished data, and reports in various agency files. Field investigations conducted from 1982-1985 by USFWS - ANWR staff and cooperators as well as studies for which refuge scientific permits were issued are summarized in Table 1. Data from these studies and inventories were also used to meet ongoing information and monitoring needs and for use in developing certain sections of the Report to Congress (ANILCA Section 1002(h)).

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 within the study area (Chapter 8). Each chapter contains a literature cited section that is specific to that chapter.

Because much of this information will be used extensively by professional biologists and resource managers, the reference citations follow the style recommended by the CBE Style Manual Committee (1983). 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 follow that of Orth (1967). Place names mentioned in the text, especially Inupiat names are not listed in Orth (1967), but may be found in Jacobson and Wentworth (1982).

Table 1. Studies conducted on the Arctic National Wildlife Refuge coastal plain study area, 1982-1985.

Resource	Year	Project title	Investigators	Affiliation	Reports
Soils and Vegetation	1982	Landsat-assisted environmental mapping in the Arctic National Wildlife Refuge, Alaska	D. Walker	Univ. Colorado	CRRFL Report 82-37 on file, ANWR, Fairbanks
			W. Acevedo	Technicolor Gov. Serv.	
			K. Everett	NASA/Ames Res. Cent.	
			L. Gaydos	Ohio State Univ.	
				USGS	
			J. Brown	NASA/Ames Res. Cent.	Status unknown
				U.S. Army Corp of Eng. (CRRFL)	
			P. Webber	Univ. Colorado	
		Vascular plants at Sadlerochit springs	D. Murray	Univ. Alaska, Fairbanks	
	1983	1:63,360 scale geobotanical mapping studies in the Arctic National Wildlife Refuge	D. Walker	Univ. Colorado	Geobotanical map on file, ANWR, Fairbanks
			P. Webber	Univ. Colorado	
			K. Everett	Ohio State Univ.	
		Cooperative land cover/terrain mapping of the Arctic National Wildlife Refuge	C. Marcon S. Talbot M. Shashv L. Strong L. Pank	USFWS, Anchorage USFWS, Anchorage USGS, Anchorage USGS, Anchorage USFWS, Research, Fairbanks	Work in progress
		Soil evolution and biogeochemical dynamics in arctic Alaska	F. Ugolini	Univ. Washington	Status unknown
		Studies on balsam poplar	M. Edwards P. Dunwiddie	Univ. Washington Univ. Washington	Status unknown
	1984	Cooperative land cover/terrain mapping of the ANWR	C. Marcon S. Talbot M. Shashv L. Strong L. Pank	USFWS, Anchorage USFWS, Anchorage USGS, Anchorage USGS, Anchorage USFWS, Research, Fairbanks	Work in progress
		Effects of winter seismic exploration on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1984	N. Felix T. Jorgenson	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-1 Impacts?
		Soil evolution and biogeochemical dynamics in arctic Alaska	F. Ugolini	Univ. Washington	Status unknown
		Mapping vegetation, land-forms and soils for resource inventory and geographic information system	K. Von Schleider	Environmental Systems Research Institute, Redlands, CA	Status unknown
	1985	Effects of winter seismic trails on visual resources, vegetation, and permafrost on the coastal plain of the Arctic National Wildlife Refuge	N. Felix T. Jorgenson M. Raynolds R. Lipkin D. Plank B. Lance	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-21 ^d

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
		Airphoto analysis of seismic trails on the coastal plain of the Arctic National Wildlife Refuge	M. Felix T. Jorgenson M. Reynolds R. Lipkin D. Blank B. Lance	USFWS-ANWR, Fairbanks	ANWR Progress Report No. 86-3Id
		Snow distribution on the coastal plain of the Arctic National Wildlife Refuge	M. Felix T. Jorgenson M. Reynolds R. Lipkin D. Blank B. Lance	USFWS-ANWR, Fairbanks	ANWR Progress Report No. 86-1Id
		Accuracy assessment of Landsat land cover types	L. Pank	USFWS-Research, Fairbanks	Denver Wildlife Research Center Progress Report FY86-1
		Landsat cover map for the Arctic National Wildlife Refuge	Planning	USFWS, Anchorage	Work in progress
		Seasonal toxin production in plants: revegetation of disturbed areas (Okpilak River)	N. Grulke	Univ. Washington	Status unknown
		Soil evolution and biogeochemical dynamics (Okpilak River)	D. Marrett	Univ. Washington	1984 NSF Progress Report on file, ANWR, Fairbanks
Birds	1982	Terrestrial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge	M. Spindler P. Miller	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY83-5a
		Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1981 and 1982	R. Bartels M. Zellhoefer	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY83-3a
		Distribution, abundance, and productivity of whistling swans in the coastal wetlands of the Arctic National Wildlife Refuge, Alaska	R. Bartels M. Zellhoefer P. Miller	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY83-2a
		Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1980 and 1981	M. Spindler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY83-1a

Table 1. Continued

Resource Year	Project title	Investigators	Affiliation	Reports
	Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1982	M. Spindler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY83-4a
1983	Terrestrial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge, Alaska	M. Spindler P. Miller C. Moitoret	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY84-6b
	Species accounts of migratory birds at three study areas on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1983	M. Spindler P. Miller C. Moitoret	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY84-13b
	Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1983	R. Bartels T. Doyle	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY84-7b
	Movement of molting oldsquaw within the Beaufort Sea coastal lagoons of the Arctic National Wildlife Refuge, Alaska, 1983	R. Bartels T. Doyle T. Wilmers	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY84-6b
	Distribution, abundance, and productivity of fall staging lesser snow geese on coastal habitats of northeast Alaska and northwest Canada, 1983	M. Spindler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY84-2b
	Distribution, abundance, and productivity of tundra swans in coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1983	R. Bartels T. Doyle	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY84-8b
1984	Terrestrial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge	C. Moitoret P. Miller R. Oates M. Masteller	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-13c
	Species accounts of migratory birds at three study areas on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1984	P. Miller C. Moitoret M. Masteller	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-14c

Table 1. Continued.

Resource Year	Project title	Investigators	Affiliation	Reports
	Migratory bird use of coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1984	A. Brackney J. Morton J. Noll	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-11 ^c
	Movements of molting oldsquaw within the Beaufort Sea coastal lagoons of the Arctic National Wildlife Refuge, Alaska, 1984	A. Brackney J. Morton J. Noll M. Masteller	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-12 ^c
	Distribution, abundance, and productivity of fall staging lesser snow geese on coastal habitats of northeast Alaska and northwest Canada, 1984	R. Oates A. Brackney M. Masteller	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-7 ^c
	Ecology of lesser snow geese staging on the coastal plain of the Arctic National Wildlife Refuge, Alaska, fall 1984.	A. Brackney M. Masteller J. Morton	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-8 ^c
	Distribution, abundance, and productivity of tundra swans in the coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1984	A. Brackney J. Morton J. Noll M. Masteller	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-10 ^c
	Distribution and relative abundance of golden eagles in relation to the Porcupine caribou herd during calving and post-calving periods, 1984	F. Mauer	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-3 ^c
	Birds and mammals along the Hulahula	R. Gill M. Amaral	USFWS, Anchorage	Trip report on file, ANWR, Fairbanks
1985	Terrestrial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge	R. Oates D. Douglas M. McWhorter C. Babcock R. Field S. Gehman T. Maxwell J. Morton	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-17 ^d

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
		Species accounts of migratory birds at eight study areas on the coastal plain of the Arctic National Wildlife Refuge, Alaska	R. Oates M. McWhorter D. Douglas C. Babcock R. Field S. Gehman T. Maxwell J. Morton	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-18 ^d
		Migratory bird use of the coastal lagoons system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1985	A. Brackney R. Platte J. Morton	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-15 ^d
		Habitat use and behavior of molting oldsquaw on the coast of Arctic National Wildlife Refuge, Alaska, 1985	A. Brackney R. Platte	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-17 ^d
		Distribution, abundance and productivity of fall staging lesser snow geese on coastal habitats of northeast Alaska and northwest Canada.	R. Oates A. Brackney M. McWhorter R. Platte J. Morton G. Muehlenhardt C. Bitler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-10 ^d
		Ecology of lesser snow geese on coastal plain of the Arctic National Wildlife Refuge, Alaska, fall 1985	A. Brackney R. Platte J. Morton D. Whiting	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-11 ^d
		Distribution, abundance and productivity of tundra swans in coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1985	A. Brackney R. Platte	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-13 ^d
		Distribution and relative abundance of golden eagles in relation to the Porcupine caribou herd during calving and post-calving periods, 1985	F. Mauer	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-4 ^d
Mammals					
Caribou	1982	Evaluation of techniques for assessing neonatal caribou calf mortality in the Porcupine caribou herd	F. Mauer G. Garner L. Martin G. Weiler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 83-6 ^a

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
		Fall, winter, and spring distribution of the Porcupine caribou herd, 1981-1982	K. Whitten R. Cameron	Alaska Dept. of Fish and Game (ADF&G), Fairbanks	ADF&G Interim Report, 1982 ^a
		Size and composition of the Porcupine caribou herd, 1982	K. Whitten R. Cameron	ADF&G, Fairbanks	Work in progress
		Studies of the Central Arctic caribou herd	R. Cameron K. Whitten	ADF&G, Fairbanks	Work in progress
		Surveys of the Central Arctic caribou herd		Renewable Resources Consulting Services Ltd., Anchorage	Status unknown
		Migratory energetics of caribou	L. Duquette	Univ. Alaska, Fairbanks	Work in progress (M.S. Thesis)
	1983	Size and composition of the Porcupine caribou herd, 1982	K. Whitten R. Cameron	ADF&G, Fairbanks	ADF&G Interim Report, 1983 ^b
		Calving distribution and initial productivity in the Porcupine caribou herd, 1982	K. Whitten R. Cameron	ADF&G, Fairbanks	ADF&G Interim Report, 1983 ^b
		Studies of the Porcupine caribou herd, 1982-1983	K. Whitten	ADF&G, Fairbanks	ADF&G Preliminary Report, 1984 ^b
		Calving distribution, initial productivity, and neonatal mortality of the Porcupine caribou herd, 1983	K. Whitten G. Garner F. Mauer	ADF&G, Fairbanks USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY84-12 ^b
		Probe: Spatial and temporal distribution of biting and parasitic insects on the coastal plain and adjoining foothills of the Arctic National Wildlife Refuge, Alaska	L. Pank E. Friedman C. Curby A. Jones	USFWS-Research, Fairbanks	DWRC Progress Report, 1984 ^b
		Yearling mortality study of the Porcupine caribou herd		Yukon Dept. of Renewable Resources Whitehorse, Y.T.	Work in progress
		Spring migration and staging of male caribou in the Porcupine caribou herd		Canadian Wildlife Service (CWS), Whitehorse, Y.T.	Work in progress
		Behavioral, foraging, and movement patterns of a cow caribou during spring migration of the Porcupine caribou herd	L. Duquette	Univ. Alaska, Fairbanks	M.S. Thesis

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
		Development and alteration of movement patterns in the Central Arctic caribou herd	R. Cameron K. Whitten	ADF&G, Fairbanks	ADF&G Interim Report on file, ANWR, Fairbanks
		Surveys of the Central Arctic caribou herd		Renewable Resources Consulting Services Ltd., Anchorage	Status unknown
		Surveys of the Central Arctic caribou herd		Alaska Biological Research, Fairbanks	Status unknown
	1984	Fall and winter movements, distribution, and annual mortality patterns of the Porcupine caribou herd, 1983-1984	K. Whitten F. Mauer G. Garner D. Russell	ADF&G, Fairbanks USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks CWS, Whitehorse Y.T.	ANWR Progress Report No. FY85-17 ^c
		Calving distribution, initial productivity, and neonatal mortality of the Porcupine caribou herd, 1984	K. Whitten F. Mauer G. Garner	ADF&G, Fairbanks USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-18 ^c
		Probe: Spatial and temporal distribution of biting and parasitic insects on the coastal plain and adjoining foothills of the Arctic National Wildlife Refuge	L. Pank C. Curbv R. Mankivell C. Simon R. Wright	USFWS-Research, Fairbanks	DWRC Progress Report ^c
		Yearling mortality of the Porcupine caribou herd	D. Russell	Yukon Dept. of Renewable Resources, Whitehorse, Y.T.	Work in progress
		Spring migration and staging of male caribou in the Porcupine caribou herd	A. Martel D. Russell	CWS, Whitehorse, Y.T.	Work in progress
		Occurrence of Central Arctic herd caribou in the Arctic National Wildlife Refuge during the spring and summer	R. Cameron K. Whitten	ADF&G, Fairbanks	ADF&G Preliminary Report, 1985 ^c
	1985	Fall and winter movements, distribution, and annual mortality patterns of the Porcupine caribou herd, 1985	K. Whitten F. Mauer G. Garner	ADF&G, Fairbanks USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-21 ^d
		Movements of the Porcupine caribou herd prior to, during, and after calving	F. Mauer K. Whitten G. Garner	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-6 ^d
		Mortality of neonatal caribou calves in the Porcupine herd	F. Mauer G. Garner K. Whitten	USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks ADF&G, Fairbanks	ANWR Progress Report No. FY86-22 ^d

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
		Porcupine caribou herd population census	K. Whitten et al.	ADF&G, Fairbanks	ADF&G Report
		Distribution of biting and parasitic insects which may affect Porcupine caribou	L. Pank	USFWS-Research, Fairbanks	DWRC Progress Report No. FY86-2 ^d
		Assessment of impacts on Porcupine caribou herd	L. Pank	USFWS-Research, Fairbanks	DWRC Progress Report No. FY86-3 ^d
		Movements of satellite collared caribou in the Porcupine and Central Arctic herd	L. Pank W. Regelin	USFWS-Research, Fairbanks ADF&G, Fairbanks	DWRC Progress Report No. FY86-4 ^d
		Movement patterns in the Central Arctic caribou herd in the Arctic National Wildlife Refuge in spring and summer	R. Cameron	ADF&G, Fairbanks	ADF&G Report on file ANWR, Fairbanks
Muskox	1982	Population size, productivity, and distribution of muskoxen in the Arctic National Wildlife Refuge, Alaska	P. Reynolds L. Martin G. Weiler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY83-7 ^a
	1983	Comparative habitat use by muskoxen in northern Alaska	C. O'Brian	Univ. Alaska, Fairbanks	Work in progress (M.S. Thesis)
		Population dynamics and distribution of muskoxen in the Arctic National Wildlife Refuge, Alaska	P. Reynolds L. Martin T. Wilmers T. Doyle	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY84-10 ^b
		Comparative habitat use by muskoxen in northern Alaska	C. O'Brian	Univ. Alaska, Fairbanks	Work in progress (M.S. Thesis)
	1984	Population and herd dynamics, distribution, movements, and habitat use of muskoxen in the Arctic National Wildlife Refuge, Alaska, 1982-1984	P. Reynolds L. Martin G. Weiler J. Noll J. Morton	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-1 ^c
		Effects of winter seismic exploration activities on muskoxen in the Arctic National Wildlife Refuge, Alaska, January - May 1984	P. Reynolds D. LaPlant	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-2 ^c
		Comparative habitat use by muskoxen in northern Alaska	C. O'Brian	Univ. Alaska, Fairbanks	Work in progress (M.S. thesis)

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
Moose		Ecology of muskoxen on the Arctic National Wildlife Refuge, 1982-1985	P. Reynolds J. Herriges M. Masteller	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-2 ^d
		Movements and activity patterns of a satellite collared muskox on the Arctic National Wildlife Refuge, 1984-1985	P. Reynolds	USFWS-ANWR, Fairbanks	ANWR progress Report No. FY86-5 ^d
		Effects of aircraft overflights on muskoxen on the Arctic National Wildlife Refuge, 1982-1985	P. Reynolds	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-8 ^d
		Effects of winter seismic exploration activities on muskoxen on the Arctic National Wildlife Refuge, 1982-1985	P. Reynolds	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-24 ^d
		Comparative habitat use by muskoxen in northern Alaska	C. O'Brian	Univ. Alaska, Fairbanks	Work in progress (M.S. thesis)
	1983	Population size, composition, and distribution of moose along the Canning and Kongakut Rivers within the Arctic National Wildlife Refuge, Alaska, fall, 1983	L. Martin G. Garner	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 84-4 ^b
	1984	Population size, composition, and distribution of moose along the Canning and Kongakut Rivers in the Arctic National Wildlife Refuge, Alaska, spring and fall, 1984	L. Martin G. Garner	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 85-6 ^c
	1985	Population size, composition, and distribution of moose along the Canning and Kongakut Rivers in the Arctic National Wildlife Refuge, 1985	G. Garner	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-9 ^d
	Marine Mammals	Polar bear population, movements, and denning	S. Amstrup	USFWS-Research, Anchorage	Work in progress
		Polar bear population, movements, and denning	S. Amstrup	USFWS-Research, Anchorage	Work in progress
		Bowhead tissue sample	T. Albert	North Slope Environment Protection Office, Barrow	Status unknown

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
Brown Bear	1985	Polar bear population, movements and denning	S. Amstrup	USFWS-Research, Anchorage	Work in progress
		Bowhead whale surveys	B. Morris	National Marine Fisheries Service	Status unknown
	1982	Polar bear population, movements and denning	S. Amstrup	USFWS-Research, Anchorage	Work in progress
		Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge	G. Garner L. Martin G. Weiler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY83-8a
	1983	Habitat use and activities of grizzly bears in the Arctic National Wildlife Refuge	M. Phillips	Univ. Alaska, Fairbanks	Prelim. report, Dept. of Wildlife and Fisheries (M.S. Thesis)
		Ecology of Brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge	G. Garner H. Reynolds L. Martin T. Wilmers T. Doyle	USFWS-ANWR, Fairbanks ADF&G, Fairbanks USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY84-11b
		Habitat use and behavior of grizzly bears in the Arctic National Wildlife Refuge	M. Phillips	Univ. Alaska, Fairbanks	ANWR Progress Report No. FY84-1b
		Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northern portion of the Arctic National Wildlife Refuge	G. Garner H. Reynolds L. Martin G. Weiler J. Morton J. Noll	USFWS-ANWR, Fairbanks ADF&G, Fairbanks USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-9c
	1986	Habitat use and behavior of grizzly bears in the Arctic National Wildlife Refuge	M. Phillips	Univ. Alaska, Fairbanks	Work in progress (M.S. thesis)
		Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the Arctic National Wildlife Refuge	G. Garner H. Reynolds M. Masteller J. Herriges G. Weiler	USFWS-ANWR, Fairbanks ADF&G, Fairbanks USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-12d
		Brown bear denning in the northeastern portion of the Arctic National Wildlife Refuge	G. Garner M. Masteller	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-16d

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
Wolf		Brown bear census techniques	H. Reynolds G. Garner D. Reed	ADF&G, Fairbanks USFWS-ANWR, Fairbanks ADF&G, Fairbanks	ANWR Progress Report No. FY86-23 ^d
		Habitat use and behavior of grizzly bears in the Arctic National Wildlife Refuge, Alaska	M. Phillips	Univ. Alaska, Fairbanks	Work in progress (M.S. thesis)
	1983	Prey utilization by wolves and a preliminary assessment of wolf and prey densities in three drainages within the Arctic National Wildlife Refuge, Alaska	H. Haugen	Univ. Alaska, Fairbanks	ANWR Progress Report No. FY84-5 ^d
	1984	Wolves of the Arctic National Wildlife Refuge: Their seasonal movements and prey relationships	G. Weiler G. Garner L. Martin W. Regelin	USFWS-ANWR Fairbanks ADF&G, Fairbanks	ANWR progress Report No. FY85-5 ^c
		Prey utilization by wolves in two drainages within the Arctic National Wildlife Refuge and a preliminary description of wolf pack behavior around the den in the Kongakut River drainage	H. Haugen	Univ. Alaska, Fairbanks	ANWR Progress Report No. FY85-4 ^c
	1985	Food habits of wolves in the Arctic National Wildlife Refuge	G. Weiler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-19 ^d
		Ecology of wolves on Arctic National Wildlife Refuge	G. Weiler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-7 ^d
		Food habits of wolves on the Kongakut River	H. Haugen	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY86-3 ^d
	1983	Ecology of arctic foxes at Demarcation Bay	B. Burgess	Univ. Alaska, Fairbanks	M.S. Thesis
	1984	Distribution and abundance of wolverines in the northern portion of the Arctic National Wildlife Refuge	F. Mauer	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY85-16 ^c

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
Small Mammals	1983	Microtine rodents and ground squirrels of the coastal plain and foothills of the Arctic National Wildlife Refuge: distributions, densities, and general ecology	C. Babcock	Univ. Alaska, Fairbanks	ANWR Progress Report No. FY84-3b
	1984	Microtines and ground squirrels of the coastal plain of the Arctic National Wildlife Refuge: Notes on distributions, densities, and general ecology	C. Babcock	Univ. Alaska, Fairbanks	ANWR Progress Report No. FY85-15c
		Small mammal specimen collecting	S. McDonald	Univ. Alaska, Fairbanks	Results on file, ANWR, Fairbanks
	1985	Microtine rodents and ground squirrels of the coastal plain and foothills of the Arctic National Wildlife Refuge: distribution, densities, and general ecology	C. Babcock	Univ. Alaska, Fairbanks	ANWR Progress Report No. FY86-15d
		Food habitats of microtine rodents on the Arctic National Wildlife Refuge	C. Babcock	Univ. Alaska, Fairbanks	ANWR progress report Report No. FY86-20d
		Vegetation patterns and microtine rodent use of tundra habitats in northeastern Alaska	C. Babcock	Univ. Alaska, Fairbanks	M.S. Thesis
Fish	1982	Aquatic studies on the north slope of the Arctic National Wildlife Refuge 1981 and 1982	M. Smith R. Glesne	USFWS-Fairbanks Fishery Resources (FFR)	FFR Progress Report FY83-1a
		Environmental characterization and biological use of lagoons in the eastern Beaufort Sea		L.G.L. Ecological Research Associates Inc., Bryant, Texas	Final report for Outer Continental Shelf Environ. Assessment program NOAA, Juneau
	1983	Fisheries studies on the north slope of the Arctic National Wildlife Refuge, 1983	D. Daum P. Rost M. Smith	USFWS-FFR, Fairbanks	FFR Progress Report No. FY 84-1b
		Abundance, distribution, and diversity of aquatic macroinvertebrates on the north slope of the Arctic National Wildlife Refuge, 1982 and 1983	R. Glesne S. Deschermeier	USFWS-FFR, Fairbanks	FFR Progress Report No FY84-2b

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
		Aquatic survey of the Kaktovik dredging operation, 1983	P. Craig	L.G.L. Consulting Services Ltd., Anchorage	Final report to North Slope Borough on file, ANWR, Fairbanks
	1984	Fisheries investigations on the Arctic National Wildlife Refuge, Alaska, 1984	R. West D. Wiswar	USFWS-PFR, Fairbanks	PFR Progress Report No. FY85-1 ^o
		Aquatic survey of the Kaktovik dredging operation, 1983 and 1984	P. Craig	L.G.L. Consulting Services Ltd., Anchorage	Final report to North Slope Borough on file, ANWR, Fairbanks
		The ecology of tundra ponds of the Arctic coastal plain: a community profile	J. Hobbie	Ecosystems Center Marine Biological Laboratory, Woods Hole, MA	Final Report: FWS/ORS-83/25 USFWS, Washington, D.C.
	1985	Fisheries investigations in Beaufort Lagoon, Arctic National Wildlife Refuge	D. Wiswar R. West	USFWS-PFR, Fairbanks	PFR Progress Report No. FY86-1 ^d
		Fall movements and overwintering of arctic grayling in the Arctic National Wildlife Refuge	D. Wiswar R. West T. Stevens M. Smith	USFWS-PFR, Fairbanks	PFR Progress Report No. FY86-2 ^d
		Notes on the age, growth, distribution, and summer feeding habits of arctic flounder in Beaufort Lagoon, Arctic National Wildlife Refuge	D. Wiswar	USFWS-PFR, Fairbanks	PFR Progress Report No. FY86-3 ^d
		Baseline histopathological, parasite and contaminant studies of four arctic fish species in Beaufort Lagoon, Arctic National Wildlife Refuge	R. West	USFWS-PFR, Fairbanks	PFR Progress Report No. FY86-4 ^d
		Fisheries investigations on the Kongakut River, Arctic National Wildlife Refuge	S. Deschermeier T. Stevens D. Wiswar R. West	USFWS-PFR, Fairbanks	PFR Progress Report No. FY86-5 ^d
		The freshwater food habits of pre-smolt and small resident arctic char in streams in Arctic National Wildlife Refuge, 1982 - 1985	T. Stevens S. Deschermeier	USFWS-PFR, Fairbanks	PFR Progress Report No. FY86-6 ^d

Table 1. Continued.

Resource	Year	Project title	Investigators	Affiliation	Reports
Human Culture and Lifestyle	1982	Preliminary archaeological and historical resource reconnaissance of the coastal plain of the Arctic National Wildlife Refuge		Edwin Hall and associates	Report on file, ANWR, Fairbanks
		Kaktovik area cultural resource survey	D. Libby	Univ. Alaska, Fairbanks	Preliminary report to North Slope Borough, on file, ANWR, Fairbanks
		Subsistence land use baseline for eastern and central north slope communities, Alaska	S. Pederson	ADF&G-Subsistence, Fairbanks	Work in progress
		Sociocultural assessment of proposed ANWR oil and gas exploration	R. Worl P. McMillan T. Lonner S. Beard	AFIDC, Anchorage	Report completed, for AFIDC, Anchorage on file, ANWR, Fairbanks
	1984	Caribou hunting: dimensions and recent harvest patterns in Kaktovik, northeast Alaska	S. Pederson M. Coffing	ADF&G-Subsistence, Fairbanks	Final report: Technical paper No. 92 ADF&G Division of Subsistence, Fairbanks, on file. ANWR, Fairbanks

- a. In Garner and Reynolds (1983)
 b. In Garner and Reynolds (1984)
 c. In Garner and Reynolds (1985)
 d. In Garner and Reynolds (1986)

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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 135 km of Beaufort Sea coastline between the mouths of the Canning and Aichilik Rivers (Fig. 1), excluding approximately 50 km of coastline of 26,700 ha owned by the Kaktovik Inupiat Corporation (Fig.2). The village of Kaktovik (population 203 in 1983) and the 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.

Land Status

ANWR 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 Alaska Native Claims Settlement Act (ANSCSA) Public Law 92-203. Also adjacent to the southern boundary 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 Orukhtalik Lagoon (Fig. 2) has been conveyed to the Kaktovik Inupiat Corporation (KIC) according to provisions of the ANCSA. ANILCA provided for an exchange of lands which would allow for conveyance of an additional 9,324 ha of refuge lands to KIC, which are adjacent to existing corporation lands. This exchange has not yet been completed. Native land entitlements within the refuge (except for Barter Island) originally included surface rights only. The subsurface estate was retained by the Federal government. The Federal government and the Arctic Slope Regional Corporation (ASRC) signed a land exchange agreement on 9 August 1983 which transferred ownership of the subsurface estate beneath the KIC lands from the government to ASRC in exchange for ASRC holdings outside of ANWR. Public easements across Native lands for trails, survey access, utilities, and transportation of energy, fuel, and natural resources were reserved.

Forty-four 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). Five allotments had been approved by August 1985.

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 (Wahraftig 1965). This entire area lies north of the Arctic Circle, between 141° and 166° West.

The Brooks Range is a bow-shaped belt of rugged mountains extending nearly 1000 km from the Canadian border to Cape Lisburne on the Chukchi Sea, and rising in elevation to over 2700 m in its eastern sections. The Romanzof Mountains of the eastern Brooks Range curve north to within 30 km 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 1700 m 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 180 m 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 gradually from sea level, with its shore generally rising less than 15 m, and frequently less than 3 m above the Beaufort Sea. The Arctic Coastal Plain province is narrow (15-25 km) 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. Wahraftig (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. 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. Some of 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, Tamayariak, Katakturuk, Sadlerochit, Hulahula, Okpilak, Jago, and Niguanak Rivers (Fig. 2).

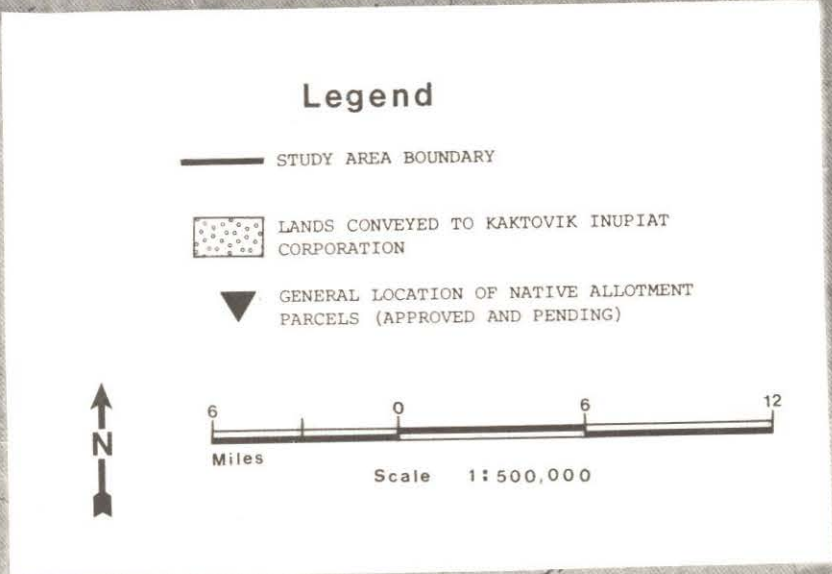
The coastline of the Beaufort Sea is irregular and characterized by a series of barrier islands and lagoons, beaches, submerged bars, spits, and river deltas resulting from longshore erosion, transport, and deposition of fluvial and marine sediments. This is in contrast with the Chukchi Sea coast to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

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 and 1980). The following discussion is derived largely from these sources.



Fig. 2 ARCTIC NATIONAL WILDLIFE REFUGE BASELINE STUDY AREA



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 period (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.

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 Wisconsin 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 30 km 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 m 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 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 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 2 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. Relict subsea permafrost is known to exist in areas of coastal retreat (Lewellen 1974).

The thickness of the permafrost layer is thought to exceed 650 m under some parts of the coastal plain, although the average depth is 200 to 300 m 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 thawed ground overlying permafrost is termed the active layer. The depth of thaw depends upon topography, microclimate, vegetation, surface moisture, and the thermal characteristics of the soil (Washburn 1973, Pewe 1975). The thickness can also vary from year to year due to varying climatic conditions. Thaw depths range from less than 15 cm in colder coastal areas to depths greater than 1 m in some river beds and exposed bedrock. Over most of the study area thaw depths range from about 15 to 45 cm, but can be highly variable depending on microsite characteristics (Felix et al. 1986a). More detailed relationships of thaw depths to terrain characteristics are presented in the soils descriptions in Chapter 3. The active layer absorbs heat and insulates the underlying permafrost, thus preserving the stability of ice-rich terrain.

Ice content in the permafrost is an important factor in determining the surface character of the terrain, the distribution of vegetation types, and sensitivity to natural and man-made disturbances. Ice is commonly found in fine-grained sediments but is also found in gravels and bedrock (Kreig and Reger 1982). Ice contents near the surface of the permafrost (upper 30 cm) were found to be extremely variable in the study area, ranging from 0 to 80% (Felix et al. 1986a). Ground ice in the thaw lake plains near Barrow ranged from 50 to 75% in the upper 2 m, and was primarily composed of small ice segregations (Sellman and Brown 1973). Massive ice lenses up to 10 m thick have been found in the foothills near the Sagavanirktok River (Kreig and Reger 1982).

Ice wedges, which commonly occur in the study area, are V-shaped masses of vertically foliated ice that underlie the troughs of tundra polygons and may attain a width of 3 to 5 m and reach depths of 10 m (Pewe 1975). In the thaw lake plains near Barrow, 10 % of the perennially frozen near-surface soils are composed of ice wedges (Brown 1967). In general, ice wedges 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 ice aggradation is the presence of pingos; isolated, conical ice-covered hills, 20 to 400 m in diameter and up to 70 m 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. These features result from naturally induced thermal instability, although thermokarst can also be initiated by human caused 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).

The active layer is a dynamic unit which is reshaped by seasonal freezing and thawing and is continually moving and adjusting on even the most gentle slopes. Heaving and sorting movements result in a wide variety of patterned ground that includes hummocks, mud boils (non-sorted circles of frost boils), sorted circles, stone stripes, and solifluction lobes (Washburn 1973). Hummocks and frost scars are particularly common features of the upland terrain of the study area, and greatly affect the vegetation patterns as discussed in Chapter 3. Frost action also causes the mass transfer of material downslope mainly by solifluction and frost creep.

Solifluction, the gradual downslope movement of fine-grained water-saturated surficial deposits (both mineral and organic), usually occurs over bedrock or a shallow permafrost table, and appears as lobe-like or sheetlike flows on slopes with gradients as low as 1° . These flows move at rates of up to 6 cm per year on slopes of 10 to 14° (Washburn 1973). Solifluction forms, such as discontinuous stripes or lobes, are common downslope from some outcrops and river bluffs, in the study area, where slope breaks exceed 10% (Walker et al. 1982). Water from melting snowbanks contributes greatly to formation of these solifluction deposits.

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).

Another 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 water onto and around older ice 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 4 m thick (Washburn 1973). On many rivers within the study area, e.g. Canning, Tamayariak, Nularvik, Itkilyariak, Sadlerochit, Hulahula, and Okerckovik, aufeis is a conspicuous feature on deltas and on floodplains below springs throughout the summer season.

Climate

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 (Searby 1968, Searby and Hunter 1971). 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 temperatures frequently drop below -40° C. Since high surface winds are common throughout the year, the combination of wind and temperature results in equivalent chill factors well below the actual temperatures.

The position of the arctic front is of considerable importance in determining patterns of temperature, precipitation, and wind. The arctic front is 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).

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 25 kilometers per hour (kph) with occasional intense storms generating winds in excess of 115 kph. The winds are predominantly from the east during May through December and westerly during January through April. Most of the strongest winds (greater than 40 kph) are westerly.

A distinct contrast exists between the summer climate of the immediate coast and the interior portion of the Arctic Coastal Plain (Haugen 1982). Average summer temperatures on the coast remain within a few degrees of freezing due to more frequent cloudiness and fog, and prevailing easterly winds or sea breezes off the ocean. Clear skies and higher average air temperatures occur farther inland.

The only long-term climatic records available for the study area are from Barter Island which is representative of the coastal zone (Fig. 3). The mean annual temperature is -12.3°C with 25.6°C being the highest recorded temperature and -50.6°C the lowest. Mean annual precipitation at Barter Island is 159 mm, of which 66 mm falls between July and September, reflecting higher monthly precipitation during the summer.

Based on these precipitation figures, the study area could be considered arid. However, due to low evaporation rates and the impeded drainage caused by permafrost, soils are usually saturated in the summer.

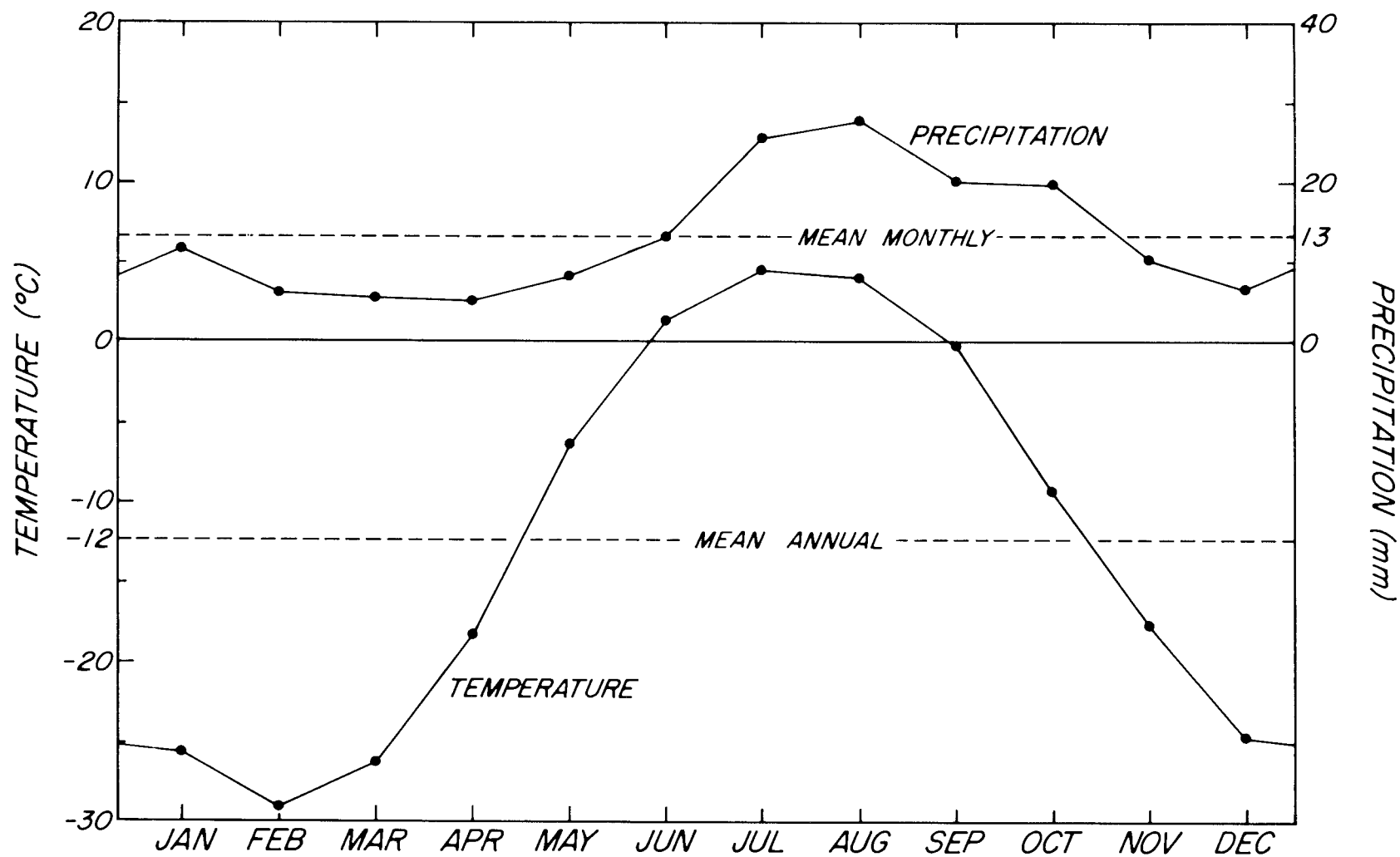


Fig. 3. Mean monthly temperature (°C) and precipitation (mm) at Barter Island for the period 1948-1983 (U.S. Dept. of Commerce, NOAA 1984).

Wyoming snow gauges have been used recently to obtain a more accurate measure of rain and snow under the windy arctic conditions. The true amount of precipitation is estimated to be 1.1 times higher in the summer and 3 times higher in the winter than the precipitation measurements obtained from the standard 8-inch gauges (Benson 1982). Mean annual winter precipitation recorded at Barter Island in 1977 through 1985 is shown in Fig. 4. Comparisons of this precipitation data between years, however, is limited by variations in measurement periods.

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 (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 1.

Table 1. Drainage characteristics and streamflow data for principle rivers within the ANWR study area (from U.S. Army Corps of Engineers 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

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 60 km inland (Walker 1974), although the higher topographic gradient of rivers within the study area would prohibit penetration on this scale. Within the deltas, freshwater is entirely replaced by seawater.

In spring (May and June), melt water begins to accumulate and flow over the surface of the inland river ice and on the deltas. As the river ice fractures and breakup begins, the increasing flow of freshwater rapidly flushes 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 cm) of fine material may occur on the sea ice

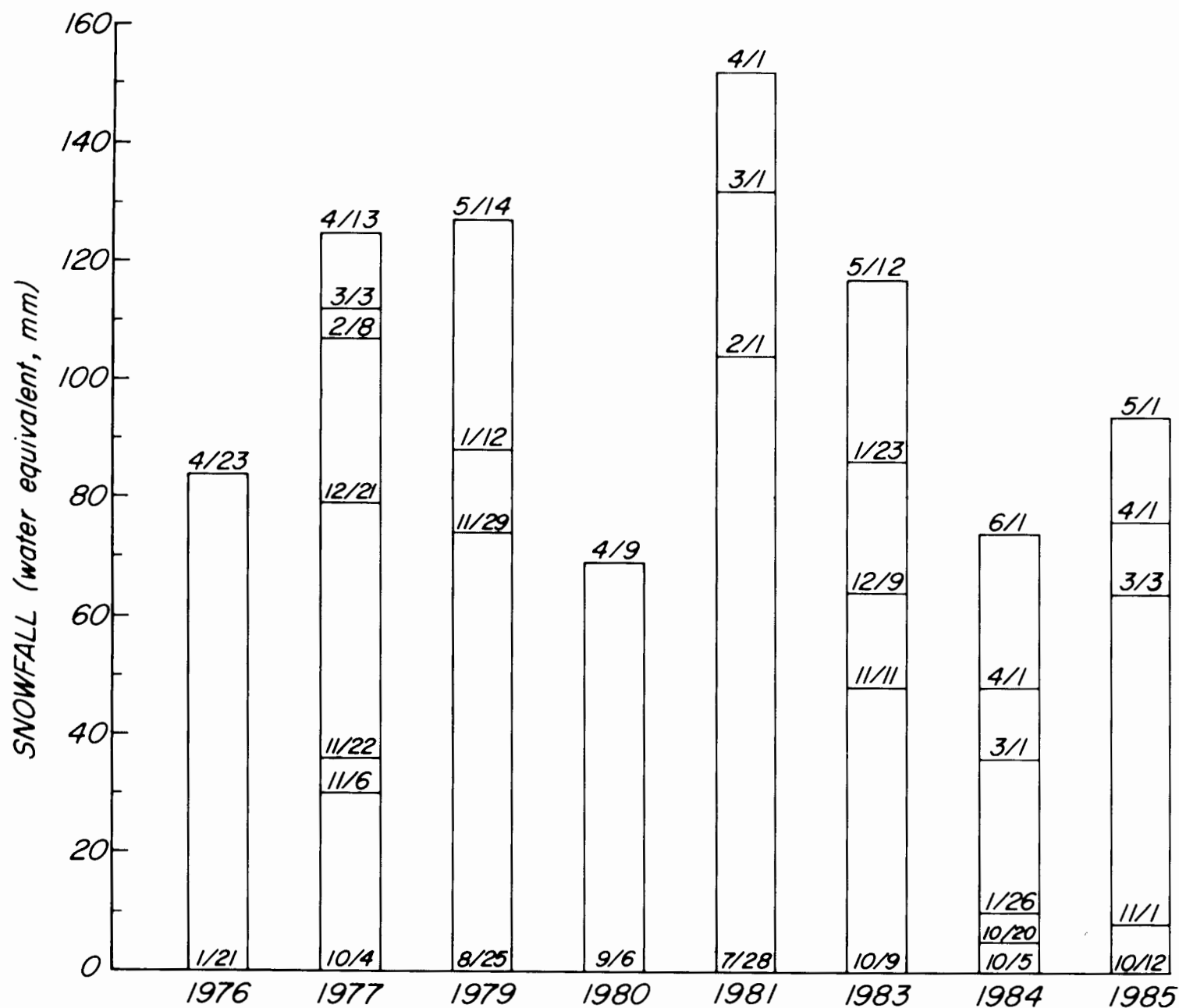


Fig. 4. Winter precipitation (water equivalent, mm) accumulated in Wyoming snow gauge at Barter Island, Alaska, 1976-1985. Data are from U.S. Dept. of Agriculture, Soil Conservation Service (1977-1985) and Benson (1982). Dates on which gauges were read are included above bars.

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 (Walker 1974). Following breakup, flooding drops off rapidly. Due to the low summer rainfall of the arctic slope, summer flooding is uncommon.

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 km² (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 nonexistent 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 occurring beneath the permafrost zone is likely to be saline (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 Okerokovik 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 8 km downstream during the coldest part of the year. Further information on the chemical and physical characteristics of streams and springs in the study area is found in Chapter 6.

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 10 m depth contour, including all barrier islands, reefs and bars. This corresponds to the beach and nearshore zone described by Short et al. (1974). The 10 m 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 lunar tide of 15 cm. 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 2-3 m). The geomorphic processes controlled by these meteorological 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 have 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 20 m or more per thaw season have been measured, although coastal retreat between Demarcation Point and Brownlow Point has averaged 1.5 m 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 Mauer 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 50 cm 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 at 5,000 to 10,000 m³ 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 70 m per year and alongshore up to 300 m per year (Wiseman and Short 1976). The net westerly movement of sediments within bar systems of the Beaufort Sea has been estimated as approaching 400,000 m³ per year, 2 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 (Naidu et al. 1984). 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 2 m above sea level) and narrow (less than 2 km), and are likely to be breached or inundated by storm surges or flooding during breakup (Hopkins and Hartz 1978).

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 usually 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 60 ppt by late winter.

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 Canadian Arctic Archipelago. The Beaufort Sea has a shallow, relatively narrow continental shelf which generally extends from 50 to 100 km off the northern Alaska coast to a well-defined shelf break at the 100 m isobath (US Dept. of Interior-Bureau of Land Management 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 200 m and covers most of the continental shelf; the upper 50 m of this layer originates primarily from terrestrial runoff and is characterized by relatively low salinities (28.5 to 33.5 ppt) and temperatures (0° to -1.5° C). Atlantic water is injected into the Arctic Basin through the passage between Greenland and Spitsbergen and is found from 200 m to 900 m in depth. It is of higher salinity and temperature (greater than 0° C). Arctic bottom water, found below 900 m, is cold (below 0° 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 10 cm 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 30 cm (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 3 months of the year (mid-July to mid-October), during which time the polar pack ice usually moves offshore 50 to 65 km 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, Naval Arctic Research Laboratory 1980). 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, Naval Arctic Research Laboratory 1980, U.S. Dept. of Interior - Bureau of Land Management 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 30 m and it is often bottomfast out to depths of 2 to 3 m. 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 (U.S. Dept. of Interior - Bureau of Land Management 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 2 m) 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 10 m) multiyear floes which are almost fresh (0 to 6 ppt) and considerably stronger than seasonal ice (Kovacs and Mellor 1974, U.S. Dept. of Interior - Bureau of Land Management 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 (Naval Arctic Research Laboratory 1980). During late July and early August, the pack ice moves northward and open water extends along the coast to the west towards Point 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 along shore 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, Naval Arctic Research Laboratory 1980).

Data Gaps

Little information is available on the distribution of ground ice in the study area and the extent and origin of massive ice beds. The amount of ground ice is an important factor in determining the effects of oil exploration and development on surface stability.

The only weather station near the study area is located on Barter Island, which is more likely to experience high winds, fog, and corresponding lower temperatures than inland locations. A series of weather stations located farther inland would provide more accurate temperature, wind, and precipitation data for the entire study area. Measurements of snow accumulation on Barter Island should be continued to determine the annual and seasonal variations in snow profiles. Annual surveys to evaluate snow distribution patterns across the study area are needed to relate snow data from Barter Island to the entire study area.

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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 stages 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 study area as defined by Section 1002(c) of the Alaska National Interest Lands Conservation Act.

The following discussion provides: 1) a summary of the development of knowledge about the soils and vegetation in and adjacent to the study area, 2) a description 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.

Soils Studies

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 (1975) unless otherwise noted. 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 the nearly level to rolling topography - the broad, smooth north trending interfluvies and the flat near-coastal areas with oriented lakes, 2) Pergelic Cryaquepts on nearly level topography with very gravelly mineral components found on the braided river valleys and their associated terraces and deltas.

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 19km² in the Okpilak lakes area and described soils along the Jago and Hulahula Rivers. Hettinger and Janz (1974) described several soils from the foothills near the Kongakut, Aichilik, and Okerokovik Rivers and from the floodplain of the Canning River in the course of route selection for a proposed Alaskan arctic gas pipeline.

Vegetation Studies in Arctic Alaska

The earliest studies of plant species occurring 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 Hultén (1968). This effort was followed by Anderson (1974). These 2 works have provided 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. More detailed discussions of vegetation and plant communities in the north have come from Sigafos (1952), Britton (1957), Spetzman (1959), Wiggins and Thomas (1962), and Johnson et al. (1966). A number of more geographically restricted community descriptions have been developed by Wiggins (1951), Hansen (1953), Churchill (1955), Hettinger and Janz (1974), Murray (1974), Batten (1977), Meyers (1985), and others. Successional processes within tundra vegetation types have been described by Churchill (1955), Churchill and Hansen (1958), and Spetzman (1959). Viereck's (1981) effort to produce an exhaustive bibliography for the vegetation of Alaska has resulted in an annotated list of references that currently contains over 300 citations.

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 conducted to the west of the study area in the National Petroleum Reserve - Alaska (NPR-A) near Barrow, along the Trans-Alaska Pipeline System (TAPS), and in the region near Prudhoe Bay.

The Barrow and NPR-A areas have been studied by Spetzman (1951, 1959), Wiggins (1951), Churchill (1955), Walker (1977), Lawson et al. (1978), Webber (1978), Kormarkova and Webber (1980), Morrissey and Ennis (1981), Walker and Acevedo (1984), Walker (1985a), and others. Markon (1980) provided a mapping system for terrestrial and aquatic habitats along the proposed Alaska Natural Gas Pipeline System. Ecological baseline studies along the northern section of the TAPS haul road were presented by Brown (1978). The Prudhoe Bay area has been described by Webber and Walker (1975), Everett and Parkinson (1977), Everett et al. (1978), Walker et al. (1979), and Walker (1985b).

Arctic tundra wetlands were studied by Bergman et al. (1977) near Prudhoe Bay. Eight wetland categories were recognized based on their degree of inundation, 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 bird habitat studies within the study area (Martin and Moitoret 1981).

Maps of vegetation, soils, and landforms of the Prudhoe Bay area were developed by Walker et al. (1980). These maps were based on 1:6,000-scale aerial photos, and were produced at a scale of 1:12,000. Plant community names included 3 parts: 1) a site moisture category (dry, moist, wet, or very wet); 2) several species that are typical of the community; and 3) a physiognomic descriptor. For example, a wet tundra community might be called

"Wet Carex aquatilis, Drepanocladus brevifolius graminoid meadow". Landform classes were used to describe the variety of patterned ground in the area, such as low-centered polygons, high-centered polygons, hummocks, and pingos. It is useful to map landforms in the arctic since the soils and vegetation are closely related to variations in the patterns of ground features. A number of special purpose maps were generated from the master maps of vegetation, soils, and landforms. These included summer off-road vehicle sensitivity, oil spill sensitivity, bird densities, peat thickness, snow depth, and active layer thickness. This series of maps provided information necessary to solve potential environmental problems associated with oil development.

A detailed statewide vegetation classification was developed by Viereck et al. (1982). This hierarchical system is based on existing vegetation attributes and includes 5 levels of resolution from major formations (forest, scrub, and herbaceous) 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). The system in general has received fairly widespread interest by state, federal, and private sectors.

Vegetation Mapping and Classification in the Study Area

In an attempt to portray the potential natural vegetation of Alaskan land, Kuchler (1966) listed 10 phytocenoses or vegetation groups. The potential vegetation was characterized as cotton sedge tundra with Eriophorum representing the principle dominant genus, with a narrow band of the water sedge tundra assemblage, characterized by Carex, along the coast from the Canning River east to approximately the Katakuruk River and inland for about 8km.

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 present in the study area. The generalized boundaries of the 4 major community types: moist tundra, high brush, wet tundra, and alpine and barren ground were superimposed on a series of maps at a scale of 1:1,000,000. Two aquatic communities were also 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 for Alaska, 1973).

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

- 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

National Wetlands Inventory maps based on the wetland classification method developed for U.S. Fish and Wildlife Service (USFWS) are available for the majority of the study area, including Flaxman Island A1; Barter Island A3-5; Mt. Michelson C2-4, D1-5; and Demarcation Pt. C3, D2-5. Flaxman Island A3 and A4 are currently being revised. The basis of this system was presented by Cowardin et al. (1979) with additional information presented in the 1978 Interagency Task Force Report: Our Nations Wetlands (Horwitz 1978).

Nodler and LaPerriere (1977) produced a Landsat map for the study area; which depicted the following 13 vegetation classes:

- I. Ice, snow, or aufeis
- II. Water or shadows
- III. Barrens
- IV. Partially vegetated ground
- V. Wet tundra or shadows
- VI. Flooded tundra or shadows
- VII. Intermediate wet-moist tundra
- VIII. Upland Dryas - heath tundra
- IX. Upland sedge tundra
- X. Upland tussock tundra
- XI. Ericaceous snow bed community
- XII. Hummocky frost-heaved ground
- XIII. Dry tundra

The map was used on several occasions in the field to determine if a relationship existed between habitat usage by wildlife and the vegetation classes that were portrayed. It was generally found that a reasonably good correlation existed between the coastal and riverine tundra areas characteristically utilized by waterfowl (Spindler 1978). However, the upland sedge tundra and upland tussock tundra classes did not appear to be related to observed use by caribou (Weiler 1980).

An updated and expanded Landsat map of the study area was produced by Walker et al. (1982). Twelve landcover classes were identified on satellite imagery based on vegetation, landform, and soils data collected at numerous field sites (Appendix I, Table 1). This map has been used by the refuge staff for wildlife and vegetation studies over the past 3 field seasons.

An accuracy assessment by Strong et al. (1983) and refuge field studies identified a number of errors in this map. Errors occurred mainly among similar classes along moisture gradients (wet sedge, moist/wet sedge, and moist sedge, prostrate shrub) and along shrub and tussock gradients (moist sedge, prostrate shrub; moist sedge tussock, dwarf shrub; and moist dwarf shrub, sedge tussock tundra). Errors also occurred between partially vegetated and barren areas. Riparian shrublands, which provide habitat for many wildlife species, are not readily separated by Landsat due to their linear distributions on the coastal plain. Studies of tundra birds have found that Landsat delineated habitat classes can not be clearly related to use by migratory birds (Oates et al. 1986). Microhabitat features (such as ponds, ridges, shrubs, etc.) can not be distinguished.

Geobotanical maps (1:63,360 scale) of 6 areas of the coastal plain were produced by Walker et al. (1983) (Fig. 1). The 1:63,360 scale vegetation mapping units derived from photo-interpretation were presented as part of a hierarchical classification scheme which described tundra vegetation at 4 levels: 1) very small scale units, 2) Landsat landcover units, 3) photo-interpreted units, and 4) plant community descriptions. Codes for the map polygons (Appendix II, Tables 2 and 3, Figs. 1 and 2) used a system in which information about vegetation, vegetation diversity, landforms, surface forms, and percentage water (or soils) were coded in the following fraction format:

Vegetation code(s); Diversity code
Landform code(s); Surface form code(s); % Water code

Vegetation nomenclature was based on moisture, plant life forms, and physiognomy. Vegetation diversity codes were based on the number of color tones or textures identifiable on aerial photographs. This scheme permitted most areas of high vegetation diversity to be identified. Landform/terrain units used in the map legend were primarily based on the system of Kreig and Rieger (unpublished), which was modified to include common features such as hill slopes, pingos, and bluffs. Surface form units in the map legend were primarily patterned ground and permafrost features that could be recognized on 1:60,000 scale aerial photographs. Surface form units also included river alluvium, incised stream drainages, icings, dunes, and beach features. Percentage water was interpreted for 5 of the mapped areas, excluding the Mt. Michelson D-3 quadrangle. The codes, developed as an indicator of wetland terrain, were based on visual estimates of the percentage of open water in each map unit. Soils were interpreted by K.R. Everett on the Mt. Michelson (D-3) quadrangle only. Soil names follow the U.S. soil taxonomy (Soil Survey Staff 1975) and were coded as complexes that indicate dominant and subdominant soils in each map unit.

A few site specific botanical studies have been conducted in the study area. Murray (1974, 1979b) described the flora at several sites within the refuge including Beaufort Lagoon and Sadlerochit Springs. Meyers (1985) studied the narrow linear band of tidewater influenced vegetation along the coast of the study area. Sixteen plant communities and habitat types were described. The habitat types included salt marsh (tidal and upper storm zone), salt marsh/beach, salt marsh/dune, salt marsh/upland, gravel beach/salt marsh, and strand/dune/coastal meadow.

A Landsat-assisted landcover/terrain mapping effort of the entire Arctic National Wildlife Refuge (ANWR) including the study area was conducted in 1983 and 1984 by C. Markon, S. Talbot, and B. Kirk (USFWS), M. Shasby and L. Strong (USGS Anchorage field office), and L. Pank (USFWS research division). Photo interpretation and classification of the multi-spectral scanner data were completed in 1984. The first draft of the landcover maps was finished in October 1984. Problems were encountered with developing a uniform classification system across this large diverse area. Modifications were made to the existing Walker et al. (1982) classification scheme and 22 classes of landcover were eventually identified and final maps were completed in 1985. An accuracy assessment was conducted, and data analysis is presently in

progress. The landcover classes found on the coastal plain are described in Appendix III, Table 1. Estimated area of each landcover class is shown in Appendix III, Table 2. Vegetation descriptions in the Report to Congress utilize this Landsat classification, because these data were available on computer tapes and scenarios could be developed on a geobased information system.

The North Slope Borough is presently developing an integrated geographic system to provide Borough-wide coverage at a regional scale. Maps at 1:250,000 scale are available for the entire study area, and 1:63,360-scale maps are available for Barter Island A4, A5; Demarcation Point D4, D5; Mt. Michelson D1, D2, D3; and Flaxman Island A1. Nine manuscript maps which include related variables are produced for each area. Titles of these maps are as follows:

- I. Integrated terrain unit
- II. Surface hydrology
- III. Political and administrative units
- IV. Infrastructure, settlements, and special features
- V. Energy and mineral resources
- VI. Elevation provinces
- VII. Historic/archaeologic sites
- VIII. North Slope Borough planning data
- IX. Subsistence land use

The integrated terrain unit map includes vegetation, soils, landform, and slope. Mapping of these variables was based on image interpretation of aerial photography and Landsat imagery. Vegetation types are classified according to level III of Viereck et al. (1982). Landform classes and soil types are equivalent to those used by Walker et al. (1983).

A cross walk illustrating the relationships between classification systems was developed for the Landsat landcover classes described by Walker et al. (1982), USGS and FWS, and Walker and Acevedo (1984); the National Wetlands Inventory classifications (Cowardin et al. 1979); level C photo-interpreted map units of Walker et al. (1983), and level III and IV units of Viereck et al. (1982) (Appendix III, Table 3). A similar cross walk which includes the Landsat classification of Nodler and LaPerriere (1977), Prudhoe Bay stand types (Walker 1981), Pt. Storkerson wetlands (Bergman et al. 1977), and the International UNESCO classification (1973) was presented in the Initial Baseline Report (USFWS 1982).

Description of Soils and Vegetation of the Study Area

The vegetation of the 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 Aleksandrova (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.

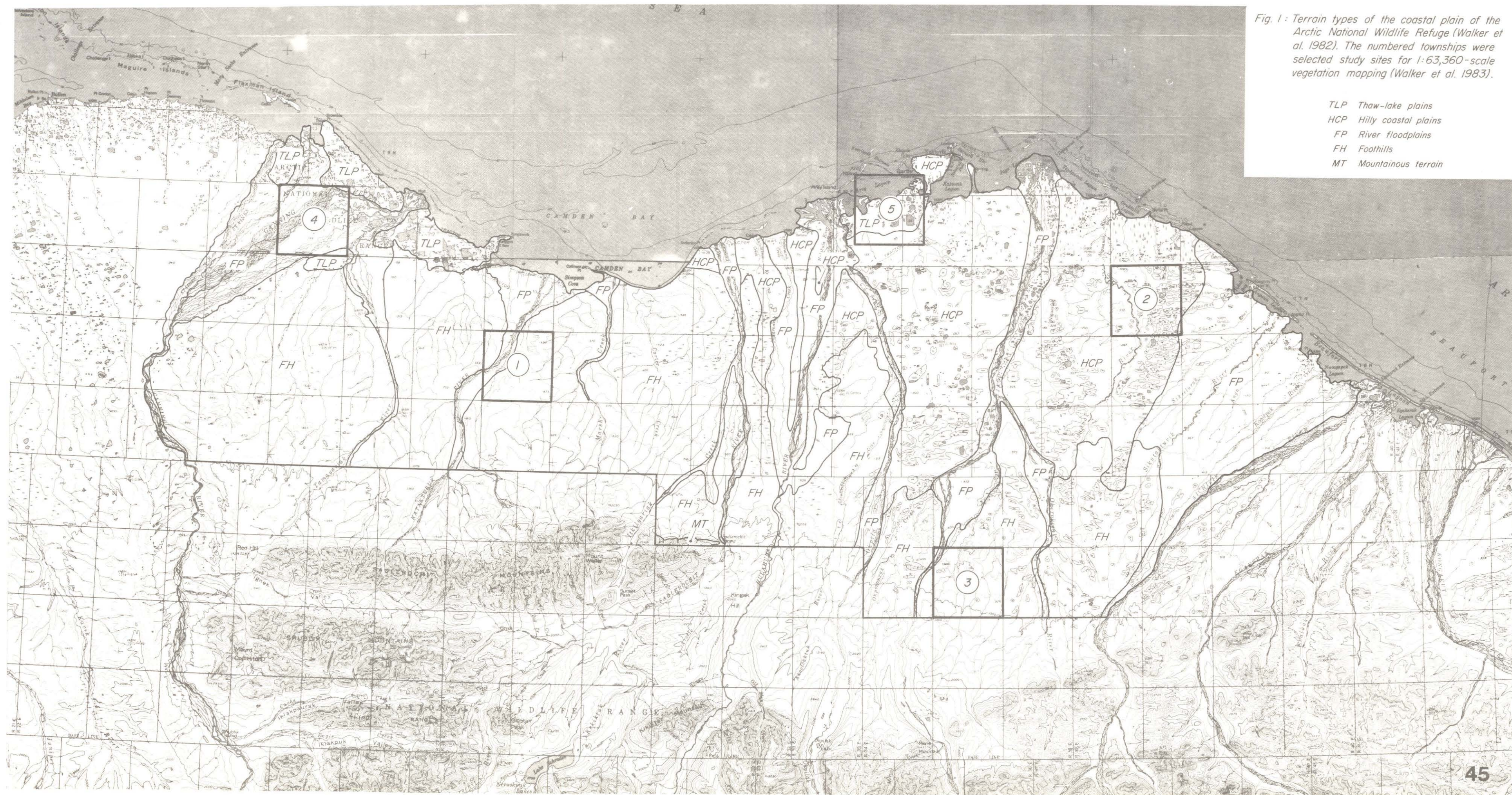


Fig. 1: Terrain types of the coastal plain of the Arctic National Wildlife Refuge (Walker et al. 1982). The numbered townships were selected study sites for 1:63,360-scale vegetation mapping (Walker et al. 1983).

- TLP Thaw-lake plains
- HCP Hilly coastal plains
- FP River floodplains
- FH Foothills
- MT Mountainous terrain

The following discussion is based upon material by Walker et al. (1982). The study area is divided into the following terrain types: 1) flat thaw-lake plains, 2) hilly coastal plains, 3) foothills, 4) alpine tundra, and 5) river floodplains including deltas and braided drainages and ancient deltas (Fig. 1). Descriptions of Landsat landcover classes follow Walker et al. (1982), as this classification system has been used most extensively for wildlife and vegetation studies in the study area. Detailed descriptions of vegetation, landforms, and soils for each landcover class are presented in Appendix I, Table 1. Area of each landcover class within the regional terrain types is presented in Table 1.

Flat Thaw Lake Plains

A much narrower belt of plain occurs in the study area than is found further west at Prudhoe Bay and in the NPR-A because of the proximity of the Brooks Range and Sadlerochit Mountains to the coast. 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, primarily near the flat braided deltas of rivers (Plates 1 & 2, Fig. 1). These areas are best developed in the delta confluence of the Canning and Tamayariak Rivers and extend for some 12-15 km eastward in a narrow coastal belt. A narrow zone also occurs from the delta of the Hulahula River to a few km east of the Jago River. Barter Island is included in this zone.

These small areas of thaw lake plains appear to be remnants of a once more extensive plain. They are topographically similar to the thaw lake plain west of the Canning River, being composed of more than 30% water confined to small (generally less than 260 ha) shallow, elliptical oriented lakes. Areas between the lakes are poorly drained as a result of a very low surface hydraulic gradient and thin active layer. Some form of microrelief is nearly always present except in vegetation-covered basins of relatively recently drained lakes. It consists mostly of low-centered non-orthogonal polygons, strangmoor or complexes of disjunct low-centered polygons (Table 2).

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 or all of the thaw period. Soils common to the wet and very wet areas are Fibro Histic Pergelic Cryaquepts or occasionally Histic Pergelic Cryaquolls and Pergelic Cryaquepts. 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 III, 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 (Tieszen 1978, Brown et al. 1980), Fish Creek (Lawson et al. 1978), and Prudhoe Bay (Brown 1978, Walker et al. 1980, Walker 1981). The dominant Landsat landcover 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. Micro-topography on a scale of less than 1 m of elevational difference is the major influence on the distribution of plant

Table 1. Area (ha) of the land cover types within each regional terrain type, Arctic National Wildlife Refuge study area.

Land Cover Type	Regional Terrain Type					Totals
	Thaw Lake Plains	Hilly Coastal Plains	Foothills	Alpine Tundra	Flood Plains	
Water	3,954	2,685	735	32 ^a	7,141	14,547
Pond/Sedge Tundra Complex or Aquatic Tundra or Shallow water	1,711	1,724	308	41 ^a	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 Tundra	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

^a Shadow



Plate 1. Wet sedge tundra on the thaw lake plain.

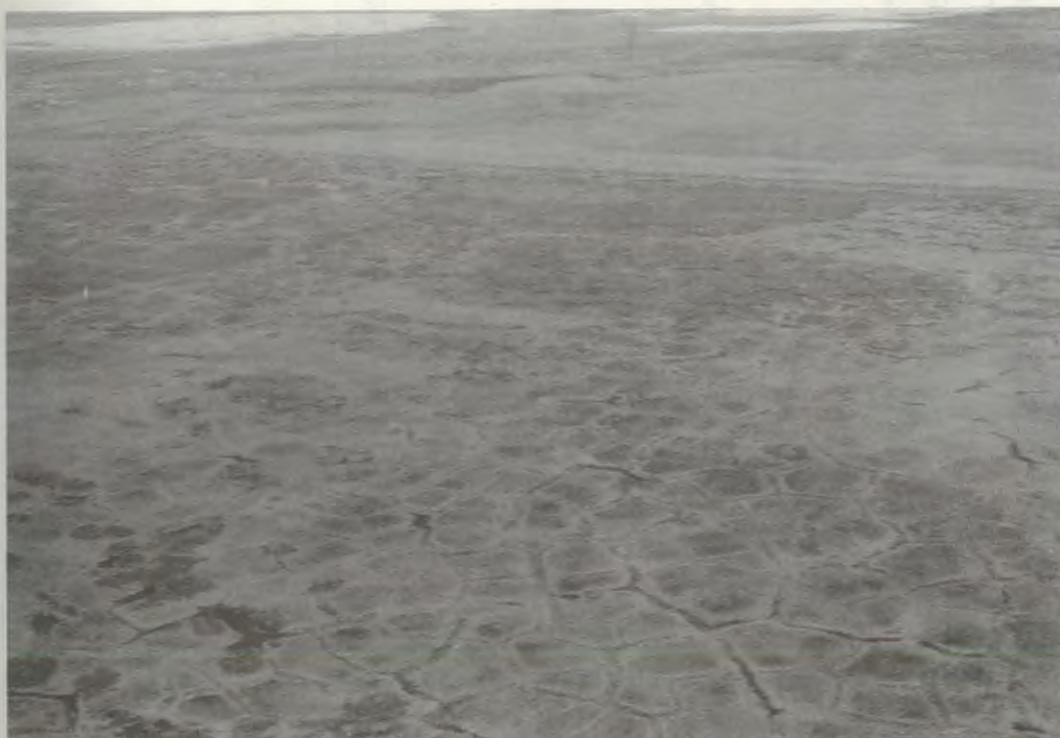


Plate 2. Low-centered polygons.

Table 2. Landform and soil associations within the Arctic National Wildlife Refuge study area.

Terrain Type	Mesoscale	Microscale ^a	Soil
Thaw lake	(1) Thaw lake complex	(1) High-centered polygons	Inceptisols (1) Pergelic Cryaquepts
	(2) Drained lake basin (less than 4 km ²)	(2) Low-centered polygons	(2) Sparohistic Pergelic Cryaquepts ^b
	(3) Flat	(3) Mixed high- and low-centered polygons	(3) Fibro/hemihistic Pergelic Cryaquepts
Hilly	(1) Crest/interfluv	(4) Disjunct polygons	(4) Pergelic Cryosaprists
Coastal	(2) Slope (less than 5%)	(5) Frost boils	(5) Pergelic Cryofibrists
Plain	(3) Thaw lake complex	(6) Strangmoor	(6) Pergelic Cryohemists
	(4) Pond complex	(7) Pond complex	(7) Pergelic Cryaquolls
	(5) Drained lake basin	(8) Reticulate	(8) Histic Pergelic Cryaquolls
	(6) Flat	(9) Featureless	(9) Ruptic-Entic Pergelic Cryaquolls
Foothills	(1) Crest/interfluv	(10) Solifluction and/or mudflow	(10) Pergelic Cryoborells
	(2) Slope (over 5%)		(11) Pergelic Cryorthents
	(3) Stream complex		(12) Fluventic Pergelic Cryorthents ^b
	(4) Flat		(13) Cryopsamments
Alpine	(1) Crest		(14) Riverwash
	(2) Slope (over 10%)		(15) Rock
	(3) Flat		
Riverine	(1) Terrace		
	(2) River Island Complex		
	(3) Flat		

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

^bUnofficial taxonomic terms

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, Britton 1957, Carson and Hussey 1962, 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 information is available regarding thaw-lake mechanisms, the cycle and successional patterns are still incompletely understood (Mackay 1963). The major 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 fluxes are important considerations in evaluating whether the present environment is in a steady state or whether it is still in a period of relatively rapid climatic and vegetational change.

A steep temperature gradient associated with the coastal strip plays a primary role in determining the vegetation of the thaw-lake plains. 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, and more moderate temperatures are found inland (Conover 1960, Cantlon 1961, Haugen and Brown 1980, and Walker 1981). Coastal fog also causes low levels of radiation. Low amounts of total summer warmth, reflected in the number of annual thaw-degree days are primarily responsible for a distinctive band of coastal vegetation that has fewer shrub species, limited tussock formation, reduced moss and lichen growth, and fewer 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° C July mean isotherm. Worldwide, this zone is equivalent to the arctic subregion of Aleksandrova's (1980) tundra region. Near Barrow the coastal strip is about 100km wide, at Prudhoe Bay it is about 25 km wide. Within the ANWR study area the coastal strip is less than Prudhoe Bay because of the narrowness of the coastal plain, and there is likely a more compressed coastal temperature gradient, although no data are available to substantiate this hypothesis.

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 the study area it has been studied by Meyers (1985) in the Beaufort Lagoon and Camden Bay areas.

Hilly 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 tundra with small thaw lakes and pond complexes (Fig. 1). This region is quite different from the areas with large oriented thaw lakes, because stream drainages are well defined and have large expanses of relatively well-drained terrain associated with them (Plates 3 & 4). This type of terrain is common within the coastal plain portion of the ANWR, covering over 22% of the study area. Elevations within the region rise gradually from sea level to about 150 m.

The vegetation on ridges is moist sedge tundra which may or may not contain tussocks. The dominant Landsat landcover classes are moist sedge, prostrate shrub tundra, and moist sedge/barren tundra complex. The latter class is associated mainly with upland terrain where frost scars occupy 30% of most surfaces. Frost scars 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. The active layer depth is 30 to 50 cm in August at the time of maximum thaw. The depressions between ridges contain moist/wet sedge tundra complex, wet sedge tundra, and thaw lakes. Soils are similar to those of the thaw lake plain.

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, which lie 30 to 55 km from the sea coast. The hills in this region are interspersed with the drainages of the Tamayariak River, Katakturuk River, Nularvik River, Marsh Creek, Carter Creek, Itkilyariak Creek, and the Sadlerochit River. The crests of several hills, particularly in the vicinity of the Katakturuk and Tamayariak River have barren gravel outcrops. East of the Sadlerochit River, the foothills are further from the coast. In the vicinity of the Jago River (at 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.

The crests of hills 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 (Plates 5 & 6). Thermokarst pits are common 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 sapric organic overlying dark colored organic rich mineral materials. Cryaquepts occur as frost scars that may occupy up to 40% of the polygon



Plate 3. Hilly coastal plain with Brooks Range Mountains in background.



Plate 4. Moist sedge/barren tundra complex on hilly coastal plain.

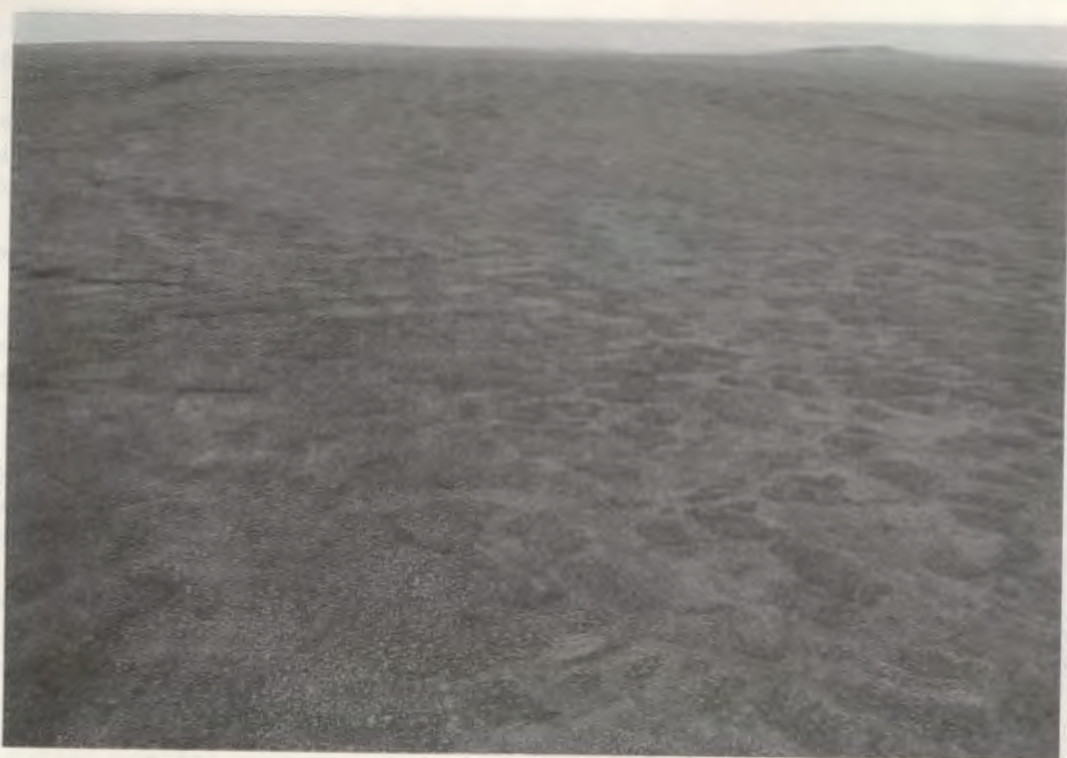


Plate 5. High-centered polygons on foothills terrain.



Plate 6. Moist sedge tussock, dwarf shrub tundra.

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 (more than 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 35 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.

The slopes are generally greater than 5% and are covered with cotton grass tussocks (Eriophorum vaginatum), willow (Salix spp.), and birch (Betula nana s.l.). 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 during the thaw season (Everett 1980). 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. 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. In most cases, 4-15 cm of Hemic or Sapric organic matter overlies mineral materials into which organic material is commonly enmixed. Active layer thicknesses range between 30 and 50 cm, and the presence of water table is uncommon. Within the water tracks Histic Pergelic Cryaquepts are most common. Active layer thickness here is between 35 and 50 cm and a water table is almost always present, commonly within 10 cm of the surface.

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 increase, and 65-80% of the surface may be comprised of active frost scars. In such cases, sedge tussocks are generally absent and grasses, especially Arctagrostis latifolia, are common. 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.

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 greater than 1 m and ice volumes beneath these soils 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 phenomenon is due principally to the water added from snowbank melt.

Vegetation in the foothills is predominantly moist tussock sedge, dwarf shrub tundra. In some areas the shrub vegetation is dominant and the landcover class is a moist dwarf shrub, tussock tundra. Terrain with water track complexes is classed as moist tussock sedge, dwarf shrub/wet dwarf shrub tundra complex. A few steep, mainly south-facing slopes, have well-developed shrub tundra. 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 (Hopkins and Sigafoos 1951, Sigafoos 1952, Racine and Anderson 1979). This effect is apparent within ANWR where areas with numerous frost-scars have completely different plant communities than non-frost-scar areas. Successional patterns related to tundra fires have recently been recognized as another important factor in the foothills (Racine 1980).

Alpine Tundra

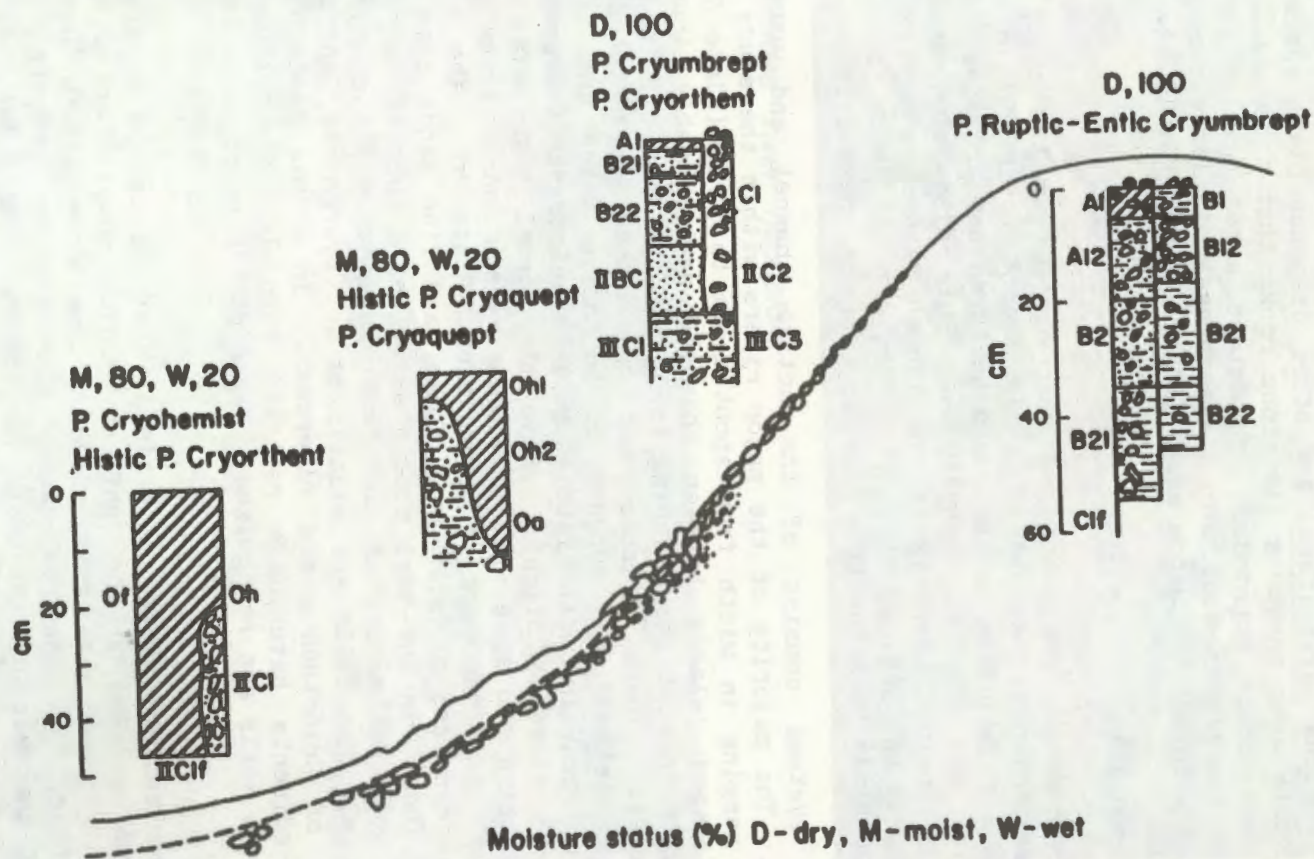
There is only a small area of alpine terrain within the study area in the vicinity of Sadlerochit Spring. This area is similar to other alpine areas in the Brooks Range. Crests here range to 1250m and have only sporadic vegetation and ground pattern.

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 positions preclude 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. 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 occasion Pergelic Cryaquolls do occur in finer textured 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 snowbanks 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. 2). 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 distribute mineral material over the surface of otherwise organic rich soils. Solifluction slopes are naturally unstable with a complex of perched water tables and subsurface drainages.

**FIG 2. Idealized Toposequence Across Alpine Terrain Type
Arctic National Wildlife Refuge**



Vegetation communities in these areas are identified as partially vegetated by Landsat classification because they are 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), prostrate willows (Salix arctica, S. chamissonis, S. phlebophylla), and small forbs. Sadlerochit Springs is of special interest because of the presence of poplars (Populus balsamifera) and other disjunct plant species (Murray 1979a, 1979b). This area includes limestone rocks that comprise the major outcrops of the Sadlerochit Mountains. 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 Murray 1976).

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.

Riverine systems consist of the active channel and usually 1 or more terraces. The majority of the major rivers within the study area are braided channels ranging in width from about 1 km to 4 km (Plate 7). Most of the diamond shaped islands between channels are probably inundated at least sporadically in most years during the period of melt-off (usually late May to early June). These islands may be either unvegetated or vegetated. Unvegetated islands are subject to intensive water and ice scouring, and consist of gravels with little soil development (riverwash). Vegetated islands are elevated slightly above the normal high water mark because of channel cutting and have widely ranging vegetation coverage - depending upon the extent and frequency of inundation (Plate 8). 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 A1 horizon has developed and some mottling occurs in the fine sediments. The active layer normally exceeds 1 m. The soils are classified as Cryorthents, and most islands are complexes of Cryorthents and riverwash. In a few cases where fine sandy surface sediments have been reworked into low discontinuous sand dunes, Cryopsamment soils are recognized. Permafrost here 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 snowmelt flooding (Fig. 3). 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 horizon may be from a few to 15 cm thick. The channel areas are poorly to very poorly drained with fibrous organic horizons up to 20 cm or more thick overlying mottled gray silt and



Plate 7. Braided river floodplain.

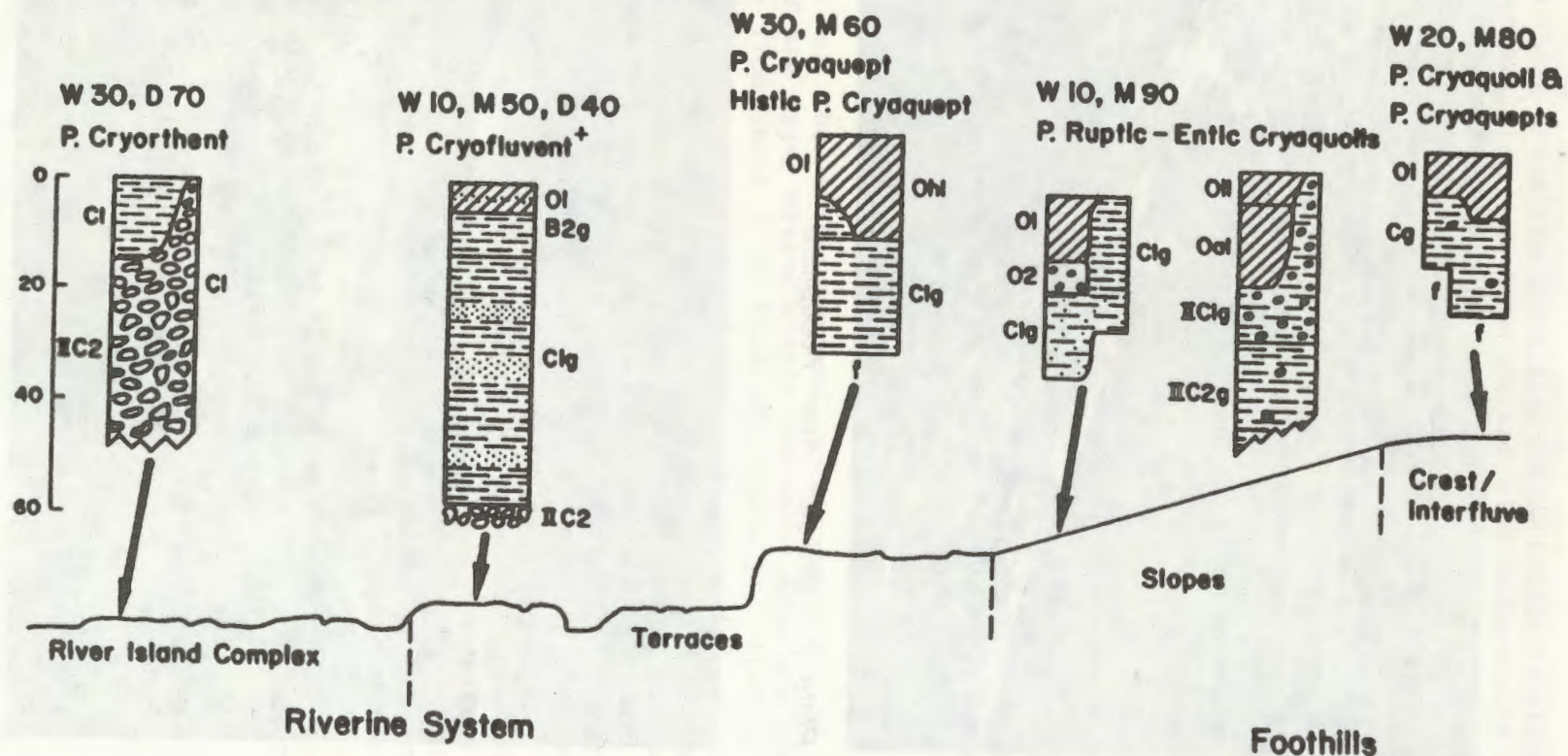


Plate 8. Riparian willows.

**FIG 3. 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



silt loam textured materials. Permafrost is encountered usually within 50 cm. 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. 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, 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. 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%) along the margins of rivers and a narrow strip along their crests are included within the Riverine system. 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 erosion 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 A horizons. Wetter areas occur upslope and behind the lobes. In either case, the soils are Pergelic Cryaquolls.

The topographic contrast associated with these bluffs 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 wind-blown 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.

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 (Appendix I, Table 1). 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 not as extensive as riparian willow communities further west, such as on the Sagavanirktok, Kuparuk, and Colville Rivers. This phenomenon is most apparent on the Landsat classification, which shows only partially vegetated areas adjacent to the larger rivers within the refuge. 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.

Dense willow communities also occur along some of the smaller drainages in bands too narrow to appear on Landsat images. These smaller streams and quieter interchannel areas of some 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).

Dry terraces just above the main braided channels often have distinctive dry prostrate shrub, forb tundra (Dryas river terraces). 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, and are presently not separable in the Landsat classification.

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 does not enter into the soil taxonomy although it probably underlies these sites.

Sand Dunes

Sand dunes are rare in the study area, and are confined mostly to the delta areas of the Canning, Hulahula 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.

Data Gaps

Future vegetation and habitat information needs for the study area will require the development of a base map of a higher degree of detail than is possible with Landsat data. A base map similar to the geobotanical atlas (1:12,000) of the Prudhoe Bay region should be developed for the study area. Adequate time should be allotted for ground-truthing and accuracy assessments to ensure the development of a reliable map. A base map at this scale is needed for habitat identification for various wildlife species. If further exploration and/or development occurs on the study area, this base map is essential to aid in site selection for facilities and related activities to minimize environmental impacts.

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Chapter 4

BIRDS

Information in this chapter is divided into 4 major sections following a brief description of the birds present in the study area. The first 3 sections discuss avian utilization of the major habitat types: 1) tundra - including wetlands, uplands, and inland lakes, 2) shoreline habitats and, 3) coastal lagoons and offshore waters. The final section is an annotated species list summarizing available records for each bird species known to occur in the Arctic National Wildlife Refuge study area.

Avifauna of the ANWR Study Area

A total of 135 species of birds have been recorded in the ANWR study area (Table 1). Sixty-four species were known to breed, and 57 species may be considered as rare, casual, or accidental in their occurrence. Seven species are known to winter, 4 of which are present regularly each winter. The status of several species may be modified 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 followed by the status code. More than 1 abundance-status code can be listed for each species. The abbreviations used in Table 1 are as follows:

Abundance

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

Status

Resident (Res)
Summer Resident (SRes)
Breeder (B)
Migrant (M)
Spring migrant (SpM)
Fall migrant (FM)
Visitant (V)
Summer visitant (SV)

Other

Probable (prob)
Possible (poss)

Table 1. Status of birds known to occur on the coastal plain of Arctic National Wildlife Refuge, Canning River to Canada border as of 18 September 1985.

Species	Coastal plain in general	Inland coastal plain	Outer coastal plain and coast
Common loon	prob RV,RM		
Yellow-billed loon		RM	UM
Pacific loon	CB	CB	CB,CM
Red-throated loon			FCB,CM
Red-necked grebe			Cas SV
Horned grebe			Cas SV
Short-tailed shearwater			Cas SV
Tundra swan		UV	CB,CS Res
Trumpeter swan			RB
Canada goose			UB,U to FCM
Brant			UB,AM
Greater white-fronted goose	U to FCSpM,CFM		
Snow goose	USpM,RSV,AFM		
Ross' goose			Cas SpM
Mallard		RB	UM,RSV
Northern pintail	CM,CSRes,RB		
Green-winged teal		UB	RB
Northern shoveler			RM,RSV
Eurasian wigeon			Cas V
American wigeon			U to FCM
Greater scaup			UM,USV
Lesser scaup		RB,RSV	
Common goldeneye			RSpM,RSV
Oldsquaw		CB	CB,ASRes,AM
Harlequin duck		RB,USV	
Steller's eider			RB,RSRes
Common eider			UB,FCM,FCSRes
King eider			UB,UM
Spectacled eider			UB
White-winged scoter		poss RB	UM,USRes
Surf scoter			UM,USRes
Black scoter			UM,USRes
Common merganser		Cas SV	
Red-breasted merganser		UB,USRes,FCM,Cas SV	RB,RSRes,FCM
Northern harrier	RSV		
Northern goshawk		RSV	
Rough-legged hawk		UB,USRes	
Golden eagle		prob RB,U to FC SRes	U to FCSRes
American kestrel	Cas V		
Merlin		poss RB,RV	RV
Peregrine falcon		poss RB,RSRes	USV,UFM
Gyr Falcon		UB,URes	RV
Willow ptarmigan		CRes,CB	URes,UB
Rock ptarmigan		CRes,CB	CB,CRes
Sandhill crane		RSpM	RB,USRes
Semipalmated plover		RB	RB,RSV

Table 1. Continued.

Species	Coastal plain in general	Inland coastal plain	Outer coastal plain and coast
Lesser golden-plover		FCB,FCM	FCB,CM
Black-bellied plover		RM	RSpM,RB,FCFM
Eurasian dotterel			Cas SV
Killdeer			Cas SV
Black-tailed godwit			Acc M
Hudsonian godwit	Cas V		
Bar-tailed godwit			RM
Whimbrel		RB	UV
Upland sandpiper		Locally U to FCB	
Lesser yellowlegs			Cas M
Spotted sandpiper		UB	
Wandering tattler		UB	
Ruddy turnstone		UB	FCB,UM
Red-necked phalarope		FCB	CB,C to AM
Red phalarope		UB	FCB,U to FCM
Common snipe		RSV,poss B	RV
Long-billed dowitcher			UB,FCSRes, CFM
Red knot			RM
Sanderling			RSpM,CasB, UFM
Semipalmated sandpiper		CB	AB,AM
Western sandpiper			Cas SpM,FCFM
Least sandpiper			RM,RV
White-rumped sandpiper			RSpM,poss RB, UFM
Baird's sandpiper		FCB	UB,UM
Pectoral sandpiper		CB,CM	CB,AM
Sharp-tailed sandpiper	Cas M	Cas M	
Dunlin			UB,FCFM
Stilt sandpiper		UB, UM	FCB,FCM
Buff-breasted sandpiper	Locally R to FCB		UM
Pomarine jaeger	CSpM,Locally U to CSV,B		
Parasitic jaeger	FCSRes,B		
Long-tailed jaeger	FCSpM,CSRes	FCB	UB
Glaucous gull		prob UB,USRes	CB,AM
Slaty-backed gull			Cas V
Herring/Thayer's gull	RM,RSV		
Mew gull	RSpM,RSV	prob RB	
Bonaparte's gull	Cas V		
Ivory gull			RM
Black-legged kittiwake			RM
Ross' gull			Cas M
Sabine's gull			UB,Um
Arctic tern		RB	FCB,SV,M
(Thick-billed) murre			RM
Black guillemot			RB,UV,USRes
Horned puffin			Cas V
Snowy owl		RSRes	R to CB,SRes

Table 1. Continued.

Species	Coastal plain in general	Inland coastal plain	Outer coastal plain and coast
Short-eared owl		R to CB	R to FCB,M
Common nighthawk	Cas V		
Eastern kingbird	Acc V		
Say's phoebe	Cas V,Acc FM		
<u>Empidonax</u> sp.			Acc V
Horned lark		RB,RV	Cas V
Violet-green swallow			Acc SpM
Bank swallow			Cas M
Barn swallow	Cas V		
Cliff swallow		RSpM,RB	
Gray jay	Acc V		
Common raven		URes	URes
American dipper		Locally UB,URes	
American robin		Cas SV	
Varied thrush	Acc V		
Hermit thrush	Acc		
Gray-cheeked thrush	Cas V		
Northern wheatear		RV	
Bluethroat		RB,RM	
Yellow wagtail	Locally R to FCB		
Water pipit		RB,FCFM	RB
Cedar waxwing		Acc V	
Northern shrike		RV,poss B	
Orange-crowned warbler			Acc M
Yellow warbler		poss RB	Cas V
Wilson's warbler	Cas,FM		
Red-winged blackbird		Cas V	
Rusty blackbird			Cas M
Brown-headed cowbird	Acc V		
Redpoll	Locally R to AB,SV		
Pine siskin	RV		
Savannah sparrow	Locally U to FCB		
Dark-eyed junco	RM		
American tree sparrow		Locally R to FCB	
Chipping sparrow		Cas V	
Clay-colored sparrow		Acc V	
White-crowned sparrow		R to FCB	
White-throated sparrow			Acc V
Fox sparrow		RSV,poss B	
Lapland longspur	AB		
Smith's longspur	RV		
Snow bunting	CB		

Bird Use of Tundra Habitats

Several studies of tundra birds, whose major objectives were to describe intensity of bird use on various tundra habitat types, have been conducted during the past 15 years within the ANWR study area. In 1970 Schmidt (1970) censused birds near Beaufort Lagoon on randomly-located quadrats (402 x 402 m, 0.62 km²) to determine waterfowl-use days. Andersson (1973) estimated densities of certain shorebird species at the Nuvagapak Point area in 1970. Salter and Davis (1974) used ground transect surveys to quantify bird use in several Yukon and Alaska north slope habitat types, including 5 sites and 10 habitat types on the coastal plain of ANWR. Previously, 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 km² of area surveyed). Spindler (1978a) censused nesting and transient bird populations on 4 different tundra habitat types prevalent near the Okpilak River Delta in 1978 (Fig. 1). A total of 1.75 km² was sampled, 3 0.5 km² plots and 1 0.25 km² plot, each representing a different habitat type. At Demarcation Point in both 1978 and 1979, Burgess (1980) censused nesting birds on a single 0.30 km² plot in an area of varied tundra habitats. Martin and Moitoret (1981), Martin (1983) and Moitoret (1983) conducted intensive studies of nesting and transient bird populations in relation to habitat conditions and prey base on ANWR in 1979 and 1980, at the Canning River delta (Fig. 1). 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, Singilik and Square Lake, and 4 outer coastal plain sites, Storkerson Point, Meade River delta, East Long Lake, and Island Lake.

An intensive study of tundra bird use was conducted on the ANWR coastal plain from 1982-1985 as part of the 1002 baseline studies. The primary objective was to investigate variations in bird use in 7 different habitat types (Table 2) as defined by Landsat imagery (Walker et al. 1982) and discussed in Chapter 3. Secondary objectives were to document changes from reproductive to post-reproductive seasons, annual variation, and variation associated with different sampling locations.

Replicate 10-ha plots located in habitats delineated by recent Landsat imagery were sampled for nest and bird density data at 8 different sites (Table 3, Fig. 1). Censuses were conducted weekly during the reproductive season (10 June - 18 July), and 1 or more post-reproductive season (19 July - 30 August) censuses (Table 4) were conducted annually (Oates et al. 1986b). All locations were not sampled during all years of the study. This study design hampered examination of annual variability, but provided sampling opportunity for additional locations (Table 3). A combination of data from plots and systematic documentation of sightings incidental to censuses were incorporated to describe distribution, status, breeding phenology, and migration.

Table 2. Habitat types for bird census plots, Arctic National Wildlife Refuge, Alaska 1982-1985. Correspondence with the dominant Landsat cover units (Walker et al. 1982), or other vegetation types where applicable, is shown.

No. ^a	Habitat class Abbreviated name	Landsat cover unit	Dominant cover types not separated by Landsat
II	Flooded	Pond/Sedge Tundra Complex (IIa) Aquatic Tundra (IIb) Wet Sedge Tundra - Noncomplex (IIIb)	
III	Wet Sedge	Wet Sedge Tundra - Noncomplex (IIIa)	
IV	Moist Sedge		moist sedge tundra (mesic) ^b sedge-willow tundra (mesic) ^c willow-sedge tundra ^c
IVa	Mosaic	Moist/Wet Sedge Tundra Complex (IVa) Wet Sedge Tundra-Moist Complex (IIIc)	
V	Moist Sedge-Shrub	Moist Sedge, Prostrate Shrub Tundra (Va) Moist Sedge/Barren Tundra Complex- (frost-scar tundra-Vb)	
VI	Tussock	Moist Sedge Tussock, Dwarf Shrub Tundra (VIa, b)	
IX	Riparian	Dry Prostrate Shrub, Forb Tundra (<u>Dryas</u> River Terraces-IVb) Partially Vegetated Areas-River Bars (IX) Barren Gravel or Rock(X) Barren Mud or Wet Gravel(XI)	low willow ^c

^aNumber generally corresponds with dominant Landsat cover unit number.

^bHomogenous moist sedge meadow with little or no micro-relief (Spindler et al. 1984a).

^cVegetation type described by Viereck et al. (1982).

Fig.1 Locations of terrestrial bird studies on ANWR coastal plain from 1978 to 1985.



Table 3. Numbers of plots of each habitat type^a censused at terrestrial bird study locations, Arctic National Wildlife Refuge 1982-1985.

Location	Census years	Habitat type						
		IX	II	III	IVa	IV	V	VI
Okpilak ^b	1982, 1983, 1985	2	3	3	4	-	2	-
Katakturuk	1982, 1983, 1985	-	-	1	-	2	3	3
Jago Bitty	1983, 1985	3	-	3	-	3	3	3
Aichilik	1984, 1985	3	-	3	-	3	3	3
Sadlerochit ^c	1984, 1985	4	-	3	3	-	3	3
Jago Delta	1984, 1985	3	3	3	3	-	3	-
Marsh Creek	1985	3	-	-	-	-	3	3
Niguanak	1985	-	3	3	-	-	3	3

^aHabitat descriptions modified by Spindler et al. 1984a.

^bRiparian plots censused only in 1983.

^cFourth replicate plot (594) censused only in 1985.

Table 4. Census effort for terrestrial birds on Arctic National Wildlife Refuge 1982-1985.

Approx. beginning date of census period	Census period	Year			
		1982	1983	1984	1985
<u>Reproductive season:</u>					
10 June	1	-	-	+	+
17 June	2	+	+	+	+
24 June	3	+	+	+	+
1 July	4	+	+	+	+
8 July	5	+	+	+	+
<u>Post-Reproductive Season</u>					
22 July	6	-	-	-	+
5 August	7	-	-	-	+
12 August	8	-	+	+	+
19 August	9	+	-	+	+ ^a
26 August	10	-	-	-	- ^a

^aOnly censused at Niguanak and Jago Delta sites.

The Landsat habitat classification system was modified (Spindler et al. 1984a) to account for its inability to discern linear riparian willow habitats and to distinguish between differing habitats with similar spectral reflectances (Moist Sedge and Mosaic). In addition, small patches (less than 100 m by 100 m) of a Landsat habitat interspersed in an area of a different Landsat habitat were normally undetected. Finally, other studies of tundra bird habitat use indicated that habitat preference was probably influenced by habitat characteristics which could not be measured at the Landsat level of resolution (Myers and Pitelka 1980, Troy 1985).

Spring Migration

For most species, the coastal plain was the terminus of spring migration: these birds arrived on the tundra and began breeding activities (Table 1). For a few species, the ANWR coastal plain was part of their spring migration corridor and was used by most individuals for resting and feeding while enroute to main breeding areas elsewhere. Brant used the coastal plain primarily as a migratory corridor. They were dependent on tundra vegetation, specifically saline Wet Sedge (wet saline tundra 3d), for resting and feeding while enroute to the main breeding grounds in Canada. Large numbers of Pacific and red-throated loons, as well as short-eared owls, arctic terns, and glaucous gulls used the coastal plain tundra for feeding and resting in early to mid-June. Many of these moved to other nesting or summering areas by late-June (Spindler 1978a, Martin and Moitoret 1981). Snow geese used Wet Sedge meadows for grazing while enroute to breeding areas. Red knots migrating to Canadian breeding grounds occasionally stopped to rest and feed in Wet Sedge tundra. Sanderlings in migration frequently stopped to forage on coastal bluffs and dunes while enroute to breeding areas (Spindler 1978a, Martin and Moitoret 1981). Pomarine jaegers, perhaps many thousand, migrated low over the coastal plain feeding on birds and small mammals as they flew to Canadian breeding grounds (Spindler 1978a, Martin and Moitoret 1981).

Reproductive and Post-Reproductive Seasons

A detailed description of bird habitat use during the reproductive and post-reproductive seasons is presented in the following section for each major habitat type. Unless otherwise noted, the material in this section represents a summarization of material from Spindler and Miller (1983), Spindler et al. (1984a), Moitoret et al. (1985) and Oates et al. (1986b).

Habitats

Riparian (Type IX)

Riparian habitats supported the highest mean densities of total birds ($X=403/\text{km}^2$) and the greatest species richness ($X=7.0/.1 \text{ km}^2$) during the breeding season (Fig. 2). Similarly, this habitat was among the highest in density of nests and diversity of nesting species (Fig. 2). Ruddy turnstone, Baird's sandpiper, and American tree sparrow nests were found only in Riparian habitat as were large percentages of the nests of redpolls, savannah sparrows, yellow wagtails, short-eared owls, long-tailed jaegers, buff-breasted sandpipers, semipalmated sandpipers, lesser golden-plovers, rock ptarmigan, and northern pintails (Fig. 3). High percentages of the observations of these species were also made in Riparian habitat (Fig. 3).

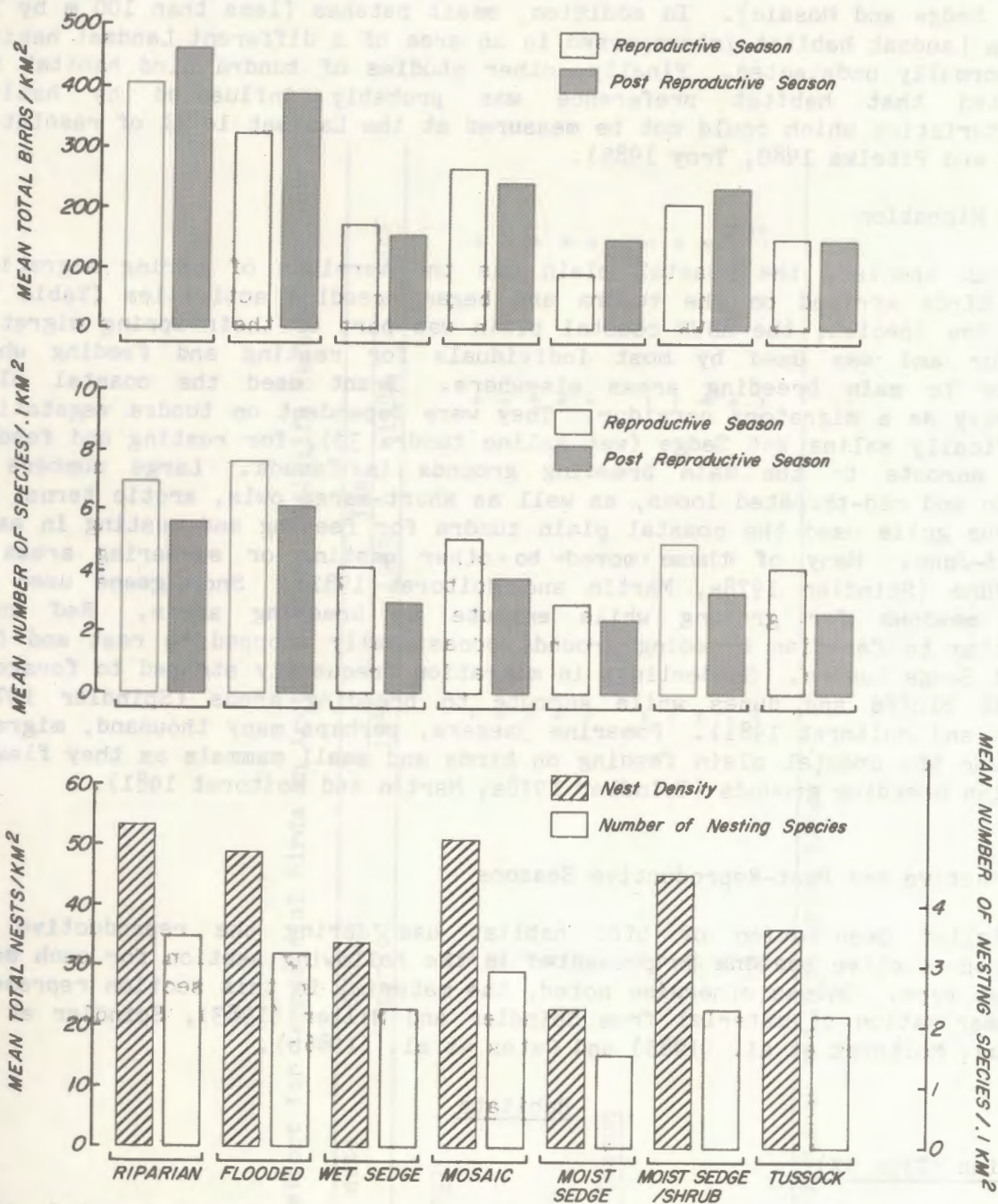


FIG. 2. MEAN NUMBERS OF SPECIES AND SPECIES NESTING PER 0.1 km² AND MEAN NUMBERS OF TOTAL BIRDS AND TOTAL NESTS PER km² ON STUDY PLOTS IN 7 HABITATS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

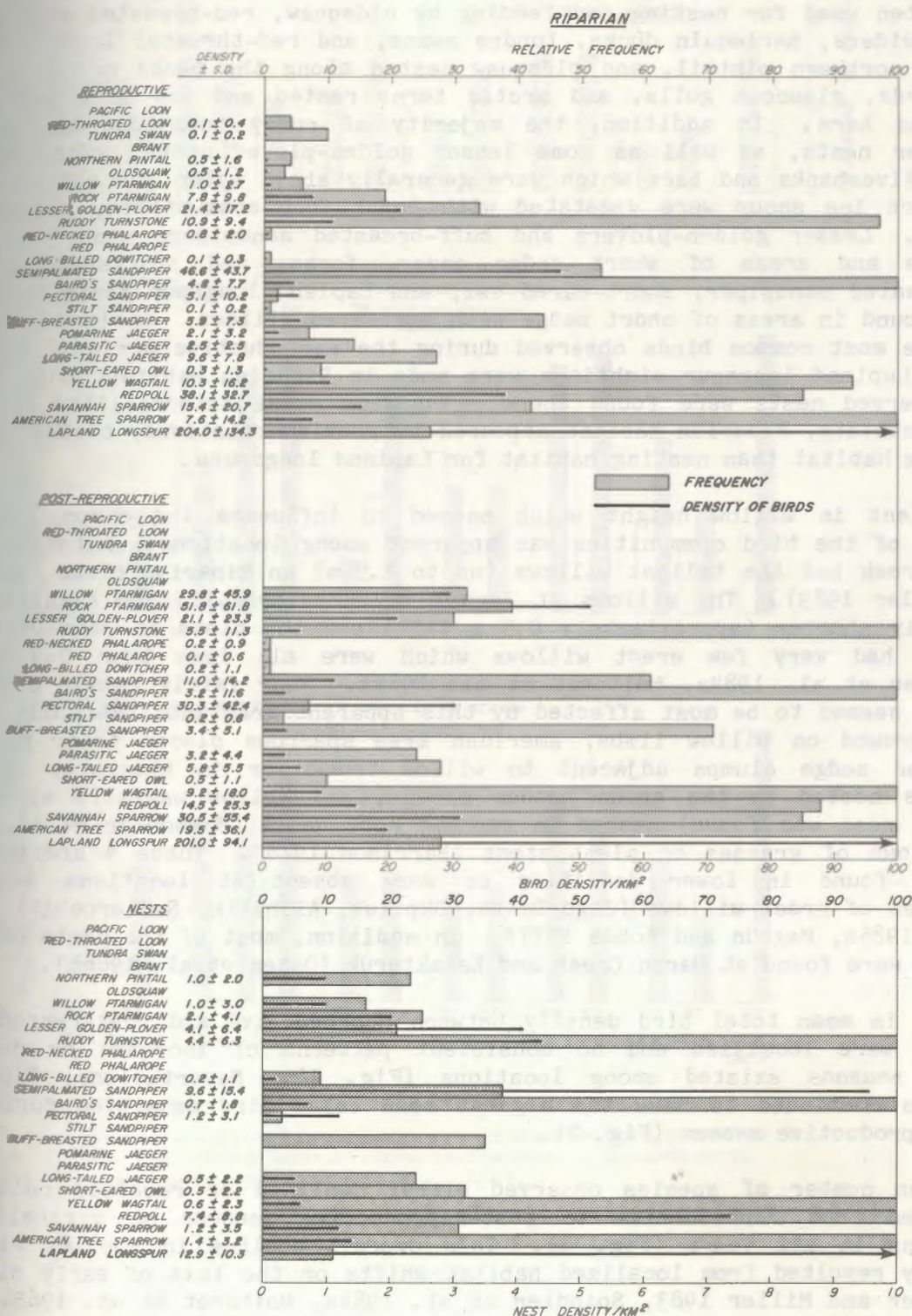


Fig. 3. Relative frequencies^a and mean densities/km² of selected species of birds and their nests observed in Riparian habitat during the reproductive and post-reproductive seasons on Arctic National Wildlife Refuge, Alaska, 1982-1985.

^a Frequencies were weighted to account for differential sampling intensities among habitats and locations (Table 3).

Riparian areas provided a unique variety of environmental components which contributed to high species diversity. Rivers, streams, sloughs, and ponds were often used for nesting and feeding by oldsquaw, red-breasted mergansers, common eiders, harlequin ducks, tundra swans, and red-throated loons. Common eiders, northern pintail, and oldsquaw nested along the banks or on islands. Shorebirds, glaucous gulls, and arctic terns rested and fed on gravel, mud, and sand bars. In addition, the majority of ruddy turnstone and Baird's sandpiper nests, as well as some lesser golden-plover nests, were found on bars. Riverbanks and bars which were generally above water and not subjected to severe ice scour were vegetated with Dryas forb communities, sedges, and willows. Lesser golden-plovers and buff-breasted sandpipers nested on Dryas terraces and areas of short sedge cover, forbs, and scattered willows. Semipalmated sandpiper, short-eared owl, and Lapland longspur nests were most often found in areas of short sedge with scattered willows. Lapland longspurs were the most common birds observed during the reproductive period. Although 27% of Lapland longspur sightings were made in Riparian habitat, only 11% of the observed nests were found there. Assuming equal detectability of nests among habitats, Riparian habitat appeared to provide relatively higher quality foraging habitat than nesting habitat for Lapland longspurs.

A gradient in willow height which seemed to influence the composition and density of the bird communities was apparent among locations. Katakturuk and Marsh Creek had the tallest willows (up to 1.5 m) on Riparian plots (Spindler and Miller 1983). The willows at Jago Bitty, Sadlerochit, and Aichilik were generally shorter (approximately 0.5 m tall) and the plots at Jago Delta and Okpilak had very few erect willows which were all less than 0.3 m tall (Spindler et al. 1984a, Moitoret et al. 1985). Four fairly common passerine species seemed to be most affected by this apparent gradient. Redpolls nested above ground on willow limbs, American tree sparrows placed their nests in grass or sedge clumps adjacent to willow trunks or in thickets, savannah sparrows nested on the ground under shrubs, and yellow wagtails apparently (only 1 nest was found) nested in exposed root balls (McWhorter et al. 1986) or hollows of grasses or plant stems (Harrison 1978). These 4 species were usually found in lower densities or were absent at locations with low densities of erect willows (Jago Delta, Okpilak, Aichilik, Sadlerochit) (Oates et al. 1986a, Magoun and Robus 1977). In addition, most of the nests of these species were found at Marsh Creek and Katakturuk (Oates et al. 1986b).

Changes in mean total bird density between reproductive and post-reproductive seasons were localized and no consistent patterns of increase or decrease across seasons existed among locations (Fig. 4). Nevertheless, Riparian habitats continued to have the highest mean total bird densities during the post-reproductive season (Fig. 2).

The mean number of species observed either declined or remained relatively unchanged from reproductive to post-reproductive seasons at virtually all locations in all years (Fig. 4). This overall decline in species richness probably resulted from localized habitat shifts or the loss of early migrants (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). Red-throated loons and oldsquaw moved to lagoon and offshore areas soon after breeding (Spindler 1979a). Nonbreeding pintails and pomarine jaegers were early migrants. Densities of ruddy turnstones, semipalmated sandpipers, Baird's sandpipers, buff-breasted sandpipers, and redpolls declined, but their relative use of Riparian habitat remained high (Fig. 3).

RIPARIAN HABITAT

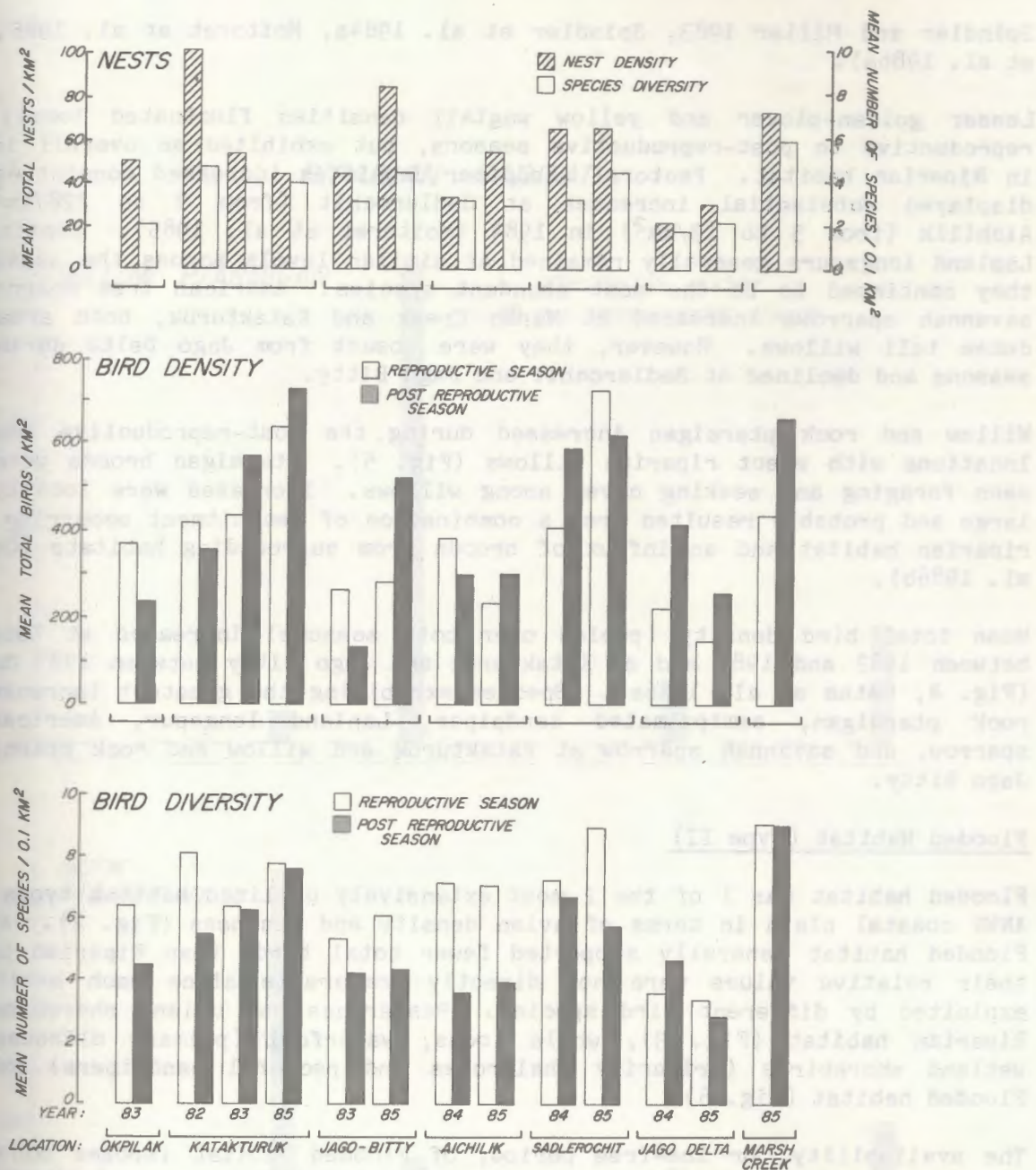


FIG. 4. MEAN NUMBERS OF SPECIES AND SPECIES NESTING PER 0.1 KM² AND MEAN NUMBERS OF TOTAL BIRDS AND TOTAL NESTS PER KM² IN RIPARIAN HABITAT AT 7 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986a).

Lesser golden-plover and yellow wagtail densities fluctuated locally from reproductive to post-reproductive seasons, but exhibited an overall increase in Riparian habitat. Pectoral sandpiper densities increased consistently and displayed substantial increases at Sadlerochit (from 9 to 228/km²) and Aichilik (from 5 to 13/km²) in 1984 (Moitoret et al. 1985). Densities of Lapland longspurs generally remained at similar levels across the seasons and they continued to be the most abundant species. American tree sparrows and savannah sparrows increased at Marsh Creek and Katakturuk, both areas with dense tall willows. However, they were absent from Jago Delta during both seasons and declined at Sadlerochit and Jago Bitty.

Willow and rock ptarmigan increased during the post-reproductive season at locations with erect riparian willows (Fig. 5). Ptarmigan broods were often seen foraging and seeking cover among willows. Increases were locally quite large and probably resulted from a combination of recruitment occurring within riparian habitat and an influx of broods from surrounding habitats (Oates et al. 1986b).

Mean total bird density (pooled over both seasons) increased at Katakturuk between 1982 and 1985 and at Katakturuk and Jago Bitty between 1983 and 1985 (Fig. 4, Oates et al. 1986a). Species exhibiting the greatest increases were rock ptarmigan, semipalmated sandpiper, Lapland longspur, American tree sparrow, and savannah sparrow at Katakturuk and willow and rock ptarmigan at Jago Bitty.

Flooded Habitat (Type II)

Flooded habitat was 1 of the 2 most extensively utilized habitat types on the ANWR coastal plain in terms of avian density and richness (Fig. 2). Although Flooded habitat generally supported fewer total birds than Riparian habitat, their relative values were not directly comparable since each habitat was exploited by different bird species. Passerines and upland shorebirds used Riparian habitat (Fig. 3), while loons, waterfowl (primary oldsquaw), and wetland shorebirds (primarily phalaropes and pectoral sandpipers) exploited Flooded habitat (Fig. 6).

The availability, or ice-free period, of Flooded habitat imposes constraints on the breeding chronology of tundra nesting birds. The relatively short reproductive season associated with arctic ecosystems has imposed strong selection pressures on length of the breeding period and limited the northward range of many species (Uspenskii 1984). Unusually late thaws can have detrimental effects on reproductive success. Breeding initiation for aquatic and shoreline nesters is largely determined by the completion of thaw, overflow, and restoration of water levels. While Flooded habitat remained frozen, many bird species foraged in small troughs and ponds in the upland tundra. Depending on how long Flooded habitats remain unavailable, birds may delay nesting, shift habitats, or abort reproductive activities altogether (Uspenskii 1984).

The Landsat classification of Flooded habitat (Chapter 3) conglomerated several of the wetland classes distinguished by Bergman et al. (1977). Since patterns of avian distribution have been correlated with the Bergman

RIPARIAN HABITAT

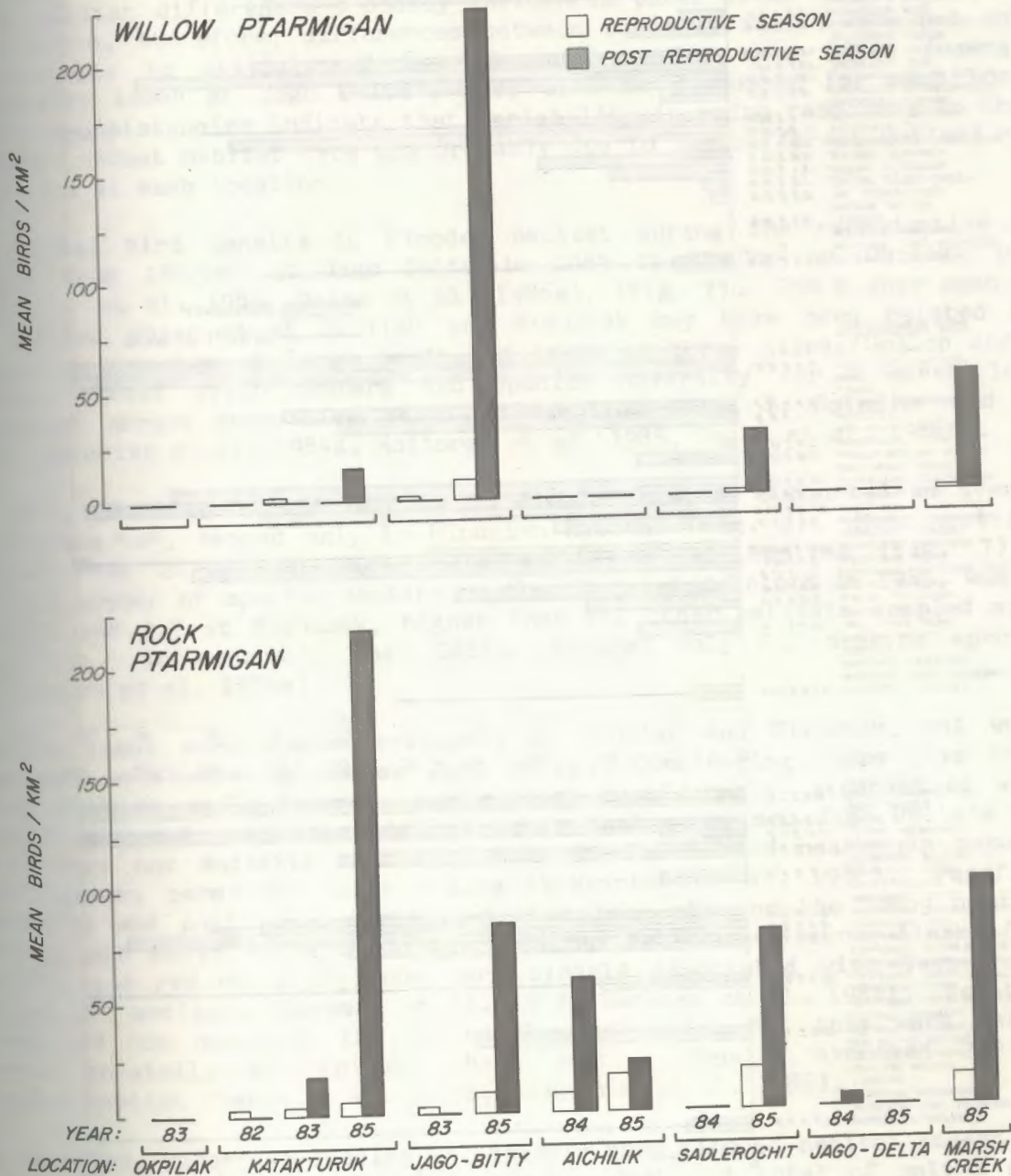


FIG. 5. MEAN DENSITIES OF WILLOW AND ROCK PTARMIGAN OBSERVED IN RIPARIAN HABITAT AT 7 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

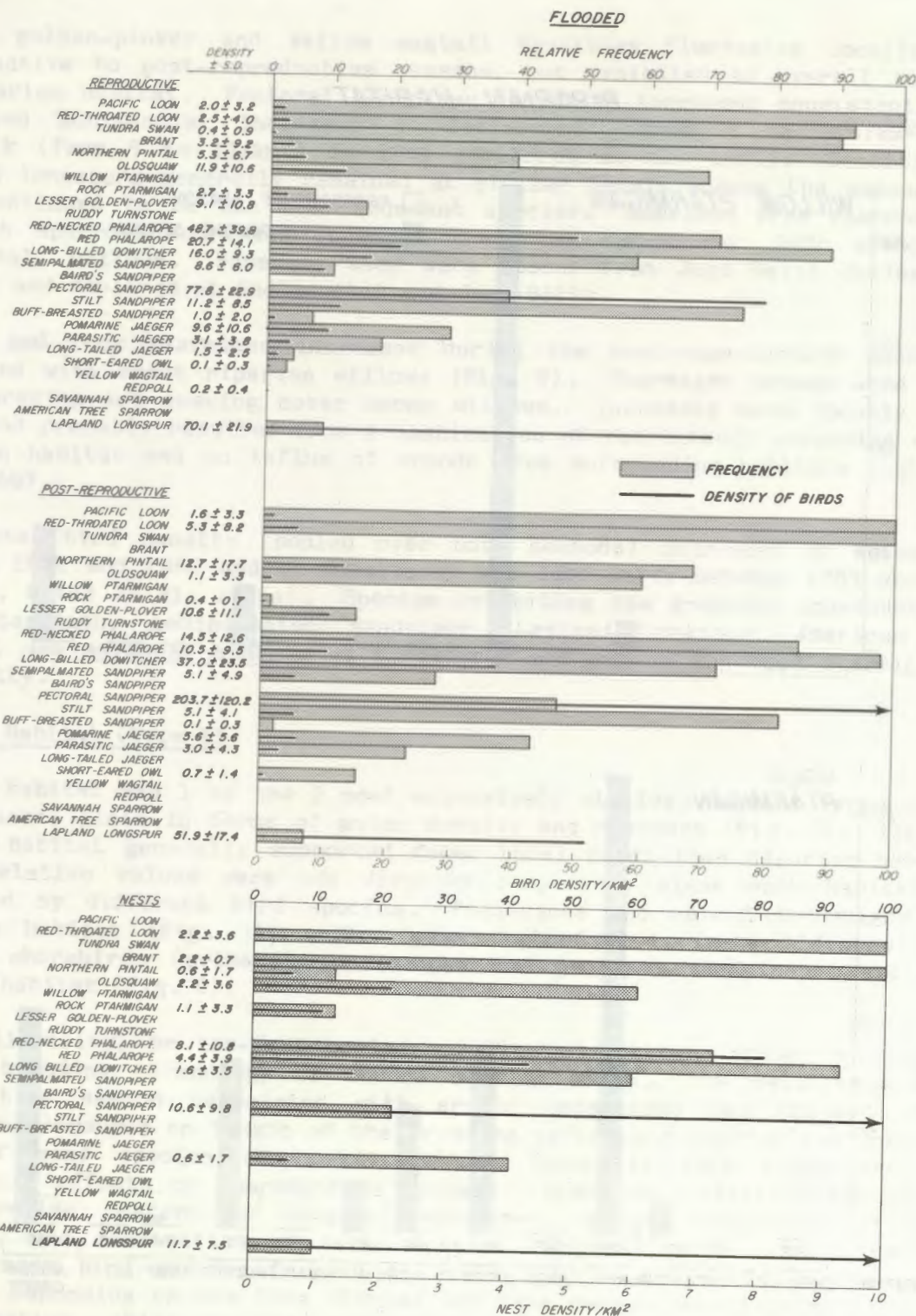


FIG. 6. Relative frequencies^a and mean densities/km² of selected species of birds and their nests observed in FLOODED habitat during the reproductive and post-reproductive seasons on ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

^a. Frequencies were weighted to account for differential sampling intensities among habitats and locations (TABLE 3).

classification (Bergman et al. 1977, Derksen et al. 1981), briefly contrasting the wetland types at each study location will clarify the subsequent discussion. Flooded plots at Okpilak (coastal) and Niguanak (inland) locations contained deep-Arctophila (Class V) lake systems, while at Jago Delta (coastal), flooded plots consisted of shallow-Carex (Class II) and shallow-Arctophila (Class III) wetlands. In general, Flooded habitat sampled at Jago Delta was comprised of shallow, often ephemeral ponds, while plots surveyed at Okpilak and Niguanak encompassed larger expanses of deeper water. These habitat differences probably influenced total avian numbers and species composition, therefore, differences between study locations were not entirely attributable to spatial effects. Because results were often inconsistent (typically lower at Jago Delta), they will be discussed for each location. These inconsistencies indicate that variability in avian responses to the more general Landsat habitat type was probably due to the different wetland classes occurring at each location.

Mean total bird density in Flooded habitat during the reproductive season ranged from 189/km² at Jago Delta in 1984 to 479/km² at Okpilak in 1985 (Moitoret et al. 1985, Oates et al. 1986a), (Fig. 7). The higher mean number of species observed at Okpilak and Niguanak may have been related to the extensive coverage of large ponds and lakes at those sites (Gollop and Davis 1974a). Total avian numbers and species diversity for a given location increased across successive years of sampling (Fig. 7, Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986a).

In 1985, mean total nest density on Flooded habitat supported an average of 50.0 nests/km², second only to Riparian habitat (Fig. 2). Mean nest density ranged from 20/km² at Jago Delta to 67/km² at Okpilak (Fig. 7). The average number of species nesting on the 10 ha study plots in 1985, was 4.0 at Okpilak and 3.7 at Niguanak, higher than all other habitats sampled at those locations. In contrast, Jago Delta averaged only 2.0 nesting species/0.1 km² (Oates et al. 1986a).

Pacific loons were common residents at Okpilak and Niguanak, but were not observed on Flooded plots at Jago Delta. Considering loons dive to feed, often nest on small islands, and require considerable expanses of water to take flight and land, the shallow ponds that comprised Jago Delta's flooded plots were not suitable habitat. However, loons bred nearby in association with larger, permanent water bodies (McWhorter et al. 1986). Pacific loon abundance was positively correlated with lake size on the Yukon north slope (Gollop and Davis 1974a). On the National Petroleum Reserve-Alaska (NPR-A), Pacific and red-throated loons were closely associated with Deep-Arctophila (Class IV) wetlands (Bergman et al. 1977, Derksen et al. 1981). Red-throated loons did not occur at the inland Niguanak site, but they were relatively common coastally at Okpilak, where nesting density averaged 2.2/km² in Flooded habitat (Oates et al. 1986a, McWhorter et al. 1986).

As expected, waterfowl species extensively used Flooded habitat except at Jago Delta where densities were substantially lower. A total of only 6 northern pintails and 5 oldsquaw were sighted over 2 years of sampling (Moitoret et al. 1985, Oates et al. 1986a). Among all waterfowl species, northern pintails had the lowest affinity to Flooded habitat during the reproductive season (Fig. 6). Across the Yukon north slope, waterfowl use was highest at lakes that had several habitat features in common: shoreline brush for nest cover, areas of sedge marsh for concealment of young and good forage, and at least part of the

FLOODED HABITAT

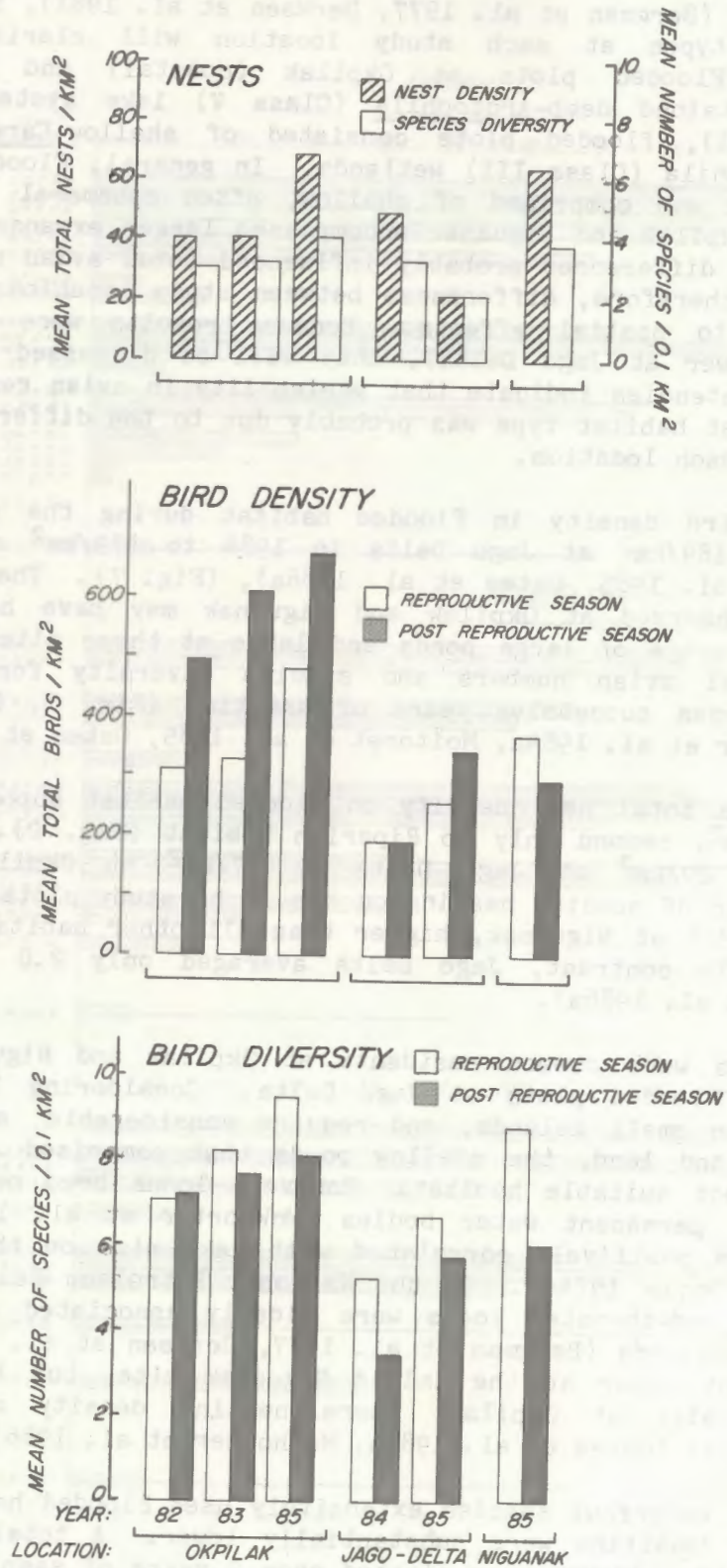


FIG. 7. MEAN NUMBERS OF SPECIES AND SPECIES NESTING PER 0.1 km² AND MEAN NUMBERS OF TOTAL BIRDS AND TOTAL NESTS PER km² IN FLOODED HABITAT AT 3 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

shoreline formed into a shallow basin to accommodate surface feeding ducks and shorebirds (Gollop and Davis 1974a). Oldsquaw were the most abundant waterfowl breeders on the coastal plain, and over 68% of the observations of oldsquaw during the breeding season were in Flooded habitat, as well as 60% of the oldsquaw nests (Fig. 6, Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b).

Several shorebirds, including pectoral and stilt sandpipers, long-billed dowitchers, and phalaropes were closely associated with Flooded tundra during the reproductive season. Pectoral sandpipers were the most abundant and widely distributed shorebird on the ANWR coastal plain, and their average density was highest in Flooded habitat ($X=78/\text{km}^2$ reproductive season, Fig. 6). Flooded tundra was not primary nesting habitat for pectoral sandpipers. Although their average nest density ($10.6/\text{km}^2$) exceeded other shorebirds in Flooded habitat (Fig. 6), pectoral nest density was comparable in Wet Sedge and Moist Sedge-Shrub higher habitats and higher in Mosaic habitat.

Red-necked and red phalaropes were closely associated with Flooded habitat, attaining average reproductive densities of 49 and 21 birds/ km^2 , respectively (Fig. 6). Average phalarope nest densities were also several times greater in Flooded areas compared with other habitats ($8.1/\text{km}^2$ for red-necked and 4.4 nests/ km^2 for red phalarope, Fig. 6). Red-necked phalaropes were the more abundant and widespread, while red phalarope distribution was primarily coastal (Fig. 6). Annual and seasonal fluctuations in phalarope numbers varied considerably (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). In 1978, red phalaropes were more abundant than red-necked phalaropes (68.0 vs $38.4/\text{km}^2$ respectively) in Flooded habitat at Okpilak (Spindler 1978a), however, since 1982, the ratios have been reversed (Fig. 8, Spindler and Miller 1983, Spindler et al. 1984a, Oates et al. 1986b). High red phalarope densities at Jago Delta (Fig. 8) may have been due, in part, to the more shallow wetland types that comprised the study plots (Derksen et al. 1981), and/or to the proximity of littoral areas (Connors et al. 1979, as cited by Derksen et al. 1981).

During the reproductive season, over half of the long-billed dowitcher and stilt sandpiper observations were made in Flooded habitat (Fig. 6). Flooded habitat supported relatively few semipalmated sandpipers. The greatest use was observed coastally, especially during 1985 (Oates et al. 1986a), when semipalmated sandpiper density at Okpilak and Jago Delta averaged $13/\text{km}^2$ during the reproductive season. Semipalmated sandpipers and lesser golden-plovers were never observed nesting in Flooded habitat. Lesser golden-plover reproductive-season densities were intermediate to those in other habitat types, averaging 9 birds/ km^2 (Fig. 6). The average Lapland longspur nest density was higher than that of other bird species in Flooded habitat (Fig. 6), but was the lowest longspur nest density across all habitat types. Similarly, the relatively high population densities attained by longspurs in Flooded habitat amounted to less than 10% of the observations across all habitats (Fig. 6).

Mean total bird densities increased during the post-reproductive season at Okpilak, and Jago Delta (1985), but at the inland location of Niguanak total numbers declined (Fig. 7, Oates et al. 1986b). The trend for post-reproductive densities to decline inland and rise coastally (Myers and Pitelka 1980) was accompanied by a general decrease in mean numbers of species observed (Fig. 7).

FLOODED HABITAT

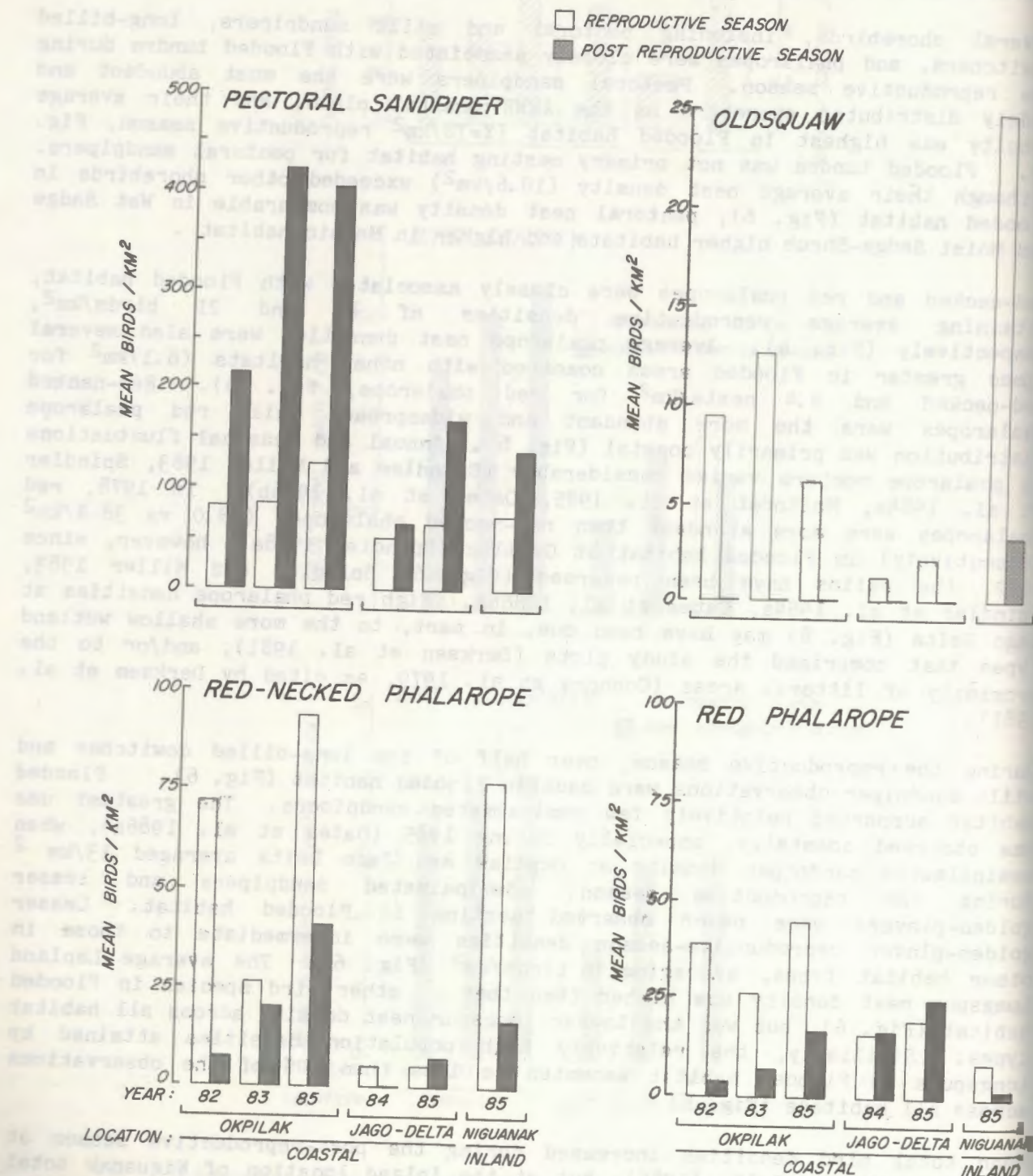


FIG. 8. MEAN DENSITIES OF PECTORAL SANDPIPERS, OLDSQUAW, RED-NECKED PHALAROPES, AND RED PHALAROPES OBSERVED IN FLOODED HABITAT AT 3 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

pectoral sandpipers averaged 204 birds/km² during the post-reproductive season as pectoral adults attended chicks, and later, migrating flocks congregated in Flooded areas. The following reproductive season for pectoral use was consistent for all locations and years, excluding Jago Delta, 1984 (Fig. 8, Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986a). The highest local post-reproductive pectoral density averaged 423/km² at Okpilak in 1983 (Spindler et al. 1984a). Martin (1983) reasoned that heavy use of wet/flooded tundra by late summer migrants reflected an abundance of midge (Diptera: Chironomidae) larvae in pond sediments. This abundance of food probably attracted the many shorebird family groups that concentrated in Flooded areas after hatching. The proximity of Flooded habitat may affect breeding densities in other habitat types for those species that rely on Flooded tundra as brooding areas.

Flooded areas were frequently visited by late-season flocks of long-billed dowitchers. Stilt and semipalmated sandpiper numbers decreased after the reproductive season. Pintails utilized flooded terrain to a greater extent in the post-reproductive season (Fig. 6), as overall densities increased at both Okpilak and Niguanak. Late-season use of Flooded tundra by oldsquaw, excluding the larger lakes, was negligible at all locations. Males left during mid-summer and gathered in coastal lagoons and shoreline waters, while females molted and attended broods on large deep lakes before joining the coastline congregations (see Species Accounts). The high density of oldsquaw at Niguanak ($X=25/\text{km}^2$ Fig. 8) appeared to consist largely of non-breeders. However, several females with broods gathered during August on the large lake near the Niguanak study location.

Data from surveys of avian use of the ANWR coastal plain were in agreement with findings reported by Uspenskii (1984): the main bulk of tundra bird populations occur in terrains that have moderate and high degrees of water gathering in topographic depressions. Flooded habitat was one of the more critical habitats for a large proportion of the resident and migratory bird populations.

Wet Sedge (Type III)

Wet Sedge tundra generally supported relatively low densities of mean total birds and nests with low to moderate species diversity (Fig 2), but exhibited some of the highest local and annual variability in bird use of any habitat studied. This habitat has a wide range of characteristics within the Landsat class and a large variety of microsites and inclusions of other vegetation types. Typically, Wet Sedge is composed of low-centered polygons and/or strangmoor of varying density. Vegetation varies from predominantly sedges, to sedges with a thick moss mat, to sedges with shrub-rich strangs. Surface water cover also varies widely between years within and among locations depending on the amount of winter snow accumulation, time of snow melt, and summer precipitation. Usually, this habitat has standing water early in the summer and is free of water later in the season. However, in wet years Wet Sedge habitat may remain almost continuously flooded, while in dry years it may be free of surface water from the onset of summer. Avian density, species diversity, and species composition of birds utilizing Wet Sedge for nesting and foraging may be related to availability and interspersed of microsites, as well as to the extent, depth, and duration of standing water.

In 4 annual comparisons Wet Sedge ranked fourth to sixth among 7 habitats studied for mean total bird density during the reproductive season. It supported substantially lower mean densities of total birds than Riparian, Flooded, and Mosaic tundra in 1982 and 1983, and Riparian and Flooded tundra in 1985 (Spindler and Miller 1983, Spindler et al. 1984a, Oates et al. 1986b). Average total bird densities varied slightly among years ($X=171/\text{km}^2$), but varied widely between locations (Fig. 9). Sadlerochit supported the highest mean number of total birds in 1984 ($X=211/\text{km}^2$, Moitoret et al. 1985), and in 1985 ($X=401/\text{km}^2$) was second only to Sadlerochit Riparian and Okpilak Flooded habitat for total bird densities (Oates et al. 1986b). In contrast, Wet Sedge at Aichilik supported the second lowest mean total bird densities ($X=96/\text{km}^2$) recorded in any habitat in 1984 and 1985.

Mean total nest densities averaged $33.9/\text{km}^2$ for all years and Wet Sedge ranked sixth among 7 habitats (Fig. 2). As with total bird density, nest density varied among locations; Sadlerochit supported an average of 40 nests/ km^2 in 1984 and 1985, whereas no nests were discovered in Wet Sedge at Katakturuk in 1983 and 1985 (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). Total nest densities at Okpilak in 1978 ($X=45/\text{km}^2$) and at Canning Delta in 1979 ($X=59/\text{km}^2$) and 1980 ($X=93/\text{km}^2$, Martin and Moitoret 1981) were markedly higher than those at most locations studied from 1982-1985.

A moderate number of avian species were attracted to Wet Sedge habitat during the reproductive season (Fig. 2). Mean species diversity was lower than in Flooded and Riparian habitats during all years. For most locations, species diversity varied only slightly among years from the mean of 4.3 species (Fig. 9).

There was high variability in diversity and composition of species using Wet Sedge at different locations. Northern pintail, oldsquaw, rock ptarmigan, red-necked phalarope, and short-eared owl were present only at Sadlerochit, Jago-Bitty, and Niguanak. Savannah sparrows were only observed at Sadlerochit and Jago-Bitty, and willow ptarmigan were only recorded at inland foothill locations (Jago-Bitty and Aichilik). Lesser golden-plovers, pectoral sandpipers, semipalmated sandpipers, and lapland longspurs were present at all locations in varying densities. Stilt sandpipers were observed in low densities at all locations except Katakturuk and Sadlerochit, and red phalaropes were rarely seen in Wet Sedge at coastal locations only (Okpilak and Jago Delta).

Like total bird diversity, the mean number of nesting species was also intermediate ($X=2.3/0.1\text{km}^2$) relative to other habitats, ranking below Riparian, Flooded, and Mosaic habitats in all years (Fig. 2). Among locations, Wet Sedge ranged from lowest of habitats used by nesting species at Okpilak (1985) and Katakturuk (1983, 1985) to second highest (next to Riparian habitat) at Jago Bitty and Sadlerochit in 1985 (Spindler et al. 1984a, Oates et al. 1986b).

Lapland longspurs were the most abundant nesters in Wet Sedge at all locations, with an average nesting density of $14.2/\text{km}^2$. Typically, they nested in raised microsites such as sedge-willow strangmoors or small hummocks. The habitat was apparently not of high importance as it supported

WET SEDGE HABITAT

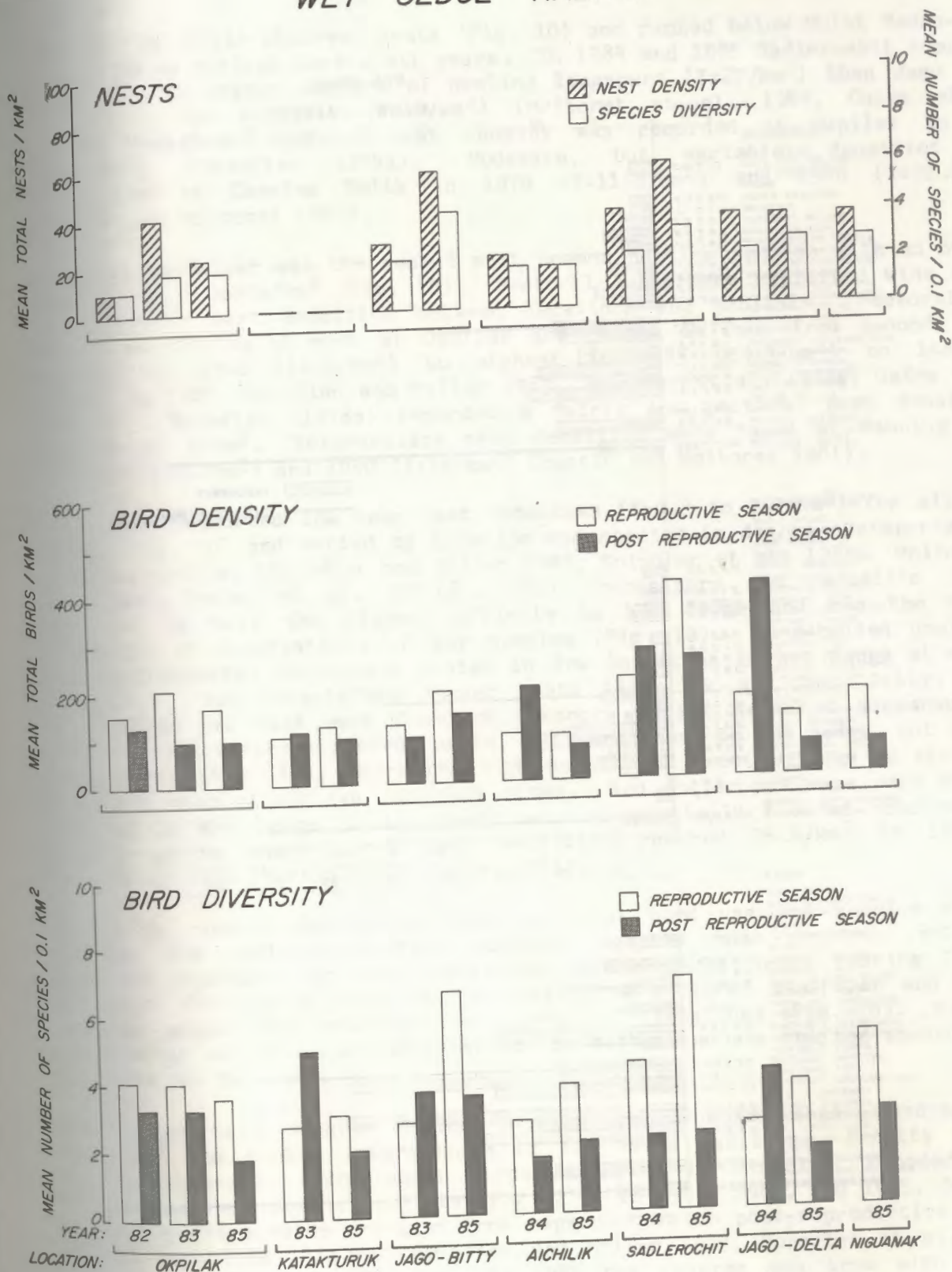


FIG. 9. MEAN NUMBERS OF SPECIES AND SPECIES NESTING PER 0.1 KM^2 AND MEAN NUMBERS OF TOTAL BIRDS AND TOTAL NESTS PER KM^2 IN WET SEDGE HABITAT AT 7 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

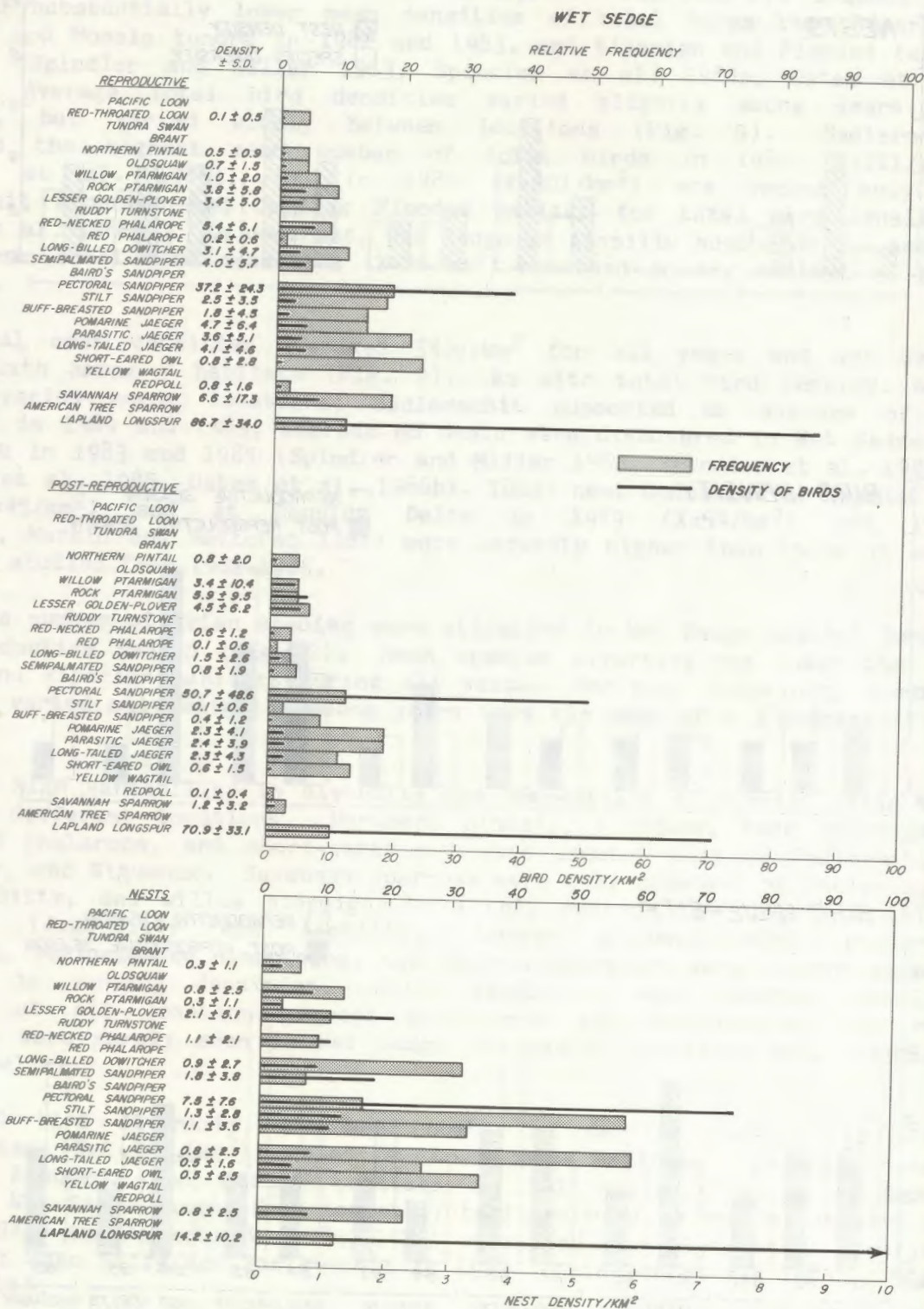


FIG. 10. Relative frequencies^a and mean densities/km² of selected species of birds and their nests observed in Wet Sedge habitat during the reproductive and post-reproductive seasons on Arctic National Wildlife Refuge, Alaska, 1982-1985.

^a Frequencies were weighted to account for differential sampling intensities among habitats and locations (Table 3).

only 11% of their observed nests (Fig. 10) and ranked below Moist Sedge-Shrub and Riparian habitat during all years. In 1984 and 1985 Sadlerochit supported substantially higher numbers of nesting longspurs ($X=27/\text{km}^2$) than Jago Delta ($X=17/\text{km}^2$) and Aichilik ($X=10/\text{km}^2$) (Moitoret et al. 1985, Oates et al. 1986a). Highest longspur nest density was recorded at Okpilak in 1978 ($X=29/\text{km}^2$) (Spindler 1978a). Moderate, but variable, densities were determined at Canning Delta in 1979 ($X=11.0/\text{km}^2$) and 1980 ($X=22.0/\text{km}^2$) (Martin and Moitoret 1981).

Pectoral sandpiper was the second most common nesting species with an overall average of 8 nests/ km^2 (Fig. 10). Pectoral sandpipers exhibited wide annual variation in nest densities between locations and habitats. Pectoral nest densities fluctuated most at Okpilak and ranged in rank from second, below Mosaic, in 1982 ($10.0/\text{km}^2$) to highest in 1983 ($23.3/\text{km}^2$) to last (no nests) in 1985 (Spindler and Miller 1983, Spindler et al. 1984a, Oates et al. 1986b). Spindler (1978a) recorded a fairly low pectoral nest density at Okpilak of $6/\text{km}^2$. Intermediate nest densities were found at Canning Delta in 1979 ($X=11/\text{km}^2$) and 1980 ($X=15/\text{km}^2$) (Martin and Moitoret 1981).

Wet sedge supported low mean nest densities ($X=0.3$ to $2.1/\text{km}^2$) for all other birds (Fig. 10) and varied by location and species in degree of importance as breeding habitat (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). Stilt sandpipers and parasitic jaegers appeared to have the closest affinity to Wet Sedge and had the highest frequency of observations of any species (Fig. 10). Long-billed dowitchers and buff-breasted sandpipers nested in low densities in Wet Sedge at coastal locations. Two long-tailed jaeger nests (Aichilik and Jago Bitty) and 1 short-eared owl nest were found on hummocks in Wet Sedge at Niguanak (Fig. 10). Of all savannah sparrow nests, 23% were found in Wet Sedge, but only at Sadlerochit (Fig. 10), where the high density of erect willows on strangmoor may have been attractive for nest sites. Red phalaropes were only observed nesting in Wet Sedge tundra (very wet and partially flooded complexes) at Canning Delta where total nest densities reached $26.0/\text{km}^2$ in 1979 and $48.0/\text{km}^2$ in 1980 (Martin and Moitoret 1981).

Wet Sedge tundra usually declined in total bird use and species richness through the post-reproductive season. Despite this decline, Wet Sedge appeared important at some locations during early brood rearing (through mid-July) for insect foraging, especially by pectoral sandpiper and Lapland longspur adults with newly hatched chicks and fledglings (Fig. 10). By August the habitat was often uniformly dried and most avian use shifted toward wetter habitats for foraging.

Mean total bird density during the post-reproductive season averaged 151 birds/ km^2 and ranked intermediate to low among habitats. Density in 1985 was substantially below total birds supported by Riparian, Flooded, Moist Sedge-Shrub, and Mosaic habitats (Fig. 2). In 1982, 1983, and 1985, densities of nearly all species declined from reproductive to post-reproductive seasons at all locations (Fig. 9, Spindler and Miller 1983, Spindler et al. 1984a, Oates et al. 1986a). However, in 1984 the reverse was true with density increases at Aichilik, Sadlerochit, and Jago Delta, as a result of high numbers of pectoral sandpipers at Sadlerochit, Jago Delta, and Aichilik and high Lapland longspur numbers at Jago Delta and Aichilik (Fig. 11, Moitoret et al. 1985). In 1985, use of Wet Sedge by birds at Jago Delta decreased from the 1984 high of $398/\text{km}^2$ due to the fluctuations in numbers of pectoral sandpipers and Lapland longspurs.

WET SEDGE HABITAT

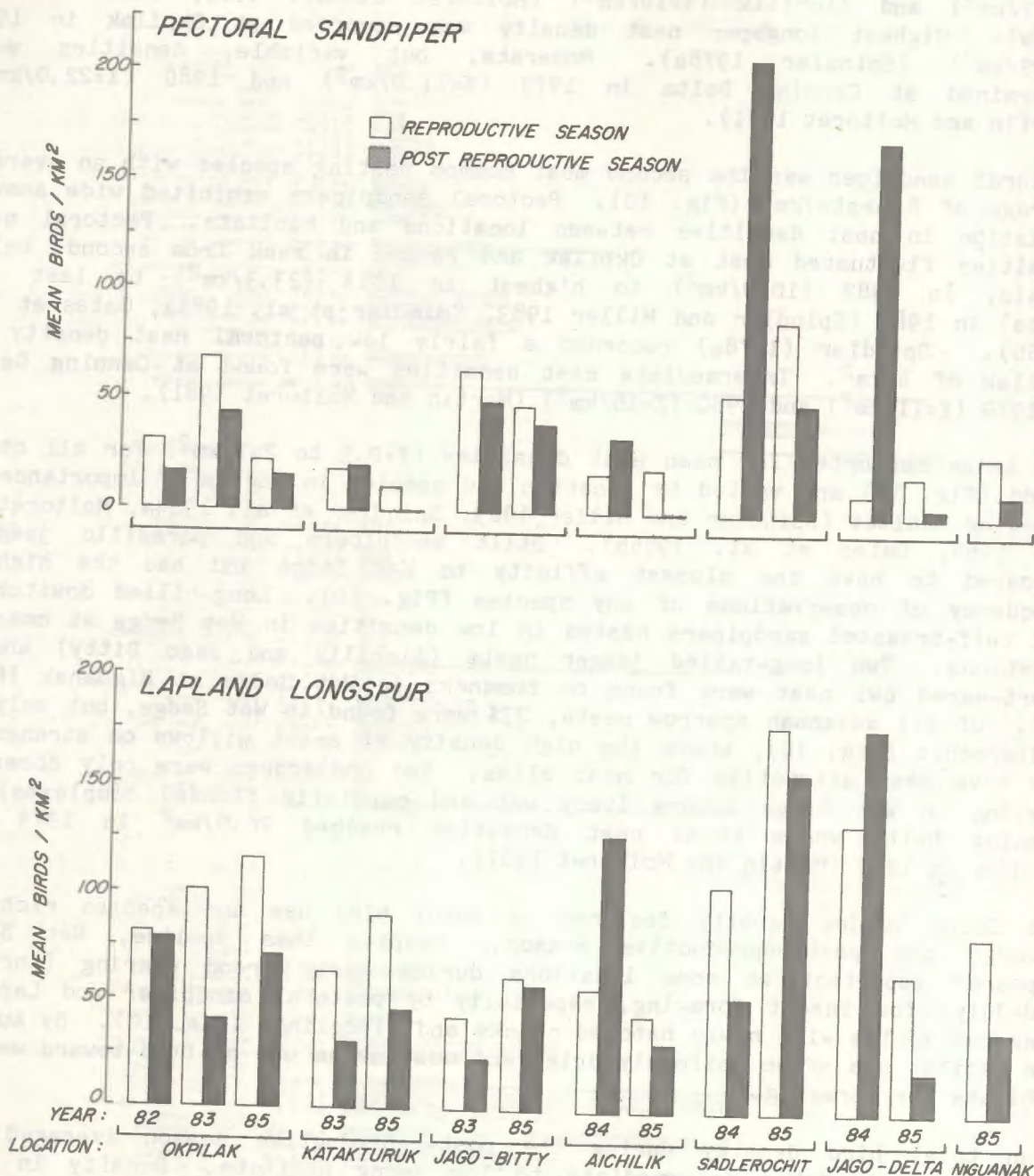


FIG. 11. MEAN DENSITIES OF PECTORAL SANDPIPERS AND LAPLAND LONGSPURS OBSERVED IN WET SEDGE HABITAT AT 7 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

The mean number of species in Wet Sedge also declined during post-reproductive season at most locations in most years to an overall mean of 2.8 species/0.1km² (Fig. 9). Mean numbers of species observed increased during post-reproductive period at Jago Bitty and Katakturuk in 1983 and decreased in 1985 (Spindler et al. 1984a, Oates et al. 1986b).

Although Lapland longspur use and frequency of observation generally decreased, their average density (71/km²) remained highest of all species in the post-reproductive period (Figs. 10, 11). Although longspur family groups were commonly observed early in the season, Wet Sedge ranked sixth or seventh overall among habitats for longspur densities. Density varied by location and between years, ranging from 23/km² at Jago Bitty in 1983 to 180/km² at Jago Delta in 1984 (Fig. 11, Spindler et al. 1984a, Moitoret et al. 1985).

Pectoral sandpipers were more variable in their use of Wet Sedge than Lapland longspurs, but together the 2 species accounted for major fluctuations in total bird densities during post-reproductive season. In 1982, 1983, and 1985 pectoral numbers generally declined in Wet Sedge during post-reproductive period at all locations (Fig. 11, Spindler and Miller 1983, Spindler et al. 1984a, Oates et al. 1986b). Movements of large flocks of male pectoral sandpipers (through mid-July) and female and juvenile groups (early to mid-August) may temporarily swell densities in lowland habitats (Myers and Pitelka 1980). This phenomenon apparently occurred in 1984 when pectoral sandpiper densities increased during post-reproductive season (Fig. 11, Moitoret et al. 1985).

Declines in overall avian diversity were the result of departure of several species at different locations (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). Oldsquaw and redpolls left Wet Sedge at all locations where they had been present during reproductive season, and most locations were vacated by stilt sandpipers, semipalmated sandpipers, and red-necked phalaropes. Presence and degree of use by northern pintail, rock and willow ptarmigan, lesser golden-plover, long-billed dowitcher, buff-breasted sandpiper, short-eared owl, and savannah sparrow varied by location and year, but mean densities exceeded 6/km² and frequency of occurrence did not exceed 13% in Wet Sedge (Fig. 10). Overall, parasitic and long-tailed jaeger abundance remained consistent from reproductive to post-reproductive seasons. Parasitic jaeger use of Wet Sedge (and most habitats) appeared to be related to availability of longspur, shorebird, and ptarmigan fledglings for prey (Maher 1974, McWhorter et al. 1986).

Mosaic Habitat (Type IVa).

Mosaic habitat, surveyed at the 3 coastal locations, supported moderately high numbers of mean total birds and species during the reproductive season and typically supported high mean nest densities (Fig. 2, Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). This habitat was characterized by diverse microhabitats with a mixture of low-center and high-center polygons created by continual ice wedge formation and melting on flat coastal terrain or in drained lake basins (Spindler 1978a, Martin 1983). Variety and interspersed of microhabitats were among the highest of all habitats: polygonization formed a continuum of vegetation types ranging from deep trough ponds to Wet Sedge and Moist Sedge along trough edges to the drier high-polygon rims and centers typically composed of Shrub-Sedge

communities (eg. lichens, dwarf shrubs and ericaceous species) (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). Microrelief often varied as much as 0.5 m or more from trough to polygon rim. High-centered polygons were typically snow free by early June and were used immediately by Lapland longspurs and shorebirds as snow receded (Spindler 1978a). Polygon troughs and low-center polygons were generally ice free by the second week in June. They provided abundant insect larvae and these areas were the first heavily utilized foraging areas at coastal locations.

Mean total bird densities in Mosaic habitat during the reproductive season varied from 233/km² in 1985 to 309/km² in 1984 (Moitoret et al. 1985, Oates et al. 1986b). Ranking third among habitats, Mosaic supported densities which were typically below Riparian and Flooded tundra and higher than Moist Sedge and Tussock habitats in 1983 and 1985 (Fig. 2, Spindler et al. 1984a, Oates et al. 1986a).

Mean total nest density in Mosaic habitat was variable between locations and years and ranged from 36.0 nests/km² in 1985 to the highest of all habitats ($X=78.3/\text{km}^2$) in 1984 (Moitoret et al. 1985, Oates et al. 1986b). Greatest nest densities recorded in Mosaic habitat on ANWR were 87.0/km² at Okpilak in 1978 (Spindler 1978a) and 138.0/km² at Canning Delta in 1980 (Martin and Moitoret 1981).

Mean number of species (5.4/0.1 km) varied little among years during the reproductive season, and Mosaic ranged from second to fourth among habitats in species richness, usually below Riparian and Flooded in most years (Fig. 2) and comparable among locations (Fig. 12). A total of 19 species were observed in Mosaic during the reproductive season (Fig. 13) from 1982 to 1985 with almost equal diversity and composition recorded at Okpilak (17 species), Sadlerochit (16), and Jago Delta (16). Lapland longspurs, pectoral sandpipers, and semipalmated sandpipers were observed most frequently at all locations. Buff-breasted and stilt sandpipers were only seen at Okpilak and Jago Delta, whereas savannah sparrows and ruddy turnstones were only observed (in low densities) at Sadlerochit. Jaegers and owls primarily utilized the habitat for foraging during the reproductive season. Snowy owls were fairly common in 1985, using high hummocks and polygon rims for perches while hunting microtine rodents (McWhorter et al. 1986).

Eleven species were recorded nesting in Mosaic and mean diversity over all years varied from 2.0 (1983) to 3.7 species/0.1 km² (1984) (Spindler et al. 1984a, Moitoret et al. 1985). Mosaic habitat typically ranked third at all locations, below Riparian and Flooded in species diversity (Fig. 2), but was highest of all habitats ($X=3.7$ species/0.1 km²) in 1984.

Lapland longspur and pectoral sandpiper nests accounted for high proportions of the total nests and for major annual fluctuations in total nest densities. Mosaic typically ranked second or third below Moist-Sedge Shrub and Tussock for relative importance as Lapland longspur nest habitat and supported an average of 20.0 nests/km² (Fig. 13). Pectoral sandpipers were the second most abundant nesting species with a mean nest density of 14.2/km². Over the years, Mosaic supported the highest relative frequency of observed pectoral nests (Fig. 13) and ranked highest among all habitats at Jago Delta (1984 and 1985) and second to Flooded tundra at Okpilak (1982, 1983, 1985) (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates

MOSAIC HABITAT

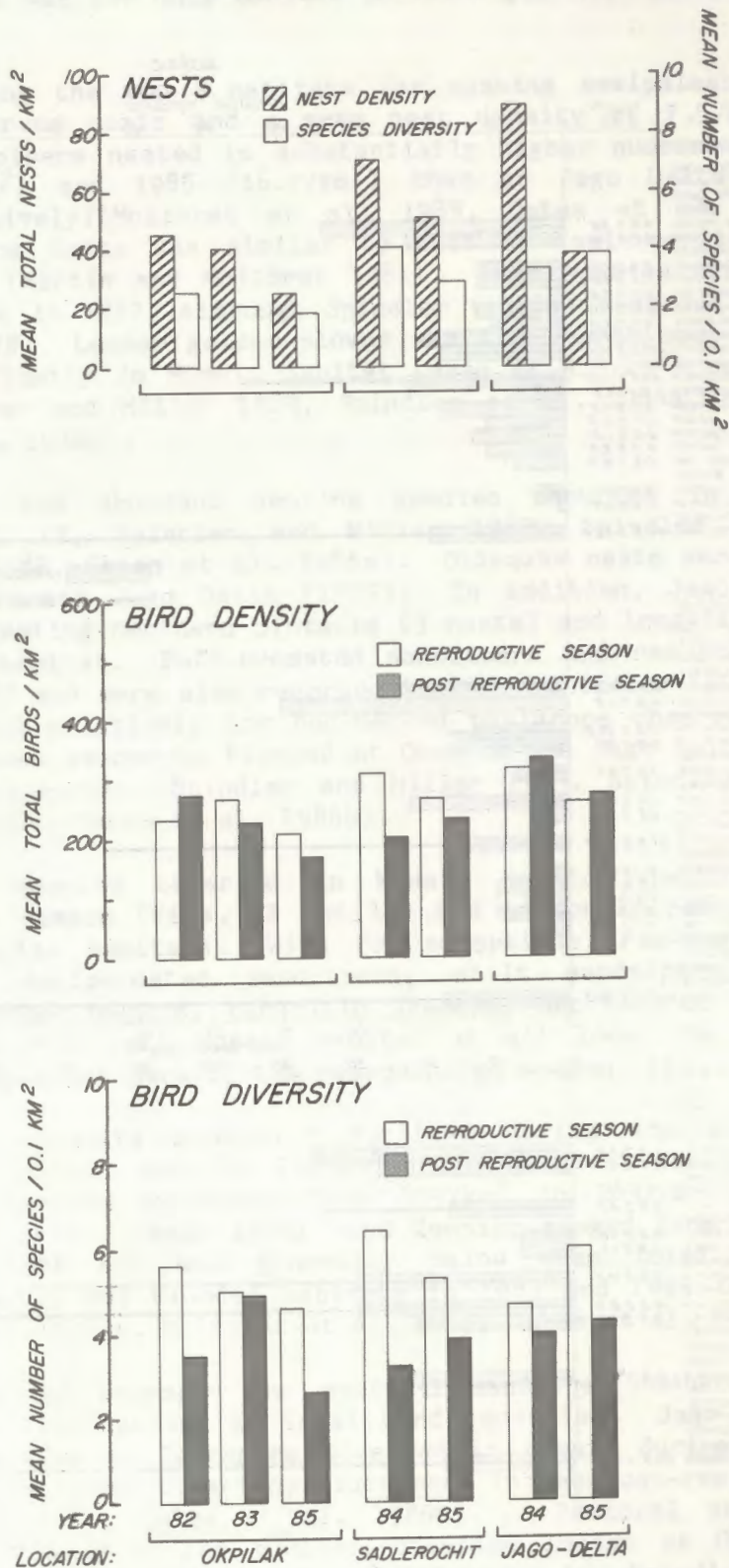


FIG. 12. MEAN NUMBERS OF SPECIES AND SPECIES NESTING PER 0.1 KM² AND MEAN NUMBERS OF TOTAL BIRDS AND TOTAL NESTS PER KM² IN MOSAIC HABITAT AT 3 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

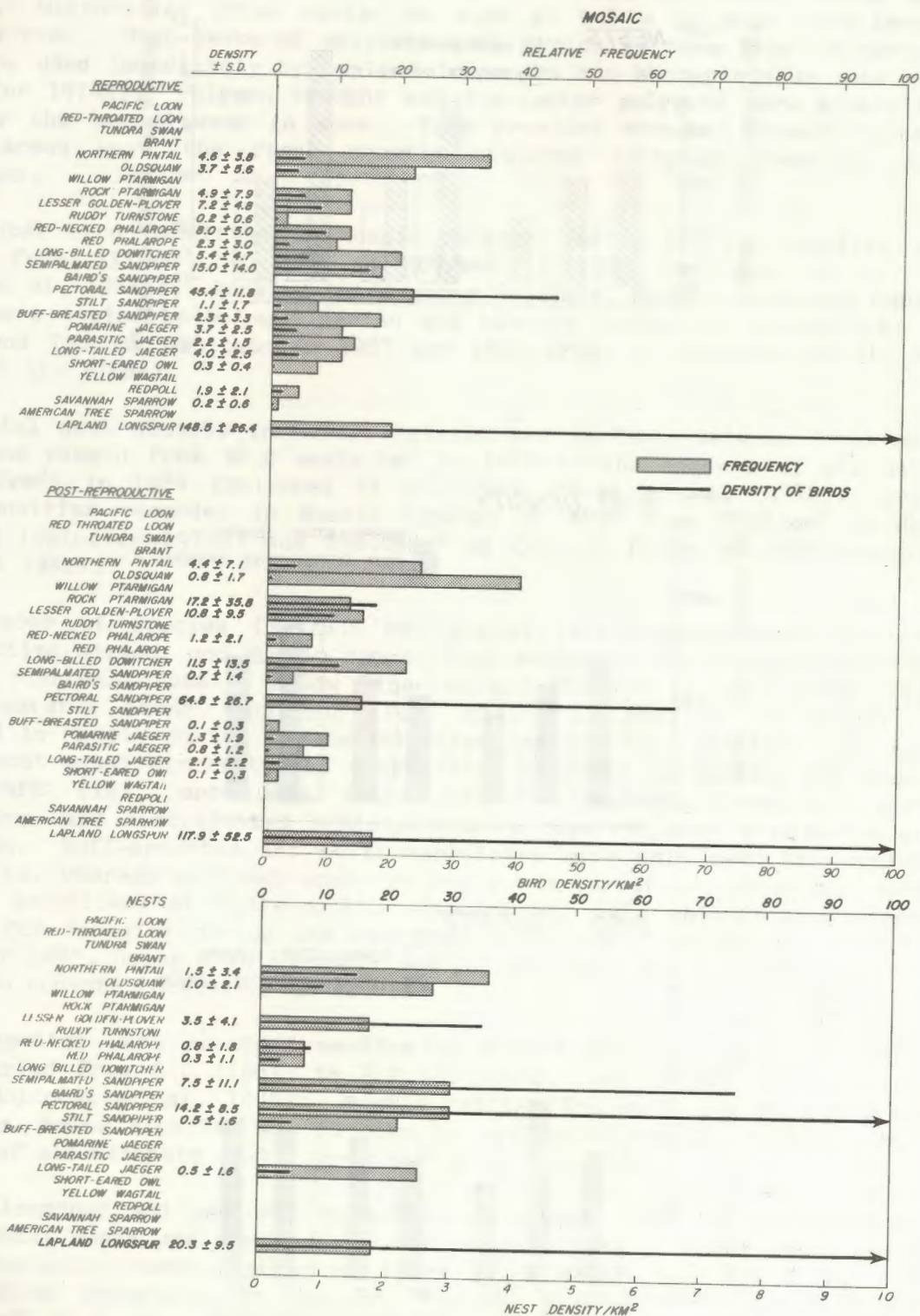


FIG. 13. Relative frequencies^a and mean densities/km² of selected species of birds and their nests observed in Mosaic habitat during the reproductive and post-reproductive seasons on Arctic National Wildlife Refuge, Alaska, 1982-1985.

^a. Frequencies were weighted to account for differential sampling intensities among habitats and locations (Table 3).

et al. 1986b). It was the only habitat in which pectoral sandpipers nested at Okpilak in 1985.

Mosaic ranked among the top 3 habitats for nesting semipalmated sandpipers, with 30% of observed nests and a mean nest density of $7.5/\text{km}^2$ (Fig. 13). Semipalmated sandpipers nested in substantially higher numbers at Sadlerochit in 1984 ($23.3/\text{km}^2$) and 1985 ($16.7/\text{km}^2$) than at Jago Delta (6.7 and 3.3 nests/ km^2 respectively) (Moitoret et al. 1985, Oates et al. 1986b). Nest density at Canning Delta was similar to that at Sadlerochit with $20.0/\text{km}^2$ recorded in 1980 (Martin and Moitoret 1981). This species was only observed nesting at Okpilak in 1982, although Spindler (1978a) recorded a nest density of $6.0/\text{km}^2$ in 1978. Lesser golden-plover was the fourth most common species and nested consistently in Mosaic habitat (mean of $3.5/\text{km}^2$) each year at all locations (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b).

Several of the less abundant nesting species occurred in high relative frequencies (Fig. 12, Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986a). Oldsquaw nests were found once at Sadlerochit (1984) and Jago Delta (1985). In addition, Jago Delta had the only records of nesting northern pintails (3 nests) and long-tailed jaegers (1 nest) in Mosaic habitat. Buff-breasted sandpipers and red phalaropes nested at Okpilak in 1982 and were also recorded there by Spindler (1978a). Although Mosaic habitat had relatively low red-necked phalarope observations and nest densities, it ranked second to Flooded at Okpilak and Jago Delta and second to Wet Sedge at Sadlerochit (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b).

Mean number of species observed in Mosaic habitat declined during the post-reproductive season (Figs. 12 and 13) and typically remained lower than Flooded and Riparian habitats. With few exceptions, red-necked phalaropes, red phalaropes, semipalmated sandpipers, stilt sandpipers, buff-breasted sandpipers, pomarine jaegers, parasitic jaegers, short-eared owls, redpolls, and savannah sparrows left Mosaic habitat at all locations where they had occurred during at least part of the reproductive season (Fig. 13).

Mean total bird density generally declined during the post-reproductive season, with an overall mean of $240/\text{km}^2$. The greatest decline was apparent in 1984 when densities decreased from $309/\text{km}^2$ to $263/\text{km}^2$ between seasons (Moitoret et al. 1985). Mean total bird density ranged from $209/\text{km}^2$ in 1985 to $263/\text{km}^2$ in 1984 and was generally below mean total bird densities observed in Riparian and Flooded habitats in 1983 and 1985 (Figs. 4, 7, and 12, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b).

Variation in Lapland longspur and pectoral sandpiper numbers accounted for annual and local fluctuations in total bird densities. Jago Delta supported the highest densities of longspurs observed in Mosaic during 1984 and 1985, and, in contrast to other locations, increased in the post-reproductive period (Moitoret et al. 1985, Oates et al. 1986b). Pectoral sandpiper density increased substantially during post-reproductive season at Okpilak in 1983, Jago Delta in 1984, and Sadlerochit in 1985 (Fig. 14, Spindler et al. 1984a, Oates et al. 1986b). Initial influxes of pectoral sandpipers were largely comprised of early migrating males. Juvenile flocks moved through later (See Annotated Species List).

MOSAIC HABITAT

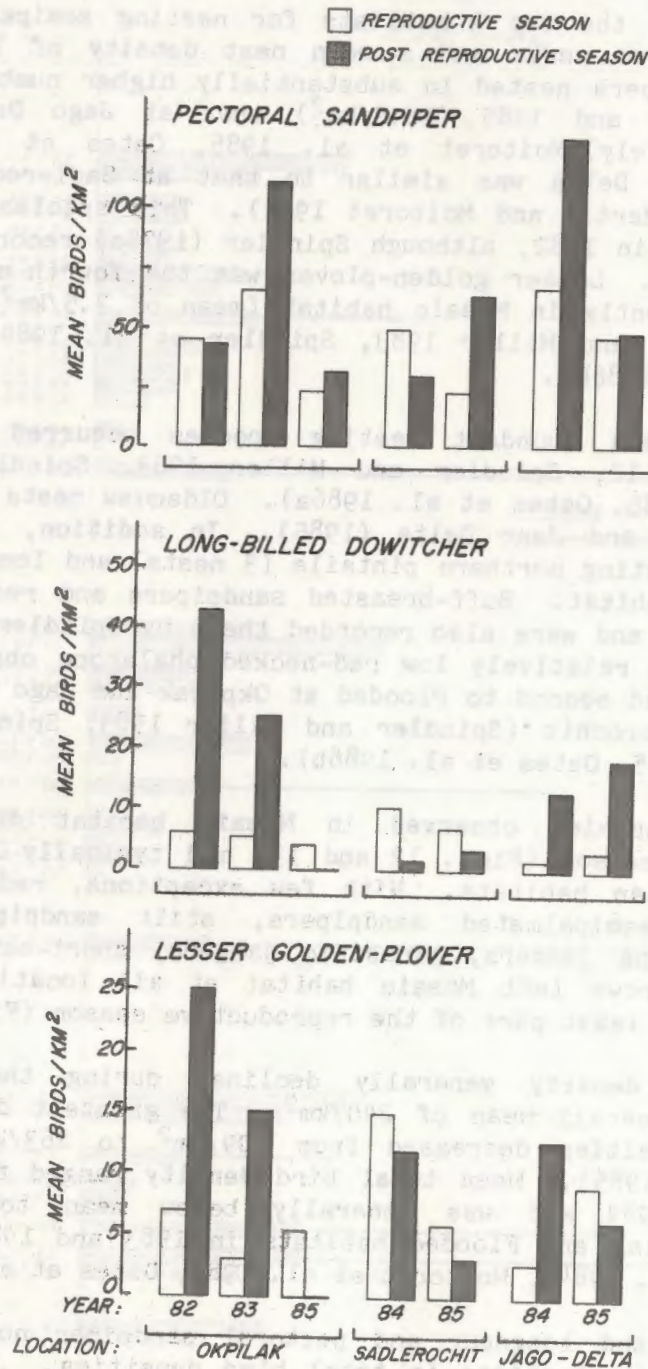


FIG. 14. MEAN DENSITIES OF PECTORAL SANDPIPERS, LONG-BILLED DOWITCHERS, AND LESSER GOLDEN-PLOVERS OBSERVED IN MOSAIC HABITAT AT 3 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

Varied microhabitats of Mosaic habitat provided cover and available ponds for foraging and brood rearing through the post-reproductive period. Early migrant flocks of adult and juvenile lesser golden-plovers and long-billed dowitchers were observed at Jago Delta and Okpilak (Fig. 14). Rock ptarmigan and northern pintails (adults with young) were observed more frequently during post-reproductive than reproductive season at Sadlerochit and Jago Delta, and 40% of all oldsquaws observed after the nesting period were seen in Mosaic at Jago Delta (Fig. 13).

Moist Sedge (Type IV)

Moist Sedge ranked consistently among the lowest relative to other habitats in mean total birds ($91/\text{km}^2$), mean numbers of species ($2.9/0.1\text{km}^2$ plot), mean total nests and mean number of nesting species during the reproductive season (Fig. 2) (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986a). Magoun & Robus (1977) considered Moist Sedge to be an important habitat due to its frequent close association with Wet Sedge Meadow and Flooded Meadow. Lapland longspurs were the most common species associated with this habitat, but occurred in low density ($60/\text{km}^2$) relative to other habitats (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). Less common species included long-tailed jaegers, rock ptarmigan, lesser golden-plover, pectoral sandpipers, redpolls, and savannah sparrows (Fig. 15). Moist Sedge was, however, an important habitat for nesting stilt sandpipers, lesser golden-plover, and to a lesser extent, for buff-breasted sandpipers, willow and rock ptarmigan, pectoral sandpipers, and Lapland longspurs (Fig. 15).

Mean total bird densities were higher during the 1984 post-reproductive season than during both the 1984 reproductive season and the 1985 post-reproductive season (Fig. 16, Moitoret et al. 1985, Oates et al. 1986a). Both differences appeared to be the result of a large ingress of pectoral sandpipers and Lapland longspurs (resulting in densities of $105/\text{km}^2$ and $173/\text{km}^2$, respectively) at Aichilik during the post-reproductive season. Influxes of pectorals during the post-reproductive season also occurred in Moist Sedge at Katakturuk in 1982 (from 2 to $115/\text{km}^2$) and Jago Bitty in 1985 (from 4 to $28/\text{km}^2$) (Spindler and Miller 1983, Oates et al. 1986a). Rock ptarmigan moved into Moist Sedge during the post-reproductive season in moderate numbers at Aichilik in 1984 (from 5 to $25/\text{km}^2$) and 1985 (from 6 to $13/\text{km}^2$) (Moitoret et al. 1985, Oates et al. 1986a). In addition, post-reproductive season influxes of willow and rock ptarmigan occurred at Jago Bitty (from 3 to $47/\text{km}^2$, and from 11 to $72/\text{km}^2$, respectively) and Marsh Creek (from 3 to $16/\text{km}^2$, and from 5 to $41/\text{km}^2$, respectively) in 1985.

Moist Sedge-Shrub (Type V).

The Moist Sedge-Shrub habitat type was utilized by several bird species occurring in moderate to relatively low densities (Fig. 17, Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986a). The average total bird density in Moist Sedge-Shrub was consistently lower than Flooded or Riparian habitat, and comparable to that observed in Mosaic, Tussock, and Wet Sedge (Fig. 2). However, avian abundances varied considerably depending on the year and location of sampling (Fig. 18). The extent of polygonization, interspersed of ponds, and density of vegetation influenced shorebird distribution in tundra habitats near Barrow (Myers and

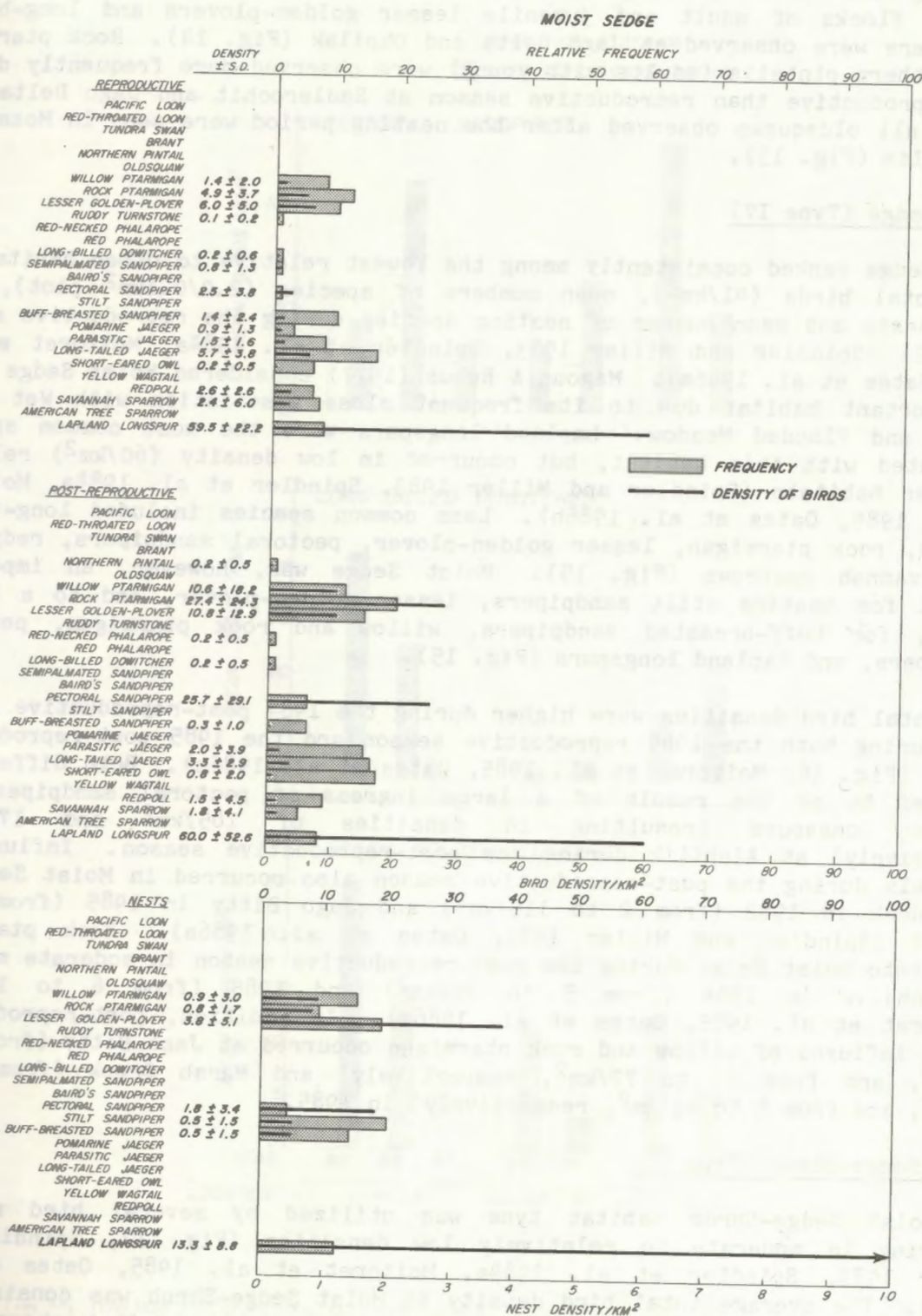


FIG. 15. Relative frequencies^a and mean densities/ km^2 of selected species of birds and their nests observed in Moist Sedge habitat during the reproductive and post-reproductive seasons on Arctic National Wildlife Refuge, Alaska, 1982-1985.

^a Frequencies were weighted to account for differential sampling intensities among habitats and locations (Table 3).

MOIST SEDGE HABITAT

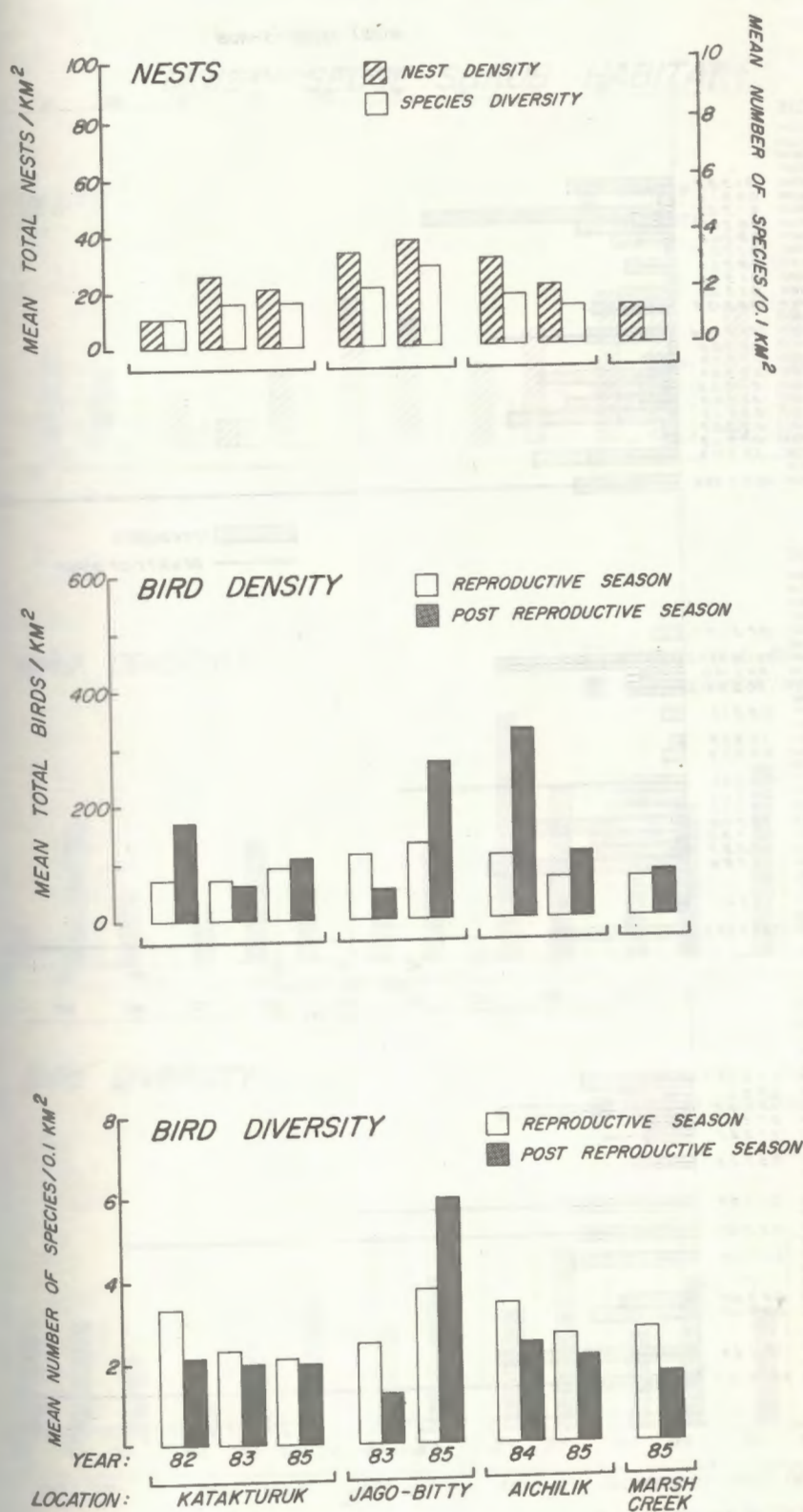


FIG. 16. MEAN NUMBERS OF SPECIES AND SPECIES NESTING PER 0.1 KM² AND MEAN NUMBERS OF TOTAL BIRDS AND TOTAL NESTS PER KM² IN MOIST SEDGE HABITAT AT 4 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

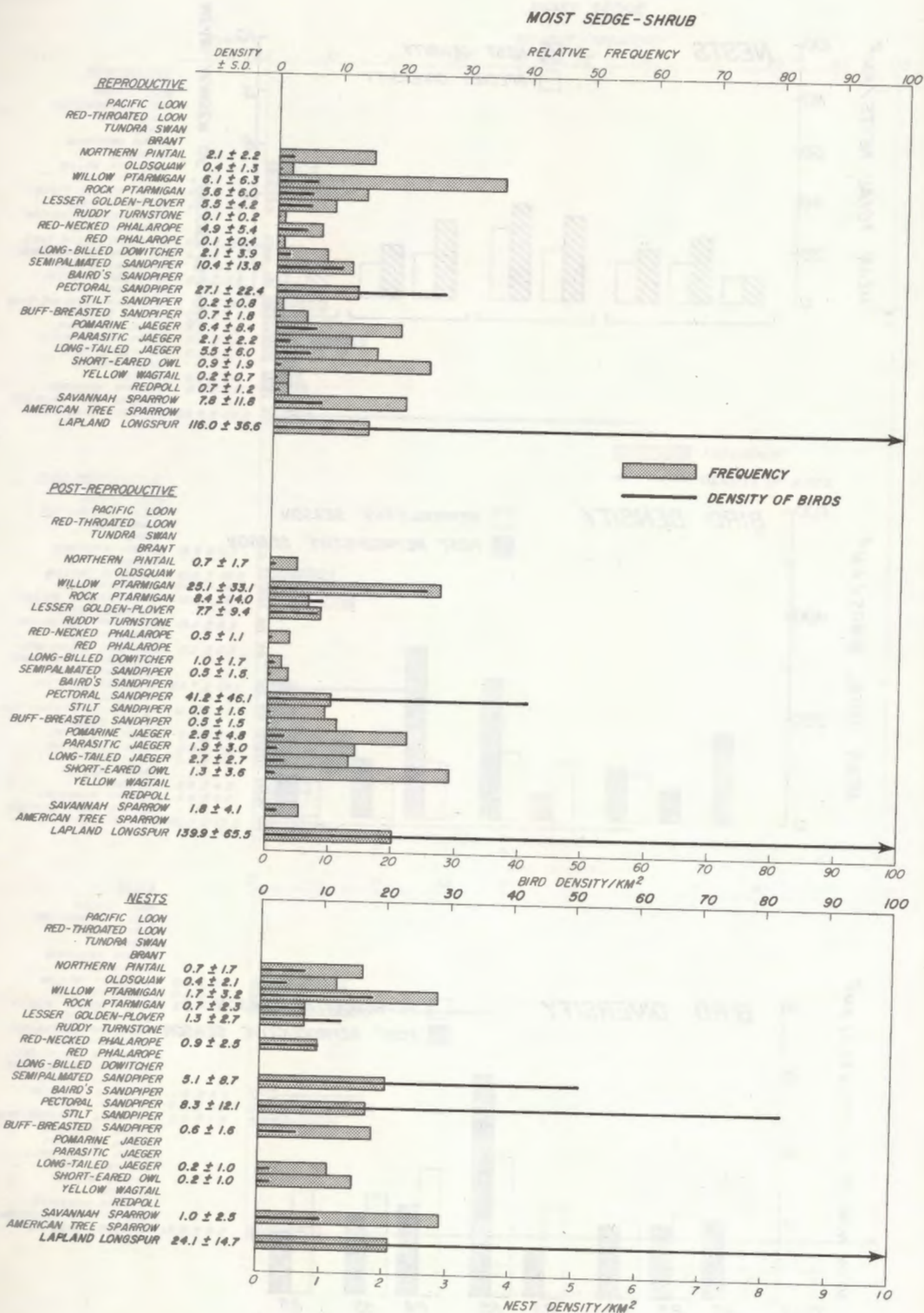


FIG. 17. Relative frequencies^a and mean densities/km² of selected species of birds and their nests observed in Moist Sedge-Shrub habitat during the reproductive and post-reproductive seasons on Arctic National Wildlife Refuge, Alaska, 1982-1985.
 a. Frequencies were weighted to account for differential sampling intensities among habitats and locations (Table 3).

MOIST SEDGE-SHRUB HABITAT

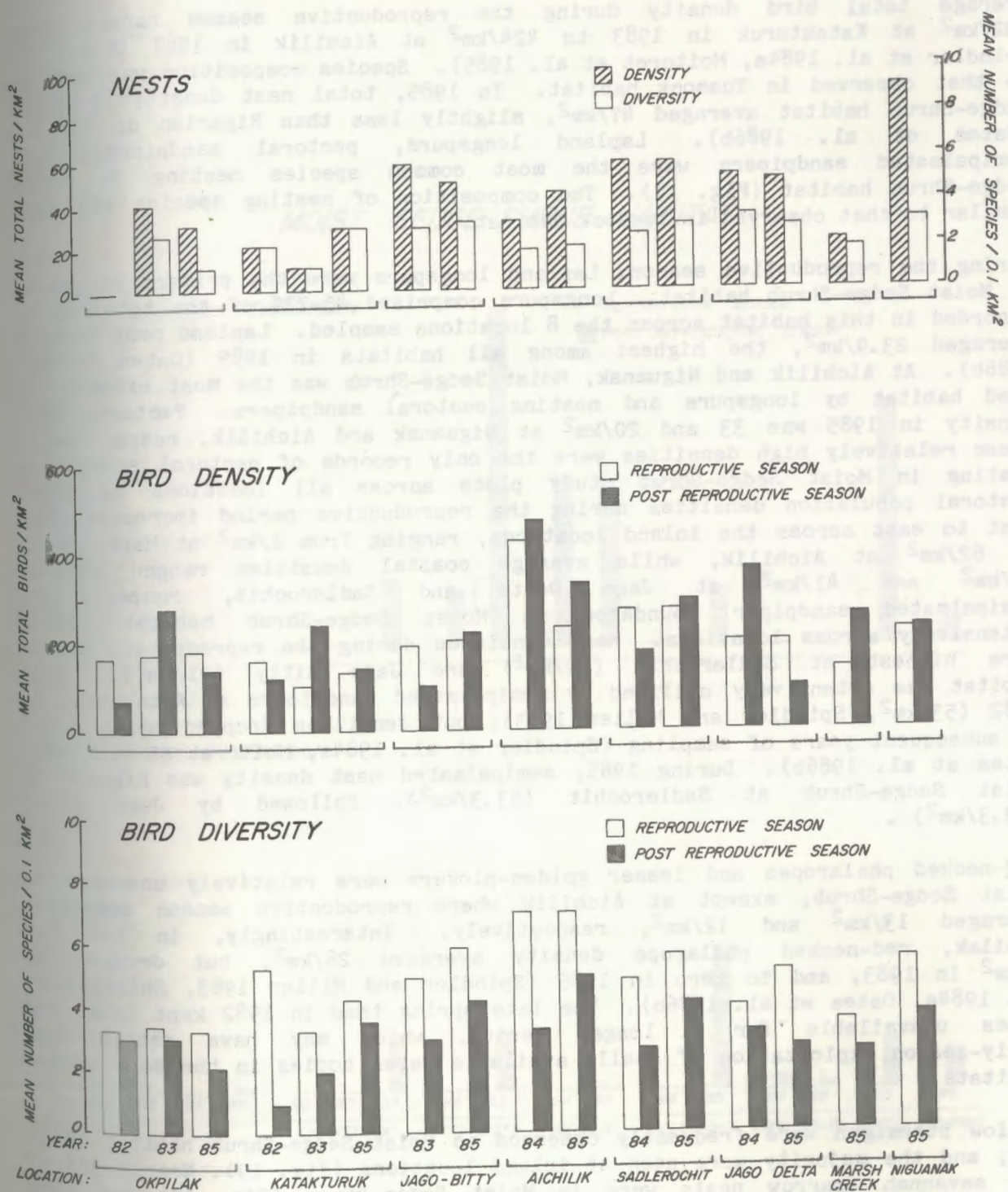


FIG. 18. MEAN NUMBERS OF SPECIES AND SPECIES NESTING PER 0.1 KM² AND MEAN NUMBERS OF TOTAL BIRDS AND TOTAL NESTS PER KM² IN MOIST SEDGE-SHRUB HABITAT AT 8 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

Pitelka 1980). These 3 environmental parameters varied considerably within Moist Sedge-Shrub, which likely influenced avian compositions and densities (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b).

Average total bird density during the reproductive season ranged from 102/km² at Katakturuk in 1983 to 424/km² at Aichilik in 1984 (Fig. 18, Spindler et al. 1984a, Moitoret et al. 1985). Species composition was similar to that observed in Tussock habitat. In 1985, total nest density in Moist Sedge-Shrub habitat averaged 47/km², slightly less than Riparian or Flooded (Oates et al. 1986b). Lapland longspurs, pectoral sandpipers, and semipalmated sandpipers were the most common species nesting in Moist Sedge-Shrub habitat (Fig. 17). The composition of nesting species was also similar to that observed in Tussock habitat.

During the reproductive season, Lapland longspurs were the primary occupants of Moist Sedge-Shrub habitat. Longspurs comprised 45-73% of the total birds recorded in this habitat across the 8 locations sampled. Lapland nest density averaged 23.9/km², the highest among all habitats in 1985 (Oates et al. 1986b). At Aichilik and Niguanak, Moist Sedge-Shrub was the most extensively used habitat by longspurs and nesting pectoral sandpipers. Pectoral nest density in 1985 was 33 and 20/km² at Niguanak and Aichilik, respectively. These relatively high densities were the only records of pectoral sandpipers nesting in Moist Sedge-Shrub study plots across all locations in 1985. Pectoral population densities during the reproductive period increased from west to east across the inland locations, ranging from 1/km² at Marsh Creek to 62/km² at Aichilik, while average coastal densities ranged between 15/km² and 41/km² at Jago Delta and Sadlerochit, respectively. Semipalmated sandpiper abundance in Moist Sedge-Shrub habitat varied extensively across locations. Mean densities during the reproductive season were highest at Sadlerochit (32/km²) and Jago Bitty (21/km²). This habitat was extensively utilized by semipalmated sandpipers at Katakturuk in 1982 (53/km², Spindler and Miller 1983), but densities dropped below 6/km² in subsequent years of sampling (Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). During 1985, semipalmated nest density was highest in Moist Sedge-Shrub at Sadlerochit (23.3/km²), followed by Jago Bitty (13.3/km²).

Red-necked phalaropes and lesser golden-plovers were relatively uncommon in Moist Sedge-Shrub, except at Aichilik where reproductive season densities averaged 13/km² and 12/km², respectively. Interestingly, in 1982 at Okpilak, red-necked phalarope density averaged 28/km², but dropped to 1/km² in 1983, and to zero in 1985 (Spindler and Miller 1983, Spindler et al. 1984a, Oates et al. 1986b). The late spring thaw in 1982 kept lakes and ponds unavailable for a longer period, which may have necessitated early-season exploitation of small, available water bodies in the more upland habitats.

Willow ptarmigan were frequently observed in Moist Sedge-Shrub habitat (Fig. 17), and the majority were seen at inland locations (Fig. 19). Nearly 30% of the savannah sparrow nests were in Moist Sedge-Shrub (Fig. 17) and they occurred in Moist Sedge-Shrub exclusively at the inland foothill locations.

During the post-reproductive season, bird species diversity declined across all locations and years, but changes in total density varied locally (Fig. 18).

MOIST SEDGE-SHRUB HABITAT

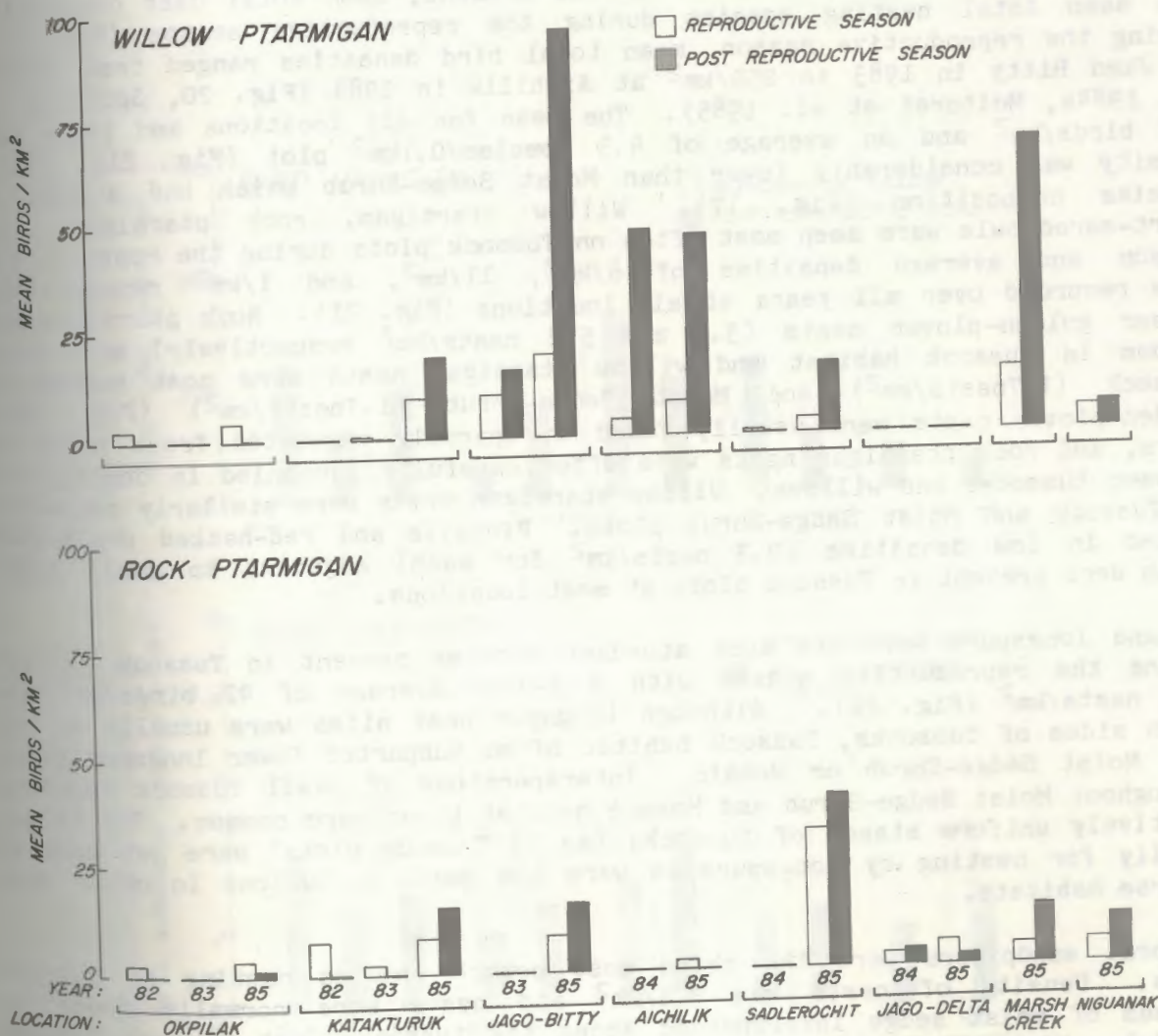


FIG. 19. MEAN DENSITIES OF WILLOW AND ROCK PTARMIGAN IN MOIST SEDGE-SHRUB HABITAT AT 8 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

Red-necked phalaropes and semipalmated sandpipers occurred in low densities (less than $2/\text{km}^2$) at only a few locations. Pectoral sandpiper density increased greatly at Aichilik during the post-reproductive season, averaging $195/\text{km}^2$ in 1984 (Moitoret et al. 1985, Oates et al. 1986b) and $104/\text{km}^2$ in 1985. Seasonal changes in Lapland longspur densities were highly variable and displayed no apparent trends. Willow ptarmigan increased substantially during the post-reproductive season period of 1985 (Fig. 19), largely due to the recruitment of juveniles and influxes of family groups. The largest mean density of rock ptarmigan in Moist Sedge-Shrub habitat was recorded at Sadlerochit atop the more xeric river bluffs ($32/\text{km}^2$ reproductive and $40/\text{km}^2$ post-reproductive, Fig. 19).

Tussock (Type VI)

Tussock habitat was intermediate to low relative to other habitats in mean total bird densities, mean total species present, mean total nest densities, and mean total nesting species during the reproductive season (Fig. 2). During the reproductive season, mean total bird densities ranged from $90/\text{km}^2$ at Jago Bitty in 1983 to $259/\text{km}^2$ at Aichilik in 1984 (Fig. 20, Spindler et al. 1984a, Moitoret et al. 1985). The mean for all locations and years was $153 \text{ birds}/\text{km}^2$ and an average of $4.3 \text{ species}/0.1\text{km}^2 \text{ plot}$ (Fig. 21). This density was considerably lower than Moist Sedge-Shrub which had a similar species composition (Fig. 17). Willow ptarmigan, rock ptarmigan, and short-eared owls were seen most often on Tussock plots during the reproductive season and average densities of $8/\text{km}^2$, $11/\text{km}^2$, and $1/\text{km}^2$ respectively were recorded over all years at all locations (Fig. 21). Rock ptarmigan and lesser golden-plover nests (3.5 and $5.2 \text{ nests}/\text{km}^2$ respectively) were most common in Tussock habitat and willow ptarmigan nests were most common in Tussock ($1.7\text{nests}/\text{km}^2$) and Moist Sedge-Shrub ($1.7\text{nests}/\text{km}^2$) (Fig. 21). Golden-plover nests were usually found on sparsely vegetated frost boils or scars, and rock ptarmigan nests were often carefully concealed in depressions between tussocks and willows. Willow ptarmigan nests were similarly concealed on Tussock and Moist Sedge-Shrub plots. Pintails and red-necked phalaropes nested in low densities ($0.3 \text{ nests}/\text{km}^2$ for each) adjacent to small ponds which were present in Tussock plots at most locations.

Lapland longspurs were the most abundant species present in Tussock habitat during the reproductive season with a 4-year average of $92 \text{ birds}/\text{km}^2$ and $19.3 \text{ nests}/\text{km}^2$ (Fig. 21). Although longspur nest sites were usually on the south sides of tussocks, Tussock habitat often supported fewer longspur nests than Moist Sedge-Shrub or Mosaic. Interspersions of small Tussock habitats throughout Moist Sedge-Shrub and Mosaic habitat types were common. The large, relatively uniform stands of tussocks (as in Tussock plots) were not used as heavily for nesting by longspurs as were the small inclusions in other more diverse habitats.

Pectoral sandpipers were the third most common species nesting on Tussock plots. Density of nests was $3.8/\text{km}^2$ and nests were normally found in patches of moist sedge interspersed among the tussocks (not in pure Tussock stands). Highest nesting densities of pectoral sandpipers in Tussock habitat were recorded at Aichilik in 1985 ($10 \text{ nests}/\text{km}^2$, Oates et al. 1986b), where high nesting densities were also recorded in Moist-Sedge Shrub ($20/\text{km}^2$). Mean density of semipalmated sandpiper nests was $1.1 \text{ nests}/\text{km}^2$, which represented less than 5% of the 4 year mean (Fig. 21). Savannah sparrows (0.5

TUSSOCK HABITAT

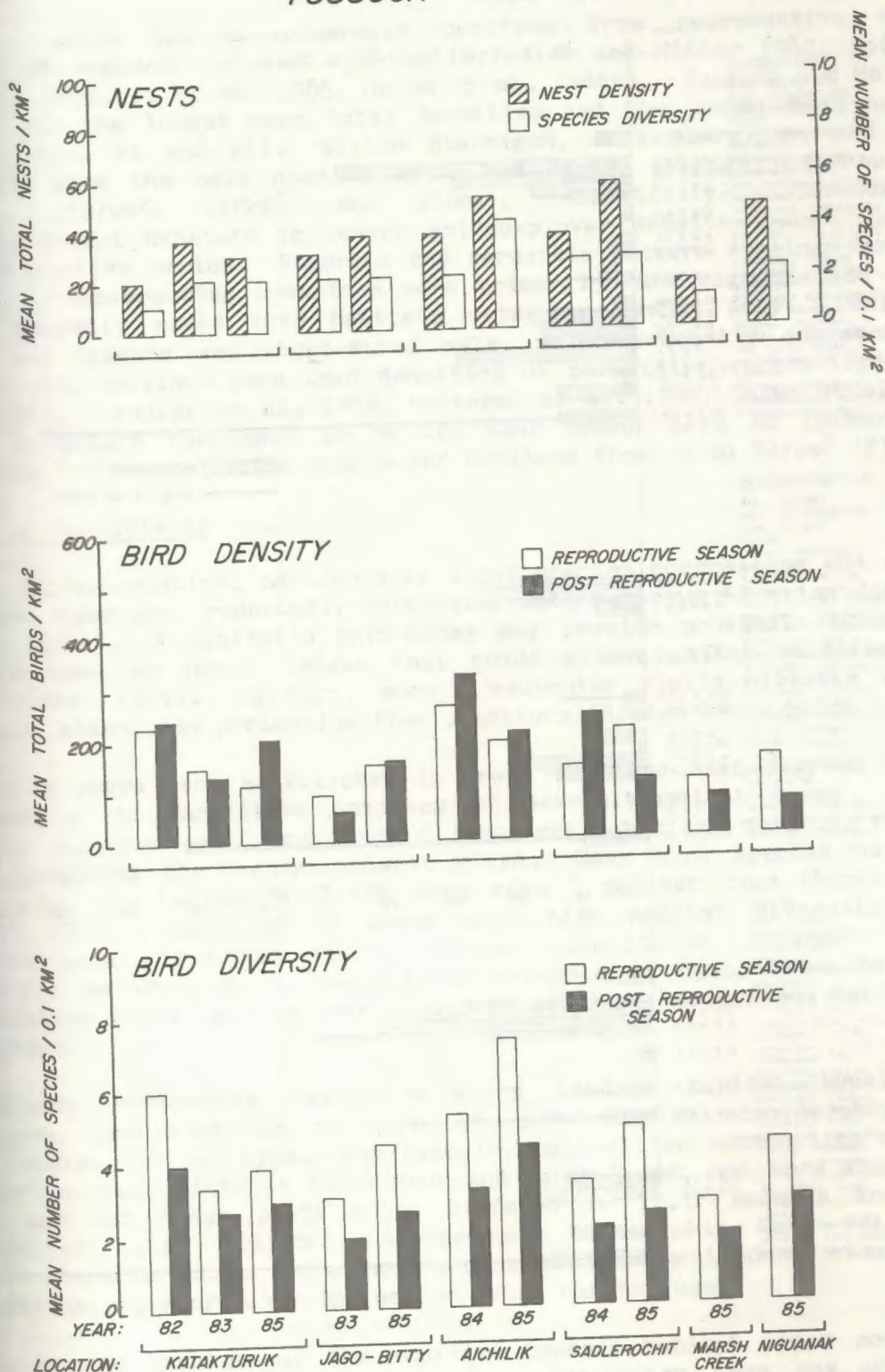


FIG. 20. MEAN NUMBERS OF SPECIES AND SPECIES NESTING PER 0.1 KM² AND MEAN NUMBERS OF TOTAL BIRDS AND TOTAL NESTS PER KM² IN TUSSOCK HABITAT AT 6 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985.

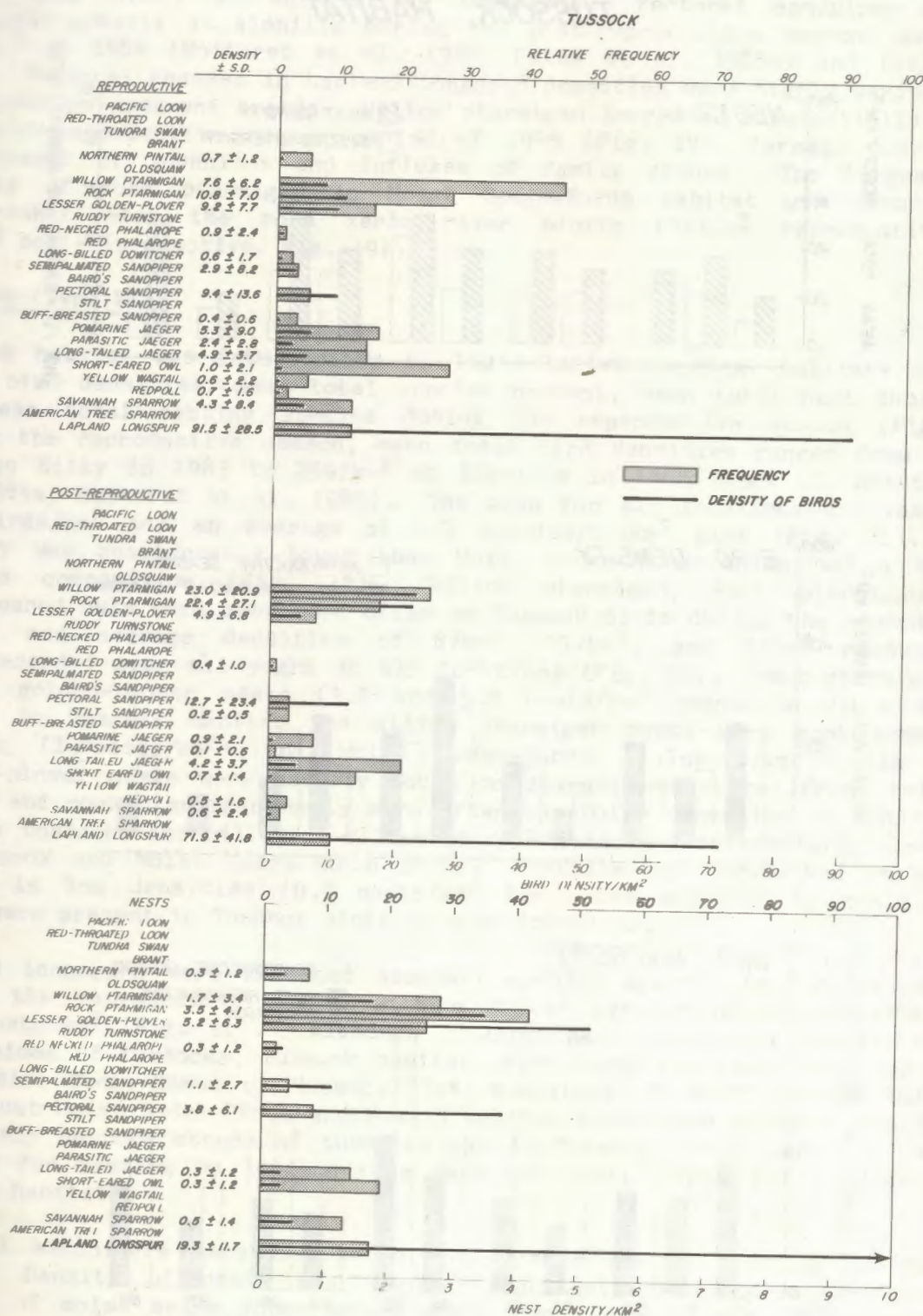


Fig. 21. Relative frequencies^a and mean densities/km² of selected species of birds and their nests observed in Tussock habitat during the reproductive and post-reproductive seasons on Arctic National Wildlife Refuge, Alaska, 1982-1985.

a. Frequencies were weighted to account for differential sampling intensities among habitats and locations (Table 3).

0.3 nests/km²), long tailed jaegers (0.3 nests/km²) and 19% of short-eared owls (0.3 nests/km²) also nested in Tussock habitat (Fig. 21).

Use of Tussock habitat generally declined from reproductive to post-reproductive seasons for most species (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). Tussock and Moist Sedge habitats had the lowest mean total densities and the lowest mean numbers of species (Figs. 21 and 16). Willow ptarmigan, rock ptarmigan, and pectoral sandpipers were the only species which had higher average post-reproductive densities (22/km², 22/km², and 13/km², respectively). Tussock ranked among the lowest habitats in lesser golden-plover density (5/km²) during the post-reproductive period. Pomarine and parasitic jaegers declined to very low densities. Non-breeding pomarines were primarily June migrants and parasitic jaegers probably moved into habitats with more avian prey. Densities of long-tailed jaegers and short-eared owls, which primarily consumed rodents (Maher 1974), declined less than densities of parasitic jaegers (Spindler and Miller 1983, Spindler et al. 1984, Moitoret et al. 1985, Oates et al. 1986b). Lapland longspurs continued to be the most common bird in Tussock habitat during the post-reproductive season and declined from 92 to 72/km² (Fig. 21).

Sources of Variability

Habitat characteristics, particularly plant species composition and vegetative structure, have been repeatedly correlated with patterns of avian distribution (Shugart 1981). A habitat's physiognomy may provide proximal factors in the necessary cues to search images that guide avian habitat selection (Hilden 1965, Klopfer 1965). In turn, such a mechanism yields ultimate factors as food, nest sites, and protection from predators (Hilden 1965, Balda 1975).

The 8 bird camps were established in areas that had high degrees of habitat interspersation to facilitate sampling of several habitat types. Thus, the locations surveyed were comprised of large-scale habitat mosaics, relative to random locations across the coastal plain. Many bird species have adopted exploitation strategies involving more than 1 habitat type (MacArthur 1964, Anderson 1980). Sampling in areas with high habitat diversity may have generated avian densities and/or species compositions different from those that would be obtained in very large expanses of homogeneous habitat, and extrapolating these results over extensive areas of homogeneous habitat is not appropriate.

Physiognomic components within a given Landsat habitat type, such as shrubiness, pondiness, or micro-relief, often varied considerably within a given Landsat habitat type. For example, tall-willow communities were common in Riparian study plots at Katakturuk and Marsh Creek, but were absent at Jago Delta; and Wet Sedge plots often differed in their amounts and types of micro-relief (e.g. polygons, strangmoor, hummocks). Such "fine-grained" habitat characteristics were not separated by the Landsat classification. nevertheless, they probably influenced avian habitat use.

Despite coarse resolution, the modified Landsat habitat types accounted for significant amounts of avian variation more often than any other factor investigated. However, in most analyses, the habitat effect interacted with 1 or more additional factors, revealing that the influence of Landsat habitat on avian distribution was often dependent on the season, the location under consideration, and/or the year of sampling.

Analyses of seasonal changes were confined to 1985 data because of the high degree of temporal variability during the post-reproductive period (Fig. 22) and the small number of samples taken during the post reproductive periods in 1982, 1983, and 1984 (Table 4, Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985).

Seasonal differences often varied across habitats. For example, Lapland longspur density increased in Riparian and Moist Sedge-Shrub habitats and decreased in all other habitats during the post-reproductive season (Fig. 23). Pectoral sandpiper density increased in all habitat types except Wet Sedge, and the increase was disproportionately large in Flooded habitat (Fig. 23). Seasonal fluctuations may have resulted from changes in habitat requirements (movement from nesting to brood rearing or staging areas) or from changes in habitat quality (fluctuating water levels or insect availability).

Analyses were conducted to determine the effects of location and possible interactions with habitat and season. These analyses were restricted to locations that had common habitats, which resulted in 3 major groups of locations: inland locations, coastal locations, and coastal and inland locations with wetlands. Difference among sampling locations often varied with habitats and seasons. Densities of Lapland longspurs at Katakturuk were substantially higher in Riparian habitat than in Moist Sedge-Shrub while densities were similar in those habitats at other inland locations (Fig 24). At the coastal locations, there were significant differences between locations and between seasons, but no significant interactions. At locations with wetlands, longspur densities increased in Moist Sedge-Shrub at Niguanak during the post-reproductive period, but decreased at Jago Delta and Okpilak (Fig 24).

Variations in bird densities or species composition among different locations could result if breeding ranges or migratory routes were not uniformly distributed across the ANWR coastal plain, either along east/west or coastal/inland gradients. Additionally, non-uniform avian distributions between locations may indicate differing resource availabilities such as invertebrate prey (Holmes and Pitelka 1968), or high-density areas might simply reflect aggregated bird populations randomly inhabiting an unsaturated environment (Wiens 1981).

Habitat interactions with location may have resulted for several reasons: 1) avian habitat use was determined by the presence of "fine-grained" environmental features which varied within habitats at different locations, but were not delineated by the Landsat classification; 2) different segments of a species' population (post-breeding males, incubating females, non-breeding juveniles) were engaged in different activities at different locations, and used different habitats; 3) bird species had differential habitat preferences depending on the habitats available (e.g. in wetlands, shorebirds may use the most mesic habitat type available at a given location); or 4) avian habitat use depended on the juxtaposition of other habitats, and total habitat availability differed between locations (e.g., a species might breed in any upland habitat type if it was adjacent to a flooded area for brood rearing).

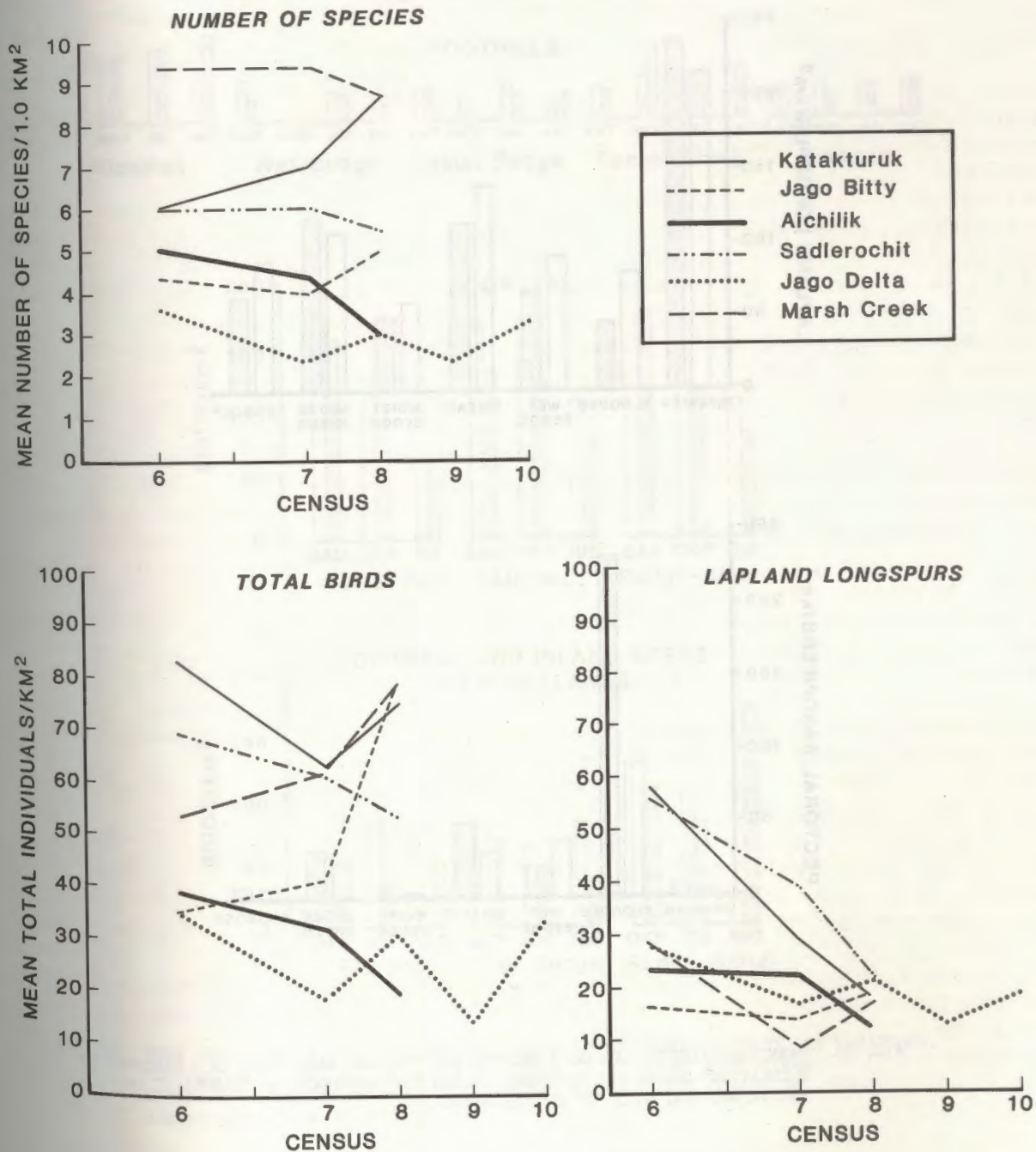


FIG. 22. MEAN DENSITIES OF LAPLAND LONGSPURS, TOTAL BIRDS, AND MEAN NUMBERS OF SPECIES OBSERVED IN RIPARIAN HABITAT AT 6 LOCATIONS DURING THE POST-REPRODUCTIVE SEASON ON ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1985.

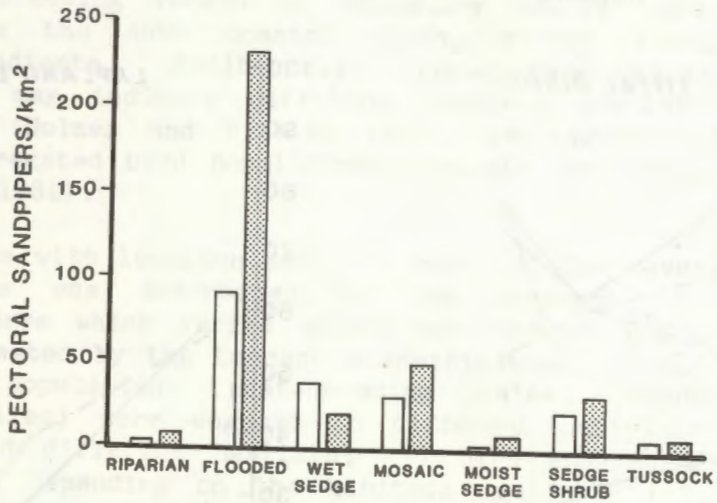
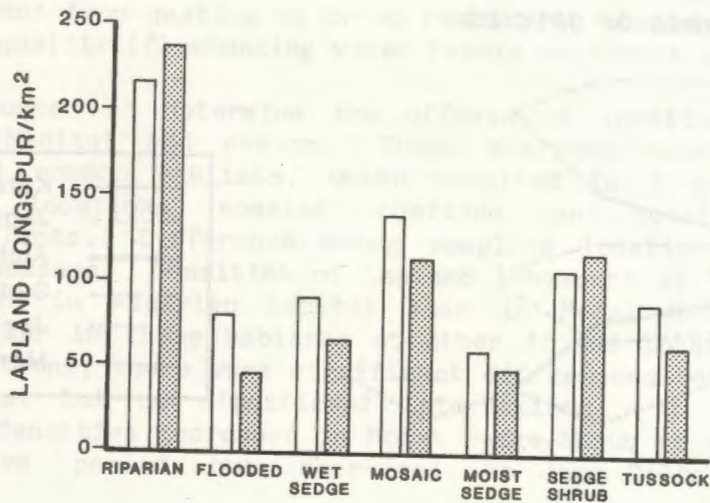


FIG. 23. MEAN DENSITIES OF LAPLAND LONGSPURS AND PECTORAL SANDPIPERS IN 7 HABITATS AT 8 LOCATIONS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS OF 1985, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA.

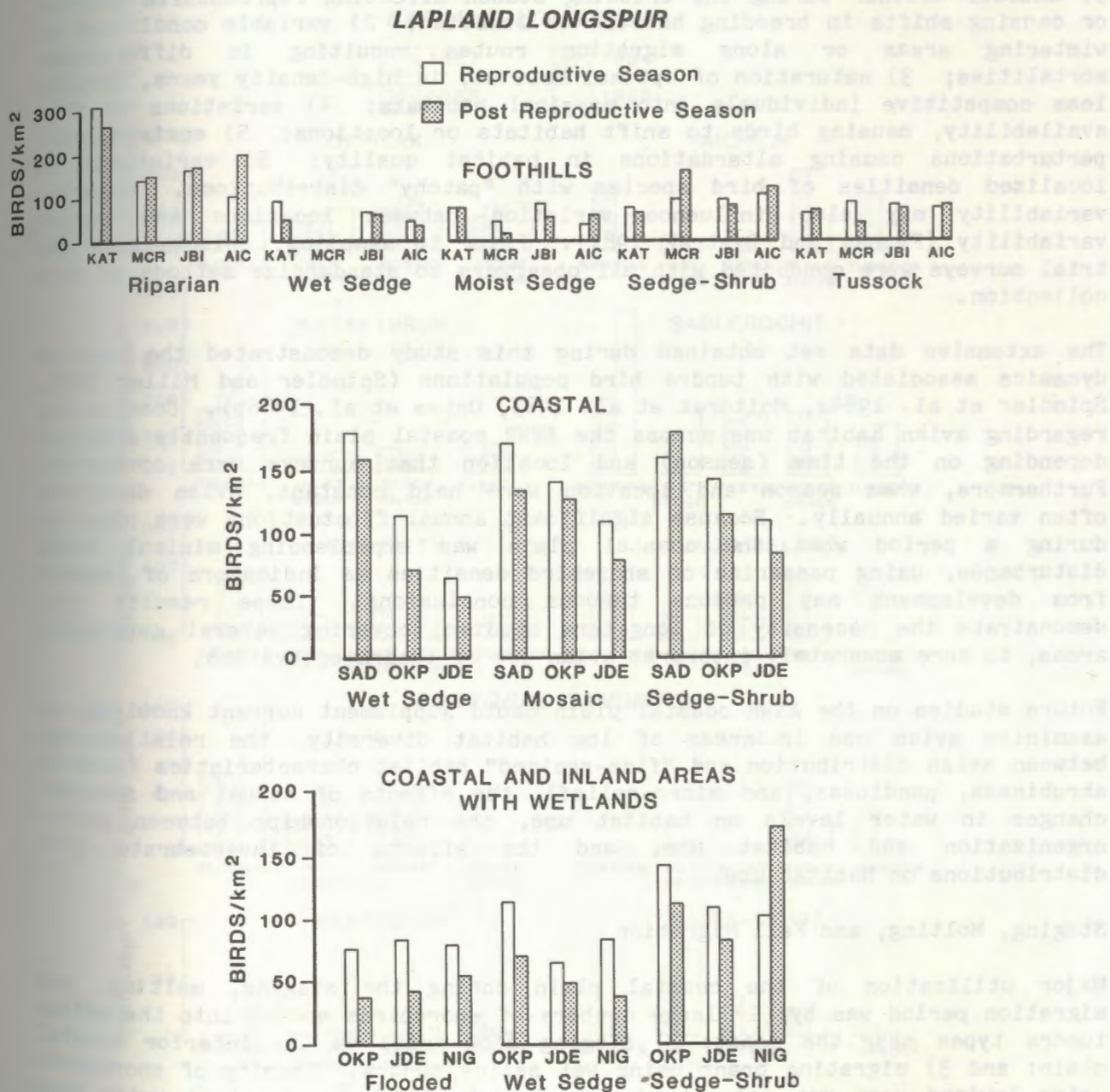


FIG. 24. MEAN DENSITIES OF LAPLAND LONGSPURS IN HABITATS COMMON TO FOOTHILLS LOCATIONS, COASTAL LOCATIONS, AND IN HABITATS COMMON TO LOCATIONS WITH FLOODED WETLANDS DURING THE REPRODUCTIVE AND POST-REPRODUCTIVE SEASONS OF 1985, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA.

Because of differences in sampling frequencies across years, analyses of annual variation were conducted on the most consistent data set: censuses 2-5 of the reproductive season. In addition, tests of annual variation were conducted for each location to maintain balanced data sets with respect to habitat. Analyses frequently revealed significant differences due to year as well as interactions between year and habitat (Fig. 25). Several sources of variation could cause patterns of avian distribution to differ between years: 1) unusual weather during the breeding season affecting reproductive success or causing shifts in breeding habitat or location; 2) variable conditions at wintering areas or along migration routes resulting in differential mortalities; 3) saturation of optimal habitat, in high-density years, forcing less competitive individuals into marginal habitats; 4) variations in food availability, causing birds to shift habitats or locations; 5) environmental perturbations causing alternations in habitat quality; 6) variations in localized densities of bird species with "patchy" distributions. Observer variability may also influence variation between locations and annual variability (Faanes and Bystrak 1981). Prior to sampling, orientations and trial surveys were conducted with all observers to standardize methods of data collection.

The extensive data set obtained during this study demonstrated the complex dynamics associated with tundra bird populations (Spindler and Miller 1983, Spindler et al. 1984a, Moitoret et al. 1985, Oates et al. 1986b). Conclusions regarding avian habitat use across the ANWR coastal plain frequently differed depending on the time (season) and location that surveys were conducted. Furthermore, when season and location were held constant, avian densities often varied annually. Because significant annual fluctuations were observed during a period when the coastal plain was experiencing minimal human disturbance, using passerine or shorebird densities as indicators of impacts from development may produce tenuous conclusions. These results also demonstrate the necessity of long-term studies, covering several geographic areas, to more accurately interpret avian use of tundra ecosystems.

Future studies on the ANWR coastal plain could supplement current knowledge by examining avian use in areas of low habitat diversity, the relationships between avian distribution and "fine-grained" habitat characteristics (such as shrubiness, pondiness, and micro-relief), the effects of annual and seasonal changes in water levels on habitat use, the relationships between social organization and habitat use, and the effects of invertebrate prey distributions on habitat use.

Staging, Molting, and Fall Migration

Major utilization of the coastal plain during the staging, molting, and migration period was by: 1) large numbers of shorebirds moving 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. Density of shorebirds using lowland very wet sedge tundra in August ($320/\text{km}^2$) was about twice that observed in the June-July breeding periods at the Canning Delta due to a coastal shift in shorebird abundance (Martin and Moitoret 1981). The Landsat habitats receiving the greatest use at this time were Flooded, and Wet Sedge.

Canada geese molted in river deltas, such as the Canning Delta, during the latter half of July (Martin and Moitoret 1981). Snow goose staging usually

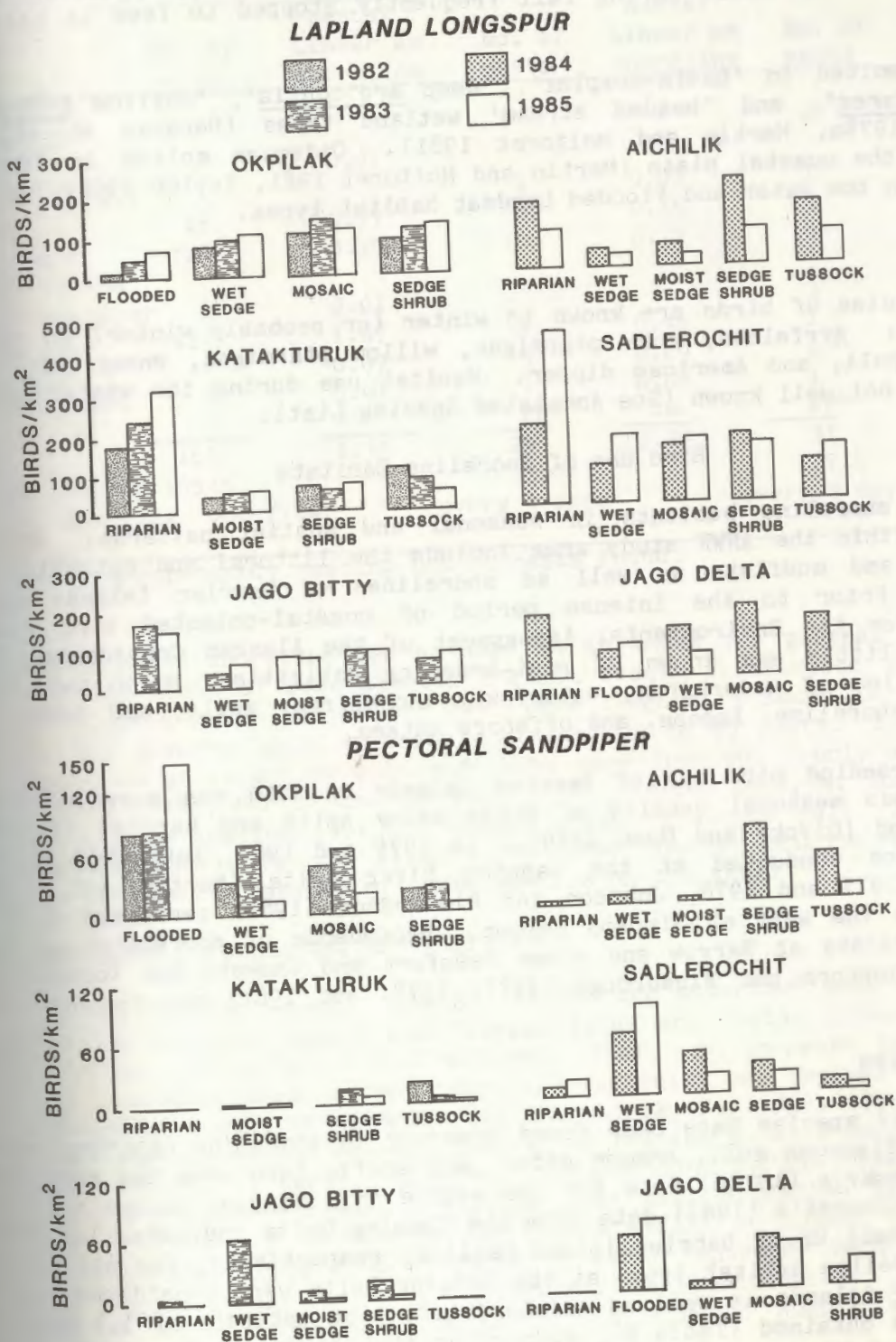


FIG. 25. MEAN DENSITIES OF LAPLAND LONGSPURS AND PECTORAL SANDPIPERS OBSERVED IN 7 HABITATS AT 6 LOCATIONS DURING THE REPRODUCTIVE SEASON, 1982-1985, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA.

began during the latter half of August and extended into the latter half of September (see Annotated Species List). Both upland foothill tundra (Moist Sedge-Shrub and Tussock) and coastal wet tundra (Wet Sedge and Mosaic) were used extensively by snow geese. Small numbers of greater white-fronted geese staged in river deltas in August (Martin and Moitoret 1981). A significant eastward migration across the outer coastal plain occurred from mid-August to early September (see Annotated Species List). Brant migrating westward along the Beaufort Sea coast during fall frequently stopped to feed in Saline Wet Sedge.

Pintails molted 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 molted in 'deep-open lakes' on the coastal plain (Martin and Moitoret 1981, Taylor 1986), which are included in the water and Flooded Landsat habitat types.

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, common raven, redpoll, and American dipper. Habitat use during the winter by these species is not well known (See Annotated Species List).

Bird Use of Shoreline Habitats

Birds use shoreline habitats in seasonal and spatial patterns. Shoreline habitats within the ANWR study area include the littoral and estuarine zones of rivers and mudflats as well as shorelines of barrier islands and the mainland. Prior to the intense period of coastal-oriented bird research conducted for the Environmental Assessment of the Alaskan Continental Shelf, 1975-1981, little was known of post-breeding activities, which may involve high densities of waterbirds, waterfowl, shorebirds, gulls, and terns using estuarine, shoreline, lagoon, and offshore waters.

In 1976, breeding bird use of barrier islands on ANWR was surveyed (Divoky 1978a) as was 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). In 1977 and 1978, Johnson and Richardson (1981) performed shoreline transects to the west at Simpson Lagoon. Dependence of shorebirds on arctic littoral habitats at Barrow and other Beaufort and Chukchi Sea locations was studied by Connors and Risebrough (1977, 1978, and 1981) and Connors et al. (1979).

Nesting Species

A total of 12 species have been found breeding in shoreline habitats on ANWR (Table 5). Glaucous gull, common eider, and arctic tern were the most common nesters. Divoky's (1978a) 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, etc.) an estimate of 1.1 nests per lineal km was obtained (Table 8), suggesting that barrier islands may support higher numbers of shoreline nesters than do other shoreline habitat types.

Table 5. Bird species found nesting in shoreline habitats of the Arctic National Wildlife Refuge, Alaska, 1976 and 1980. Sources: 1976--Divoky (1978a); 1980--Martin and Moitoret (1981).

Species	1976		1980			
	Barrier islands		Barrier islands		All shoreline	
	Brownlow to Demarcation		Canning River delta		Canning River delta	
	No. of nests	Nests/ Linear km shoreline	No. of nests	Nests/ Linear km shoreline	No. of nests	Nests/ Linear km shoreline
Tundra swan					2	0.07
Brant	2	0.02				
Northern pintail			1	0.08	1	0.04
Oldsquaw	18	0.17	2	0.15	3	0.11
Common eider	21	0.20	10	0.77	6	0.22
Ruddy turnstone					5	0.18
Baird's sandpiper	1	0.01			3	0.11
Glaucous gull	113	1.07	6	0.46	1	0.04
Arctic tern	7	0.07	9	0.69	9	0.33
Black guillemot	1	0.01	1	0.08	1	0.04
Snow bunting			Pr ^a	--	Pr ^a	--
Totals	163	1.55	29	2.23	31	1.13
Total km sampled	105.5		13.0		27.5	
Frequency Sampling	once/year		every 4 days		every 4 days	

^aPr= present and probably nesting but no nests found.

Nests/lineal km of shoreline can be used as an index for general comparisons (Table 5), but nests of some species are not evenly distributed and occur in colonies. Common eider and arctic tern were frequently found in colonies of 2-8 nests and glaucous gull colonies contained up to 39 nests. Such colonies were usually on an island or spit and nests were frequently only a few meters apart (Divoky 1978a, Martin and Moitoret 1981, Levison 1980, M. Spindler pers. com.). 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 these species on the ANWR.

Summer Residents, Transients, and Migrants

Following the nesting season, some shorebirds and waterfowl move coastally to wetter tundra habitats (Myers and Pitelka 1980) and arctic littoral habitats (Connors et al. 1979, Martin and Moitoret 1981). An increase in total bird use of all shoreline areas on the Canning River delta was obvious in mid-July, and was composed mostly of oldsquaw and shorebirds (Fig. 26). 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 through early September. Passerine use of shoreline areas increased from late July through August as the young fledged (Martin and Moitoret 1981).

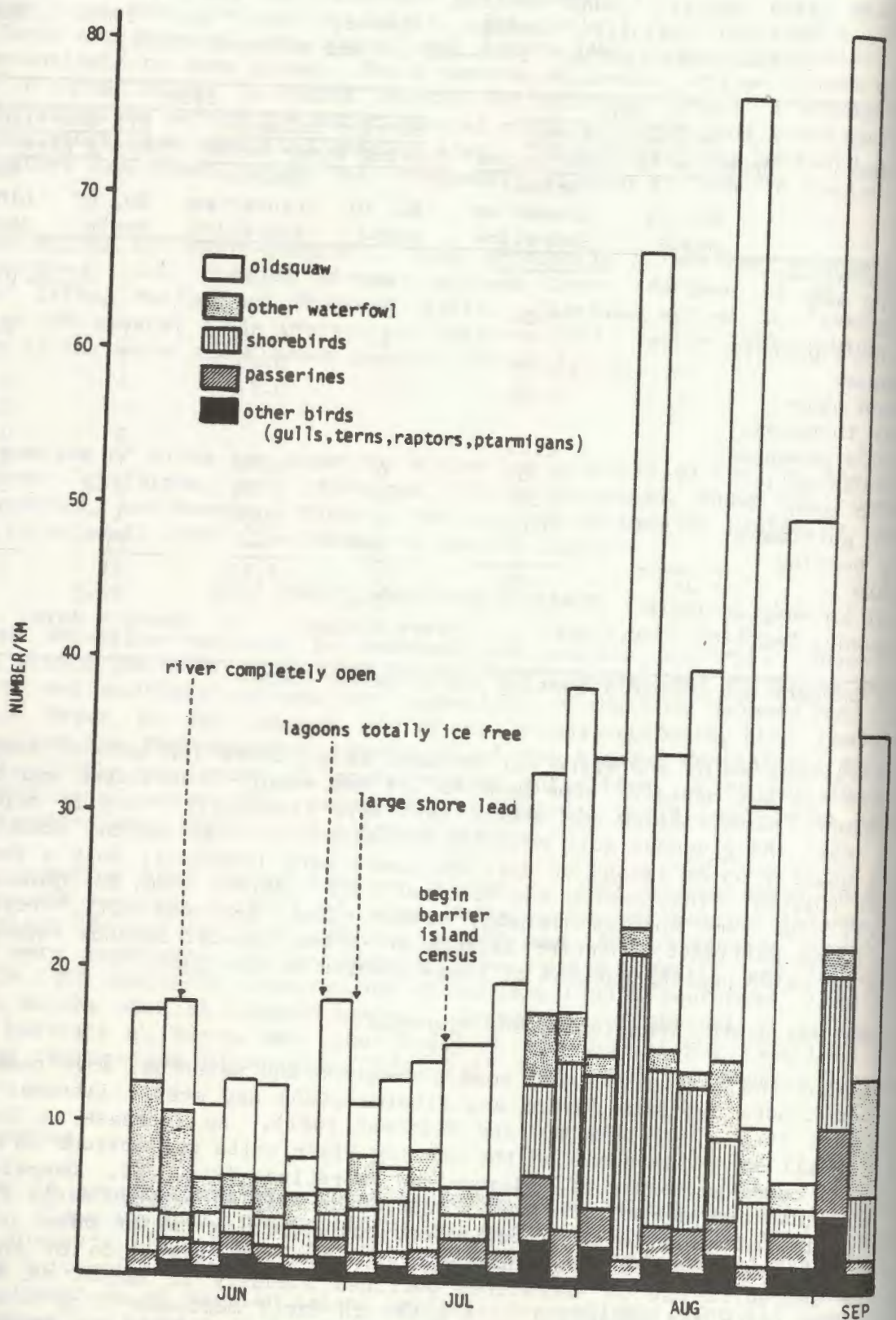


Figure 26. Total bird use of shorelines, Canning River Delta, 1980. Source: Martin and Moitoret (1981).

Table 6. Presence/absence of bird species on shoreline transects by date, Canning River Delta, 1980.

	June	July	August	Sept.		June	July	August	Sept.
Yellow-billed Loon	0000000	0000000	0000000	00	Pectoral Sandpiper	0000000	0000000	0000000	00
Arctic Loon	0000000	0000000	0000000	00	Red Knot	0000000	0000000	0000000	00
Red-throated Loon	0000000	0000000	0000000	00	White-rumped Sandpiper	0000000	0000000	0000000	00
(unidentified loon)	0000000	0000000	0000000	00	Baird's Sandpiper	0000000	0000000	0000000	00
Whistling Swan	0000000	0000000	0000000	00	Dunlin	0000000	0000000	0000000	00
Canada Goose	0000000	0000000	0000000	00	Long-billed Dowitcher	0000000	0000000	0000000	00
Brant	0000000	0000000	0000000	00	Stilt Sandpiper	0000000	0000000	0000000	00
White-fronted Goose	0000000	0000000	0000000	00	Western Sandpiper	0000000	0000000	0000000	00
Snow Goose	0000000	0000000	0000000	00	Semipalmated Sandpiper	0000000	0000000	0000000	00
(unidentified goose)	0000000	0000000	0000000	00	(Baird's/Semi/W-r Sandpiper)	0000000	0000000	0000000	00
Mallard	0000000	0000000	0000000	00	Buff-breasted Sandpiper	0000000	0000000	0000000	00
Gadwall	0000000	0000000	0000000	00	Bar-tailed Godwit	0000000	0000000	0000000	00
Pintail	0000000	0000000	0000000	00	Sanderling	0000000	0000000	0000000	00
Green-winged Teal	0000000	0000000	0000000	00	Red Phalarope	0000000	0000000	0000000	00
Shoveler	0000000	0000000	0000000	00	Northern Phalarope	0000000	0000000	0000000	00
American Wigeon	0000000	0000000	0000000	00	(unidentified phalarope)	0000000	0000000	0000000	00
Greater Scaup	0000000	0000000	0000000	00	(unid. small shorebird)	0000000	0000000	0000000	00
Oldsquaw	0000000	0000000	0000000	00	(unid. medium shorebird)	0000000	0000000	0000000	00
Common Eider	0000000	0000000	0000000	00	(unid. large shorebird)	0000000	0000000	0000000	00
King Eider	0000000	0000000	0000000	00	Pomarine Jaeger	0000000	0000000	0000000	00
(unidentified eider)	0000000	0000000	0000000	00	Parasitic Jaeger	0000000	0000000	0000000	00
White-winged Scoter	0000000	0000000	0000000	00	Long-tailed Jaeger	0000000	0000000	0000000	00
Surf Scoter	0000000	0000000	0000000	00	(unidentified jaeger)	0000000	0000000	0000000	00
Black Scoter	0000000	0000000	0000000	00	Glaucous Gull	0000000	0000000	0000000	00
(unidentified scoter)	0000000	0000000	0000000	00	Sabine's Gull	0000000	0000000	0000000	00
Red-breasted Merganser	0000000	0000000	0000000	00	Black-legged Kittiwake	0000000	0000000	0000000	00
(unidentified duck)	0000000	0000000	0000000	00	Arctic Tern	0000000	0000000	0000000	00
(unidentified waterfowl)	0000000	0000000	0000000	00	Black Guillemot	0000000	0000000	0000000	00
Gyr Falcon	0000000	0000000	0000000	00	Snowy Owl	0000000	0000000	0000000	00
Peregrine Falcon	0000000	0000000	0000000	00	Short-eared Owl	0000000	0000000	0000000	00
Rock Ptarmigan	0000000	0000000	0000000	00	Common Raven	0000000	0000000	0000000	00
Willow Ptarmigan	0000000	0000000	0000000	00	Empidonax sp.	0000000	0000000	0000000	00
(unidentified ptarmigan)	0000000	0000000	0000000	00	Redpoll	0000000	0000000	0000000	00
Golden Plover	0000000	0000000	0000000	00	White-throated Sparrow	0000000	0000000	0000000	00
Black-bellied Plover	0000000	0000000	0000000	00	Lapland Longspur	0000000	0000000	0000000	00
Ruddy Turnstone	0000000	0000000	0000000	00	Snow Bunting	0000000	0000000	0000000	00

0=species not observed 0=species observed flying only 0=species observed on shore or water only
 0=species observed both on shore or water AND flying Source: Martin and Moitoret (1981).

A total of 59 species was documented using the shoreline transects on the Canning River delta in 1980 from June to September (Table 6). "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, 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 by Martin and Moitoret (1981), the outside and inside barrier island and inside east spit transects showed the highest level of bird use (Fig. 27). The outside of the east and west spits showed generally intermediate levels of use. Low levels of 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 3 mainland shore transects (bay, bluff, and river), except during specific peaks of migration (Fig. 27). With few exceptions, waterfowl dominated the spit and barrier island transects. In general, the 3 outside shoreline transects (Fig 27) showed more use by waterfowl (especially oldsquaw) than did the transects on inside shorelines (Fig 27). 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. Bird use within each of the 10 distinct shoreline habitat types is summarized from Martin and Moitoret (1981).

The river transect (Fig. 27) received heavy use by waterfowl in early June, 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 June, as it was the first habitat to become snow-free. Subsequent use of the river transect was low. Shorebird use of the mudflats at the river mouth occurred in mid-July.

The inner lagoon shoreline transect (Fig. 27) showed relatively little bird use in June and especially July. In late August and September, 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. Phalarope migration caused a peak of bird use in August.

The bay transect (Fig. 27) received little use by waterfowl, although the adjacent ponds 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.

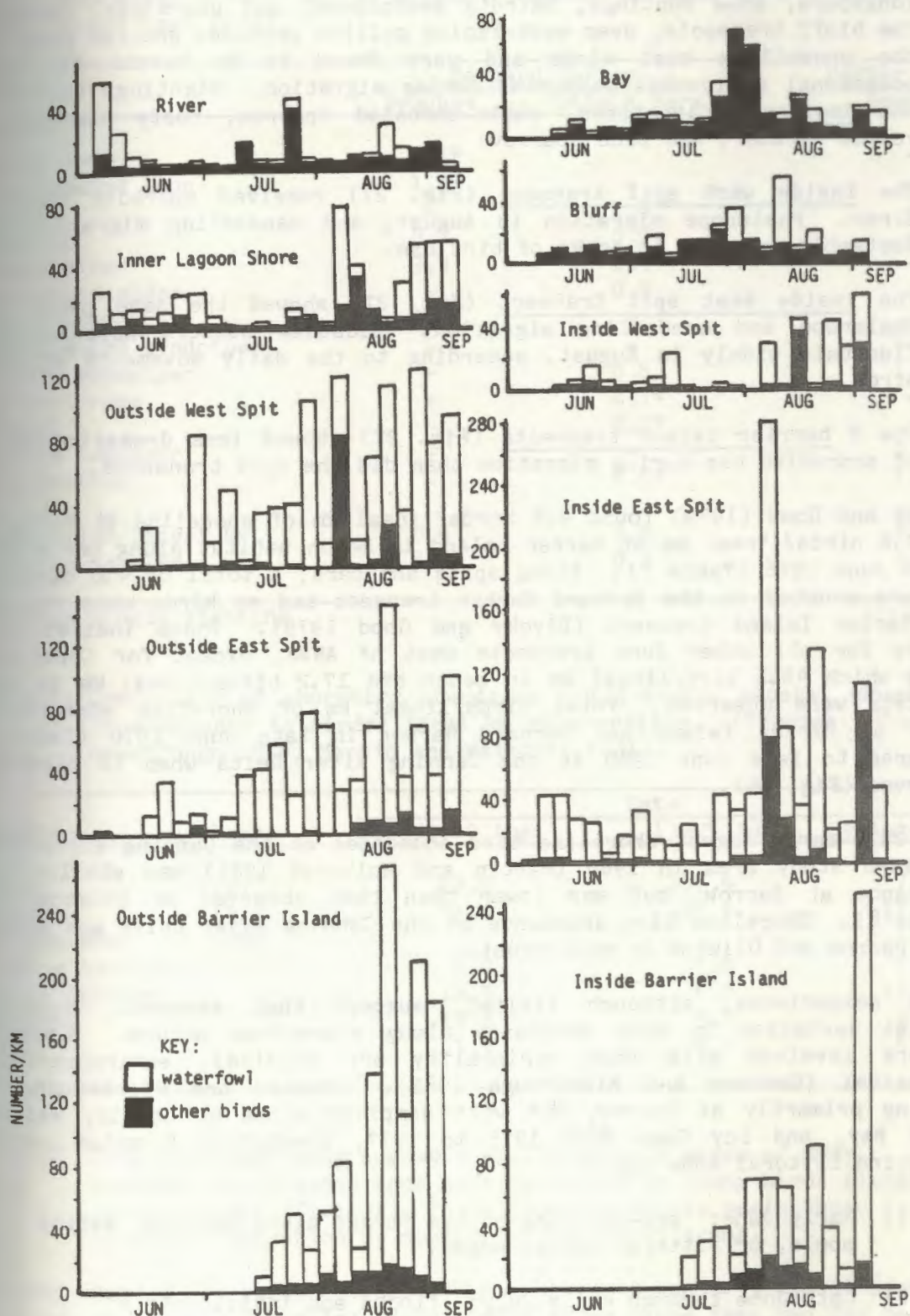


Figure 27. Bird use of shoreline habitats by transect, Canning River Delta, 1980. Source: Martin and Moitoret (1981).

The bluff transect (Fig. 27) was little used except by Lapland longspurs, snow buntings, Baird's sandpipers, and ptarmigan. Within the bluff transects, deep west-facing gullies provided shelter from the prevailing east winds and were found to be havens for the occasional accidental passerine during migration. Sightings included the Empidonax flycatcher, white-throated sparrow, rusty blackbird, yellow warbler, and tree sparrow.

The inside west spit transect (Fig. 27) received sporadic use by birds. Phalarope migration in August, and sanderling migration in September resulted in peaks of bird use.

The inside east spit transect (Fig. 27) 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 (Fig. 27) showed less dramatic peaks of shorebird use during migration than did the spit transects.

Divoky and Good (1979) found 9.5 birds/lineal km of shoreline at Bernard Spit and 2.6 birds/lineal km at Barter Island in beach habitat along the ANWR coast on 24 June 1976 (Table 7). Along spits and bars, a total of 4.0 birds/lineal km were counted on the Bernard Harbor transect and no birds were recorded on the Barter Island transect (Divoky and Good 1979). These indices exceeded values for all other June transects west of ANWR, except for Cape Lisburne along which 40.1 bird/lineal km in beach and 17.2 birds/lineal km in spit/bar habitats were observed. Total birds/lineal km of shoreline appeared to be lower at Barter Island and Bernard Harbor in late June 1976 (Table 7) as compared to late June 1980 at the Canning River Delta when 18 bird/km were observed (Fig. 26).

Late July-early August shoreline bird abundance at the Canning River Delta on the ANWR study area in 1980 (Martin and Moitoret 1981) was similar to bird abundance at Barrow, but was lower than that observed at Oliktok in 1977 (Table 8). Shoreline bird abundance at the Canning River Delta was lower than both Barrow and Oliktok in mid-August.

These comparisons, although limited, suggest that seasonal, annual, and spatial variation in bird abundance along shorelines occurs. Some of the factors involved with this variability are physical, environmental, and biological (Connors and Risebrough 1981). Connors and Risebrough (1977), working primarily at Barrow, but with sampling sites at Lonely, Wainwright, Peard Bay, and Icy Cape from 1975 to 1977, identified 4 major periods of shorebird littoral zone use:

- (1) Early June: 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.

Table 7. Indices of abundance of birds (birds/km) 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 phalarope	-	0.1*	-
Redpoll	-	0.1*	-
Lapland longspur	-	-	0.3*
Snow bunting	-	0.1*	1.0
Total birds/lineal km	0.5	4.0	2.6
Total km sampled	8.3	0.3	3.1

*Denotes single sighting

Table 8. Comparison of shorebird abundance for 3 arctic coastal areas. Index of abundance is birds/lineal km of shoreline. (Sources: Connors and Risebrough 1978, Martin and Moitoret 1981).

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

- (3) Late July and early August: adults of both sexes of many 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) August and early September: the heaviest use of littoral areas occurred. Juveniles leave tundra areas where they had fed before fledging and flock in littoral habitats to begin their southward movements independently of, and later than the adults.

Connors and Risebrough (1977) identified 2 major gradients in littoral habitats based upon foraging and microhabitat data. One corresponded to the position of the foraging site with respect to the water line; the second described changes in habitat related to particle size of the substrate. Species using the littoral zone around Barrow responded differently to these gradients. Several different types of shoreline habitats were used by shorebirds including mudflats, 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 (Connors and Risebrough 1977). Shorebirds foraging in brackish mudflats, lagoon edge, and Wet Saline Tundra pool areas within the littoral zone west of ANWR 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) suggested that shorebird staging and feeding in the littoral zone preceding fall migration functions as an energy storage process immediately before migration and that littoral habitats are critical for arctic shorebirds. Additionally, band recovery data near Barrow indicate high turnover rates with individual birds using a particular shoreline area for only a few days before moving on. Each stretch of shoreline is apparently important to more than just local birds.

The magnitude and timing of post-breeding shoreline movements observed by Connors and Risebrough (1981) were correlated with post-breeding season air temperatures. Warmer late-summer temperatures, resulted in higher bird densities in the littoral zone, and earlier migration peaks. Bird species which showed similar annual fluctuations in use of the littoral zone were not species which shared the same breeding habitats, however, they did occur together in the same post-breeding habitats (Connors and Risebrough 1981). These species/habitat associations were as follows:

Gravel Beaches

ruddy turnstone
sanderling
red phalarope

Littoral Flats, Lagoon Edges

lesser golden-plover
semipalmated sandpiper
western sandpiper
Baird's sandpiper
pectoral sandpiper
dunlin
long-billed dowitcher
red-necked phalarope

Despite the limited geographical area sampled on ANWR, it was apparent that shoreline habitats were important for waterfowl, shorebirds, and other seabirds and waterbirds (Martin and Moitoret 1981). Species which nested on barrier islands (primarily waterfowl and seabirds) generally nested in higher densities than on other shorelines. Shorebird use peaked in late July and early August during staging and migration. Waterfowl, particularly oldsquaw, increased through July and remained at high levels through early September as birds molted, staged and migrated. The concentration of large numbers of birds from widespread geographic areas into shoreline habitats suggests that impacts to these habitats could potentially have population-wide effects on some bird species.

Bird Use of Lagoon and Offshore Habitats

The greatest concentrations of summer resident waterbirds on ANWR occur in the shallow coastal waters of the Beaufort Sea. This area includes shallow coastal lagoons protected by gravel barrier islands, shoals, and nearshore waters (see Chapter 2). Aerial lagoon surveys conducted on ANWR include Schmidt (1970), Frickie and Schmidt (1974), Spindler (1979a), Bartels and Zellhoefer (1983), Bartels and Doyle (1984b), Brackney et al. (1985b), and Brackney et al. (1986a). 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 the primary habitats for molting waterfowl and staging shorebird populations in the arctic region of Alaska. Aerial surveys over the coastal lagoons and offshore waters of ANWR were standardized in 1981 (Bartels and Zellhoefer 1983), and conducted annually from 1981-85 as part of the baseline study. A transect was flown along a 400 m wide band directly seaward of the barrier islands (offshore transect) and complete surveys were flown on 10 selected lagoons.

During the baseline study, a total of 33 bird species were observed in the lagoons and offshore transect with 21 to 32 avian species recorded each year. (Bartels and Zellhoefer 1983, Bartels and Doyle 1984b, Brackney et al. 1985b, Brackney et al. 1986a). Annual peak estimates ranged from 20,812 in 1982 to 35,091 in 1983. Oldsquaw accounted for 91.1% of the birds observed during the surveys.

A major characteristic of bird populations using the lagoons of ANWR was seasonality of use. In all years of ANWR aerial surveys (1981-1985), the use of lagoons by birds began with snow melt in June (Bartels and Zellhoefer 1983, Bartels and Doyle 1984b, Brackney et al. 1985b, Brackney et al. 1986a). During this period, river overflow covered the deltaic portions of the lagoons and provided the first open water of the season (Bartels and Zellhoefer 1983). This phenomenon is common in other arctic coastal areas (Bergman et al. 1977, Schamel 1978, Johnson and Richardson 1981). Bird use remained at low levels until ice-out occurred, usually in late-June to mid-July (Bartels and Zellhoefer 1983, Bartels and Doyle 1984b, Brackney et al. 1985b, Brackney et al. 1986a). Populations gradually increased through July until a peak was reached in August, then populations gradually declined. However, a second smaller 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 (Bartels and Zellhoefer 1983).

Lagoon Habitats

Seasonal Use

Several avian groups commonly utilize the ANWR coastal lagoons (Table 1). Red-throated and yellow-billed loons are common breeders and migrants. Oldsquaw is the most abundant migrant, summer resident, and the major avian consumer in the lagoon ecosystem. The second most abundant avian consumer and a common scavenger is the glaucous gull. Red and red-necked phalaropes are abundant coastal nesters and abundant late summer and fall migrants. Common and king eiders are uncommon nesters and migrants, and surf and white-winged

scoters are uncommon migrants. Black brant are uncommon nesters and common fall migrants.

Three to 5 aerial surveys were conducted annually on 10 selected coastal lagoons from late July through early September during the baseline study. Weekly mean numbers of oldsquaw and all bird species were calculated for the 10 lagoons and the offshore transect for the 5 years of study. Total bird numbers increased early in the season with a peak in early to mid-August (Fig. 28a, Bartels and Zellhoefer 1983, Bartels and Doyle 1984b, Brackney et al. 1985b, Brackney et al. 1986a). The majority of birds observed in the lagoons and offshore were oldsquaw (Fig. 28a). Mean oldsquaw numbers peaked during early-August and then declined sharply from mid-August to September (Fig. 28b). The large September increase in numbers of other species (Fig. 28a) is due to an estimated 16,000 phalaropes tallied during a September 1983 survey in the offshore transect (Fig. 28c). Eiders and scoters showed large fluctuations in mean numbers from late July to September, with a general trend downward (Fig. 29e). Glaucous gull numbers were stable through late August with a sharp increase in September probably due to an influx of juveniles and breeding adults from the coastal plain following the breeding season (Fig. 29f). Mean loon numbers appeared to decrease from mid-August to September (Fig. 29a) and mean numbers of geese increased sharply in the last 2 weeks of August due to migrant and staging black brant and white-fronted geese using the brackish wetlands adjacent to the lagoons (Fig. 29e).

Bird use in the coastal lagoons exhibited regular seasonal fluctuations, although the timing of these fluctuations varied from year to year. Gollop and Richardson (1974) and Johnson and Richardson (1981) documented similar use patterns for at other Beaufort Sea coastal areas. Their data and the data from the baseline study highlight the importance of these coastal areas to migratory birds.

To compare the relative value of the 10 selected lagoons, an index was calculated from the products of the density ratio (lagoon density/grand density), the proportion of birds per lagoon, and the mean number of species present (Table 9). This index was devised to compare the importance of the lagoons for waterbirds with respect to density, total population use, and species richness. The density ratio and proportion were used to make the index independent of temporal variations in total population size between aerial censuses. A lagoon with a high bird density that was limited in size or supported few species had less value than lagoons with high densities, high population levels, and high species richness.

High species richness and a large proportion of the birds observed during surveys (primarily oldsquaw) placed a relative higher value for all birds on Demarcation Bay, Jago, and Nuvagapak Lagoons (Table 9). Medium value lagoons were Oruktalik, Tamayariak, and Simpson Cove. Tapkaurak, Arey, Brownlow, and Egakrak rated low despite the high species richness in Egakrak and Arey Lagoons. A similar measure of relative value for oldsquaw only, showed a high value for Oruktalik, Jago, Simpson Cove, and Demarcation Bay, medium value for Nuvagapak, Tamayariak, and Tapkaurak Lagoons, and low value for Arey, Brownlow and Egakrak Lagoons. The high density ratios at Oruktalik raised the value on that lagoon for oldsquaw in relation to the total species value.

Brackney et al. (1986a) compared the relative value measures (Table 9) with the physical characteristic of the lagoons (Table 10) by multiple regression

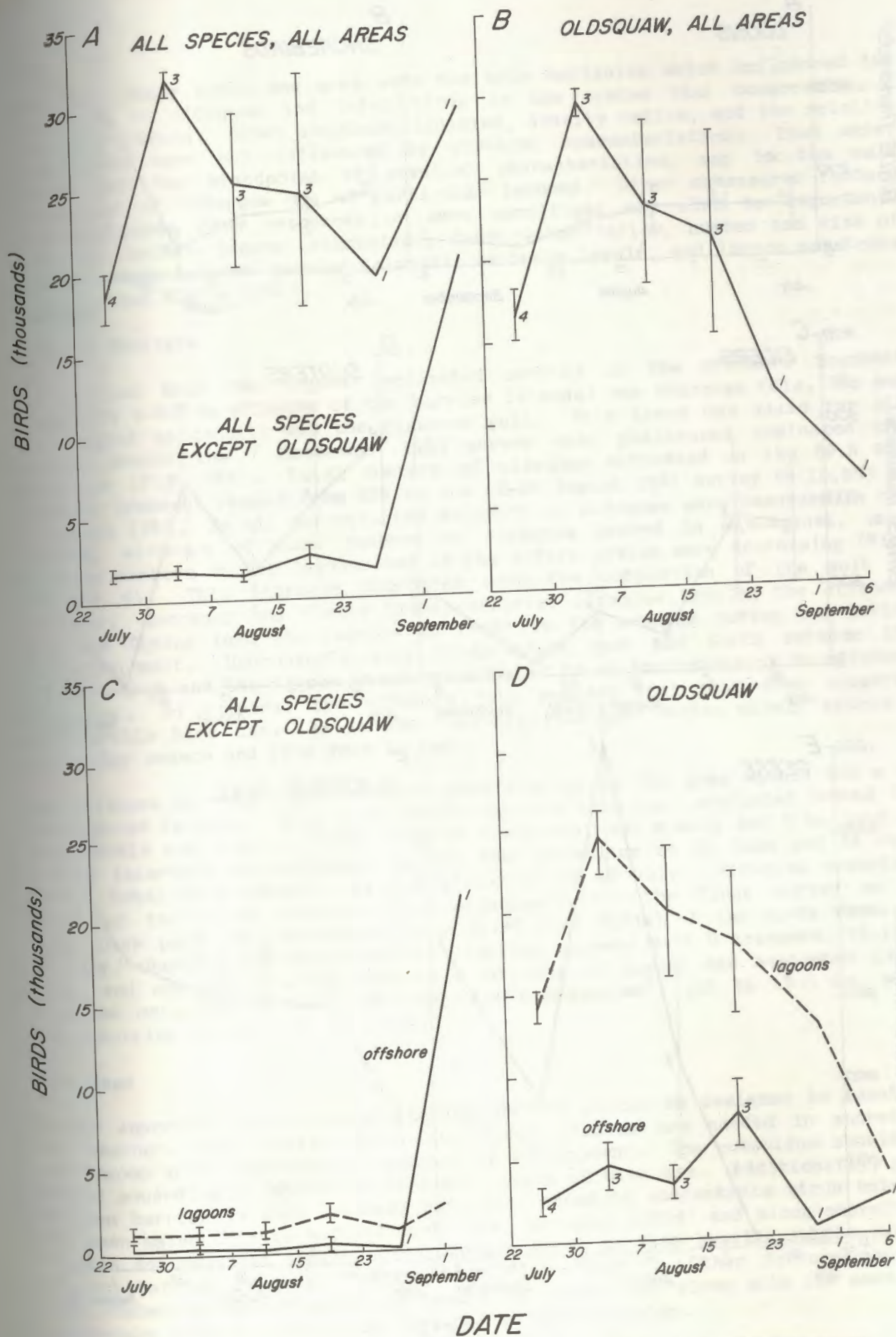


FIG. 28. SEASONAL DISTRIBUTION OF MEAN NUMBERS OF OLDSQUAW AND ALL SPECIES IN LAGOON AND OFFSHORE HABITATS, ARCTIC NATIONAL WILDLIFE REFUGE 1981-1985. VERTICAL BARS INDICATE S.E. AND NUMBERS INDICATE SAMPLE SIZE.

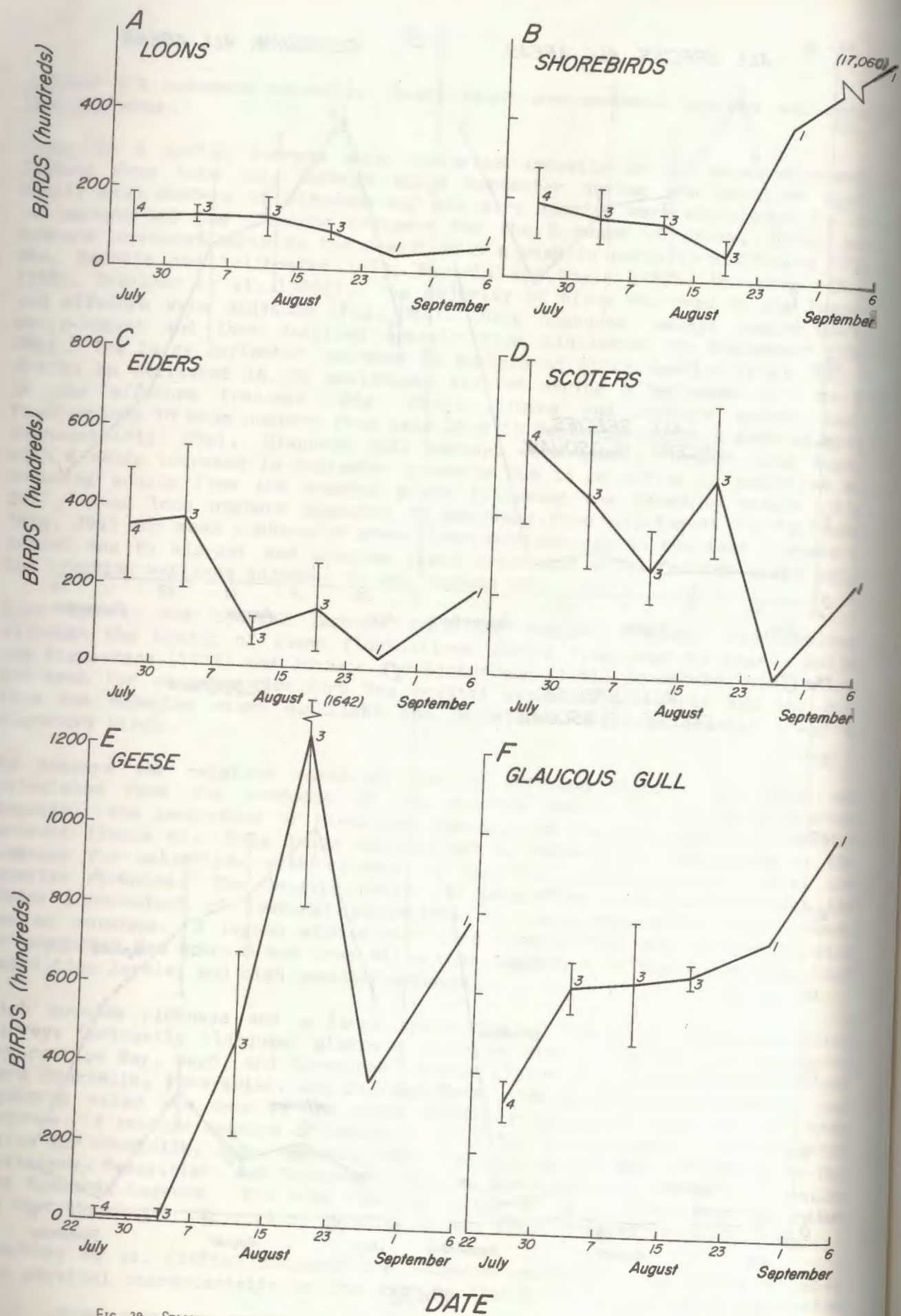


FIG. 29. SEASONAL DISTRIBUTION OF MEAN NUMBERS OF VARIOUS WATERBIRD GROUPS IN LAGOON AND OFFSHORE HABITATS, ARCTIC NATIONAL WILDLIFE REFUGE 1981-1985. VERTICAL BARS INDICATE S.E., AND NUMBERS INDICATE SAMPLE SIZE.

analysis. Water depth and area were the only variables which influenced the proportion of oldsquaw and total birds in the system that occurred in a particular lagoon. Other abundance indices, density ratios, and the relative value index were not influenced by physical characteristics. Thus water depth, from the standpoint of physical characteristics, may be the main determinant of oldsquaw use of particular lagoons. Other unmeasured factors which influence food resources or wave conditions may also be important. These may include lagoon orientation, fresh water inflow, number and size of passes (breaks between barrier islands), salinity levels, and lagoon substrate (Brackney and Platte 1986).

Offshore Habitats

The species with the highest estimated density in the offshore transect (generally 0-400 m offshore of the barrier islands) was oldsquaw (Fig. 28c and d). Second in density was the glaucous gull. This trend was valid for all surveys except the 7 September 1983 survey when phalaropes dominated the estimates (Fig. 28b). Total numbers of oldsquaw estimated on the 88.8 km² offshore transect ranged from 825 on the 22-26 August 1981 survey to 10,993 on 18 August 1984. In all surveys, the majority of oldsquaw were recorded in the lagoons, although offshore numbers of oldsquaw peaked in mid-August, when oldsquaw numbers in the lagoons and in the entire system were decreasing (Fig. 28b and d). This increase coincided with the completion of the molt in oldsquaw. Brackney and Platte (1986) observed oldsquaw leaving the offshore area and flying into the lagoons to roost in the evening during the period following molt. Undoubtedly many birds moved back and forth between the offshore area and the lagoon which contributed to an inconsistency in offshore estimates. In summary, the offshore data suggest that this area supports considerable bird use. As in the lagoons, this use varies widely within a particular season and from year to year.

The offshore surveys discussed here were limited to the area within 400 m of the barrier islands. Only very limited surveys have been conducted beyond 400 m. Frickie and Schmidt (1974) flew 28 transects, 400 m wide and 8 km long at 0.4 km intervals perpendicular to the ANWR coastline on 22 June and 16 July 1974. Total bird density was 1.8 birds/km² on 16 July. Oldsquaw comprised 64.4% of the birds observed (1.2 oldsquaw/km²). The first survey on 22 June, over pack ice, documented only 38.4% (988 birds) of the birds found on 16 July. Bartels and Doyle (1984b) flew two surveys with 4 transects, 16.1 km long, and one survey with transects 5 km long in August and September 1983. Oldsquaw occurred at low densities (4.4 oldsquaw/km²) out to 14.5 km, with 90% occurring within 5 km of shore.

Data Gaps

Future shorebird population monitoring efforts should be designed to identify the weather-caused variability. Additional studies are needed in shoreline and lagoon areas potentially impacted by development. The coastline should be mapped according to shoreline type and levels of bird use. Additionally, gaps between barrier islands (passes) have been shown to concentrate birds both in the open water (Martin and Moitoret 1981, Spindler 1981d) and along shorelines (Martin and Moitoret 1981). Oldsquaw are known to feed heavily in the passes between barrier islands (Brackney and Platte 1986). Other factors causing this concentration may exist and should be identified, along with the means to adequately protect passes from disturbance and pollution.

Table 9. Measures of the relative value of 10 selected lagoons for oldsquaw and all species, from Brackney et al. (1986a).

Lagoon	All species				Oldsquaw		
	Proportion ^a of total	Mean ^b density ratio	Mean ^c No. Species	Relative ^d index value (rank)	Proportion ^a of total	Mean ^b density ratio	Relative ^e index value (rank)
Oruktalik	0.08	2.24	5.4	0.94(5)	0.08	2.59	2.07(1)
Jago	0.18	1.10	7.3	1.45(2)	0.18	1.13	2.03(2)
Simpson Cove	0.17	0.97	7.3	1.18(4)	0.17	1.07	1.93(3)
Demarcation Bay	0.17	1.13	8.9	1.71(1)	0.17	1.11	1.90(4)
Nuvagapak	0.13	1.13	9.0	1.35(3)	0.13	1.11	1.44(5)
Tamayariak	0.08	1.34	6.4	0.70(6)	0.08	1.40	1.12(6)
Tapkaurak	0.08	1.15	5.1	0.46(7)	0.09	1.16	1.04(7)
Arey	0.06	0.46	8.5	0.24(8)	0.06	0.47	0.28(8)
Brownlow	0.02	0.41	4.9	0.04(10)	0.02	0.43	0.09(9)
Egaksrak	0.03	0.70	7.5	0.17(9)	0.01	0.23	0.02(10)

^a No. birds in lagoon/no. birds counted (all surveys combined).

^b Density in lagoon/grand density in the system, mean of all surveys (N=15).

^c Mean No. species in the lagoon (N=15 surveys).

^d Density ratio X proportion birds per survey X mean No. species present.

^e Density ratio X proportion birds per survey X 10.

Table 10. Physical characteristics of 10 lagoons on the ANWR Coastline (from Brackney et al. 1986a).

Lagoon	Area (km ²)	Mean depth(m)	Barrier island length (km)	Shoreline Length (km)	Mudflat length (km)	Lagoon ^a type
Oruktalik	8.8	1.4	4.4	8.4	0	Pulsing
Jago	47.3	1.9	13.7	15.1	9.9	Limited exchange
Simpson Cove	44.4	2.8	2.7	23.1	1.8	Open
Demarcation Bay	38.7	3.2	7.4	59.2	0	Pulsing
Nuvagapak	31.2	2.0	10.9	27.8	0	Pulsing
Tamayariak	15.9	1.8	4.6	12.6	4.5	Open
Tapkaurak	20.5	1.4	9.6	9.0	0	Pulsing
Arey	40.6	0.6	13.8	30.9	0	Pulsing
Brownlow	13.1	0.3	10.6	14.8	2.6	Limited exchange
Egaksrak	14.0	0.3	12.5	3.5	11.5	Pulsing

^a Definitions from Hachmeister and Vinelli (1983).

Information is needed on the frequency and fidelity with which brant use individual coastal mudflats and the energetic importance of these foraging areas. Data on the origin and destination of oldsquaw using ANWR lagoons, their residence time, turnover rates, and comparable population estimates between ANWR lagoons and other Beaufort Sea coastal lagoons is needed to determine the relative importance of coastal lagoons on ANWR to continued maintenance of the population.

Annotated Species List

Currently known status, population levels, habitat use, and distribution of birds on the ANWR study area are presented in this annotated species list. Status/abundance categories used are: abundant, common, fairly common, uncommon, rare, casual, accidental, resident, migrant, breeder, and visitant (adapted from Kessel and Gibson 1978). Status and distribution designations, particularly of the less common species, are considered tentative because of the relatively limited time period (1978-1985) in which intensive bird studies on the ANWR coastal plain have been conducted and the limited coverage of these studies. Geographic distribution of avifauna was divided into 2 general regions. Coastal, or outer coastal plain, denotes that area within approximately 10 km of, and including, the Beaufort Sea shoreline from the Canning River Delta to the U.S. - Canadian border. Intensive study sites in this geographic area included Canning Delta, Sadlerochit, Okpilak Delta, and Jago Delta. Inland, or inland coastal plain, indicates that portion from the coastal belt southward to, and including, the northernmost foothills of the refuge. This region includes all other intensive study sites, but may be modified in text as "mid-plain thaw lakes region" (Niguanak), or "foothills" (Jago Bitty, Katakturuk Gorge, Marsh Creek, Katakturuk, Sadlerochit Springs, and Aichilik). This list is presented in phylogenetic order and includes the documentation used for determining the species status and distribution presented by Table 1.

Brief summaries are presented for the less common species. Accounts for species that are more common, or for which more data exists, include available information on status and distribution, spring migration and chronology, breeding, staging, habitat use, fall migration and chronology, and wintering, as well as habitat use and relative population density information specific to the ANWR study area or the immediate surroundings. Names of tundra habitat types follow the 1982 Landsat classification by Walker et al. (1982).

Unless cited otherwise, source materials for the species discussions are from studies conducted at discrete locations within ANWR for 1 or more years (Table 11). The majority of this information has not been published in the scientific literature.

RED-THROATED LOON - Fairly common coastal breeder, common coastal migrant. Red-throated loon distribution was restricted to coastal peripheries. Arrival dates ranged over the first week of June, with a peak eastward migration noted at Canning Delta between 4 and 7 June 1980. As with Pacific loons, red-throated loons sometimes arrived before appreciable open water was available, and relied on overflow water on river deltas. Red-throated loons used smaller ponds for nesting than did Pacific loons, especially shallow-Arctophila, deep-Arctophila, and beaded streams (Derksen et al. 1981). Nest construction began in mid-June and incubation started as early as 21 June. Nest density in Flooded habitat at Okpilak averaged 2.2/km² between 1982 and 1985. Following the hatch in late-July, adult red-throated loons were observed making regular feeding flights to nearshore Beaufort Sea waters. The fall migration of red-throated loons occurred between 18 August and 6 September, peaking on about 1 September, at Canning Delta in 1980.

PACIFIC LOON - Common breeder, common coastal migrant. Pacific loons were common inhabitants of both inland and coastal thaw lake plains. Tundra lakes and ponds were often ice-covered in early June, and loons arriving from the

Table 11. Site specific studies of birds on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1978-1985.

Study site	Year of study	Reference
Okpilak Delta	1978	Spindler (1978a)
Canning Delta (including Brownlow Point and Lagoon)	1979-1980	Martin and Moitoret (1981) Martin (1983) Moitoret (1983)
Okpilak Delta, Katakturuk	1982	Spindler and Miller (1983)
Okpilak Delta, Katakturuk, Jago Bitty	1983	Spindler et al. (1984b)
Jago Delta, Sadlerochit, Aichilik	1984	Miller et al. (1985)
Okpilak Delta, Jago Delta, Sadlerochit, Aichilik, Niguanak, Jago-Bitty, Marsh Creek, Katakturuk	1985	McWhorter et al. (1986) Oates et al. (1986b)
ANWR lagoon aerial surveys	1981-1982	Bartels and Zellhoefer (1983)
	1983	Bartels and Doyle (1984b)
	1984	Brackney et al. (1985b)
	1985	Brackney et al. (1986a)
Swan surveys on ANWR Coastal Plain	1981-1985	Bartels et al. (1983) Bartels and Doyle (1984a) Brackney et al. (1985d) Platte and Brackney (1986)
Snow goose surveys and studies	1978-1985	Spindler (1978b), Spindler (1981a), Spindler (1983), Spindler (1984a), Oates et al. 1985, Oates et al. (1986a), Brackney et al. (1985a), Brackney et al. (1986b).
Oldsquaw ecology studies on ANWR coastal lagoons	1983-1985	Bartels et al. (1984) Brackney et al. (1985c), Brackney and Platte (1986)

west were reliant on overflow water at river mouths. As breeding areas became available, typically in mid-June, the loons moved onto large, deep tundra ponds and lakes and began courtship and nest building. Nests were commonly placed on small islands in densities ranging from 0.6 to 2.0/km². After a 28-29 day incubation period (Harrison 1978), chicks were attended by both adults at the breeding site. Use of lagoon and estuarine habitats by Pacific loons increased in late July and August as family groups moved from tundra wetlands to coastal waters, and as adults began frequent flights to the lagoons. Several adults (10-18) gathered on the large 0.5 km² lake at the inland Niguanak site during late August 1985. Peak fall migration of Pacific loons was observed from 28 to 30 August 1979 at Canning Delta, although westward movement occurred over a wider time range in 1980 (18 August to 6 September). Pacific 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 (Spindler 1981b).

COMMON LOON - Probable rare migrant or visitant. The species breeds on the Mackenzie River Delta, Northwest Territories (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 in ANWR (Spindler 1978a).

YELLOW-BILLED LOON - Uncommon coastal migrant, rare inland migrant. Yellow-billed loons were most frequently observed on the Sadlerochit during 1985. Flocks of 1-8 individuals, flying eastward, were seen daily between 5-18 June and 7-16 August, while groups of 3-5 birds were less common during 11-23 July. The earliest record of yellow-billed loons on ANWR coastal plain was 1 June 1985, when 9 flew southeast over the Okpilak bird camp. Individuals were also observed in flight on 8 June, 23 July, and 4 August 1985. Similar, but fewer, records exist for the Jago Delta area. Yellow-billed loons were observed in low numbers (less than 5 per transect) in lagoon and nearshore aerial transects in July, August, and September 1978-1981 (Spindler 1981b). Three individuals were seen at Beaufort Lagoon on 7 June 1980, with additional sightings several times a week in coastal lagoons and shoreline waters between Demarcation Bay and Pokok Bay (Levison 1980). One to 4 individuals were sighted along the coast near Brownlow Point in July and August 1979 and 1980. The only inland observations of yellow-billed loons were single individuals on the large 0.5 km² lake at the Niguanak bird camp on 9 July and 29 August 1985.

HORNED GREBE - Casual summer visitant. One adult was collected near Flaxman Island in July 1930 (Bailey 1948).

RED-NECKED GREBE - Casual summer visitant. Schmidt (1970) recorded 1 individual on the Kogotpak River (near Beaufort Lagoon) on 15 June 1970.

SHORT-TAILED SHEARWATER - Casual 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).

TUNDRA SWAN - Common breeder in coastal river delta areas, especially ponds and lakes in and near drained-basin complexes. The first observed arrival dates for tundra swans on ANWR range from 24 May to 1 June (Levison 1980, Spindler 1978a, Martin and Moitoret 1981, McWhorter et al. 1986,). Swans

begin departing the ANWR coastal plain in mid-August and the non-breeders and failed breeders are the first to migrate (Jacobson 1979, Martin and Moitoret 1981, Spindler 1981c). 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).

Swans on the ANWR coastal plain are part of the eastern continental population which winters on the east coast of the United States. During migration they depart to and arrive from their major migration corridor in the MacKenzie River Valley to the east of ANWR (Sladen 1973, Bellrose 1980, Pacific Flyway Study Committee 1983). A 3 year mean of 363.77 ± 80.6 SD (range 271-403) swans have been counted on ANWR in spring surveys (Bartels and Doyle 1984a, Brackney et al. 1985d, Brackney and Platte 1986) compared to an estimated 3000-4000 swans on the entire north slope (Pacific Flyway Study Committee 1983) and a 10 year mean (1975-84) of 81,600 swans in Alaska from both western and eastern populations (Conant and Hodges 1984). Fall surveys on ANWR have averaged 360.5 ± 95.4 (range 280-485) SD adult swans (Spindler 1981c, Bartels et al. 1983, Bartels and Doyle 1984a, Brackney et al 1985d, Platte and Brackney 1986).

Swan concentration areas and general range were defined during swan observations on aerial surveys for 1977-1985 (Platte and Brackney 1986). The majority of tundra swans nest and reside in concentration areas on the ANWR coastal plain where the habitat is most suitable: the Canning-Tamayariak River delta, the Demarcation Bay lakes, the Hulahula-Okpilak River delta/Barter Island lakes, the Pingokraluk Point and the Aichilik-Egaksrak-Kongakut River deltas (Fig. 30).

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 1978c, 1979b, 1980, 1981b). Clutch completion on the Canning Delta was during the first week of June 1979, and about a week later in 1980 (Martin and Moitoret 1981). Mean nest densities during 1983-1985 for the concentration areas ranged from 0.05 ± 0.05 SD nests/km² at Demarcation Bay to 0.22 ± 0.04 SD nests/km² on the Aichilik-Egaksrak-Kongakut deltas (Table 12). In 1984, the Aichilik-Egaksrak Kongakut deltas supported a high of 0.25 nests/km². Nest densities on ANWR concentration areas were similar to other areas on the north slope (Table 12), but were considerably lower than on the Yukon-Kuskokwim Delta, which supports the vast majority of tundra swans in Alaska. During the 3 years of spring surveys a mean of 81.7 ± 17.2 SD nests were found on ANWR (range=66-100).

Reproductive success and output varies considerably from year to year and area to area (Table 12). Mean total cygnet production was higher on the Canning-Tamayariak delta (40.5 cygnets/year) than the Aichilik-Egaksrak Kongakut deltas (37.7 cygnets/year) or the Hulahula-Okpilak delta (26.5 cygnets/year). An average of 129.5 ± 59.53 SD cygnets were produced each year on ANWR from 1981-1985. Production ranged from 42 cygnets in 1982 to 169 cygnets in 1983.

Densities of adult swans on the ANWR study areas were similar to or higher than those in other concentration areas on the north slope (Table 13). The Aichilik-Egaksrak-Kongakut deltas supported the highest density of adults with

Table 12. Mean tundra swan population statistics by area on the Arctic National Wildlife Refuge, 1982-1985.

Location	Area (km ²)	Spring survey 1983-1985				Fall survey 1982-1985				
		No. Nests	Nest density (No./km ²)	No. Adults	Adult density (No./km ²)	No. broods	Brood density (No./km ²)	No. Cygnets	No. Adults	Adult density (No. km ²)
Canning-Tamayariak Delta	227	29.3	0.73	115.7	0.51	16.3	0.07	40.5	106.8	0.47
Hulahula-Okpilak Delta	85	11.7	0.14	39.0	0.46	8.8	0.10	26.5	54.5	0.64
Jago Delta	19	1.7	0.07	7.0	0.37	0.8	0.04	1.8	5.3	0.28
Aichilak-Egaksrak- Kongakut Delta	112	24.7	0.22	118.8	1.06	14.5	0.13	37.8	134.8	1.20
Pingokraluk Point	13	2.0	0.15	5.3	0.41	1.8	0.13	4.8	7.5	0.58
Demarcation Bay	70	3.3	0.05	17.3	0.25	2.0	0.02	5.5	12.3	0.18
All concentration areas	526	73.7	0.14	303.0	0.58	44.0	0.08	116.8	321.2	0.61
Other areas	7174	9.0	0.01	60.7	0.01	6.0	t ^a	12.8	39.5	0.01
All areas	7700	81.7	0.01	363.7	0.05	50.0	0.01	129.5	360.5	0.05

^at Less than 0.01.

Fig.30 Tundra swan concentration areas and general distribution.

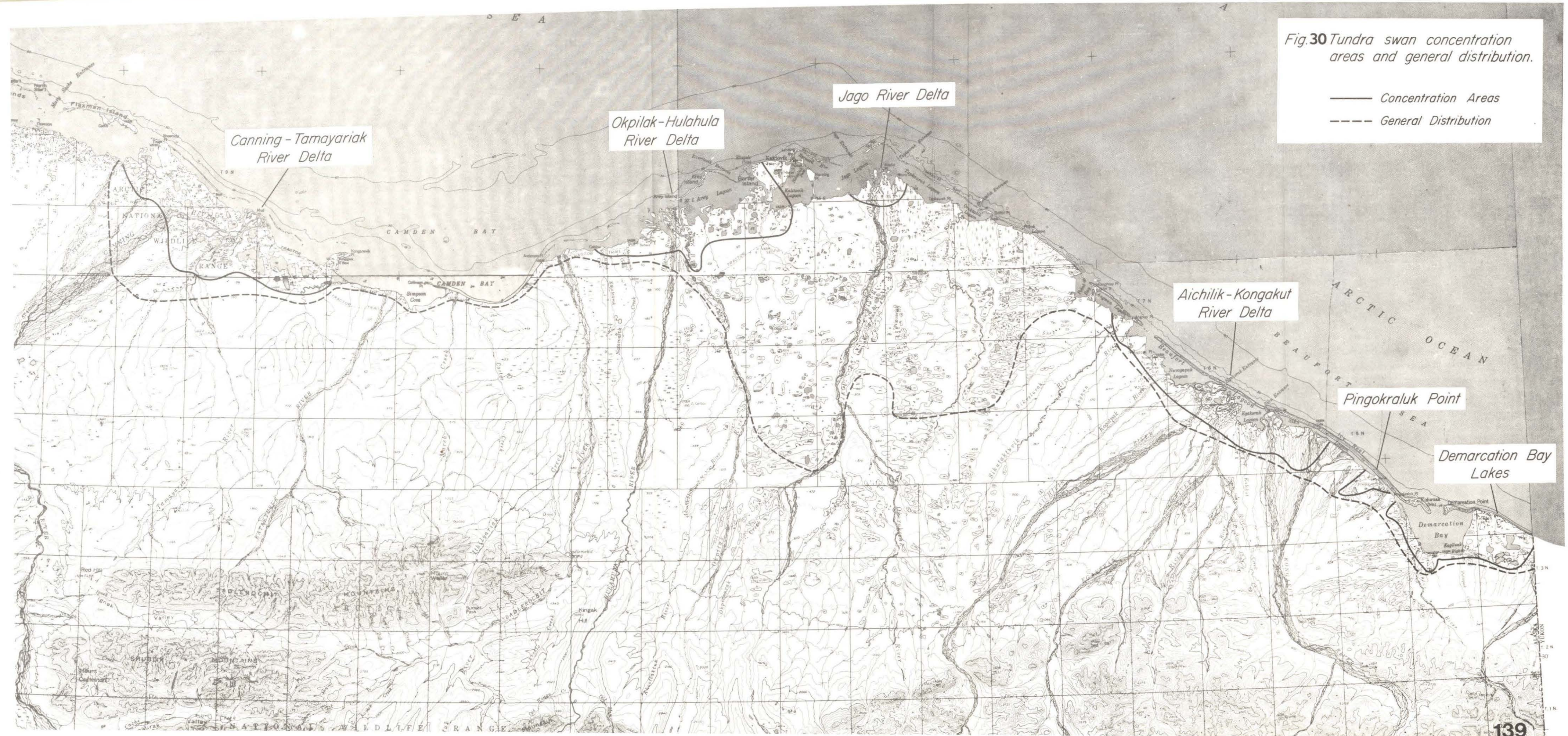


Table 13. Mean densities of adult tundra swans and nests in several Alaskan locations.

Location	Years	Swan density (adults/km ²)	Nest density (nest/km ²)	Reference
ANWR concentration areas ^a	1981-1985	0.45-0.64	0.10-0.17	Platte and Brackney (1986)
Aichilak-Egaksrak ^a Kongakut Deltas	1981-1985	0.63-1.29	0.18-0.25	Platte and Brackney (1986)
Colville Delta ^b	1982-1983	0.51	0.11-0.22	Hawkins (1983)
Sagavanirktok River Delta ^b	1977	0.17	---	Welling and Sladen (1978)
Fish Creek ^b	1977	0.42	---	Welling and Sladen (1978)
Umiat ^b	1977	0.16	---	Welling and Sladen (1978)
East Longlake ^b	1977-1978	0.20	---	Derksen et al. (1981)
Storkerson Point ^b	1977-1978	0.10-0.30	---	Derksen et al. (1981)
Kewatin NWT	1975-1976	0.85	---	McLaren and McLaren (1984)
Kobuk River Delta ^c	1983-1984	0.41-0.47	0.13-0.18	Spindler and Hall (1984)
Selawik NWR, all areas ^d	1983-1984	0.28-0.39	0.09-0.10	Spindler and Hall (1984)
Yukon-Kuskokwim			1.50	Dau (1980)

^a Arctic National Wildlife Refuge.^b Other north slope locations.^c 1983 swan density.^d Selawik National Wildlife Refuge, northwest Alaska coast.

a mean of 1.06 ± 0.38 SD swans/km² in June and 1.20 ± 0.31 SD adult swans/km² in the fall (Table 12). Densities of 0.10 to 0.51 adult swans/km² have been observed at 6 sites on the north slope (Table 13). Mean swan densities (1981-1985) on the 7700 km² ANWR coastal plain (including 526 km² of primary habitat and 7174 km² of unproductive upland habitats) were 0.05 adult swans/km² as compared to 0.08 and 0.12 swans/km² in NPR-A in 1977 and 1978, respectively (King 1979). Overall swan densities on the coastal plain of ANWR are apparently lower than north slope areas farther west. In contrast, densities within the ANWR concentration areas are as high or higher than elsewhere on the north slope.

TRUMPETER SWAN - Rare coastal breeder. R. LeResche (in Kessel and Gibson 1978) observed a pair in late July 1972 at Simpson Cove. Pairs with 3 cygnets were recorded by Canning River (16 September 1973), at Simpson Cove (10 August 1974), and in a pond by Demarcation Bay on 8 August 1974 (Kessel and Gibson 1978).

GREATER WHITE-FRONTED GOOSE - Uncommon to fairly common spring migrant and common fall migrant over coastal plain. Spring migration is primarily westward (Salter et al. 1980), extending from late May to mid-June. Early-season surveys at Canning Delta noted first arrivals on 17 May 1979 and 26 May 1980, and observations occurred until 29 June 1979 and 15 June 1980. First arrival at Beaufort Lagoon was 29 May 1980, and birds were seen fairly regularly throughout the month of June. Small groups were infrequently seen grazing on the tundra at coastal locations in June. A group of 4 pair was involved in courtship display in Moist Sedge habitat at Jago Delta on 6 June 1984. A single pair resided throughout June along lake banks in Flooded habitat at Niguanak in 1985; no attempt at breeding was observed. No observations of greater white-fronted geese on the ANWR coastal plain were made from 2-30 July.

Beginning in mid-August, white-fronted geese were observed in a pronounced eastward migration over the ANWR coastal plain. A total of 10,228 geese migrated past Beaufort Lagoon/Pingokruluk Point in 1980, with peak movements on 29 August (6,334 birds) and 2 September (3,304 birds) (Levison 1980). Between 23 and 30 August 1985, 149 greater white-fronted geese were observed at Jago Delta; the majority were in feeding flocks of less than 30 individuals. However, during the same time period, 3,202 geese migrated over the Niguanak area, about 27 km south of Jago Delta. The majority of greater white-fronted geese apparently moved over the interior coastal plain, at least to the Beaufort Lagoon area, rather than following the shoreline, as brant did. Fall migration at Canning Delta was observed beginning 16 August 1979, and 12 August 1980. In 1979, flocks of 3-325 birds scattered widely across the tundra to graze. Similar observations were made at Niguanak in 1985, with heaviest grazing along lake banks and beaded streams (McWhorter et al. 1986, Brackney unpubl. data). Small areas were stripped of vegetation as birds uprooted Carex plants. Maximum numbers at 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 was apparently completed by 3 September 1980 when the last flock was seen. However, flocks were seen over the Katakturuk delta as late as 14 September 1978 (Spindler 1978c).

SNOW GOOSE - Uncommon spring migrant, rare summer visitor, and abundant fall migrant on coastal plain of ANWR. The major nesting colonies of the western arctic population, with the estimated number of breeding birds, are 165,000 at

Banks Island, Northwest Territories, 3,800 at Anderson River Delta, Northwest Territories, 800 at Kendall Island, Northwest Territories (Krebs 1983), 80 at Sagavanirktok River Delta, Alaska (Johnson et al. 1985), and 60,000 at Wrangell Island, USSR (Welling et al. 1981). Geese from these colonies mix during the winter in the Imperial and Central valleys of California, Rio Grande valley of New Mexico, and the state of Chihuahua in Mexico (Bellrose 1980). On the Alaska north slope, outside of the Sagavanirktok River delta, scattered pairs have been reported breeding irregularly near Meade River, Teshekpuk Lake, East Long Lake, 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. Mid-summer records on ANWR are of lone stragglers or widely scattered flocks grazing on the tundra (Levison 1980, Martin and Moitoret 1981, McWhorter et al. 1986, Schmidt 1970).

Snow geese are first observed during spring migration each year along the Beaufort Sea coastline of ANWR 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 the 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). Snow goose occurrences on ANWR in the spring do not indicate a definite migration toward any one of the major colonies. Observations which include information on direction of movement indicate both westerly and easterly movements (Burgess 1980, Johnson et al. 1975, Martin and Moitoret 1981, Salter et al. 1980, Schmidt 1970, Spindler 1978b). Early arrival dates on and near ANWR have ranged from 13 May to 29 June (Rand 1946, Gavin 1971, Johnson et al. 1975, Martin and Moitoret 1981, Miller et al. 1985, Gollop and Davis 1974b, Spindler 1978b, Burgess 1980, Levison 1980, Robus 1979, Bergman et al. 1977). The peak date of egg-laying on the Anderson River delta colony is about 9 June (Johnson et al. 1975).

Prior to fall migration snow geese from the Banks Island, Anderson Delta, and Kendall Island colonies annually stage on the north slope of ANWR, the Yukon Territory, the MacKenzie River delta Northwest Territories, and the Parry and Bathurst Peninsulas Northwest Territories (Koski 1975, 1977a and b). 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, Spindler 1983, Spindler 1984a, Oates et al. 1985, Oates et al. 1986a, Brackney et al. 1986b). Estimated numbers of snow geese on the entire staging area have fluctuated annually ranging from 163,198-597,000 (Fig. 31). These fluctuations are believed to be caused by annual variation in reproduction and recruitment, although some geese are missed during surveys. On the ANWR study areas the estimates of staging snow geese over 11 years of surveys have ranged from 0 to 325,700 with a mean of $135,992 \pm 112,837$ SD. During 4 of those years more than 190,000 snow geese staged on ANWR.

The chronology of staging also varies annually (Fig. 32). Adult and young geese leave the colony on the Anderson Delta at the end of August (Barry 1967)

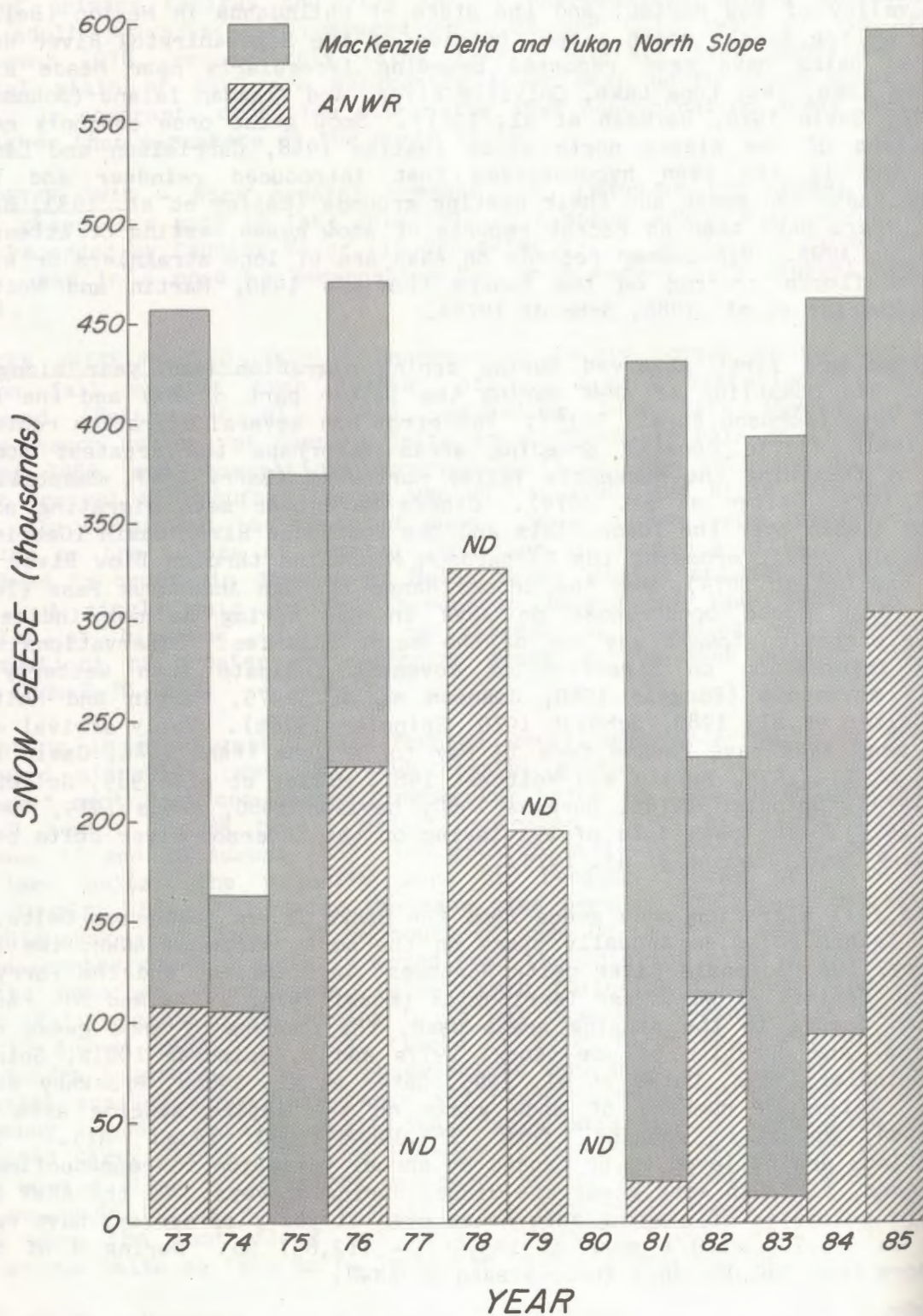


FIG. 31. PEAK NUMBERS OF FALL STAGING SNOW GEESE ON THE ANWR COASTAL PLAIN, THE YUKON NORTH SLOPE, AND THE MACKENZIE DELTA, 1973-1985.

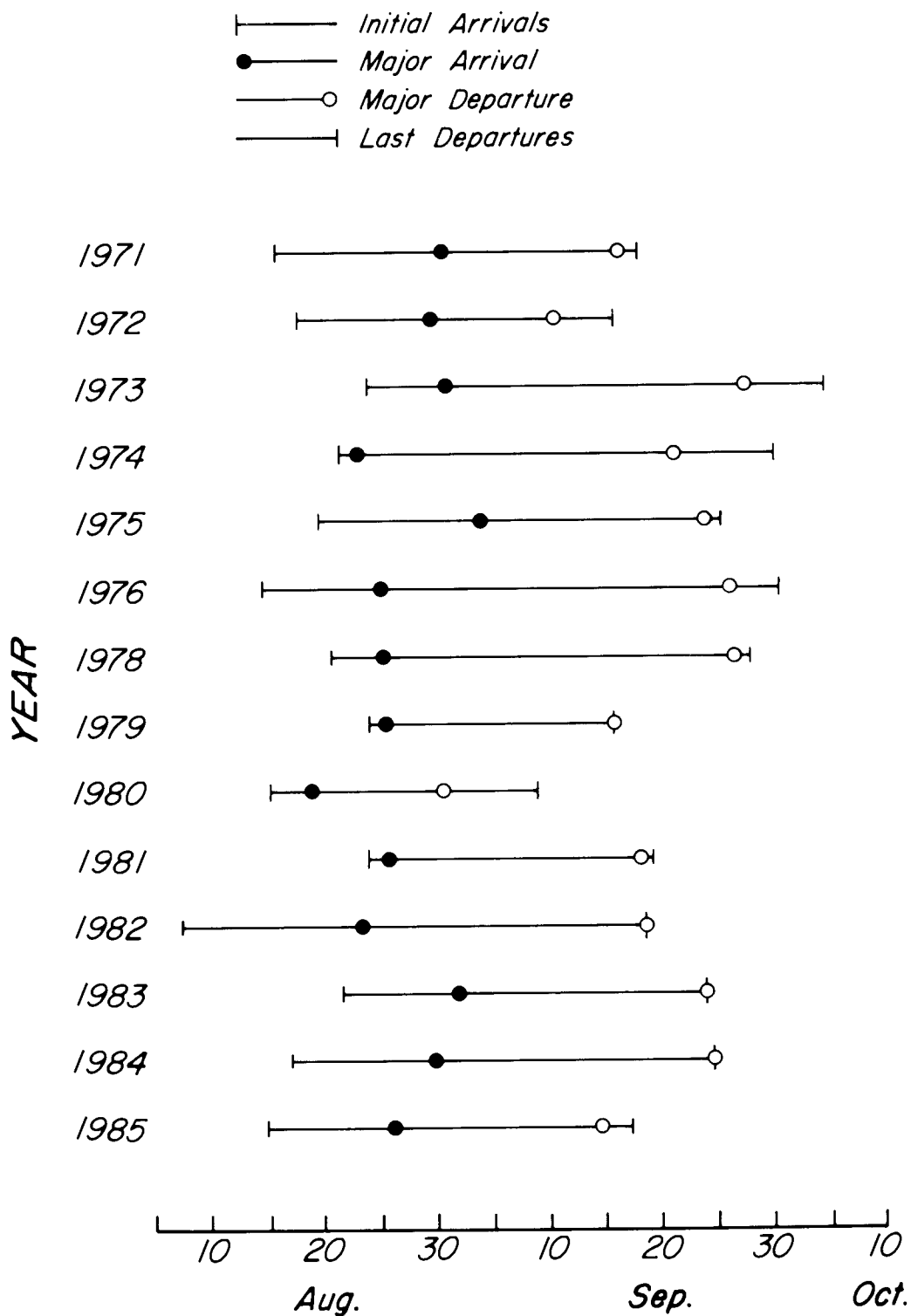


FIG. 32. CHRONOLOGY AND DURATION OF STAGING SNOW GEESE ON THE ANWR COASTAL PLAIN 1971-1985.

and probably leave the Banks Island nesting area at approximately the same time (Johnson et al. 1975). Birds may stop over on the Bathhurst and Parry Peninsulas for up to a week and then move west. During a normal year, the westward movement is followed by a 1 or 2 week period of little movement (Johnson et al. 1975). The timing and magnitude of western movement into or through the Mackenzie River delta, Yukon north slope, and ANWR coastal plain may be influenced by severe weather (Johnson et al. 1975, Koski 1977a, b) or available food resources (Koski 1977a, Brackney et al. 1985a). The dates of the major arrival of snow geese on the ANWR coastal plain from 1971-1985 were 26 August to 1 September, and dates of major departure from the coastal plain were 15-19 September. The first westerly migrating flocks have been sighted between 15 and 24 August, with the earliest major influx of snow geese onto ANWR occurring on 19 August 1980. The latest date of major departure was 27 September 1978, and the latest date snow geese have been seen on the ANWR staging area have ranged from 9 September to 4 October (Fig. 32). A. Thayer (pers. comm.) has reported seeing snow geese as late as mid-October in the early 1970's.

Johnson et al. (1975) concluded that the main departure from the north slope is gradual and occurs just ahead of freezing weather. Deep snow cover, which hampers feeding activity, may cause a sudden departure (T. Barry pers. comm.). Koski (1977b) suggested that snow geese remain on the staging area long enough to accumulate sufficient energy reserves, respective of the weather conditions.

Estimations of age-ratios were used as indicators of population productivity. Percent young observed varied annually from 0.1% juvenile birds in 1974 to over 54% juvenile birds in 1973 and 1975 (Fig. 33). Productivity of the western arctic snow goose populations is affected significantly by inclement June weather (Barry 1967). Percent young also varied spatially on the staging grounds. Samples including the Mackenzie Delta area have a tendency to yield higher percentages of juvenile birds than do samples including only the Alaska and Yukon north slopes (Spindler 1983). This pattern would be expected if fewer family groups migrate as far west as subadults or adults which failed in their attempts to nest.

The distribution of fall staging snow geese has been extremely variable for the years that data are available, 1973-1976 and 1978-1985 (Fig. 34, 35, 36, 37). In 1974, 1976, 1978, 1979, 1984, and 1985, snow geese staged over a wide 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. In other years staging 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 1977 no snow goose surveys were conducted. In 1975 and 1980 much of the population had apparently staged on the Yukon north slope. In 1981, the distribution of 20,000 snow geese on ANWR was fairly widespread, although approximately half the geese staged north of the 305 m contour line between the upper Aichilik and Okerokovik Rivers. During the fall of 1982, the area between the upper Aichilik and Okerokovik Rivers again received the most concentrated and longest duration of use. In 1983, only 11,000-14,000 geese staged on ANWR, and these were dispersed over much of the coastal plain. In 1984, the concentration areas were between the Jago and Okerokovik Rivers, in the Jago Bitty and Pilak hills area, and along the upper and lower Aichilik River. The heaviest concentrations in 1985 (102,000 geese) occurred in the foothills between the Aichilik and Okpilak Rivers.

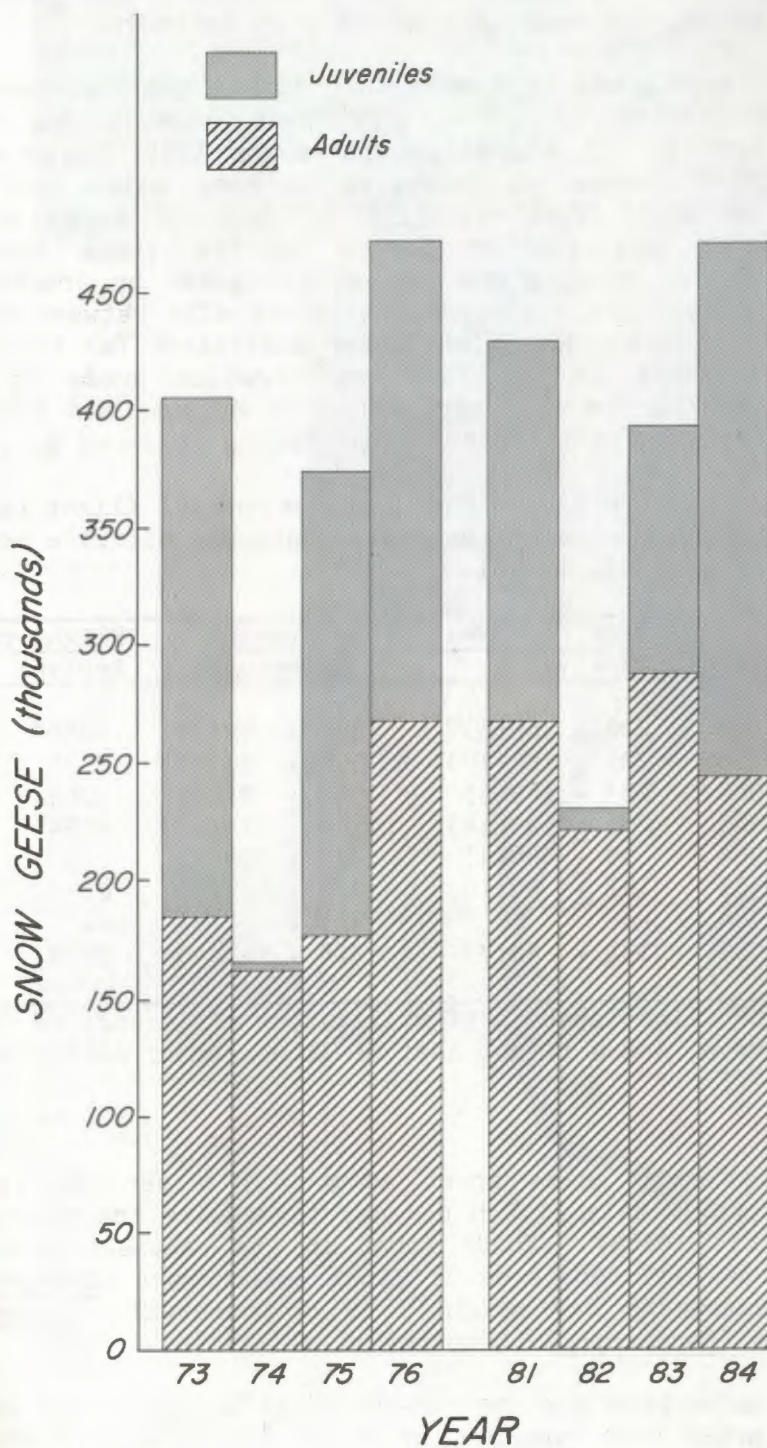


FIG. 33. ANNUAL VARIATION IN THE PROPORTION OF JUVENILE SNOW GEESE ON THE NORTH SLOPE AND MACKENZIE DELTA, 1973-1984.

Specific and consistently used "core" staging areas could not be precisely defined. The extreme annual variation in the numbers of snow geese on the ANWR coastal plain (Fig. 31) resulted in large annual changes in intensity and use of specific areas. No area was used at a consistently higher intensity (Fig. 38) or contained a consistently higher proportion of the population each year (Brackney et al. 1986b) although the inland areas between the Aichilik and Hulahula Rivers north of the 305 m contour contained birds in all years. The area between the upper Aichilik and the Okpilak Rivers was the most consistently used by geese, but densities were highly variable.

Staging activities of snow geese on the eastern Alaska and Yukon north slopes involve resting and feeding to allow sufficient accumulation of energy reserves for completion of fall migration (Patterson 1974, Davis and Wisely 1974). Patterson (1974) documented increases in body weights of 14.3% in adult males, 17.1% in adult females, 9.5% in juvenile males and 23% in juvenile females during the staging period on the Yukon north slope. Whole-body fat reserves of staging snow geese collected by Brackney et al. (1986b) on the ANWR coastal plain increased substantially between arrival and departure (Table 14). Incoming juveniles lacked sufficient fat reserves for a 2100-2400 km nonstop flight to the fall concentration areas in southeast Alberta (Table 14). Similar results were found by Wypkema and Ankney (1979) for snow geese of the eastern arctic population staging at James Bay, Ontario.

Table 14. Body fat reserves (g dry weight) and theoretical flight range of fall staging snow geese on the Arctic National Wildlife Refuge (from Brackney et al. 1986b).

Sex	Year	Fat reserves during staging		Flight range (km)	
		Arrival	Departure	Arrival	Departure
Adult males	1984	226 \pm 64(6) ^b	653 \pm 42(3)	3240 ^a	7699
	1985	239 \pm 102(10)	594 \pm 93(14)	3338	7559
Adult females	1984	243 \pm 179(3)	587 \pm 21(3)	3268	7335
	1985	251 \pm 125(14)	559 \pm 119(10)	3554	7726
Juvenile males	1984	99 \pm 46(4)	412 \pm 101(7)	1297	5899
	1985	141 \pm 56(10)	320 \pm 127(7)	2075	4560
Juvenile females	1984	--	411 \pm 71(6)	--	5746
	1985	131 \pm 40(7)	316 \pm 121(4)	2074	4904

^a Based on a 70 km/hr flight speed, 80% utilization efficiency of fat, 2% minimum fat reserve, and a flight cost of 11.0 x basal metabolic rate.

^b Mean \pm SD (n).

In 1984-1985, staging adult geese spent about 8.3 h per day feeding and juvenile geese fed approximately 11.7 h per day to acquire the observed energy intake (Brackney et al. 1986b). Foods found in the esophageous of 74 snow geese collected in 1984-1985 consisted of 72.4% cottongrass (Eriophorum spp.) tubers and shoots (aggregate dry weight), 15.4% horsetail (Equisetum spp.) shoots, and 7.0% sedge (Carex spp.) (Brackney et al. 1986b).

Spindler (1978b) characterized the vegetation types within areas utilized by geese in 1978. The areas were composed of moist tussock--dwarf shrub tundra with lesser amounts of wet sedge and moist sedge tundra. The areas utilized

Fig.34 Distribution of fall staging snow geese.




—— 1973 
 ---- 1974 
 1976 



Fig.35 Distribution of fall staging snow geese.

—— 1978 
 ---- 1979 

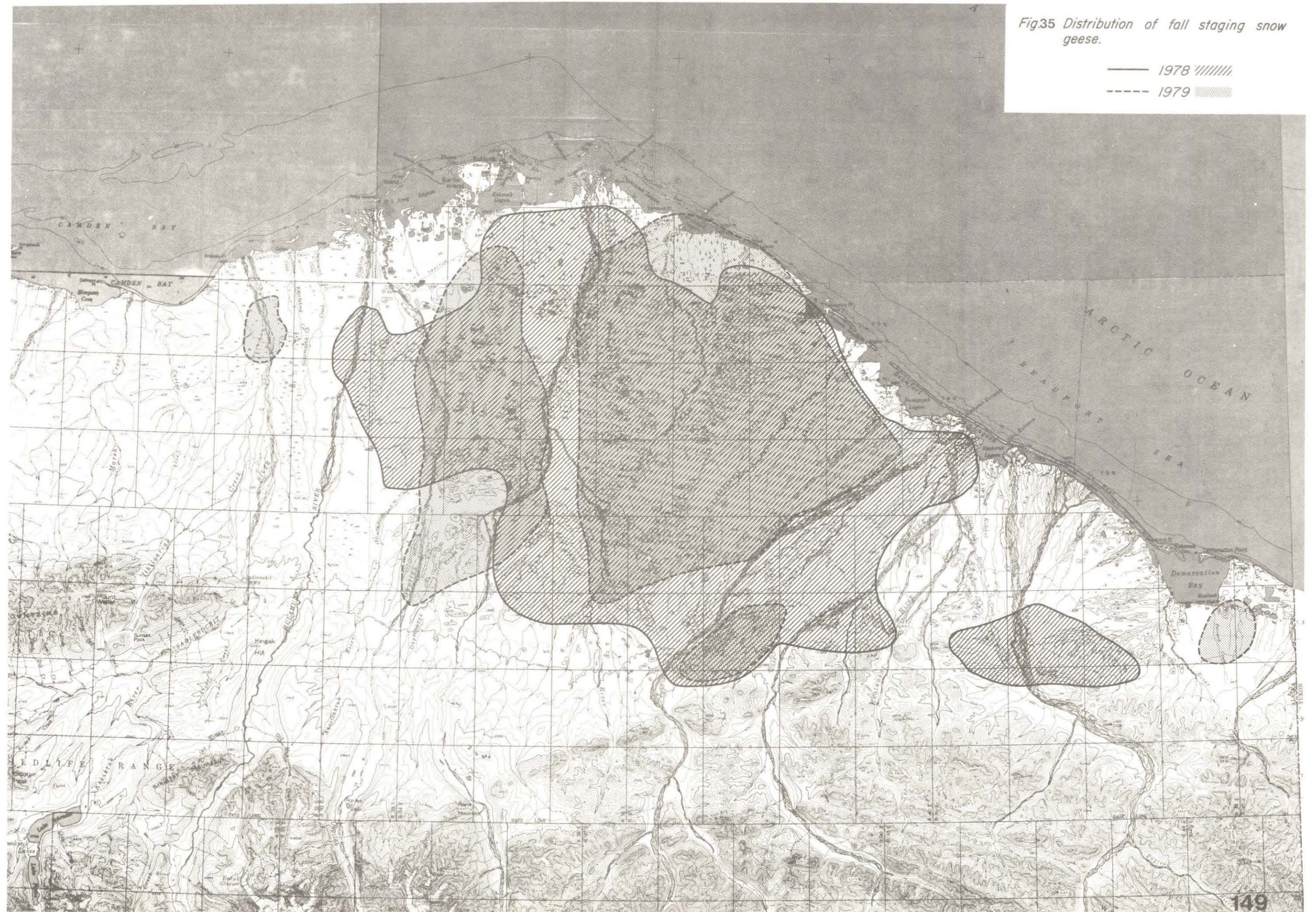


Fig.36 Distribution of fall staging snow geese.

—— 1981 // 1981
- - - 1982 // 1982
..... 1983 // 1983

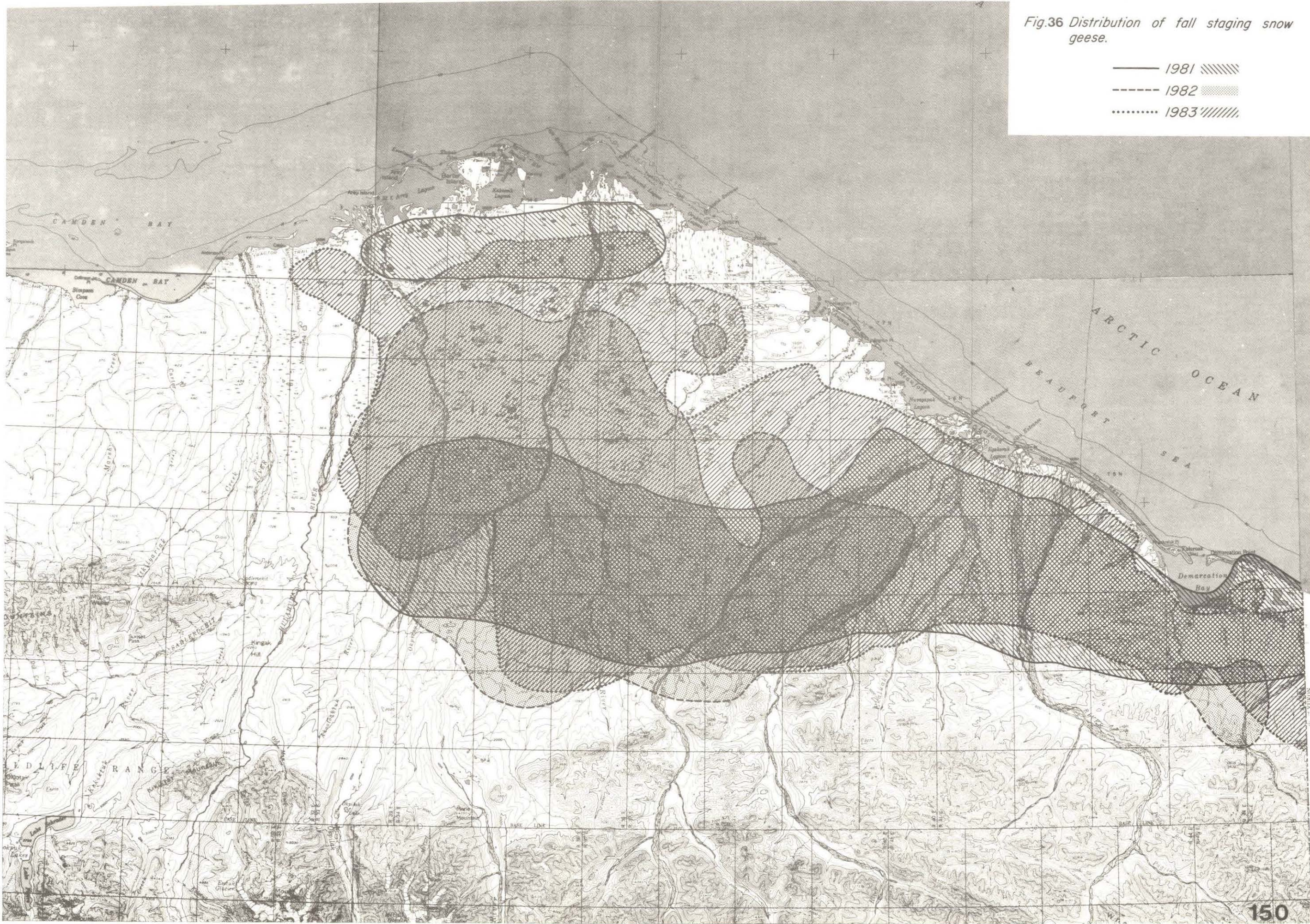


Fig37 Distribution of fall staging snow geese.

----- 1984
 ——— 1985

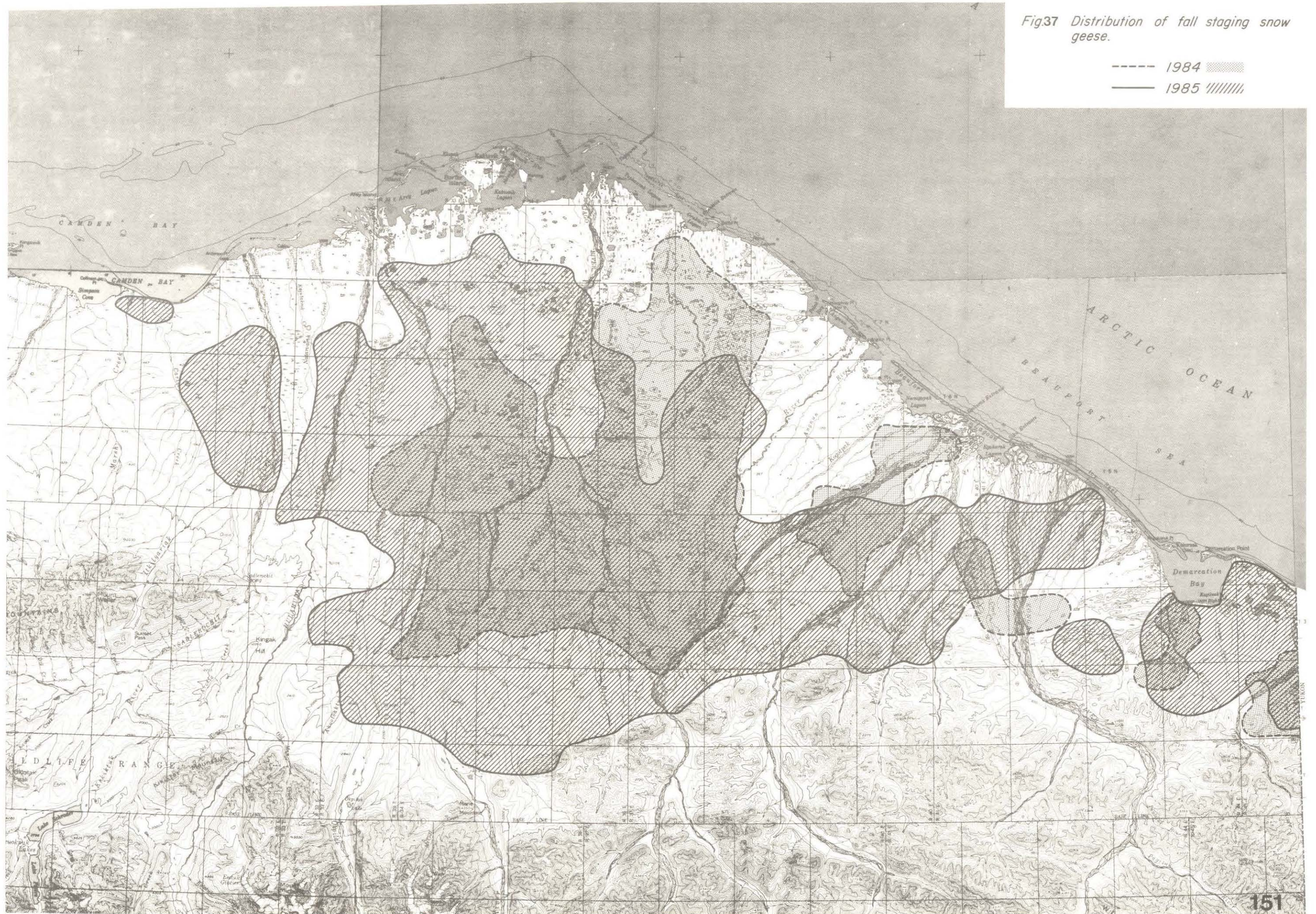
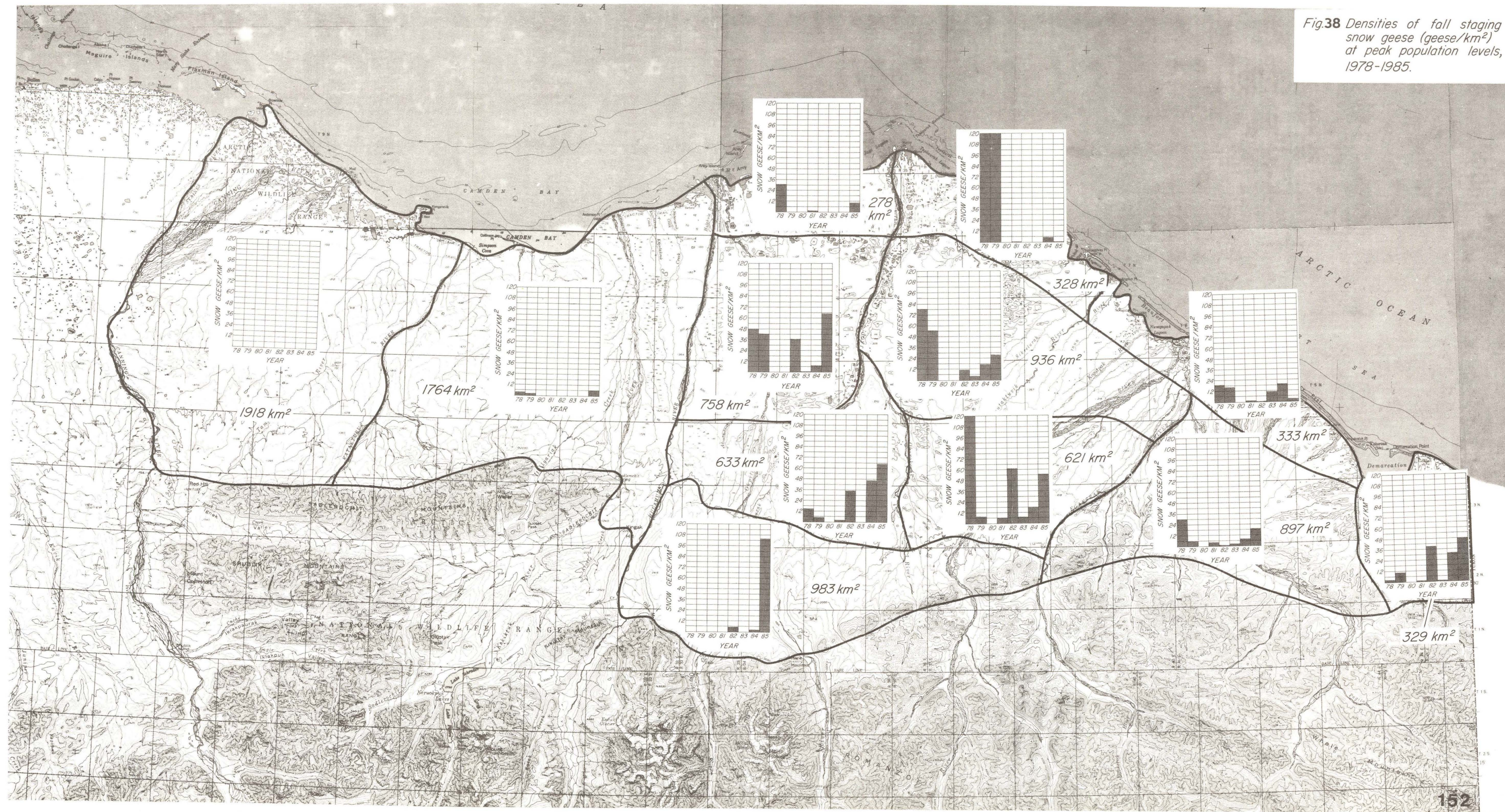


Fig.38 Densities of fall staging snow geese (geese/km²) at peak population levels, 1978-1985.



in years of more widespread staging have included additional areas of homogeneous wet sedge tundra, flooded sedge tundra, and tussock tundra. Within these areas the birds have been observed feeding primarily in low center polygon centers, isolated wet sedge areas, or along the edge of permafrost scar pits in upland tussock habitats (Brackney et al. 1986b). Staging geese use lakes as night roosts and thus their distribution may be limited by the availability of roosting lakes (Brackney et al. 1986b), or other suitable roosting sites.

Because feeding snow geese consume the root stocks and lower stems of cottongrass, they destroy the entire plant (Brackney et al. 1985a). The low biomass production in the arctic (Cargill and Jeffries 1984) and the high variability in annual reuse of areas by geese suggests that food resources are not renewable on an annual bases. Brackney et al. (1986b) hypothesized that reuse of feeding locations were on a multiyear cycle due to the extensive removal of cottongrass in years of high feeding intensity and duration, and the slow recovery of the vegetation. Therefore, habitat needs of the population for pre-migratory staging may be greater than the amount used in any given year.

ROSS' GOOSE - Casual spring migrant. One individual was observed on 13 June 1980 at the Canning Delta.

BRANT - Uncommon breeder in coastal plain basin-complex wetlands, locally abundant migrant along Beaufort Sea coast. Spring migration was eastward and peaked in the last week of May and the first week of June. At the Okpilak Delta in 1978, peak spring movement of about 10,000 birds was 4-6 June. Upon arrival at Okpilak on 6 June 1982, flocks totaling 680 were counted, and on 7 June 1300 brant flew over the area. In 1985, large flocks of brant moved eastward between 2 and 11 June. In 1980 at Beaufort Lagoon, Levison (1980) 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. Spring migration was noted at Jago Delta during early June 1984-1985. Flock size averaged about 70, and ranged between 4 and 250 in 1984. During spring migration along the ANWR coast, brant usually followed lagoon shorelines and cut across points of land, sometimes 1-5 km inland. The tendency for brant to use the lagoon shorelines in spring may be related to their use of the saline coastal vegetated mudflats which were usually located on gradually sloping lagoon shorelines (Nodler 1977). Brant were observed using these vegetated mudflats in early to mid-June near the Okpilak Delta where they grazed on Puccinellia phryganoides and Carex subspathacea. These mudflats may be critical to brant during spring migration since there are often limited amounts of snow-free vegetation at this time.

On ANWR, brant nested on islands and peninsulas within basin-complex and flooded tundra wetlands. Brant were found breeding on the ANWR coastal plain in a small colony of 15 pairs at the Okpilak Delta in 1978, and broods were seen at Beaufort Lagoon in 1970 (Schmidt 1970), and at Canning Delta in 1979 and 1980. Brant were not known to breed on the Okpilak Delta in 1982, although 1 nest was found in 1983, and a small colony of 6 nests was found during early to mid-June 1985 with an average clutch of 4.6 eggs. All eggs apparently hatched between 25 June and 3 July, and no broods were observed. The precocial young are usually led to the shore by the adults (Harrison 1978). A single brant nest was found on 4 July 1984 at Jago Delta on a small mossy island surrounded by Arctophila at the edge of a deep lake. The nest

was abandoned on 11 July; the remains of 3 eggs broken at 1 end indicated predation by glaucous gulls or parasitic jaegers, species that were present in the area when the nest was first visited.

Fall migration past Beaufort Lagoon began on 22 August 1970 (Schmidt 1970) and 14 August 1980 (Levison 1980). Peaks of fall migration in 1980 occurred 26, 29, 30, 31 August, and 1-3 September. A total of 28,863 brant were counted migrating west past Pingokruluk Point during the 1980 fall migration watch, with 16,452 others being counted on 1 September (Levison 1980). This is the highest actual count made on ANWR. Fall migration past Canning Delta was first observed on 17 August 1979 and 18 August 1980. Duration of the migration in both years was about 3 weeks. The peak of the fall migration in 1979 was from 24-26 August, but in 1980 it was delayed by strong westerly winds until 10 September. In both years at Canning Delta, fall migration tended to be more evenly spread through time than the spring migration. The total count of brant passing Canning Delta in 1979 was 24,627, nearly double the previous eastern Beaufort Sea coastal fall count of 14,806 made by Schweinsburg (1974) on 25 August-6 September at Nunalak Spit, Yukon Territory and nearly equals the estimated total of 26,000 observed during spring migration along the Yukon coast (Richardson and Johnson 1981). Large flocks migrated westward along the Jago Delta coastline in late August, with the largest movements noted on 23 August 1985. Flock size often ranged from 25 to 50, but some exceeded 450 individuals. Lagoon surveys conducted between 16-22 August 1982, 1983, and 1984 estimated an average of 1226 geese that was comprised largely of brant (see Fig. 29). Brant migrate in spring and fall along or close to the coast from the Mackenzie River west to about Cape Halkett.

CANADA GOOSE - Uncommon breeder in coastal river deltas and drained-basin wetlands; uncommon to fairly common migrant on coastal plain. The species migrates in low numbers into the area in spring from the east and departs in the fall to the east (Salter et al. 1980). Reported arrival dates were 27 May 1979 and 20 May 1980 at Canning Delta; 16 May 1979 at Sadlerochit (Robus 1979), 4 June 1978 at Okpilak Delta, and 6 June 1980 at Beaufort Lagoon (Levison 1980). On the ANWR study area, nesting was observed on islands in basin-complex wetlands surrounded by deep water. Incubation was initiated on 12 June 1979 at Canning Delta; the first brood was observed on 5 July 1979. Nesting density was estimated at 0.25 nests/km² in 1979 and 0.30 nests/km² in 1980 in the few areas in which nests were found. Successful nesting at Jago Delta was confirmed by the presence of 5 goslings with adults in Flooded habitat, on 7 July 1984, and by a sighting of young with a flock on 19 July 1985. One nest was found at Okpilak on 11 June 1985 which was being incubated. The nest contained 6 eggs on 25 June, 4 eggs on 30 June, and was noted empty on 8 July 1985. At Canning Delta, adults with broods moved to large lakes and salt water in lagoons shortly after the hatch.

Following the breeding season a molt migration to the west was apparent in late June-early July as non-breeders and failed breeders vacated tundra habitats and were seen migrating west, probably to Teshekpuk Lake (Derksen et al. 1981, Martin and Moitoret 1981). Some birds which do not reach Teshekpuk Lake before losing flight may spend 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. On 7 August 1985, 30-50 individuals foraged in Moist Sedge-Shrub habitat on the Okpilak River Delta. Eastward fall migration began mid-August and lasted until the end of

the month. Over 20 Canada Geese with at least 4 full grown goslings were observed at Jago Delta on 27 August 1985.

GREEN-WINGED TEAL - Uncommon breeder inland; rare coastal breeder. The earliest observation on the ANWR study area was of a pair at Sadlerochit Springs on 22 May 1979 (Robus 1979). Green-winged teal were usually recorded as singles, pairs, or infrequently as small flocks (up to 16 individuals) mostly in June. Ten adults, including at least 3 pair with broods of up to 8 young were observed in a wet, mossy riparian area at the base of the Sadlerochit Mountains south of the Katakturuk camp, on 20 July 1983. One female and 5 young were seen on 12 August 1985 on the river at Marsh Creek. Schmidt (1970) found a nest near Beaufort Lagoon, and a female was flushed from a nest in Mosaic habitat at Okpilak on 11 June 1985. Late-summer observations were uncommon: 1 individual at Aichilik on 13 August 1985, and 1 bird at Niguanak on 27 August 1985.

MALLARD - Uncommon migrant, rare breeder. Small groups of 1-3 mallards were infrequently observed in Flooded or Riparian habitats during late May and early June primarily at the ANWR coastal study sites. The only breeding observation for mallards on the ANWR coastal plain was made at a large lake 11.5 km southeast of the Jago Bitty camp. On 2 July 1983, 4 pairs were noted at the lake, followed by a sighting of 8 adults and 10 ducklings on 25 July. Levison (1980) observed mallards in groups of 1-15 birds on 8, 9, and 15 August 1980 near Beaufort Lagoon. On 12 August 1985, a group of 12 flew east over Sadlerochit and 2 individuals were noted on the river at Jago Delta.

NORTHERN PINTAIL - Common migrant and summer resident, fairly common breeder. 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 occurred in late-May to early-June. Open water at river delta mouths in late May-early June usually attracted the first pintails until open water became available in wetland basin complexes during the first or second week of June. Pintails were the most common dabbling using tundra habitats on the ANWR coastal plain. They were observed daily in a diversity of habitats at several locations. Average densities during the reproductive season (June to mid-July) were highest in Flooded and Mosaic habitats, with 5.3 and 4.6 birds/km², respectively. Both densities were lower than studies at Prudhoe Bay and sites west of ANWR (Derksen et al. 1981).

Population levels and breeding efforts fluctuated widely on the north slope, apparently increasing when drought conditions on the North American prairie potholes occurred (Derksen and Eldridge 1980). Northern pintails nested in all habitats except Tussock, but were most common in Mosaic (1.5 nests/km²) and

Riparian (1.0 nests/km²). Clutch size ranged from 6 to 8, and nest sites were commonly in protected microsites near ponds, lakes, or small river channels. Hatch dates extended from 30 June through mid-July, and females attended broods on small ponds.

The ANWR coastal plain also provided molting and staging habitat in the form of basin-complex, beaded stream, and Flooded tundra wetlands. In early July (8 July 1978) flocks as large as 23 birds were observed at Okpilak Delta. In mid-to-late July, birds undergoing wing molt were observed in Flooded

Arctophila and Carex habitats. Wetlands with extensive Arctophila were used by molting pintails on the Canning Delta. The average pintail density in Flooded habitat increased to 12.7 birds/km² during the post-reproductive period (mid-July through August), while densities in other habitats remained constant or decreased.

Eastward fall migration began in early August. At Beaufort Lagoon, Levison (1980) 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. Peak migration of pintails from the north slope occurred on 14 August 1980, when over 900 birds were counted flying east at Canning Delta. Major fall migration past Canning Delta ended by 20 August 1980. During late August 1985, small flocks of 5-25 individuals (mostly juveniles) were observed on coastal lagoons and nearshore waters at Jago Delta. Small flocks of up to 30 birds were seen as late as 2 September 1980 at Brownlow Lagoon.

NORTHERN SHOVELER - Rare migrant and summer visitant. The earliest observed date on ANWR was 22 May 1979, when a pair was seen at Sadlerochit Springs (Robus 1979). Additional pairs of shovelers were observed in Flooded habitat during early June at Jago Delta in 1984 and 1985, and at Okpilak delta in 1985. Schmidt (1970) reported a drake at the Aichilik River delta on 24 June 1970. From 1 to 3 individuals were seen on 4 occasions on 22 June 1979 at Demarcation Point (Burgess 1980). At Canning Delta, the species was not recorded in 1979, but was seen fairly regularly in 1980, when 1 to 4 birds were observed on 10 dates from 7 June through 14 August, and a few shovelers probably molted in the area using dense Arctophila beds for cover during the molt.

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

AMERICAN WIGEON - Uncommon to fairly common migrant. The earliest observations during spring migration were on 22 May 1979 in the interior coastal plain at Sadlerochit Springs (Robus 1979), where open water most of the winter provided an attractant for early-arriving waterbirds (Spindler 1979b). On the coast, American wigeons arrive in the last few days of May (25 May 1979) at Demarcation Point (Burgess 1980) and 29 May 1980 at Canning Delta. Observations of singles, pairs, and flocks of wigeons were frequent through June along coastal lagoons and deltas. Schmidt (1970) recorded 3 flocks in the Beaufort Lagoon area, with a maximum of 50 seen on 24 June 1970. No birds were seen in July, and only 2 flocks were observed flying east over Canning Delta on 19 August 1980.

GREATER SCAUP - Uncommon to fairly common coastal migrant; locally rare to uncommon summer visitant. Greater scaup were seen regularly along the coast during spring migration. Earliest observation was 1 June 1985 at Sadlerochit Lagoon. Sightings through June were fairly common of single birds and flocks swimming and feeding in lagoons with oldsquaw and scoters. A flock of 50 scaup in a raft of scoters was noted at Aichilik River delta during the last week of June 1970 (Andersson 1973). Pairs and small flocks of up to 10 were also observed in ponds and Flooded habitat near the coast. Two drakes and a hen remained in a small, drained-basin wetland at Okpilak delta from 11-29 June in 1978. A single inland sighting was made of a scaup which flushed from tall willows in Riparian habitat near Jago Bitty camp on 10 June 1983.

Observations of greater scaup during July and August were predominantly in eastern coastal lagoons and at Canning Delta, where flocks of up to 5 were observed almost weekly from 6 June through 21 August in 1979 and 1980. Dates of peak scaup numbers observed in lagoons during aerial surveys varied considerably from 1981-1985. A maximum of 46 were recorded on 25 July 1982 (all at Jago Lagoon) and 82 were observed along a 400 m wide coastal transect on 24 August 1981. Forty scaup spp. were observed at Demarcation Bay on 6 September 1983, the latest observation date on the ANWR coastal plain.

LESSER SCAUP. Rare inland breeder; rare summer visitant to coastal plain. Lesser scaup are abundant breeders on south slope and commonly breed in Brooks Range, but are rarely observed on the arctic coastal plain. The earliest sighting on ANWR occurred on 11 June 1984 when a single bird was seen in Flooded habitat at Jago Delta. In 1983, 2 lesser scaup were observed in a pond 11.5 km south of Jago Bitty camp on 2 July, and later in season, an adult with a brood of 6 chicks were seen in a pond 1.6 km east of Marie Mountain.

COMMON EIDER - Uncommon breeder in coastal wetlands and on barrier islands; fairly common migrant and summer resident along ANWR Beaufort Sea coast. Barry (1974) estimated that over a 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. It is possible that common eiders occasionally winter in leads and polynyas 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). The first spring observations on ANWR were 1 May 1980 (Spindler 1980) and 27-31 May 1980 (Martin and Moitoret 1981). 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, Northwest Territories in late-May to mid-June (Barry 1974). Following spring migration, small numbers were seen on the tundra on the Okpilak River delta in mid-June 1978 (Spindler 1978b) and on open water in coastal lagoons and the Beaufort Sea near Canning Delta in June 1979-80.

Initiation of 9 nests at Canning Delta in 1979-1980 occurred during the last 2 weeks of June and the first few days of July. Divoky (1978a) found the following number of nests in 1975 and 1976: Konganevik Point Island (8), Arey Island (1), 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 tundra at Okpilak was estimated to be 0.04 nests/km². At Canning Delta 1980 the first broods were seen on 17 July 1980. Only 5 broods were seen off Brownlow Point in mid-to-late August 1979 despite intensive weekly shoreline surveys. An eider nest was discovered on the bank of the Sadlerochit River 1 km inland from coast in 1984 and 1985.

The earliest documentation of westerly migration of non-breeding eiders is mid-June. 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 present on 27-30 June 1979, and 200 eiders were observed in an open lead off Brownlow Point on 10 July 1979. Comparable use of the Brownlow Point area by eiders was not seen in 1980.

In both 1979 and 1981 a major westward movement of eiders, of which at least 90% were male common eiders, was noted passing Canning Delta from the end of July to 10 August. Peak movement was on 28 July 1980, when more than 500 birds/h were counted; in 1979 peak movement of 150 birds/h was noted on 21 July. By contrast Johnson and Richardson (1981) reported about 35 common eiders/h migrating west past Pingok Island on 20-25 July 1977, at which time 157 king eiders/h were reported flying west. During the molt migration Johnson and Richardson (1981) estimated 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 nearshore waters of ANWR (Spindler 1979a, Bartels and Zellhoefer 1983). Eider numbers (not identified by species) averaged 351-373 birds in lagoons and on the offshore transect in late July through early August 1981-85. Mean numbers showed a downward trend through August and rose slightly in September. At Simpson Lagoon, eider densities offshore in the Beaufort Sea peaked at 1.5 eiders/km² on 28 and 29 July 1977. Along the south shore of the barrier islands, densities peaked at 1.6 eiders/km² on 28 to 29 July 1979 (Johnson and Richardson 1981). Densities along the shoreline and mainland varied from 0 to 1.2 and 0 to 1.8 eiders/km², and eiders were not seen in mid-lagoon waters (Johnson and Richardson 1981).

Fall migration of common eiders is largely a movement of female and juvenile eiders, since the majority of males departed during the earlier molt migration (Thompson and Person 1963). At Brownlow Point, small numbers migrated west between 14-31 August 1979, most of which were females and juveniles. Fewer total numbers of eiders were seen passing Brownlow Point between 19 August and 1 September 1980, but a peak rate of 45 eiders was observed on 1 September. By comparison, Johnson and Richardson (1981) counted a peak rate of 47 birds/day between 21 August and 22 September 1977 and 135 birds/day in 1978 at Simpson Lagoon. They observed eiders in Harrison Bay as late as 22-23 September 1977-1979. Common eiders were observed on lagoon and nearshore transects along the ANWR coast as late as 9-10 September 1980 (Spindler 1981b) and 20 September 1981 (Spindler 1981b). Observations by Bartels (1973), Watson and Divoky (1974), and Divoky (1978a) indicate that migration often occurs 13-16 km offshore in the Beaufort Sea, and may not be detected by observers along the shore.

KING EIDER - Uncommon breeder in coastal 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). 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) suggested that they probably arrive in offshore leads and polynyas 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). Arrival dates for king eiders on the ANWR and nearby areas were 14 May through 7 June (Brooks 1915, Dixon 1943, Johnson et al. 1975, Spindler 1978b, Martin and Moitoret 1981). At the Canning Delta eastward migration was not detected; 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 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.

Data on 7 nests at Canning Delta (1979-1980), 3 nests at Okpilak (1983), and 1 nest at Niguanak (1985) indicated that egg laying began during the second week of June. Nest sites ranged from wet tundra with pools nearby, to mesic tundra with shallow-*Carex* ponds, and the deep-*Arctophila* portions of Flooded habitat. To the west of ANWR, at Storkerson Point, they were more common nesters in similar Flooded habitats (Bergman et al. 1977). Female adults with chicks were observed in Flooded tundra ponds at Jago Delta and at Niguanak through July in 1985.

A molt migration was not evident past Canning Delta in either 1979 or 1980, although, a few males were seen flying west on 1 August 1980. 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 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). Barry reported over 1 million king and common eiders migrating westward past the Mackenzie River delta. 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). Eider numbers (both species) estimated from lagoon surveys from 1982-1985 showed a steady decline (Fig. 29c) from a late July mean of 351 to 23 in late August and an increase to 206 in September.

SPECTACLED EIDER - Uncommon breeder in coastal wetlands. The species was observed arriving at Canning Delta on 1 June 1979 and 5 June 1980, and at Demarcation Bay on 12 June and 26 June (Burgess 1980). 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. Levison (1980) observed 2 birds off shore of the barrier island at Beaufort Lagoon on 24 July 1980, and Brooks (1915) collected 5 at Humphrey 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 (Burgess 1980) and 2 pairs were observed foraging in Flooded tundra during mid-June at Okpilak in 1982. Egg-laying is reported to commence on the north slope during the second week in June

(Gabrielson and Lincoln 1959, Andersson 1973), although an incomplete clutch was first discovered on 19 June at Okpilak in 1985. At Canning Delta, 3 broods were located in 1979, the first of which was seen on 28 July, only 1 brood was found at Canning Delta in 1980. One brood was observed at Okpilak on 16 July 1985. Females with broods used shallow-Carex and deep-Arctophila wetlands in Flooded habitat. Johnson et al. (1975) reported that spectacled eiders preferred coastal areas with shallow, muddy water. Following the onset of incubation, departure of males from the Beaufort Sea nesting areas was reported by Gabrielson and Lincoln (1959). Three males and 1 female at Angun Point on 1 September were the only fall records for the species on ANWR (Schmidt 1970).

STELLER'S EIDER - Rare breeder and summer resident on coastal barrier islands, lagoons, 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 (Myers 1958). East of Barrow the species decreases in abundance and regularity of breeding (Gavin 1970 and 1971, Watson and Divoky 1974). Several birds, believed to be nesting locally, were observed at Humphrey Point on 13 June 1914 (Dixon 1943). 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.

HARLEQUIN DUCK - Uncommon summer visitant and rare breeder along rivers in of inland coastal plain. Date of earliest observation on ANWR was 21 May 1979 at Sadlerochit Springs (Robus 1979). June records include several pairs, or single males and females at Sadlerochit Springs (1978, 1979, Robus 1979), Katakturuk (1982, 1983, 1985), Aichilik (1984), Jago Bitty (1985), and Marsh Creek (1985). Repeated observations of a pair swimming on the river were recorded from 12-29 June 1983 at Katakturuk and from 9-20 June at Jago Bitty in 1985. No harlequin duck nests were discovered on the coastal plain, but a hen with 5 ducklings was seen swimming in Marsh Creek on 12 August 1985. Five immature harlequins were subsequently observed in the river on 3 more occasions in August.

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 nearshore waters (Bartels and Zellhoefer 1983, Bartels and Doyle 1984b, Brackney et al. 1985c, Brackney et al. 1986a). The abundance of oldsquaw has prompted intensive study as a key species on the north slope (Johnson and Richardson 1981, Brackney and Platte 1986, Taylor 1986).

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 ranged from 22 May to 1 June (Johnson et al. 1975, Levison 1980, Martin and Moitoret 1981). 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/h (Martin and Moitoret 1981). In general, spring

movements of oldsquaw past the Canning Delta were generally not as intense as the fall movements in 1980 (Martin and Moitoret 1981). Richardson and Johnson (1981) estimated the spring movement past Oliktok, near Prudhoe Bay, at 178.3 birds/h from systematic radar and visual watches during 2-10 June 1977. 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.

Oldsquaw were observed using river delta overflow waters as soon as they became available (31 May-1 June) on the Canning Delta in 1979-1980 (Martin and Moitoret 1981). The earliest observation of oldsquaw using tundra wetlands on ANWR is 7-10 June (Spindler 1978a, Martin and Moitoret 1981). Habitat use by oldsquaw on the tundra is a reflection of the preferences of the highly territorial breeding adults (Alison 1975, Derksen et al. 1981). During the breeding season on NPR-A, oldsquaw prefer deep Arctophila ponds (Class IV wetlands of Bergman et al. 1977), deep open lakes, (Class V), beaded streams (Class VII), and to a lesser extent shallow Carex and Arctophila wetlands (Bergman et al. 1977, Derksen et al. 1981). These wetlands are used primarily for feeding and loafing. All of these wetlands are within the Aquatic Tundra habitat (Class IIb-c) of Walker et al. (1983). Of 26 nests found on the ANWR coastal plain from 1978-1985, 9 (34.6%) were located in Aquatic Tundra habitat, 8 (30.8%) were in wet graminoid tundra, 3 (11.6%) were in partially vegetated Riparian habitat, and 2 (7.7%) in Mosiac. One nest each (3.8%) were found in Moist Sedge Shrub, Moist Tussock Sedge and Moist Shrub Riparian (Spindler 1978a, Martin and Moitoret 1981, Spindler and Miller 1983, Miller et al. 1985, McWhorter et al. 1986). Habitat use by broods in NPR-A in 1977-78 was primarily in deep Arctophila ponds, deep open lakes, and shallow-Carex ponds (Derksen et al. 1981).

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. Minimum estimated nesting density was 0.40-0.45 nests/km² in 1979-1980 at Canning Delta (Martin and Moitoret 1981), and 2.0 nests/km² at Okpilak Delta in 1978 (Spindler 1978a). Densities of adult oldsquaw on the Canning Delta in 1979 decreased from 4.9 birds/km² in June to 1.1 bird/km² in August, and were similar to densities observed at other arctic coastal sites west of ANWR. Densities ranged from 1.1 to 4.6 birds/km² at 6 sites in NPR-A during 1977-1978 (Derksen et al. 1981) and ranged from 0.3-5.1 in June to 0.1-9.0 in August at Storkerson Point in 1971-1975 (Bergman et al. 1977).

Egg-laying peaked during the last week of June and the first week of July at the Canning Delta in 1979-1980. The first broods were seen on 18-23 July with some nests still incubated as late as 28 July (Martin and Moitoret 1981). In NPR-A during 1971-1973, nest initiation ranged from 9-23 June (Bergman et al. 1977).

After mating, male oldsquaw vacate the tundra breeding areas by late July and presumably go to nearby large, deep, open lakes and coastal lagoons to molt (Alison 1975, Vermeer and Anweiler 1975, Schamel 1978, Derksen et al. 1981, Martin and Moitoret 1981, Taylor 1986). The occurrence 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, Bartels et al. 1984, Bartels and Doyle 1984b, Brackney et al. 1985b, Brackney

and Platte 1986). However, the proportion of birds molting in ANWR lagoons which bred on the ANWR coastal plain is unknown. An obvious westward migration occurs during this time (Martin and Moitoret 1981, Spindler 1978a) and the magnitude of this movement suggests that birds could be arriving from some distance to the east (M. Spindler per com., Gollop and Davis 1974b, Levison 1980). Furthermore, the turnover rate of individual birds using each lagoon is unknown. Johnson and Richardson (1981) indicated that large flocks of flightless molting oldsquaw move (swam) from lagoon to lagoon. If this phenomenon occurs frequently, then lagoon use by oldsquaw is dynamic and the numbers of birds present and the individual birds present are not static. Oldsquaw fitted with radio transmitters in 1983-1984 were sedentary during the molt period, but then exhibited interlagoon movements following molt (Bartels et al. 1984, Brackney et al. 1985c).

On ANWR coastal lagoons, peak oldsquaw abundance found in aerial surveys occurred in early-August 1981-1985, with a 3 year mean of $29,563 \pm 1189.7$ SD oldsquaw in 10 selected lagoons and a 400 m wide offshore strip. Oldsquaw densities averaged 81.4 ± 3.7 SD birds/km² (range 20.6-92.0 for all surveys) during the peak period in early-August. The highest oldsquaw density recorded on ANWR was 327.2 birds/km² on Tamayariak lagoon from 7-13 August 1982. In comparison, Johnson and Richardson (1981) found the peak and average density of oldsquaw in Simpson Lagoon was 566 and 145 birds/km², respectively, with an estimated total population of 50,000 birds (in 1 lagoon) on 28-29 July 1977. Seasonal abundance of oldsquaw during 1981-1985 indicates a gradual buildup of birds occurs through July until a peak is reached in late July or early-mid August followed by a decline into mid-September (Fig. 28).

Oldsquaw also use large, deep, open lakes on the tundra for molting (Derkson et al. 1981, Taylor 1986). Inland lakes were used more frequently by females than by males at the Canning Delta (Martin and Moitoret 1981), but the opposite pattern was observed at East Long Lake in NPR-A (E. Taylor pers. comm.). In addition to coastal lagoons and inland lakes, oldsquaw were the most abundant species observed in nearshore Beaufort Sea aerial surveys flown 0-400 m offshore of the barrier islands (Bartels and Zellhoefer 1983, Bartels and Doyle 1984b, Brackney et al. 1985b, Brackney et al. 1986a). Densities of oldsquaw seaward of the barrier islands have ranged from a low of 19.1 birds/km² on 22-23 July 1981 to a maximum of 123.8 birds/km² on 18 August 1984 (Bartels and Zellhoefer 1983, Brackney et al. 1985c). Nearshore use by oldsquaw is generally low in July and increases during August and September as more oldsquaw gain flight capability after molt (Brackney et al. 1985c). Martin and Moitoret (1981) noted that at Brownlow Point most oldsquaw sought protection inside the barrier islands while they were molting, but that some oldsquaw were seen outside the barrier islands lagoon before molting.

Aerial transect data show spatial differences in the concentration sites for oldsquaw. Johnson and Richardson (1981) reported that 90% of all birds seen in aerial surveys at Simpson Lagoon were in the lee of the barrier island chain. They 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." Brackney et al. (1985c) partitioned radio telemetry and aerial survey transect data into gross habitat types and found that oldsquaw selected the aquatic habitat within 200 m of the following areas in order of

preference: lagoon side of barrier islands, lagoon mainland shoreline, ocean side of barrier islands, passes between barrier islands, and ocean mainland shoreline. Use of open water in the lagoons and in the Beaufort sea was lower than expected based on the availability of these habitats. However, behavioral studies found that a higher proportion of oldsquaw in flocks were feeding while in passes (53%), and open water habitat of the lagoon (20.9%) and ocean (27.1%), than along the barrier islands (4.5%) or lagoon shorelines (7.6%) (Brackney and Platte 1986). Thus, the protection of barrier islands, spits, sandbars, and protective shorelines are important for resting oldsquaw, and open water habitats and passes between the ocean and lagoon are important feeding locations. Since oldsquaw appear to catabolize little of their body energy reserves of fat and protein during molt (Brackney and Platte 1986), they must acquire the energy and protein necessary for molt from the lagoon and offshore aquatic system.

Epibenthic invertebrate species Mysis relicta, M. littoralis and the amphipod Onisimus glacialis were the primary food items in the crop and gizzard of 54 oldsquaw collected by Johnson (1984) at Simpson Lagoon. Mysids comprised 58.7% and amphipods 14.2% of the diet by volume. Eighteen oldsquaw collected by Brackney and Platte (1986) at Nuvagapuk Lagoon on ANWR contained 30.3% amphipods, 23.8% mollusks, and 12.8% mysids by volume. Altogether, oldsquaw are known to consume fish and prey from 17 major aquatic invertebrate groups in the Beaufort Sea. Oldsquaw are apparently opportunistic feeders which consume the most available prey items in the highest proportions (Peterson and Ellarson 1977, Johnson 1984).

Fall migration of oldsquaw along the ANWR coast is westward and intensive during major movements, with a peak of 538 birds/h observed during 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, Martin and Moitoret (1981) observed 4,728 oldsquaw of an estimated 20,800 migrating west past the Canning Delta. From 18 August to 6 September 1980 an estimated 32,000 oldsquaw migrated past the Canning Delta during the first half of oldsquaw fall migration. By comparison, Johnson and Richardson (1981) counted 33,000 oldsquaw flying west past Pingok island between 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 reasoned that "oldsquaws do occur far offshore in the Beaufort Sea during late August and September (Searing and Richardson 1975, Divoky 1978a). It is probably that a significant fraction of autumn migration is not near the coast at Simpson Lagoon." Timson (1976) estimated that 240,500 oldsquaw migrated west past Barrow during 3-16 September 1975. During migration, individual oldsquaw may use a lagoon for only a short period. Johnson and Richardson (1981) noted "considerable turnover" of individual oldsquaw in Simpson Lagoon from 22 to 23 September 1977-1979. Oldsquaw utilized ANWR lagoon and nearshore waters as late as 20 September and elsewhere along the Beaufort Sea Coast at Prudhoe Bay as late as 15 October (Johnson and Richardson 1981).

BLACK SCOTER - Uncommon coastal migrant. The species nests mainly from the eastern Aleutians and Alaska Peninsula 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 Brownlow Point: a flock of

50 was seen on 24 June 1980, and 4 males and a female were observed on 29 August 1979. One black scoter was also observed swimming in the sea among a group of white-winged scoters off Brownlow Point. Burgess (1980) saw 200 black scoters on 21 June and 70 black scoters on 28 June flying past Demarcation Point in 1979. Black scoters may also frequent inland 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 (Spindler 1980).

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. An unusual pre-molt migration that is in the direction opposite to their fall migration route has also been observed (Johnson et al. 1975, Johnson and Richardson 1981). The earliest record of surf scoters along the ANWR coast was of a flock of males swimming in the lagoon near Sadlerochit on 7 June 1984. Several groups of from 12 to 53 scoters were observed flying west over Brownlow Lagoon in late June and early July of 1979 and 1980; 200 adults (mostly males) fed and rested in Simpson Cove on 30 June 1982 (Spindler and Miller 1983). Surf scoters seem to occur regularly at Beaufort Lagoon where Andersson (1973) recorded 980 drakes foraging in the lagoon on 28 June and saw flocks of 50 to 100 passing northwest past Nuvagapak Point at the end of June 1970. Inland, 1 surf scoter was observed on 19 June and 3 flocks of from 25 to 38 birds were seen from 30 June through 15 July on the lake at Niguanak in 1985. A definite westward molt-migration of surf scoters was noted in early July 1980 at Canning Delta. Levison (1980) 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.

In 1978-1980, mid-summer densities of surf scoters on the ANWR coastal lagoons were estimated during aerial surveys at 0.24 to 0.31 birds/km² in late July and early August, and 0.07/km² during early September in the transects just south of the barrier island chain. Male surf scoters were the identifiable and abundant scoter on the ANWR coast during lagoon surveys from 1982 to 1985. Mean scoter numbers (Fig. 29) fluctuated weekly from 274-595 with no clear trend from late July to August.

Following the mid-summer molt period, surf scoters were not observed returning eastward in the same numbers in which they were seen migrating westward prior to the molt. Some surf scoters possibly migrated farther offshore or some birds 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). Salter (1974) observed 35 surf scoters flying south up the Mackenzie Valley, Northwest Territories between 9 September and 10 October 1974.

WHITE-WINGED SCOTER - Uncommon coastal migrant and summer resident along the Beaufort Sea coast of ANWR; possible breeder near inland lakes. 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 and 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 Nuneluk Spit and Clarence Lagoon, Yukon Territory in early June

1975 (Johnson et al. 1975), and past Canning Delta in early June 1979-1980. Birds 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 of ANWR have been 1 June (Canning Delta, 1979), 3 June (Sadlerochit, 1984 and 1985), 5 June (Canning Delta, 1980), 6 June (Komakuk Beach, 1975), 8 June (Beaufort Lagoon, 1980), and 13 June (Demarcation Point, 1914) (Johnson et al. 1975, Burgess 1980, Levison 1980 Martin and Moitoret 1981).

Most late June and July observations of white-winged scoters are of singles or flocks of 2 to 6 birds resting in lagoons or flying west. Levison (1980) observed groups of 2 to 72 from mid-June through late August 1980 at Beaufort Lagoon. In 1985, small flocks were seen flying south and southeast as far inland as Jago Bitty on 15 and 18 June. On 2 July, 4 were observed with a flock of 38 surf scoters on the lake at Niguanak bird camp. On 10 July 1979, a count of 100-150 was made at Brownlow Point. 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. Because white-winged scoters are not readily identifiable from other scoters during lagoon surveys, little information is available on this species. Johnson et al. (1975) stated that "there is little evidence that white-winged scoters actually molt along the Beaufort Sea coast." It is suspected that the migration seen along the Beaufort Sea coast occurs prior to their departure for molting areas farther south.

White-winged scoters apparently leave the Beaufort Sea earlier than surf scoters, and possibly as early as mid August (Johnson et al. 1975). Since more westbound molt-migrants were seen passing Nuneluk Spit in June-July than returning eastward as migrants in August, (Gabrielson and Lincoln 1959), Johnson et al. (1975) 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." Fall observations of white-winged scoters on ANWR are insufficient to determine direction of fall migration; drakes and hens were observed flying in various directions past Brownlow Point from 20-29 August 1979.

COMMON GOLDENEYE - Rare spring migrant and summer visitant to lagoons and coastal wetlands. Two males swam and fed in the ocean near Sadlerochit River on 7 June 1984, and Levison (1980) 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 the Canadian border. Common goldeneyes have also been recorded in wetlands along north-flowing rivers in the Brooks Range (e.g. Hulahula River).

COMMON MERGANSER. Casual summer visitor. The only records of common mergansers on the ANWR coastal plain occurred in the northern-most foothills of the Brooks Range in 1985. On 10 June a drake merganser flew north along the Jago River near Jago Bitty and a hen was observed swimming in Okpirourak Creek on 1 July.

RED-BREASTED MERGANSER Uncommon breeder along rivers of the foothills and inland coastal plain; rare breeder along coastal river areas; fairly common coastal migrant. Initial spring migration routes into the Beaufort Sea area are not known, but Salter et al. (1974) suggested a possible migration down

the Mackenzie River Valley, thence westward along the coast. The earliest ANWR observation was of 4 birds at Sadlerochit Springs on 22 May 1978; red-breasted mergansers were subsequently seen regularly along Sadlerochit River from the Springs to within 15 km of the coast (Robus 1979). Singles, pairs, and groups were observed on the river by Aichilik camp from first week of June through mid-August in 1983 and 1985. Along the coast, pairs and small groups (primarily females or sub-adults) were seen in the Sadlerochit area, flying and swimming along the river and in the lagoon, from 5 June - 18 July in 1984 and from 8 June - 14 August in 1985. The species was seen regularly in late-June and July at Canning Delta in 1979 and 1980 and at Jago Delta in 1984. Ten mergansers were observed in Brownlow Lagoon on 10 July 1980; most sightings at Jago Delta occurred in ponds of Flooded habitat and along the river.

Evidence of breeding on the ANWR coastal plain includes 3 birds accompanying a brood of 9 at Demarcation Bay on 7 August 1978, a brood on the Canning River inland coastal plain (Valkenburg et al. 1972), and a hen with 3 young on the Staines River at Canning Delta. A hen with brood on the Sadlerochit delta was seen on 13-14 August 1985. 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 Nuneluk Spit, Yukon Territory between 10 July and 13 August 1972 (Gollop 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 occurrence of red-breasted mergansers in coastal lagoons increased in late-July and reached a peak of 0.70 birds/km² on 5 September 1978, and 0.18 birds/km² on 20 August 1980. Groups of 30 and 50 were counted during aerial surveys in mid-August at Tapkaurak Lagoon in 1982 and Simpson Cove in 1983, respectively.

NORTHERN HARRIER - Uncommon to rare visitor to the coastal plain. 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 was slight: a defensive pair was observed at the Sagavanirktok/Lupine River area on 31 July 1975 (Kessel and Gibson 1978). Salter et al. (1980) called this species an "uncommon visitor" to the Yukon coastal plain and reported no nesting. Harriers were infrequently observed as single birds at all study locations from 1982-1985. Two pairs were observed north of camp at Marsh Creek during the spring and summer, and 1 pair was observed at Jago Bitty during June and early July; however, no evidence of breeding was found. Harriers were also observed at Beaufort Lagoon in 1970 (Andersson 1973) and 1980 (Levison 1980), Sadlerochit Springs in 1979 (Robus 1979), and at Canning Delta in 1979.

GOSHAWK - Rare summer visitant to foothills of inland coastal plain. One adult was seen at Sadlerochit Springs on 20 May 1979 (Robus 1979). 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 west of ANWR, 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 inland summer resident and breeder along river bluffs and near steep foothill slopes; rare coastal breeder. Earliest records were of single adults seen on 14, 18, and 20 May 1979 at Demarcation Point (Burgess 1980). Spindler observed 2 adults at Okpilak Delta on 4 June 1978. One individual was seen at Canning Delta on 9 June 1980. One adult was seen at its nest near Eagle Creek in mid-April 1975 (D. Roseneau pers. comm.). Most records for the study area are for early summer. Presence of rough-legged hawks on the coastal plain varied considerably among years. Martin (1980) 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 (Lemmus sibericus and Dicrostonyx torquatus) in the area in 1976. A pair of rough-legged hawks attempted to nest atop a collapsed steel tower (approximately 3 m off the ground) at Beaufort lagoon in 1985. A pair also nested atop a mound in flat open tundra at Okpilak in 1982. 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." 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. Robus (1979) 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. Single nests were found on Katakturuk Bluffs in 1983 and 1985, and 6 nests were found along a 5.5 mile section of Igilatvik Creek near the Jago Bitty camp in 1985; 7 pairs of hawks were observed and at least 2 nests fledged young. Intensive surveys in ANWR north of the continental divide in 1973 indicated about 20 active nests (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 to 30 August (Table 15).

Table 15. 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	21 April to 7 May	15 May to 21 July	15 June to 21 Aug	31 July to 30 Aug
Gyrffalcon	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		15 May to 7 June	21 June to 4 Aug	15 Aug on
Short-eared owl		7 June to 7 July	7 July to 21 Aug	15 Aug on

GOLDEN EAGLE - Uncommon to fairly common summer and fall resident; probable rare breeder in foothills of inland coastal plain. Golden eagles were common summer visitants to the coastal plain in years when calving and post-calving caribou were present in the area. Roseneau (1974) reported 33 subadults out of 35 total birds observed on the coastal plain between the Tamayariak and Egaksrak Rivers. Mauer (1985) found 89% of 192 age-identifiable eagle observations in 1984 were of subadult birds. Many of these subadults using the coastal plain in June and early July were utilizing carrion from dead caribou adults and calves, as well as preying on live calves (Roseneau and Curatolo 1976, Mauer 1985). Observed locations of subadult golden eagles shifted eastward as the Porcupine caribou herd migrated into Canada (Figs. 39 and 40), but it is not known if individual birds actually followed the caribou (Mauer 1985).

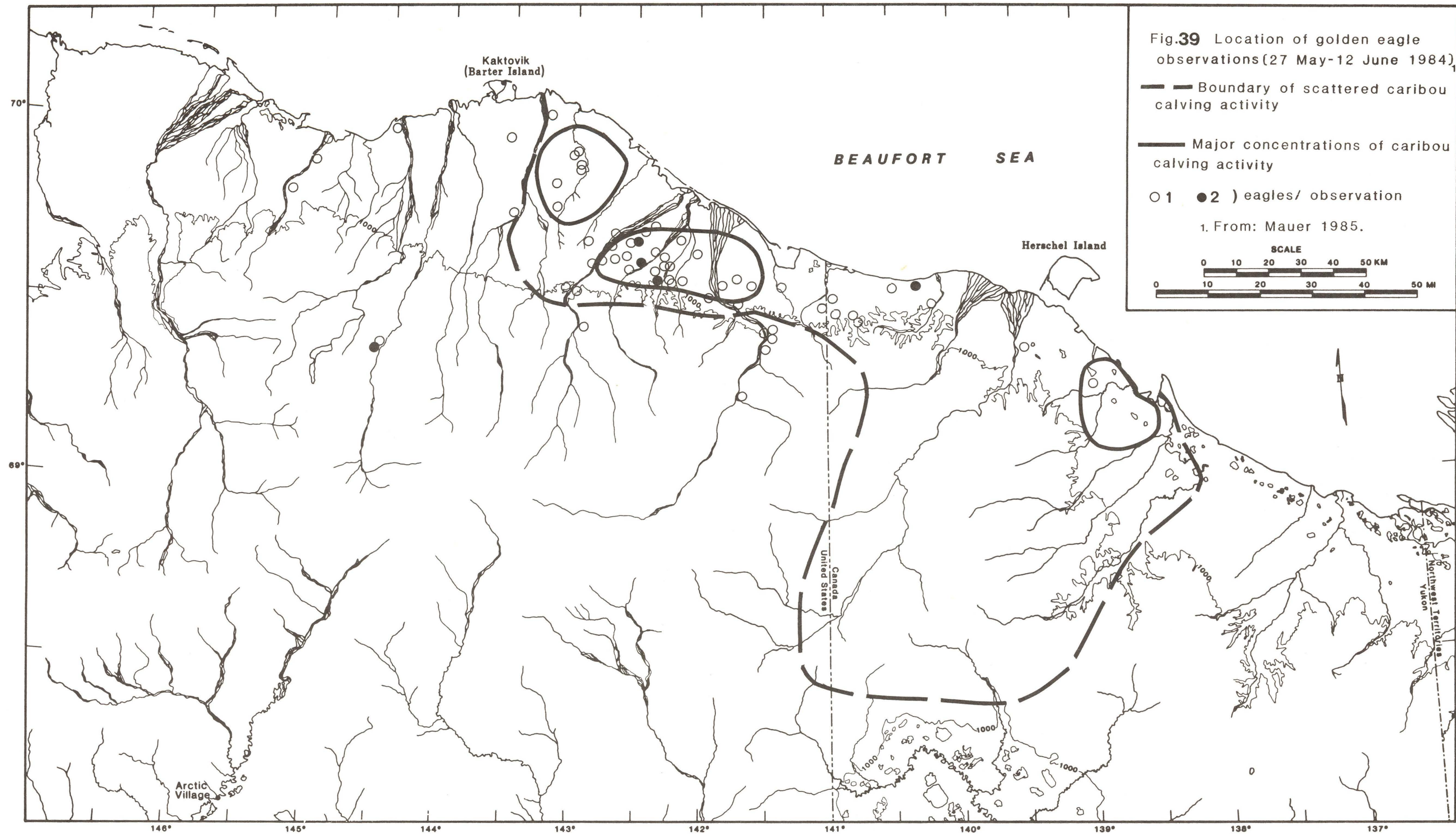
Golden eagles were 1 of the more abundant cliff-nesting raptors in the Brooks Range portion of ANWR (Fig. 41) (Roseneau 1974, Spindler 1979b, Mauer 1985). On the ANWR coastal plain study area, nesting sites were documented on bluffs near the 300 m contour line along the Katakturuk River (Roseneau 1974, Roseneau et al. 1980). Adjacent to ANWR, nesting was reported in suitable river cliff terrain on the Yukon coastal plain (Salter et al. 1980) and in NPR-A (NPR-A Task Force 1978).

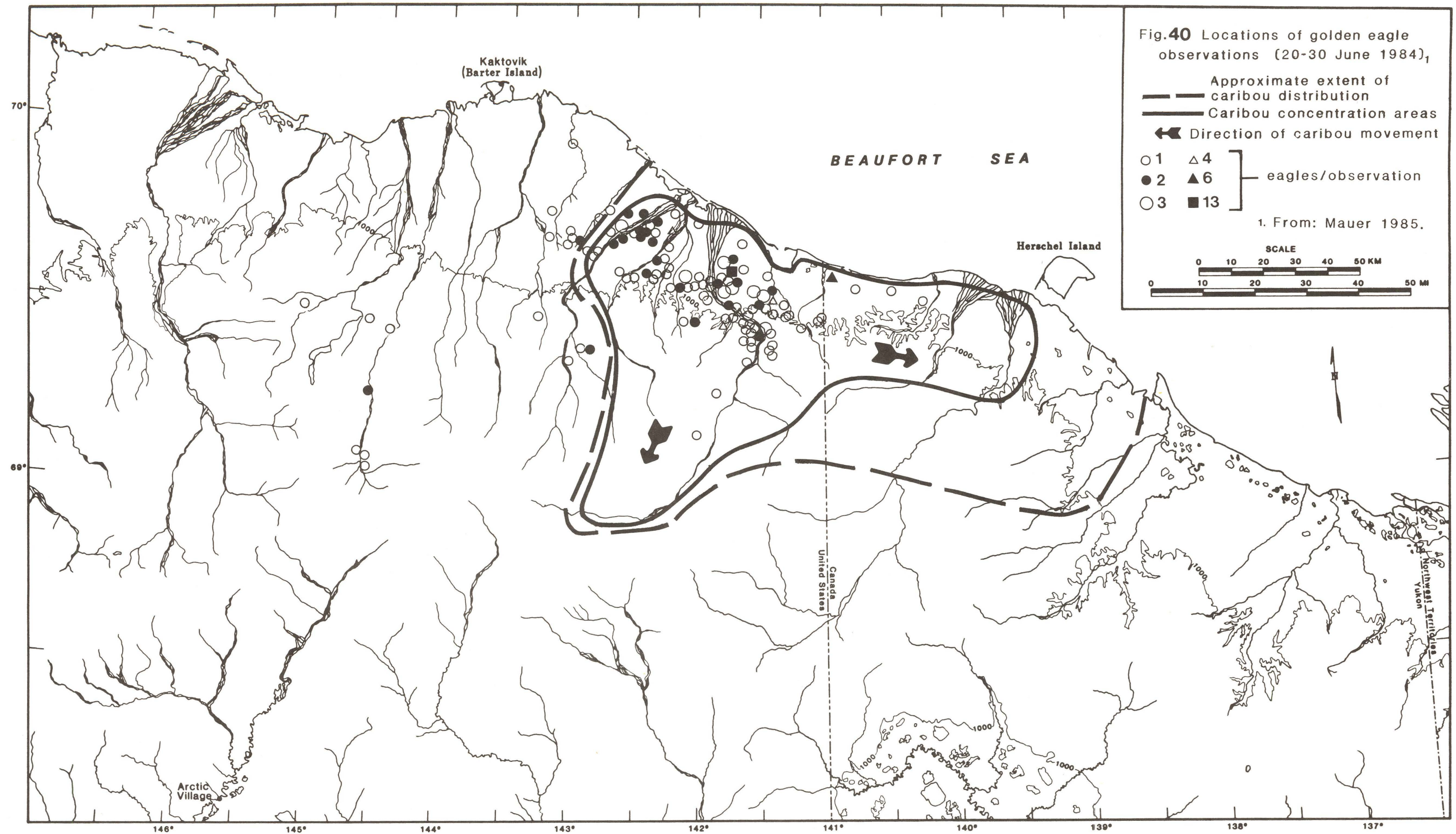
AMERICAN KESTREL - Casual summer visitor to the ANWR coastal plain. This species nested in low numbers south of the continental divide in the Brooks Range (Spindler et al. 1980), and was documented on the ANWR coastal plain on 3 occasions: 1 was seen at Demarcation Point in 1978 (Burgess 1980), 1 was observed at Beaufort Lagoon in late May 1980 (Levison 1980), and a male was seen at Brownlow Point on 27 May 1980 using the DEW-line buildings as shelter and feeding on snow buntings. An adult female was observed at Sadlerochit Springs on 5 June 1976 (D. Roseneau pers. comm.).

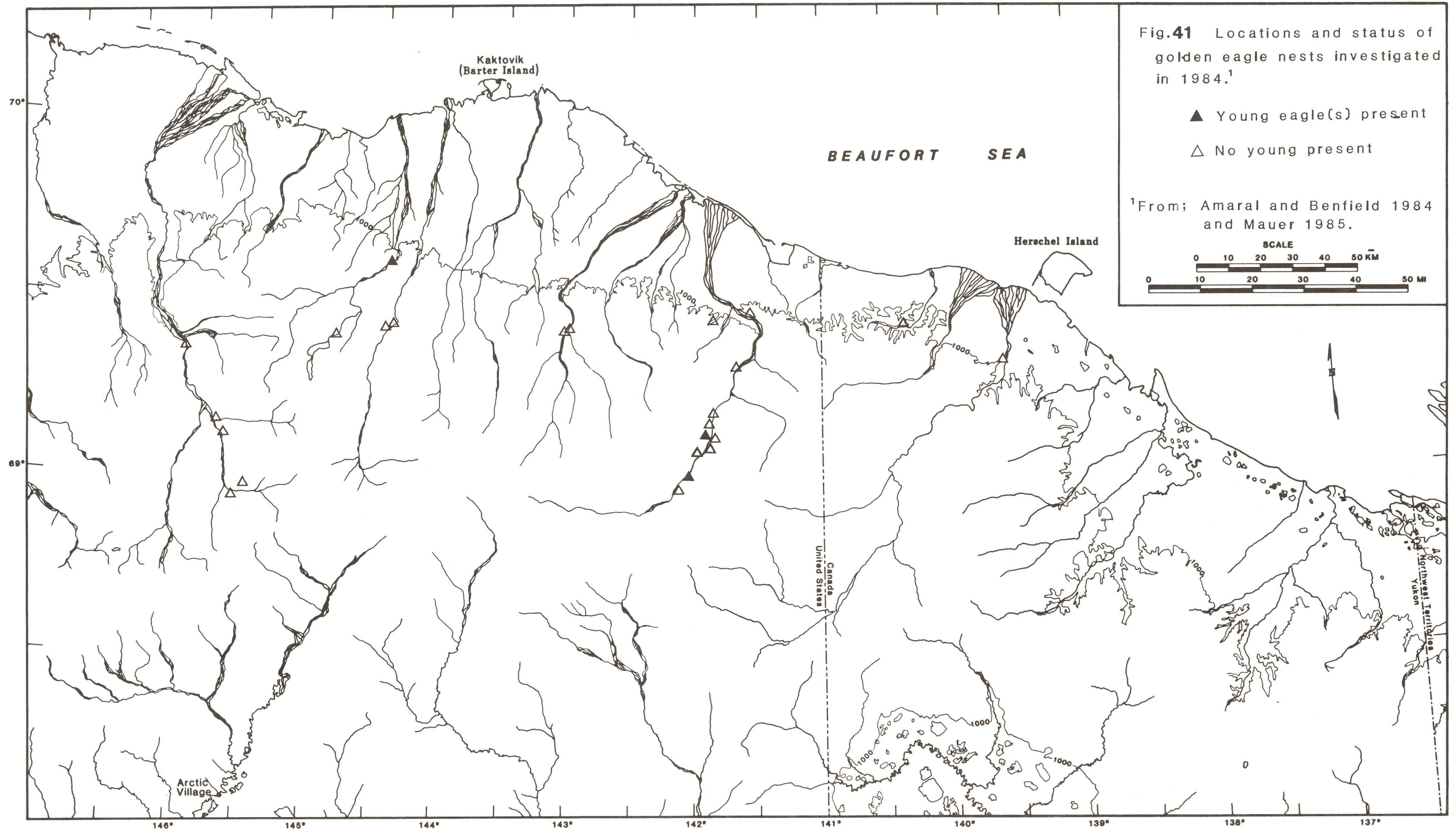
MERLIN - Rare coastal spring and summer visitant; possible rare breeder in foothills of inland coastal plain. Merlins nest along the Kongakut River in the Brooks Range, near and upstream from Mt. Greenough (M. Spindler pers. com. data, P. Martin pers. com.). Reynolds (1974 as cited by Roseneau 1974) observed a merlin in the upper Canning drainage.

Occurrence on the ANWR coastal plain has been documented 7 times: P. Martin (pers. com.) observed 1 bird near Nuvagapak Point on 11 July 1976, Spindler (1978c) observed an adult perched on DEW line buildings at Beaufort Lagoon on 23 May 1978, 1 individual was reported by Burgess (1980) at Demarcation point in 1978, 2 observations of single birds were made at Jago Delta in August 1984, and 2 observations were made at Niguanak in August 1985.

PEREGRINE FALCON - Rare summer resident and possible breeder in cliff and river bluff terrain of inland coastal plain; uncommon summer visitant and fall migrant over coastal tundra and lagoons. Peregrine falcons nesting on the north slope of Alaska arrive at nest sites between 21 April and 7 May, nesting occurs from about 15 May to 21 July, brood-rearing is from 15 June to 21 August, fledging occurs between 31 July and 30 August (Table 15, NPR-A Task Force 1978). Fall migration is during late August through mid-September (Levison 1980, Martin and Moitoret 1981). 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 arctic subspecies of peregrine falcon (Falco peregrines tundrius) which inhabits the north slope of Alaska underwent a drastic population decline beginning in the early 1960's as a result of pesticide contamination of its food supply. In 1973, the peregrine falcon was placed on the Endangered Species List (Endangered Species Act of 1973, 16 U.S.C. 1531-1543). Because of its endangered status, populations and productivity of peregrines associated with known areas of relative abundance (Colville and Sagavanirktok Rivers) are well documented by annual or biannual surveys (Ambrose et al. in press). Other areas known to have smaller populations of nesting peregrines (such as the ANWR) were surveyed less frequently (Roseneau 1974, Roseneau and Bente 1980, Amaral and Benfield 1985). During the mid-1970's the arctic peregrine falcon populations nesting in northern Alaska reached their lowest level, approximately 35% of historical levels (Ambrose et al. in press). Over the past 10 years, peregrine populations associated with major areas of productivity (Colville and Sagavanirktok Rivers) have gradually increased to historic levels (Ambrose et al. in press). In areas where smaller populations of peregrines were known historically, numbers remain well below recovery levels (Ambrose et al. in press).

Table 16. 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 ^a	Number of nesting locations	Potential habitat
Kavik	2	1 reported	small portion headwaters and near 610 m elev.
Canning	6-7	3 confirmed 3 reported	Between 69° 37' and 69°29' N. Upper drainage, between 69°21' and 69°00'N below 762 m elev. Best locations are generally at tributary valley entrances.
Tamayariak	2		
Katakturuk	2-3	1 reported	Upper drainage, primarily the west fork between 244 and 610 m elev.
Marsh Creek	2-3		Upper main drainage between 305 and 610 m elev.
Carter Creek	2		Lower 4.8 - 6.4 km.
Sadlerochit	4-5	1 confirmed	Between 274 and 762 m elev., but centered in upper reaches and Sadlerochit Springs area.

Table 16. Continued.

River drainage	Habitat rating ^a	Number of nesting locations	Potential habitat
Hulahula	2-3	1 reported	Kingak Hill vicinity or Kikiktat Mountain vicinity.
Okpilak	2		
Jago	2-3	2 reported	VABM Bitty vicinity Marie Mountain vicinity
Aichilik	3-4	2 reported	Primarily between 69°29' and 69°20' N.
Egaksrak	3-4	--	Primarily between 69 35' and 69 25' N.
Ekaluakat	2-3	--	Headwaters area
Siksikpalak	1	--	--
Kongakut	5-6	3 reported	Primarily between 69 34' and 69 00' N.
Clarence (Alaskan portion)	2-3	--	Between 69°29' N and U.S.-Canadian Border.

^aHabitat 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.

In the northern portion of ANWR, surveys conducted during 1972-1973 identified 3 active nests among 20 historical or suspected historical sites (Table 16) (Roseneau 1974, Roseneau et al. 1976). Surveys in 1980 found no nesting activity (Roseneau et al. 1980). In 1984, 1 pair of peregrines was observed at a historical nest site on the Canning River, but did not produce young (Amaral and Benfield 1985). In 1985, an active nest was recorded on the Aichilik River south of the study area (M. Amaral pers. comm.). A single peregrine was also observed in 1985 at bluffs on the Jago River near VABM Bitty, within the study area (M. Amaral pers. comm.). Based on recent survey results there are slight indications of peregrines re-establishing historical nest sites within ANWR. This trend is expected to continue, as productivity in the prime habitats west of the refuge reaches former levels (Ambrose et al. in press).

Observations of non-nesting peregrine falcons in the ANWR study area are fairly common. Peregrines were seen during June and July at Canning Delta in 1979 and 1980, at Sadlerochit Springs in 1974 (Roseneau 1974), on Barter Island in 1976 (D. Roseneau pers. comm.), at Jago Bitty in 1982, and at

Okpilak, Jago Delta, Sadlerochit, and Niguanak in 1985. August and September observations were made at Demarcation Point in 1979 (Burgess 1980); Sadlerochit Springs and 10 km inland along Sadlerochit River in 1979 (Robus 1979); Flaxman Lagoon, Brownlow Point, and the West Branch site at Canning Delta in 1979 (Martin and Moitoret 1981); and at Niguanak, Sadlerochit, and Jago Delta in 1985.

In August-September 1980, Levison (1980) 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 17). 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.

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. D. Roseneau (pers. comm.) 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.

Table 17. Peregrine falcon and falcon spp. observations made during migration watches at Beaufort Lagoon and Pingokraluk Point, 15 August-4 September 1980 (Source: J. Levison and D. Blomstrom 1980 cited in Spindler 1981d).

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 Beaufort 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 buntings 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.

GYRFALCON - Uncommon permanent resident nesting on cliffs, outcrops and river bluff terrain of inland coastal plain; rare coastal visitant. Gyrfalcons nest earlier than other raptor species on the ANWR coastal plain (Table 15). 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).

Roseneau (1974) reported 12 active eyries in the ANWR north of the continental divide near the following locations in 1972-1973: Red Hill near the Canning River, Sadlerochit Springs and other areas in the Sadlerochit Mountains, the eastern Shublik 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 were apparently of hunting or migrating birds. Gyrfalcons were rare summer visitants at Aichilik, Katakturuk, and Marsh Creek, and rare fall visitants at Sadlerochit, Marsh Creek, Niguanak, and Jago Bitty. Several of these observations involved gyrfalcons in pursuit of ptarmigan. No gyrfalcons were seen at bird study sites in 1982-1984. Observations were also made at Demarcation Point in 1979 (Burgess 1980), near Pokok Lagoon in 1970 (Andersson 1973), on Canning Delta in 1979 and 1980, and on the Sadlerochit River 10 km inland in 1980 (Robus 1979).

WILLOW PTARMIGAN - Fairly common to common inland resident and breeder; uncommon coastal resident and breeder, decreasing in abundance northward in proximity to the coast wherever dwarf shrubs become scarce. In April and mid-May a general northward migration of willow ptarmigan was observed through ANWR, with flocks of several thousand seen flying from the Brooks Range north toward the coastal plain (M. Spindler pers. comm.). 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": 1 before the end of March and the other after the end of March. Willow ptarmigan arrived on the outer coastal plain in mid to late-May (Spindler 1978a, Robus 1979, Burgess 1980). Observations of Brooks (1915) and Martin and Moitoret (1981) suggested 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.

Preferred breeding habitat for ptarmigan on the north slope was flat tussock-heath tundra with small patches of dwarf shrub or tall shrub if available (Spindler 1978a, Salter et al. 1980). Hatching generally occurred in late June or early July. Nests were well concealed among sedges, tussocks, or low willows. Martin and Moitoret (1981) noted flocking of this species at Canning Delta in late August 1979. 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 (Spindler 1981b). Irving (1960) observed southward movement of willow ptarmigan through Anaktuvuk Pass beginning about 1 October which was not as

large as the northward movement in spring. Weeden (1964) indicated that there was 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 single-sex groups in winter in the Mackenzie River delta, Northwest Territories. These data suggested that mostly males winter on the ANWR coastal plain, but wintering status of ptarmigan species on ANWR is unknown. M. and E. Simms of Kaktovik (pers. comm.) reported willow ptarmigan are the most frequently seen and hunted ptarmigan species near Barter Island in mid-winter, however, mid-winter populations are very low compared to those in April to August.

ROCK PTARMIGAN - Common year-round resident and breeder on inland coastal plain; common coastal breeder, rare coastal winter resident. Very small numbers were present in mid-winter near Barter Island (M. and E. Simms pers. comm.). Irving (1960) and Weeden (1964) stated that rock ptarmigan apparently did not undertake the large scale long distance migrations as did willow ptarmigan.

Rock ptarmigan were observed inland along the Sadlerochit River on 11 May 1979 (Robus 1979), and by the coast at Demarcation Point on 19 May 1979 (Burgess 1980). The species was seen at Canning Delta by the third week of May 1979 and 1980, and was most often seen in late May on wind-swept coastal or lake shore bluffs. Rock ptarmigan were generally more common in drier upland and Riparian habitats during the breeding season. Nests were difficult to locate as a result of excellent camouflage, cryptic eggs, and reluctance of females to flush. Hatching was observed in late June and early July. Females with broods were seen in Riparian, Tussock, or Moist Sedge-Shrub habitats. Rock ptarmigan appeared to be more common than willow ptarmigan at coastal sites and about equal in numbers at inland sites.

Martin and Moitoret (1981) observed post-breeding flocking at 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." August flocking was also observed at inland sites from 1982-1985, but 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 or below the lower altitudinal limit of their nesting range in timberline areas 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: females mostly used areas below timberline and males mostly used areas at or above timberline (Weeden 1964).

SANDHILL CRANE - Rare breeder and uncommon summer resident on outer coastal plain; rare inland spring migrant. Cranes arrived on the outer coastal plain in late May to early June, where they were often seen feeding in Flooded or Wet Sedge habitats. Spindler (1978a) suspected breeding at Okpilak in 1977, after finding a weathered crane egg-shell in 1978. In the Beaufort Lagoon area, groups of 2-4 were seen in 1970, 1974, 1976, and 1980 in late June and July (Andersson 1973, Levison 1980, P. Martin pers. comm.). Robus (1979) 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 (Burgess 1980). A pair of cranes was seen on the west side of Demarcation Bay on 4 August 1981 (Spindler 1981b).

Martin and Moitoret (1981) obtained 9 records for the species on Canning Delta from 3-30 June 1980; most observations were of 1 or 2 birds flying, but some birds were 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 Territory north slope, since records are sparse to the west (Sage 1974, Derksen et al. 1981). Despite fairly frequent observations, no breeding was confirmed east of the ANWR study area (Salter et al. 1980). Fall migration is probably to the east, since an easterly migration was observed on the Yukon Territory north slope (Salter et al. 1980).

BLACK-BELLIED PLOVER - Rare breeder, uncommon spring migrant, and fairly common fall migrant across outer coastal plain; rare inland migrant. Black-bellied plovers do not breed in high densities nor do they migrate in large flocks (Bent 1929). Only 2 nesting accounts exist for the ANWR coastal plain: at Canning Delta in 1980, and in Flooded habitat at Jago Delta in 1984 (hatched 14 July). Spring migration, during early June, consisted of single or paired individuals flying through or stopping to forage in Mosaic, Wet Sedge, and Flooded habitats. Subsequent sightings were rare until mid-August when flocks of 4-42 adult birds passed across coastal peripheries and foraged along mudflats and gravel or mud bars. By late August, most flocks were comprised of juvenile birds.

LESSER GOLDEN-PLOVER - Fairly common breeder on ANWR coastal plain; common to abundant 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). Earliest arrival date on ANWR was 26 May 1979 and 1980 at Canning Delta, and the same date in 1979 at Demarcation Point (Burgess 1980). Nests were found in frost scars, boils, and similarly exposed areas in Tussock, Moist Sedge-Shrub, Riparian (especially Dryas river terraces), Mosaic, and Moist Sedge habitats (Figs. 21, 17, 3, 12, 15).

Hatching began on 17 and 19 July 1979, and 10 July 1980 at nests monitored at Canning Delta. First hatching generally occurred during the first week in July from 1982-1985. Most nests hatched in mid-July and some nests hatched as late as early August. Habitat use by golden-plovers changed between the nesting and brood rearing period: upland tundra (Moist Sedge-Shrub, Tussock, and Moist Sedge) was used early in the season for nesting and foraging, June through mid-July, whereas adults accompanied by broods frequented Wet Sedge, Riparian, and Flooded tundra after early to mid-July (Figs. 3, 6, 10, 15, 17, 21). Lowland wet tundra types at Canning Delta were used also by fall migrating adults in mid-July and a second peak of migrant juveniles in mid-August. Flocks ranging in size from 3 to 27 birds were seen heading east and northeast from inland areas and east from coastal areas.

Fall migration out of the study area was 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 (Levison 1980). 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).

SEMIPALMATED PLOVER - Rare coastal breeder and summer visitant; rare breeder inland. Semipalmated plovers were closely tied to gravel bars and Dryas terraces on the coastal plain. Nests consisted of scrapes on bare ground and were found on Dryas terraces, along bluffs (at Katakturuk), on river banks,

and on gravel bars. Hatching took place during the last week in June and the first 2 weeks in July.

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).

EURASIAN DOTTEREL - Casual summer visitant to outer coastal plain. Andersson (1973) recorded 1 dotterel at Nuvagapak Point near Beaufort Lagoon on 19 June 1970.

LESSER YELLOWLEGS - Casual coastal migrant. One individual was sighted on coastal mudflats south of Barter Island on 26 June 1978 (Spindler 1978a). Magoun and Robus (1977) observed the "very uncommon" lesser yellowlegs in coastal vegetated mudflats and Moist Sedge terrains. No sightings have been reported on the ANWR coastal plain since 1978.

WANDERING TATTLER - Uncommon inland breeder. Wandering tattlers were observed exclusively along foothill rivers of the western ANWR coastal plain. The earliest sighting was 6 June 1985 at Marsh Creek, where on 8 July, 3 adults with at least 3 chicks were sighted in Riparian habitat. Adults utilized river banks and Dryas terraces at Katakturuk River, 24-34 km upstream from the camp site on 21-24 July 1983. This evidence suggested that wandering tattlers nested in higher densities along foothill and alpine streams of the Brooks Range. No observations were made east of Marsh Creek.

SPOTTED SANDPIPER - Uncommon inland breeder. Spotted sandpipers utilized Riparian habitat along the western foothills of the ANWR coastal plain. Infrequent sightings were made during June and July at the Marsh Creek, Katakturuk, and Jago Bitty bird camps. However, 16-34 km upstream from Katakturuk camp, over 15 individuals were observed in Riparian areas between 14 and 20 July 1983, suggesting that spotted sandpipers were more abundant in the extensive foothills or alpine tundra areas. One nest was observed in Riparian habitat at Marsh Creek, and the chicks were first seen on 24 July. Two spotted sandpipers were seen at Sadlerochit Springs on 14 and 16 August (Magoun and Robus 1977). The only observation east of the Jago River was at Aichilik on 5 June 1984.

UPLAND SANDPIPER - Locally uncommon breeder of inland foothills. Nests, young, or territorial and defensive behavior during the breeding season were reported from mid to upper Kongakut River, Aichilik River, and Marsh Fork and Canning River (Kessel and Gibson 1978).

WHIMBREL - Rare inland breeder; uncommon visitant over entire coastal plain. Nesting whimbrels were observed exclusively at inland foothill locations. A single nest, initiated between 10 and 15 June 1985, was located on a hummock in Wet Sedge at Aichilik bird camp. The nest contained 2 eggs of disparate size, and was probably a reneest, as 4 eggs are normally laid (Bent 1927). Chicks were observed on 20 July, which closely corresponded to dates of adult distraction displays at Jago Bitty and Katakturuk, indicating that whimbrels probably bred at these inland foothill locations as well. Flocks of 3-18 individuals foraged in a variety of habitats at Aichilik during July 1984 and 1985. Whimbrels were most commonly observed flying overhead or foraging in

groups of 1 to 17 in mesic habitats across coastal areas during July. However, dates of observation at Canning Delta ranged from 6 June to 20 August in 1979.

BLACK-TAILED GODWIT - Accidental migrant. One juvenile black-tailed godwit, flying east with a flock of long-billed dowitchers, was observed at Jago Delta on 27 August 1985.

HUDSONIAN GODWIT - Casual visitant. One was seen at Canning Delta on 5 July 1980. This is the only record on the Alaska Beaufort Sea coast, east of Barrow (Kessel and Gibson 1978).

BAR-TAILED GODWIT - Rare spring and fall migrant across the outer coastal plain. The majority of bar-tailed godwit sightings were on the western periphery of ANWR at Canning Delta (Martin and Moitoret 1981). Observations were recorded on 5 and 14 August 1979, 4, 6, 16, and 29 June 1980; all were single birds except the 14 August sighting of 2 individuals. One pair and a single godwit were seen on 11 and 15 June 1984, respectively, at Sadlerochit bird camp. During the same year, solitary birds were observed at Jago Delta on 12 June and 18 August. Most bar-tailed godwits were sighted in flight; the few on the ground were recorded in Wet Sedge, Riparian, and mudflat habitats.

RUDDY TURNSTONE - Fairly common breeder. Ruddy turnstones exclusively utilized Riparian habitat and mudflats across the coastal plain (Fig. 3). Densities were higher in more northern areas, possibly related to the more extensive Riparian zones. Only study sites that included Riparian habitat reported nesting turnstones. From wintering grounds in Australia (Bent 1929), the turnstone is one of the earliest shorebirds to arrive on the arctic coastal plain. Martin and Moitoret (1981) saw ruddy turnstones at Canning Delta on 27 May 1979 and 29 May 1980. Nests were initiated early to mid-June in sparsely vegetated microsites along gravel bars and barren floodplain habitats (Fig. 3). Generally, 4 eggs were laid and hatching occurred in late June and early July. After hatch, adults attended the chicks in gravel bar areas or occasionally Moist Sedge and Dryas benches (Fig. 3). Ruddy turnstones aggressively defended their nest sites and young. They dispersed from breeding areas in early August, and were infrequently observed alone or in small groups on coastal mudflats.

RED KNOT - Rare coastal migrant. The only red knots observed on the ANWR coastal plain were at Canning Delta. One to 4 individuals were sighted on 5 occasions during June of 1979 and 1980, and 2 juveniles fed on the ocean side of the Brownlow Lagoon barrier islands on 21 August 1980.

SANDERLING - Rare spring and uncommon fall coastal migrant; casual inland breeder. Sparse numbers of spring migrants passed along the coastal extremities of ANWR during early June. One or 2 individuals, observed on 6 occasions in 1980, utilized snowless dunes on the Canning River Delta. Three sanderlings were sighted at Okpilak Delta on 2 June 1978, and a flock of 15 adults (some in molt) foraged along mudflats at Sadlerochit on 6 June 1985. At the inland Katakturuk bird camp on 14 July 1982, 1 adult in nuptial plumage was observed with 2 chicks in Riparian willow and Dryas terrace habitats; the nest was suspected as early as 15 June. Sanderlings primarily reproduce on the northern coasts and islands of Canada and Greenland (Scott 1983). Fall migration counts at Brownlow Point peaked on 28 August 1979 when 32 flew west.

in 7 h of observation, and on 30 August 1980, when 40 flew west in 6 h. Late summer shoreline surveys at Jago Delta in 1985 recorded 4 juveniles on 21 August.

SEMIPALMATED SANDPIPER - Common to abundant breeder and fall migrant. Semipalmated sandpipers were most abundant across the western portion of the ANWR, especially in areas with extensive Riparian habitat. Courtship activities began soon after their arrival in late May and early June. Clutches were completed and aerial flight displays were very common during mid-June. Semipalmated sandpipers nested on relatively dry microsites, particularly in Riparian zones, but also in Mosaic and Moist Sedge-Shrub habitats that were proximate to water courses (Figs. 3, 12, 17). After hatching in early July, this species utilized Riparian or Flooded habitats exclusively (Figs. 3, 6).

Semipalmated sandpipers dispersed from inland breeding areas over the latter weeks of July and numbers increased on coastal mudflats, lagoons, and river deltas. Early flocks were probably composed of adult females which leave soon after the broods hatch (Ashkenazie and Safriel 1979), while the larger flocks that gathered on coastal mudflats during mid-August were mostly juveniles. The shifts in habitat use exhibited by semipalmated sandpipers, as well as overall densities, have been relatively consistent during years that bird investigations have been conducted on the ANWR coastal plain.

WESTERN SANDPIPER - Casual spring and fairly common fall coastal migrant. Flocks of 1-13 western sandpipers were observed on 10 occasions from 14-29 August during 1979 and 1980 surveys at Canning Delta. Numbers peaked after the main movement of semipalmated sandpipers, and utilization was restricted largely to marine littoral and estuarine habitats. Approximately 400 western sandpipers foraged with 300 semipalmated sandpipers on the Okpilak coastal mudflats on 11 August 1985. Flocks of 3-20 westerns, mostly juveniles associating with semipalmated sandpipers, were observed during late August 1985 at the Jago Delta mudflats. Two mid-August sightings were noted at Sadlerochit in 1984 and 1985. The only spring migrant was a single bird seen on 15 June 1979 on the shore of Brownlow Lagoon.

LEAST SANDPIPER - Rare migrant. Spindler (1978a) observed 3 least sandpipers foraging in Wet Sedge habitat on 19 June, and 1 individual in Mosaic habitat on 20 and 23 June 1978, at Okpilak Delta. During 1985, 1 least sandpiper was sighted on 21 June in Riparian habitat at the Katakturuk bird camp.

WHITE-RUMPED SANDPIPER - Rare spring migrant and uncommon fall migrant along western coastal regions; possible rare breeder. The majority of white-rumped sandpiper observations were from surveys at Canning Delta during 1979 and 1980. Groups of 1-3 individuals were seen on 4 dates between 1 and 10 June in both years. Sightings included flight displays and utilization of dunes and marshes. A total of 41 fall migrants, as singles or in groups of 2-11, were observed between 6 and 18 August 1980; only 1 individual was seen in 1979. Most sightings were along shoreline transects. Martin and Moitoret (1981) attributed much of the annual variation to inter-year population differences. Single white-rumped sandpipers were observed at several locations in other years: 13 August 1984, Sadlerochit; 10 August 1985, Niguanak; 11 August 1985, Aichilik; 1 August 1983 and 12, 27 August 1985, Jago Delta. Nearly all coastal sightings were along mudflats, while inland observations were in Riparian habitat. Defensive behavior of adult white-rumped sandpipers,

observed on 17 and 21 July 1978 in coastal vegetated mudflats at Okpilak led Spindler (1978a) to conclude that breeding had occurred.

BAIRD'S SANDPIPER - Fairly common breeder, uncommon migrant. Baird's sandpipers arrived on the ANWR coastal plain in early June, following their long migration from the southern regions of South America (Bent 1927). They were most abundant within Riparian habitats across the foothills and western portions of the refuge (Fig. 3). Their distribution extended south along the

Canning and Hulahula Rivers, into the alpine meadows of the Brooks Range (Martin and Moitoret 1981), as well as northward to the coastal deltas and lagoons. Clutches were completed by the latter half of June. Nests were located within sparse tufts of grass or near debris in well-drained sites along gravel bars, river banks, and bluffs (Fig. 3).

After the young hatched in mid-July, family groups utilized barren ground Riparian habitat (Fig. 3). Baird's sandpipers were rare after mid-August, and there were no significant observations of flocking. Single juveniles occurred infrequently along river gravel bars at Jago Delta in late August 1985.

PECTORAL SANDPIPER - Common breeder, abundant fall migrant. Although pectoral sandpipers displayed broad distribution and utilized all habitat types on the ANWR coastal plain, 2 interrelated trends were apparent: abundance increased from foothills to coastal areas, and from drier, upland habitats to lowland saturated terrains (Figs. 3, 6, 10, 12, 15, 17, 21). Nest densities were highest in mesic areas such as Wet Sedge, Mosaic, and Flooded habitats (Figs. 6, 10, 12). Utilization of Moist Sedge-Shrub habitat appeared related to the interspersions of small ponds and/or the proximity of mesic areas.

Pectoral sandpipers arrived on the north slope during late May, following their migration from southern South America (Bent 1927). Males established territories upon arrival, and their display flights were observed throughout June; peak courtship activities occurred during mid-June. Clutches of 4 eggs were usually completed in mid-June, but reported dates ranged from 10 June to 12 July. Males left the breeding grounds soon after mating, and presumably with unsuccessful females, they comprised the large wave of low-flying flocks (usually 6-15 individuals) that migrated eastward across the coastal plain during the latter half of July.

Pectoral sandpiper density rose sharply in Flooded habitat during the post-reproductive season (Fig. 6). After hatch, during the first half of July, family groups congregated in flooded areas. Females aggressively defended these brooding grounds, often with assemblages of other shorebird species that attended their young in the area (e.g. semipalmated sandpipers, long-billed dowitchers, stilt sandpipers, and red-necked phalaropes). Smaller eastward movements during early August may have consisted of adult females initiating migration. Finally, a large surge of juvenile flocks migrated eastward over the coastal plain during late August. Flock sizes ranged from 5-25 across inland areas while staging groups on coastal mudflats reached up to 290 individuals.

SHARP-TAILED SANDPIPER - Casual migrant. A single individual was observed foraging along the bank of a large inland lake at Niguanak bird camp on 27 August 1985. It was temporarily joined by a pectoral sandpiper. There were no previous records of sharp-tailed sandpipers on the north slope (Kessel and Gibson 1978).

DUNLIN - Uncommon coastal breeder; fairly common fall migrant across outer coastal plain. Dunlins arrived in late May; and the only observation of spring flocking on ANWR was on 6 June when 10 individuals were observed in a mixed-shorebird flock at Sadlerochit. ANWR may represent the eastern breeding boundary for dunlins on the north slope (Martin and Moitoret 1981). A total of 11 nests were located on the Canning, Sadlerochit, and Jago River Deltas, in Mosaic and Moist Sedge-Shrub habitats. Clutches were completed by mid-June, and hatching occurred the first week of July. Dunlin observations were relatively uncommon at locations other than those previously mentioned. During August, dunlins gathered along coastal mudflats, pond edges, and stream channels. The flocks were generally comprised of juveniles foraging with other small shorebirds. At Jago Delta in late August, flock sizes ranged from 5-50, with a peak of 190 on 30 August 1985.

STILT SANDPIPER - Uncommon to fairly common breeder; fairly common fall migrant. Stilt sandpipers bred at inland and coastal areas with slightly higher numbers recorded at the mid-plain thaw lakes area at Niguanak in 1985. In all years first observation dates ranged from 1-8 June when single birds, pairs, and small flocks were seen feeding on coastal wetlands and in Flooded and Wet Sedge tundra (Figs. 6, 10). With the exception of Canning Delta in 1979 and 1980, nesting stilt sandpipers were only observed at study sites east of Sadlerochit: Okpilak Delta, Jago Delta, Niguanak, Jago Bitty, and Aichilik. Male courtship displays appeared to extend through a major portion of the incubation period at several locations (from 7 June through 9 July). Clutches of 2 to 4 eggs were laid predominantly on small, dry, sedge hummocks in Wet or Moist Sedge habitat (Figs. 10, 15). Earliest record of flight capable young was on 12 July 1983 at Jago Bitty. Observations of hatching or young chicks ranged from 27 June through approximately 7 July at coastal and inland sites. Chicks moved with adults into Flooded tundra or wetter portions of upland habitats soon after hatching where they remained through mid-July.

Aggregations of stilt sandpipers, pectoral sandpipers, long-billed dowitchers, and lesser golden-plovers with their broods were noted at Niguanak in Flooded habitat from July through the beginning of August. Stilt sandpipers were fairly common fall migrants, especially in marine littoral habitat and coastal wetlands. Most fall observations were of juveniles feeding singly or with mixed flocks of shorebirds. Juveniles were seen during 5-13 August 1979 at Canning Delta. The peak of migration occurred between 8-13 August.

BUFF-BREASTED SANDPIPER - Locally rare to fairly common breeder. Breeding densities of buff-breasted sandpipers fluctuated locally on coastal plain from 1978 to 1985 and showed annual variation in use of breeding habitats at both inland and outer coastal locations. At Canning Delta, 6 and 5 nests were found on river bluffs, Moist Sedge, and sparsely vegetated areas in 1979 and 1980, respectively. Seven nests were discovered at Okpilak from 1978-1983; 3 were located on high-polygon and upland ridges in 1978, 3 occurred in Flooded and Wet Sedge tundra in 1982, and 1 pair nested in Riparian habitat in 1983. No nests were found at this study site in 1985. Highest nest densities for the entire ANWR coastal plain were observed in 1985 when buff-breasted sandpipers nested at 7 of 8 locations studied, with 4 nests each at 2 coastal sites and from 1 to 4 nests each at 5 inland locations. Buff-breasted sandpipers were generally present in small numbers when observers arrived between 1-12 June. Males gathered in flocks of 2 to 6 on exposed Moist Sedge tundra and Dryas river terraces where elaborate courtship displays peaked

during the second week of June (Figs. 3, 15). Although buff-breasted sandpipers nested in all habitats in 1978-1985, they predominantly chose Moist Sedge or Dryas-prostrate shrub microsites near Flooded tundra or river drainages, or near small ponds associated with upland Mosaic and Moist Sedge-Shrub habitats (Figs. 3, 6, 12, 15, 17). All nests contained clutches of 4 eggs; at 3 nests where clutch completion and hatch dates were observed, an incubation period of 23 to 26 days was noted. Young capable of flight were observed at Aichilik on 13 July 1984, where observed hatching dates ranged from 5-20 July. In mid-July, single adults moved with chicks to Riparian habitat, snow-melt ponds, and Flooded tundra (Figs. 3, 6). Most adults were absent by early August and juveniles were infrequently observed singly or in small flocks along coastal wetlands and by lakes and rivers in early fall. Latest observation was of a single bird flying near the Okpilak River delta on 18 August 1982.

LONG-BILLED DOWITCHER - Uncommon breeder, fairly common summer resident, common fall migrant. Long-billed dowitchers were most abundant in Flooded habitats, and utilization of Wet Sedge and Mosaic habitat was less extensive (Figs. 6, 10, 12). This species arrived on the coastal plain during the first week in June, a few days later than other breeding shorebirds. Incubation was initiated in mid-June and nests were observed in Flooded, Wet Sedge, and Mosaic habitats (Figs. 6, 10, 12). Dowitcher nests were difficult to locate, but the defensive and agitated behavior of adults, frequently observed during late June, suggested that breeding pairs were more widespread than nest data indicated. Adults attended chicks in Flooded habitat where they foraged in saturated soils around pond peripheries. Adults left the breeding grounds in small flocks during late July. One month later, large cohesive flocks of juveniles surged eastward across the north slope; the largest influxes occurred along the outer coastal plain.

COMMON SNIPE - Rare summer resident and possible breeder. Common snipe were infrequently seen or heard in aerial display during June and early July at various locations. Two display sites at Katakturuk in 1983 were associated with Mosaic tundra in proximity to willow communities. A 1984 display site at Sadlerochit was also associated with Mosaic habitat. At the Aichilik bird camp, snipe were heard over Tussock and Moist Sedge-Shrub habitats during June 1984. Other observation areas included inland portions of the Sadlerochit and Okpilak Rivers, the confluence of Eagle Creek and the Canning River, Demarcation Point (Martin and Moitoret 1981), Barter Island, and Flooded habitat south of the Niguanak bird camp (Magoun and Robus 1977).

RED-NECKED PHALAROPE - Fairly common breeder. Red-necked phalarope distribution was closely associated with Flooded habitat (Fig. 6). Use of Wet Sedge, Mosaic, and Moist Sedge-Shrub was less frequent, apparently dependent on the presence of small ponds or troughs (Figs. 10, 12, 17). The smaller water bodies melted first, and were available for birds arriving in early June. As thawing continued, phalaropes dispersed into areas with more extensive, permanent lakes and ponds. Courtship began soon after arrival, and nests were constructed in sedge communities near permanent water. During the latter half of June, females left the breeding grounds in small groups that probably gathered along the coast. Density of females reached 500/km² at Canning Delta between 25 June and 12 July 1979 and 1980; the staging females diminished by 25 July in both years.

After the first week of July, eggs hatched and the males attended chicks in saturated sedge communities. Family groups of other shorebird species congregated in the wet habitats as well. Such habitats may have afforded the young shorebirds optimal food availability and cover from predators. Adults readily formed aggressive mixed-species flocks in response to intruders.

During late August, males and juveniles gathered in small flocks and joined migration movements along the coastline. On 6 and 8 September 1983, 16,425 red-necked and red phalaropes were observed within a 400 m wide aerial lagoon survey transect paralleling the northern coastline of ANWR. Phalaropes used littoral habitat extensively during late summer, and an east-west gradient in species composition has been reported (Martin and Moitoret 1981). West of ANWR at Barrow, red-necked phalaropes were rarely observed, while along the Yukon-Beaufort coast to the east, they outnumbered red phalaropes 20:1; more equal ratios of the phalarope species would be expected along the ANWR coast.

RED PHALAROPE - Fairly common coastal breeder; uncommon inland breeder. Red phalaropes occurred almost exclusively in Flooded tundra habitat, particularly in coastal areas (Fig. 6). The largest density of nesting red phalaropes observed on ANWR was at Canning Delta, the most extensive thaw-lake plain on the refuge (Martin and Moitoret 1981). Red phalaropes were fairly common breeders at Okpilak, another area of coastal thaw-lake plain. The few individuals observed at inland sites were also associated with extensively flooded areas.

Red phalaropes arrived in early June, and their courtship and nesting activities peaked during the latter half of June. Nest sites were common in Flooded habitat; however, Mosaic and Wet Sedge habitats were used at Okpilak in 1982, possibly due to the late spring that kept Flooded areas frozen (Figs. 6, 8, 10, 12). Density of red phalaropes in habitats other than Flooded was probably dependent on the presence of small ponds. Like the red-necked phalaropes, female red phalaropes grouped in small flocks, left the breeding grounds, and gathered on coastal mudflats and lagoons during early July. Males attended young in Flooded habitats through July, and they dispersed during the first half of August. The coastal thaw-lake plains of ANWR appear to be near the eastern limit of the red phalarope's breeding range, and reported evidence suggests that late summer staging occurs in areas further west (Connors and Risebrough 1977; Johnson and Richardson 1981, as cited by Martin and Moitoret 1981).

POMARINE JAEGER - Common spring migrant; locally rare to common breeder and summer visitant. Pomarine jaegers were seen as a common eastward spring migrant across the coastal plain with peak migration movement during the first week of June. They also moved through the eastern Brooks Range from late May through June and apparently timed visits at inland locations with the presence of migrating caribou concentrations. Pomarine, as well as parasitic and long-tailed jaegers, remained in these areas through most of June (probably to feed on caribou calf carcasses, Maher 1974).

The relationship between high lemming density and breeding by pomarine jaegers has been well documented (Pitelka et al. 1955, Maher 1974). Local breeding densities as high as 7.9/km² were documented at Barrow (Maher 1974). Until 1985, the only record of successful breeding by pomarine jaegers on ANWR was of 5 nests in the Beaufort Lagoon area during the high lemming year of 1976

(Martin 1976, cited in Martin and Moitoret 1981). Only 1 pomarine was sighted in the same area in 1974. In 1970, and from 1978-1984, pomarines were locally common spring migrants and summer visitants hunting in pairs or small groups over all habitat types. They were generally absent from the study areas by mid-July, presumably when microtine populations had declined (Andersson 1973). In 1985, a year of relatively high lemming abundance (Babcock 1976), pomarine jaegers were common to abundant breeders at wetter inland regions (Niguanak) and fairly common breeders in Flooded tundra along the outer coastal plain (Jago Delta, Okpilak). Although only 1 nest was located at Aichilik, pomarines probably bred in low densities along other inland Riparian areas in 1985 as well. Relatively high numbers of adults with fledged young were observed along the Niguanak and Tamayariak Rivers in late July when live-trapping surveys revealed moderate numbers of lemmings and tundra voles (Microtus oeconomus) (Babcock 1986).

Pomarine nests held clutches of 2 eggs and were located on high, dry hummocks or polygon ridges in Flooded and Wet Sedge habitats. Hatching dates ranged from 9-14 July. At Niguanak, adults brought downy chicks from nearby sites to the lake and smaller Flooded tundra ponds in a conspicuous movement soon after hatching.

Migrating adults were observed in early August moving and hunting singly or in small groups over Flooded and Wet Sedge habitats along the coastal plain. Local juveniles remained with adults in Flooded and Riparian tundra until late August. A large flock of adults and juveniles congregated at the lake by Niguanak on 29 and 30 August 1985.

PARASITIC JAEGER - Rare to uncommon breeder; fairly common summer resident. Parasitic jaegers were generally present as apparent residents on the coastal plain as singles, pairs, or small groups in early June. Little migrational movement was detected. As with other jaeger species, parasitics were observed in small flocks where caribou concentrated in foothills and fed on calf carcasses through mid-June.

Parasitic jaegers nested in low densities from 1982 to 1985 at coastal and inland locations. One and 2 nests were located in 1979 and 1980 respectively at Canning Delta. From 1982 to 1985, single nests were found at the coastal locations at Okpilak (1982, 1983), Sadlerochit (1983, probable 1984, 1985), and Jago Delta (1984), and at the inland site at Jago Bitty (1983). Highest numbers of nests were noted in 1985 at Jago Bitty and Jago Delta (2 and 3 nests respectively). At least 1 to 4 adults were observed hunting at all tundra bird camp locations from 1982-1985 throughout the breeding season, indicating more breeding pairs may have existed than were observed. Parasitic jaegers generally nested on drier sedge or moss hummocks in Wet Sedge and Moist Sedge habitats and less often in Moist Sedge-Shrub and Flooded tundra (Fig. 10). During incubation and early brood rearing, parasitic jaegers were the most aggressive species observed, often flying after snowy owls, glaucous gulls, other jaegers, arctic foxes, and humans when the intruders were greater than 0.5 km away from parasitic jaeger nests. Hatching of 2 egg clutches ranged from 30 June through 12 July. Unlike pomarine jaegers, parasitics did not move young to wetter habitats after hatching and young remained with adults in the vicinity of the nest site until fledged.

Adults ranged over all habitats to hunt through June and early July, but became increasingly conspicuous predators on birds in Riparian, Flooded, and

Moist Sedge-Shrub tundra after hatching and juvenile movements of most species had occurred (Figs. 3, 6, 17). Prey ranged in size from Lapland longspur (the most frequently observed prey item) to pectoral sandpiper and juvenile ptarmigan. Pairs hunted together knocking prey to ground as a team and were highly efficient through July and early August. At Sadlerochit, adults captured up to 10 longspur juveniles in 1 day over Riparian habitat, carrying each back to almost fledged young.

Young fledged in the first week of August and remained in the area, hunting as a family group for up to 2 weeks longer. Through late August small groups of juveniles and adults congregated in Riparian, Flooded, and coastal wetland areas. Latest observation was at Okpilak on 23 August 1982.

LONG-TAILED JAEGER - Fairly common spring migrant and common summer resident; uncommon to fairly common breeder. The earliest coastal observations of long-tailed jaegers were on 31 May 1985 at Sadlerochit. No conspicuous migrational movement was seen; birds were present at most locations in early June, hunting over all habitats as singles, pairs, and in groups of 3 to 10. Like pomarine jaegers, the diet of breeding birds was composed mostly of microtine rodents throughout the season and the breeding effort in a specific year was possibly related to lemming and vole abundance.

Higher densities of nesting long-tailed jaegers and spring transients were noted at inland locations. Highest numbers of nests were recorded in 1985, a relatively high lemming year, when 13 were found at the 5 inland locations. Highest numbers were observed at Jago Bitty (6 nests) and Marsh Creek (4 nests). Numbers of nesting long-tailed jaegers were also highest on the outer coastal plain in 1985 when 5 nests were recorded at 3 locations. Only 3 nests were found in 1984: 1 nest at Jago Delta and 2 at Sadlerochit. No nests were recorded between 1978 and 1983.

Of the 3 jaeger species, long-tailed jaegers nested in drier and frequently more upland habitats. Nest sites were predominantly on Dryas-prostrate shrub and Riparian terraces, and fewer were located on prostrate shrub or moss hummocks in Wet Sedge, Moist Sedge, Moist Sedge-Shrub, and Tussock tundra (Figs. 3, 10, 15, 17, 21). Hatching dates of 1 to 2 egg clutches were generally from 3-10 July; the earliest date was recorded at Jago Bitty on 29 June 1985 and the latest was at Aichilik on 18 July 1985.

Occasionally, large flocks were seen in mid-season on the coastal plain: a flock of 50 was seen near the Kongakut River on 2 July 1970 (Andersson 1973) and several flocks of 20-200 were observed on the Aichilik River on 20 July 1974 (P. Martin pers. comm.) and 24 June 1984. A group of 50 hunted over the Sadlerochit River from 3-7 July 1985, coinciding with and possibly related to a large insect emergence. Maher (1974) found that insects were a major component of the diet of non-breeding birds. During August, at coastal and inland locations, small adult groups and adults with fledged young were observed hunting over coastal wetlands, Riparian habitats, and drier, upland tundra. Latest observation was on 28 August 1985 of a single adult flying over Jago Delta.

BONAPARTE'S GULL - Uncommon breeder in south slope wetlands; casual visitor to north slope (Spindler 1984b).

MEW GULL - Rare spring migrant and summer visitant on coastal plain; probable rare breeder in foothills south of coastal plain. Earliest observation was on 7 June 1984 when a mew gull harassed several glaucous gulls over the Aichilik River. One or 2 mew gulls were regularly seen in Riparian habitat at Aichilik through July in 1984 and 1985, and a nest was suspected there on a river gravel bar in both years. Small flocks and single gulls were sighted over lagoons and Riparian areas near the coast on 12 occasions from 1981-1985. Seven sightings were made in early to mid-June, 3 during July, and 2 in early August; the latest observation occurred on 5 August 1984.

HERRING/THAYER'S GULL - Rare migrant and summer visitant. Herring/Thayer's gulls were recorded on 8 occasions at Canning Delta from 28 May through 4 September in 1979 and 1980. During the 1982-1985 period, single gulls were observed flying or hunting over Flooded, Riparian, and Mosaic habitats on 7 occasions at coastal sites and on 5 occasions along river drainages at inland locations. All observations were during late May or in June, except 1 sighting at Simpson Cove during an aerial lagoon survey on 10 August 1983.

SLATY-BACKED GULL - Casual summer visitant. The only records of slaty-backed gulls on the ANWR coastal plain occurred in 1985 at Sadlerochit. On 3 July an adult hunted along the river 1 km inland from the coast with a flock of 20 glaucous gulls and 30 long-tailed jaegers. A dark plumaged first-year bird was observed flying along the coast by Anderson Spit on 19 July.

GLAUCOUS GULL - Common breeder and common to abundant migrant on outer coastal plain; uncommon summer resident and probable breeder inland. Glaucous gulls arrived early in the spring on the Beaufort Sea coast. Jacobson (in Spindler 1978a) reported an early arrival date of 8 May 1978 at Kaktovik on Barter Island. On 23 May 1980, 380-400 gulls were present in Kaktovik feeding on whale carcasses left by villagers from the autumn hunt (Martin and Moitoret 1981). No conspicuous migration movements were noted, but gulls were present at all coastal locations in early June with scattered observations of small groups heading eastward. They fed in flocks of up to 30 in lagoons and flew widely over Riparian and Flooded habitats. Through June and July, numbers along rivers dwindled, but large flocks continued to swim and feed in lagoons and along shoals. Inland, gulls were uncommon spring visitants, although from 1 to 4 were seen regularly through mid-August at Aichilik in 1984 and 1985, and a nest was suspected in Riparian habitat at Aichilik.

Glaucous gulls nested singly or in loose colonies, sometimes in close proximity to flocks of non-breeding adults. Glaucous gull nests were found exclusively at coastal sites, with the highest number recorded at Okpilak in 1978 (14 nests). A colony of 8 nests was found at the "ruins" near Tapkaurak Lagoon in 1985. Nest sites were typically on mounds or islets in Flooded tundra and on raised mudflats at river mouths. A nest was also suspected on a gravel bar along the Sadlerochit River near the coast in 1984 and 1985. All nests contained clutches of 2 eggs. Known hatching dates were on 17 and 30 July 1980 at Canning Delta, but downy chicks were reported near nest sites on 4 July 1985 at Sadlerochit, and on 11 July 1984 at Jago Delta.

Adults stayed with young close to nest sites in Flooded tundra and along mudflats through July. Juveniles were frequently observed in early fall among larger flocks of adults along the coast. Numbers of glaucous gulls increased in lagoons through August, with a peak number of 307 gulls recorded at Jago

Lagoon on 24 August 1983. At this time, much of their flying consisted of local movements, but a predominantly westward direction was noted in early September.

BLACK-LEGGED KITTIWAKE - Rare migrant. Black-legged kittiwakes occurred commonly in migration at Barrow (Bailey 1948), but were only recorded in 1980 and 1983 along the ANWR coast. A large westward movement of gulls, terns, loons, jaegers, and waterfowl was observed at Brownlow Point on 29-30 August 1980 after severe winds during a storm. Hundreds of adult kittiwakes in flocks of up to 30 were among these birds. A peak movement came through on 1 September when 438 were counted in 7 h of observations, and an estimated 2000 kittiwakes flew west past Brownlow Point during 1-3 September. On 10 August 1983 a rare inland sighting was recorded of an immature kittiwake flying over Jago Bitty camp. The only documentation of kittiwakes during 1981-1985 aerial lagoon surveys also occurred in 1983 when 5 were counted in Brownlow Lagoon.

ROSS' GULL - Casual migrant. First recorded on ANWR on 2 June 1985 when 1 bird flew southwest along the coast near the Okpilak River delta. A flock of 10 Ross' gulls was observed during an aerial lagoon survey near the Hulahula River delta on 15 August 1985.

SABINE'S GULL - Uncommon breeder and migrant. Date of earliest observation was on 31 May 1979 at Canning Delta. Sabine's gulls were infrequently seen at all coastal locations as singles, pairs, and small flocks flying east along the coast during the migration period. Most observations of Sabine's gulls were in June along the outer coastal plain where they were seen in a variety of habitats, especially around estuaries, lagoons, and tundra lakes.

Sabine's gulls bred at Canning Delta where 3 nesting colonies and a total of 9 nests were located in 1979 and 1980. At least 2 of these colonies had active nesting pairs each year. All nests were located on islands in lakes surrounded by deep water. Hatching was observed from 8-19 July and the first fledgling gulls were seen on 19 July, indicating considerable asynchrony in nesting. In July and August, Sabine's gulls were seen regularly in small numbers on Canning Delta shoreline transects, but no large flocks were recorded. Single Sabine's gulls were observed only rarely east of the Canning Delta during aerial lagoon surveys in 1981-1985. On 6-8 September 1983, 408 were observed along a 400 m wide offshore transect. Flocks of 78 and 174 were recorded in Oruktalik Lagoon and Egaksrak Lagoon respectively, both on the eastern portion of the ANWR coast.

IVORY GULL - Rare migrant along arctic coast (Spindler 1984b).

ARCTIC TERN - Fairly common migrant and summer visitant; fairly common breeder on barrier islands, and rare breeder on inland coastal plain. Small flocks of up to 12 birds were seen infrequently along the coast flying eastward during the first week of June. Along the outer coastal plain, singles, pairs and small flocks of terns were observed at least weekly through June and July foraging over lagoons, small lakes and rivers. Highest numbers of nesting terns were reported at Canning Delta in 1979 and 1980. Here they bred primarily on gravel beaches of the barrier islands and spits, but also on islands in lakes and on river gravel bars. Terns may have bred along the coast east of Canning Delta, but only 1 nest was located at Sadlerochit in 1985. Inland, terns were primarily rare to uncommon visitants associated with lakes and larger river drainages. A brood of 2 chicks defended by 3

adults was observed by a large lake 11 km northeast of Jago Bitty camp in 1983. Clutches of 1 to 2 eggs were laid in scrapes on the bare ground and incubation began as early as 17 June at Canning Delta. Known hatching dates were in early July, and first fledged juveniles were seen in mid-August.

Terns gathered in flocks during August to feed in lagoons, and a flock of 90 adults and juveniles recorded at Jago River delta on 30 August 1985. Generally, no migration movement or direction was determined, but after high storm winds an estimated 1400 arctic terns flew westward over Brownlow Point during 1-2 September 1980.

MURRE SPP. - Rare migrant. Three unidentified murre were seen flying west past Brownlow Point on 1 September 1980. Nearest breeding colonies of thick-billed murre are at Cape Parry on the Parry Peninsula, Northwest Territories, (Johnson et al. 1975) and at Cape Lisburne in the Chukchi Sea (Sowls et al. 1978b).

BLACK GUILLEMOT - Rare breeder; uncommon migrant and summer visitant. One or 2 black guillemots were recorded on 7 dates during August 1979 in the sea off Brownlow Point. First seen in Brownlow Lagoon on 17 June 1980, they were observed frequently in this area throughout the summer. A pair nested in a half-buried oil drum on a barrier island east of Brownlow Lagoon reef where up to 9 guillemots at a time (28 July) were seen through the season. Elsewhere on the outer coastal plain, 2 guillemots were observed on a barrier island spit at Anderson Point (Sadlerochit) on 29 July 1983 and 2 were observed on 22 July 1985 near the barrier island of Tapkaurak Lagoon. From 1982-1985, guillemots were seen infrequently during August and September aerial lagoon surveys, with a peak of 17 observed on 4 August 1983 along a 400 m wide offshore transect.

HORNED PUFFIN - Casual visitant. One was seen flying low along the beach in a westward direction past Brownlow Point on 1 September 1980. This sighting coincided with sightings of murre and kittiwakes, all probably related to storm winds during the previous 2 days. The nearest major breeding colony is at Cape Lisburne (Sowls et al. 1978), but numerous sightings were made from 1976-1980 at black guillemot nesting colonies on Seahorse Island, Deadman Island, and Cooper Island (Divoky and McElroy 1980, as cited in Martin and Moitoret 1981).

SNOWY OWL - Rare visitant in years of low lemming populations; uncommon breeder and common summer resident on outer coastal plain during years of higher lemming densities. High fluctuations in snowy owl abundance were noted on the ANWR outer coastal plain from 1976 through 1985; in all years snowy owls were rarely observed at inland locations.

In 1976, a relatively high lemming year, 2 nests were located near Beaufort Lagoon and owls were regularly observed along the coast. From 1 to 5 owls were summer residents at Okpilak in 1978 and an estimated 0.1 owl/km² was found during coastal aerial surveys (Spindler 1978b). Several owls were sighted regularly through the season at Canning Delta in 1980, but no nests were discovered. Owls apparently increased in the Okpilak area in 1982 and approximately 1.0-2.5 owls/km² were estimated along coast. In contrast, only 1 and 4 sightings of owls were reported at coastal sites during the 1983 and 1984 seasons, respectively. In 1985, a year of relatively high lemming abundance, owls were resident on ANWR by the last week in May. Two to 5

adults and immatures were observed daily at coastal locations from June through August. Most of these appeared to be non-breeders. Snowy owls primarily hunted in Mosaic, Flooded, Wet Sedge, and Moist Sedge-Shrub habitats from bluff, hummock, polygon ridge, and driftwood perches. A small influx of visiting owls occurred in mid-July. Observed frequency of hunting owls increased in Riparian areas coinciding with the emergence of arctic ground squirrel young (Spermophilus parryii) from burrows.

Two nests were found in 1985, 1 in Wet Sedge habitat at Jago Delta and 1 near the lake at Niguanak. Young hatched by approximately 15 June at Niguanak and in mid-July on the coast. Fledging occurred from 16-18 August at Jago Delta and young were observed with adults in Flooded tundra throughout the end of August. A few adult owls were still present on Barter Island after the first snows of the season on 11 September.

SHORT-EARED OWL - Common inland breeder and fairly common coastal breeder in years of high lemming densities; rare spring visitant on inland coastal plain and rare migrant along coast in years of low lemming densities. Use of the ANWR coastal plain by short-eared owls appeared to be cyclic and probably was greatly influenced by fluctuating lemming and vole populations. Owls were most commonly seen hunting in Moist Sedge-Shrub, Riparian, Wet Sedge, and Flooded habitats in 1985, but were observed flying over all habitats in 1982-1984. Nests were most commonly found in Riparian zones in Moist Sedge-Shrub, Wet Sedge, or Wet Sedge with willow microhabitats. Clutch size ranged from 2 to 7 and averaged 5.45 (n=7). Clutches were generally completed during the first and second weeks of June. Reported incubation period is 24-28 days (Harrison 1978).

COMMON NIGHTHAWK - Casual visitant (Spindler 1984b).

EMPIDONAX SPP. - Accidental visitant. An unidentified Empidonax flycatcher was found dead on 17 June 1979 along the bluffs on the east shore of Flaxman Lagoon (Martin and Moitoret 1981).

SAY'S PHOEBE - Casual visitant, accidental fall migrant. One bird was seen in mid-August 1983 along a coastal bluff at Arey Lagoon near Okpilak. Observations have also been made along the Aichilik and the mid- and upper Kongakut Rivers (Kessel and Gibson 1978).

EASTERN KINGBIRD - Accidental visitant to north slope (Spindler 1984b).

HORNED LARK - Rare inland breeder and visitant; casual coastal visitant. A pair with 1 fledgling was seen on 20 June on the creek bluff 3 km south of Marsh Creek camp in 1985. A nest was suspected to be present in willows on a south facing slope of VABM Bitty in 1982. Other observations were made at Aichilik camp in June 1985, Katakturuk camp in June 1983, and Demarcation Point in June 1978 (D. Troy pers. comm. in Martin and Moitoret 1981).

VIOLET-GREEN SWALLOW - Accidental spring migrant. A single specimen was found dead in Kaktovik in late May 1985.

BANK SWALLOW - Casual migrant. Three birds were seen flying over a large lake south of Tapkaurak Lagoon near Jago Delta camp in 1985. A bird was observed along the Canning River in 1975 (Kessel and Gibson 1978).

CLIFF SWALLOW - Rare spring migrant and breeder on the north slope of Brooks Range. Cliff swallows were reported nesting on the Kongakut, Aichilik, and Canning rivers (Kessel and Gibson 1978).

BARN SWALLOW - Casual visitant. Two birds were seen at Jago Delta in late June 1985, 1 in late June 1984 at Aichilik, and 1 in mid-June 1983 at Okpilak Delta. Kessel and Gibson (1978) reported an observation on Barter Island in 1975.

GRAY JAY - Accidental. One bird was observed on 22 July 1978 in Kaktovik (Spindler 1978a).

COMMON RAVEN - Uncommon resident. Ravens were infrequently seen at all study sites as single birds or in flocks of 2 to 4 flying over all habitats. They were most commonly seen hunting over Riparian habitats where they were often mobbed by shorebirds. During the breeding season they were often mobbed by nesting jaegers.

AMERICAN DIPPER - Uncommon breeder and resident at Sadlerochit Springs (Spindler 1984b).

BLUETHROAT - Locally rare migrant and breeder in uplands and foothills (Kessel and Gibson 1978).

NORTHERN WHEATEAR - Rare visitant on inland coastal plain. Observations were made in mid- to late August 1985 at Niguanak, Marsh Creek, and Aichilik.

GRAY CHEEKED THRUSH - Casual visitant. Birds were seen in tall willows on Eagle Creek in 1972 (Valkenburg et al. 1972) and in June 1979 on Brownlow Point.

HERMIT THRUSH - Accidental. A single male was heard and seen in a willow thicket from 3-19 July 1985 at Marsh Creek.

AMERICAN ROBIN - Casual summer visitant on inland coastal plain. Several observations of single birds were made at Katakturuk in 1983 and 1985. Several birds were seen between the Sadlerochit and Shublik mountains in 1983.

VARIED THRUSH - Accidental visitant. Observations were made at Aichilik in 1985, Sadlerochit Springs in May 1979 (Robus 1979, in Martin and Moitoret 1981), and Demarcation Point in May 1979 (Burgess 1980, in Martin and Moitoret 1981).

YELLOW WAGTAIL - Locally rare to fairly common breeder. Presence and density of wagtails appeared to be correlated with Riparian habitat and increasing willow height, with bird densities typically higher on the inland coastal plain in areas with taller willows, but fluctuating annually (Figs. 17, 21). Wagtails were also seen less commonly and at generally lower densities in Moist Sedge-Shrub and Tussock habitats. Nests were extremely difficult to detect. Two nests were found: 1 was in a willow root ball in Riparian habitat, contained 6 eggs and hatched on approximately 23 June 1985; the other was in Tussock habitat, contained 5 eggs and hatched on 29 or 30 June 1983.

WATER PIPIT - Rare breeder across coastal plain; fairly common inland fall migrant. Breeding water pipits were observed at Okpilak Delta in 1978. Breeding probably occurred at Jago Bitty in 1982 and 1985. Pipits were also seen on the Canning Delta in 1979 and 1980.

CEDAR WAXWING - Accidental visitant. Two waxwings were seen in shrub thickets on the south side of Jago Bitty 11 km south of camp on 2 July 1983.

NORTHERN SHRIKE - Rare visitant and possible breeder on inner coastal plain. One bird was observed in Riparian habitat at the gorge 27 km south of Katakturuk camp in late July 1983. Shrikes were possible breeders 14 km south of Jago Bitty camp on 24 July 1983, and a nest was found at Peters Lake in late May 1985.

ORANGE-CROWNED WARBLER - Accidental migrant. One bird was seen on a bluff along Flaxman Lagoon shoreline in May 1980.

YELLOW WARBLER - Casual coastal visitant; probable rare inland breeder. Single birds including a singing male were seen or heard in willow thickets in mid-June at Jago Bitty in 1985 and Katakturuk in 1983. A single bird was seen on the Canning Delta in 1979. Martin (1976) observed 1 adult with young fledglings along the Kongakut River in 1976.

WILSON'S WARBLER - Casual fall migrant. A single female was seen in Riparian willows in August 1984.

AMERICAN TREE SPARROW - Locally rare to fairly common inland breeder. Tree sparrows were most commonly seen in erect willows on hillsides and along inland river drainages (Fig. 3). Nests were on the ground under willows in Riparian habitats (Fig. 3). Clutch sizes were of 4-5 eggs and hatching occurred in late June to early July, and the normal nestling period was 9-10 days (Harrison 1978). Tree sparrows occurred as a casual fall migrant at Sadlerochit in 1984 and were generally absent from the coastal plain by late August.

CHIPPING SPARROW - Casual summer visitant. A single singing male was observed in a willow in Riparian habitat at Katakturuk on 23 June 1983.

SAVANNAH SPARROW - Locally uncommon to fairly common breeder. Overall highest densities in 1985 were at inland locations in Riparian habitat with erect willows (Fig. 3). However, highest densities at any location were observed in Wet Sedge plots at Sadlerochit, where habitat was highly interspersed with Moist Sedge willow stands (Figs. 10 and 15). Savannah sparrows were probable, although uncommon, breeders and rare fall visitors in 1982; they were observed most often in Tussock tundra and occasionally in Riparian and Moist Sedge-Shrub habitats (Figs. 3, 17, 21).

Earliest recorded arrival of savannah sparrows was on 1 June 1983, at an inland site. Nests were usually found in Riparian (most locations) and Wet Sedge (Sadlerochit) habitat types (Figs. 3, 10). Savannah sparrow nests were generally on the ground in dense sedge-willow vegetation. First hatching was observed on 26 June in 1983, 16 June in 1984, approximately 24 June 1985. Clutch size ranged from 4 to 6 eggs (1982-1985). Fledging was probably completed by the second week in July.

One bird was seen standing at the high tide line at Tapkaurak Lagoon on 2 August 1984. Last dates of observation were 17 August 1984, 15 August 1983, and 25 August 1982.

CLAY-COLORED SPARROW - Accidental visitant. A single male was observed singing in late June from a willow perch in Riparian habitat at Marsh Creek in 1985.

FOX SPARROW - Casual coastal summer visitant; rare summer resident and possible breeder on inland coastal plain. A pair was seen 10 km south of Jago Bitty camp in willow on a south facing slope in 1983. A single bird was seen at Okpilak Delta in late June 1982.

WHITE-THROATED SPARROW - Accidental visitant. One bird was seen from 9-28 August at Brownlow Point in 1979 or 1980.

WHITE-CROWNED SPARROW - Locally rare to fairly common inland breeder. White-crowned sparrows probably bred at Katakturuk in 1983 and 1985, but were absent in 1982. They were locally rare visitant or summer residents at Jago Bitty in 1983 and 1985, respectively, and rare spring visitors at Niguanak in 1985. Nests were found at Marsh Creek in 1985.

White-crowned sparrows were largely restricted to medium height (approximately 1 m) and taller willow stands in Riparian habitat or on hillsides. Nests, which were on the ground in willow thickets and contained 4 to 5 eggs, hatched in late June or early July. The incubation period was 9-15 days with a nestling period of 9-11 days (Harrison 1978).

DARK-EYED JUNCO - Rare migrant. From 1 to 5 were seen daily in the mid-Kongakut River valley in early August 1976 (Martin and Moitoret 1981). Juncos were also seen on Brownlow Point in August 1979 and June 1980.

LAPLAND LONGSPUR - Abundant breeder. Lapland longspurs were commonly found in all habitats and were usually present upon arrival of observers in early June. Habitats of highest longspur density varied among locations within years and within locations among years. No preference was apparent in observed bird or nest densities for coastal or inland locations. The highest densities of longspurs were generally found in drier upland (Mosaic, Moist Sedge-Shrub, and Tussock) and Riparian habitats within each location (Figs. 3, 12, 17, 21). However, the lower density habitats at some locations at times had higher densities of longspurs than the highest density habitats at other locations.

Males were displaying when observers arrived in early June and continued until late June or early July. During the breeding season, Riparian habitat often had the highest number of longspurs, yet the lowest number of nests (Fig. 3). The greatest nest densities were generally in Moist Sedge-Shrub, Tussock, Mosaic, or Moist Sedge habitats (Figs. 12, 15, 17, 21). Nests were often located on the south side of tussocks or polygon rims and were virtually always lined with white ptarmigan feathers. Nests generally contained 5 eggs which began hatching the third week in June (fourth week in 1982). "Helper" males often assisted the parent longspurs in feeding the chicks. One of the males (suspected to be the helper) often began molting into winter plumage prior to the other male. Most young were fledged by the end of the second

week in July. Some shifts in habitat use (primarily toward wetter communities) occurred during late July and early August at some locations, but the general trend was for densities to remain in similar proportions among the habitats. Numbers declined at most localities during the latter half of August, and flocks of 20 to 30 birds (mostly juveniles) were seen along the coast. A few longspurs remained at all locations until the termination of observations on 18 August 1985 (1 September at Niguanak and Jago Delta).

SMITH'S LONGSPUR - Rare visitant. Single birds were seen in June and August 1985 near Okpilak Delta, at Jago Bitty in July, and Katakturuk in June and August 1983. Kessel and Gibson (1978) reported sightings from Aichilik, Kongakut, Hulahula, and Canning drainages.

SNOW BUNTING - Locally common breeder. Snow buntings commonly nested on Barter Island and probably were present along the entire coast, nesting in drift material or man-made structures (Martin and Moitoret 1981). They were also observed in the foothills in a Riparian area 35 km south of Jago Bitty in 1983 and above 600 m in the Sadlerochit Mountains. Snow buntings arrived on the coast at Kaktovik as early as mid-April (Spindler 1978a) and left in migration as late as the second week in September (Martin and Moitoret 1981).

RED-WINGED BLACKBIRD - Casual visitant. Two males were observed in a willow thicket at the mouth of Okpirourak Creek near Jago Bitty on 22 June 1985.

RUSTY BLACKBIRD - Casual migrant. One bird was seen in June 1980 on Brownlow Point.

BROWN-HEADED COWBIRD - Accidental visitant (Spindler 1984b).

REDPOLL - Locally rare to abundant breeder. Generally more common inland where willows have more height and density than those nearer the coast. Redpolls were usually present on the tundra when observers arrived in the first week of June at inland sites, and 1 to 2 weeks later at sites along the coast. Nests were most commonly found elevated in willows (Fig. 3). Clutch size in 1982-1985 was generally 4 to 5. First hatching at inland locations ranged from 18 to 19 June (1982-85) and from 26 June to 10 July (1982-85) at coastal sites. Young were fledged by mid-July in most years, late July in late years. Redpolls were most common in Riparian habitat and were often seen in flocks of 2 to 8 from mid-June until migration (Fig. 3). Redpolls sometimes were observed with yellow "bibs" which resulted from a dusting of yellow pollen while feeding on insects in willow catkins (Miller et al. 1985). Densities of redpolls declined rapidly in late summer and the last sightings varied annually: 26 August in 1982, 11-16 August in 1983, 16 July in 1984.

PINE SISKIN - Rare visitant (Spindler 1984b).

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Chapter 5

MAMMALS

This chapter presents information on mammalian species that occur within the ANWR study area and adjacent marine environments. Information is presented by species or species groups and each section includes a data gap 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 and microtine rodents) are discussed as groups.

Caribou (Rangifer tarandus granti)

Early biological studies of caribou in Alaska (Nelson and True 1887, Murie 1935) and Canada (Clarke 1940) 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 in the late 1960's and early 1970's, and plans were made for industrial development in the arctic, the welfare of large herds of barren ground caribou became an issue of concern. As a result, major investigations were undertaken by government and industry. In 1970 caribou studies were initiated in northeastern Alaska and northern Yukon Territory by Renewable Resources Consulting Services Limited (under contract with Canadian and Alaskan Arctic Gas Studies) and Interdisciplinary Systems Limited (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 indepth 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 1975-1977, while government efforts have continued to the present time. Studies of calving distribution, productivity, neonatal mortality, summer, fall, and winter distribution, and mortality of the Porcupine herd (PH) were conducted during 1982-1985 as part of the 1002 baseline study program.

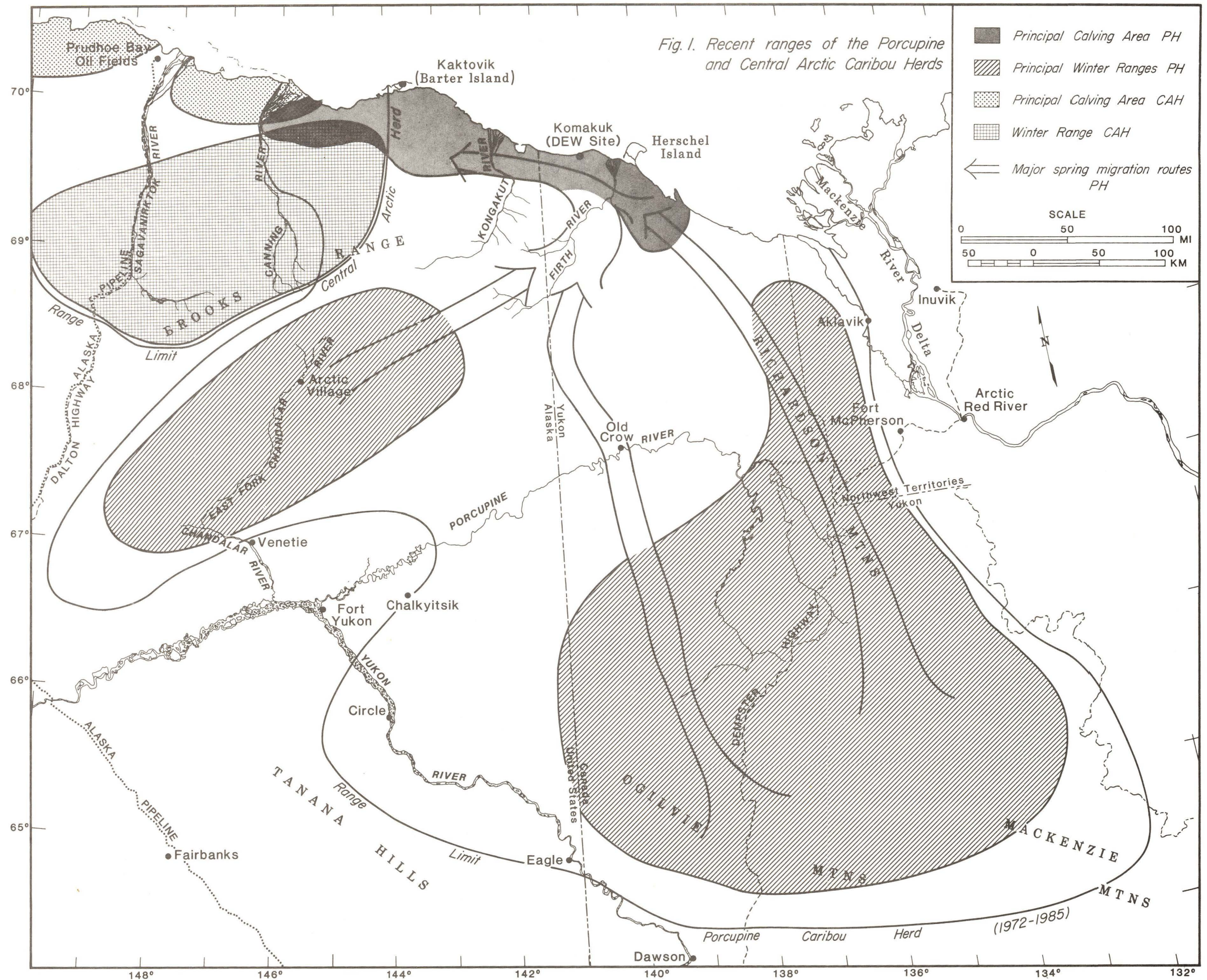
As a result of these studies, considerable information on caribou in the region of the ANWR study area has been collected. Of particular significance is the historical analysis provided by Skoog (1968) and further historical examinations by Kevan (1970) and LeResche (1975). Updates on the distribution and movements of Alaskan caribou are provided by Hemming (1971) and Davis (1980). Much of the recent literature on the PH has been assembled by Calef (1974), Curatolo and Roseneau (1977), Thompson and Roseneau (1978), Davis (1978 and 1980), Kelsall and Klein (1979), LeBlond (1979), and U.S. Department of State (1980). Kelsall and Bisdee (1980)

compiled an extensive annotated bibliography featuring 682 cross-referenced entries on the PH and related references. A popular description of the life history and ecology of caribou has been recently completed by Calef (1981).

Current or recent investigations of the PH have focused on the following topics: energetics of spring migration (Duquette 1984), bioenergetics/modelling (Fancy 1986), winter activity patterns and foraging behavior (Russell and Martell 1985), calving habitat utilization and activity patterns (Martell in prep), distribution and habitat use by male caribou during spring/summer (Martell et al. in press), neonatal mortality on calving grounds and post-calving areas (Mauer et al. 1983, Whitten et al. 1984, 1985a, 1986a), winter distribution and mortality (Whitten et al. 1985b and 1986b, Russell and Nixon 1986), abundance/distribution of parasitic insects (Pank et al. 1984, 1985, 1986), response of post-calving caribou to insect harassment (Nixon-ongoing), post-calving movements/ecology (Russell-ongoing), evaluation of satellite telemetry for the study of caribou ecology (Pank and Regelin 1985, ongoing).

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). Use of caribou by early Inupiat Eskimos on the arctic coastal plain and foothills has also been documented (MacNeish 1956).

The first written references of caribou in the ANWR study area are those of Franklin's exploration of the arctic coast of northeastern Alaska in 1825-1827 (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) surmised that the northeastern Alaska-northern Yukon Territory caribou were at a high level prior to 1900, but shifted their range away from the arctic coast and more to the west in the early 1900's. Caribou from the McKinley and Forty-mile 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 Forty-mile herd may have occurred in 1964, but it was not determined if a permanent emigration had occurred (Skoog 1968). Although these early accounts summarized by Skoog (1968) are sketchy and accurate population estimates were not available, 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 1975, Calef 1974, Roseneau et al. 1974). This population of caribou is called the Porcupine herd in reference to its semi-annual crossing of the Porcupine River. Caribou herds or populations are currently defined as any group of caribou that traditionally calve in an area that is distinct from other groups (Skoog 1968). Currently 2 caribou herds, the PH and the central arctic herd (CAH) use the ANWR study area during various periods of the year (Fig. 1).



Porcupine Herd

Range, Distribution, and Movements

The PH currently numbers about 165,000 individuals (Whitten 1986) and ranges over an area of about 250,000 km² (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 of the PH begins with a gradual drift of caribou toward the northern limits of their wintering areas (Calef 1974). The onset and progression of spring migration appears to be influenced by weather, snow conditions and the advancing pregnancy of the adult females (Pruitt 1959, Henshaw 1968, Duquette 1984, Whitten et al. 1984a, 1985a, 1986a). Routes of travel are related to topography, snow conditions, winter distributions, and tradition (Thompson 1978).

Three major spring migration routes of the PH have been identified: the Richardson, Old Crow, and Brooks Range routes (Fig. 1). The Richardson route runs through the Richardson, Barn, and British Mountain ranges of northwestern Canada and is usually used by caribou that have wintered in the Richardson Mountains or the Peel River basin of the Yukon and Northwest Territories (Calef 1974, Roseneau et al. 1974, Roseneau and Curatolo 1976). Caribou that winter in the Ogilvie Mountains (Hart, Ogilvie, Blackstone, Tatonduk, and Kandik River drainages) migrate north via the Old Crow route through the Keele Mountains, cross the Porcupine River in the vicinity of Old Crow, and continue north through the Old Crow Flats and uplands west of the Old Crow Flats, and over the British Mountains in to the Firth River valley (Roseneau et al. 1974, Roseneau and Curatolo 1976). Caribou that winter in the Arctic Village - Chandalar Lake area of Alaska migrate northeast along the Brooks Range route, 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 and Richardson routes (Roseneau et al. 1974, Roseneau and Stern 1974a, 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). Considerable annual variation occurs within each migration route as to the exact route followed by migrating caribou (Thompson 1978).

Spring migrations generally are in 2 phases, with groups comprised predominately of pregnant females moving first, followed by groups comprised of mainly juveniles and bulls (Kelsall 1968). Typically, the first movement of caribou traveling the Richardson route may reach the Blow River on the arctic coast by mid- to late May, whereas the second movement is just beginning to cross the Peel River at this time (Thompson 1978). Similar time-space relationships occur during spring migration on the Old Crow and Brooks Range routes. During the early phase of spring migration the pregnant females typically move in long, single-file lines, tending to follow wind-swept ridges and frozen lakes and rivers where travelling is usually less difficult and predators are more easily detected (Kelsall 1968, Thompson 1978). Deviations into snow filled valleys and over seemingly more difficult terrain can occasionally occur.

The average walking rate (approximately 4.0 km/h) and average daily net movement rate (approximately 7-8 km/24 h) of migrating females of the PH appear to be fairly constant throughout much of the spring migration (Duquette 1984). As the migration progresses across the arctic foothills (where snow conditions are often improved over those encountered during early migration south of the mountains), a maximum net movement rate of 25 km/24h is often sustained over several days resulting in a final rapid movement to the calving grounds (Whitten et al. 1985a). The spring migration of males and juveniles of the PH is more deliberate and appears to be influenced by phenology of vegetation and social factors (Martell et al. in press).

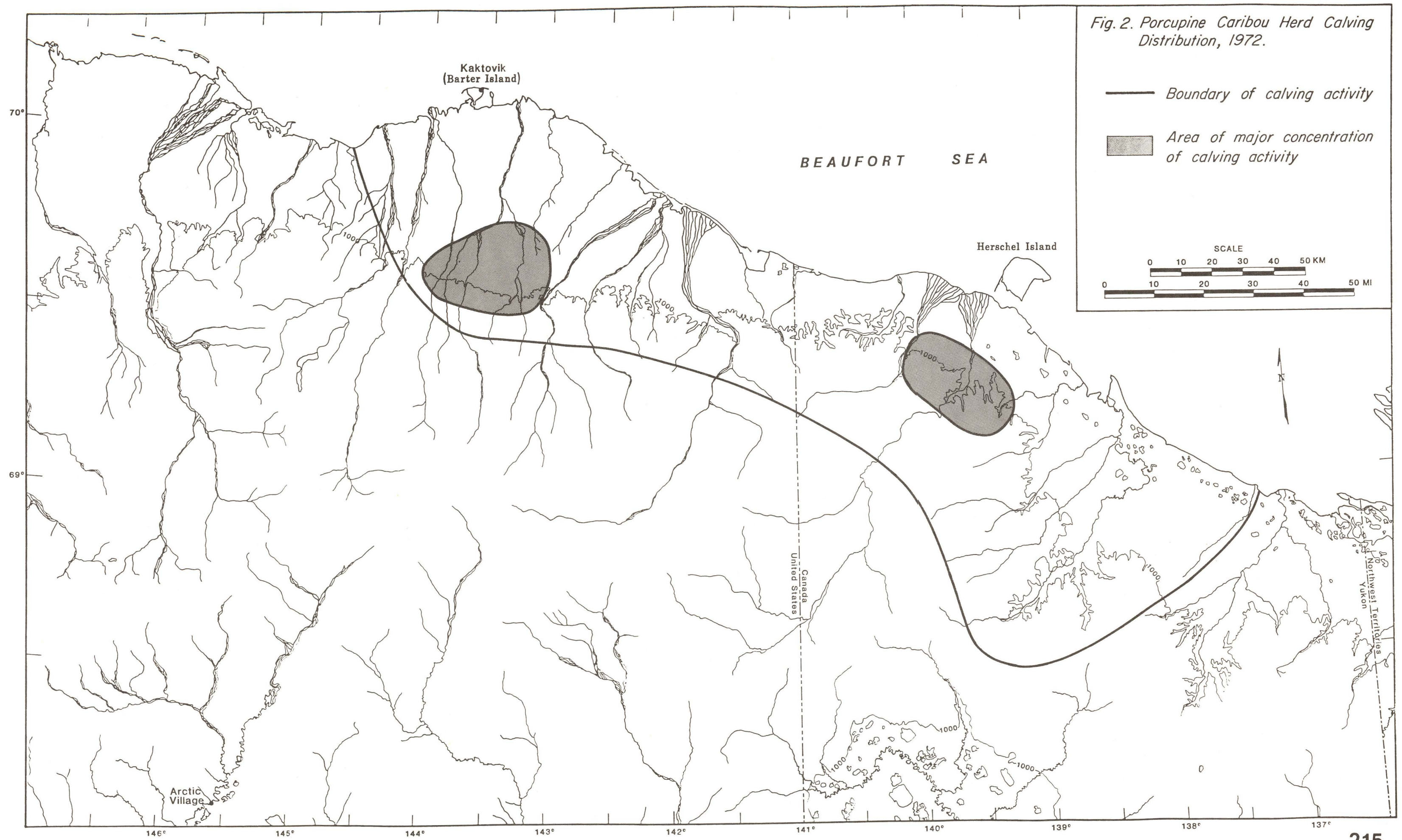
Calving. The calving grounds of the PH are international in scope, extending along the arctic foothills (up to 1,100 m elevation) and arctic coastal plain to the Beaufort Sea coast from approximately the Babbage River in Canada to the Canning River in Alaska (Fig. 1). Over the past 14 years in which similar data have been collected, substantial variation in distributions of calving within this overall area has occurred. Distributions of calving for the PH from 1972 through 1985 are presented in sequential order in Figs. 2-15. Factors such as the location of winter distributions, weather and snow conditions encountered enroute to the calving grounds, and the snow-melt pattern on the calving grounds when migrating females arrive, all interact to influence calving distribution during any given year. The date cows arrive on the calving grounds also varies annually due to these factors (Table 1.). In years of difficult snow conditions, calving can occur along the migration routes (Lent 1966). In 1972 and 1982 significant levels of calving activity occurred in the Old Crow Flats, British Mountains, and on the coastal plain east of the Firth River (Figs. 2 and 12), when migration of the PH was delayed by snow and weather conditions (Roseneau et al. 1974, Mauer et al. 1983, Whitten and Cameron 1984a). Conversely, in 1975 when snow conditions along the migration routes were light and arriving cows found a relatively snow-free calving grounds, nearly all of the herd calved on the extreme western portion (Fig. 5) of the traditional area (Roseneau and Curatolo 1976, Surrendi and DeBock 1976).

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

Winter	Arrival date ^a	Snow cover (estimated)	Major wintering area ^b
1970-1971	30 May	heavy	Ogilvie Mountains
1971-1972	26 May	heavy	southern Richardson Mountains
1972-1973	24 May	medium	central Richardson Mountains
1973-1974	5 May	light	central-eastern Yukon coastal plain
1974-1975	12 May	light	central-eastern Yukon coastal plain
1975-1976	20 May	medium	central Richardson Mountains

^aDate on which caribou crossed Alaska-Yukon Territory border.

^bArea nearest calving grounds where significant numbers of wintering caribou were observed.



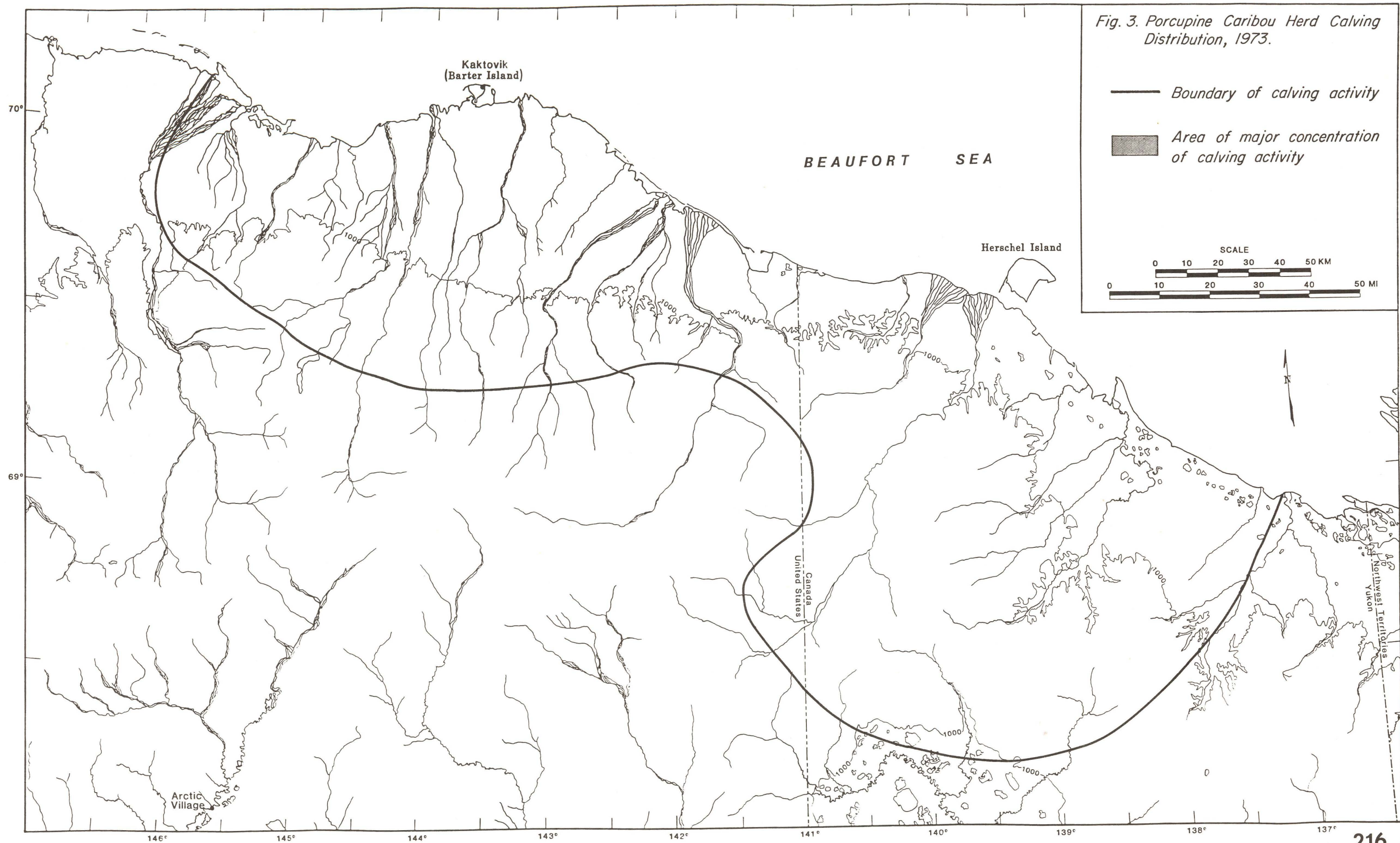
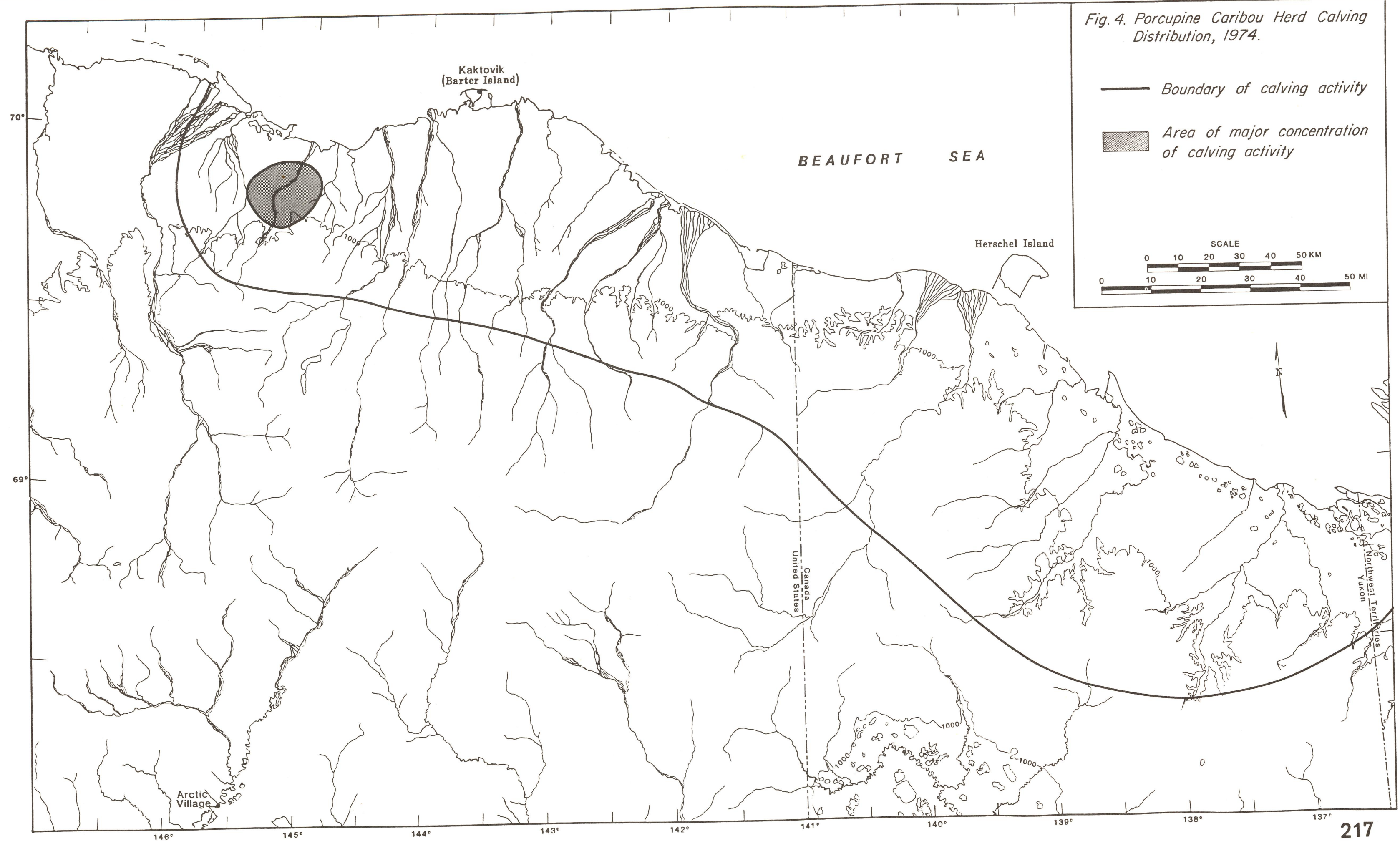


Fig. 4. Porcupine Caribou Herd Calving Distribution, 1974.



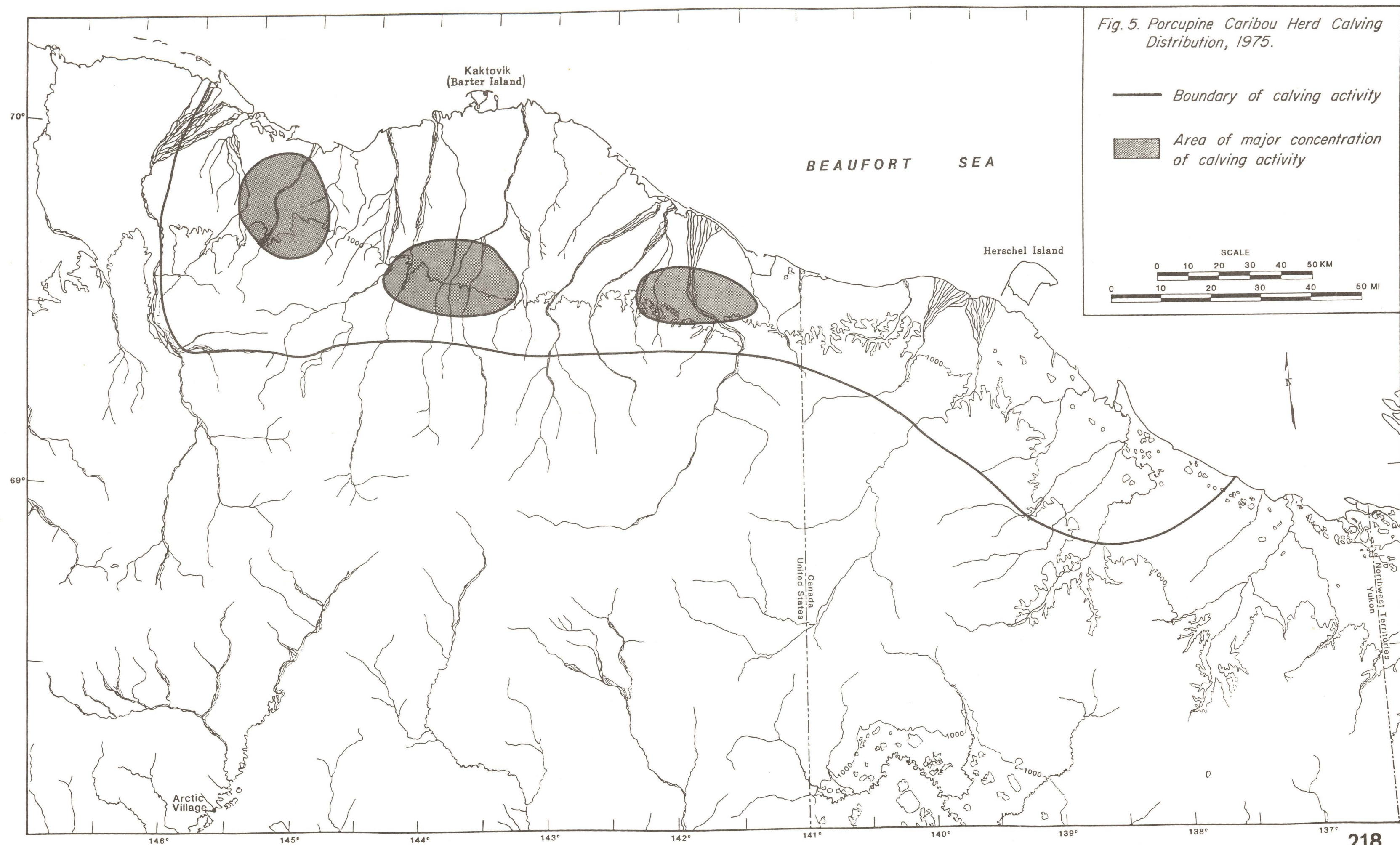
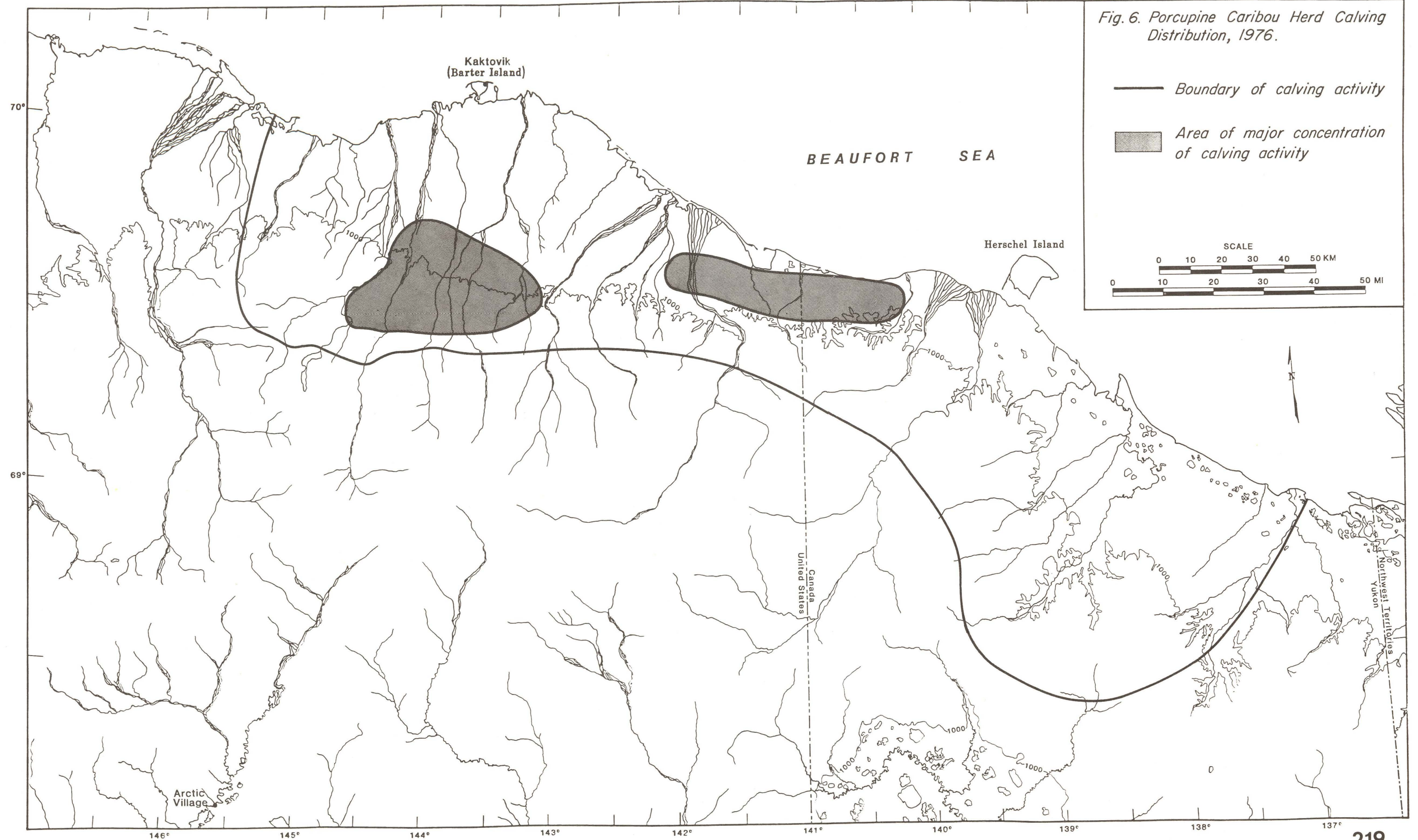
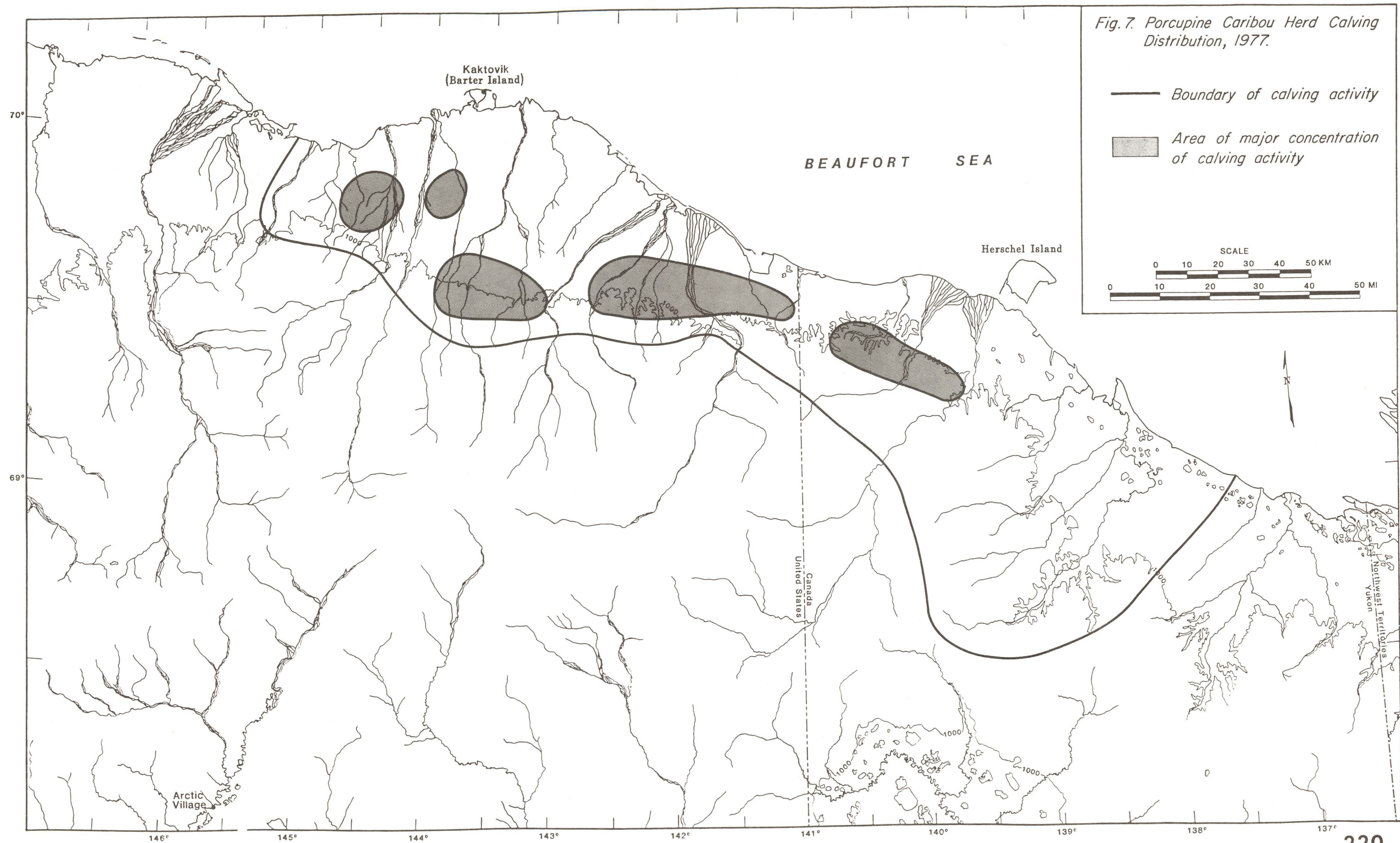


Fig. 6. Porcupine Caribou Herd Calving Distribution, 1976.





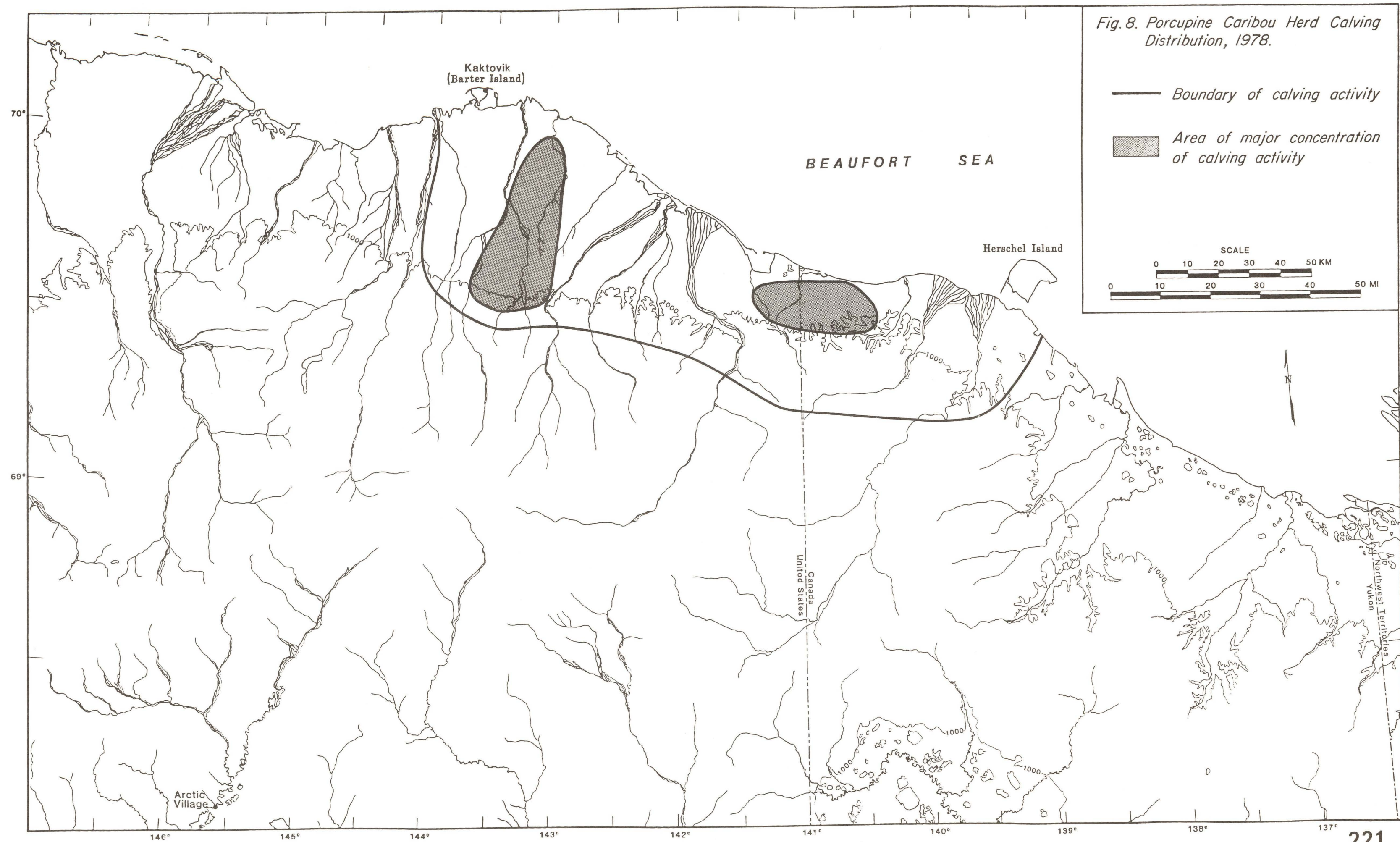


Fig. 9. Porcupine Caribou Herd Calving Distribution, 1979.

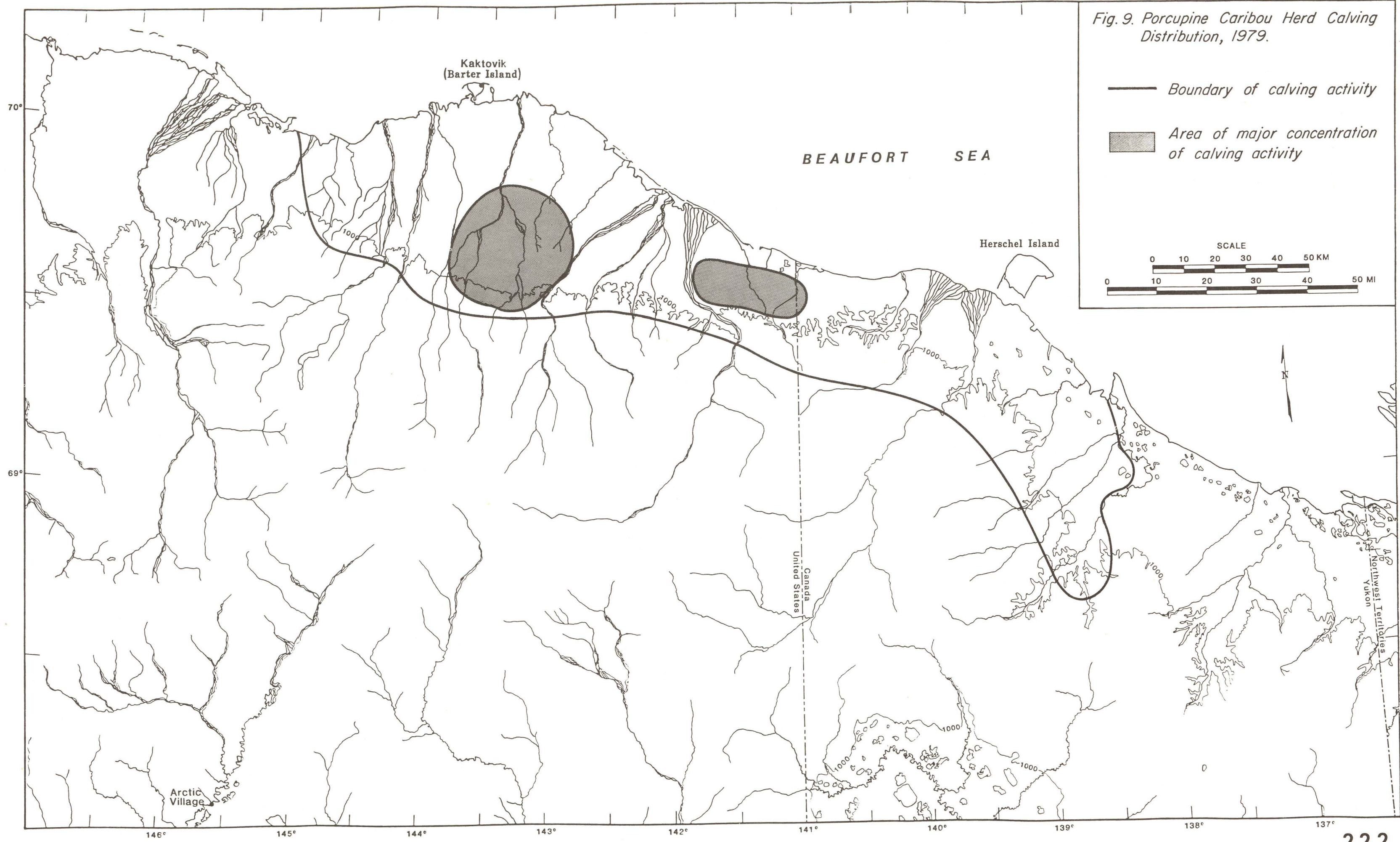
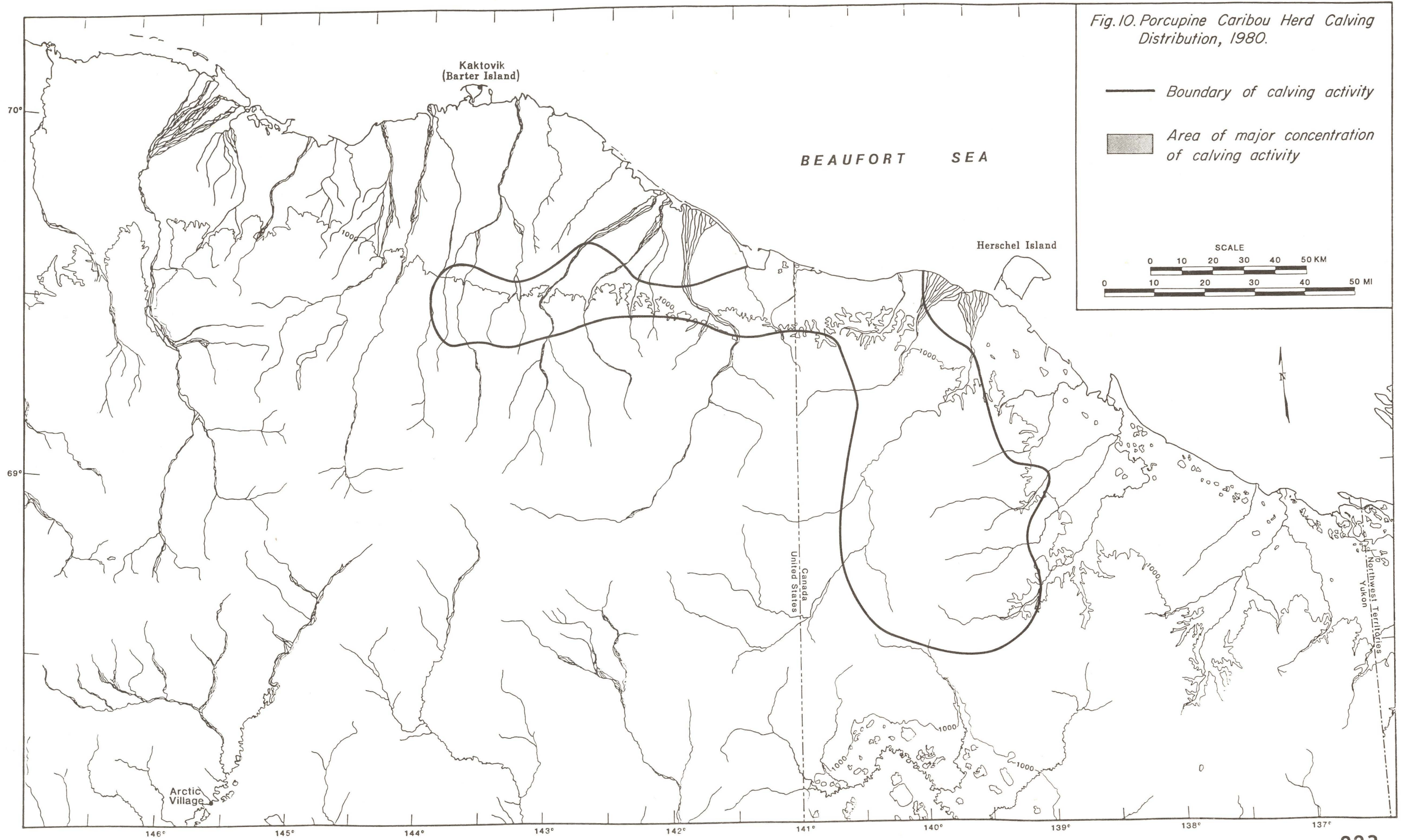
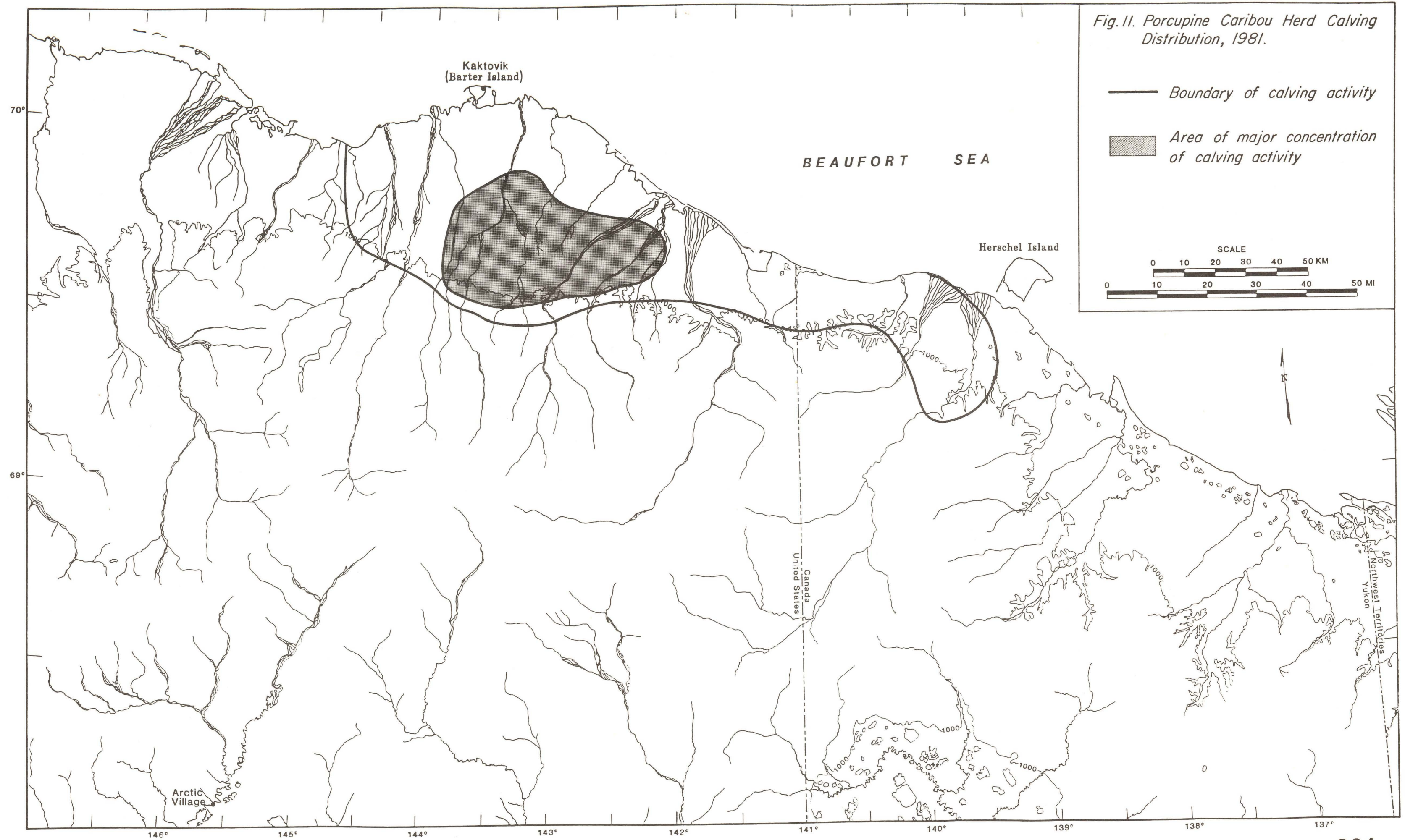


Fig.10. Porcupine Caribou Herd Calving Distribution, 1980.





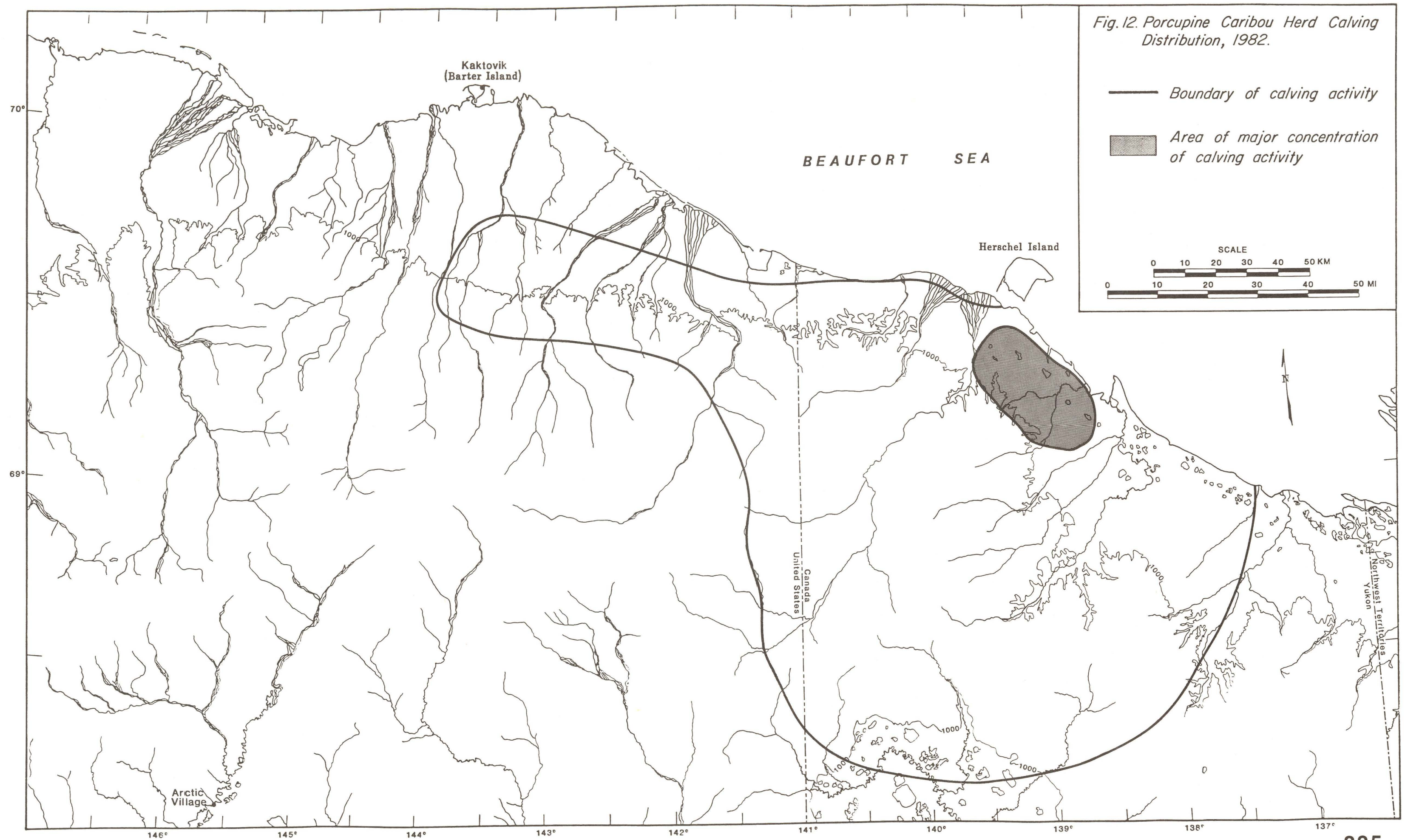


Fig.13. Porcupine Caribou Herd Calving Distribution, 1983.

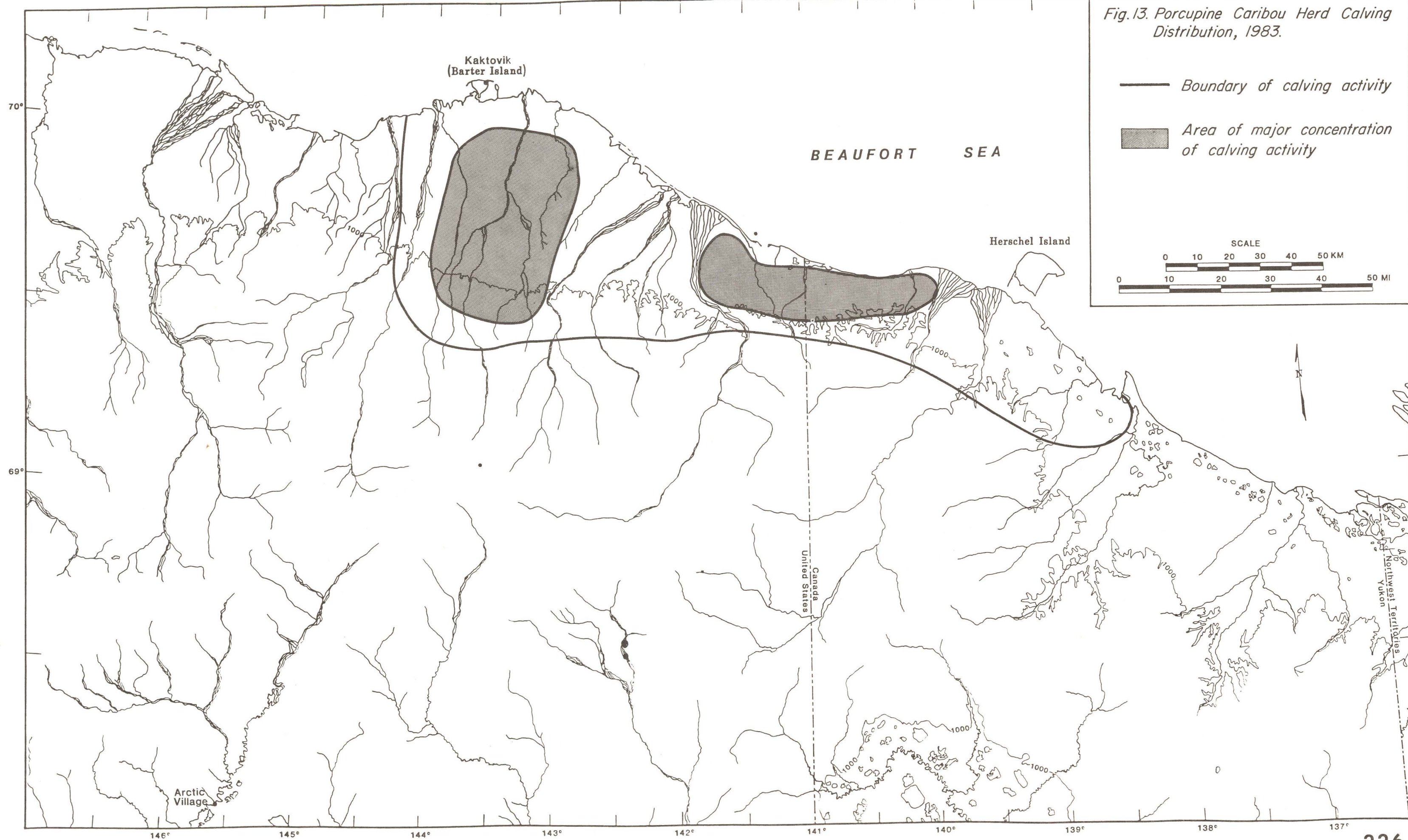
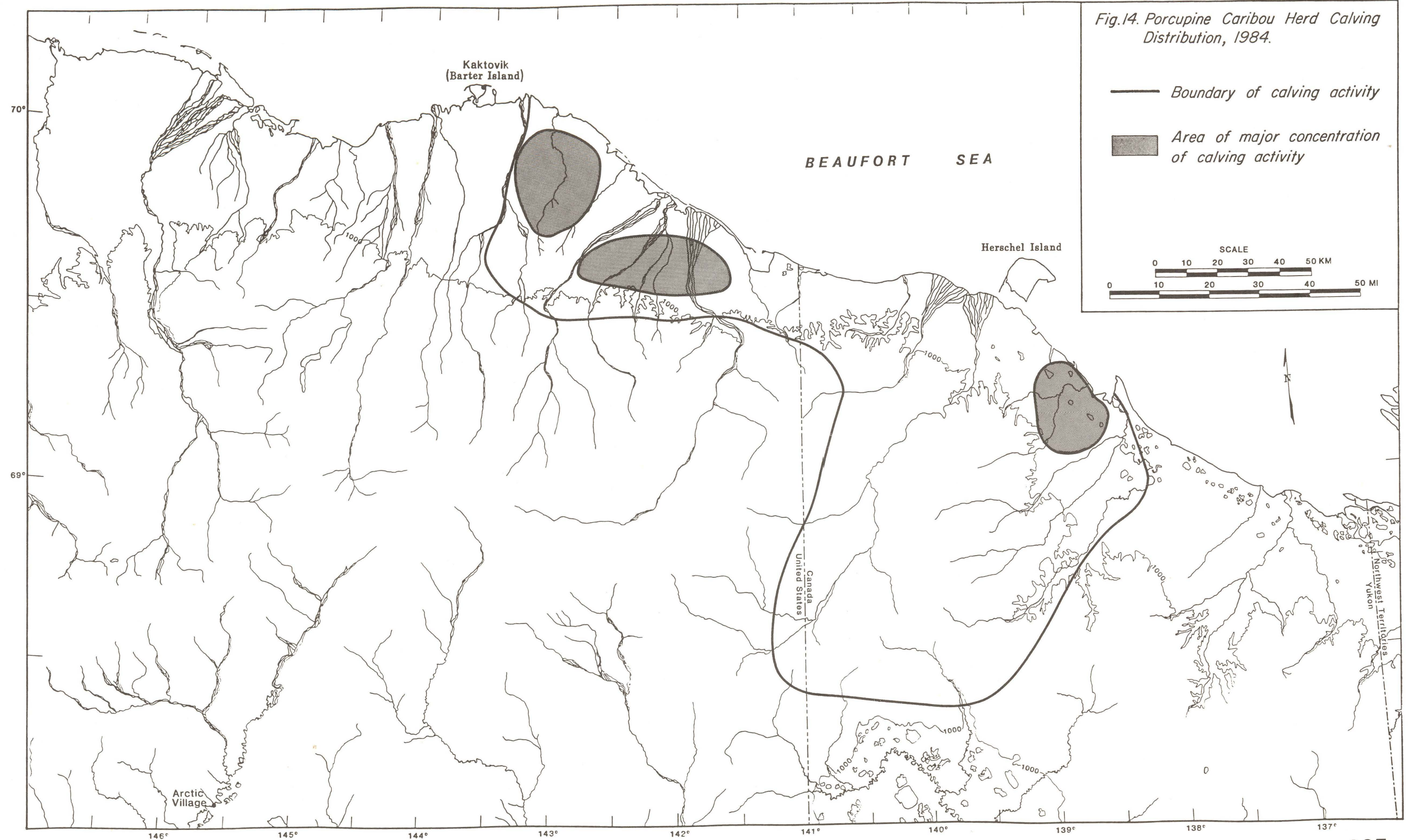


Fig.14. Porcupine Caribou Herd Calving Distribution, 1984.



— Boundary of calving activity

▒ Area of major concentration of calving activity



The calving habitat most consistently used by major concentrations of the PH is centered in the uplands of the Jago River, extending as far west as the Sadlerochit River, and east to the Aichilik River (Fig. 16). Major concentrations of calving in this area have extended from the northern margins of mountainous terrain on the south to within 6 km of the coastline on the coastal plain to the north. Generally referred to as the "core" calving area of the PH, major concentrations of calving have occurred within this area in 10 of the last 14 years (U.S. Fish and Wildlife Service 1982, Whitten et al. 1984, 1985a, and 1986a). Uplands of the Niguanak Ridge and along the Niguanak River have been a frequently used northern extension of the "core" area (Figs. 8, 9, 11, 14). More westerly concentrations of calving also occurred during 1974, 1975, and 1977 between Camden Bay and the Sadlerochit Mountains (Figs. 4, 5, and 7). Scattered calving activity has occurred in varying distributions each year throughout much of the study area.

Movement of pregnant females onto the "core" calving grounds is from the east and southeast along the foothills and mountain valleys where snow-melt occurs early. In years when snow-melt is advanced, migration onto the calving grounds occurs along a more northerly, broad front across the foothills and coastal plain. Upon arrival within the "core" calving area, many caribou often move northward along corridors of early snow melt associated with major river courses.

The calving grounds of most Alaskan caribou herds are relatively snow-free by the time of calving (Lent and Lono 1962, Skoog 1968). An area of early snow-melt along the arctic foothills and southern coastal plain from Herschel Island to the Canning River has been documented by satellite images and generally corresponds with areas of PH calving activity (Lent 1980). Snow-melt is relatively early in this area because it lies inland from the cooler coastal environment, is elevated sufficiently to experience frequent warming by spring temperature inversions, and receives more solar radiation than the frequently fog-covered northern coastal plain (Calef and Lortie 1973, Lent 1980). In addition, the cotton grass tussock (Eriophorum vaginatum) 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. Migration to traditional calving grounds may also be related to predator (wolf) avoidance (Bergerud 1974b). Although a variety of possible advantages may be associated with a particular caribou herd's calving grounds, no universal characteristic common to all North American calving grounds has been identified, except that these areas are consistently or traditionally used for calving (Fleck and Gunn 1982). A combination of advantageous characteristics most likely exists which differentiate caribou calving grounds from adjacent areas.

Although considerable annual variation in calving location has been observed, timing of calving differs little from year to year. In the PH, the first calf of the season is usually observed in the last week of May, and peak of calving is in early June (3-8 June). A slightly earlier calving peak of 1 June was noted in 1985 (Whitten et al. 1986a). Calving is essentially completed by 15 June.

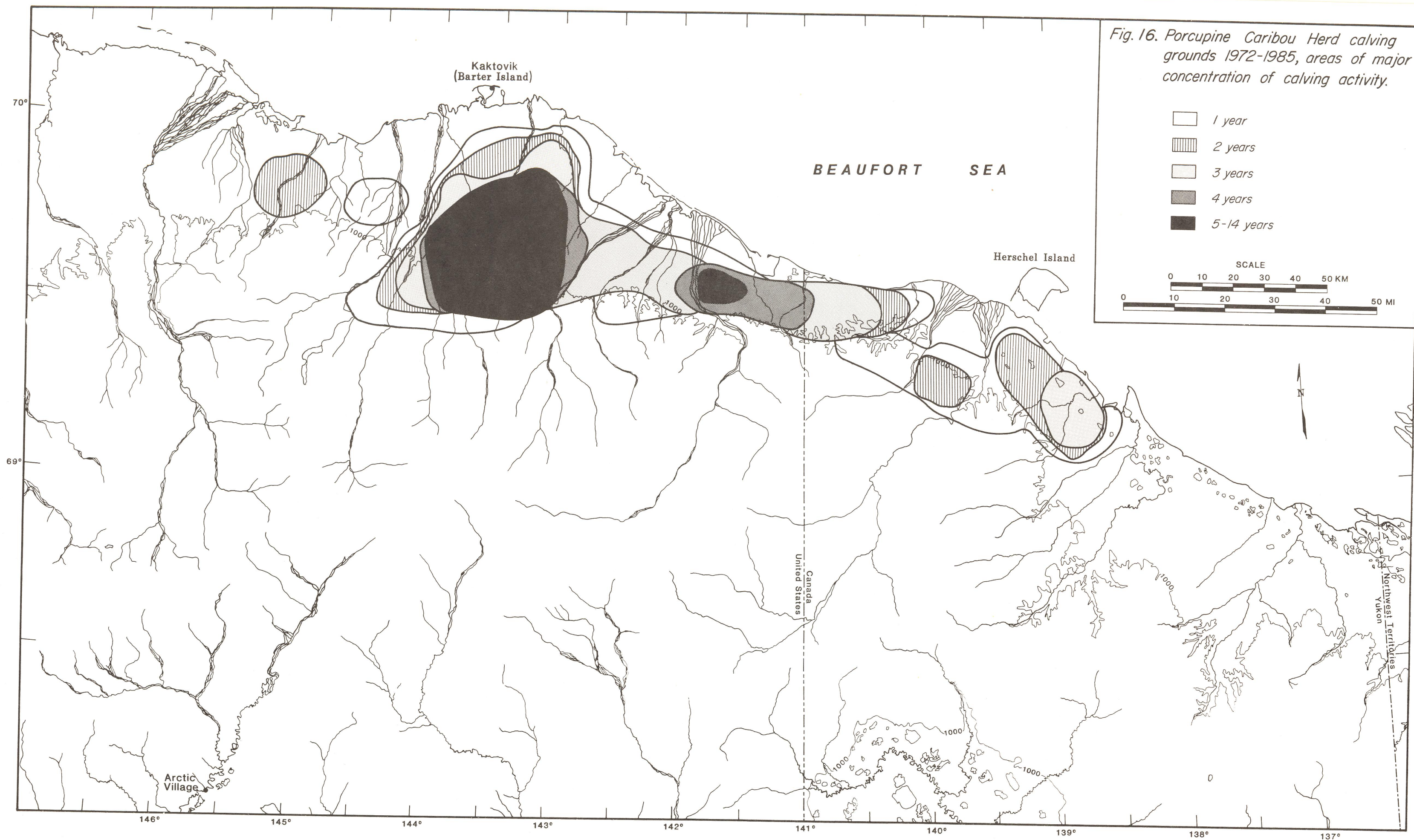
Cows are usually alone or near small groups at the time of birth. After the calf is born, the cow licks the calf and often consumes or mouths the afterbirth (Lent 1964, Calef and Lortie 1973). The cow and calf usually remain near the birth place for the first day (Skoog 1968). Caribou calves are precocious, and are able to stand and nurse within an hour or two following birth (Kelsall 1968, Curatolo and Roseneau 1977). After the first day the calf can walk well enough to follow its mother and can run for considerable distances (Kelsall 1968). By 1 week of age the calves can travel with swiftly moving caribou bands (Skoog 1968). The cow/calf bond in caribou is relatively strong compared to other ungulates (Lent 1974). However, separations 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 approaching humans (Calef and Lortie 1973) and predators (Roseneau and Curatolo 1976) in their search for the maternal cow.

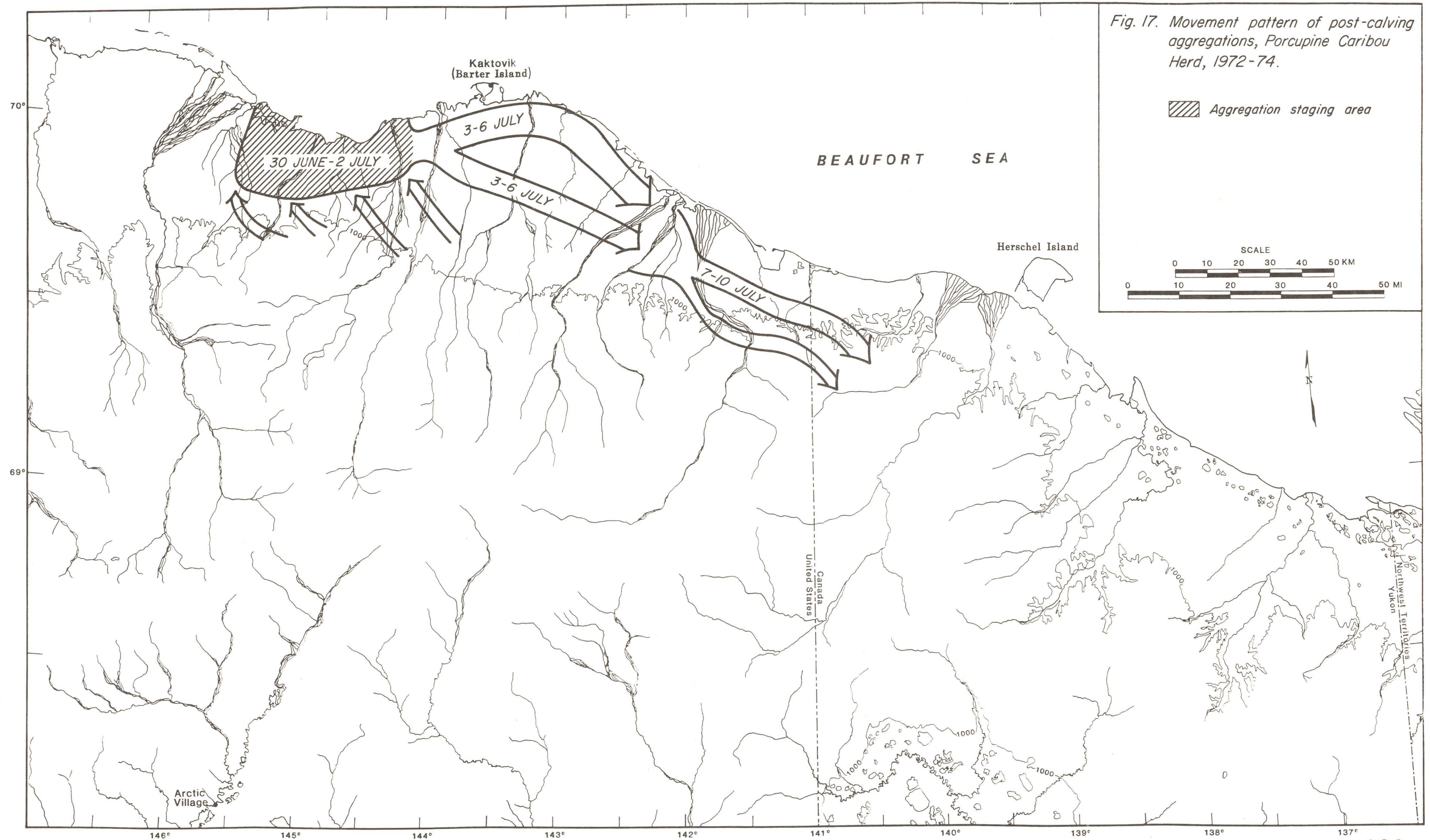
After giving birth, cows with young calves gather into small "nursery bands". Forage utilized during and immediately following calving is primarily the new growth shoots and floral parts of Eriophorum which provide a highly nutritious and digestible food for caribou (Lent 1964, Klein 1970, Kuropat and Bryant 1980). Use of river terraces and vegetated gravel bars along river courses by PH cow/calf pairs is also common during the period immediately following calving (Whitten et al. 1986a). Female caribou are perhaps at the lowest point of their energy cycle at this time, due to the stresses of winter, pregnancy, migration, birth of calves, lactation, antler growth, and pelage molt (Dauphine 1976). The availability of high quality forage resources on the calving and post-calving habitats is important for growth of young calves as well as for body maintenance of adult caribou.

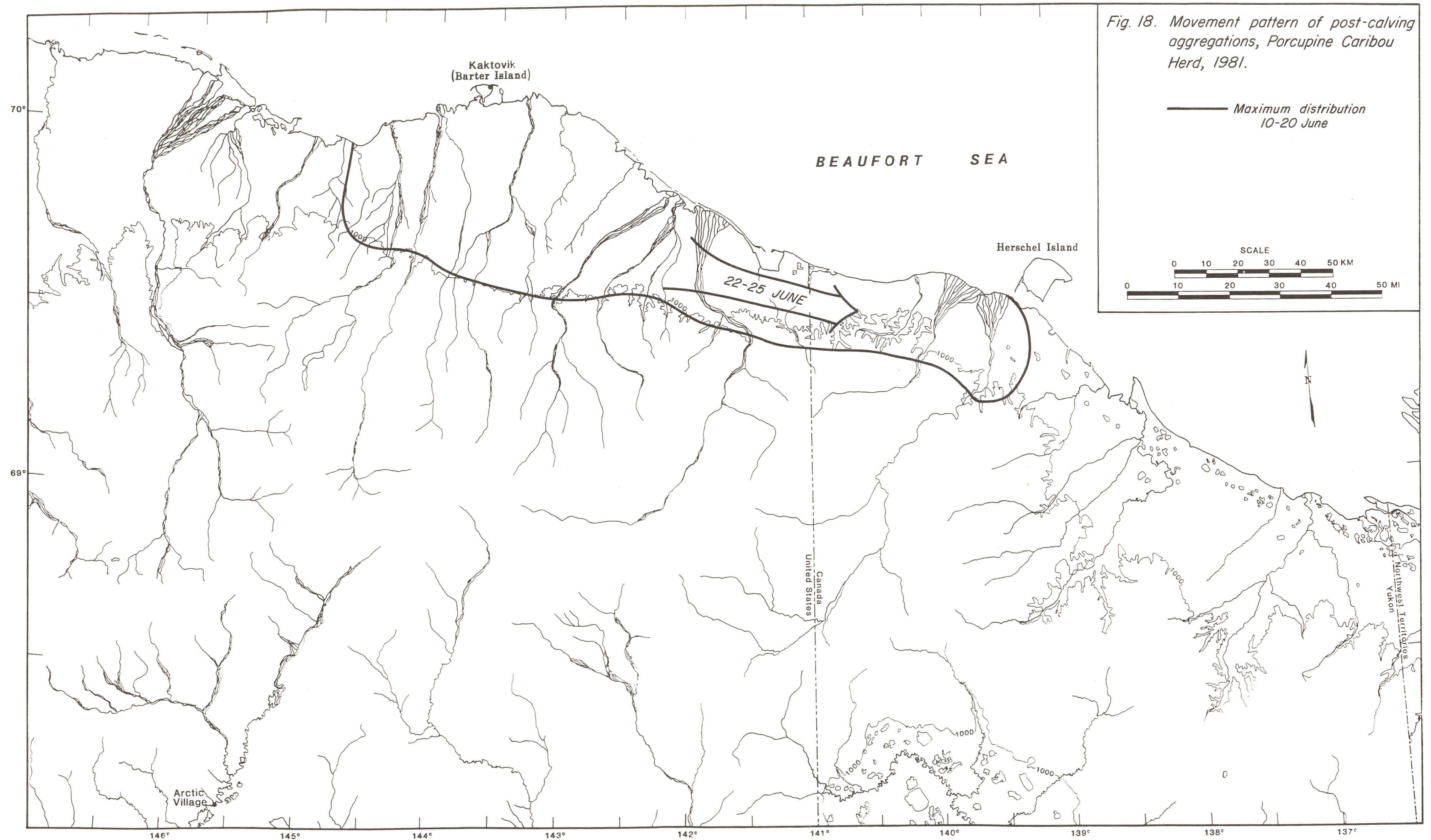
Movements of the nursery bands within the "core calving area" are gradual and have little directional unity during the first 7-10 days following birth of calves (Whitten et al. 1984, 1985a, 1986a). Cow/calf groups located on the immediate eastern periphery of this "core calving area" tend to shift westward towards the central calving area (Calef and Lortie 1973, Whitten et al. 1985a, and 1986a).

Post-calving. The post-calving season of the PH begins about 15 June and extends until the large herds disperse in early August. Following calving, nursery bands of cows with young calves begin to coalesce, forming ever larger groups. Most groups also begin to increase their rate of movement and tend to move in a unified direction (Whitten et al. 1984, 1985a, 1986a). Considerable annual variation is associated with the post-calving movement patterns of the PH on the coastal plain of ANWR. Post-calving movement patterns for 4 years (1972, 1981, 1982, 1985) are examples which illustrate the range of variation observed during the past 15 years (Fig. 17-20).

During the mid-1970's (1972-1975) post-calving groups of the PH commonly shifted westward after calving, and formed large aggregations in the foothills south of Camden Bay (Fig. 17) (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 group aggregation south of Camden Bay and by early July these large aggregations began a rapid







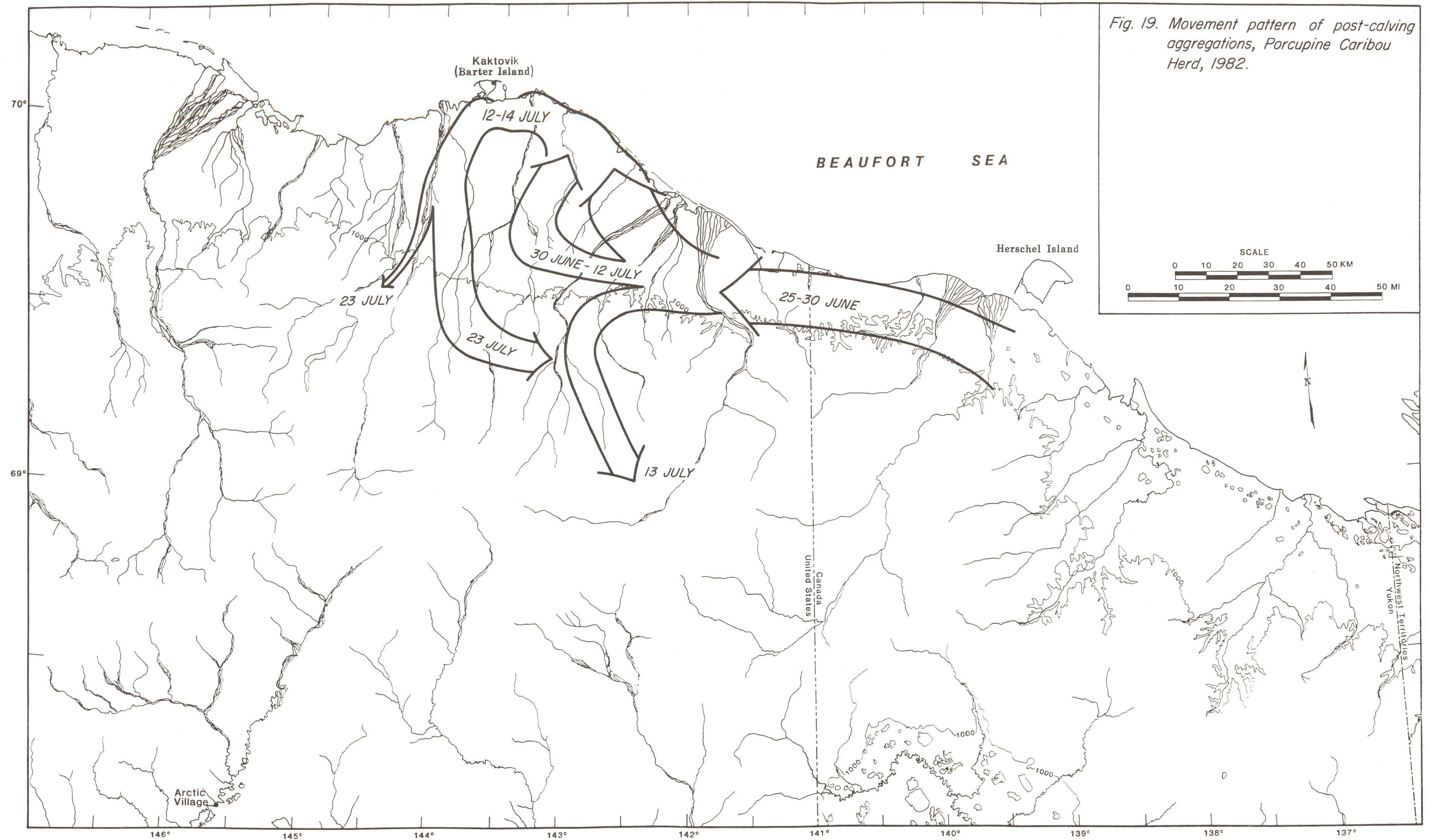
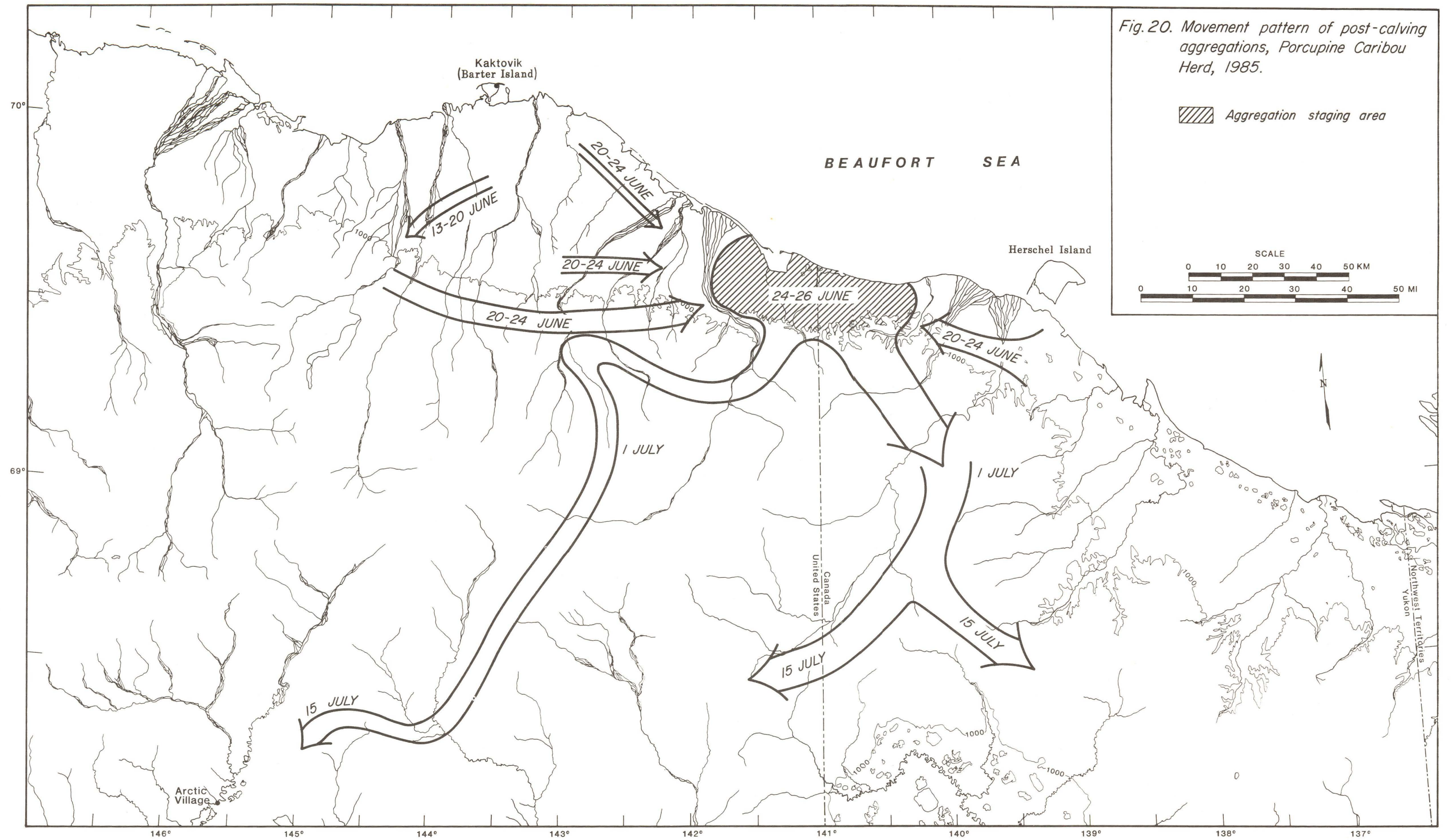


Fig. 19. Movement pattern of post-calving aggregations, Porcupine Caribou Herd, 1982.



movement eastward on a broad front extending from the coastline to 30 km inland (LeResche and Linderman 1975). When insect harassment conditions became severe, these groups were often observed in the coastal tidelands, on ice-pans of lagoons, and in nearshore waters (Roseneau and Stern 1974a). By about July 10, most of the PH aggregation entered Canada and continued on an easterly course through the British and Barn Mountains.

In some years (e.g. 1972, 1983, and 1985), residual groups numbering up to 10,000 caribou remained on the Alaskan coastal plain and foothills through the summer months (Roseneau and Stern 1974a, Whitten et al. 1984, 1986a). These groups moved erratically over the area in response to insect harassment conditions. Residual groups in late summer commonly used the area between the Sadlerochit Mountains and Schrader Lake (Roseneau and Stern 1974, Whitten et al. 1985a, 1986a). Eventually some caribou in these groups moved south in the fall, while others overwintered in the Schrader Lake area (Whitten et al. 1985b).

In some years (e.g. 1976 and 1981), the Porcupine herd failed to form large aggregations (Fig. 18) (Curatolo and Roseneau 1977, Bartels pers. comm.). Caribou did not move in large numbers to the coast, but gathered instead 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 Egakrak and Kongakut Rivers prior to crossing the Kongakut and moving into Canada by June 30 (Fig. 18) (Bartels pers. comm.).

In 1982, spring migration was delayed by a late breakup and most of the PH calved in Canada east of the Firth River (Mauer et al. 1983, Whitten and Cameron 1984a). A rapid westward movement began in late June, with large groups of caribou entering Alaska on the coastal plain and foothills during June 25-30 (Fig. 19). Aggregations containing primarily females and calves ranged on the coastal plain east of the Jago River and several large groups consisting mostly of bulls and yearlings predominated in the foothills east of the Aichilik River from June 30 to July 12. The coastal plains groups oscillated frequently between the foothills and coastal areas in response to insect harassment conditions. In response to extreme insect harassment conditions very large, densely packed aggregations of caribou assembled along the coastline from the Okpilak River delta to the Aichilik River delta during July 12-14. One group of over 500 caribou moved onto Barter Island on July 13. Groups in the foothills moved rapidly southeastward through the eastern Brooks Range and into Canada. When insect harassment conditions subsided in mid-July, the coastal plain aggregations drifted south and separated into several smaller groups. Some groups moved up the Okpilak River to the glaciers, then retraced their route north out of the mountains and drifted southeast, up the Jago and Aichilik Rivers and across the continental divide. One residual group moved up the Hulahula River and crossed west to the Schrader Lake area, where it remained through August.

In 1985, post-calving movements began with a gradual southwestern shift into the foothills (Fig. 20) where large, loose aggregations in excess of 10,000 caribou per group formed (Whitten et al. 1986a). By about June 20 a rapid eastward movement began and cow/calf aggregations merged with groups of juveniles, barren cows, and bulls that had moved west towards the calving grounds. Simultaneously, cow/calf groups from calving habitats east of the Firth River in Canada initiated a westward movement on June 20. By June 26 the east and west moving aggregations merged in the vicinity of the

international border, south of Demarcation Bay. Nearly the entire PH was present in loosely-scattered aggregations at this time. On June 27 the herd separated, with approximately 60% moving southeastward into the British Mountains of Canada, and the remaining 40% moving south, through the eastern Brooks Range of Alaska (Whitten et al. 1986a). By early July the southward moving Alaska groups were south of the continental divide and by mid-July were in the vicinity of Arctic Village. Caribou moving southeastward into Canada separated into smaller groups several times and some of the animals shifted southwestward, re-entered Alaska and eventually mixed with Alaskan groups on the southern slopes of the Brooks Range (Whitten et al. 1986a).

The aggregation behavior of caribou observed during post-calving movements may be related to the appearance of harassing insects, especially mosquitoes (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 are believed to contribute to accidents, crippling, and cow-calf separation (Calef and Lortie 1973, Roseneau and Curatolo 1976). During the height of the insect harassment season (July to mid-August), caribou seek relief on windy ridges, along coastlines, and on snow fields, aufeiss, mud flats, river deltas, and gravel bars. Movement of the herd is almost continuous and little time is spent for foraging and grazing when insect harassment is extreme.

August Dispersal. The large post-calving aggregations of the PH tend to separate into several groups as the herd moves south through the Brooks Range and British Mountains. This continues through the remainder of the summer and by early August, caribou tend to be widely scattered over a broad region extending from the East Fork of the Chandalar River in Alaska to the Richardson Mountains in Canada. It is believed that reduced harassment by mosquitos as well as possibly increased harassment by warble and nasal bot flies may influence the dispersal pattern in caribou (Curatolo 1975). During the dispersal season, caribou feed predominately on willow (Salix spp.) in the abundant shrub communities south of the Brooks Range and British Mountains. During the 1970's a westward movement of caribou from Canada to Alaska was common during late July to mid-August (Roseneau and Curatolo 1976). Because of an apparent change in post-calving movement patterns during the 1980's caribou have recently been observed moving eastward into Canada during the same period (Whitten et al. 1986b).

Fall Migration. Movement patterns of the PH during fall migration (October) also show considerable annual variation. During the 1970's caribou commonly moved east into Canada during mid-September. In recent years up to one-third of the herd has moved west into Alaska from Canada during late September to early October (Whitten et al. 1986b). Autumn snow storms sometimes accelerate caribou movement toward traditional winter ranges (Lent 1966, Bergerud 1974b). The PH crosses the Porcupine River during fall migrations near the international border, in the vicinity of Old Crow and near the mouth of the Bell River (Surrendi and DeBock 1976), but timing of river crossings varies considerably from year to year. After crossing the Porcupine River, most of the herd usually moves into the Keele Mountains and Nahoni Range and continues in a southerly direction (Calef 1974). In some years, large numbers of caribou move into the Richardson Mountains (Kevan 1970 as cited by Calef 1974, Russell and Nixon 1986). Caribou in Alaska move in a southwesterly direction along the south flanks of the Brooks Range in the vicinity of Arctic Village.

Rutting Season. 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. The PH breeds during the middle of October while enroute to the winter ranges (Calef 1974). Throughout September the bulls become increasingly aggressive and begin brief sparring matches with other males. Large bulls are dominant and tend to spar mostly with other bulls of similar size. Usually the sparring matches are not violent and last about 5 min. (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 (Dauphine 1976).

The rut is synchronous and lasts about 2 weeks. This accounts for the short period in which the calves are born (Dauphine and McClure 1974). Caribou are usually sexually mature at 2 years of age (Skoog 1968). Cows can have several estrus cycles until conception takes place (Skoog 1968). Harems are not formed and bulls usually mate with more than 1 cow. The gestation period is about 210 days. Caribou sex and age classes are quite evenly mixed during the rut (Lent 1965).

Winter Activity. The PH uses 2 major winter ranges: the central Yukon Territory and northeastern Alaska in the vicinity of Arctic Village (Fig. 1). Other commonly used areas are the Richardson Mountains of the Yukon and Northwest Territories, and along the lower Coleen River (Thompson and Roseneau 1978, Russell and Nixon 1986). Annual variations have occurred in the use of various winter ranges during 1970-1986) (Table 2). During the winter of 1972-1973 most of the herd was found in the Arctic Village area. In 1978-1979 about half of the herd wintered in Alaska, from the Yukon River to the Brooks Range with the most concentration in the Coleen Valley (Whitten pers. comm.). The remainder of the herd wintered along the international border on the upper Kandik and Tatonduk Rivers. During the winter of 1981-1982 large numbers of the PH crossed the Yukon River near Eagle, Alaska, and moved northwest to winter in the Tanana Hills near Eagle Summit. Large numbers of caribou wintered in the northern slopes of the Richardson Mountains during the winter of 1984-1985. The most consistently used winter range in Alaska extends southwesterly from approximately the upper Sheenjek River to Chandalar Lake, and includes Old Woman Creek, the Koness River, and the East, Middle, and North Forks of the Chandalar River, and the Christian, Wind, and Junjik River drainages. Up to 1,000 caribou of the PH overwintered near Schrader Lake (north of the Brooks Range) during 1983-1984 and 1985-1986 (Whitten et al. 1986b).

Overlap of winter ranges and potential intermingling occurred between the PH and the Forty-mile herd during the winter of 1981-1982, and between the PH and the CAH Herd in the winters of 1983-1984 and 1985-1986 (Whitten and Cameron 1983a, Whitten et al. 1986a). Radio-collared caribou migrated to their respective calving grounds the next spring following these overlaps of winter range (Whitten and Cameron 1983a, Farnell and Russell 1984, Whitten et al. 1985a).

Wintering groups of caribou do not remain on 1 feeding site for the entire winter (Henshaw 1968); instead there are frequent short distance movements. Wintering caribou often feed by excavating snow "craters" using their forelimbs. Snow depth and hardness greatly influence the amount of energy required to excavate these craters (Pruitt 1960, Thing 1977). Caribou select feeding areas and specific cratering areas within these areas where snow conditions do not exceed depth and hardness thresholds (LaPerrier and Lent 1977).

Table 2. Annual variation in estimated numbers (1,000's) of caribou of the Porcupine herd distributed on the various winter ranges^a.

Winter	Canadian Locations						Alaskan Locations				
	Ogilvie & Peel Basins and Eagle Plains	Richardson Mountains	Yukon/NWT coastal plain	Old crow area	Nahoni- Keele Mountains	Bell River	Chandler- Sheenjek area	Coleen River area	Arctic slope	Hodzana River basin	Tanana Hills
1970-1971	38-70	2-3	-	-	-	-	1	-	-	-	-
1976-1972	40-62	17-30	-	-	-	-	1.4-2.5	-	0.2-0.4	0.9	-
1972-1973	12	5	0.2-0.3	-	-	-	30-40	1+	0.2-0.4	2-3	-
1973-1974	60	-	5	5	-	-	-	1+	1-2	-	-
1974-1975	NA ^b	10	1	-	-	-	10-15	-	0.2	-	-
1975-1976	Most Pop.	Few	-	2-3	-	1	-	-	-	-	-
1976-1977	Most Pop.	-	0.2-0.3	-	-	-	0.1	200	-	-	-
1977-1978	Most Pop.	-	-	-	-	-	0.1-1+	1.0-1.5	-	-	-
1978-1979	-	-	-	-	1/2 Pop.	-	est. 1/2 Pop.	-	-	-	-
1979-1980	90	-	-	-	-	-	20	-	-	-	-
1980-1981	77	-	-	-	-	-	20	-	-	-	-
1981-1982 ^c	40	16	-	6	-	-	20	-	-	-	20
1982-1983 ^c	20	20	-	-	-	20	10	-	-	-	-
1983-1984 ^c	92	-	-	-	-	-	48	-	1	-	-
1984-1985 ^c	-	70	10	-	-	10	60	-	-	-	-
1985-1986 ^c	110	-	-	-	-	-	50	-	0.5	-	-

^aEstimates based on information in Doll et al. 1974a, Roseneau and Stern 1974, Roseneau et al. 1974, Roseneau et al. 1975, Curatolo and Roseneau 1977, Thompson and Roseneau 1978, Whitten and Cameron 1983a, Farnell and Russell 1984, Russell and Martell 1985, Russell and Nixon 1986, Whitten 1984, Whitten et al. 1985b, 1986b, Arctic National Wildlife Refuge files (1979-1981).

^bNA=no estimate available

^cEstimate derived from proportions of radio-collared caribou present.

Wintering distributions of the PH vary annually due to regional differences in snow conditions (Russell and Martell 1984). Thompson and Roseneau (1978) observed wintering caribou of the PH "most often in broad rolling valley bottoms or slopes with moderate tree cover and continuous snow cover; or on wind-swept 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 wind-swept ridges are also frequented by wintering caribou because of the ready access to food sources and the good visibility which permits detection of predators (Thompson and Roseneau 1978).

Population Characteristics

Numbers of animals in the PH appear to have remained relatively stable from 1961-1979, but have increased steadily since 1979 (Table 3). Initial productivity of radio-collared females 3 years or older during 1983-1985 has averaged about 75% (Whitten et al. 1984, 1985a, 1986a). Few 2 year-old radio-collared females produced calves, indicating that currently this cohort is not a significant contributor to herd productivity (Whitten et al. 1986a). Mortality studies using radio-collared calves indicate a first year mortality rate of about 41.5% (Whitten 1986). Annual mortality of radio-collared adults and yearlings (predominately females) has ranged between 8-12%. Yearling composition in June is believed to be about 35 yearlings/100 females (Whitten 1986). A ratio of 60 adult males/100 adult females was measured during classification surveys conducted in fall 1980 (Whitten and Cameron 1981). Current productivity and mortality rates, and herd composition data indicate an estimated 10.5% annual increase in the PH during 1983-1985 (Whitten 1986). Should this trend continue for the next 5 years, the PH could contain 270,000 caribou by 1990.

Table 3. Porcupine herd population estimates 1961-1985.

Year	Population (1000's)	Census method	Source
1961	110-117	calving grounds census	Skoog 1968
1964	140	calving grounds census	Skoog 1968
1972	101	APDCE ^a	LeResche 1972
1977	105	APDCE	Bente and Roseneau 1978
1979	110	modified APDCE	Whitten and Cameron 1980a
1982	137	modified APDCE	Whitten and Cameron 1984b
1983	135	modified APDCE	Whitten 1984
1984	149	projection estimate	Whitten 1986
1985	165	projection estimate	Whitten 1986

^aAPDCE = Aerial photo-direct count extrapolation techniques.

Extent, Location, and Carrying Capacity of Habitats

The range of the PH is dominated by mountainous terrain and the herd may spend up to 11 months of the year in landscapes associated with various mountain ranges, valleys, and intermountain basins, plains and plateaus (Calef 1974). A wide variety of plant communities, forage resources, snow conditions, and

insect densities are encountered as the herd moves through its range. Because of the immensity of the PH range and its remote nature, a comprehensive study and analysis of the herd's range has not been accomplished. Some recent studies, however, have begun to describe some of the habitat relationships of the herd.

Martell et al. (in press) examined habitat utilization by male caribou during spring and early summer in a major staging area in the northern Yukon Territory and found that male caribou selected dwarf shrub heath and tussock meadow communities in late May - early June and willow thickets in late June. Spring and early summer distributions of bull caribou was primarily in response to snow-melt patterns and vegetation phenology. Movements of males appeared to be related to social factors (Martell et al. in press). Winter range studies of the PH in the Yukon Territory indicate that snow conditions are a major factor influencing regional winter distributions of caribou in most years (Russell and Martell 1984). Calving grounds studies in northwestern Alaska have shown that adult female caribou use primarily tussock meadow habitats during and immediately following calving (Kuropat and Bryant 1980). Kuropat (1984) also documented that caribou movements, distribution, and foraging behavior of cow/calf groups were closely related to vegetation phenology and nutrient availability during the period immediately after calving. Several authors have described utilization of coastal areas, snow drifts, ice pans, barren ridges, river deltas, mud flats, and gravel bars by caribou for relief from harassment by insects, (Calef and Lortie 1973, White et al. 1975, Surrendi and DeBock 1976).

Due to the wide-ranging migratory behavior of barren ground caribou the concept of carrying capacity as it is traditionally used for less migratory herbivores, such as livestock, is not entirely applicable for caribou (Skoog 1968). Certain areas within a caribou herd's range may not be used by caribou for a long period. But as herd movement patterns shift (possibly due to climatic changes), these infrequently used areas may become important. Such aspects of caribou range ecology require a broad interpretation of the carrying capacity concept, which includes considerations of these vast, lightly used areas which may be important in the long term. Several efforts have been made to theoretically calculate the carrying capacities of certain caribou ranges. Using basic range inventory techniques, such efforts have usually identified much higher capacities than are actually exhibited by the populations (Calef 1974). Some theoretical carrying capacities have varied from 1.2 caribou/km² on the Forty-mile Caribou herd range (Skoog 1956) to 3.7 reindeer/km² on the Mackenzie River delta reindeer range (Porsild 1929 as cited by Calef 1974). No density value has been derived for the PH. Using the estimated range size of 250,000 km² (Mair and Cowan 1978), the PH currently occupies its range at a density of approximately 0.66 caribou/km². It is likely that there may be significant areas within the PH range that are not used by caribou and that the actual density of occupied habitat is higher. Carrying capacity values useful to caribou management cannot be developed until a comprehensive understanding of the herd's range and its utilization is achieved.

Portions of the PH range in Alaska which include calving and post-calving habitats have been mapped for vegetation and landform (Walker et al. 1982) and other components of the herd's range within the ANWR are currently being mapped (See Chapter 3). Land cover on Canadian portions of the herd's range are also beginning to be mapped. However, substantial work is still needed to develop a comprehensive range map for the PH.

Central Arctic Herd

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 herd (WAH) and the PH (Fig. 1) was confirmed by Cameron and Whitten (1976 and 1979). Previous publications (Olson 1959, Skoog 1968, Gavin 1971, LeResche 1972, Child 1973, Roseneau et al. 1974, Roseneau and Stern 1974, White et al. 1975, Roseneau and Curatolo 1976) had also mentioned or described caribou that were presumably of the Central Arctic Herd (CAH). 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 (Cameron et al. 1985). The Prudhoe Bay, Kuparuk, and Milne Point oil field complexes, the Trans-Alaska Pipeline, and the Dalton Highway occur within the range of the CAH.

The CAH winters primarily in the foothills and mountain valleys of the southern portion of its range. Pregnant females migrate north in the spring to calving grounds located on the northern coastal plain. The CAH calving distribution extends across 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 and Cameron 1985). Calving activity in the Prudhoe Bay area was reported by Gavin (1971), Child (1973), and White et al. (1975), when the Prudhoe Bay oil field was beginning to be developed. Later studies (Cameron and Whitten 1979 and 1980, Cameron et al. 1981, Whitten and Cameron 1985) indicate an absence of calving near the coast at Prudhoe Bay during 1976-1985 possibly due to avoidance of the area by calving caribou. Two centers of concentrated calving activity have been identified. One area lies west of Prudhoe Bay in the vicinity of the Kuparuk and Ugnuravik Rivers, the other area is east of Prudhoe Bay, primarily in the Bullen Point to Canning River delta area (Shiedler 1986). A portion of this eastern calving grounds extends into the ANWR study area (Cameron et al. 1985). Surveys conducted in 1981 indicate that the Canning River delta area may support more calving caribou than the Kuparuk area (Whitten and Cameron 1985).

Following calving, portions of the CAH usually move eastward along the coast in post-calving aggregations. Caribou movements from the west often cross the Canning River delta and pass into the ANWR study area (Cameron et al. 1985). These aggregations gradually disperse into smaller groups; some move back along the coast to the west, others remain in the Canning River delta to Marsh Creek area. In mid-July, when insect harassment intensifies, bands of CAH caribou can be found seeking relief on the coastal beaches, sand dunes, shorefast ice, and barrier islands of the Canning River delta to Camden Bay area.

A gradual southward movement of the CAH 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 the CAH also winter east of the Canning River in the ANWR study area in the foothills north of the Sadlerochit Mountains, along the Canning River, and in the vicinity of Schrader Lake, (Cameron et al. 1985).

Population Characteristics

As a result of detailed studies in 1974 and 1975, ADF&G biologists estimated that the CAH numbered about 5,000 (Cameron and Whitten 1976). The herd was estimated at 6,000 in 1978, 9,000 in 1981 (Whitten and Cameron 1983b), and about 15,000 in 1985 (Whitten pers. comm.). The apparent herd increase over the past 10 years has been attributed to high calf production and survival as well as relatively light hunting pressure (Whitten and Cameron 1983b).

Extent, Location, and Carrying Capacity of Habitats

The range of the CAH currently consists of approximately 45,000 km² of treeless arctic tundra located north of the Brooks Range continental divide. Most of the range is a broad expanse of low arctic coastal plain which gradually transcends to a wide foothill region. The southern margin of the range consists of mountainous terrain. The arctic coastal plain is characterized by flat, poorly drained tundra with numerous thaw lakes and ponds. Wet sedge meadows predominate. The foothills region is characterized by rolling uplands where tussock tundra (*Eriophorum vaginatum*) is the predominate vegetative cover. Riverine habitats in the foothills support dense shrub communities (willow) and complex mosaics of forbs, herbs, and lichens. The mountainous terrain consists of barren rock and scree slopes, dry upland meadows, and braided river beds with extensive gravel deposits. Detailed vegetative cover maps have been developed for portions of the CAH's range in the vicinity of the Prudhoe Bay oilfields and the Trans Alaska Pipeline Corridor (Markon 1980, Walker et al. 1980). A broad scale vegetation mapping program is currently being developed for the region by the North Slope Borough.

Because the CAH is relatively non-migratory and remains north of the Brooks Range throughout the year, its pattern of habitat utilization differs substantially from that of the PCH. In spring pregnant females of the CAH move north to calving areas near the coast where no new growth of forage occurs at the peak of calving activity (Roby 1978). Calving habitats are characterized by low wet tundra. Parturient caribou often select elevated polygon ridges during the calving period (Roby 1978). Use of tussock uplands for calving by the CAH is usually limited due to a lack of this habitat in the calving grounds.

Male caribou tend to follow plant phenology which progresses from south to north (Whitten and Cameron 1980c, Roby 1978). This pattern results in a spatial separation of males and females. Segregation of sexes continues through the summer with males demonstrating a strong affinity for riparian areas, especially during August (Roby 1978, Curatolo 1985). Carruthers et al. (1984) suggests that natural habitat selection patterns based on sex may account for the low representation of females and young calves near oil and gas development areas reported by Cameron and Whitten (1980), and Whitten and Cameron (1985). Resolution of these conflicting interpretations has not been entirely possible due to a lack of adequate baseline data on caribou habitat use patterns prior to petroleum developments. Recently, the comparison of caribou habitat use prior to and after construction and use of a new road system has shown that female caribou with young calves do avoid disturbed areas (Dau and Cameron in press).

The CAH obtain relief from insects (mosquitoes) primarily in coastal habitats. Potential insect relief areas in mountainous terrain in the southern portion of the range are not used, perhaps due to of the relative distance from calving areas and summer ranges. Important insect relief habitat for the CAH occurs within the ANWR study area in the Canning River delta and the coastal area at Camden Bay.

During winter most caribou of the CAH utilize habitats in the southern foothills and mountain valleys where lichens are more abundant. Although the north slope is generally low in lichen abundance, they are the most heavily utilized winter forage items by the CAH (Roby 1978). Another preferred winter food is a wintergreen species (Equisetum variegatum) which is intensively grazed along river courses (Roby 1978).

Because of the relative low abundance of lichens in the tundra ranges north of the Brooks Range, the winter range carrying capacity of the CAH may be limited in comparison to the PH and western arctic herd which move to rich lichen areas south of the Brooks Range (Roby 1978). It is not known however, to what extent alternative winter forge can be successfully utilized by caribou wintering in the CAH. Currently, the CAH occupies its range at a density of approximately 0.33 caribou/km².

Effects of Human Activities on Caribou

Interactions between man and caribou in northeastern Alaska date 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 caribou herds (Klein 1980a).

Western man introduced firearms to northeastern Alaska, and the ease of killing caribou increased. Historical accounts indicate fairly high harvests 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 the Yukon Territory brought a wave of miners into the southern range of the PH. 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 PH and CAH 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, Yukon Territory and Circle, Alaska. Oil and gas exploration within the PH's range began in Canada during the early 1960's in the Eagle River - Peel River plateau region. 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 routes of the PH (Fig. 1).

Other significant human events which have influenced the PH and CAH, directly or indirectly, were establishment of the Arctic National Wildlife Range in 1960, the introduction of snowmobiles as a form of winter transportation (late 1960's), discovery of oil and gas at Prudhoe Bay and the Mackenzie River 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 expanded the boundaries of ANWR, and resulted in geological and geophysical exploration in the ANWR coastal plain. Native groups and government officials have recently reached agreement on land claims and caribou management issues on Canadian lands within the range of the PH. A national park has also been established in the northern Yukon.

The sport harvest of the PH has remained relatively low in Alaska. State law currently allows for an annual bag limit of 5 caribou from the PH's range. Recent subsistence harvests of caribou by Kaktovik residents have varied between 43 and 110 caribou per year and have been about equally divided between the PH and CAH herds (Pedersen and Coffing 1984). Annual subsistence harvest of caribou from the PH by residents of the Arctic Village area range from 300 to 1,000 (Whitten pers. comm.) with an additional 1000 to 3000 caribou harvested annually in Canada (Yukon Department of Renewable Resources pers. comm.). The annual harvest of caribou from the PH has been estimated at less than 5,000 and has averaged 5% or less of the estimated total population (LeResche 1975, Surrendi and DeBock 1976, Davis 1980, Whitten and Cameron 1980b). The reported harvest of the CAH has increased from 81 (1982-1983) to 368 (1984-1985) and 800-1000 (1985-1986), due primarily to increased use of the Dalton Highway by sport hunters (Barnett 1983, Whitten pers. comm.).

Excessive harvests and, in some cases, predation have been attributed to declines in several North American caribou populations (Bergerud 1974a, Davis et al. 1980). Current harvest levels of the PH appear to be sustainable. However, some biologists have expressed concern that if harvest levels increase slightly, a decline may occur (Bergerud 1980). Of particular concern is the prospect of increased harvest levels resulting from improved access afforded by new roads such as the Dempster Highway in Canada (for the PH) and the Dalton Highway in Alaska (for the CAH).

Other human interactions with both the PH and CAH caribou include contact by recreationists, air charter operators, trappers, geologists, biologists, other scientists, and land administrators. Concern has been expressed about the potential effects of human contact with on the calving grounds and post-calving areas, especially during post-calving migrations of the PH at river crossings (Calef and Lortie 1973), although no data are available to evaluate the effect of this type of disturbance.

Natural Processes Affecting Caribou

Naturally occurring events or factors which influence caribou populations were extensively discussed by Skoog (1968) and Kelsall (1968). Thomson (1973), Bergerud (1974b), Curatolo 1975), and Roby (1978) provided descriptions of the behavioral responses of wild reindeer and caribou to external environmental factors. Weather, predation, insects, and forage resources usually exert the strongest influences on caribou populations. Other natural factors known to influence caribou include diseases, parasites, accidents, and fire.

Weather

General climatic data for the study area are presented in Chapter 2, but detailed information regarding many facets of weather which may affect

caribou in the study area is lacking. Storms with high winds, low temperatures, and moisture were assumed to be associated with observed high calf mortality on calving grounds in northern Canada east of the Mackenzie River (Banfield 1954, Kelsall 1968). A recent re-evaluation of such cases indicates that factors other than weather may have been responsible for the reported calf mortality (Miller and Gunn, in press). Comparable instances of storm-induced calf mortality have not been reported on calving grounds in the study area or elsewhere in Alaska.

Much has been written regarding snow conditions and caribou (Pruitt 1959, Lent 1964, Henshaw 1968, Kelsall 1968, Skoog 1968, LaPerriere and Lent 1977, Thompson and Roseneau 1978, Lent 1980). When ice-crusted snow prevents access to winter forage massive die-offs of caribou can occur (Klein 1968, Skoog 1968). Apparently ice-crusting is not common for caribou herds associated with the ANWR study area. Ice-crusting conditions are more prevalent in western Alaska bordering the Bering Sea (Skoog 1968). Deep snow combined with late spring breakup tend to retard spring migration, resulting in caribou failing to reach the central calving ground prior to the birth of calves. Increased mortality of calves may occur under such conditions (Lent 1966).

Predation

Predation is considered to be a significant mortality factor for most North American caribou herds (Kelsall 1968, Skoog 1968, Bergerud 1974b). The influence of predation on the PH and CAH is not yet fully understood. Studies on predator populations, movements, and food habits were begun only recently, and data over the entire range of these herds have not been collected. The brown 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). Wolves, brown bears, and golden eagles are the primary predators of both the PH and CAH. A brief overview of each of these species relative to predation of PCH and CAH caribou is presented here. Additional information about these predators are discussed in Chapter 4 and later sections of this chapter.

Wolves. For most large caribou herds in North America, the wolf is the most significant predator (Kelsall 1968, Skoog 1968). The wolf has been hypothesized as a central factor in the evolution of behavioral characteristics of caribou resulting in adaptations such as migrations to areas of low wolf density for calving; synchrony of calving; gregarious behavior; the size, shape and clumping nature of groups; formation of aggregations; alertness to moving stimuli; and avoidance of ambush terrain (or structures resembling ambush features) (Bergerud 1974a and 1974b, Dauphine and McClure 1974, Cummings 1975, Curatolo 1975, Roby 1978). The density of wolves in the ANWR study area and remainder of the arctic slope of ANWR is considered to be relatively low. A minimum of 17 wolves were associated with calving and post-calving habitats of the PH within the northern portion of the ANWR in both 1984 and 1985 (Weiler et al. 1985 and 1986). This number remained constant in spite of wolf mortalities due to rabies and hunting during the spring of 1985. Most wolf sightings and relocations of radio-collared wolves were in the foothill and mountain provinces south of the ANWR study area. Nine wolves were known to inhabit that portion of the range of the CAH within or adjacent to the ANWR study

area during 1984 and 1985. Wolf densities throughout the remainder of both herd's ranges are not known. Wolf predation on young caribou calves on the calving grounds of the PCH has been relatively low (Whitten et al. 1984, 1985a, and 1986a). During calving and post-calving periods, detected cases of wolf predation on all age classes of PH caribou were located predominately in the foothill and mountain provinces to the south and southeast of the "core" calving grounds (Whitten 1984, 1985a, and 1986a). These locations correspond closely to known areas of wolf occurrence (Weiler et al. 1985, 1986). Wolves are considered to be rare on and adjacent to calving areas of the CAH (Roby 1978, Shiedler 1986).

Brown Bears. Brown bears are generally more numerous in and adjacent to the ANWR study area than are wolves and may be a more significant predator of young calves on the PH calving grounds (Calef and Lortie 1973; Roseneau and Curatolo 1976; Garner et al. 1984, 1985, and 1986; Whitten et al. 1984, 1985a, and 1986a). Movements of most radio-collared brown bears inhabiting the foothill and mountain provinces located south and southeast of the PH "core" calving area correspond closely with caribou arrival upon and occupancy of the calving grounds (Garner et al. 1984, 1985, and 1986). Evidence collected during calf mortality studies, as well as other wildlife studies, indicated that brown bears killed young calves during a relatively short time period when newborn calves lack adequate mobility to escape (Garner et al. 1984, 1985, and 1986; Whitten et al. 1984, 1985a, and 1986a). Brown bears are also effective scavengers of caribou carcasses of all age classes on the calving and post-calving areas. The overall effect of predation by brown bears on the total calf cohort of the PH is negligible (Whitten et al. 1984, 1985a, 1986a). Brown bears are relatively uncommon on the calving areas of the CAH and probably are an insignificant mortality factor for this herd (Roby 1978, Shiedler 1986).

Golden Eagles. Relatively high numbers of golden eagles in and adjacent to the calving and post-calving areas of the PH have been observed (Calef and Lortie 1973, Roseneau and Curatolo 1976, Whitten et al. 1984, Mauer 1985b, and 1986). A majority (80-90%) of golden eagles observed in association with the herd during the calving and post-calving season were sub-adults (Roseneau and Curatolo 1976, Mauer 1985b). During this time, most adult golden eagles occupied nesting territories located in the mountains south of the calving grounds (Mauer 1985b). Golden eagles prey on young caribou calves from the beginning of calving in late May until as late as July 26 (Mauer 1985b). During this period, PH caribou calf mortality due to predation by golden eagles may equal or exceed that of brown bears (Whitten et al. 1984, 1985a, and 1986a; Mauer 1985b and 1986). Although eagles are considered the most mobile of the 3 predators on the calving grounds, most predation of calves by eagles occurred in the foothill and mountain provinces located to the south and southeast of the "core" calving areas (Whitten et al. 1984, 1985a, and 1986a; Mauer 1985b and 1986). Golden eagles are apparently less abundant on calving areas of the CAH and are not considered a significant mortality factor (Roby 1978).

Investigations of neonatal caribou calf mortality on the PH calving grounds and post-calving areas found that predation by wolves, brown bears, and golden eagles accounted for 54-80% of observed mortality (Whitten et al. 1984, 1985a, 1986a). Other factors such as pneumonia, drowning and starvation/abandonment contributed to the remainder of early calf mortality. Overall calf mortality on the PH calving grounds and adjacent

areas was low, ranging from 10-25% (Whitten et al. 1984, 1985a, 1986a). At current conditions and calving distributions, predation occurring on the PH calving grounds does not appear to have a significant effect on the population. Predation observed among calves born nearer to higher density predator areas in the south/southeastern foothill and mountain terrains was 3 times higher than calf predation within the "core" calving area (Whitten et al. 1984, 1985a, and 1986a).

Insects/parasites

Effects of insect harassment on caribou have been well documented. From late June to late July caribou are plagued by mosquitoes. During the end of this period, oestrid flies (warble and nasal bot flies) emerge and harassment from these insects usually lasts beyond mid-August. Kelsall (1968) hypothesized that post-calving aggregations were partially a response to insect (mosquito) harassment. The advantage of clumping behavior was shown by Helle and Aspi (1983) who found significantly less mosquitoes at the center of reindeer groups than at the periphery. White et al. (1975) reported that under extreme mosquito harassment, CAH caribou at Prudhoe Bay 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 Forty-mile herd moved to north facing slopes for relief from mosquitoes (Curatolo 1975). Calef and Lortie (1973) reported that PH clumped into dense groups and sought relief from insects by standing and lying on snow drifts and wind swept ridges. In contrast, August dispersal may be a response to warble fly harassment (Curatolo 1975). Caribou harassed by oestrid flies elicit "aberrant running" behavior (Curatolo 1975) and "rigid standing" (Epsmark 1968). In reindeer, severe insect harassment influenced growth and survival of young calves (Haukioja and Salovaara 1978, Helle and Tarvainen 1984).

Warble flies (Oedemagena tarandi) and nasal bot flies (Cephenomyia trompe) are 2 parasites of caribou (Kelsall 1968, Skoog 1968). During July and August, adult warble flies lay eggs on the hair of caribou. Hatched larvae bore through the skin and migrate to the back region, where they remain throughout the winter. In June, the larvae emerge and drop to the ground. Serious infestations range from several 100 to as many as 1000 warble larvae on a single caribou (Dieterich 1980). Heavy warble fly infestations can impair the animal's overall health, cause local infections, and sometimes result in death (Dieterich 1980).

Nasal bot flies 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.

Forage Resources

The influence of range conditions (forage quality, quantity, and availability) on the health and productivity of reindeer and caribou herds has received considerable study. Although there are many complex inter-relationships which remain only poorly understood, a few principles are well established. Several northern ungulates, including caribou,

exhibit seasonal growth cycles in which there is rapid body growth of the calves and body fat accumulation in adults during the summer, followed by a period of little or no growth during winter (Wood et al. 1962, Dauphine 1976, White et al. 1981). Summer nutrition, body growth, and fat accumulation are important in several aspects. Poor range conditions or disturbed foraging activity can reduce milk production in lactating female caribou (White and Luick 1984). Adequate forage resources and access to those resources during the period after calving and before insect harassment begins are important for growth of calves and nutritional maintenance of adults (Zigunov 1961, Reimers et al. 1983). Summer weight gain has been shown to be an important factor in survival of reindeer calves (Haukioja and Salovaara 1978), and the breeding and pregnancy success of adults. Body weight and nutritional status apparently determine the age of sexual maturity of the female calf (Reimers et al. 1983). The level of insect harassment can affect summer weight gain and calf survival (Helle and Tarvainen 1984). Therefore, access to insect relief habitat is important to herd recruitment and productivity. The health and nutritional status of pregnant females influences fetal growth (Skoglund 1984), calving time (Reimers et al. 1983), calf birth weight, and calf survival (Rognmo et al. 1983, Skoglund 1984). Quality of winter range can also influence herd productivity and growth (Skoglund 1985). Most studies of range ecology, nutrition, and herd productivity have been conducted on domestic and wild reindeer herds in Scandinavia where predator populations are low or non-existent. Although some studies have been done in northern Canada (Dauphine 1976) and Alaska (White et al. 1975), more information is needed about range ecology of the large migratory caribou herds of North America where predation may modify the relationship between range condition and caribou populations.

Diseases

Brucellosis is considered by Skoog (1968) to be the most important of the numerous diseases which have been found in caribou. This bacterial disease, endemic to caribou and reindeer throughout the world, can cause abortions, retained placentas, infection of male 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) and is increasing in reindeer herds in western Alaska (Dieterich 1980). The status of brucellosis in the PH and CAH is not known. Relatively few cases of pneumonia and inherited defects have been found which caused mortality among young calves of the PH (Whitten et al. 1984, 1985a, and 1986a).

Accidents

Caribou are victims of a number of accidents during their long migrations. Many observed accidents occur in association with water crossings. In the barren lands of northern Canada, drowning losses have been reported where herds cross rivers in the vicinity of rapids (Clarke 1940, Kelsall 1968). In 1984, over 10,000 caribou of the George River herd in eastern Canada died of drowning and injuries resulting from being swept over a falls on the Caniapiscaw River located downstream from a hydroelectric facility (Gouldreault pers. comm.). Caribou have been observed drowning after falling through thin ice on lakes and rivers (Skoog 1968). Others die from falls from cliffs (Skoog 1968). A relatively low incidence of drowning was

documented among calf mortalities of the PH (Mauer et al. 1983, Whitten et al. 1985a). The incidence of crippled animals in large post-calving aggregations of the PH 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).

Fire

Wildfire is common throughout the forested portions of winter range used by the PH (Calef 1974). Distribution of the CAH is north of the Brooks Range where fire is quite rare. Fires are known to destroy lichens which are often important winter forage for caribou. The importance of forest fires in nutrient recycling, habitat diversity, and long term cycles of lichen abundance was reported by Skuncke (1969) and Viereck (1973). Forest fires on winter range may have resulted in population declines in caribou herds (Palmer and Rouse 1945; Leopold and Darling 1953b; Scotter 1967, as cited by Klein 1980b). However, Bergerud (1974a) disagrees and concluded the destruction of lichens by fire was probably not responsible for caribou population declines in North America 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. Miller (1980) demonstrated that caribou showed greater preference for medium aged lichen stands over older stands and reported caribou uses of recent burn areas. Klein (1980b) concluded that 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 assuring continued lichen growth and diversity of ecological systems.

Data Gaps

Ongoing population monitoring surveys should be continued and refined. Improvement in the accuracy of caribou population estimation and methods that will yield more representative herd composition data are needed. Special emphasis is needed to determine the applicability of extrapolating impact assessment data from the non-migratory CAH to the migratory PH.

Muskoxen (Ovibos moschatus)

Muskoxen were formerly found throughout arctic Alaska (Hone 1934), but were probably extirpated on the arctic coast between 1858 and 1865 (Allen 1912, Reed 1946). Wilkenson (1972) speculated that muskoxen were exterminated rapidly after early whalers introduced firearms to the Eskimo population. But Cambell (1978) stated that few if any firearms were present on the arctic coast before 1850 and suggests that muskoxen were progressively exterminated as Nunamuit Eskimos colonized the coastal plain beginning about 200 years ago. He presented archaeological evidence which indicates that hunters could kill groups of muskoxen using the most primitive of weapons. Will (1984) reported that muskoxen were relatively easy for 19th century Inuit Eskimos to procure in large numbers and that hunting strategies included killing single animals or entire herds.

Muskoxen were reestablished on the ANWR coastal plain study area when animals brought from Nunivak Island were released at Barter Island in 1969 and at Kavik in 1970. In 1972 and 1973, muskox surveys were conducted in the summer on the arctic coastal plain (Roseneau and Warbelow 1974) and

between 1978 and 1981, pre-calving population censuses of muskoxen were made annually (U.S. Fish & Wildlife Service 1982). Studies of habitat use and activity patterns of a muskox herd along the Sadlerochit River were conducted in 1978 and 1979 (Jingfors 1980, Robus 1981). A study to compare muskox habitat use in different drainages was begun in 1983 (C. O'Brian, pers. comm.). From 1982 to 1985, population and herd dynamics, seasonal distribution, movements, and habitat use of muskoxen on the ANWR coastal plain were documented as part of the ANWR baseline study. During this study a total of 45 individuals were captured and 43 animals were radio-collared. Population information was collected during spring and fall surveys, and during post-calving composition counts. Radio-collared individuals were relocated weekly during summer and monthly during winter to document distribution, movements and habitat use (Reynolds et al. 1983, 1984, 1985 and 1986).

During the ANWR baseline study, the study area was divided into 3 sub-areas on the basis of historical and current use by subpopulations of muskoxen: 1) the Tamayariak area between the Canning River and the Katakturuk River; 2) the Sadlerochit area between the Katakturuk River and the Jago River; and 3) the Okerokovik area between the Jago River and the Canadian border (Reynolds et al. 1986). For purposes of analysis, the year was divided into 6 seasons, relative to life cycle activities of the muskoxen (Table 4).

Table 4. Seasons of the year relevant to muskox life cycle activity.

Name of season	Dates of season
Winter	mid-November to early March
Pre-calving	mid-March to mid-April
Calving	late April to mid-June
Summer	late June through July
Rut	August to mid-September
Fall	late September to early November

Population Size and Productivity

Muskoxen were reintroduced to the ANWR coastal plain in 1969 when 51 muskoxen (27 males and 24 females) from Nunivak Island were brought to Barter Island (Griffin 1969, Hout 1969, Jennings 1970a). The animals were released in 4 small groups in late March and early April. Over half the animals were less than 2 years old (Jennings 1970a). A total of 38 muskoxen were seen in small groups south of Barter Island 2 days after the last group was released (Griffin 1969), but initial mortality was high. At least 9 animals died by mid-April and 6 apparently moved east into Canada, where 3 to 5 were reportedly shot (Neiland 1969, Thayer 1969a and 1969b, Lent 1971, Jennings and Burris 1971). Another bull was shot south of the Brooks Range in October 1969 (Hinman 1969, Thayer 1969a). Therefore the initial transplant on the ANWR coastal plain probably did not exceed 35 muskoxen.

Sightings of muskoxen in the first few months following the initial transplant suggest that dispersal and mortality may have further decimated numbers of animals on the ANWR coastal plain. Only 10 different individuals were seen between June and August 1969 (Thayer 1969c). Knutson (1969), in

an extensive survey to locate muskoxen, observed only 17 muskoxen in early September 1969. Thayer (1970) reported seeing 18 individuals in February 1970. Mortality of another bull was documented in August 1970 (Jennings 1970b). In June 1970, 13 more muskoxen (3 males and 10 females, 2-3 years old) were released at the Kavik River airstrip, about 145 km southwest of Barter Island and 26 km west of ANWR's western boundary (Jennings and Burris 1971). Nothing is known about initial mortality of the Kavik transplant.

In spite of initial mortality and long range dispersal of some animals after the Barter Island transplant, enough muskoxen survived to form the nucleus of breeding populations on the ANWR coastal plain. A maximum of 48 muskoxen may have been present on or near the refuge after the 1970 Kavik transplant, assuming that all 13 of these animals survived and moved west to the ANWR coastal plain. A maximum of 27 individuals was counted in 1971 (Griffin 1971), and population estimates were 29 and 33 animals older than calves in 1972 and 1973, respectively (Roseneau and Warbelow 1974). These data suggest that initial mortality and/or dispersal exceeded documented levels.

The ANWR muskox population is growing rapidly (Fig. 21). From an estimated population of 36 animals in summer 1972, the post-calving population increased to an estimated 476 animals in November 1985 (Reynolds et al. 1986). The population has doubled every 3 to 4 years since 1976, and annual rates of increase have ranged from 0.16 to 0.32 ($X=0.22 \pm .07$ SD) for pre-calving population estimates since 1978 (Table 5).

Table 5. Numbers of muskoxen observed in the Arctic National Wildlife Refuge during spring, summer and/or fall, 1972-1986.

Year	Spring pre-calving census		Summer population or composition counts		Fall total population	
	Total number	Annual rate of increase	Total number	Number of calves	number	Source
1972	--	--	36	7	--	a
1973	--	--	36	8	--	a
1974	--	--	38	--	--	b
1976	--	--	67	15	--	b
1977	--	--	90	18	--	b
1978	86	--	108	28	--	c
1979	112	0.30	--	--	--	d
1980	148	0.32	--	--	--	e
1981	186	0.26	--	--	--	f
1982	219	0.18	--	--	240	g
1983	257	0.17	211	46	311	g
1984	301	0.17	341	72	384	g
1985	352	0.17	419	98	476	g
1986	408	0.16	--	--	--	g

- a Roseneau and Warbelow 1974
b U.S. Fish and Wildlife Service 1972
c Ross (1978)
d Ross (1979)
e Ross (1980)
f Ross (1981)
g current study

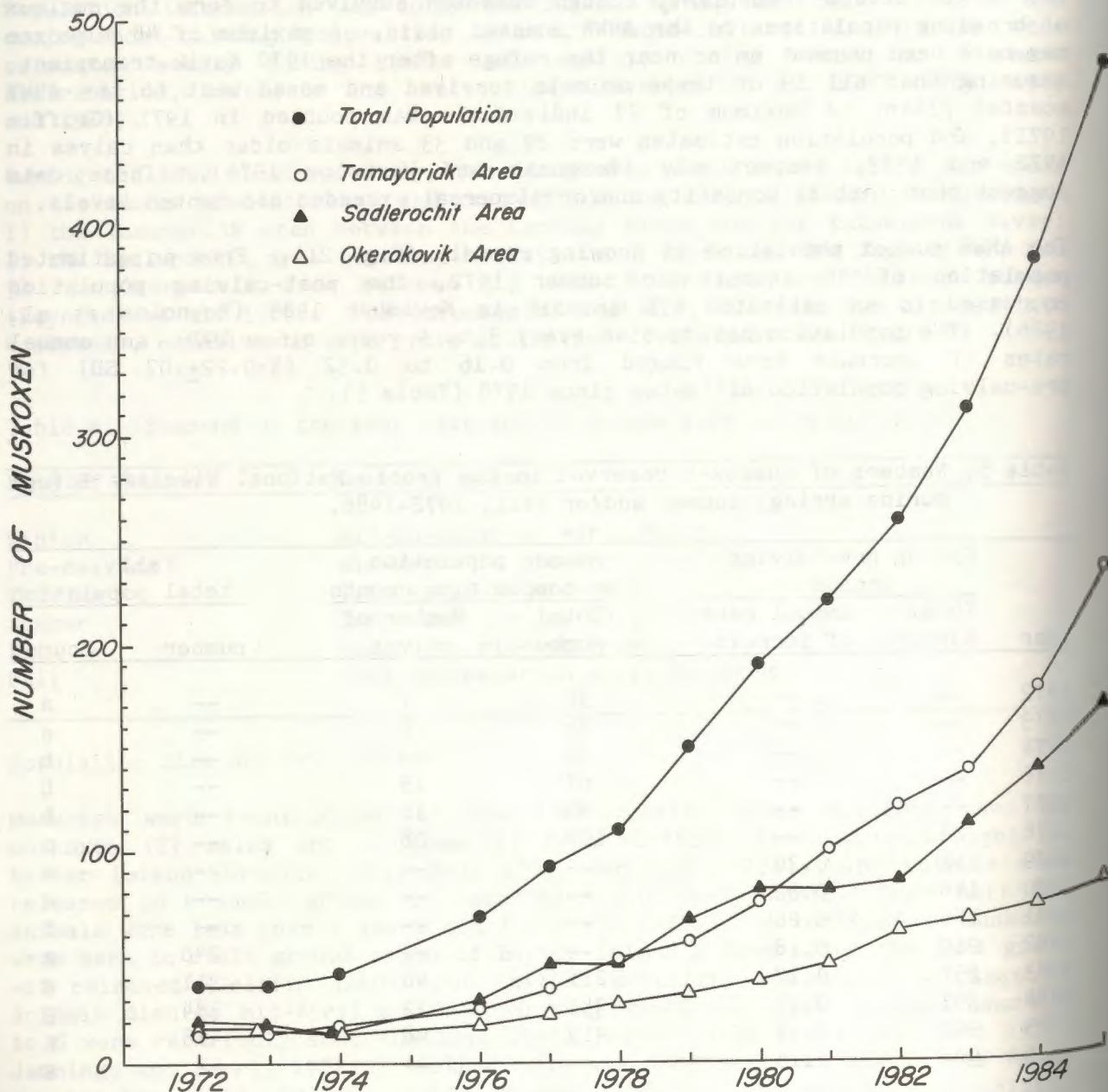


Fig. 21. Estimated number of muskoxen in post-calving populations in the Arctic National Wildlife Refuge, 1972-1985.

This rapid increase in population size, typical of populations exploiting a new environment, is the result of high productivity, high survival of young-aged animals, and low mortality rates for all animals. Similar population increases were documented in a transplanted muskox population in West Greenland (Thing et al. 1984) and in muskox populations in the Northwest Territories, Canada (Gunn 1984). Estimated numbers of calves, observed in the ANWR muskox population from 1972-1985, suggest that productivity has been relatively high during most of the past 13 years (Reynolds et al. 1986). From 21-23% of all animals seen in post-calving surveys in 1983-1985 were calves, and ratios of calves/animals older than calf ranged from 0.27 to 0.30 ($\bar{X}=0.28 \pm 0.02$ SD) (Table 6). Productivity for the entire study area ranged from 0.66 calf/cow in 1983 to 0.75 calf/cow in 1984 and 1985, for cows 3 years and older (3+) (Table 6). Calf production by 2-year old cows along the Sadlerochit River was documented by Jingfors and Klein (1982) in 1979. Population growth closely approximates ($R^2=.98$) an exponential curve. Assuming population growth continues at the same rate, the muskox population may exceed 1000 animals by 1990.

Table 6. Parameters of muskoxen productivity, in early to mid summer in the Arctic National Wildlife Refuge, 1972-1985.

Parameter	Year							
	1972	1973	1976	1977	1978	1983	1984	1985
Number calves classified	7	8	15	18	28	46	72	98
Calves/total classified	0.19	0.22	0.22	0.20	0.25	0.22	0.21	0.23
Calves/ older animal	0.24	0.27	0.29	0.25	0.33	0.28	0.27	0.30
Calves/adult cow (3+)					0.79	0.66	0.75	0.75
Total number calves ^a						68	81	111

^a Calculated by: calves/total x total population (fall census)

In 1984 and 1985, total population counts in fall were higher than those observed during spring pre-calving counts combined with total number of calves estimated for the population. This increase in numbers of animals older than calves observed between spring and fall may be due to immigration, an underestimation in the numbers of calves, and/or animals missed during the spring census. The latter possibility appears to be the most likely: in spring, small groups of animals on windblown ridges can be difficult to see and could have been missed. As total counts in spring may underestimate the population, fall counts were used as an estimate of total population when calculating total numbers of calves (Table 6).

Productivity of 15 radio-collared cows was observed for 2 to 4 consecutive years (Reynolds et al. 1986). Nine (60%) of these cows produced calves yearly for 2 or more years and 4 (27%) had calves every other year (Table 7). Of the 2 cows which produced calves only once in 3 years, 1 was a barren 16 year old cow. The other cow produced a calf at age 6, but did not calve at age 4 or 5. Calf/cow ratios for radio-collared cows were similar to those observed for the entire population during 1982-1985 (Reynolds et al. 1986). The high productivity observed in ANWR is similar to muskox productivity recorded for transplanted populations and populations exploiting new habitat in Greenland

(Lassen 1984, Thing et al. 1984), Canada (Gunn et al. 1984) and Nunivak Island (Smith 1984), but contrasts with low productivity and reproductive failures of muskoxen documented in the Canadian high arctic (Tener 1965, Gray 1973, Gunn 1984).

Table 7. Productivity of radio-collared cow muskoxen in the Arctic National Wildlife Refuge, 1982-1985.

No. consecutive years observed	Number of cows producing calves			
	Yearly	Alternate years	2 + years	Totals
2	3	3	-	6
3	5	1	1	7
4	1 ^a		1	2
Totals	9	4	2	15

^a Calf stillborn the first year.

Low mortality has also allowed the rapid expansion of the ANWR muskox population. In the past 4 years, the death of 29 individuals has been documented and accounted for 2.3-2.7% of the population per year (Table 8). Nineteen (66%) of these animals were adult bulls. A limited hunting season established by the State of Alaska in 1983 has resulted in a total harvest of 13 bull muskoxen. Two bulls were killed or scavenged by a radio-collared brown bear in late summer 1983 and 2 young aged cows were also killed or scavenged by brown bears during the late winter of 1984-1985. Three radio-collared cows which died in 1984 and 1985 were old-aged animals, originally brought to the refuge from Nunivak Island. When released at Barter Island in March 1969, they were 11 or 36 months old and therefore died at ages 16 to 19 years ($\bar{X}=17.3 \pm 1.5$ SD). Assuming no animals immigrated into this transplanted population between November 1983 and April 1985, and calves were the only source of recruitment, estimates of 7-12% annual loss (mortality and dispersal) to the population were calculated for 1983-1986 (Table 9).

Mortality during the first years of life is often high in ungulate populations (McCullough 1984). High survival of muskox calves and yearlings was documented in the ANWR population between 1983 and 1985 (Fig. 22). Numbers of individuals were extrapolated from summer composition counts, and fall population counts except in 1982. The ratio of calves/total animals ($38/240=0.150$) observed from the air during the 1982 fall census was multiplied by the number of animals in the 1983 spring census (257), resulting in a minimum estimate of 41 calves in 1982. Average survival rates (Downing 1980) were 85% for calves and 92% for yearlings between 1983 and 1985. Jingfors and Klein (1982) documented 100% survival of calves and yearlings in a muskox herd on the Sadlerochit River during 1979-1980.

Herd Dynamics

Prior to 1982, most muskoxen were thought to be associated with 1 of 3 large "herds", each of which showed an affinity for a specific geographic area (U.S. Fish and Wildlife Service 1982). In 1979, muskoxen observed by Jingfors (1980) along the Sadlerochit River remained in 1 large herd from March to

Table 8. Muskox mortalities observed in the Arctic National Wildlife Refuge, 1982-1985.

Cause of Mortality	Year				Totals
	1982	1983	1984	1985	
<u>Hunting:</u>					
M	-	4	5	4	13
F	-	-	-	-	-
calf	-	-	-	-	-
<u>Fighting:</u>					
M	1	-	-	-	1
F	-	-	-	-	-
calf	-	-	-	-	-
<u>Predation/scavenging:</u>					
M	-	2	-	-	2
F	-	-	-	2	2
calf	-	-	1	-	1
<u>Old-age/malnutrition:</u>					
M	-	-	-	-	-
F	1	-	1	2	4
calf	-	-	-	-	-
<u>Unknown:</u>					
M	2	1	1	-	4
F	1	-	-	-	1
calf	<u>1</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>1</u>
Totals	6	7	8	8	29
% Pop.	2.7	2.7	2.7	2.3	

Table 9. Estimates of annual loss (mortality and dispersal) to the pre-calving muskox population in the Arctic National Wildlife Refuge, 1983-1984.

Time Frame t and t+1	Pre-calving population (P _t)	Total number calves (C _t)	Population 1 year later (P _{t+1})	Annual loss (L _t =(P _t +C _t)-P _{t+1})	Percent loss L _t /P _t +C _t)
1983-1984	257	68	301	24	7.4
1984-1985	301	81	352	30	7.9
1985-1986	352	111	408	55	11.9

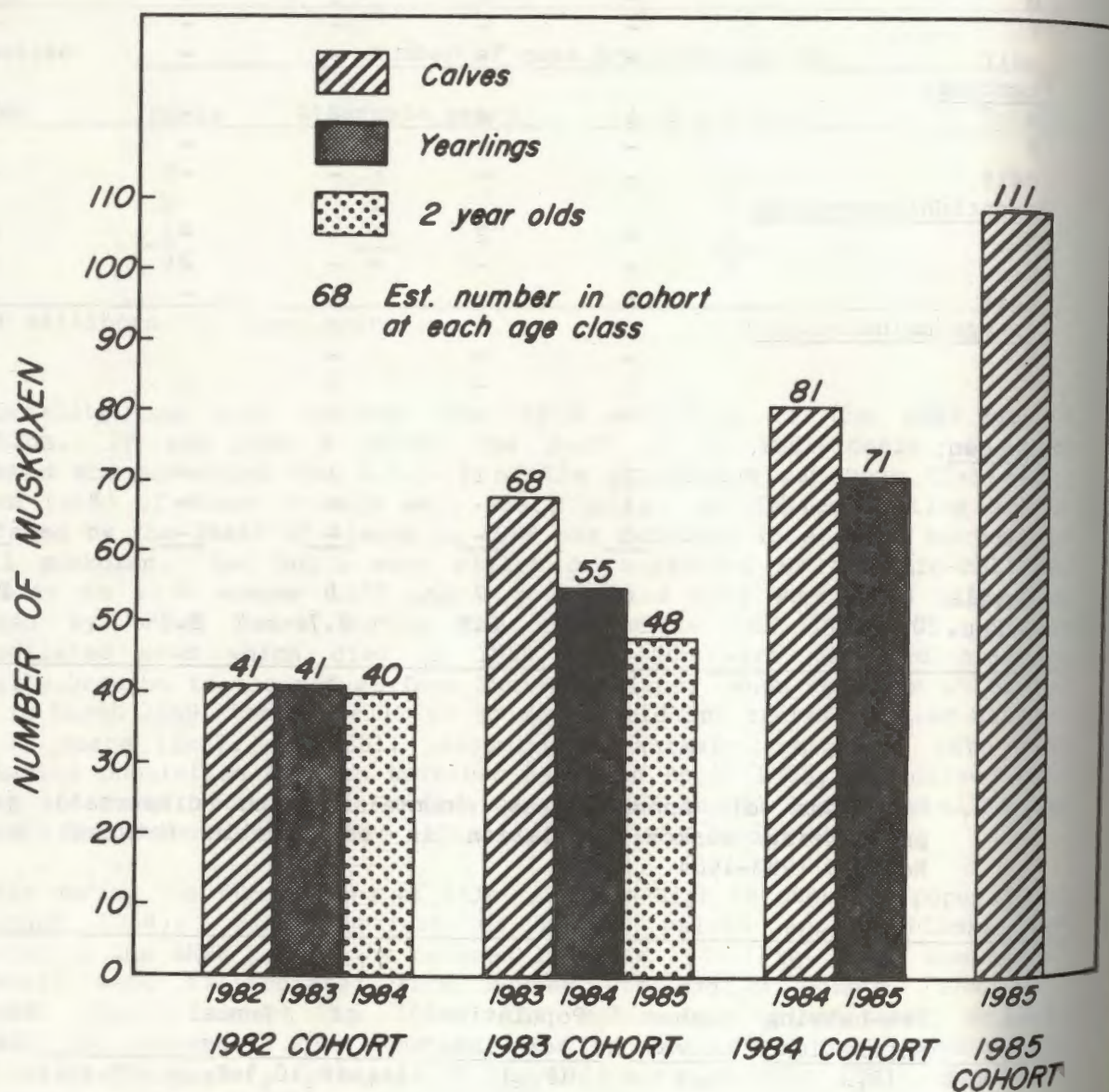


Fig. 22. Production and survival of calf and yearling muskoxen in the Arctic National Wildlife Refuge, 1982-1985.

November with only infrequent temporary fracturing into smaller groups, primarily during the rut. However, Jingfors and Klein (1982) predicted that the large herd observed in 1979 would eventually fracture into smaller units. The existence of numerous muskox herds on the ANWR coastal plain during 1982-1985 was documented with the use of radio-collared muskoxen (Reynolds et al. 1983, 1984, 1985, and 1986). These herds apparently belong to 1 of 2 subpopulations. The Okerokovik subpopulation utilizes the area between the Jago River and Kongakut River. Bulls in this subpopulation also range into Canada as far east as the Firth River. The Sadlerochit/Tamayariak subpopulation utilizes the area from the Hulahula River to the Canning River. Bulls in this subpopulation also range westward as far as the Sagavanirktok River (Reynolds et al. 1985, 1986).

Different types of muskox groups were observed in these 2 subpopulations during 1982-1985 (Reynolds et al. 1986). Most commonly seen were mixed-sex herds, comprised primarily of cows, sub-adults, and calves with possibly 1 or more adult bulls. Small groups of cows and cows with calves, as well as single cows were seen less frequently. Bull groups were made up of bulls older than 3 years of age. Bulls were also observed alone. Gunn (1982) stated that muskoxen spend most of their life in mixed-sex herds, but bulls also occur in single-sex groups of 2-5 and as solitary animals.

Mixed-Sex Herds and Cow Groups. Herd size calculations were based on observations made during radio-relocation flights and spring and fall surveys. Mixed-sex herds ranged in size from 2 animals (a bull and a cow) to 118 animals. More than 80% of all mixed-sex herds contained between 5 and 30 individuals (Reynolds et al. 1986). Smith (1976) seldom saw mixed-sex herds smaller than 5 animals on Nunivak Island.

Mean herd size of mixed-sex herds ranged from 13.6 ± 11.2 SD in 1982 to 21.5 ± 17.5 SD in 1984 (Fig. 23) but were not statistically different between years. Seasonal differences in herd size, related to social behavior were also observed. The largest mixed-sex herds were seen in pre-calving, winter and fall seasons, when mean herd size for all years ranged from 21.7 ± 15.9 SD to 27.2 ± 22 SD muskoxen per mixed-sex herd. The smallest herds were seen during the rut ($X = 12.2 \pm 8.5$ SD). This trend was observed all 4 years of the study (Fig 24). On Bathurst Island, Gray (1973) found monthly mean herd size changed from highs in February, April and October to lows in July and August. On Melville Island (Miller et al. 1977, as cited in Gunn 1982) also observed a decrease in average herd size from 17.2 in March-April to 10.0 in July-August.

Most mixed-sex herds observed during radio-relocation flights on ANWR were small to moderately sized throughout the year. But the number of herds containing fewer than 10 animals reached maximum in August as herds fragmented into harems during the rut (Reynolds et al. 1985). Smith (1976) describes a harem as a temporary social unit which existed only during the rut between a single bull and a group of cows. However, Smith (1976) suggests that a basic social structure independent of bulls may exist. After the rut, muskoxen in the ANWR study area congregated along rivers in large herds, and the proportion of herds with more than 30 muskoxen reached a yearly maximum (Reynolds et al. 1985).

Maximum herd size observed was larger each year as the population increased, suggesting that the upper limit to herd size has not yet been reached. Mean

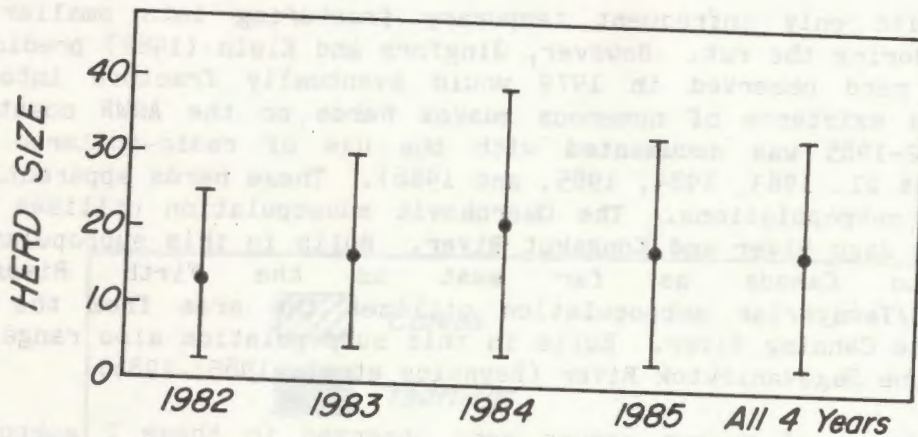


Fig. 23. Mean size of mixed-sex muskox herds (including cow groups) in the Arctic National Wildlife Refuge, 1982-1985.

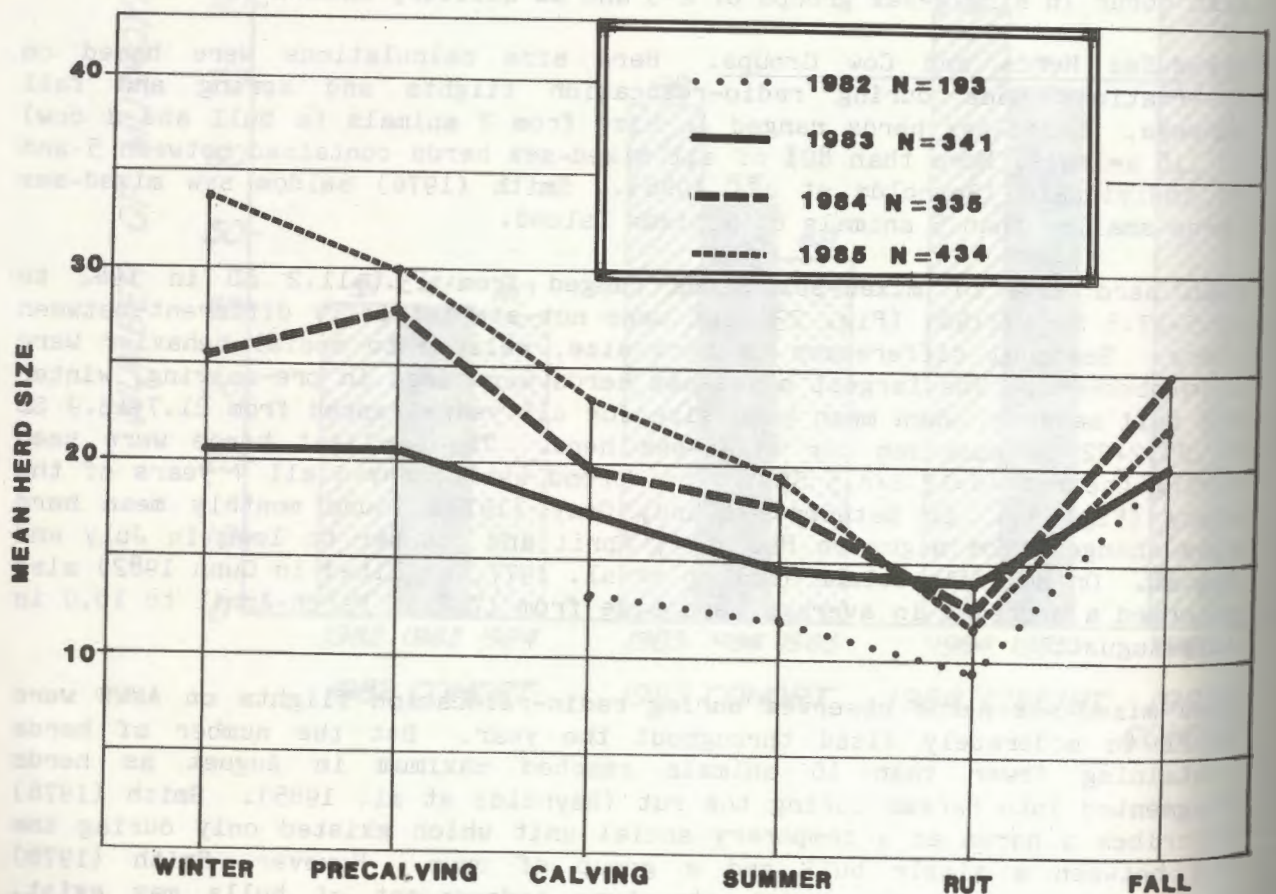


Fig. 24. Seasonal variation in the mean size of mixed-sex muskox herds in the Arctic National Wildlife Refuge, 1982-1985.

herd size during the rut ranged from 9.5 to 14.3 animals from 1982-1985, suggesting that optimum harem size may be within this range (Reynolds et al. 1986).

Since 1982, mixed-sex muskox herds in ANWR have not been stable units over long periods of time. Total numbers and marked individuals within a herd remained the same in some instances for several weeks, then changed as herds encountered one another and intermixed (Reynolds et al. 1986). Some years intermixing occurred when herds came together during pre-calving and calving seasons. Intermixing of herds also frequently occurred when animals congregated on major rivers after leaf emergence of willows in late June and after the rut in late September. Mixed-sex herds appeared to be more stable in winter (Reynolds et al. 1986).

Single cows and small groups of cows (ranging in size from 2 to 10 individuals) were seen infrequently. Only 4% of over 1300 observations of muskox groups containing cows were single cows or cow groups. Mean size of known cow groups was 4.4 ± 2.2 SD during 1982-1985. Old aged cows were seen alone or with a calf or young cow on several occasions (Reynolds et al. 1986). Smith (1976) seldom saw cows alone and suggested that animals which become separated quickly tried to rejoin the herd. Gunn (1982) speculated that parturient cows would be unlikely to leave the protection of the herd to give birth. Observations of ANWR muskoxen during 1982-1985 indicate that at least some cows are alone during birth, possibly because they or the newborn calf are unable to keep up with a moving herd (Reynolds et al. 1985).

Bull Groups and Single Bulls. Bull groups in the ANWR study area ranged in size from 2 to 10 animals. Mean bull group size (excluding single bulls) calculated from observations made during radio-relocation flights and seasonal surveys, ranged from 4.6 ± 2.0 SD bulls per group during the pre-calving season to 2.6 ± 0.6 SD bulls per group during the rut. Observations of single bulls comprised 15% of all bull observations during the pre-calving period, but increased to 78% during the rut. Bull groups were spatially segregated from mixed-sex herds, particularly in winter, pre-calving and calving seasons. Many marked bulls did not remain with mixed-sex herds for long periods of time, but moved from herd to herd (Reynolds et al. 1986). All marked males were associated with bull groups or were observed alone during at least part of the year during 1982-1985 (Reynolds et al. 1985).

Distribution, Movements, and Range

Muskoxen observed in the ANWR study area from 1982 to 1985 were concentrated in distinct geographic locations between the Canning River and the Katakturuk River, along the Sadlerochit River and between the Jago River and the Aichilik River (Fig. 25). Historical data indicates that these areas have been used by muskoxen since shortly after the animals were released at Barter Island in 1969 and at Kavik River in 1970 (Fig. 26). In the Okerokovik area, 11-13 muskoxen, including 9 adults, were observed in 1972 and 1973 (Roseneau and Warbelow 1974) and from 1978 to 1981, 14-23 muskoxen were seen along the Okerokovik, Niguanak, and Angun Rivers (U.S.Fish and Wildlife Service 1982). Along the Sadlerochit River, 5-9 muskoxen were seen between April 1969 and March 1970 (Lent 1971), 11-14 animals including at least 8 adults were seen in 1972 and 1973 (Roseneau and Warbelow 1974), and 36-74 muskoxen were observed between 1978 and 1981 (U.S.Fish and Wildlife Service 1982). Jingfors (1984) described the home

range affinity of muskoxen along the Sadlerochit River in 1979. Animals in the Okerokovik area and Sadlerochit area were probably survivors of the 1969 Barter Island transplant, which eventually segregated into 2 mixed-sex herds (Reynolds et al. 1986).

Muskoxen have been observed in the Tamayariak area since at least 1972 (Fig. 26). These animals were probably survivors of the 13 muskoxen released at Kavik in 1970 (Reynolds et al. 1986). Ten to 11 animals, including 8 adults, were seen between the Kavik River and the Katakturuk River in 1972 and 1973 (Roseneau and Warbelow 1974), and 32 to 66 muskoxen were observed along the forks of the Tamayariak River from 1978 to 1981 (U.S. Fish and Wildlife Service 1982). Movements of marked bulls, and less frequently of marked cows, indicate that animals in the Tamayariak and Sadlerochit areas belong to the same reproductive subpopulation (Reynolds et al. 1986).

Muskoxen utilized the same geographic areas during 1982-1985, when extensive data on distribution and movements of marked animals were collected (Fig. 25). Distribution expanded beyond these core areas each year of the study, in part because additional marked animals were added each year. However, dispersal of mixed-sex herds into new areas has also occurred since 1982 (Reynolds et al. 1986).

Mixed-sex herds dispersed into the upper Katakturuk River in 1982 and 1983. Small bull groups and solitary bulls had been seen along the Katakturuk River since 1979 (U.S. Fish and Wildlife Service 1982). However, no long term use by mixed-sex herds was observed until August 1982, when a mixed-sex herd of 6 muskox, which had moved between the Tamayariak area to the Sadlerochit area in June and July, moved to the upper Katakturuk River. This herd, joined by other animals and a second herd in 1983, remained between the upper Katakturuk River and Nularvik River during winter, pre-calving, and calving seasons. These animals summered on the forks of the Tamayariak River, the creeks south of Camden Bay, and the lower Katakturuk River during 1983-1985. At least some of these muskoxen moved back to the Tamayariak River in June 1984. In the fall of 1985, 137 muskoxen were located along the upper Katakturuk River. Increasing use of this area by animals from the Tamayariak area suggests population pressure in localized areas may be resulting in dispersal (Reynolds et al. 1986).

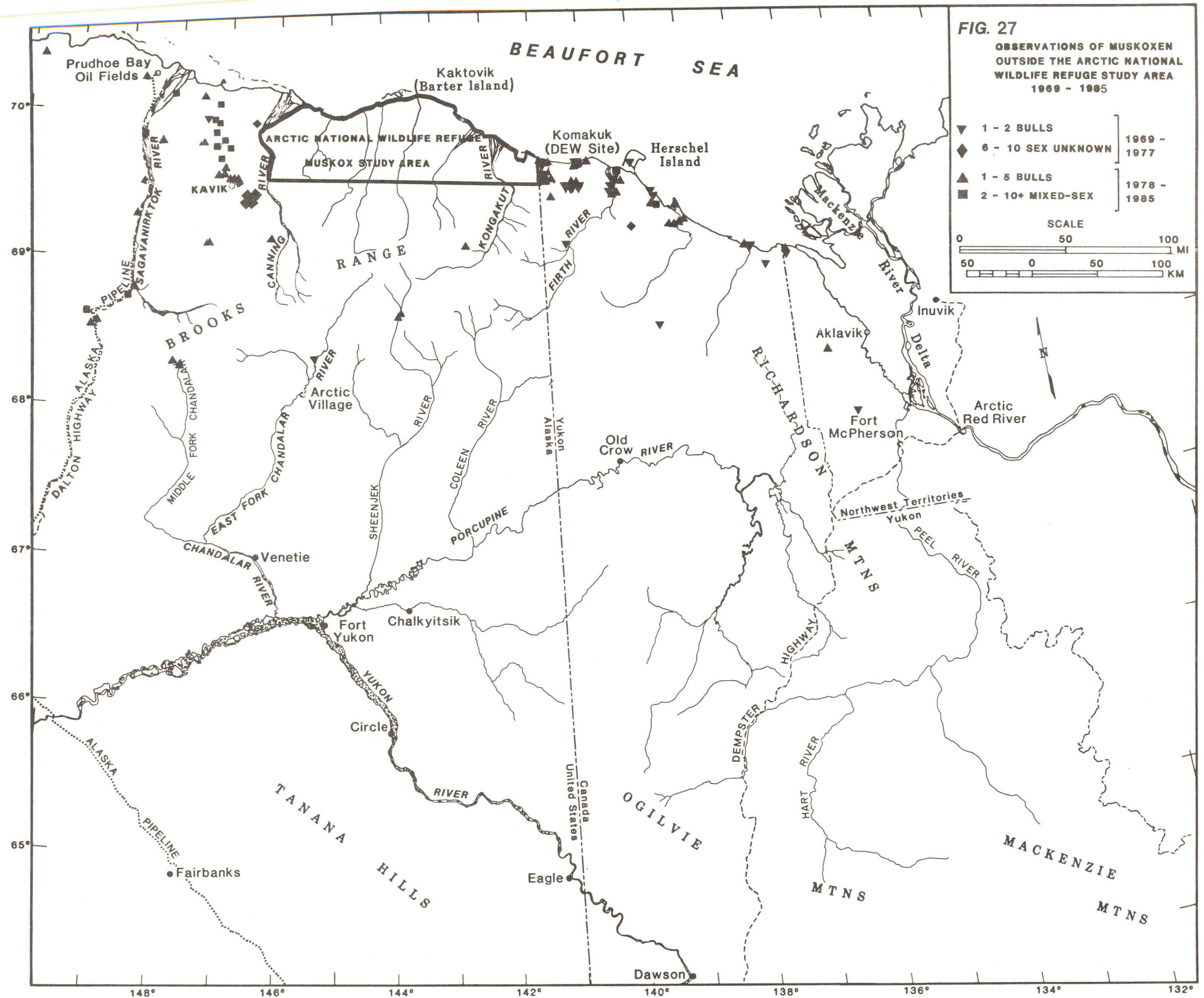
Muskoxen may also have dispersed eastward from the Okerokovik River. A mixed-sex herd of 14 animals apparently moved 30 km southeast from the Angun River to tributaries of the Ekaluakat and Siksikpalak Rivers in early April 1984. This herd spent the following winter along the western tributary of the Aichilik River and ranged between the Aichilik River and the Kongakut River throughout 1985 (Reynolds et al. 1986).

In addition to dispersal within the study area, bulls have dispersed or made temporary movements east, west, and south of the ANWR study area (Fig. 27). Some animals moved long distances soon after the Barter Island transplant. In August 1969, within 5 months of being released at Barter Island, 3-5 muskoxen were shot in Canada as far east as the Mackenzie River delta (300 km east of Barter Island) and another muskox was shot north of Arctic Village, 240 km south of Barter Island (Lent 1971). Solitary bulls and small groups of animals have been observed in northwestern Yukon Territory, Canada, almost every year since 1972 (Roseneau and Warbelow 1974, K. Jingfors pers. comm., J. Russell pers. comm.). Between 1982 and 1985, as



FIG. 26 Observations of muskox in the Arctic National Wildlife Refuge 1969-1981





many as 5 bulls were seen between the Canadian border and the Babbage River. These included radio-collared bulls which moved between Canada and the Kongakut River (Reynolds et al. 1986).

West of the ANWR, muskoxen have also been sighted since 1970 (Fig. 27). Solitary bulls and at least 1 mixed-sex herd of 9-19 animals have been seen several times along the Sagavanirktok River and adjacent drainages from Prudhoe Bay to Toolik Lake between 1970 and 1983. Radio-collared bulls moved between the Tamayariak area and Prudhoe Bay in 1985 and 1 radio collared bull moved at least 100 km west to the Ivishak River in 1985 (Reynolds et al. 1986). Muskox bulls have also been seen 190 km west of the study area on the Colville River near Nuiqsuit, and 300 km southwest along the Killik River. In 1984 and 1985, single bulls were seen 50 km south of the ANWR study area in the Romanzof Mountains, and 300 km southwest of the ANWR study area along the middle fork of the Chandalar, the upper east fork of the Chandalar River, and on the Sheenjek River, all of which are south of the Brooks Range divide (Reynolds et al. 1986).

A mixed-sex herd and bull groups were also seen along the Kavik River 26 km west of the ANWR study area during 1983-1985. Radio collared bulls moved between the Tamayariak area and Kavik River in 1985. Muskoxen seen on the Kavik River during 1983-1985 were included in ANWR fall population estimates and comprised 2-3% of the population (Reynolds et al. 1986).

Winter and Pre-Calving Distribution of Mixed-Sex Herds. Distribution and movements of mixed-sex muskoxen herds observed from 1982-1985 showed seasonal trends in the use of specific geographic areas (Reynolds et al. 1985, 1986). In winter, in the Tamayariak area, herds were found along creeks south of Konganevik Point, the upper Tamayariak near VABM Yari, and in the uplands near VABM Tam. During the month of April, 1983-1985, most herds in the Tamayariak River were in the vicinity of VABM Yari. Some animals moved to the west fork of the Tamayariak River in early April and remained there until mid-May (Fig. 28).

Most mixed-sex muskoxen herds wintering in the Sadlerochit area remained along the river during late winter 1983-1985 (Fig. 28). During 1982 and 1983, muskoxen were found on the ridges south of the upper Sadlerochit River in late March and early April. In mid-March 1984 and late February 1985, most animals had congregated into 1 large herd and moved to the hills east of Carter Creek, where in previous years they had calved (Reynolds et al. 1985).

Muskoxen in the Okerokovik area were found along the lower Sikrelurak and Angun Rivers and along the Niguanak River in January through March 1984. In 1983 and 1985, mixed-sex herds also overwintered along these rivers, as well as on the Okerokovik River. In March 1985, the animals joined 1 large herd which moved to bluffs between the Okerokovik and the Jago Rivers near VABM Pilak (Fig. 28).

Calving and Post-calving Distribution of Mixed-Sex Herds. By May, during the peak of calving, mixed-sex muskox herds along the main fork of the Tamayariak River moved downstream toward VABM Mala and other animals remained on the west fork of the Tamayariak River (Fig. 29). In early June, muskoxen from both areas moved west to the Canning River delta. In 1982, some animals from the Tamayariak area also calved in the Carter Creek hills with muskoxen from the Sadlerochit River drainage.

Mixed-sex herds which overwintered in the upper Katakturuk River also calved in this area (Fig. 29). Two different mixed-sex herds were present in 1984, but most of these animals joined into a single large herd during calving in 1985 (Reynolds et al. 1985).

In 1984 and 1985, muskoxen that moved to the Carter Creek hills in March and February calved along or adjacent to upper Carter Creek (Fig. 29). In 1982 and 1983, movements to the Carter Creek hills occurred in late April. Most Sadlerochit muskoxen calved in the Carter Hills in 1982 and in the adjacent Marsh Creek hills in 1983 (Fig. 29). Some animals remained on the ridges of the upper Sadlerochit to calve in May 1982 and 1983. Only 1 old-age cow calved here alone in 1984.

During 1982-1984, most mixed-sex muskox herds overwintering along the Angun and the Sikrelurak Rivers remained on these rivers until late April when they moved to the Niguanak River to calve (Fig. 29). In 1985, Okerokovik animals, which had moved to Pilak bluffs east of the Jago River in early March, remained in this area until early June when they moved to the Okerokovik River (Reynolds et al. 1986). This same area had been used during calving and post-calving seasons in 1984 by an old-aged cow accompanied by a 3-year old cow, which gave birth to a calf. A 16-year old cow calved alone on the Angun River in 1984, but joined a herd on the upper Angun River in early June. In all 4 years, mixed-sex herds calving on the Niguanak River, the Angun River, or Pilak bluffs, moved to the Okerokovik River in late June (Fig. 29).

Table 10. Use of calving areas during mid-May by muskoxen in the Arctic National Wildlife Refuge, 1982-1985.

Location	Estimated numbers of muskoxen			
	1982	1983	1984	1985
<u>Okerokovik Area:</u>				
Niguanak River	25	21	25	--
Angun River	6 ^a	10	1	--
Okerokovik River	1 ^b	7 ^b	--	--
Siksikpalak River	--	--	15	11
Pilak bluffs	--	--	3	46 ^d
<u>Sadlerochit Area:</u>				
Carter Creek hills	70 ^c	9	101	--
Marsh Creek hills	--	55	--	--
Upper Sadlerochit River	22	5	1	--
Between Carter Creek and Sadlerochit River	--	--	--	114
<u>Tamayariak Area:</u>				
Tamayariak River, main fork	26	55	49	24
Tamayariak River, west fork	--	19	18	72
Upper Katakturuk River	--	21	49	46
Totals	150	202	262	313

^aOn the Niguanak River until late May.

^bNo calves in herd by late June.

^cIncluding muskoxen from both Tamayariak and Sadlerochit areas.

^d21 muskoxen moved to Niguanak River between 29 April and 22 May.

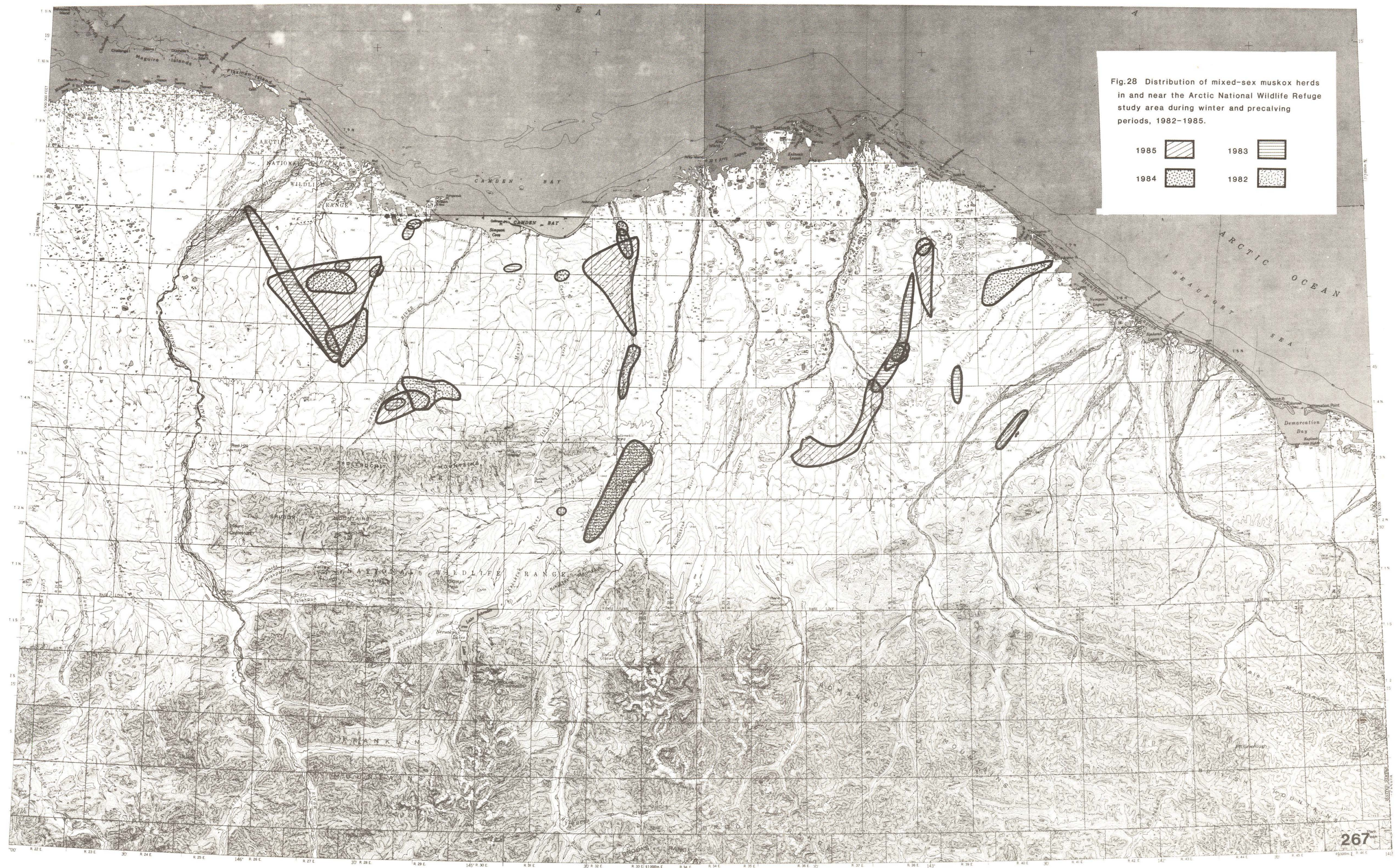


Fig.28 Distribution of mixed-sex muskox herds in and near the Arctic National Wildlife Refuge study area during winter and precalving periods, 1982-1985.

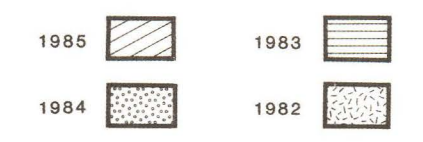
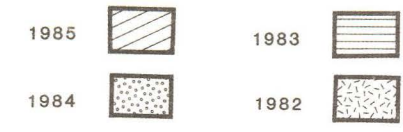




Fig. 29 Distribution of mixed-sex muskox herds in and near the Arctic National Wildlife Refuge study area during the peak of calving (May), 1982-1985.



The mixed-sex herd of 14 animals which apparently dispersed east in 1984, calved on tributaries of the Ekaluakat River and Siksikpalak River in 1984 and near the mouth of the Ekaluakat River in 1985 (Fig. 29). In June 1985 they moved east to near the Kongakut River.

Areas used during the peak of calving in mid-May varied from year to year. (Table 10). Most variations were a shift in distribution to adjacent areas or dispersal of some animals into new areas (Reynolds et al. 1986).

Summer, Rut, and Fall Distribution of Mixed-Sex Herds. Throughout the summer, rut, and fall, muskoxen showed similar patterns during 1982-1985 (Fig. 30) (Reynolds et al. 1985, 1986). Animals congregated along major rivers during the latter half of June after leaf emergence of riparian willows. Throughout July and August, as herds dispersed into small rutting groups, distribution was more widespread, but remained along or adjacent to rivers and creeks. After the rut, animals again congregated in large herds along major rivers in late September.

Muskoxen in the Tamayariak area were concentrated primarily along the west and main forks of the Tamayariak River, and in the uplands south of Konganevik Point (Fig. 30). In late September 1984 and 1985 many moved west to the Canning River delta. By late October, all had again congregated along the main fork of the Tamayariak River during 1982-1984. In early November 1985, almost all mixed-sex herds in the Tamayariak area were located along the Katakturuk River. Mixed-sex herds along the Katakturuk River spent the summer and rut along the lower Katakturuk River and the uplands south of Konganevik Point, between the Katakturuk River and the Tamayariak River (Fig. 30).

In the Sadlerochit area, mixed-sex muskox herds were found along the Sadlerochit River from Sadlerochit Springs to the mouth of the river throughout the summer and fall. Herd distribution was most extended in August and September during the rut when animals dispersed onto adjacent uplands and into adjacent drainages (Fig. 30).

In the Okerokovik area, mixed-sex herds were observed along the Okerokovik River and adjacent hills in July and August. Some animals moved along the Niguanak River in August and several moved to the mouth of the Angun River in late October 1984 and 1985 (Fig. 30).

Mixed-sex muskox herds in all 3 geographic areas made periodic movements to river deltas on the arctic ocean coast (Reynolds et al. 1986). Muskoxen in the Tamayariak area moved to the Canning River delta in early to mid-June and again in late September. Animals in the Okerokovik area moved to the mouth of the Angun River during these same time periods. Muskoxen along the Sadlerochit River moved to the river delta on the coast at least once each summer. Vegetative cover at these locations did not appear to be particularly lush and riparian willows were not present. Muskoxen may be attracted to these coastal areas by the presence of salt on the vegetation. Muskoxen in Greenland are attracted to salt licks, particularly in early summer, when physiological requirements for sodium are high (H. Thing, pers. comm.).

Observation of radio-collared cows during 1982-1985 showed that most cows had a high fidelity to a specific geographic area (Reynolds et al. 1986). Jingfors (1984) described range fidelity of animals along the Sadlerochit River area. Movements of muskoxen can be defined as local movements which occur during the course of feeding activities over 1 or several days or directed movements in which animals travel relatively rapidly from 1 use area to another (Reynolds et al. 1986). Long range movements between geographic areas were infrequently seen, but in 1982 and 1983, 3 radio-collared cows, traveling alone or in different groups, moved from the Tamayariak area to the Sadlerochit area after calving or during summer. One of these cows returned to the Tamayariak area within a few weeks with a group which included a radio-collared cow from the Sadlerochit area and a radio-collared bull originally captured in the Tamayariak area. Another cow overwintered in the Sadlerochit area and returned to the Tamayariak area in the following summer. The third cow moved to the Katakturuk River, where it remained for the next 3 years. These movements may have been related to the fracturing of large herds and the dispersal of herds into new areas (Reynolds et al. 1986).

Detailed movements on 1 cow muskoxen in the Okerokovik area were recorded between August 1984 and August 1985 with the use of an experimental satellite collar (Reynolds, 1986). More than 300 locations on this animal defined areas of high use and movements between these areas (Fig. 31). The animal moved between use areas more frequently in summer, rut, and fall. In winter, this muskox and the 46 animals with which she was associated stayed within very limited areas for up to 2 months (Reynolds 1986). Jingfors (1984) found the lowest movement rates of muskoxen on the Sadlerochit River occurred during calving and the highest during periods of severe insect harassment.

Distribution of Bull Groups and Single Bulls. Bull groups and solitary bulls observed during 1982-1985 were often spatially segregated from mixed-sex herds (Fig. 32). Bulls occurred near the Canning River on the west side of the ANWR study area in all 4 years (Reynolds et al. 1986). Bull use of the upper Katakturuk River was documented in 1979 and 1981 (Ross 1979, Ross 1981). Radio-collared bulls used the upper Katakturuk primarily from mid-March to mid-June during 1982-1984 (Reynolds et al. 1986). Small bull groups overwintered on the south slopes of the eastern end of the Sadlerochit Mountains during 1983-1985. These bulls remained on the mountain slopes until mid-June, when these groups dispersed and solitary animals moved to the lower Sadlerochit River where they joined mixed-sex herds (Reynolds et al. 1986). Bulls have been observed along the Kongakut River on the eastern edge of the Okerokovik area since 1973 (Roseneau and Warbelow 1974). From 1982-1985, bulls were seen along the Kongakut River throughout the year, and radio-collared bulls were often present in this area (Reynolds et al. 1986).

Radio-collared bull muskoxen ranged over larger areas than did radio-collared cows. Bulls made long movements between the Sadlerochit and Tamayariak areas, particularly in July and August (Reynolds et al. 1986). Marked bulls also moved between the Tamayariak area and the Kavik and Sagavanirktok Rivers in 1985. One radio-collared bull moved 100 km west to the Ivishak River and apparently did not return (Reynolds et al. 1986).

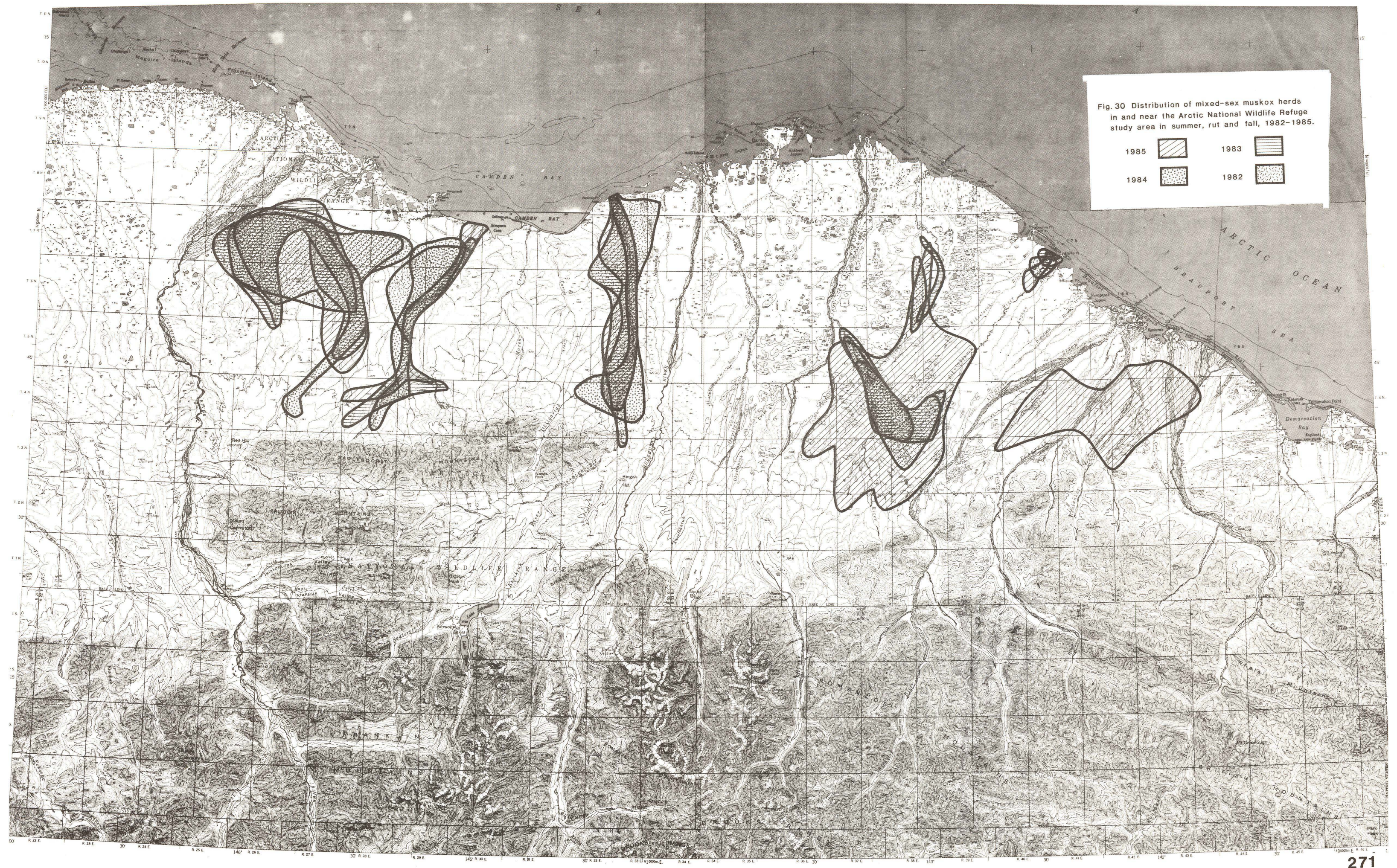


Fig. 30 Distribution of mixed-sex muskox herds in and near the Arctic National Wildlife Refuge study area in summer, rut and fall, 1982-1985.

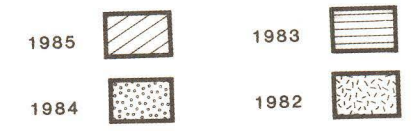





Fig. 31 Distribution and major movements of a satellite-collared cow muskox in the Arctic National Wildlife Refuge study area, Aug. 1984–Sept. 1985

-  Summer, rut and fall (June–Oct.)
-  Winter, precalving and calving (Nov.–May)
-  major movements

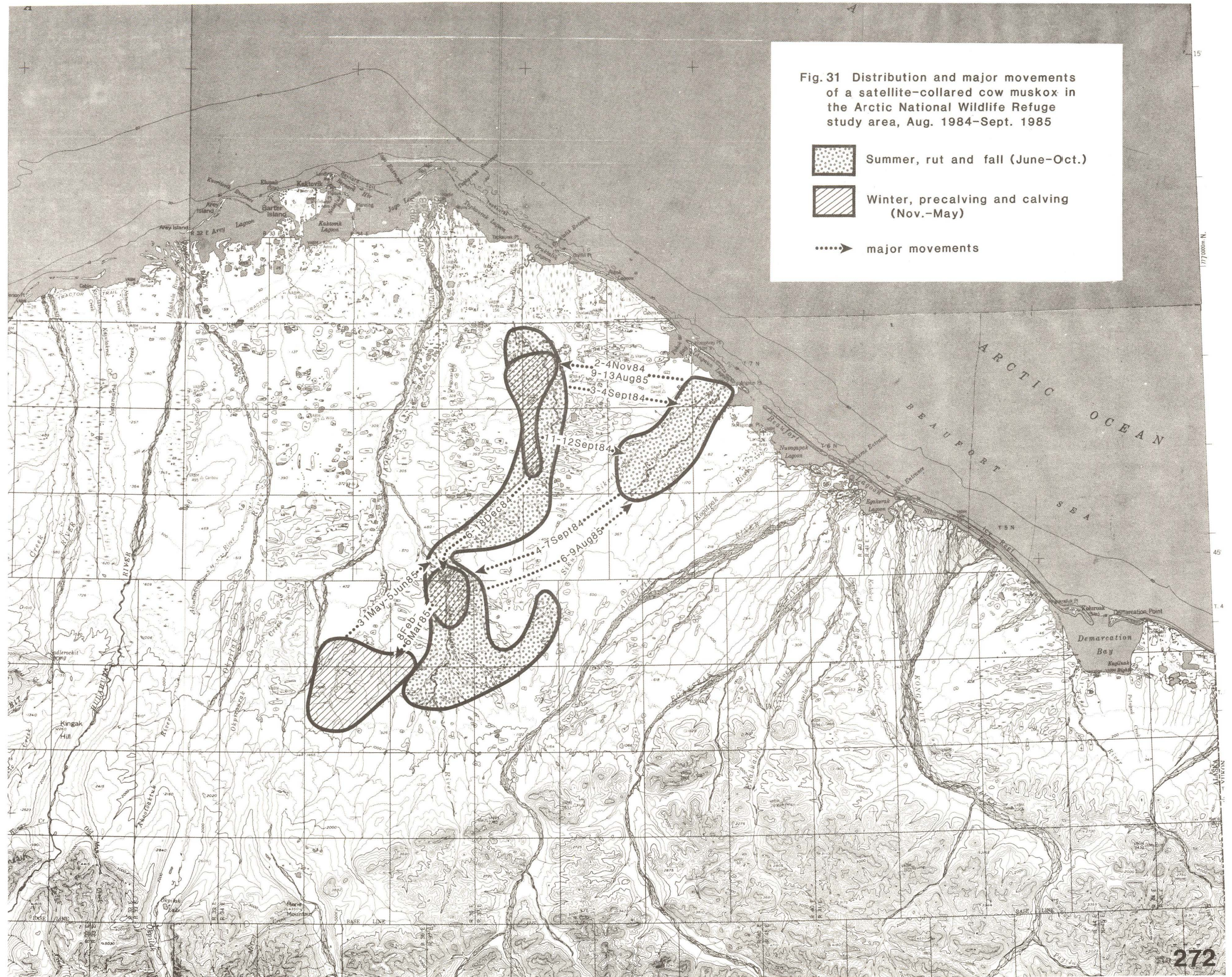




Fig.32 Areas in or near the Arctic National Wildlife Refuge study area used primarily by bull groups or single bull muskoxen, 1982-1985.

Marked bulls in the Okerokovik area ranged between the Okerokovik River on the west and the Firth River in northeast Canada (Reynolds et al. 1986). At least 1 male moved 140 km east to the Babbage River in Canada and apparently did not return. Long range movements east, west, and south of the study area and observed movements of 2 marked bulls between the Sadlerochit and Okerokovik areas may have been dispersal of young-aged males or males ejected by harem groups during the rut (Reynolds et al. 1986).

Habitat Use and Carrying Capacity

Habitat occupied by muskoxen was documented by recording terrain features and land cover categories in which muskox herds were observed during radio-relocation flights and seasonal surveys. Seasonal occupancy of different terrain features was apparent during 1982-1985 (Reynolds et al. 1986). River and creek drainages were most frequently occupied by muskoxen throughout the year, except during the pre-calving season (Fig. 33). Major river drainages were occupied in winter, summer, and fall. During the rut, muskoxen were often associated with small creek drainages rather than large rivers. During winter, pre-calving, and calving seasons, ridges, plateaus, and bluffs, that often blow partly free of snow, were occupied by some muskoxen. Occurrence of muskoxen on this terrain type reached a maximum during the pre-calving season in all 4 years (Reynolds et al. 1986). By April on the north slope of Alaska, inversions can result in temperatures 10°C higher on ridges than in the surrounding drainages and snow ablation is accelerated in upland areas (Reynolds et al. 1986). Lent and Knutson (1971) found that muskoxen tended to congregate where snow was absent or present in relatively shallow depths (10-30 cm). Gunn (1982) stated that muskoxen appeared to feed more intensively where snow cover was absent.

Land cover categories (snow, wet sedge, tussocks, tall shrub, low shrub/forb, and bare) were identified on the basis of features recognizable from the air. Each category, with the exception of snow, included 1 or more vegetation categories (Table 11) described in Appendix 1, Table 2. Muskox observations in the bare category, which included sightings on unvegetated gravel bars as well as outcrops or talus slopes on ridge tops or mountain sides, were combined with observations in the low shrubs/forb category, as these 2 categories occur adjacently or as complexes that were not always distinguishable (Table 11). The low shrub/forb category encompassed a wide variety of communities including moist dwarf and low shrub tundra in non-riparian areas, dry tundra on ridges and mountain slopes, and dryas terraces, forb-rich river bars and open riparian shrubland along river flood plains.

Table 11. Vegetation categories in land cover classes identified from the air and occupied by mixed-sex muskox herds during radio-relocation flights and seasonal surveys in 1982-1985.

Land cover category	Vegetation categories from Appendix 1, Table 2
Snow	none
Wet sedge	11b, 11c, 111a, 111b
Tussock	Vb, V1a, V11a, V1c, V11c
Tall shrub	V111c
Low shrub/Forb	1Va, Va, Vc, Vd, Ve ^a , V11b, V111a, V111b, 1Xb, 1Xc ^a , 1Xa, 1Xd, 1X; ^a
Bare	Xa, Xc, Xd

^a may also be classed as "Bare"

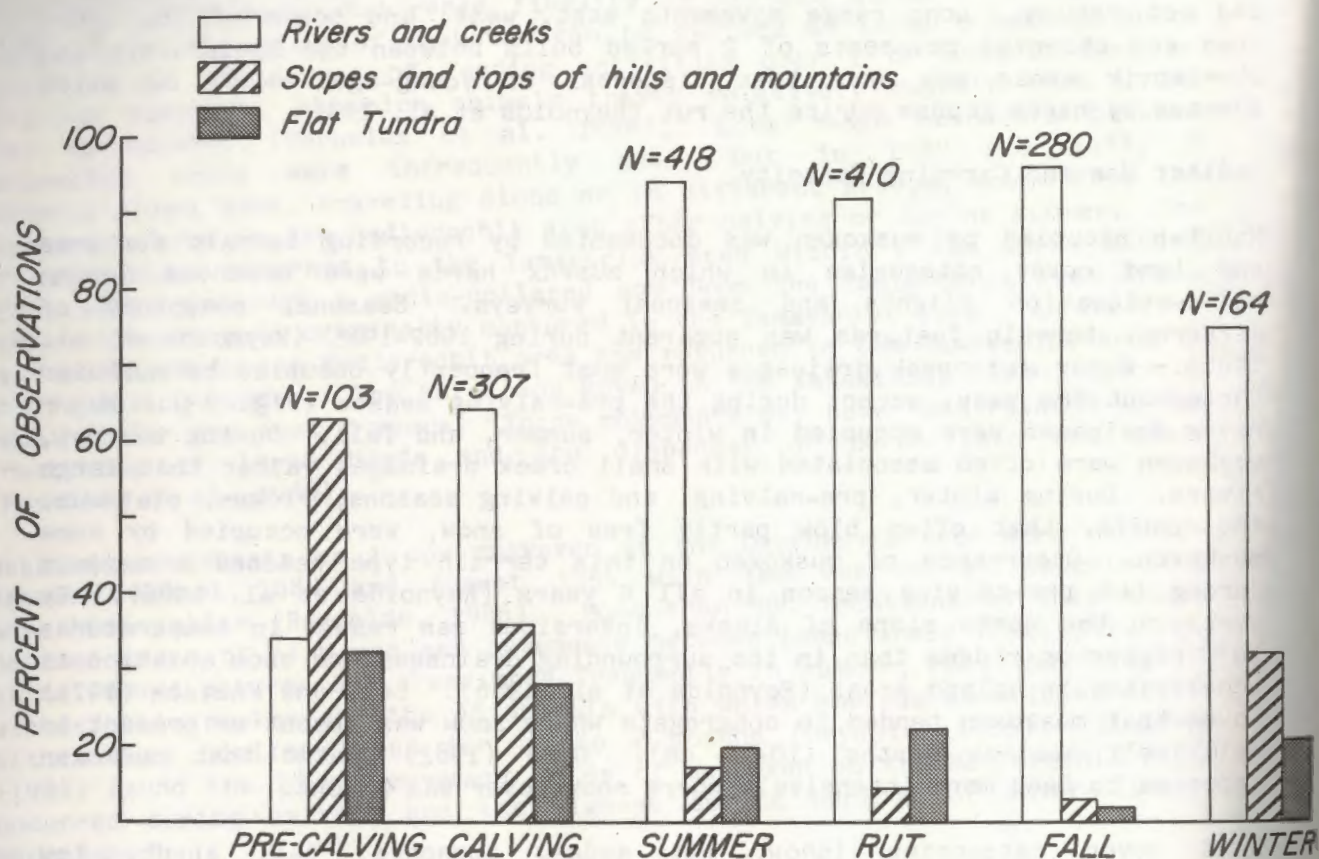


Fig. 33. Seasonal association of mixed-sex muskox herds with terrain features, observed during radio-relocation and seasonal surveys in the Arctic National Wildlife Refuge, 1982-1985.

The tall shrub category was restricted to stands of riparian willow along major rivers, while the tussock category included communities containing both tussock forming-sedges and dwarf and low shrubs. The wet sedge category included wet sedge and graminoid communities.

Seasonal differences in muskox occupancy of land cover categories, were apparent during 1982-1985 (Reynolds et al. 1986). Snow, present in all seasons, comprised 37%-95% of all land cover observations from fall through calving (Fig. 34A). Low shrub-forb communities were occupied most frequently throughout the year (Fig. 34B). Muskox association with vegetation followed a phenological progression. In late May or early June during the calving period, as the snow melted first on bluffs and ridges, muskoxen were often found in upland areas of low shrub-forb communities or tussock communities. Robus (1984) found that the tussock-forming sedge Eriophorum vaginatum was a preferred food item for muskoxen using the Sadlerochit area in late May. In late June and early July, as willows emerged, muskoxen moved back into major river drainages during all 4 years. Occupancy of tall shrub and adjacent communities of low shrub-forb or bare gravel bars continued through summer and rut. Robus (1981) found that as riparian willows initiated growth they became important food items for muskoxen along the Sadlerochit River in summer and willows were selected throughout most of the growing season (Robus 1984). Tall shrub communities along gravel bars were occupied in September and October as animals congregated on major river drainages (Fig. 34B). Snow covered the vegetation except for tall riparian willows by early October 1982, early November 1983 and 1985, and mid-October 1984.

Major components of habitat occupied by muskoxen on the ANWR coastal plain are river systems with diverse low shrub-forb and tall willow communities, situated near uplands, hillsides, plateaus, or bluffs where low snow cover can be found in winter, pre-calving, and calving seasons. The presence of these components in many areas not currently used by muskoxen indicates the population will probably continue to increase and expand into unexploited habitat (Reynolds et al. 1986).

Availability of highly nutritious and abundant forage species apparently have contributed to the high productivity seen in the ANWR muskox populations. Robus (1981) found that production of the willow Salix alexensis, a preferred muskoxen forage species, peaked in early August at 82.4 g/m² along the Sadlerochit River. In contrast, a peak biomass value for Salix arctica of 18.6 g/m² was recorded on Bathurst Island in the Canadian high arctic, an area where productivity of muskoxen (numbers of calves/cows) was lower than that observed on the Sadlerochit River (Jingfors 1980). Gunn (1984) suggested that the muskox breeding cycle is related to the quality of summer forage. Snow cover is also apparently a factor controlling muskox populations in Greenland (Vibe 1958 and 1967, as cited by Thing et al. 1984) and high arctic Canada (Parker et al. 1975; Parker 1978, as cited by Thing et al. 1984).

Differences in terrain features, vegetation communities, and snow cover may account for the slower rate of population growth in the Okerokovik area, compared with the Sadlerochit and Tamayariak areas (Reynolds et al. 1986). Muskoxen were rarely seen in the area between the Hulahula River and Jago River (Fig. 25), which is characterized by a lack of major topographic features. Snow cover may also be greater in this area (Felix et al. 1986).

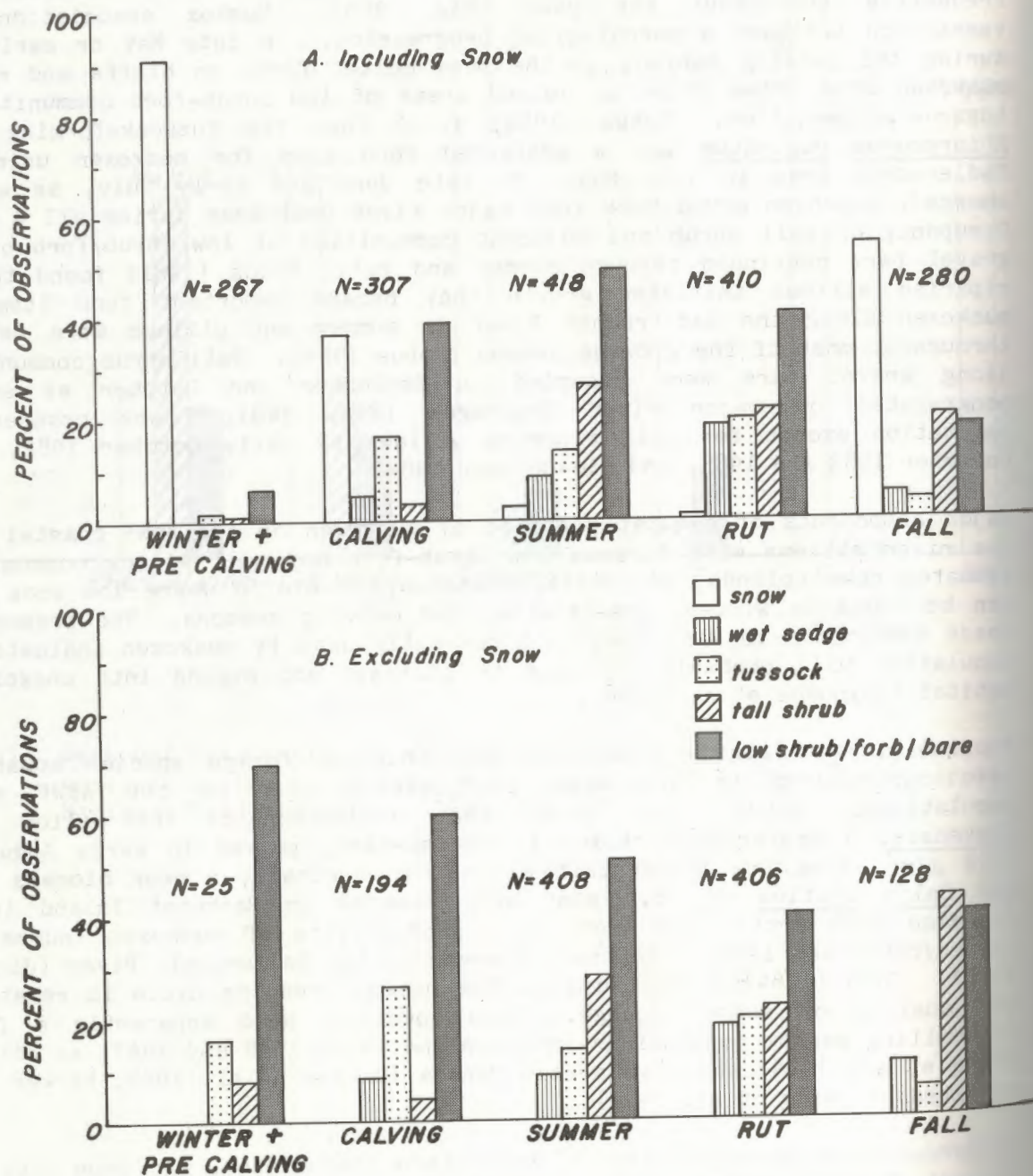


Fig. 34. Seasonal association of mixed-sex muskox herds with land cover categories observed during radio-relocation and seasonal surveys in the Arctic National Wildlife Refuge, 1982-1985.

Qualitative examination of summer and winter muskox use areas in 1985 suggests that current population densities are not impacting vegetation growth in high use areas (Reynolds et al. 1986). However, quantitative measurements are needed to determine the interrelationships between the habitat and this rapidly growing population.

The ANWR muskox population has apparently not yet reached carrying capacity, assuming that carrying capacity is habitat controlled. Population growth is increasing exponentially. The growth curve may still be in the accelerating phase of a logistic ("s" shaped) curve which has not yet reached the point of inflection (Kendeigh 1961). At this point, the population is assumed to be at maximum sustainable yield (McCullough 1984). If the growth curve has passed this point, the rate of growth may have started to decelerate. Eventually the population may reach the point where net productivity declines to zero, defined by McCullough (1984) as K carrying capacity. This is the maximum number of animals an environment will support without destruction of vegetation according to McCullough (1984). Caughley (1976, 1979) predicted that a herbivore population introduced into a habitat will increase rapidly (erupt), decrease and eventually fluctuate about an equilibrium. Gunn (1984) suggests that dispersion of populations could retard or prevent eruptions and subsequent declines. The ANWR muskox population is apparently in the eruptive phase of population growth and dispersal into new areas is occurring.

Impacts of Human Activities and Natural Causes

Human activities not related to resource development may affect ANWR muskox populations, distribution, movements, and habitat use. Legal hunting has been permitted on a limited basis since 1983. Initially, most hunters used private aircraft to hunt, but soon learned that snowmachines were a more efficient way to hunt. Local residents have not used muskoxen as a meat source since the animals were transplanted into the area, probably because there has been no traditional use of muskoxen in this area for at least 100 years and the limited hunting season, when opened, required a big game fee of \$500. In 1986, when 5 permits for bull muskoxen were issued in Kaktovik and fees were lowered to \$25, local residents showed interest in hunting muskoxen. Muskox herds in the Sadlerochit area and Okerokovik area are within easy access of Kaktovik by snowmachine. Although hunting regulations, seasons and limits presumably will be set to insure an appropriate harvest, poaching of animals may increase as people discover how easy it is to hunt muskoxen. Legal and illegal hunting probably would have to increase substantially before the ANWR muskox population would be effected, but distribution, movements, and habitat use may be changed if animals are repeatedly disturbed by snowmachines. Circumstantial evidence suggest that animals may move fairly long distances when harassed by snowmachines (Reynolds et al. 1986).

Brown bears and wolves are potential predators on muskoxen, but the low mortality rates in the ANWR muskox population indicate that predation is not currently a factor in population regulation (Reynolds et al. 1986). Bears appear to be more significant predators than wolves at the present time. Bear populations adjacent to the ANWR coastal plain were relatively high in 1982-1985 (Garner et al. 1986a). Bear predation or scavenging was observed on 5 occasions between 1982-1985 (Table 8). A radio-collared bear was seen on 2 different carcasses of bull muskoxen. In addition, 1 bear was observed

stalking a herd of muskoxen. The muskoxen formed a defensive circle when the bear was at least 600 m away, then ran and reformed the circle 3 times before running to the top of a hill and out of sight. Single muskoxen are probably more susceptible to predation by bears. Miller and Gunn (1982) described grizzly predation on a single bull muskox.

No incidence of wolf predation was observed in 1982-1985, although wolves were seen near a bull muskox. Gray (1970) observed a lone wolf attack and kill a single bull muskoxen. Miller and Gunn (1977) described an unsuccessful attack of a single wolf on a herd of muskoxen.

Data Gaps

Population numbers and composition, and habitat quality should be monitored to document changes in this rapidly expanding population. This information is essential for management of the population to avoid over-population. Limited data collected in 1984-1985 indicate that muskoxen reduce both movements and activity in winter as an energy conserving mechanism (Reynolds 1986). However, more data are needed on winter distribution, movements, activity, and habitat use to predict and mitigate potential impacts resulting from resource development on the ANWR coastal plain.

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 in lower densities 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 1968b, Mould 1977), with speculation that use of tundra habitats may be an effort by moose to seek relief from insect harassment (Mould 1977).

The occurrence 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 1953a, 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 1953a, Kelsall 1972) and changing habitat conditions caused by a gradual holarctic warming trend have been proposed (Leopold and Darling 1953a). Recent archaeologic evidence supports 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). Roseneau and Stern (1974b) observed more moose along the Chandalar River on the south side on the Brooks Range 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. 1974b), with sporadic occurrences along other river drainages between the 2 rivers.

In ANWR, moose range onto the coastal plain during the summer months. The dynamics of seasonal population shifts and the relative importance of the coastal plain as a component of the habitat requirements of moose is discussed below. 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. The most stable population is associated with the Canning River on the northwestern portion of ANWR (Fig. 35). Surveys were conducted along the Canning River during 1972-1975, 1977, 1978, 1980, and 1983-1985. The second moose concentration area is the upper Kongakut River drainage in the northeastern part of ANWR (Fig. 36), where surveys were conducted during 1972, 1973, 1977, 1978, 1980, and 1983-1985. For the purpose of this report, only the 1980, 1983, 1984, and 1985 aerial surveys are used for direct comparisons. Timing and areas surveyed in previous surveys varied between years. Direct comparison of the resultant data sets is difficult.

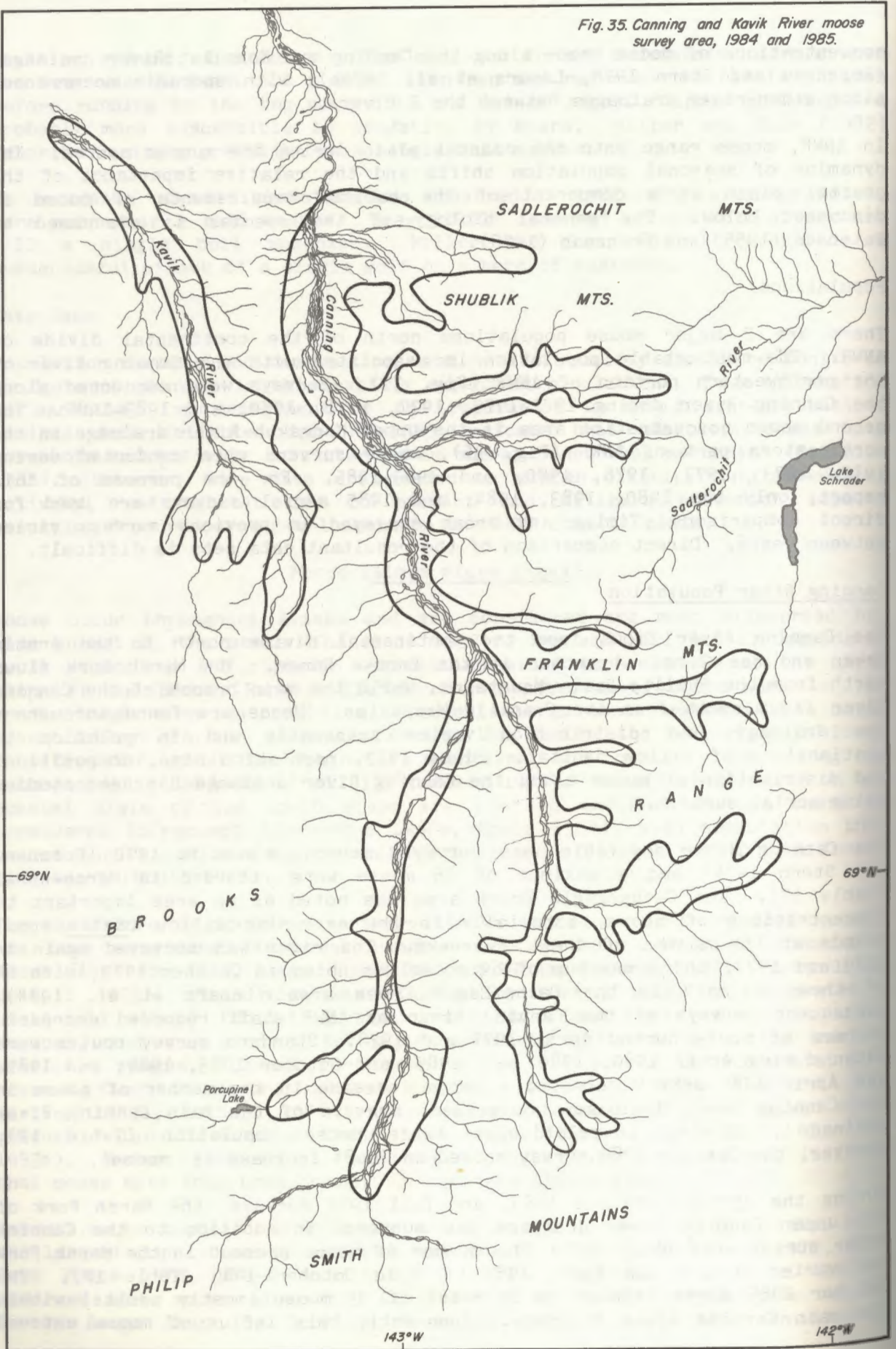
Canning River Population

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. Moose are found throughout the drainage, but distribution varies seasonally and in relation to availability of willow habitat. Since 1972, population size, composition, and distribution of moose along the Canning River drainage has been studied using aerial surveys.

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 12). The Cache/Eagle Creek area was noted as an area important to concentrations of moose, especially in the extensive willow (*Salix* spp.) stands at the mouths of these 2 creeks. The river was surveyed again in 1973 and 1974, and a maximum 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 during April 1977 and 1978. Standard survey routes were flown during April 1980, 1984, and 1985, and October 1983, 1984, and 1985. The April 1980 survey detected a large increase in the number of moose in the Canning River drainage. Subsequent surveys of the main Canning River drainage indicated a relatively stable moose population (Table 12). However, the October 1985 survey showed an 20.8% increase (33 moose).

During the spring 1984 and 1985, and fall 1985 surveys, the Marsh Fork of the upper Canning River drainage was surveyed in addition to the Canning River survey area (Fig. 35). The number of moose present in the Marsh Fork was varied from 44 in April 1985 to 9 in October 1985 (Table 12). The October 1985 survey showed an increase of 33 moose (mostly adults) within the main Canning River drainage. Apparently this influx of moose entered

Fig. 35. Canning and Kavik River moose survey area, 1984 and 1985.



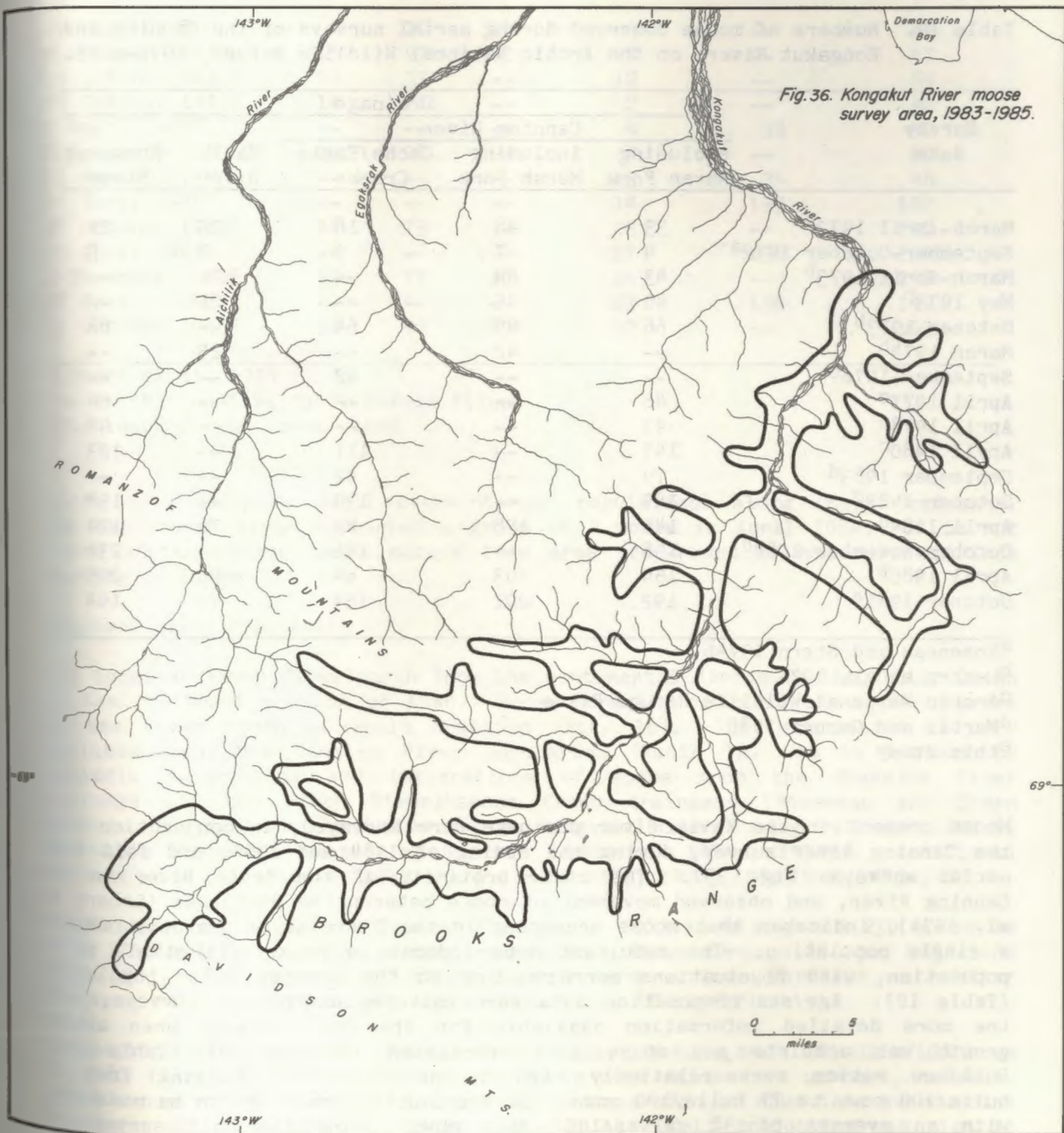


Fig.36. Kongakut River moose survey area, 1983-1985.

the drainage through the Marsh Fork in the spring of 1985. The source of the additional moose is unknown. However, these data indicate that the seasonal north and south movements along the drainage described by Lenarz et al. (1974) may function as the method for integrating influxes of moose from surrounding drainages into the Canning River moose populations.

Table 12. Numbers of moose observed during aerial surveys of the Canning and Kongakut Rivers on the Arctic National Wildlife Refuge, 1972-1985.

Survey date	Drainage				
	excluding Marsh Fork	Canning River including Marsh Fork	Cache/Eagle Creeks	Kavik River	Kongakut River
March-April 1972 ^a	33	48	16	25	21
September-October 1972 ^a	4	7	2	3	8
March-April 1973 ^b	43	64	--	24	--
May 1973 ^b	40	45	--	21	--
October 1973 ^b	66	69	64	--	68
March 1974 ^b	--	42	--	25	--
September 1976 ^c	--	--	42	--	--
April 1977 ^c	48	--	--	--	54
April 1978 ^c	43	--	--	--	58
April 1980 ^c	147	--	111	--	123
September 1983 ^d	79	--	42	--	--
October 1983 ^d	149	--	130	--	158
April 1984 ^d	149	158	84	76	134
October-November 1984 ^d	158	--	146	--	239
April 1985 ^e	159	203	69	96	205
October 1985 ^e	192	201	154	79	194

^aRoseneau and Stern 1974b

^bLenarz et al. 1974

^cArctic National Wildlife Refuge Files

^dMartin and Garner 1985

^ethis study

Moose present in the Kavik River drainage were surveyed, in conjunction with the Canning River survey, during the spring of 1984 and 1985, and fall 1985 aerial surveys (Fig. 35). The close proximity of the Kavik River to the Canning River, and observed movement of moose between the drainages (Lenarz et al. 1974), indicates that moose occurring in the 2 drainages probably compose a single population. The resultant data indicate a relatively stable moose population, with fluctuations corresponding to the Canning River population (Table 12). Age/sex composition data were gathered during all surveys, with the more detailed information available for the fall surveys when antler growth was complete and moose were aggregated for the rut (Table 13). Bull/cow ratios were relatively high during 1983-1985, ranging from 67 bulls/100 cows to 77 bulls/100 cows. Calf production appeared to be moderate, with an average of 38 calves/100 adult cows during the fall surveys of 1983-1985. Over-winter calf survival appears to be high (Table 13). However, seasonal moose movements along the Canning River drainage complicate a detailed assessment of calf survival rates.

Table 13. Composition of moose observed during surveys along the Canning River, 1973-1985.

Date	Bulls	Cows	bulls	Calves	Yearling adults	Unclassified Totals
26 May 1973 ^a	7	21	14	3	--	45
6 October 1973 ^a	15	23	2	7	--	47
16 October 1973 ^a	20	37	--	12	--	69
17 October 1973 ^a	14	21	--	7	--	42
1 March 1974 ^a	--	--	--	4	38	42
21 September 1976 ^b	14	24	--	4	--	42
11 April 1977 ^b	--	--	--	13	35	48
25 April 1980 ^c	--	--	--	14	133	147
30 October 1983 ^c	44	73	7	25	--	149
20 April 1984 ^c	--	--	--	17	132	149
2 November 1984 ^c	47	77	10	24	--	158
26 April 1985 ^c	--	--	--	23	136	159
21 October 1985 ^c	51	90	19	32	--	192

^aLenarz et al. 1974

^bArctic National Wildlife Refuge Files

^cMuehlenhardt and Garner 1986

These data indicate small overwintering populations along these drainages. The Okpirourak River supported a group of 7 moose in April 1984. It is not known whether these moose occupy this area year-round or had migrated from another drainage.

Kongakut River Population

The Kongakut River flows north from the continental divide to the Arctic Ocean in the northeast portion of ANWR. Moose normally occur in the upper reaches of the river south of Whale Mountain (Fig. 36). This population is more variable than the Canning River population (Table 12) and is subject to periodic emigrations and immigrations of moose from the Sheenjek River drainage and the Firth River/Mancha Creek drainages (Roseneau and Stern 1974b). Surveys were conducted in the Kongakut River during 1972 and 1973 by Renewable Resources Consulting Service (Jakimchuk 1974a, 1974b). Additional surveys were conducted by ANWR staff during 1977, 1978, 1980, and 1983-1985.

Populations varied from a low of 8 moose in 1973 to a high of 239 moose in 1984 (Table 12). Standard survey routes were flown during 1980 and 1983-1985 (Fig. 36). The results of these surveys were not as variable as earlier surveys, but still indicate a mobile population (Table 12).

Composition data for 1973 indicated 89 bulls/100 cows and 128 bulls/100 cows in 1983 (Table 14). The reasons for these high ratios are unknown, however, the low hunting pressure and the extensive dispersion of cows into surrounding drainages may contribute to these high ratios. Calf production was high in the Kongakut drainage with an average of 45 calves/100 cows during 1983-1985. Over-winter calf survival also appears high, but the population is too variable to determine accurate estimates.

Table 14. Composition of moose observed during surveys along the Kongakut River, 1973-1985.

Date	Bulls	Cows	Yearling bulls	Calves	Unclassified adults	Totals
11 October 1973 ^a	25	28	--	15	--	68
13 April 1977 ^b	--	--	--	9	45	54
26-27 April 1980 ^c	--	--	--	25	98	123
27, 29 Oct. 1983 ^c	59	62	16	21	--	158
18-19 April 1984 ^c	--	--	--	19	115	134
30 October 1984 ^c	83	102	16	38	--	239
27-28 April 1985 ^c	--	--	--	23	182	205
23-24 October 1985 ^c	64	87	12	31	--	194

^aLenarz et al. 1974

^bArctic National Wildlife Refuge Files

^cMuehlenhardt and Garner 1986

Other Drainages

Moose populations in other drainages north of the Brooks Range within ANWR were surveyed during 1972, 1973, 1977, and 1984. In March and April 1972, Roseneau and Stern (1974b) 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. During April 1984, a survey was conducted of all major drainages from the Kavik River on the west to the Kongakut River on the east. A total of 12 moose were counted along the Aichilik River and 12 along the Egaksrak River.

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 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 minimal along the Canning River, with 2 to 6 moose taken per year. 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 variable and dependent upon local moose population fluctuations (ANWR file data).

Habitat

Willow Communities

Willows (Salix spp.) 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 1974b).

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 occurring 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 poplar (Populus balsamifera) occurs in relatively discrete stands at several locations along the Canning River; however, little browsing was noted on 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 poplar 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 occurring 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. glarca, and S. brachycarpa (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 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, Katakturuk River, and the Hulahula River (Martin and Garner 1985) on the coastal plain 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 12). 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. However, 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 the northern Yukon Territory (Ruttan 1974). One characteristic of moose wintering north of the Brooks Range is a high degree of local movements from 1 willow stand to the next (Roseneau and Stern 1974b). Moose were often sighted in 1 willow stand along a drainage, and a few days later this stand may 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 provide some evidence. This population is apparently subject to the influence of mass emigration and immigration of moose to and from adjacent drainages.

Roseneau and Stern (1974b) documented an emigration in April 1972 of almost 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 during September-October 1972 to a high of 68 moose during October 1973 (Table 12). 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 November 1984 (Table 12) may have been the result of a similar influx of wintering moose 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 1974b, Roseneau and Stern 1974b, Doll et al. 1974b, Lenarz et al. 1974, Coady 1979), but recent data suggest that this use may be more extensive than previously suspected (Magoun and Robus 1977, Martin and Garner 1985). 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.

Marine Mammals

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, Amstrup et al. 1986). Ringed seals are associated with the landfast ice (that which is attached to the shore, also called shorefast) as well as moving ice, while bearded seals are found only in the moving pack ice. Between the landfast ice and the moving pack, a flaw or lead zone occurs which contains some open water (Stirling and Cleator 1981). Lead zones are important habitat for non-breeding ringed seals and bearded seals, as well as 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 migrations. 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 Population Size

Polar bear distribution is circumpolar in the northern hemisphere. Polar bears range from 88° north on the polar ice pack and have been seen as far south as St. Matthew and occasionally to the Pribilof Islands (DeMaster and Stirling 1981). Most polar bears remain associated with the ice year round. However, there is considerable seasonal and annual variation in their exact distribution. In general, they are most abundant in the drifting pack ice zone where ringed seals, their primary food source, occur (Lentfer 1971). They are usually most common along the Beaufort Sea coast in late fall and early winter.

At least 6 distinct polar bear 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). Using tag recoveries, differences in body and skull sizes, and levels of mercury in the tissues, Lentfer (1974b) advanced a theory that 2 discrete populations of polar bears occur along the Alaska coast divided by a line running northwest from Point Lay. Additional cranial measurements taken by Wilson (1976) also support this hypothesis. Larsen et al. (1983) have shown that electrophoretic activities of certain blood proteins in polar bear blood do not differ according to geographic location and cannot identify different populations. Bears found within the ANWR study area belong to the northern Alaska population. There appears to be limited movement between the 2 Alaskan populations (Amstrup et al. 1986).

Estimates of the world population of polar bears vary from 10,000 to 20,000 animals (DeMaster and Stirling 1981). Brooks (1978) estimated a total of 2500 to 3000 polar bears in the northern Alaska population. Amstrup et al. (1986) estimated the population of polar bears in the Beaufort Sea at 1,800 (± 600 SD), and concluded densities were similar in western Alaska.

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 10 May yielded few observations. Lono (1970) reported that breeding continues until about mid-July on Spitzbergen. 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 enter dens in October and November (Lentfer 1976b, Amstrup unpublished data). The timing is thought to be dependent upon ice movement, snow conditions, availability of food, 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 or 2 helpless cubs, about 25.4 cm long (Harrington 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 during March or 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) reported that a female was observed entering a den on 14 October and emerging 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 - 2 weeks while the cubs gain strength and become acclimated to the air temperatures outside the den (Lono 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*). Of the kills, 80% 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 can also capture seals in open water (Furnell and Ooloooyuk 1980), but this event is not common, and ringed and bearded seals rarely haul out on land. Therefore, 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 (Lono 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). However, foods other than seals are insignificant from an energy standpoint. Since females do not feed for about 5 months during denning, it is important that adequate food sources are 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 ice covered or nearly so for 10 or more months of the year. Existing open water begins to freeze in September or October and the

nearshore ice does not melt until late May or early June. With the exception of some denning females, polar bears inhabit the ice throughout the winter. The 2 main types of sea ice present in winter are landfast ice, which is anchored to the shore, and drift or "pack" ice which is kept in constant motion by winds and currents. Pack ice is comprised of all stages of ice formation including "multi-year" ice which has been through at least one summer melt season. 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 as a denning area. 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. Results of an USFWS research program which captured and tagged polar bears near the ANWR study area indicated that the autumn population near Barter Island is comprised largely of adult females, family groups, and subadults. Adult males were uncommon (Amstrup et al. 1986).

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 denning sites.

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 (Harrington 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 (Harrington 1968). Dens have been found on land, offshore islands, shorefast ice, and drifting ice.

Of historic maternity dens 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 the study area on the shorefast ice (Fig. 37, Table 15). A polar bear near what appeared to be a den was observed on the coastline midway between Pokok Bay and Pokok Lagoon by USFWS 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. Thirteen of the previously mentioned 35 dens were found on the National Petroleum Reserve-Alaska, to the west of the study area.

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) documented 3 sightings of cubs recently out of dens. Ave Thayer (pers. comm.), observed many tracks of adult bears with cubs near Demarcation Bay in the wilderness area of 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 surveys in the spring of 1981, Johnson (1981) noted areas of potential denning habitat. In the study area, the following drainages had good to excellent potential denning habitat: Katakturuk, Angun, Okerokovik, and Jago Rivers, and Carter and Marsh Creeks.

Harrington (1968), Lønø (1970), Uspenski and Kistchinski (1972), Moore and Quimby (1985), Larsen (1976) and Lentfer and Hensel (1980) have provided detailed descriptions of polar bear dens. More recently, Amstrup (unpublished data) found that the majority (87%) of Beaufort Sea polar bears den on the sea ice rather than on land. He further found that the most significant land denning areas in Alaska are along the coast and in the foothills of ANWR. These findings were based upon radio telemetry and thus not biased by investigator predispositions toward particular areas.

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 the Subsistence section in chapter 7.

Table 15. 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 - 0.4 km. S VABM Maybell	1 April 1977	ANWR files
2. 69°56'N 144°28'W	3 April 1974	ANWR files
3. Between Carter Creek and Sadlerochit R. - 2 dens were 68.6 m apart	4 April 1974	ANWR files
4. 69°49'N 144°35'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 November 1968	USFWS 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	USFWS Den Log
8. 69°32'N 141°25'W 12.9 km S of Demarcation Bay on fork of Turner River	14 November 1981	USFWS
9. 70°10'N 143°40'W	March 1951	USFWS 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
12. 69°35'N 142°36'W 25.5 km up Egaksrak River.	27 December 1984	USFWS
13. 70°06'N 145°41'W 0.4 km W of VABM Nob	27 December 1984	USFWS
14. 69°51'N 143°00'W 27.4 km up Niguanak River	7 December 1985	USFWS
15. 70°01'N 142°43'W 2.4 km S of Pokok Lagoon	7 December 1985	USFWS
16a. 70°02'N 142°40'W 1.0 km SE of Pokok Lagoon	17 November 1983	USFWS
16b. No co-ordinates 17.7 km up Niguanak River (moved den after tagging)	6 March 1984	USFWS
17. 70°09'N 144°26'W 3.2 km N of Hulahula R. Delta	20 April 1982	USFWS
<u>Possible dens</u>		
18. 16 km W of Kaktovik and 6.5 km N of VABM Barbara.	21 March 1975	Moore 1975
19. 14.5 km W of Kaktovik and 6.5 km N of the W end of Arey Island.	22 March 1975	Moore 1975
20. On shoreline between Pokok Bay and Pokok Lagoon	19 October 1981	USFWS
21. 69°38'N 143°40'W 56.3 km S of Kaktovik	10 April 1983	USFWS



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 along the coast, denning may be delayed or reduced, and cub production may be lowered (Harington 1968, Lono 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 may affect polar bear populations.

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 USFWS 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 Population Size

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 least 6 aerial censuses of ringed seals have been conducted within the ANWR study area (Table 16). In 1970, ringed seals were censused along the north coast of Alaska to establish baseline data on 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 (1976) used 2 methods to estimate ringed seal density in the Beaufort Sea from Camden Bay on the west to Shingle Point on the east. 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).

USFWS personnel conducted aerial surveys along the ANWR coast on 22 June and 16 July 1974. A total of 28 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.

Table 16. Densities of ringed seals obtained during surveys of the Arctic National Wildlife Refuge coast from 1970-1975 using different techniques.

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

^aDensity extrapolated from segments 1 through 5 of the non-parallel flight line method.

^bNon-parallel flight line method.

^cParallel flight line method.

^dSome bearded seals may be included in this count.

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. Average mean density of 0.44 seals/km² (Table 16) 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/km² (Frost and Lowry 1981), and to the density of 0.46 seals/km² for the Beaufort Sea from Camden Bay to Shingle Point (Moore 1976).

The highest density of seals adjacent to the ANWR were recorded during parallel flight line surveys in 1975 near Beaufort Lagoon (Moore 1976) (Table 16). During the same year, ringed seal densities were higher to the east in Yukon Territory where 1.56 seals/km² were observed using the parallel flight line method at Komakuk Beach in the Yukon territory, and 1.19 seals/km² were observed in the Herschel Island area between the Firth and Babbage Rivers using the non-parallel method (Moore 1976).

Ringed seal densities from west to east along the Beaufort Sea coast from 1970 to 1985 were summarized Frost et al. 1985 (Table 17). Densities were variable between years and between locations. Density figures 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 the proportion of the population 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 in the Beaufort Sea (Burns and Harbo 1972, Lowry et al. 1979, Frost and Lowry 1981).

Table 17. Ringed Seal densities (seals/km²) on the shorefast ice of the Beaufort Sea based on aerial surveys conducted in 1970-1985. Parentheses indicate densities based on survey coverage of less than 343 km² (modified from Frost et al. 1985)

Sector	Year							Combined
	1970	1975	1976	1977	1981	1982	1985	
B1 ^a	0.63	1.1	0.45	0.38	0.41	0.38	0.65	0.69
B2 ^b	0.44	0.50	0.33	(0.18)	0.42	0.49	0.80	0.46
B3 ^c	0.58	0.28	0.59	(0.22)	0.44	0.52	0.97	0.57
B4 ^d	(1.2)	(0.88)	(0.15)	(0.48)	0.49	(0.32)	0.59	0.59
B5 ^e	--	--	--	--	--	--	(0.22)	--
All Area	0.61	0.73	0.40	0.33	0.43	0.44	0.83 ^F	0.57 ^F
(Km ²)	3,440	3,557	1,828	1,238	4,880	2,003	2,909 ^F	19,856 ^F

- a Point Barrow to Lonely
- b Lonely to Oliktok Point
- c Oliktok Point to Flaxman Island
- d Flaxman Island to Barter Island
- e Barter Island to U.S.-Canada Border
- f Does not include Sector B5

Life History

The age at which female ringed seals reach productive maturity is 6-10 years, but most do so at 7-9 years of age. Males reach sexual maturity at 7-8 years of age (Burns and Eley 1977). Females are impregnated after 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 of seals 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, shrimp, 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). 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 arctic 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 through ice that is 2 m thick 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 these areas consistently contain the highest densities of breeding seals. 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 predation by polar bears (Burns and Eley 1978). The lairs, which function to protect ringed seal pups from predators (mainly polar bears and arctic foxes (Alopex lagopus) and 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 that are deeper than 3 m and have an open connection to the ocean do 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 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, J. Levison saw 1 - 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). USFWS 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 (unpublished data) saw 1 seal 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 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, domestic dogs, wolves, and ravens. They are also a subsistence resource for the Inupiat village of Kaktovik on Barter Island. (See Chapter 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 decline is evident in the census data for Alaska (Table 16). However the consistency of survey effort between years is unknown, and a conclusive statement in support the hypothesis is not possible.

Data Gaps

Ringed seal use of lagoon systems on the north slope 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 Population Size

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 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) stated that "...the region approaches being marginal habitat for these seals". Burns and Harbo (1972) noted that bearded seals occurred on moving pack ice in the Beaufort Sea survey areas in early June, but none were found in the Flaxman Island to Barter Island segment of the survey where extensive landfast ice was still present. In 7.9h 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 2-6 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 conducted in the Canadian Beaufort Sea recorded 2,759+729 SD bearded seals in 1975 and 1,197+235 SD 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 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 6-7 years and females at 4-7 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 north in the spring and retreats south in the 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 1978).

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 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 by 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 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 Chapter 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 Population Size

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 related 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), while Richardson et al. (1985) reported the population at 3871 based on a more recent estimate by the IWC (International Whaling Commission 1984).

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 5-6 months of age, but it is not known how long they remain with their mothers. Males reach sexual maturity at a length of 11.6 m and physical maturity at 14.0 to 14.7 m. Females reach sexual maturity at 12.2 m 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).

Little information is available on food habits of bowhead whales in the Alaskan Beaufort Sea, but Lowry and Burns (1980) collected data from five stomachs of whales taken between 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 1977).

Lowry and Burns (1980) stated that "ringed seals and arctic cod are probably the most significant trophic competitors of bowhead whales in the Beaufort Sea". The effects of this competition for food on the recovery of this stock of bowheads is unknown (Marquette et al. 1981)

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 parallel 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 and found that most whales migrate within the first third of the lead closest to the shorefast ice (Marquette et al. 1981).

From Point 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. 38). 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 Bockstoe (1980) hypothesized 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.

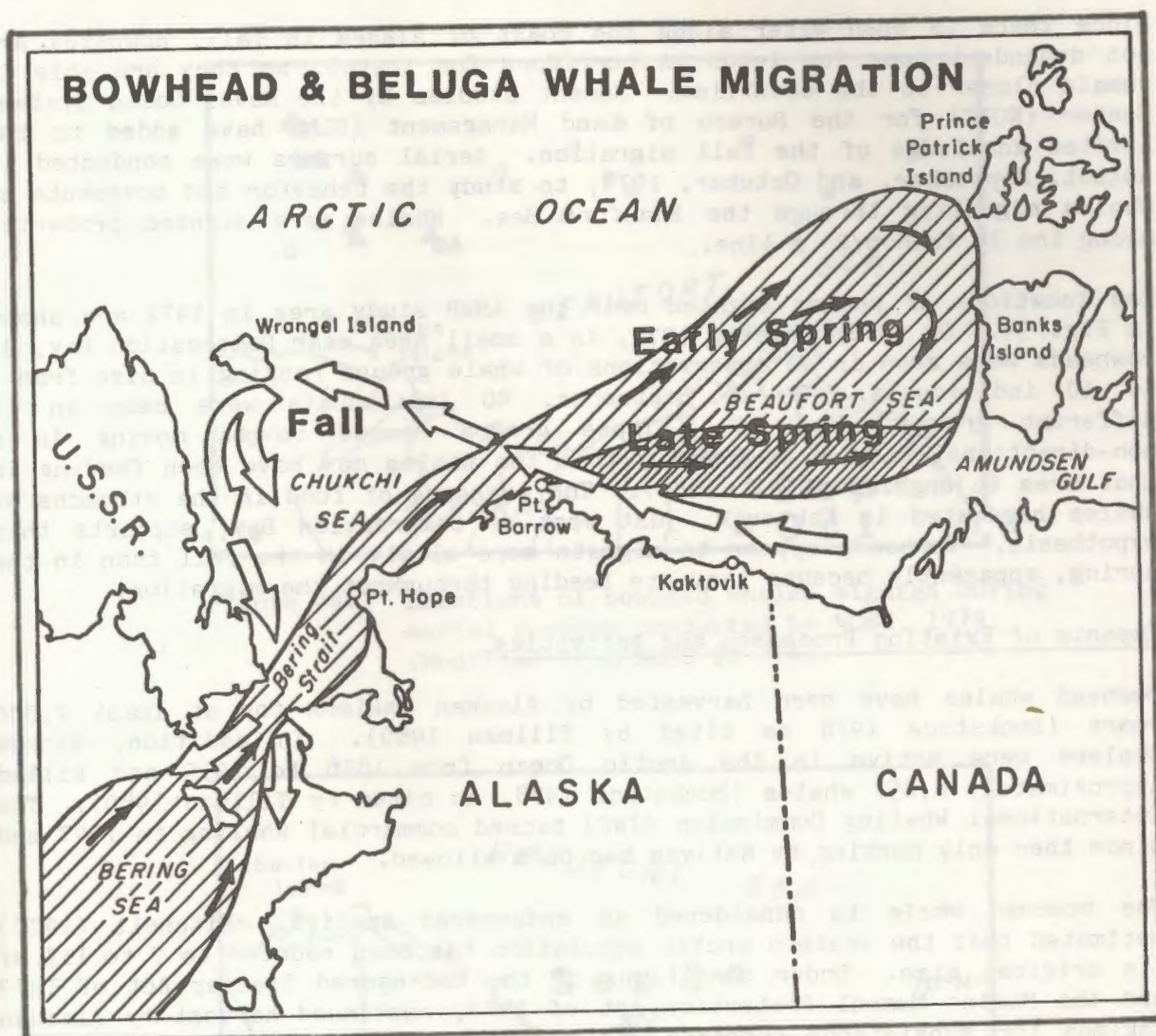


Figure 38. Generalized spring migration pattern of bowhead and belukha whales and fall migration route of bowhead whales. (After Richardson and Fraker 1981).

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 in 1979 are shown in Fig. 39. On 24 September, 1979, in a small area near Demarcation Bay, 35 bowheads were seen in 10 observations of whale groups ranging in size from 1 to 10 individuals. On 26 September, 40 individuals were seen in 14 different groups (Fig. 39). 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 appear to migrate more slowly in the fall than in the spring, apparently because they are feeding throughout the migration.

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 natives 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. Therefore, the National Marine Fisheries Service (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.



Figure 39a. Locations of bowhead whales sighted during aerial surveys conducted by NOSC, 1979. (Modified from NOSC TD 314).

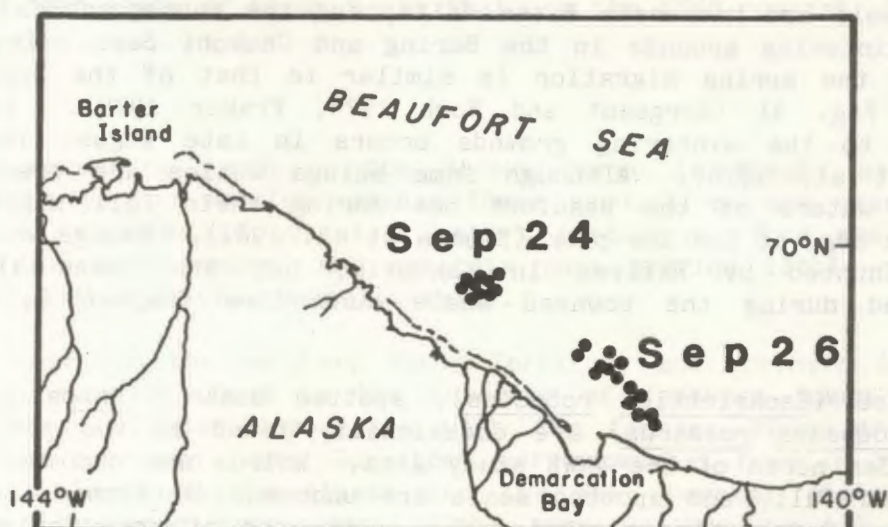


Figure 39b. September 1979 sightings of bowhead whales near Demarcation Bay. (Modified from NOSC TD 314).

The quota for 1981 was 17 whales landed and 32 strikes; for 1982 was 18 landed and 19 strikes; for 1983 was 9 landed and 18 strikes; for 1984 was 25 strikes; and for 1985 was 18 strikes. 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 Chapter 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 (Delphinapterus 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 migration is similar to that of the bowhead whales shown in Fig. 31 (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 Chapter 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 occurrence 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.

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.

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. Research projects conducted for the Arctic Gas studies described 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. The baseline study program included a 4 year study of brown bears that use the ANWR coastal plain study area.

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 18). Adult males associated with the Canning River drainage in Alaska and the northern Yukon Territory were somewhat heavier than their counterparts in northwestern Alaska and the ANWR coastal plain 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. All weights of bears captured on the ANWR coastal plain were spring weights, therefore, the apparent smaller size of adult males may not be as pronounced as these data indicate.

Table 18. Average weights (kg) of adult brown bears in northern Alaska and Yukon Territory.

Location and sex	Sample size	Average weight	Weight range	Source
Interior-southern Yukon Territory:				
Male	40	139	106-240	Pearson 1975
Female	21	95	74-124	
Northern Yukon Territory:				
Male	25	169	-----	Pearson 1976
Female	31	111	-----	
Canning River Drainage, Northeast Alaska:				
Male	--	180	136-268	Reynolds 1976
Female	18	109	88-141	
ANWR coastal plain, Northeast Alaska:				
Male	54	139	93-202	Garner et al. 1986a
Female	65	94	68-127	
Northwestern Alaska				
Male	19	167	107-218	Reynolds 1980
Female	24	111	84-177	

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 19). 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 19). Another factor influencing bear densities between areas on the north slope is food availability and the seasonal variations in that availability. Reynolds (1979, 1980) and Garner (In Press) 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. Reynolds and Garner (In Press) also attributed the high density of bears in northeastern ANWR to the seasonal availability of PH caribou in early summer.

Table 19. Summary of reported brown bear population densities in North America.

Estimated density (km ² per bear)	Area	References
	<u>Contiguous States:</u>	
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
	<u>Canada:</u>	
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
	<u>Alaska:</u>	
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, In Press
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	
63	coastal plain, northern foothills, and adjacent high foothills on ANWR	Garner et al. 1984,

Densities of brown bear on the ANWR study area were believed to be low by Curatolo and Moore (1975), however, the results of the current study program indicates a relatively high density of brown bears (Table 19). The drainages between the Canning River on the west and the Kongakut River on the east were believed to have lower densities than those reported for the Canning River (Quimby 1974a), but the recent study results indicate that densities in the ANWR study area are 1.0 - 2.3 times higher than those reported for the Canning River.

Brown bears have large cumulative home ranges with the largest occurring in northwestern Alaska (Table 20). 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, Garner et al. 1983).

Table 20. 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 (Craighead 1976)	M	6	161
	F	14	73
Western Montana (Rockwell et al. 1978, as cited by Reynolds 1980)	M	3	513
	F	1	104
Southwestern Yukon (Pearson 1975)	M	5	287
	F	8	86
Northern Yukon (Pearson 1975)	M	9	414
	F	12	73
Northwestern Alaska (Reynolds 1980)	M	8	1350
	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 km² (n=5), compared to males in northwestern Alaska with an average yearly range 510 km² (n=7). Female bears in northeastern Alaska had an average yearly range of 319 km² (n=8), compared to an average yearly range of 269 km² (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 northeastern Alaska study area, and bears would have to depend upon other more widely dispersed food sources. Data analysis of home range sizes of 99 bears in the northwestern portion of ANWR are currently ongoing.

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 km², range 231-1776 km²), breeding females (290 km², range 98-546 km²), subadult females (194 km², range 88-316 km²), and females with offspring (181 km², range 39-479 km²). 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).

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 (1974a), and Magoun (1976); in 1973 by Doll et al. (1974b); 1977 by Magoun and Robus (1977), and in 1982-1985 by Garner et al. (1983, 1984, 1985, 1986a). During surveys of the PH 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 - 1985. ANWR personnel also recorded brown bear observations during post-calving surveys in June 1981-1985. In general, brown bears appeared on the coastal plain in late May or early June, with the majority of sightings occurring during June and July. Bear sightings were common in the foothills habitat extending from south of Barter Island west into Canada prior to 1982. The highest number of bear observations was usually the area lying between the Aichilik River on the west and the Canadian border on the east. The baseline study program revealed 2 high density areas on the ANWR coastal plain and foothills. The first area is the Jago-Bity area and includes the area around the large island. This area extends from the high foothills in the south to the junction of the Jago and Okerokovik River on the north, from the Okpuirak River on the coast to the Aichilik River on the east. The second high density area is the Kongakut River caribou pass area. This area extends from the Clarence River on the east to the Ekaluakut River on the west, and from the Kongakut River at its confluences with Pajlik Creek on the south to the coastline on the north at Demarcation Bay.

Productivity

Sex ratios reported by Reynolds 1974, 1976, and Curatolo and Moore (1975) for northeastern Alaska brown bears was approximately 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 27.5 years for 30 adult females (Reynolds 1980). On ANWR in 1985, 19.0% of the population were cubs, 16.8% were 3-4 year olds, and 48.2% were adults. Garner et al. (1986a) concluded that the populations were stable or increasing slightly. Maximum age of 27 adult males in ANWR was 23 years and maximum age of 39 adult females was 25 year.

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 Garner et al. 1985 and 1986a). 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, Garner et al. 1984).

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). Preliminary analysis indicated a minimum reproduction interval of 3.6 years on ANWR (Garner et al. 1984).

Litter size for brown bears ranges between 1.58 and 2.34 cubs per litter (Table 21), with litter sizes in northeast Alaska being lower than most other localities in North America. Average litter size for 30 litters in northeastern ANWR from 1982-1985 was 2.0 cubs per litter (Garner et al. 1986a). 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 21. Reported litter sizes for brown bears in North America (Adapted from Curatolo and Moore 1975).

Litter size	Location	Reference
2.3-2.1	Yellowstone National Park, Wyoming	Craighead et al. 1974
2.3	Southcentral Alaska	Glenn and Miller 1970
2.3	Kodiak Island, Alaska	Troyer and Hensel 1964
2.2	Kodiak Island and Alaska Peninsula	Hensel et al. 1969
2.1-1.8	central Brooks Range, Alaska	Crook 1972
2.0	northwest Alaska, NPR-A	Reynolds 1980
2.0	Glacier National Park, British Columbia	Mundy and Flook 1973
1.8	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
1.6	Canning River drainage, Alaska (mountainous portion)	Quimby 1974a
1.6	southern Yukon Territory	Pearson 1972, 1975
2.0	ANWR study area, northeast Alaska	Garner et al. 1986

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, Garner et al. 1986a). On the ANWR study area from 1983 through 1985, the assumed mortality rate ranged from 25.0 - 52.3% for cubs, and 57.1 - 100.0% for yearlings. Overall, the average mortality rates for cubs and yearlings was 43.4% and 64.3% respectively (Garner et al. 1986a).

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 harvest rates are low and range from 3 - 5 bears annually. These harvest data 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 omnivores and their habitat use patterns are a reflection of this foraging strategy (Hechtel 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, Garner et al. 1986a). 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, Garner et al. 1986). 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 were 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), dispersing 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 (Reynolds and Garner In Press). Bears kill both adults and calves (Lent 1964; Skoog 1968; Doll et al. 1974; Reynolds 1979 and 1980; Garner et al. 1983, 1984, 1985, and 1986a). 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. A similar relationship between the high bear density on ANWR and the seasonal availability of PH caribou was hypothesized by Reynolds and Garner (In Press).

Bears did not extend their normal home ranges to take advantage of caribou calving in NPR-A. Rather, bears were more dependent upon the caribou 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. However, on ANWR there does appear to be a shift in areas of home range use when caribou are present. A majority of the radio-collared bears that normally resided east of the Hulahula River, shifted their use areas north onto the coastal plain in early June. They usually remained in this area until caribou emigrated from the coastal plain in early to mid-July. Bears then gradually shifted their use areas south into the foothills. Several dispersing young males (4 - 7 years old) appeared to follow the emigrating caribou to the east (Garner et al. 1986a).

During August and September, bears moved back into the river valleys and moved 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 weeks in October, however denning has been recorded as early as 26 September and as late as 7 November (Quimby 1974a, Quimby and Snarski 1974, Curatolo and Moore 1975, Reynolds et al. 1976, Reynolds 1979 and 1980). Contrary to brown bears denning in Yellowstone Park (Craighead and Craighead 1972), dens in the arctic were dug 2 or 3 days prior to entering them for the winter (Garner et al. 1983, 1984, 1985 and 1986a). 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 temperatures of -10°C 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 den site 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, Garner et al. 1983, 1984, 1985, 1986a; 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 mountains. 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 ANWR, average measured aspects of 129

dens were southeasterly (145° - 150°), with a majority of the densities occurring in southeast - southwest slopes (Garner et al. 1984, 1985, and 1986a). 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. In other areas, however, the shrubby or woody vegetation assists in accumulating 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). In ANWR, only 7 of 199 recorded dens occurred within the study area (Fig. 40). Bears dened south of the study area, in the adjacent foothills and mountains (Garner et al. 1983, 1984, 1985, 1986a and 1986b).

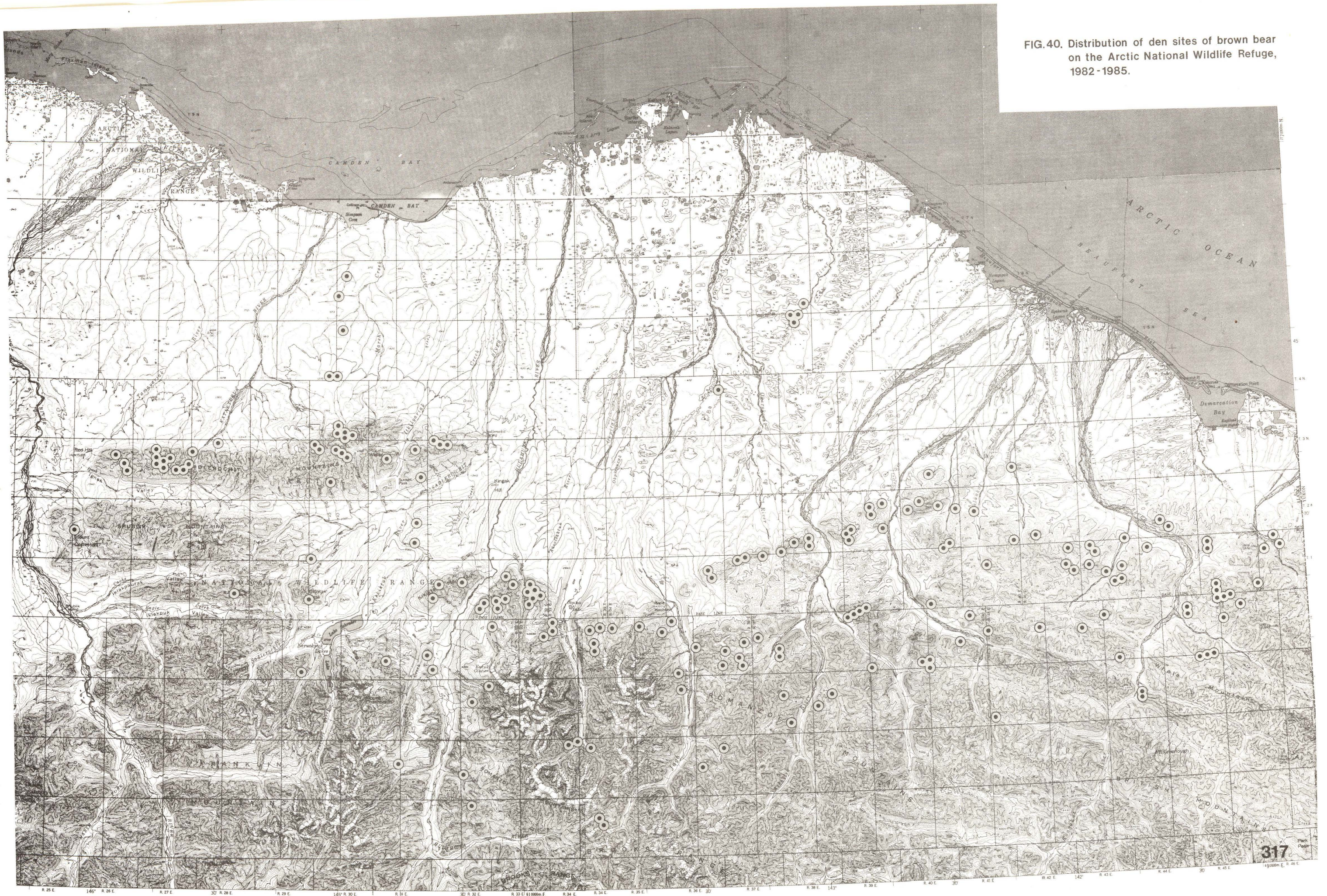
Several snow dens have been recorded for brown bears on the Alaska peninsula (Lentfer et al. 1972), the Yukon Territory (Ruttan 1974), and the Northwest Territories (Harding 1976). One snow den was recorded in the foothills south of the study area near the Aichilik River (Garner et al. 1984). Although bears apparently overwintered 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 cave den sites had vegetation either at or near the cave opening and bears used this material 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). Ten rock cave dens were located during the baseline study program (5% of all dens located). One of these caves was used by the same adult male for at least 2 consecutive years (Garner et al. 1983, 1984, 1985, and 1986).

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. Garner et al. (1986) concluded that denning habitat was probably not a limiting factor on bear population in northeast ANWR.

Gray Wolf (Canis lupus)

The gray wolf has the greatest natural range of any living mammal other than man (Nowak 1983). Wolves are found throughout those portions 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 (Fig. 41). Today their range is restricted to most of Canada and Alaska, parts of northern Minnesota and Montana (Mech 1970), northern Wisconsin (Mech and Nowak 1981), central Idaho (Kaminski and Hanson 1984), and certain regions of Mexico (Brown 1983). There are also a few animals in the upper peninsula of Michigan (excluding Isle Royal), which probably migrate from Ontario and Minnesota (Hendrickson et al. 1975) (Fig. 42). Most taxonomists recognize 32 subspecies of wolves, of which 24 occur in North America (Mech 1970). Wolves inhabiting the northern portion of ANWR and the northeastern Brooks Range have been classified as C. l. tundarum, the Alaska tundra wolf (Nowak 1983). This subspecies classification has been challenged by Rausch (1953, as cited by Nowak 1983) and Pedersen (1978), who contend that the differences between C. l. tundarum and C. l. pambasileus (the interior Alaskan wolf) are not defined well enough to warrant C. l. tundarum's classification as a separate subspecies.

FIG.40. Distribution of den sites of brown bear on the Arctic National Wildlife Refuge, 1982-1985.



1. *C. l. alces*
2. *C. l. arctos*
3. *C. l. baileyi*
4. *C. l. beothucus*
5. *C. l. benardi*
6. *C. l. columbianus*
7. *C. l. crassodon*
8. *C. l. fuscus*
9. *C. l. hudsonicus*
10. *C. l. griseoalbus*
11. *C. l. irremotus*
12. *C. l. labradorius*
13. *C. l. ligoni*
14. *C. l. lycaon*
15. *C. l. mackenzii*
16. *C. l. manningi*
17. *C. l. mogollonensis*
18. *C. l. monstrabilis*
19. *C. l. nubilus*
20. *C. l. occidentalis*
21. *C. l. orion*
22. *C. l. pambasileus*
23. *C. l. tundrarum*
24. *C. l. youngi*



Fig. 41. Former distribution of the gray wolf (*Canis lupus*) in North America. (Hall and Kelson, 1959).



Fig. 42. Present distribution of the gray wolf (*Canis lupus*) in North America. (Rue, 1981)

Life History

Wolves are the largest wild members of the dog family (Canidae). Adult males from most areas average 43-45 kg, while adult females average 36-39 kg (Mech 1970). Wolves captured on ANWR during 1984-1985 were on the lower end of this scale with males averaging 43.1 kg (n=15) and females averaging 36.7 kg (n=9) (Weiler et al. 1986). However, wolves on ANWR were captured between May and August, during a time frame considered by Seal and Mech (1983) as a period of weight loss in wolves. Seal and Mech (1983) and Peterson et al. (1984) showed seasonal variation in weights of wolves and suggested this variation was due to reduced food intake. Stephenson (pers. comm.) suggested that another factor may be that prey species are much leaner with less fat at that time of year. One wolf (a 4-year old male), which was captured twice on ANWR, weighed 52.2 kg in July and 55.8 kg the following April.

Pelage color in wolves ranges from white to gray, brown, tawny, and black. All color phases are found on ANWR with gray and brown being that most common with black, tawny, and white following in order of occurrence (Weiler et al. 1986).

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). Pack sizes vary greatly from region to region. In Alaska, 1357 sightings of wolves in packs of 2 or more were recorded by Rausch; 28% of these were in packs of 8 or more wolves (Mech 1970). Similar pack size has been recorded in areas of Minnesota, Canada, Lapland, Finland, and the USSR (Mech 1970). During 1984 and 1985, 8 packs were documented in the northeast portion of ANWR with the pack size ranging from 2 - 7 wolves before the denning season (Table 22). Rausch (1967) found that wolves in arctic areas tend to be found in smaller packs than other areas in Alaska, and thought that large pack sizes indicated high wolf populations. Zimen (1976) stated that the size of free - living packs was correlated with the density of the wolf population, size of the main prey species, and changes in the population density of the prey species.

Social order within packs is maintained through a hierarchical system which centers around a dominant male and female. The male is dominant to the female and pups, the female to the pups with order established between pups. In larger packs there is also a dominance order within and between males and females (Zimen 1976). This same hierarchy system often limits breeding activity to only the dominant male and female of the pack. However, multiple litters per pack have been recorded in Alaska (Packard et al. 1983, Van Ballenberghe 1983, Weiler et al. 1986, and Stephenson pers. comm.). Breeding in Alaska occurs in late winter from late February through March, although most females breed in the first 2 weeks of March (Rausch 1967). Gestation is 63 days with dens being prepared or visited by the parturient female as much as 4-5 weeks prior to parturition (Chapman 1977). In 1985, 1 den on ANWR was visited by a female and the entrance was dug free of snow on 5 April. Pups in arctic areas are usually born between mid-May and early June (Chapman 1977). On ANWR, a female wolf killed on 2 May 1984 carried 4 fetuses (2 males and 2 females) within 2-3 weeks of parturition (Weiler et al. 1985).

Table 22. Numbers of adult wolves and pups in the northeastern portion of Arctic National Wildlife Refuge, 1984-1985.

Wolf group	Number of adults	Number pups at den	Number pups surviving to fall
<u>1984:</u>			
Lone wolves	5	--	--
Canning River ^a	5(est.)	?	0(?)
Sadlerochit River	4	at least 1	1
Aichilik River	7	4	4
Kongakut River	6	2	2
Totals	27	7	7
Fall Totals	27		7
<u>1985:</u>			
Lone wolves	5	--	--
Canning River North ^b	4	at least 1	1
Canning River South ^c	-	at least 1	0
Hulahula River ^d	3	4-5	3
Egaksrak River	5	5	5
Drain Creek	6	4	4
Malcolm River ^e	2	4-5	1
Totals	27	19-21	14
Fall Total +	22		14

^a Haugen (1986) believed this pack was unsuccessful in raising young in 1984.

^b This pack had only 1 surviving adult by late summer.

^c Attempted second den in Canning River pack - had at least 1 pup based on placental scars.

^d One adult did not join this pack until late summer, possibly in September.

^e These animals were lone wolves in 1984, but denned in Canada in 1985.

^f Fall totals are lower than total numbers due to death and emigration.

The pups eyes open 11-15 days after birth and at about 3 weeks of age they start to appear outside the den (Chapman 1977). Whelping dens are used for varying lengths of time and were used at 2 den sites on ANWR (Haugen 1985, Weiler et al. 1986). In arctic areas, dens are usually abandoned in July; however, some may be occupied as late as August (Chapman 1977, Weiler et al. 1985 and 1986, Stephenson pers. comm.). Pups are left at rendezvous sites while adults are hunting until they are able to run with the pack. Data obtained on ANWR has failed to document use of rendezvous sites by denning wolves. In the 2 packs where use of rendezvous sites was suspected, contact with the pack was lost about the time they left the den area. Several other packs (Hulahula River, Egaksrak River, Drain Creek) appear to have stayed at the den site until the pups were able to accompany the adults. Quimby (1974b) and Chapman (1977) both documented use of rendezvous site in this area of the Brooks Range. Both parents, as well as other members of the pack, hunt and care for the young.

Density

Wolf densities in North American populations range from 1 wolf/7.8 km² to 1 wolf/520 km² (Table 23). Estimated fall densities in the northeastern Brooks Range were 1 wolf/726 km² and 1 wolf/686 km² for 1984 and 1985 respectively (Weiler et al. 1986). These estimated densities are for an area of approximately 24,700 km² (9500 mi.²), bordered on the east by the Canning River, the Malcolm River on the west, the continental divide of the Brooks Range on the south, excluding the Joe and Mancha Creek drainages, and on the north by the Beaufort Sea. If the coastal plain, where no den sites were documented, is excluded from the estimates, densities increase to 1 wolf/497 km² and 1 wolf/469 km² for 1984 and 1985 respectively (Weiler et al. 1986). These densities are considered minimum estimates based on the actual number of known wolves in the area. The existence of undetected wolves would increase densities, however this increase would probably not approach levels reported for other areas in the Brooks Range (Table 23).

Territories and Movements

Wolf packs tend to have territories that are distinct from those of neighboring packs although overlap is possible. Howling and urine marking serves as a means of spacing in wolf populations (Peters and Mech 1975, Harrington and Mech 1983). The size of pack territories varies between different geographic locations, but does not vary greatly within geographic locations (Mech 1974, as cited by Zimen 1976). Packs defend territories and usually repel or kill alien wolves; however, when food resources are scarce, packs utilize peripheral areas of their territories more and may trespass into neighboring pack territories (Mech 1977). In the Northwest Territories of Canada (Kuyt 1972) and northwestern Alaska (Stephenson 1979, James 1983), wolves tend to seasonally shift their ranges in correspondence with seasonal migration of caribou (Rangifer tarandus). In the northeastern Brooks Range (ANWR), these seasonal shifts in resident pack territories due to caribou movements have not been detected. Winter data (November to April) are scarce, however, surveys flown for relocation of caribou have failed to locate any collared pack animals in areas of overwintering caribou. Although several lone and dispersing wolves travelled south in conjunction with caribou, they failed to return with caribou the following year. Limited radio tracking data indicates that these wolves joined with other lone wolves or packs and remained in that area rather than following caribou migrations north. This data suggest that wolves belonging to resident north slope packs are using the same or slightly expanded summer ranges and remain near or north of the continental divide during winter. Alternate food would include resident prey such as Dall sheep (Ovis dalli) and moose (Alces alces), and in the Sadlerochit mountain area to the west, scattered groups of caribou from the CAH. Limited tracking data for the Sadlerochit pack during winter 1984-1985 showed that this pack stayed in the same general area used during the summer, although the area of use expanded to the west in winter.

Summer-fall activity areas for wolf packs on ANWR (Fig. 43 and 44) were derived from movements of radio-collared wolves associated with different packs. These areas show assumed use by wolf packs and their relationship to neighboring packs, however, they are not intended to be a measurement of territory size. The Canning River pack was the only pack to den in both years of the study. Due to limited radio-tracking data, locations of this pack from 1984 and 1985 were combined in Fig. 45.

Table 23. Reported densities for North American wolf populations (adapted from Stephenson 1975).

Location	Area (km ²)	Density (km ² /wolf)	Source
<u>Michigan:</u>			
Isle Royale	544	18-26	Mech 1966, Jordan et al. 1967
Minnesota	6,449	26	Olson 1938
Minnesota	10,619	44	Stenlund 1955
Minnesota	10,886	28 ^a	Mech 1973
Minnesota	1,857	24	Van Ballenberghe et al. 1975
<u>Alaska:</u>			
Southeast	19,425	65-104	Atwell et al. 1963
Coronation Island	78	8 ^b	Merriam 1964
South central (Unit 13)	51,800	130	Rausch 1967
Mt. McKinley N.P.	5,180	130	Murie 1944
Mt. McKinley N.P.	3,885	62-109	Haber 1968
Northwestern Brooks Range			
Northern foothills	--	390	Stephenson and James 1982
Northern and western areas	--	520	Stephenson and James 1982
National Petroleum Reserve Alaska			
Average	--	520	Stephenson 1979
Southern portions	--	130	Stephenson 1979
North central:			
Spring 1971	9,324	320	Stephenson 1975b
Spring 1973	9,324	194	Stephenson 1975b
Canning River area:			
Spring 1973	4,196	596	Quimby 1974b
Fall 1973	4,196	181	Quimby 1974b
<u>Canada:</u>			
Western Canada	10,878	225-288	Cowan 1947
Saskatchewan	--	103.6-215	Banfield 1951
Algonquin Park, Ontario	2,590	26	Pimlott et al. 1969
Ontario	25,900	259-518	Pimlott et al. 1969
Northwest Territories	1,243,200	155-311	Kelsall 1957
Northwest Territories	995	18 ^d	Kuyt 1972
Baffin Island	4,662	311	Clark 1971
Manitoba-Saskatchewan	3,300	20-36 ^d	Parker 1973
Manitoba- Saskatchewan-			
Northwest Territories	282,310	518 ^e	Parker 1973

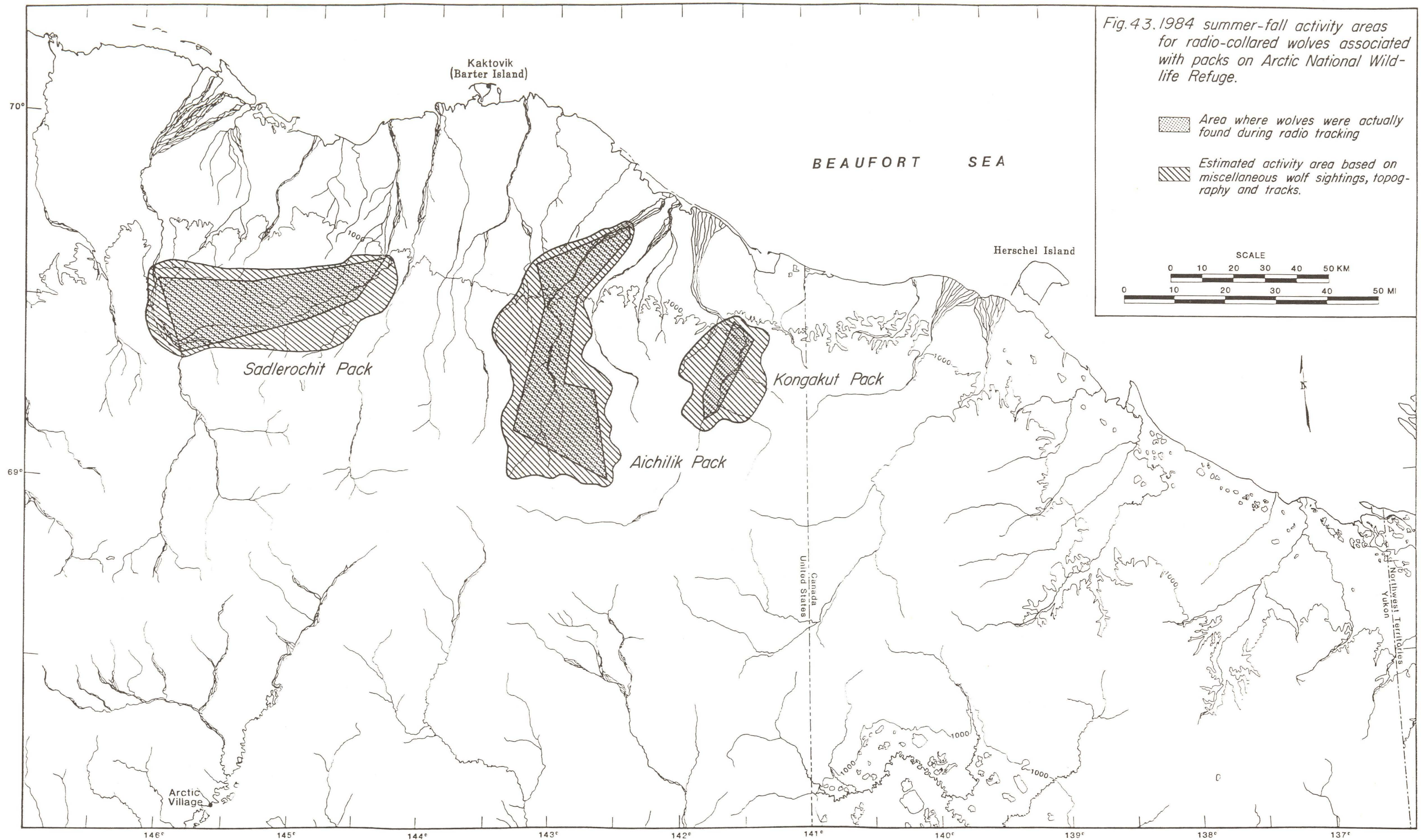
^a Average for 2 winters, 1971-1972 and 1972-1973.

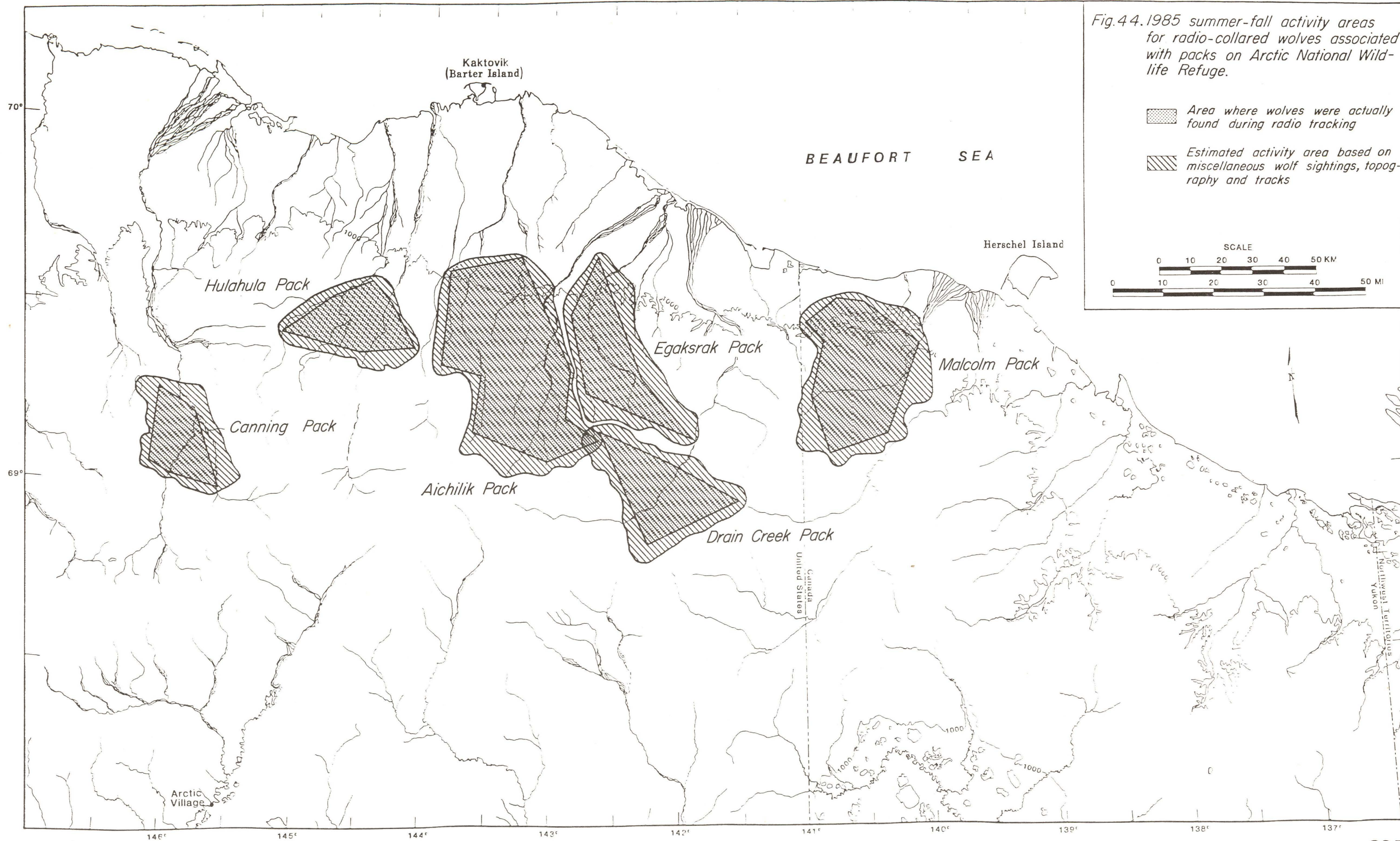
^b Artificial situation; four wolves stocked.

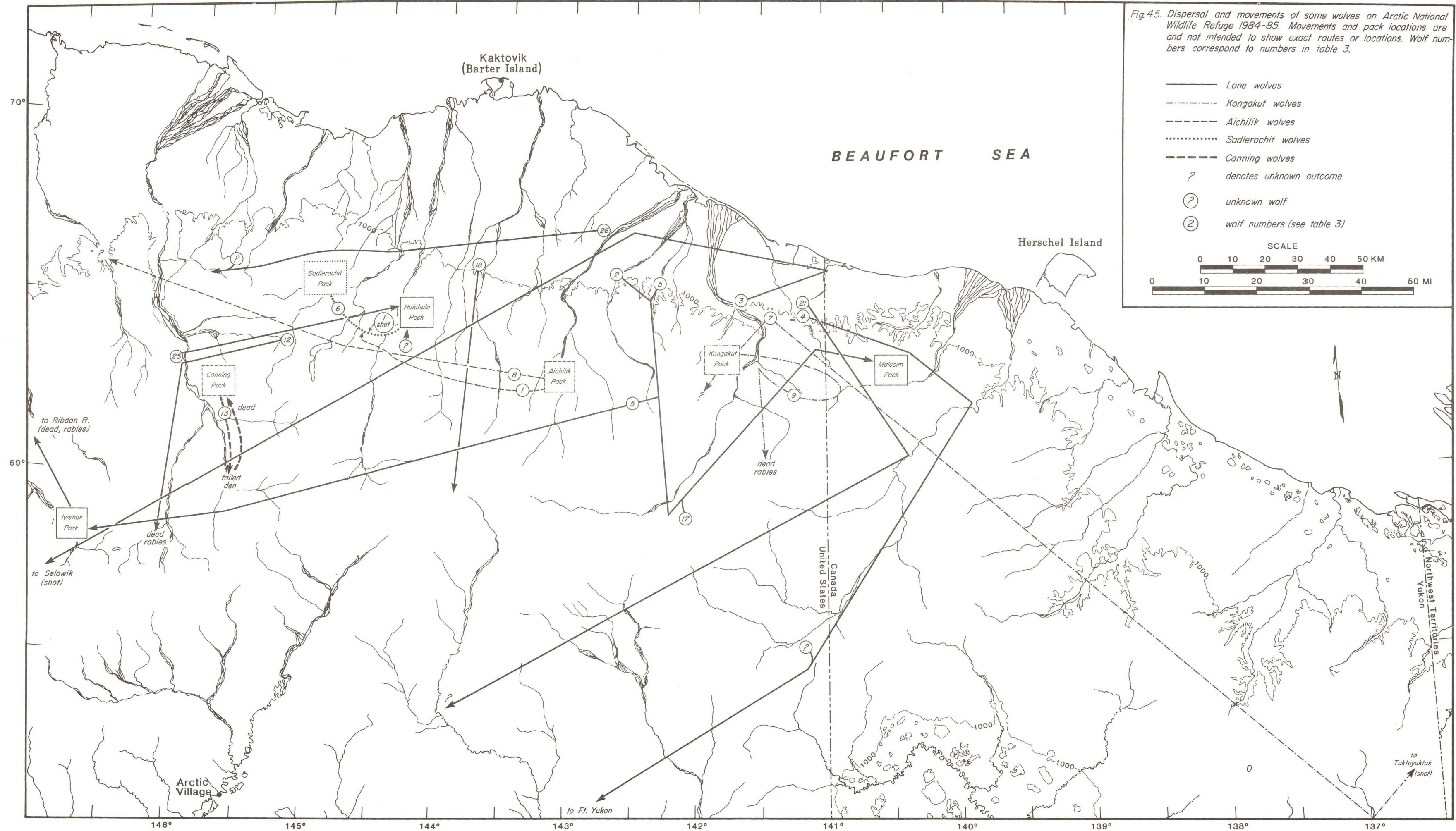
^c Maximum abundance on winter range.

^d Temporary concentration of wolves on winter range of Kaminuriak caribou herd.

^e Total year round range of Kaminuriak caribou herd.







In addition to pack members there are individuals or small groups of wolves which do not defend a territory. These individuals have either been driven from the pack or have left voluntarily and usually are low ranking or former high ranking adults (Zimen 1976). These animals live in and around pack territories and generally avoid contact with the pack or may leave the area entirely. Wolves that have left the pack voluntarily are sometimes reintegrated into the pack at a later date (Zimen 1976). Lone wolves which have left a pack may remain alone, join with another lone wolf to form the breeding pair of a new pack in a new territory, or occasionally join another pack (Messier 1985).

During the 1984-1985 ANWR study, 26 wolves were captured of which 7 were known lone wolves. Another 4 wolves were not associated with a pack, but are thought to be former members of a pack that disintegrated after at least 1 and possibly several members of the pack died from rabies (see section on disease). Five animals associated with packs at the time of their capture later dispersed. The fate of these and other marked wolves is presented in Table 24 and Fig. 45.

Dispersing wolves have been known to travel great distances. Fritts (1983) documented a movement of 886 km for a wolf from Minnesota, while Ballard et al. (1983) reported a dispersal in Alaska of 732 km by 2 wolves. One of the ANWR study wolves traveled from the Kongakut River area of the coastal plain to an area between Ambler and Selawik where it was shot. This is a distance of approximately 770 km from its last location and 826 km from its known farthest eastward location (Fig. 46). This distance represents the longest recorded movement in Alaska.

Two wolves (1 pack member and 1 lone wolf) dispersed from the area and followed caribou movements to the south and into Canada. The lone wolf (a 2-3 year old male) was captured in June 1984 near the U.S.-Canada Border. By mid-July it had moved 61 km southeast into Canada. At the end of August it was 112 km southwest of the last location and was with a large gray wolf. It stayed in the area until at least mid-November 1984, when contact was lost. These movements corresponded to general caribou movements at the time and caribou were in the immediate area each time the wolf was located. This wolf was last located in October 1985, approximately 240 km southwest of the November 1984 location.

The other wolf was a member of the Kongakut pack and was a 3-year old male. This wolf was captured in June 1984 and remained in the Kongakut general area until late July. At this time contact was lost and not reestablished until late September when the wolf was located in Canada, an eastward movement of 193 km from its last location. In early December it was 64 km northeast of its September location. Again movements corresponded to caribou movements at the time and caribou were in the immediate area each time the wolf was located. This wolf was shot in March 1986, in the Kugalik River area, east of Tuktoyaktuk, N.W.T., approximately 230 km east of its December location.

Productivity

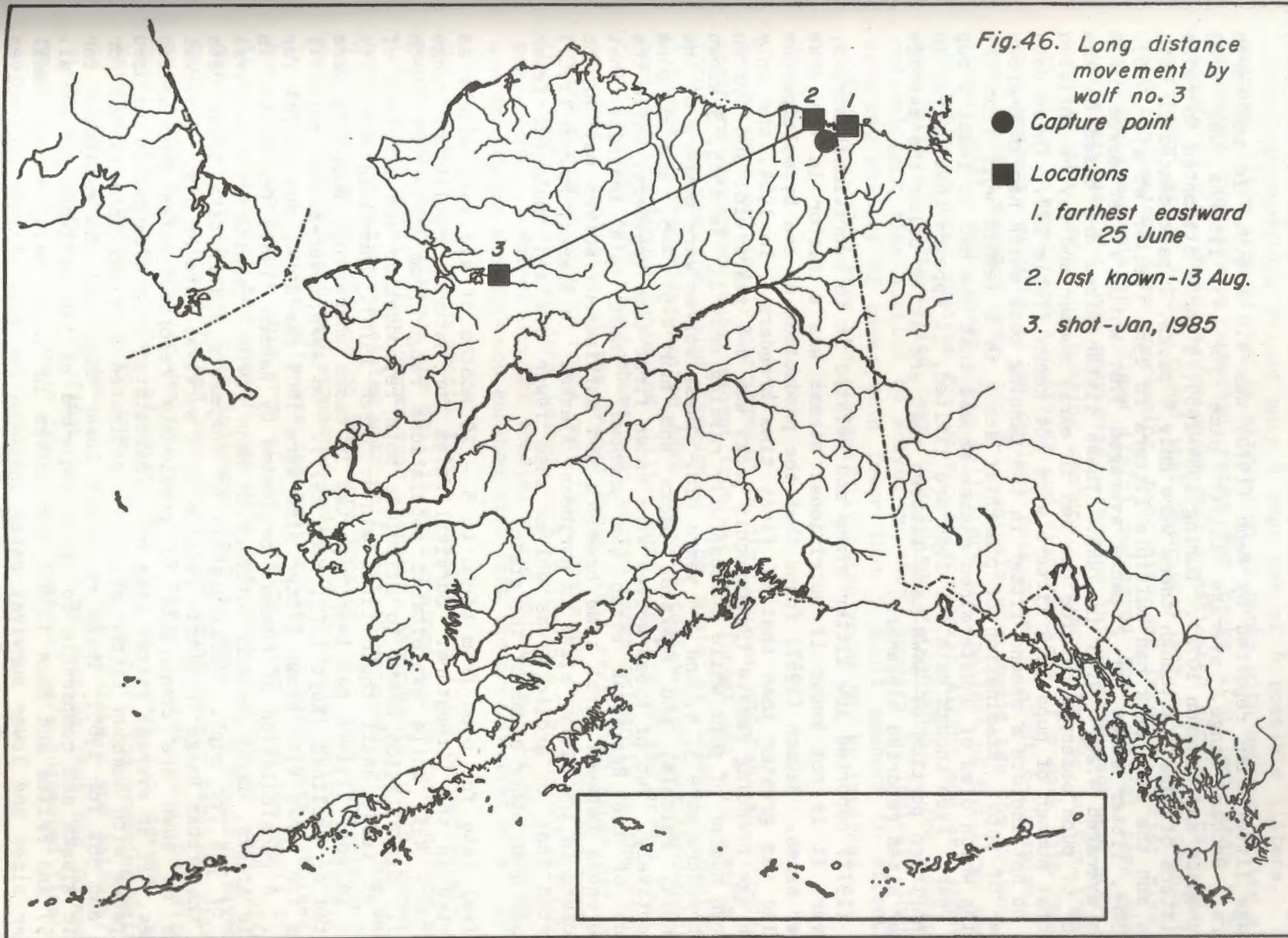
A few captive wolves have reached sexual maturity in 1 year (Medjo and Mech 1976), but nearly all females reach puberty by 22 months (Packard et al. 1983). Wolves in packs usually would not breed until older. The

Table 24. Sex, age, and fate of lone and dispersing wolves on Arctic National Wildlife Refuge during 1984-1985 (Numbers correspond to numbers on Fig. 45).

Wolf number	Sex	Age	Fate
1	M	1	Separated from Aichilik pack and joined wolf #6 in early 1985, shot in late March 1985.
2	F	3	Joined wolf #5 in June 1984, separated in July and joined wolf #17 in October and these wolves formed Malcolm pack in 1985.
3	M	1-2	Lost contact on ANWR in August 1984 - Shot near Selawik in June 1985.
4	M	2-3	Dispersed to south side of Brooks Range in July 1984 - found with 2 unmarked wolves near Ft. Yukon in October 1985.
5	M	3-4	Joined wolf #2 in June 1984, separated and dispersed to the west in July, found with Ivishak pack in November 1984 - found dead of rabies in April 1985 on the Ribdon River.
6	F	2	Separated from Saalerochit pack October 1984, joined wolf #1 in early 1985. After wolf #1 was shot, wolf #6 denned, becoming the Hulahula Pack. She was joined by unmarked wolf in July 1985, and they were joined by wolf #25 September 1985.
7	M	3	Separated from Kongakut pack in July 1984, dispersed east into Canada in August 1984. Last found near Aclavik, Canada in December 1984. Shot in April 1986 approximately 113 km east of Tuktoyaktuk, Northwest Territories.
8	F	2-3	Separated from Aichilik pack in late 1984 or early 1985. Last found on Juniper Creek west of Canning River in April 1985.
9	F	2-3	Separated from Kongakut pack September 1984 - Found dead of rabies in April 1985.
12	M	1-2	Captured 6 April 1985, - Found dead of rabies on 25 April 1985.
13	F	3-4	1 of 2 breeding females in Canning pack, denned but failed to raise pups and found dead of unknown causes on 30 June 1985.
17	M	3	Joined wolf #2 in October 1984, and they formed Malcolm pack in 1985.
18	F	1-2	Believed to be associated with the Aichilik pack, captured in May 1985. Dispersed south and lost contact in July 1985.
21	M	1-2	Captured 27 June 1985, located along Firth River on 7 July 85, last located on Sheenjek River in March 1986.
25	M	2	Captured on Canning River August 1985, joined wolf #6 in Hulahula pack in September 1985.
26	M	2-3	Captured in August 1985. Traveled west across coastal plain in October 1985 and joined unmarked wolf near Canning River.

Fig.46. Long distance movement by wolf no. 3

- Capture point
 ■ Locations
 1. farthest eastward
 25 June
 2. last known - 13 Aug.
 3. shot - Jan, 1985



probability of a female breeding depends on her social rank within the pack (Zimen 1976), while the probability of copulation and successful reproduction is higher for adults than 22-month old females (Packard et al. 1983).

Average litter size reported by Mech (1970) was 4.0 - 6.5. In the north central Brooks Range, average litter size for 43 litters was 5.23 (Stephenson and Johnson 1972). During 1984-1985, 9 packs attempted to raise 10 litters of pups. Although there were only 8 packs, 1 pack denned in both years and the same pack had multiple litters in 1985 (Weiler et al. 1986). In 1984, litter sizes for 2 packs averaged 3.0, while litter sizes in 4 packs averaged 4.20 - 4.75 in 1985. These litter sizes are based on the number of pups observed outside the den in early summer and may be inflated as total number of pups in 3 litters were not known (Table 22). These data also do not include a second litter in the Canning pack which had an unknown number of pups. Examination of placental scars in a female wolf from the Canning which died of undetermined causes showed that she had at least 1 pup that year. Even though data for 1984 are limited, it appears that wolves in the northern portion of ANWR have litters that are at or below the average litter sizes reported elsewhere.

Mech (1977) reported low litter sizes and related it to nutritional stress, however, it is not known if nutritional stress was a factor in the ANWR litter sizes. Rausch (1967) found that the production of ova by multiparous females was greater than that of first time breeders. In 1984, the only known age breeding female (Sadlerochit pack) was 6-8 years old, and had an unknown number of pups while successfully raising only 1. In 1985, 3 known age breeders were 3, 4, and 3-4 years old. These wolves were members of the Hulahula, Malcolm, and Egaksrak packs and had 4-5, 4-5, and 5 pups respectively. Two of these wolves were known first time breeders, while the status of the Egaksarak bitch was unknown. These data indicate that differences between first time breeders and multiparous wolves may not be the cause in low litter sizes in northeast Alaska. In Alaska, Rausch (1967) reported that in arctic areas wolves shed fewer ova and implanted fewer fetuses than other areas of the state.

Survival rate for pups from birth to 5 - 10 months of age vary widely as reported in the literature. Survival rates for natural populations range from 6 - 43%, while exploited populations range from 20 - 88% (Mech 1970). Exploitation seems to stimulate both reproduction and survival of pups, at least until their first winter (Mech 1970). Increased mortality rates in wolf litters has been reported in cases where food supplies were limited or declined (Kuyt 1972, Mech 1977). On ANWR, over-summer survival rates for packs with known litter size were 100% for 1984, and 68-76% for 1985. A recalculation of numbers presented by Rausch (1967) for wolves in arctic Alaska, using methods outlined by Mech (1970), results in a survival rate of 72% for pups. Recalculation of Chapman's (1977) data using data from the Brooks Range in Alaska results in a survival rate of 85%. Survival rates on ANWR are comparable to previously reported rates for arctic Alaska. If an average litter size of 4 (calculated from ANWR packs) is used for packs with unknown litter size, the estimated survival rate is 50% for 1984 and 56% for 1985. These rates are lower than previous estimates for arctic Alaska and comparable to those reported by Van Ballenberghe et al. (1975) and Fritts and Mech (1981) for wolves in Minnesota. Overall small litter sizes and lower survival rates indicate low productivity for wolves in the northeastern Brooks Range.

The survival data (Table 22), seem to indicate that over-summer survival may be related to pack size. A total of 21 pups were raised in 1984-1985, with 15 (71%) being raised by the 4 packs with 5 or more adult members. Packs with less than 5 members (includes 1984 Canning pack and 1985 Canning second litter) successfully raised only 6 pups out of 6 possible litters. If an average litter size of 4.0 is attributed to packs with unknown litter sizes, estimated over-summer survival rates for packs with less than 5 adults becomes 23-25%, while larger packs had a estimated survival rate of 100%. Harrington et al (1983) found that when prey was relatively abundant and wolf populations were increasing, pack size and December litter size were positively correlated. Zimen (1976) suggested that optimal pack size is ultimately derived from prey size. Factors influencing pack and prey size, such as the number of hunting members, replacements for wolves that are killed or injured, and advantages and disadvantages of a pack with fewer or more members, results in an optimal pack size of about 6-10 animals when deer are the primary prey, and 8-12 animals when moose are the primary prey (Zimen 1976). Dall sheep (Ovis dalli) are the smallest of the large mammals available as prey species for wolves in northeast Alaska and are about the same size as white-tailed deer (Odocoileus virginianus). The concept of optimal pack size applied to wolves on ANWR, appears to indicate that the apparent ability of packs with fewer than 5 adult members to effectively utilize available prey and successfully raise young may be impaired.

Habitat

Wolves were originally circumpolar in distribution and habitat included all Northern Hemisphere types except tropical rain forest and arid deserts (Mech 1970). Wolves are found throughout the state of Alaska. Location of information from sightings on ANWR indicate that wolves roam throughout the northeastern Brooks Range and utilize most habitats of the area. Data from the 1984-1985 ANWR study shows that wolves range primarily in the mountains and arctic foothills of the Brooks Range. This restricted range may be due to the presence of year round prey (Dall sheep and moose) and the terrain on the coastal plain renders wolves more vulnerable to harvest (Stephenson pers. comm.). Wolves use the coastal plain extensively in early summer with use decreasing sharply once caribou have left the area (Weiler et al. 1986).

Den sites of wolves in arctic Alaska usually are found on moderately steep southern exposures where the soil is well drained and unfrozen during summer (Stephenson 1974). Land forms such as banks, escarpments, dunes, kames, and moraines are often associated with wolf dens (Stephenson 1974). The dens of 7 of the 8 packs followed on ANWR were located. All dens were either on or near rivers with general exposures being southeast to southwest (Table 25). The Canning River den site was the only 1 used in both years. Wolves have been known to den in this area of the Canning River since the early 1970's. It is not known if the present den site was used previous to 1984, although development of the den site indicates that it was. The Kongakut River den had been used since 1975 and was well known among people familiar with the area. The Aichilik River den had not been reported previously, but size and development of the site indicates that it was used for several years. Neither pack denned in 1985, possibly due to death of the breeding pair due to rabies (Weiler et al. 1986). Two den sites (Hulahula and Malcolm) were first year sites used by first time breeding females that had formed new packs. Two den sites (Drain Creek and Egaksrak) were suspected first year

sites due to the lack of development around the site (tunnels, trails, numbers of scats, etc.), with the den being little more than a tunnel. The only den not found was that of the Sadlerochit pack in 1984. This pack was nonexistent in 1985 (Weiler et al. 1986).

Table 25. Locations and exposures at den sites in northeastern Alaska, 1984-85.

Wolf den	Year active	General location	Exposure of den entrances ^a
Canning North	1984	River bank	155°-240°
Aichilik	1984	Cut bank on river terrace	85°-95°
Kongakut	1984	Mound on river terrace	Natal 110°-115°; whelping 270°-280°
Canning North	1985	River Bank	155°-240°
Canning South	1985	Cut bank on river terrace	240°-250°
Hulahula	1985	River bank	210°-215°
Egaksrak	1985	River bottom	250°-270°
Drain Creek	1985	High river bank	East den 180°; West den 175°-180°
Malcolm	1985	High river bank	180°

^aAll bearings are true and were estimated from maps.

Although wolves have been known to den on the coastal plain west of ANWR (Stephenson 1975), no dens were located on the ANWR coastal plain in 1984 and 1985 although suitable habitat for denning appears to be present.

Food Habits

The gray wolf is primarily a predator of large mammals such as white-tailed deer (Odocoileus virginianus), elk (Cervus elaphus), moose (Alces alces), sheep (Ovis dalli), caribou (Rangifer tarandus), and bison (bison bison). As a species, the wolf ranges over a much wider area than any of its prey, and different populations of wolves utilize different prey species (Mech 1970). In each region, only 1 or 2 species make up most of the wolf's diet (Mech 1970). In areas where wolves reside in association with man, the wolf will also prey on domestic animals. The smallest consistent prey of wolves is the beaver (Castor canadensis) (Nowak and Paradiso 1983). Wolves also feed on a large variety of small mammals, birds and fish, which when abundant may be important over short periods when larger prey is unavailable. Ballard et al. (1981) stated that although high densities of small mammals could be an important food supplement, areas with low ungulate density have a low carrying capacity for wolves regardless of the abundance of small mammals and birds. When viewed in the total perspective of the wolf's food habits, predation on small animals is seen to play only a minor role in the life of the wolf (Mech 1970). Wolves may cache food for later use (Murie 1944, Harrington 1981), as has been reported for other canids.

Mech (1970) discussed several studies indicating that "younger" and "older" animals were preyed upon by wolves in greater numbers than occurred in the prey population. Mech and Frenzel (1971), Kuyt (1972), Carbyn (1983), and

Petersen et al. (1984) also reported similar findings. In southcentral Alaska, Ballard et al. (1981) reported that moose calves were preyed upon in proportion to their abundance. They also found that in severe winters wolves preyed upon adult moose in proportion to their occurrence in the population, while during average or mild winters relatively older moose were being preyed upon. In discussing data presented by Ballard et al. (1981), Peterson et al. (1984) suggests that wolves killed all ages of moose at about the same rate during summer as in winter, which is in contrast to a number of other studies and suggests variability in summer predation pattern.

In the north central Brooks Range, scat analysis indicated that wolves depend primarily on ungulates for food during summer months, but consume a variety of other items (Stephenson and Johnson 1972, Stephenson 1975a). Small mammals occur regularly in the summer diet and in some cases may compose as much as 50% of the diet (Stephenson 1975a). This phenomenon may be the result of caribou being rare in some areas during June and July (Stephenson and Johnson 1972). The summer diet of wolves in this area shows great variety depending on geographical, seasonal and annual differences in prey availability. These data (Stephenson and Johnson 1972), were in general agreement with results reported by Kuyt (1970) in the Northwest Territories.

In the northwestern Brooks Range, adult caribou comprised 91.8% and 94.4% of prey consumed by two wolf packs (Table 26). On ANWR, analysis of scats from den sites also showed caribou were also the major prey species consumed during the denning season during most years, although moose and Dall sheep were also utilized (Table 27). Differences in prey consumed between northwestern and northeastern Brooks Range wolf packs is probably due to differences in the resident prey populations. Dall sheep and moose were not abundant in the area of northwestern Alaska observed by James (1983). The shift from moose to caribou in the diet of the 1984 and 1985 Canning packs (Table 27), coincided with a decrease in the packs size. This may indicate the packs' inability to utilize larger prey such as moose, rather than a change in the availability of 2 prey species.

Table 26. Composition (%) of prey consumed by wolf packs in the northwestern Brooks Range, Alaska (James 1983)^a.

	Northwestern	
	Ilisliuruk pack	Anisak pack
Caribou adult ^a	91.8	94.4
caribou calf	4.8	1.2
moose adult ^d	0.7	3.0
moose calf	0.3	1.2
Dall sheep adult	--	--
Dall sheep lamb	--	--
Non-ungulate ^b	2.4	0.2

^a Summer of 1977 and 1978.

^b Non-ungulates from James were for ground squirrels only.

Table 27. Percent composition of prey consumed by wolf packs on Arctic National Wildlife Refuge.

Prey species	Canning ^a 1983 (17) ^c	Canning ^a 1984 (131)	Canning 1985 (56)	Hulahula ^b 1983 (24)	Hulahula 1985 (16)	Aichilik 1984 (158)	Egaksrak 1985 (69)	Drain Creek 1985 (88)	Kongakut ^b 1983 (73)	Kongakut ^b 1984 (142)	Malcolm 1985 (24)
Caribou	72.3	13.7	78.4	28.1	60.0	68.5	80.4	62.7	49.8	26.2	58.4
Adult	67.2	11.6	75.6	11.7	60.0	68.0	76.7	62.7	34.6	21.0	58.4
Calf	5.1	2.1	2.8	16.4	-	0.5	3.7	-	15.2	5.2	-
Dall Sheep	5.2	6.2	2.5	34.9	33.6	17.4	18.9	6.5	7.1	12.6	25.0
Adult	5.2	5.6	1.3	22.6	33.6	17.0	18.4	6.5	6.7	9.5	25.0
Lamb	-	0.6	1.2	12.3	-	0.4	0.5	-	0.4	3.1	-
Moose	-	79.2	-	13.2	-	12.0	-	26.96	42.5	59.0	16.0
Adult	-	74.2	-	-	-	12.0	-	26.4	38.9	53.5	16.0
Calf	-	5.0	-	13.2	-	-	-	0.56	3.6	5.5	-
Muskoxen	-	-	0.3	-	-	1.2	0.15	1.9	-	-	-
Snowshoe hare	-	-	1.5	-	3.35	0.43	-	1.5	-	-	-
Microtine	-	0.3	0.02	2.8	2.5	0.4	-	-	0.07	0.5	-
Marmot	-	-	0.3	-	-	0.2	0.23	-	-	-	-
Ground Squirrel	1.4	0.6	16.9	0.78	0.5	0.4	0.35	0.36	0.04	0.9	0.6
Birds	-	0.1	0.12	-	0.09	0.08	-	0.03	-	0.1	-
Waterfowl	-	-	-	-	-	-	0.01	-	-	-	-
Fish	-	-	-	-	-	0.05	-	-	-	-	-

^a from Haugen 1986^b from Haugen 1984^c number of scats

Impacts of Existing Processes and Activities

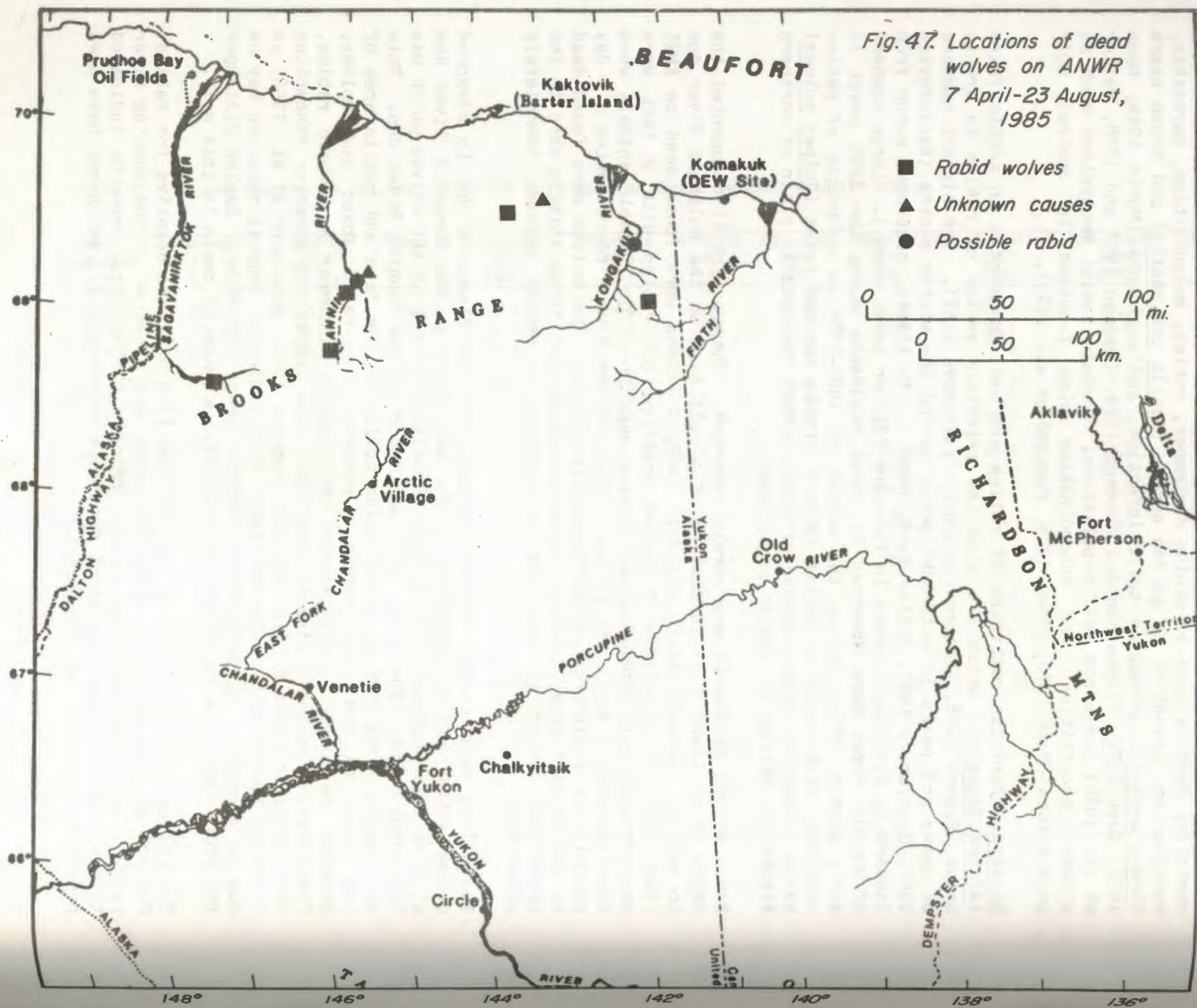
Numerous naturally occurring processes influence mortality and population numbers of wolves. In utero mortality has been reported by Rausch (1967), but the causes of such mortality were undetermined. Post-parturition mortality factors such as canine distemper, rabies, malnutrition, parasites, cannibalism, predation by golden eagles (Aquila chrysaetos) and brown bears (Ursus arctos), porcupine quill infection, and accidents (Murie 1944, Mech 1970, Kuyt 1972, Stephenson and Johnson 1972, Chapman 1977 and 1978, Weiler et al. 1986) influence wolf populations. Certain social mechanisms such as stress, competition, and subordination also function to control wolf populations (Mech 1970, Zimen 1976, Packard et al. 1983).

Disease. Periodic outbreaks of rabies are well documented in arctic foxes (Alopex lagopus), which are also the principle vector of rabies in arctic areas (Rausch 1958, Kantorovich 1964, Syuzyumova 1967). The highest numbers of cases and peaks in outbreaks occur during the winter months (Kantorovich 1964, Syuzyumova 1968, Ritter pers. comm.). In Alaska, outbreaks occur from January to April with peaks in February (Ritter pers. comm.). Large numbers of arctic foxes were observed by local residents along the ANWR coast in early winter 1984. During the winter of 1984-1985 an epizootic of rabies occurred, with cases of rabies in both arctic and red foxes (Vulpes vulpes) being documented from a number of areas across the coastal plain of northern Alaska (L. Dalton, D. Ritter pers. comm.)

Rabid wolves in Alaska are rarely recorded. Chapman (1978) documented the death of at least 6 of 10 members of a wolf pack on the Hulahula River due to rabies. Between April and July 1985, 9 wolves were found dead on ANWR (Fig. 47). Five of the 9 tested positive for rabies with 2 that were undetermined, but probable, and 2 were negative. The 5 rabid animals were found between 7 April and 17 May. Three of the 5 were found during a 4 day period over a distance of approximately 265 km. Two wolves were found dead 16 and 20 days after capture, which indicates that these animals were in the incubation period at the time of capture or became exposed immediately afterward.

Two wolves were thought to have rabies, but not diagnosed due to advanced decomposition of the carcasses. One was found at the Kongakut River den site and was believed to have been associated with 1 of the wolves which was confirmed rabid. The other wolf was found in the Canning River den. This wolf had a large number of porcupine quills in the face and muzzle area of the head, as has been commonly reported for rabid foxes and wolves. However, MacDonald (1980) stated that canine distemper may mimic rabies. Foxes having canine distemper sometimes show aggressive behavior resembling that of rabid animals (Helmbolt and Jungherr 1955; Habermann et al. 1958, as cited by Rausch 1958). Carbyn (1982) also indicated unusual behavior may be due to encephalitic implications brought on by distemper. Canine distemper therefore cannot be ruled out as the possible cause of death in this wolf.

Two wolves were found on 19 and 30 June 1985 and were negative for rabies. One was an unmarked wolf, while the other was a member of the Canning River pack. Causes of death were undetermined, but necropsy results indicated that a possible cause was viral pneumonia or bronchitis, which may have been precipitated by canine distemper.



In 1985, 9 of the 12 documented mortalities were due to disease. This represents a mortality of 26% of the known 1984 fall population.

Human Induced Mortality. 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 wolves from major agricultural areas of the U.S. and Canada. Government sponsored aerial hunting and poisoning of wolves during the 1940's and 1950's greatly reduced wolf populations in some areas of Alaska (Rausch and Hinman 1977). Wolf populations in many of these areas have since recovered. Wolves were relatively abundant on the north slope of Alaska prior to aerial wolf hunting and predator control activities, which became intensive in this area in the early to mid-1950's (Stephenson per. comm.). Between 1952 and 1958, more than 1500 wolves were killed on the north slope of the Brooks Range (Harbo and Dean 1983). In 1962 it was recognized that wolf numbers on the north slope were depressed and an annual bag limit of 2 wolves was imposed. In 1968 the Alaska Department of Fish and Game abolished bounties on wolves except for a few areas in southwest Alaska. Aerial hunting of wolves on the north slope was banned in 1970.

Human induced mortality on ANWR is the result of harvest by local residents, trapping, sport hunting, and illegal aerial hunting. Illegal aerial hunting is probably more common south of the Brooks Range, occurring only sporadically north of the Brooks Range. Few wolves are taken by sport hunters due to the fact that hides are usually not prime at the time most sport hunting for moose and dall sheep occurs. Most harvest of wolves occurs from local residents using snowmachines. In past years the extent of this harvest was unknown because most hides are used locally and therefore were usually not sealed. During 1984-1985, 10 wolves were harvested. All 10 wolves were taken by local residents of which 2 were reported but not confirmed, and 2 were taken illegally after the season closed. Seven were harvested in 1984 and 3 were harvested in 1985. No harvest has yet been reported for 1986. Human harvest in 1985 was 9% of the 1984 fall population, while the total known mortalities (human and natural) in 1985 represented 35% of the 1984 fall population.

Data Gaps

The current wolf study has shown that the wolves on ANWR are part of dynamic and wide ranging population. Interchange and formation of new packs is common, while lone wolves and dispersing animals may travel great distances and follow caribou migration. To understand the basic ecology of this population (territories, movements, and prey interrelationships), additional data are needed. These data needs include winter movements, winter food habits, and the availability and number of prey species at various times of the year.

Wolverine (*Gulo gulo luscus*)

Distribution, Range and Population Size

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 its global distribution, the wolverine is noted for its avoidance of humans, solitary-wide ranging nature, and sparse densities. These characteristics make the wolverine difficult to study, and consequently few ecological studies have been completed. The application of radio telemetry techniques in the study of wolverines has recently yielded additional knowledge of the species (Hornocker and Hash 1981, Magoun 1985, Gardner 1985).

Although wolverines are known to inhabit the coastal plain of ANWR little is known about their abundance, distribution, movements, home ranges, food habits, or other ecological relationships (U.S. Fish and Wildlife Service 1982). Records of wolverine sightings for the area are sparse. During extensive biological field studies in the early 1970's, only 26 wolverine sightings were recorded in northeastern Alaska, 10 of which occurred north of the continental divide, with 1 observation occurring within the coastal plain of ANWR (Quimby 1974b, Quimby and Snarski 1974). Recent biological field studies on the ANWR coastal plain have also resulted in a low incidence of wolverine sightings. Observer effort associated with a variety of wildlife study observations within the study area during 1982-1985 was extensive as well as intensive, yet few wolverines were observed. Efforts to capture and mark wolverines on or adjacent to the study area were also unsuccessful due to the low incidence of wolverine observations (Mauer 1985). The low number of wolverine observations during a period of high observer effort suggests that wolverine density may be relatively low in the study area.

Life History

The wolverine is the largest terrestrial member of the weasel family (Mustelidae). Adult males weigh up to 20kg (average weight for males is about 13kg), while females average about 9.5kg (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 does function as a predator.

Adult wolverines usually breed in late spring and early summer (Rausch and Pearson 1972). Magoun (1985) 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 (1985) 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 (1985) in northwest Alaska. In 1982 a female wolverine with 2 young were observed near the southern perimeter of the ANWR study area (P. Reynolds pers. comm.).

Young wolverines are born in late winter (early March in northwest Alaska) in snow dens (Magoun 1979). They grow rapidly and usually are able to move out of the den within a month (Magoun 1985). 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 January-May (Magoun 1985).

The food habits of the wolverine reflect an opportunistic feeding behavior. Wolverines have been reported killing large ungulates such as dall sheep, caribou, and moose (Burkholder 1962, Haglund 1974, Gill 1978). It is generally thought that in Alaska the wolverine is more often a scavenger than a predator of the large ungulates (Rausch and Pearson 1972). Magoun (1985) 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 their nests. An important winter food for wolverines in the tundra environment appears to be ground squirrels that are cached during the fall or excavated from their hibernacula (Magoun 1985). Cached remains of caribou calves were utilized by a wolverine during early spring 1984 in the ANWR study area and a wolverine was observed killing a ground squirrel south of the study area during late summer (Mauer 1985). These observations suggest that wolverines in the ANWR study area have food habits similar to those reported for wolverines in northwestern Alaska.

In the mixed tundra and boreal forest environments of southcentral Alaska wolverines fed mostly on ungulate carrion (primarily moose) during winter and demonstrated lower reliance on cached food resources (Gardner 1985). The abundance and turnover rate of large herbivore populations appears to influence wolverine distribution (van Zyll de Jong 1975). Results of several recent studies (Hornocker and Hash 1981, Magoun 1985, Gardner 1985) confirm this relationship. The presence of primary predators such as wolves and brown bears may also be important in increasing food (ungulate carcasses) for wolverines.

Habitat

Based on observations and tracks noted during studies in the early 1970's, and recent biological studies, it is apparent that wolverines frequent all types of terrain within the ANWR study area (Quimby and Snarski 1974, Mauer 1985). Features such as rivers and mountains do not inhibit wolverine movements (Magoun 1979), but are often utilized as territory boundaries (Gardner 1985). Magoun (1985) found that adult female wolverines with young were territorial and occupied considerably smaller home ranges than adult males. Snow drifts are important habitat as wolverine den sites (Pulliainen 1968). In the tundra environment, remnant snow drifts in small drainages with associated meltwater caverns were an important rearing habitat used by maternal females and their offspring (Magoun 1985). 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 1985). In southcentral Alaska, wolverines demonstrated seasonal shifts in habitat use: alpine tundra during summer, spruce forest during winter (Gardner 1985).

An intensive study of an essentially unharvested population of wolverines in northwest Alaska estimated fall wolverine densities of $1/55\text{km}^2$ - $1/74\text{km}^2$ in an arctic foothills area (Magoun 1985). Other reported wolverine

densities include $1/65\text{km}^2$ in northwestern Montana (Hornocker and Hash 1981) and $1/76\text{km}^2$ - $1/143\text{km}^2$ in southcentral Alaska (Gardner and Ballard 1983). In northwestern Alaska the home ranges of male wolverines were considerably larger than those of females, and overlapped several female home ranges (Magoun 1985). The average summer home range size was 94km^2 for females, and 626km^2 for males (Magoun 1985). Lactating females range over a much reduced area during March and April when young are born and reared.

Impacts of 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 1977), 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). In the tundra environment, wolverine productivity was apparently reduced when food was scarce (Magoun 1985). If caribou populations decline wolverine numbers would also decrease (Magoun 1985). Circumstantial evidence indicates that wolverine abundance throughout much of eastern and central Canada resulted from direct exploitation of wolverines as well as reductions in large herbivore populations which were a primary food source of wolverines (van Zyll de Jong 1975).

Records of wolverine pelts sealed by the Alaska Department of Fish and Game (ADF&G) indicate that an average of about 1 wolverine/year is harvested from the refuge coastal plain area (U.S. Fish and Wildlife Service 1982). Actual harvest may be higher, however, due to incomplete reporting. Magoun (1985) estimated the reported harvest of wolverines for the Alaskan north slope represented no more than 10% of the actual harvest. Wolverines are occasionally taken by trappers having traplines near the village of Kaktovik. Sealing records indicate that these animals are mostly sub-adults which may be dispersing onto the coastal plain from the foothills region to the south. According to Jacobson and Wentworth (1982), Kaktovik residents harvested 6 wolverines in 1979 and 7 in 1980. The areas most frequently hunted for wolverines by Kaktovik residents are the foothills and northern mountain areas of the Sadlerochit, Hulahula, and Okpilak River drainages.

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 during winter. Wolverine pelts are highly prized by Eskimo residents for parka ruffs. Prices paid for wolverine pelts in arctic communities are often considerably higher than those quoted from national and international markets (Quick 1952). Therefore, the harvest of wolverines within the study area may be great enough that wolverine numbers are depressed in areas where hunting pressure is high. This could partially explain the relatively low level of wolverine observations recorded for the area. More definitive information regarding wolverine abundance, productivity and actual harvest levels is necessary to determine the current status of wolverines in the ANWR study area.

Arctic Fox (*Alopex lagopus*)

The arctic fox is among the smallest of the canids, weighing from 1.4 to 3.2 kg (Chesemore 1975). It is the only canid to undergo marked seasonal color

changes and occurs in 2 color phases, the white and the blue. The white phase is white in winter while in summer it is dark brown on back, legs, tail and head with white or yellowish underparts. The blue phase varies from grayish to almost black in both summer and winter. These genetically distinct phases interbreed, and their ratios show much variation over the arctic region (Larson 1960). Both phases may occur in the same litter (Stephenson 1970).

The pelt of the arctic fox attracted many of the first European explorers and traders to the lands bordering the Arctic Ocean (Macpherson 1969). In Canada and other northern countries, arctic fox populations vitally affect the settlement and economy of large, inhabitable areas (Macpherson 1969). In northern Alaska its importance to the fur industry has declined in recent years as alternate sources of income have become established in connection with northern development (E. Follmann and F. Fay. 1981. Unpubl. report, in files of E. Follmann, Univ. of Alaska). According to Hall and Kelson (1959), there are 3 subspecies of arctic fox in Alaska, however, 2 are restricted to islands in the Bering Sea (Fig. 1). Pengilly (1981) believed there was insufficient variation between A.l. hallensis and A.l. lagopus to warrant A.l. hallensis's designation as a separate subspecies.

Distribution, Range and Size of Populations

Arctic foxes are circumpolar in distribution and inhabit the arctic or tundra zone of North America and Eurasia, and portions of the alpine zone in the mountains of Norway and Sweden, and also breeds on the barren islands of the arctic portions of the North Atlantic and North Pacific Oceans (Chesemore 1975). In Alaska, the arctic fox (white phase) inhabits the western and northern arctic coast and tundra areas (Fig. 48). The white phase is predominant on St. Lawrence, St. Matthew, Hall, and Diomed Islands, as well as most of the other islands in the Bering Sea. The blue phase is predominant on the Pribilaf and Aleutian Islands, however, the white phase does occasionally occur among the blue phase populations (Chesemore 1967).

Arctic foxes are commonly found along the coast during winter and are often observed on the sea ice where they may wander large distances and/or are transported on drifting ice floes. They have been observed on the ice pack approximately 640 km north of the arctic coast of northern Alaska (Chesemore 1975). Occasionally, arctic foxes are found in interior Alaska as far south as Arctic Village. Range of the arctic fox may be limited by habitat preference and competition with red fox (Vulpes vulpes) (Chesemore 1967).

Arctic fox populations fluctuate in cycles that have been related to the cycles in populations of microtines (Dementyeff 1958, Tchirkova 1958, Chesemore 1967, 1975, Wrigley and Hatch 1976), which are the principal prey item. In Alaska the peaks in populations occur approximately every 4 years (Chesemore 1967), while in Manitoba the peaks averaged every third year, but ranged from 2 to 7 years (Wrigley and Hatch 1976). Chesemore (1975) cited several authors that indicated average peaks at 4 year intervals in Ungava, Labrador, Greenland, Novaya, northern Quebec, and the Northwest Territories. While it appears that arctic fox population cycles are generally similar in most areas, the cyclic peaks are not necessarily synchronous. Within any given year the number of foxes in autumn will tend



Fig. 48. Distribution of arctic fox (*Alopex lagopus*) in North America. (Hall and Kelson, 1959).

to be about 3 times the number of the previous spring (E. Follmann and F. Fay. 1981. Unpubl. report, in files of E. Follmann, Univ. of Alaska). No population estimates have been attempted in Alaska.

Life History

Arctic foxes are monestrous and monogamous. Mating occurs in March or early April in northern Alaska (Chesemore 1975). Males reach sexual maturity in 10 months, while females may breed in their first year when populations and food supplies are high or not till their second year if food supplies are low (Macpherson 1969). Gestation is 52 days and the litter is born in May or June. Litter size based on placental scars averages 10.5 and does not vary between years, however; number of pups weaned varies greatly between years due to food availability (Macpherson 1969).

Males and females pair prior to the breeding season and remain together while raising the pups. Eberhardt et al. (1983) first observed foxes at dens in northern Alaska in March. In tundra habitats, foxes usually establish dens in low mounds (called "pingos") 1-4 m high (Chesemore 1975), low ridges, or dunes (Eberhardt 1977). In other areas, foxes have established dens in crevices in rocky areas near cliffs. Presence and depth of permafrost determines where arctic foxes can dig dens. Dens are often used repeatedly over the years becoming traditional den sites, although not necessarily by the same foxes. These dens are often enlarged each year with old dens having up to 100 burrow entrances in various states of repair (Macpherson 1969). Pups are born in the den, but according to Eskimos, the female often whelps on the tundra and carries the pups into the den (F. Follmann and F. Fay. 1981. Unpubl. report, in files of E. Follmann, Univ. of Alaska). The female stays in the den for several days after parturition while the male provides food during this period. Thereafter, both parents provide for the young.

Pups appear outside the den at 3 to 4 weeks of age (Tchirkova 1958, Eberhardt 1977). As the pups grow older they enlarge their area of activity around the den and begin foraging for themselves. During this time the adults gradually decrease care of the young. Fine (1980) observed that the male did not bring food to the den after pups were 8 weeks old. Garrott et al. (1984) found that the females usually provided a larger proportion of food for pups than the males. Two or more den sites are often used by the same family of foxes during the summer. Eberhardt et al. (1983) found that simultaneous use of multiple dens by fox families was common. Den moves usually occurred in early to mid-July and often only a portion, rather than the entire litter were moved. Pups disperse and leave the natal territory in mid-August (Macpherson 1969) or September (Dementyeff 1958); however, the adults usually leave the den area earlier. Males abandon the den site first and are followed later by the females. Den sites may be used during the winter months, and in years of high food abundance, adults may stay at or near the den site.

Territories and Movements

Except during the breeding season, arctic foxes are primarily solitary (Banfield 1977, as cited by Underwood and Mosher 1982), although they tend to congregate in areas of high food resources. During breeding season territories are established around the natal den. Several investigators

have recorded aggressive interactions between foxes which appeared to be territorial in nature (Bedard 1967, as cited by Stephenson 1970; Stephenson 1970; Burgess 1984). According to Eberhardt et al. (1982), territory boundaries are not regularly patrolled but are maintained by both direct (chasing) and indirect (vocalizations and scent marking) activities. The influence of territoriality on density of dens and home range sizes in periods of varying food abundance is not well understood, although Macpherson (1969) concluded that in the Aberdeen Lake area of Canada, the number of occupied dens was limited neither by habitat nor territorial behavior.

The following territory sizes in Alaska have been referred to as home ranges, however, it appears that territory would be the correct term, at least when referring to adult foxes. Burgess (1984) reported home range sizes of 23.9 km² and 18.5 km² for 2 foxes. Eberhardt et al. (1982) reported an average size of 20.8 km² \pm 1.7 for 5 juvenile foxes. Fine (1980) reported home ranges for 5 pups that ranged from 5.4 km² to 14.9 km². Home range size may vary by a factor of 6 depending on food abundance (Underwood and Mosher 1982).

During fall, winter and early spring, arctic foxes are highly mobile. In any given year foxes may move onto pack ice, make long distance movements or even mass migration in some areas (Dementyeff 1958, Tchirkova 1958, Shilyaeva 1967, Chesemore 1968a, Northcott 1975, Wrigley and Hatch 1976, Eberhardt and Hanson 1978). Movements of arctic foxes have been classified into the following 4 categories (McEwen 1951, as cited by Wrigley and Hatch 1976):

1. Local - general activities within the animals home range.
2. Seasonal - related to seasonal changes, but not involving great numbers and may not occur annually.
3. Sporadic - individual movements of great distances from normal breeding ranges and not related to any particular environmental factor.
4. Migratory - large numbers of foxes travelling in a sustained direction as a result of a decline in lemming numbers.

In Alaska there are 2 distinct seasonal movements. The first during fall and early winter when foxes move toward the coast and sea ice, and the second in late winter and early spring when they return inland (Chesemore 1967). The percentage of animals making the round trip is unknown, but Eberhardt et al. (1982) observed that most of their marked foxes were not present in successive years.

Sporadic movements of marked foxes have been described in several studies. In Alaska, movements of up to 945 km have occurred (Eberhardt and Hanson 1978), while in Canada movements of over 1500 km have been reported (Wrigley and Hatch 1976). These are straight line distances and include travel over land and sea ice.

Migration movements are usually the response of a large fox population to a decline in the lemming population. These migrations are well documented in

the U.S.S.R., but are seldom observed in North America. Migrations may occur along a wide front or a narrow corridor (Bannikov 1970, as cited by Wrigley and Hatch 1976). The direction of the migration is determined by the passability of the terrain and the direction of the prevailing winds, with foxes moving in the direction of the migration and not staying at feeding sites (Shilyaeva 1967). Sometimes a migration consists of several waves through a region (Dementyeff 1958). There is evidence (Shilyaeva 1967) that migrating foxes have a return migration in spring, but these are not well documented as many foxes die of disease, starvation, or are trapped. Wrigley and Hatch (1976) documented the existence of a migration in Manitoba. In Alaska, these migrations have not been documented.

Food Habits

Arctic fox food habits reflect the seasonal abundance and availability of prey species. In most areas, lemmings (Lemmus and Dicrostonyx) are the principal food item. In other areas, voles (Microtus) replace the lemming as principal prey. Arctic foxes are dependent on these microtines and fox population cycles correspond closely to those of the rodents. During summer months, nesting birds, eggs, and young are also an important prey item, while other food items include caribou, fish, insects, berries, ground squirrels, and carrion (Larson 1960; Chesemore 1967; Macpherson 1969; Stephenson 1970; Chesemore 1975; Eberhardt 1977; Fine 1980; E. Follmann and F. Fay. 1981. Unpubl. report, in files of E. Follmann, Univ. of Alaska; Underwood and Mosher 1982). During winter, microtines are still heavily used while carrion and other items become more important. Foxes near the coast or on sea ice feed upon carcasses of marine mammals (seals, walrus, and whales) and on gulls and sea ducks. They also follow polar bears and feed on remains of kills. Foxes are also an efficient predator on seal pups (T.G. Smith 1976). In island situations or at cliffs along the coast, sea birds replace microtines as the principal prey item (Stephenson 1970). During summer months arctic fox may cache food for use during the winter months (Stephenson 1970, Eberhardt 1977, Burgess 1984, G. Weiler pers. comm.). Caches containing over 100 birds have been found (Rue 1981).

In areas of human activity, foxes are often found foraging around garbage dumps (Eberhardt 1977, Fine 1980). In years of low food availability, artificial food sources may keep fox populations at higher than normal levels. Fine (1980) suggested that artificial food at Prudhoe Bay enabled more foxes to reproduce when lemming numbers were low. Eberhardt et al. (1983) found that the density of dens at Prudhoe Bay was approximately 3 times that on Colville River delta (an undisturbed area). In 1977, when lemming numbers were low, survival or production of juvenile foxes decreased on both areas, but the decrease was less pronounced in the Prudhoe Bay area.

Mortality

Natural predators of arctic foxes include red foxes (Vulpes Vulpes), wolves (Canis lupus), wolverines (Gulo gulo), polar bears (Ursus maritimus), brown bears (Ursus arctos), snowy owls (Nyceta scandiaca), large hawks, golden eagles (Aquila chrysactos), jaegers (Stercorarius ssp.), and domestic dogs (Canis familiaris) (Chesemore 1967 and 1975; Eberhardt 1977; E. Follmann and F. Fay. 1981. Unpubl. report, in files of E. Follmann, Univ. of Alaska); Garrott and Eberhardt 1982, Underwood and Mosher 1982). In some

areas man is the major predator. At high population levels, especially during a decline in lemming numbers, starvation, disease and in some areas trapping are the major causes of mortality during winter.

The most common lethal disease in arctic fox population is rabies. Rabies is endemic in many populations including Alaska, and epizootic outbreaks are common. These epizootics are most often associated with high population levels following a decline in microtine numbers. Arctic fox are known to be the principle vector of the disease in arctic areas with peaks in the outbreaks occurring during winter (Rausch 1958, Kantrovich 1964, Syuzyumova 1967). In Alaska outbreaks occur from January to April with peaks in February (Ritter pers. comm.). In winter 1984-1985 an epizootic of rabies occurred north of the Brooks Range in Alaska. During this time period rabies was documented in arctic and red foxes. A female arctic fox and 2 pups died from rabies at a den site on the ANWR. Five wolves also died from rabies during this time. A large increase in numbers of arctic fox trapped in interior Alaska around Arctic Village also occurred (T. Gilbert pers. comm.).

The reservoir for rabies during periods between epizootics is not known. It has been suggested that ermine (Mustela erminea) may be the natural host of rabies in the arctic or that rabies outbreaks may be associated with a rabies-like disease which occurs in lemmings (Crandell 1975). No direct evidence has been found to support either theory. Kantrovich (1964) offered evidence that normal foxes harbor a latent form of the virus. Although this has not been proven conclusively, Crandell (1975) stated that it is likely that foxes might serve as foci of infections.

Data Gaps

Data on arctic fox movements during winter are limited in Alaska. Migrations such as those documented in the U.S.S.R. have not been recorded in Alaska; however, they may occur but on a smaller scale. The red fox is considered a competitor and predator of the smaller arctic fox. Red foxes have been extending their range northward in Canada (Macpherson 1964, Macpherson 1970, as cited by Underwood and Mosher 1982). What effect this range extension has on arctic fox in terms of competition and/or displacement is not known. Rabies is the major lethal disease of arctic fox. In years of epizootics, rabies can be transmitted to other mammals and to man. It is not known if the reservoir of this disease is a virus carried by the foxes in a latent form, is related to a similar disease in lemmings, or a combination of these 2 factors.

Red Fox (Vulpes vulpes)

The red fox (Vulpes vulpes) has the greatest natural distribution of any living terrestrial mammal with the exception of man and the gray wolf (Canis lupus) (Nowak and Paradiso 1983). The wolf, however, has been extirpated from much of its former range, while the red fox has expanded its range (Figs. 49 and 50). There are 12 subspecies of red fox in North America (Fig. 49). Three subspecies of red fox are found in Alaska, but 2 are limited in range (Fig. 49), with V. v. alascensis occurring throughout most of the state and parts of Canada. Although there have been numerous studies on the red fox in other parts of North America, few studies have been done in Alaska.

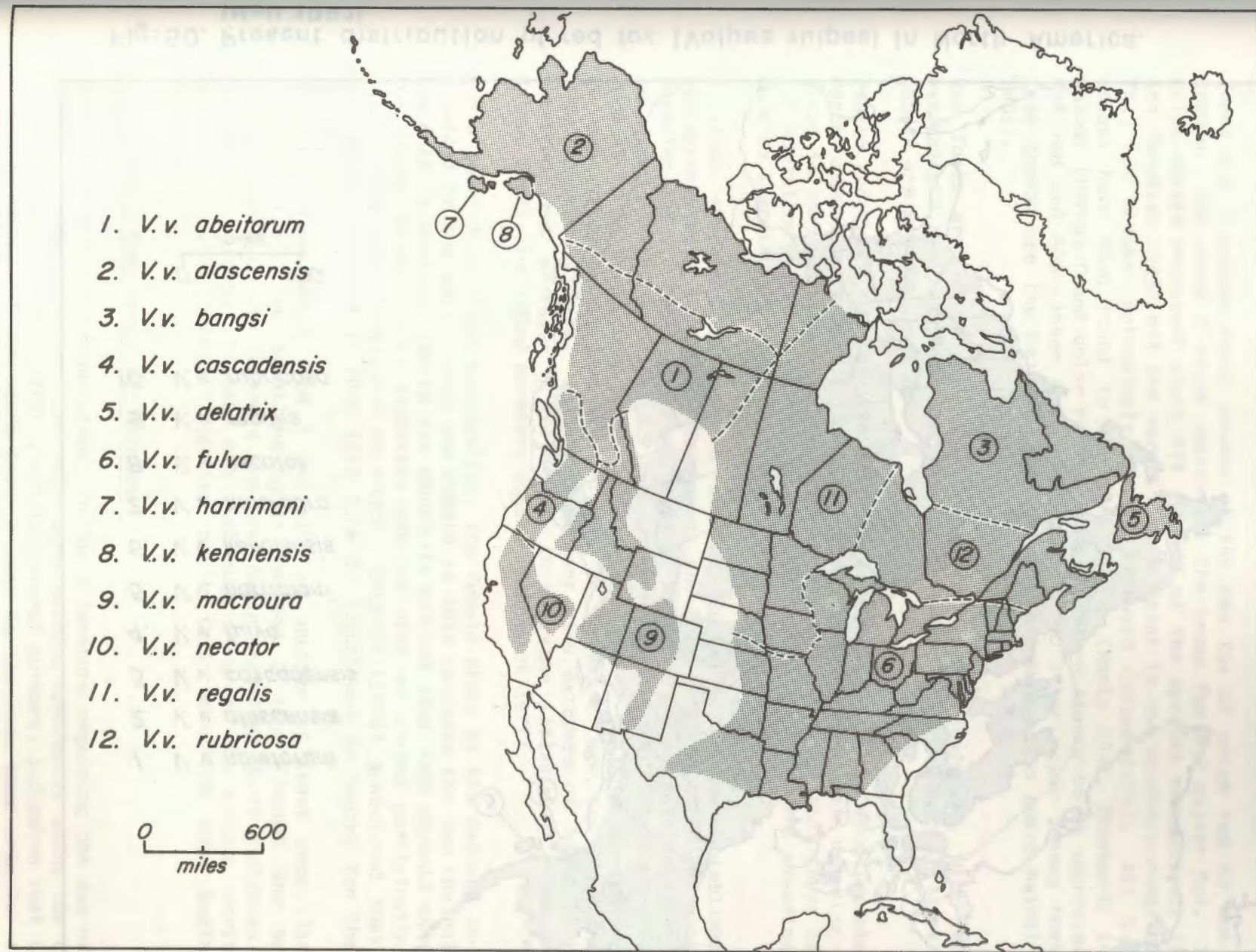


Fig.49. Former distribution of red fox [*Vulpes vulpes*] in North America.
[Hall and Kelson 1959]

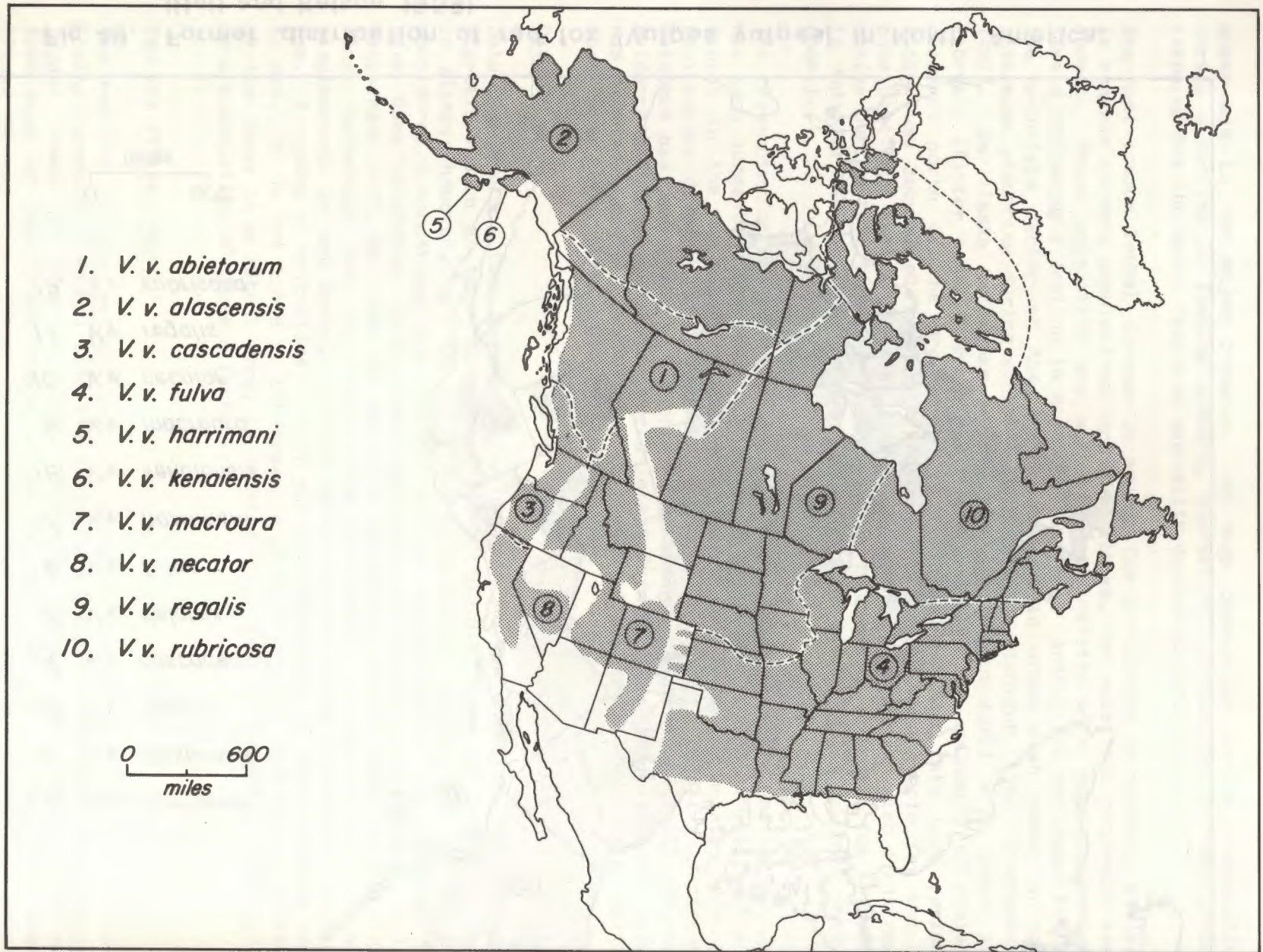


Fig. 50. Present distribution of red fox [*Vulpes vulpes*] in North America.
 [Hall 1981]

Life History

There are 3 common color phases of the red fox of which red is the most common. The other 2 color phases are the cross fox and silver fox. These color phases represent about 25% and 10% of the species respectively (Nowak and Paradiso 1983) and are rare to nonexistent in the southern range of the fox, but become increasingly common northward (Ables 1975). All 3 color phases have been found in the same litter (Marie 1944, Eberhardt 1977). Quimby (1974b) found color ratios in northeastern Alaska to be approximately 50% red and 50% either cross or silver. Two other color phases that are less common are the bastard (bluish gray) and samson (no guard hairs) (Rue 1981).

Red foxes are larger than the arctic fox (Alopex lagopus), with females averaging 4.1-4.5 kg and males 4.5-5.4 kg (Ables 1975). Foxes in Alaska and Canada are somewhat heavier.

Female red foxes are monestrous with breeding taking place from December to March depending upon latitude. Hobgood (1984) found that breeding took place in early March in southcentral Alaska, but believed that foxes in the low elevation areas of the interior were born (and therefore breeding) as much as 1 month earlier.

A vixen sometimes mates with several males, but later establishes a partnership with 1 of them (Haltenorth and Roth 1968, as cited in Nowak and Paradiso 1983). Occasionally, 2 females have litters in the same den (Pils and Martin 1978, as cited in Nowak and Paradiso 1983). Gestation ranges from 49 to 56 days, usually 51 to 53 days. Eyes of the pups open after 9 to 14 days. They emerge from the den at 4 to 5 weeks of age, and are weaned at 8 to 10 weeks of age. Litter sizes vary with extremes of 1 and 17 being reported, but averages 5 throughout their range (Ables 1975, Samuel and Nelson 1982), including northern Alaska (Eberhardt 1977).

For a short time after parturition, the female stays at the den and food is provided by the male. Once the female is able to leave the den the role of the male is unclear. While it is generally assumed that both parents care for the young, Ables (1975) described periods when no active participation by males (providing food) was observed. Hobgood (1984) speculated that the main function of males from late June to August was as sentry for the den and pups.

Pups are often moved from 1 den site to another at least once (Sargent 1972). Litters are sometimes split between 2 dens (Samuel and Nelson 1982). When pups are 10 weeks old they begin traveling short distances from the den and around 12 weeks are exploring parts of the adults territory. The family unit remains together until fall when the pups begin to disperse.

Territories, Home Range and Movements

There appears to be inconsistency in the literature regarding the use of the terms home range and territory with some authors apparently using the terms interchangeably. Ables (1975), citing several authors, indicated that there is strong evidence that adult foxes remain in the same home area for life. These home ranges are non-overlapping (Sargent 1972, Ables 1975), which indicates some form of territoriality which may be where confusion between terms originates. A family group consists of 1 adult male, 1 or 2 adult

females and young born to the females (Storm and Montgomery 1975). There appears to be mutual avoidance between family groups on adjacent territories (Sargent 1972). Agonistic displays between resident male-female pairs and introduced non-resident males was documented by (Preston 1975 as cited by Samuel and Nelson 1982). The male is responsible for territory defense, with sent marking playing an important role in defining the territory (Samuel and Nelson 1982). Territory (referred to as home range) size varies with habitat conditions and food availability and becomes larger in winter (Ables 1975). Grzimek (1975, as cited by Nowak and Paradiso 1983) stated that territories (referred to as home ranges) are 5-12 km² in good habitat and 20-50 km² in poor habitat. In southcentral Alaska, Hobgood (1984) found that summer territories (referred as home ranges) average 35.6 km² for both sexes with an average of 39.4 km² for males and 26.2 km² for females and that seasonal shifts of these areas was common.

Dispersal takes place in stages with the young wandering progressively further afield (Errington and Berry 1937, as cited by Ables 1975), and begins in September or October (Storm and Montgomery 1975, Samuel and Nelson 1982). In Alaska, Hobgood (1984) found dispersal generally occurred in October but with the earliest dispersals occurring in early September. Dispersal takes place in adults, although not as often as in juvenile foxes (Storm and Montgomery 1975). Some movements of adults outside their home range may be related to mating behavior. Hobgood (1984) found seasonal home range shifts in Alaska were common, but thought it was a response to food availability and made possible by the low fox density and lack of adjacent territories.

Food Habits

Foxes are omnivorous and feed on a wide variety of animal and plant matter depending on availability. Small mammals, birds, fruits, and insects comprise the bulk of the diet (Samuel and Nelson 1982). Carrion can be important during winter. In southcentral Alaska, Hobgood (1984) found arctic ground squirrels (Spermophilus parryii) were the most important summer food item. In winter, microtines and carrion were most important. Ptarmigan (Lagopus ssp.) were preyed upon year round, but were more important in winter. In northern Alaska, red foxes ate birds, eggs, lemmings (mostly Dicrostonyx ssp.), voles (Microtus ssp.), and ground squirrels (Spermophilus undulatus) in order of importance in spring and summer (Eberhardt 1977). Red foxes may cache food for use at a later time.

Habitat

Foxes are adaptable and occur in a variety of terrain and vegetation types. They inhabit forests, meadows, woodlots, cropland, pasture, and exposed areas. Foxes prefer areas composed of a mixture of vegetative components, but avoid large homogeneous tracts of any single type (Ables 1975). In Alaska foxes prefer broken country such as hillsides, sides of valleys, and canyons (Bee and Hall 1956, as cited by Ables 1975). Red foxes also are known to inhabit suburban areas (MacDonald 1980, Samuel and Nelson 1982).

Mortality

In utero mortality was described by Lloyd and Englund (1973, as cited by Samuel and Nelson 1982), where 10% to 20% of the red fox fetuses were resorbed. Little is known about mortality other than man-induced. Wolves

(Canis lupus), coyotes (Canis latrans), dogs (Canis familiaris), brown bears (Ursus arctos), and golden eagles (Aquila chrysaetos) are known to sometimes prey on foxes (Rue 1981). In many areas hunting and trapping are the leading causes of fox mortality. In Wisconsin, man-induced mortality was 30% in the first year and 53% during the life of a fox (Ables 1975). Few foxes live longer than 5 years (Storm et al. 1976).

Rabies, canine distemper, and infectious canine hepatitis are the most common diseases among foxes and are usually associated with high population levels. Effects of such diseases are difficult to evaluate as the animals generally died. Of these, rabies is the most widely known. Rabies is endemic in many areas of North America and Europe. In many of these areas and in Europe the red fox is the major wild vector for the disease (MacDonald and Bacon 1982). In Alaska, the arctic fox is the enzootic host for rabies with the red fox perpetuating rabies along the lower Kuskokwin River drainage, Bristol Bay region, and along the Alaska Peninsula southward to Cold Bay (Ritter 1981). Vaccination of foxes in a large area is being attempted in Ontario using rabies vaccine in baits dropped from small aircraft (Addison 1986). The effectiveness of such a program is not presently known.

Data Gaps

Data on red fox in Alaska are limited. Studies done in northern Alaska (Quimby 1974b, Eberhardt 1977) have been very limited in nature. Data are lacking on red fox populations on the north slope, where Quimby (1974b) stated that they are uncommon or scarce, but are common in the mountains. Data on habitat use, food habits, range extensions, and degree of interaction with arctic fox are either limited or unknown.

Small Mammals

Small mammals occurring on the ANWR study area include arctic ground squirrels, 3 species of microtines, (tundra vole, brown lemming, collared lemming) and at least 1 species of shrew. Tundra red-backed voles and singing voles occur in adjacent areas and may be present in the study area and mountains south of the study area (Bee and Hall 1956, Babcock 1986a).

Arctic Ground Squirrels (Spermophilus parryii)

Arctic ground squirrels are distributed across most of northern Alaska (Nodler and Hoffman 1977, Batzli and Sobaski 1980) and are found throughout the ANWR study area. In 1983-1984, a study to estimate and describe distributions, den sites, habitat use, population dynamics and predator use of ground squirrels was conducted at 3 locations (Fig. 51) in the ANWR study area (Babcock 1984 and 1985). Other studies of ground squirrels in northern Alaska have been conducted in 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 in colonies restricted to well-drained soils, which are free of permafrost (Mayer and Roche 1954, Melchior 1964). Such areas are found along ridges, river sand banks, hillocks, and other

raised areas in sandy soils (Mayer 1953). Babcock (1984 and 1985) found that the distribution of arctic ground squirrels in the ANWR study area depended primarily on suitable burrowing conditions and forage quality.

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. Den sites 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 latitudes (Batzli and Sobaski 1980).

In ANWR, dispersal of young of the year from natal colonies occurred from early July to mid-August (Babcock 1984 and 1985). Batzli and Sobaski (1980) found herbaceous dictyledons 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." Even sex ratios were observed in arctic ground squirrels live-trapped and shot at ANWR study sites in 1983 and 1984. Male weights were 600-700 g; female weights were 400-575 g, and juvenile weights were 275-325 g in early July 1983 (Babcock 1984 and 1985).

Ground squirrels are occasionally utilized as a subsistence food source by Kaktovik residents (See Chapter 7). However, their greatest importance lies in the role of a prey item in the arctic food web. The arctic ground

Fig. 51. Location of small mammal study areas, Arctic National Wildlife Refuge, 1983-1985.



squirrel is preyed upon by raptors, including snowy owls. Golden eagles and roughlegged hawks were seen hunting over ground squirrel colonies at study sites in or near the ANWR coastal plain throughout the summer of 1983 and 1984 (Babcock 1984 and 1985). Gulls and jaegers are also known to feed on them (Pruitt 1966). Ground squirrels comprise large portion of the diet of foxes and grizzly bears (Pruitt 1966) and are preyed upon by wolves and wolverines (Babcock 1984). Babcock (1985) observed grizzly bears digging in ground squirrel colonies and commonly found evidence of grizzly predation in or near the ANWR study area. Banfield (1958) felt that the central Canadian arctic population of grizzly bears could not survive in areas devoid of ground squirrels. Many ground squirrel colonies are noted to have been excavated by grizzly bears during the summer of 1981 (R. Bartels pers. comm.).

Microtine rodents

Three species of microtine rodents occur in the ANWR study area: the brown lemming (Lemmus sibericus), collared or varying lemming (Dicrostonyx spp.) and the tundra vole (Microtus oeconomus). In addition, two other species, the singing vole (Microtus miurus) and the tundra red-backed vole (Clethrionomys rutilus) occur near and possibly in the study area. The singing vole is common in the foothills and mountains adjacent to the study area (Babcock 1986a). Bee and Hall (1956) found only 2 records of the singing vole on the coastal plain although it was the most abundant microtine in the study area and was trapped by Babcock (1986a) at the Kongakut River, southeast of the Brooks Range. The tundra red-backed vole also occurs in the mountains south of the study area and may extend its range out onto parts of the coastal plain (Bee and Hall 1986).

In 1983-1984, a study was conducted to estimate and describe distributions, den sites, habitat use, population dynamics, and predator use of microtine rodents at 3 study sites (Fig. 51) in or near the ANWR study area (Babcock 1984, 1985, 1986a). Burgess (1984) examined the seasonal availability of microtine rodents as prey for arctic foxes at Demarcation Bay, near the ANWR study area. The majority of work on lemmings on the north slope of Alaska has been done at Barrow, where brown lemmings are abundant and collared lemmings are usually scarce (Batzli et al. 1980).

Distribution of the 5 microtine species found in or near the ANWR study in 1983-1984 (Babcock 1986a) was similar to that reported by Bee and Hall (1956). The brown lemming occurred more commonly toward the coast, and the tundra vole was widely distributed from the coast to the mountains. The singing vole was primarily restricted to the foothills and mountains and the red-backed vole, although present in the Peters Lake area (Bee and Hall 1956), was not captured on the study area (Babcock 1986a). In 1983-1984, tundra voles were the most commonly captured species and other species were at low den sites or restricted in their distribution at ANWR study sites (Babcock 1986a). In 1983, tundra voles showed increasing populations throughout the season and demographic profiles typical of productive populations. In 1984, lower densities were seen (Babcock 1986a). Densities of brown lemming were higher in 1978 than in 1979 at Demarcation Bay (Burgess 1984).

Brown lemming and collared lemming populations apparently fluctuate in densities on the ANWR coastal plain (Babcock 1986a). In 1985, Babcock (1986b) documented increased densities of brown lemmings at 2 ANWR study sites (Fig. 47) which also had a corresponding high diversity of microtine predators. Arctic fox, least weasel and snowy owls were seen at 1 of the 2 sites, and brown bear, wolf, ermine, and 3 species of jaegers were recorded at both sites. In 1985, pomarine jaegers and snowy owls rested successfully on the ANWR coastal plain for the first time in at least 2 years (Babcock 1986b). High brown lemming den sites may be a key factor in attracting predators into an area according to Babcock (1986b). Increased den sites of tundra voles were also documented at a third study site in 1985, where corresponding increase in predator diversity was seen, suggesting that Babcock (1986b) suggests that tundra vole populations either do not fluctuate or fluctuate out of synchrony with lemming species and do not support appreciable predation by birds.

Babcock (1986a) found that the tundra voles selected wet, graminoid-dominated troughs of polygons over other available micro habitats, and that collared lemmings appeared to select dryer rims and high centers of polygon rich in dicotyledonous plants. At Barrow, brown lemmings also used wet polygon trough micro-habitats (Batzli et al. 1983). On a larger scale, tundra voles use meadows and the banks of streams (Batzli and Jung 1980), collared lemmings use well drained ridges and areas of high centered polygons (Batzli et al. 1980) and brown lemmings use meadow areas of low center polygons and polygon troughs (Batzli et al. 1983).

Microtine rodents are extremely important components of the tundra ecosystem. They may account for most of the vertebrate grazing and browsing of the tundra and may rival ungulates in terms of production of biomass per unit area (Batzli et al. 1980). They are also an important prey resource for a wide variety of bird and mammal predators.

Insectivores

Cinereous shrews (Sorex cinereus) occur in the ANWR study area (Bee and Hall 1956) and were trapped by Burgess (1984) at Demarcation Bay adjacent to the study area. Two other species of shrews (Sorex arcticus and Sorex obscurus) may also occur in or near the ANWR coastal plain as they have been recorded in adjacent areas (Bee and Hall 1956).

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