ARCTIC NATIONAL WILDLIFE REFUGE COASTAL PLAIN
RESOURCE ASSESSMENT

1985 UPDATE REPORT
BASELINE STUDY
OF THE FISH, WILDLIFE, AND THEIR HABITATS

Volume I
Section 1002C
Alaska National Interest Lands Conservation Act

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U.S. Department of the Interior
U.S. Fish and Wildlife Service
Region 7
Anchorage, Alaska
December 1987

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1985 UPDATE REPORT BASELINE STUDY OF THE FISH, WILDLIFE, AND THEIR HABITATS

Volume I of III

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Alaska National Interest Lands Conservation Act

Edited by
Gerald W. Garner and Patricia E. Reynolds

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TABLE OF CONTENTS

Chapter Page

VOLUME I

VOLUME II

Volume III

CONVERSION TABLE

For those readers who may prefer the commonly used American units, rather than the metric (S1), the conversion factors for the units in this report are given below.

Multiply Metric S(1) Units	By	To obtain American Units
Centimeters (cm)	0.3937	Inches (in)
Meter (m)	1.0936	Yards (yd)
Kilometers (km)	0.6215	Miles (mi)
Grams (g)	0.0352	Ounces (oz)
Kilograms (kg)	2.2046	Pounds (lb)
Liters (L)	0.2642	Gallons (gal)
Square kilometers (km^2)	0.3861	Square miles (mi^2)
Square kilometers (km^2)	247.1050	Acres
Hectares (ha)	2.4711	Acres
Kilograms per hectare (kg/ha)	0.8262	Pounds per acre (lb/acre)
Cubic meters per second	35.7143	Cubic feet per second
Degrees Celsius (°C)	(°Cx1.8)=32	Degrees Fahrenheit (°F)

Chapter 1

INTRODUCTION

The Alaska National Interest Lands Conservation Act (ANILCA), Section 1002, passed by the U.S. Congress on 2 December 1980 (Public Law 96-487) provides for a comprehensive and continuing inventory and assessment of fish and wildlife resources of the coastal plain of the Arctic National Wildlife Refuge (ANWR) and an analysis of the impacts of oil and gas exploration, development, and production. This report is the fourth in a series of annual updates of new information which supplement the initial baseline report prepared in 1981 (U.S. Fish and Wildlife Service 1982). It summarizes work completed or on-going in 1985 with emphasis on studies designed to obtain new information about ANWR coastal plain resources which are being conducted by U.S. Fish and Wildlife Service (USFWS) personnel. For readers interested in quantified results, progress reports of these studies are included as appendices of this report. Other studies being conducted on or near the ANWR coastal plain are also briefly summarized in this update report. Publications or unpublished reports of these other studies may be available from the investigating agencies or individuals. The report follows the format of the initial baseline report (U.S. Fish and Wildlife Service 1982) and the 1982, 1983, and 1984 update reports (Garner and Reynolds 1983, Garner and Reynolds 1984, Garner and Reynolds 1985).

Progress reports included in Appendices I, II, III and V were written by USFWS-ANWR biologists and were reviewed by USFWS-ANWR biologists G.W. Garner and P.E. Reynolds. Reports in Appendix IV were prepared and reviewed by USFWS-Fairbanks Fisheries Resource Station (FFRS) biologists. Reports in Appendix VI were prepared and reviewed by biologists from the USFWS Alaska Fish and Wildlife Research Center (AFWRC) in Anchorage, Alaska, or the Canadian Wildlife Service (CWS) in Whitehorse, Yukon, or the Alaska Department of Fish and Game (ADFG) in Fairbanks, Alaska. Chapter 3 and most of Chapter 8 were written by USFWS-ANWR botanist N.A. Felix, Chapter 4 was written by USFWS-ANWR wildlife biologist A.W. Brackney and Chapter 6 was written by FFRS biologist R. West. All other chapters were prepared by P.E. Reynolds.

Studies summarized in this report are listed by chapter in Table 1. Many of the results reported are part of on-going studies whose findings should be viewed as preliminary.

Literature Cited

U.S. Fish and Wildlife Service, 1982. Arctic National Wildlife Refuge coastal plain resource assessment--initial report. Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Services, Anchorage, Ak. 507 pp.

Garner, Gerald W. and Patricia E. Reynolds, eds. 1982. 1982 update report. Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Ak. 379 pp.

Garner, Gerald W. and Patricia E. Reynolds, eds. 1984. 1983 update report. Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Ak. 614 pp.

Garner, Gerald W. and Patricia E. Reynolds, eds. 1985. 1984 update report. Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Ak. 777 pp.

Table 1. Arctic National Wildlife Refuge coastal plain resource assessment: status of studies in 1985.

Chapter	Project title	Investigators	Affiliation	Reports
3. Soils and Vegetation				
	Landsat cover map for the Arcitc National Wildlife Refuge	C. Markon S. Talbot B. Kirk M. Shasby L. Strong L. Pank	USFWS, Anchorage USGS, Anchorage USFWS, Anchorage	Final maps (Anchorage); Classification Scheme Appendix I
	Soil evolution and biogeochemical dynamics (Okpilak River)	D. Marrett	Univ. Washington	1984 NSF progress report on file, ANWR, Fairbanks
	Seasonal toxic production on plants; revegetation of disturbed areas (Okpilak River)	N. Grulke	Univ. Washington	Progress report on file ANWR, Fairbanks
	Vegetation of the Beaufort Sea coast, Alaska	C. Meyers	Univ. Alaska Fairbanks	M.S. thesis
4. Birds				
Tundra Habitats	Territorial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge	R. Oates D. Douglas M. McWhorter C. Babcock	USFWS-ANWR Fairbanks	ANWR Progress Report No. FY 86-14 Appendix II
	Species accounts of birds observed at eight study areas on the coastal plain of the Arctic National Wildlife Refuge, Alaska	M. McWhorter D. Douglas R. Oates S. Gehman T. Maxwell J. Morton R. Field C. Babcock	USFWS-ANWR Fairbanks	ANWR Progress Report No. FY 86-18 Appendix II
	Distribution, abundance and productivity of tundra swans in coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1985	R. Platte A. Brackney	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-13
	Distribution, abundance and productivity of fall staging lesser snow geese on coastal habitats of north-east Alaska and northwest Canada	R. Oates M. McWhorter G. Muehlenhardt C. Bitler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-10 Appendix II
	Ecology of lesser snow geese staging on coastal plain of the Arctic National Wildlife Refuge, fall 1985	A. Brackney R. Platte J. Morton D. Whiting	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-11 Appendix II

Table 1. Continued.

Chapter	Project title	Investigators	Affiliation	Reports
4. Birds (cont.)				
	Effects of aircraft disturbance on the energetics of staging lesser snow geese: a model	A. Brackney	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-6-Impacts Appendix V
	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. FY 86-4 Appendix II
	Raptor surveys of north slope rivers in the Arctic National Wildlife Refuge, 1985	M. Amaral D. James	USFWS-End. Spec. Anchorage	Report on file, ANWR, Fairbanks
Lagoons and Offshore Habitats	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 Appendix II
	Habitat use and behavior of molting oldsquaw on the coast of the Arctic National Wildlife Refuge, Alaska, 1985	A. Brackney R. Platte	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-17
	A preliminary study of epibenthic invertibrates and water quality in coastal lagoons of the Arctic National Wildlife Refuge	M. Spindler R. Meehan A. Brackney	USFWS-ANWR Fairbanks	ANWR Progress Report No. FY 86-24 Appendix II
5. Mammals				
Caribou	Fall and winter movements, distribution, and annual mortality patterns of the Porcupine caribou herd, 1984-1985	K. Whitten F. Mauer G. Garner	ADF&G, Fairbanks USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-21 Appendix III
	Calving distribution, initial productivity and neonatal mortality of the Porcupine caribou herd	F. Mauer G. Garner K. Whitten	USFWS-ANWR, Fairbanks ADF&G, Fairbanks	ANWR Progress Report No. FY 86-6 Appendix III

Table 1. Continued.

Chapter	Project title	Investigators	Affiliation	Reports
5. Mammals (cont.)				
	Distribution, movements, and juvenile mortality of the Porcupine caribou herd in northern Yukon, June 1982 - January 1986	D. Russell W. Nixon	Canadian Wildl. Serv.	CWS Report Appendix VI
	Population status and trend of the Porcupine caribou herd, 1982-1985	K. Whitten	ADF&G, Fairbanks	ADF&G Report No. 1 Appendix VI
	Caribou use of potential oil and gas development areas in the 1002 region of the Arctic National Wildlife Refuge	L. Pank C. Curby S. Fancy W. Regelin	USFWS-AFWRC Anchorage and ADF&G, Fairbanks	AFWRC Progress Report Subwork Unit 4 Appendix VI
	A sampling method to determine caribou use of coastal tundra on the Arctic National Wildlife Refuge: Caribou use of the area surrounding the Kaktovik Inupiat Corporation (KIC) exploration well No. 1 site.	L. Pank P. Kuropat	USFWS-AFWRC Anchorage	AFWRC Progress Report Subwork Unit 3 Appendix VI
	Spatial and temporal distribution of biting and parasitic insects on the coastal plain and adjoining foothills of the Arctic National Wildlife Refuge	C. Benson C. Curby B. Zimont E. Jozwiak	USFWS-AFWRC, Anchorage	AFWRC Progress Report Subwork Unit 5 Appendix VI
Muskox	Ecology of muskoxen on the Arctic National Wildlife Refuge, 1982-1985	P. Reynolds J. Herriges M. Masteller	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-2 Appendix III
	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. FY 86-5 Appendix III
	Comparative habitat use by muskoxen in northern Alaska	C. O'Brian	Univ. Alaska, Fairbanks	Work in progress (M.S. thesis)
	Effects of aircraft overflights on muskoxen on the Arctic National Wildlife Refuge, 1982-1985	P. Reynolds	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-5-Impacts Appendix V

Table 1. Continued.

Chapter	Project title	Investigators	Affiliation	Reports
5. Mammals (cont.)				
Moose	Population size, composition, and distribution of moose along the Canning and Kongakut Rivers in the Arctic National Wildlife Refuge, Alaska, spring and fall, 1985	G. Muehlenhardt G. Garner	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-9 Appendix III
Brown Bears	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. FY 86-12 Appendix III
	Habitat use and behavior of grizzly bears in the Arctic National Wildlife Refuge, Alaska	M. Phillips	Univ. Alaska, Fairbanks	M.S. thesis
Wolves	Wolves of ANWR their seasonal movements and prey relationships	G. Weiler G. Garner	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-7 Appendix III
	Food habits of denning wolves on the Arctic National Wildlife Refuge	G. Weiler	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-19 Appendix III
	Den-site behavior summer diet, and skull injuries of wolves in Alaska	H. Haugen	USFWS-ANWR Fairbanks	M.S. thesis
Foxes	Investigation of patterns of vegetation, distribution and abundance of small mammals and nesting birds and behavioral ecology of arctic foxes at Demarcation Bay, Alaska	R. Burgess	Univ. Alaska Fairbanks	M.S. thesis
Small Mammals	A microtine rodent population increase in 1985 on the coastal plain of the Arctic National Wildlife Refuge, with notes on predator diversity	C. Babcock	Univ. Alaska, Fairbanks	ANWR Progress Report No. FY 86-1 Appendix III
	Vegetation patterns and microtine rodent use of tundra habitats in north-eastern Alaska	C. Babcock	Univ. Alaska, Fairbanks	M.S. thesis

Table 1. Continued.

Chapter	Project title	Investigators	Affiliation	Reports
6. Fish				
	Fisheries investigations in Beaufort Lagoon, Arctic National Wildlife Refuge	D. Wiswar R. West	USFWS-FFR, Fairbanks	FFR Progress Report No. FY 86-1 Appendix IV
	Fall movements and overwintering of arctic grayling in the Arctic National Wildlife Refuge	D. Wiswar R. West T. Stevens	USFWS-FFR, Fairbanks	FFR Progress Report No. FY 86-2 Appendix IV
	Age, growth, distribution, and summer feeding habits of arctic flounder in Beaufort Lagoon, Arctic National Wildlife Refuge, Alaska, 1985	D. Wiswar	USFWS-FFR, Fairbanks	FFR Progress Report No. FY 86-3 Appendix IV
	Baseline histpathological and contaminant studies of four arctic fish species in Beaufort Lagoon, Arctic National Wildlife Refuge, Alaska	R. West	USFWS-FFR, Fairbanks	FFR Progress Report No. FY 86-4 Appendix IV
	Fisheries investigations on the Kongakut River, Arctic National Wildlife Refuge, Alaska, 1985	S. Deschermeier T. Stevens D. Wiswar R. West	USFWS-FFR, Fairbanks	FFR progress Report No. FY 86-5 Appendix IV
	The freshwater food habits of juvenile arctic char in streams in Arctic National Wildlife Refuge, Alaska	T. Stevens S. Deschermeier	USFWS-FFR, Fairbanks	FFR Progress Report No. FY 86-6 Appendix IV
7. Human Culture and Lifestyle				
	Caribou hunting: land use dimensions, harvest level and aspects of the hunt in Kaktovik, Alaska	M. Coffing S. Pederson	ADF&G-Subsistence, Fairbanks	Technical paper No. 102, ADF&G Division of Subsistence, Fairbanks, on file, ANWR, Fairbanks
	Subsistence land use and place name maps for Kaktovik, Alaska	S. Pederson M. Coffing J. Thompson	ADF&G-Subsistence Fairbanks	Technical paper No. 109, ADF&G Division of Subsistence, Fairbanks, on file, ANWR, Fairbanks

Table 1. Continued.

Chapter	Project title	Investigators	Affiliation	Reports
8. Impacts of Geophysical Exploration				
	Effects of winter seismic exploration on visual resources, vegetation, and surface stability of the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985	N. Felix T. Jorgenson M. Raynolds R. Lipkin D. Blank B. Lance	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-2-Impacts Appendix V
	Airphoto analysis of seismic trails on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985	N. Felix T. Jorgenson M. Raynolds R. Lipkin D. Blank B. Lance	USFWS-ANWR, Fairbanks	ANWR Progress Report No. 86-1-Impacts Appendix V
	Snow distribution on the arctic coastal plain and its relationship to disturbance caused by winter seismic exploration, Arctic National Wildlife Refuge, Alaska, 1985	N. Felix T. Jorgenson M. Raynolds R. Lipkin D. Blank B. Lance	USFWS-ANWR, Fairbanks	ANWR Progress Report No. 86-3-Impacts Appendix V
	Effects of winter seismic exploration activities on muskoxen on the Arctic National Wildlife Refuge, January-May 1984-1985	P. Reynolds D. LaPlant	USFWS-ANWR, Fairbanks	ANWR Progress Report No. FY 86-4-Impacts Appendix V

Chapter 2

DESCRIPTION OF THE STUDY AREA

No new information was acquired in 1985 to update this chapter.

Chapter 3

SOILS AND VEGETATION

Land Cover Mapping

A Landsat-assisted land cover 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, (U.S. Fish and Wildlife Service (USFWS) Alaska Regional Office), M. Shasby and L. Strong (U.S. Geological Survey), and L. Pank (USFWS Alaska Fish and Wildlife Research Center (AFWRC)). Final maps were completed in 1985. Modifications were made to the Walker et al. (1982) classification scheme and 22 classes of land cover were identified and described (see Appendix I). The estimated areas of each land cover class in the coastal plain study area are shown in Table 1.

Table 1. Areas and proportions of Landsat land cover classes within the coastal plain study area, Arctic National Wildlife Refuge.

Landsat cover class	Area (Hectares)	Proportion (%)
Forest:		
Deciduous forest/tall shrub	8	tr
Total	8	tr
Scrub:		
Dry prostrate dwarf scrub	4,180	0.7
Moist prostrate dwarf scrub	157,497	25.3
Mesic erect dwarf scrub	45,730	7.3
Total	207,407	33.3
Herbaceous:		
Very wet graminoid	1,582	0.3
Wet graminoid	85,564	13.8
Moist/wet tundra complex	96,583	15.5
Moist graminoid tussock tundra	184,680	29.7
Total	368,409	59.3
Scarcely Vegetated:		
Scarcely vegetated scree	174	tr
Scarcely vegetated floodplain	8,539	1.4
Barren floodplain	12,282	2.0
Barren scree	93	tr
Total	21,088	3.4
Other:		
Clear water (lakes, ponds, rivers)	6,997	1.1
Clouds - snow - ice	1,024	0.2
Shallow water	182	tr
Offshore water	16,545	2.7
Shadow	470	tr
Total	25,218	4.0
Total coastal plain area	622,130	100.0

During August 1985, an accuracy assessment of the Landsat-derived land cover map was conducted by L. Pank and P. Kuropat (USFWS Research Division), B. Kirk (USFWS Alaska Regional Office), and N.A. Felix (USFWS-ANWR). Twenty-two transects were selected to represent the 5 physiographic regions found in the refuge and the 7 different Landsat scenes used to produce the map. Transects were located between discrete surface features, such as mountain peaks or the confluence of 2 rivers, to enable observers to find the exact locations on the ground. Additionally, an attempt was made to place each line so that it intersected as many cover types as possible within an area.

Three observers independently determined land cover types along each transect. The observers were carried by helicopter to each of the transect lines. Several passes at low altitude were made over each line, and stops were made along the transect when observers needed a closer look. The observers recorded land cover types along the transects on color infrared aerial photographs (2x enlargements of 1:60,000 scale high altitude photography). In addition, several areas, which had homogeneous land cover on the Landsat maps, were outlined near each transect. These areas were visited on the ground and land cover determinations were made.

The differences and similarities between each observer and the Landsat map, and among the 3 observers were tabulated. Each observer evaluated the areas where they were not in agreement with the map, and attributed the disagreement to one of the following sources of error:

1. Classification errors - errors due to incorrect assignment of classes during the data handling and/or map printing steps,
2. Cut point errors - errors between closely related land cover types due to a lack of clarity or precision in the class definitions,
3. Description errors - errors due to class definitions that were not complete or detailed enough to allow the observer to accurately determine which vegetation communities areas belonged in that class,
4. Resolution errors - small errors, usually differences in dividing classes along the transect, which are probably due to the resolution of the Landsat data,
5. Observer errors - errors attributed to incorrect calls by the observer.

Preliminary analyses showed a large amount of disagreement between the Landsat map and the 3 observers. There were also many disagreements among the observers, indicating that better definitions of the land cover classes are needed to allow consistent ground identifications. Detailed analyses of the data are in progress.

Other Studies

A study of soil evolution and biogeochemical dynamics at Okpilak Lake, about 13 km south of the study area in the foothills of the Brooks Range, was continued by David Marrett of the University of Washington in June - September 1985. In 1984, the main objectives of the study included:

1. collections of soil solutions from both Spodosols and Inceptisols;
2. extensive soil description and sampling;
3. collection of weather and soil climate data;

4. descriptions of plant communities;
5. initial soil respiration studies.

The soil solutions showed clear differences between Spodosols and Inceptisols, but no seasonal differences (Marrett et al. 1985). Inceptisol solutions were less acidic, lower in organics, iron, and cations, and higher in inorganic anions (including nitrate and phosphate) and aluminum. Analyses of bulk soil samples showed that pH followed the expected trend of soil acidification with time. Reactive metal oxides (Fe, Al, Si, Mn) showed unexpected high levels in early stages of soil development. The chemical attributes of Spodosols were present in profiles of earlier stages than the morphological attributes. Plant community analyses by Dr. Nancy Grulke verified the existence of 5 distinct upland communities. The successional stages used as a basis for relative age of sorted circles showed a progression from stage 1 to stage 6 based on cover of vascular and nonvascular plants. No information is available on the objectives or results of soil studies conducted during the 1985 field season.

A study of revegetation on disturbed areas in the dwarf shrub communities at Okpilak Lake was conducted by Grulke in 1985 (Grulke 1987). Degradation and recovery of plant communities were monitored on sections of footpaths from mid-June to mid-August. Changes in plant cover and numbers of species were measured biweekly on a new trail established on June 15. Most species were greatly impacted by trampling, and much of the decrease in plant cover occurred during the first 2 weeks of use. The average decrease in total number of plant species in the 4 communities studied was 9, from an average 25 plant species in the undisturbed communities to 16 after disturbance. Decreases in plant cover were 8-58% for vascular plants, 15-29% for lichens, and 14-25% for mosses at the 2 plots where mosses were common. The largest decreases in moss cover occurred in Aulacomnium palustre, Hylocomnium splendens, and Racomitrium lanuginosum, while Ceratodon purpureus, Dicranum spp., and Polytrichum spp. were little affected by disturbance.

Recovery of plant species on 1984 trails which were abandoned in 1985 was monitored monthly in 3 plant communities. Small amounts of recovery were evident over the 2 month period. The total number of species increased by 1 to 6 plants on the 3 sites. Vascular plant cover increased 2 to 4%, while moss and lichen cover increased 4% on 1 plot, but were variable on the other 2 plots. The only vascular plant which showed a measurable increase in cover was Betula nana which increased from 3% to 7%. Vegetative sprouts and new leaves were reported on Vaccinium vitis-idaea and V. uliginosum on 1 plot.

Further studies were conducted to determine the success of transplanted species and seeded species on disturbed sites. Twenty shoots of each of the common shrub species were transplanted on bare soil in a previously disturbed area between July 10 and 15. The vigor of each shoot (100% green tissue remaining, 75%, 50%, 25%, or dead) was rated 1 month later. The success of the transplanted species was in the following order from most successful to least successful: Vaccinium vitis-idaea, Arctostaphylos alpina, Empetrum nigrum, Cassiope tetragona, Ledum palustre ssp. decumbens, Salix phlebophylla, Dryas octopetala, and Vaccinium uliginosum. Larger sod blocks (5 cm x 5 cm) which contained V. uliginosum and V. vitis-idaea were also transplanted. On these sod blocks, V. vitis-idaea had a high survival rate (74%:26%), while V. uliginosum had more mortality than survival (32%:68%). Seeds of the following species were collected in early June and planted on bare soil: Loiseleuria procumbens, Vaccinium vitis-idaea, Vaccinium uliginosum, Arctostaphylos alpina, Empetrum nigrum, Betula nana, Diapensia lapponica, and Hierochloe alpinum. Four replicates of 25 seeds of each species were planted, but none of the seeds germinated.

Grulke also planned to conduct a survey of seasonal resource availability and toxin production of low arctic shrubs utilized by caribou. Shrub species to be sampled included Salix planifolia ssp. pulchra, S. glauca, Betula nana, and Ledum palustre ssp. decumbens. Leaf area, leaf biomass, nutrient contents, phenols (including tannins), and terpenes (resins, including alkaloids) were to be measured on plant samples collected throughout the growing season (June - August). Current status of this project is unknown.

Meyers (1985) classified 16 vegetation communities within 6 habitat types in the tide-water influenced coastal zone of the study area. A description of species cover, general location, soil texture, and soil moisture was provided for each community (Meyers 1985, Table 2). A discussion of the influence of environmental factors in the distribution of these plant communities was included. The intensity and frequency of the most severe storms, sediment salinity, aspect, topography, and ice stress appear to be important factors in determining community zonation along the coast of the study area.

Literature Cited

Grulke, N.E. 1987. Degradation and recovery of footpaths in upland tundra, Okpilak Valley, Alaska. Unpub. rep. Systems ecology research group, San Diego State Univ., San Diego, CA.

Marrett, D.J., N. Grulke, and F.C. Ugolini. 1985. Soil evolution and biogeochemical dynamics in arctic Alaska. Unpub. prog. rep. Univ. of Washington, Seattle, WA.

Meyers, C.R. 1985. Vegetation of the Beaufort Sea coast, Alaska: community composition, distribution and tidal influences. M.S. thesis, Univ. of Alaska, Fairbanks.

Walker, D.A., W. Acevedo, K.R. Everett, L. Gaydos, J. Brown, and P.J. Webber. 1982. Landsat-assisted environmental mapping in the Arctic National Wildlife Refuge, Alaska. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. CRREL Rep. 82-27. 59pp.

Chapter 4

BIRDS

In 1985, a new study which examined behavior, habitat use, and body condition of molting oldsquaw (Clangula hyemalis) was conducted. Studies of terrestrial bird populations were expanded to 8 locations on the coastal plain, and other studies of migratory bird use of coastal lagoons, distribution of golden eagles (Aquila chrysaetos) during caribou calving and post calving periods, and ecology of staging snow geese (Anser caerulescens) were continued. Annual surveys of staging snow geese and tundra swans (Cygnus columbianus) were also conducted.

Bird Use of Tundra Habitats

Terrestrial Bird Populations

In 1985, U.S. Fish and Wildlife Service-Arctic National Wildlife Refuge (USFWS-ANWR) biologist R. M. Oates, D.C. Douglas, M. McWhorter, and C.M. Babcock completed the final year of work on terrestrial bird populations and habitat use of the coastal plain of the refuge. Methods and results are described in ANWR Progress Report No. FY86-14: Territorial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge (see Appendix II). Primary study objectives were to determine and compare habitat occupancy levels of breeding, resident, and transient birds, to determine breeding, resident and transient population density estimates of a quality sufficient to extrapolate to total populations of the ANWR, and to determine baseline levels of annual and seasonal variations for abundant and conspicuous species. Five breeding season (5 June-7 July) and 3 post-breeding season (8 July-15 August) bird censuses were conducted on 119 10-ha plots in 7 habitat types (Flooded, Wet Sedge, Moist Sedge, Mosaic, Moist Sedge Shrub, Tussock, Riparian) at 8 study locations on the coastal plain. Those locations included inland sites on the Katakturak River, Jago River (Jago Bitty), Aichilik River, Marsh Creek and Niguanik River. Coastal locations were near the Okpilak River, on the Jago delta, and on the Sadlerochit River. Data analysis focused on total bird numbers, total species, and 5 key breeding species (Lapland longspur, pectoral sandpiper, semipalmated sandpiper, lesser golden-plover, and red-necked phalarope).

Plant flowering and bird breeding phenologies were similar to those observed in 1982-1984. During the reproduction season, Lapland longspurs were most numerous in Riparian and upland habitats and common in Wet Sedge habitat. Red-necked phalaropes and pectoral sandpipers had significantly higher densities in Flooded Habitat and lesser golden-plovers and semipalmated sandpiper densities were higher in Riparian habitats. During the post-reproductive season, Lapland longspurs densities declined although slight increases occurred in Riparian and Moist Sedge-Shrub habitats. Lesser golden-plover densities were higher in Flooded habitat at inland locations during the reproductive season than at coastal locations. Densities declined at inland sites and increased at coastal sites during the post-reproductive season, suggesting a possible coastal shift in use of flooded habitat. Riparian and Flooded habitats had the highest densities of birds and the greatest number of species observed during the reproductive and post-reproductive seasons.

Large variations were observed in bird density and numbers of species among locations in Riparian and Flooded habitat, possibly due to wide variation in physical and vegetation characteristics in these habitat at different locations. Mean total bird densities in Wet Sedge habitats were significantly higher at Sadlerochit than at other locations during the reproductive season possibly due to the effects of willow-dominated strangs on savannah sparrow and Lapland longspur habitat use. Moist Sedge habitats at Jago Bitty were relatively more diverse than at other locations and supported higher densities of total birds than Moist Sedge habitat at other locations. Also, total bird densities increased significantly in Moist Sedge during the post reproductive season as a result of increases in ptarmigan, lesser golden-plovers, pectoral sandpipers and savannah sparrows at most locations. In Tussock habitat, total bird densities were similar between reproductive and post-reproductive seasons. Lapland longspurs comprised over half the total bird observations at meisic Tussock habitat plots.

The 1985 census data was compared to census data collected at the same locations in 1982-1984. Annual variability in bird densities was observed for some locations in every species or group tested. Fewer Lapland longspurs were observed at Okpilak in 1982 than in 1983 or 1985. Significant differences in Lapland longspur and pectoral sandpiper densities in certain habitats occurred between 1984 and 1985 with changes in both directions depending on location. Densities of semipalmated sandpipers were significantly higher in Mosaic habitat at Okpilak during 1982 than in 1983 or 1985 and higher in Flooded habitat in 1985 than in 1982 or 1983. Sandpiper numbers increased two-fold during 1985 over 1983 in Riparian habitat at Katakturuk but were lower at Aichilik in 1984. At Okpilak, lesser golden plover densities increased significantly in Moist Sedge-Shrub from 1982 to 1983 then declined by half in 1985. Plover numbers and nest densities increased significantly in Tussock habitat at Sadlerochit from 1984 to 1985. A three-fold decrease from 1982 to 1983 and a four-fold increase from 1983 to 1985 were observed in red-necked phalarope densities in Flooded habitat at Okpilak and significant increases in phalarope densities were recorded in 1983 to 1985 in Moist Sedge-Shrub and Wet Sedge habitats at Jago Bitty. Phalarope densities at Aichilik declined in Moist Sedge Shrub from 1984 to 1985. Overall, significant annual variation was observed for mean total bird densities and mean number of species in at least some habitats at virtually all locations with annual changes heavily influenced by changes in one or several abundant species. Food-availability may have been a major factor in annual variation in bird use within habitats and locations.

Variance component analysis was used to calculate the relative percentage of the total variation that was associated with each level of the sampling hierarchy (location, habitat, plot, census). The relative proportions of sampling variability attributable to locations and plots within locations varied between bird species, habitats and seasons. Variability among census within study plots was often the highest source of variation during the reproductive and post-reproductive seasons. This demonstrated the importance of conducting several censuses at a given study plot to more accurately estimate mean seasonal density. Various patterns of increasing and decreasing avian densities were observed during a given season depending on habitat, location and species considered. In most instances, the variability between censuses increased during the post-reproductive season.

Location variability may have reflected site specific differences in habitat quality that were not delineated by Landsat classification, such as differences in microrelief or food availability or the "chance" sampling of random aggregations of bird populations inhabiting an unsaturated environment (Wiens 1981). The surrounding environment within a location such as distance to major landform (ocean or mountains), or proximity of critical habitats (ie. coastal lagoons, tundra wetlands, river systems) could have strongly affected suitability of a particular area. The locations surveyed in the project were intentionally placed in areas with high interspersion of habitat types which may have biased the study towards areas with more habitat diversity. Variations in nest densities among replicate plots within habitats was usually higher than variation among locations within habitats.

Species Accounts of Migratory Birds

Species accounts of birds observed in 8 study areas on the coastal plain of the refuge were compiled by USFWS-ANWR biologists M. McWhorter, D.C. Douglas, S.D. Gehman, J.M. Morton and C.A. Babcock, R. Oates, R. Field and T.C. Maxwell. Methods and results are described in ANWR Progress Report No. FY-86-18: Species accounts of birds observed at eight study areas on the coastal plain on the Arctic National Wildlife Refuge, Alaska (see Appendix II). The accounts describe status, breeding chronology, migration and habitat-use for the 86 species of birds observed in 1985 during terrestrial bird population studies.

Tundra Swan (Cygnus columbianus) Surveys

Two aerial surveys to estimate the number of tundra swans using ANWR coastal wetlands were completed by USFWS-ANWR biologists R.M. Platte and A.W. Brackney in 1985. Methods and results are reported in ANWR Progress No FY-86-13: Distribution, abundance and productivity of tundra swans in coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1985 (see Appendix II). The 1985 surveys covered areas identical to those flown in 1981-1984. Known areas of swan use, termed concentration areas, were defined based on swan observations over the 4 year study period.

The numbers of nests (66) and pairs (127) observed during the 27-28 June 1985 survey were 15% and 34% lower, respectively, than in 1984. Although decreases in nest numbers from 1984 occurred in all concentration areas except the Jago Delta, the 22 nests located on the Canning-Tamayariak delta were 45% fewer than in 1984. On the Aichilak-Egaksrak-Kongakut delta, numbers of nests were 29% lower than 1984. In contrast, the number of nonbreeding adults observed in the 1985 spring survey increased by 25% from 1984. The total spring adult count was 403 swans, a net increase of 14 birds (3%) from 1984 and larger than the 3 year average of 363.7 adults.

In the 19-20 August 1985 survey, 485 adult swans were observed, the highest number observed in the fall since surveys were standardized in 1981. Of the 82 additional swans observed in the August survey, compared to June, 70 were nonbreeders observed as singles or in flocks. A total of 142 cygnets were counted in 1985, a decrease of 23 (14%) from 1984. The number of broods (56) was down 14% from 1984 but close to the 4-year average of 50 ± 21 sd broods per year. Numbers of cygnets have averaged 129.5 ± 59.5 sd cygnet/year. Nest success in 1985, based on the ratio of broods to nests, was 85% in 1985 compared to 63% in 1984.

During the 3 years of nesting surveys on ANWR, the Canning-Tamayariak river delta and the Aichilak-Egaksrak-Kongukut river delta were the most productive areas with an average of 29.3 ± 9.5 sd and 24.7 ± 4.2 nests/year respectively. The Hulahula-Okpilak river delta averaged 11.7 nests/year. The Aichilak-Egaksruk-Kongakut river delta had a higher mean density of nests (0.22 nests/km^2), broods (0.13 broods/km^2), and spring and fall adults (1.06 and 1.2 adults/km^2) than other areas. A comparison of ANWR concentration areas with arctic locations studied by others showed that adult swan and nest densities on ANWR are as high as those elsewhere on the north slope.

Snow Goose Surveys

USFWS-ANWR biologists R. Oates, M. McWhorter, G. Muehlenhart and C. Bitler completed surveys to document the 1985 distribution, abundance, and productivity of snow geese staging on the ANWR coastal plain. Methods and results are reported in ANWR Progress Report No. FY86-10: Distribution, abundance and productivity of fall staging less snow geese on coastal habitats of northeast Alaska and northwest Canada (see Appendix II). Surveys of snow geese staging in ANWR were initiated in 1973 and have been flown by refuge staff for the past 8 years. Objectives of the surveys were to determine chronology of migration and staging, to estimate the distribution and numbers of snow geese present during the peak of staging, to estimate the percent young present during staging, and to identify areas used consistently by staging snow geese.

An area between the United States-Canada border and the Hulahula River on ANWR was flown along a pre-determined grid of north-south flight-lines at 150 m above ground level. Two USFWS-ANWR biologists flew the Alaskan portion of the survey on 31 August and 11 September 1985 after a reconnaissance flight on 25 August. Canadian Wildlife Service (CWS) biologists flew the portion from Demarcation Bay to the Bathurst Peninsula NWT, Canada during the same time period. The report summarized data from the Alaskan portion of the survey. Estimated flock sizes, direction of movement, type of flight, and behavior were recorded and flocks were photographed. Numbers of geese in 37 enlarged photographs were counted independently by 3 counters to obtain estimates of counter variability, and some photographs were counted twice by the counters to estimate within counter variability. Estimates of snow geese numbers in all flocks were corrected for errors with a prediction equation produced by linear regression of observer estimates against mean photo counts.

The first snow geese sighted during the fall of 1985 were observed on 14 August at Niguanak Lake. A 25 August reconnaissance flight revealed 45 flocks totalling 5720 birds (uncorrected estimate) scattered from the Clarence River to Okpilak River. The first intensive survey of the ANWR coastal plain on 31 August resulted in a corrected estimate of 166,544 snow geese observed in 194 flocks between the Clarence River and Itkilyariak Creek. On 11 September a second intensive survey was flown. A corrected total of 312,473 geese in 300 flocks were observed between the Clarence River and Simpson Cove. T. Barry (pers. comm.) completed the Canadian survey the following day and observed 197,850 geese between Tuktoyuktuk and Shingle Point and another 97,162 geese on the Yukon north slope for a total of 607,485 snow geese in the population. Heavy snow and high northwest winds on 15 September precipitated a mass departure of geese from the refuge. When aircraft operations resumed on 18 September no geese were seen on the ANWR coastal plain.

Ecology of Staging Snow Geese

In 1985, a study of feeding ecology and energetics of snow geese staging on ANWR was continued by USFWS-ANWR biologists A.W. Brackney, R.M. Platte, J.M. Morton, and D. Whiting. Methods and results are summarized in ANWR Progress Report No. FY86-11: Ecology of lesser snow geese staging on the coastal plain of the Arctic National Wildlife Refuge, Fall 1985 (see Appendix II). Study objectives were to quantify the normal daily activity patterns of staging snow geese, to determine the types of foods consumed, to quantify changes in body protein and body lipid levels, to determine the caloric and protein quality of foods ingested, and to develop a model of energy expenditure and intake by staging snow geese.

A total of 112 geese were collected during the arrival and departure phases of the study in 1984 and 1985. Food items from esophageal and proventricular samples were identified, counted, weighed, and body composition was assayed by commercial laboratories. Time budgets were quantified in both years. Of the 112 geese collected, 74 (66%) contained identifiable material in the esophagus or proventriculus. Arriving geese had consumed the shoots of horsetails (Equisetem variegatum) in highest quantity (44.7% of aggregate dry weight). Departing geese had eaten the stem bases of common cottongrass (Eriophorum angustifolium) almost exclusively (58.8% of aggregate dry weight). During time budget studies, snow geese were commonly observed during the arrival period on river terraces and gravel bars where horsetails were most common, but the geese soon shifted to tundra habitats as staging progressed after senescence of the vegetation. Geese were also observed foraging on abundant stands of common cottongrass along the edges of thermokarst pits.

Common cottongrass stem bases were hand-picked for nutritional analysis, (caloric density, protein, carbohydrate, fiber, fat) and the esophagus and proventricular contents of collected geese were analyzed for caloric density, fiber and ash. Droppings were also collected and analyzed for caloric density, fiber and ash. The hand picked samples contained maintenance levels of crude protein (12%), high levels of total nonstructural carbohydrates (TNC, 16.2%), and low levels of fat (1.3%). The total dry matter digestibility of the forage was estimated at 29.5%, but may have been lower due to high levels of cellulose (16.7%) and lignin (10.1%). Cellulose was used as an indigestible marker to estimate apparent metabolizable energy of the snow goose diet at 7.34 kj/g.

Both sexes of adult and juvenile show geese showed significant weight gains between the arrival and departure collection periods (Appendix II, ANWR Progress Report No. FY86-11, Table 7). No detectable growth occurred in juveniles, and nearly all weight gain consisted of body fat. Daily fat gain, estimated by linear regression, was higher in 1985 than 1984 in all age/sex classes. In 1985, adults added fat at a significantly higher rate than juveniles. In 1985 adults, 22.5 and 21.5 g fat/day were added by males and females, respectively. Gain by juveniles was 10.6 g fat/day by males and 11.7 g fat/day by females.

Time budget observations were taken on 429 individual snow geese totaling 11,006 instantaneous scans during 1984 and 1985. The scans were pooled by 4-hour time block for each day of observation. Since qualitative observations indicated that they did not feed at night, the assumption was made that the geese rested during the period of darkness. Adult spent more time feeding in the early morning (58.8%) and evening (59.5%) than during mid-day (46.8-48.6%). Juveniles were more consistent and spent an average of 67.2% to 75.9% of each 4-hour time period feeding. Adults and juveniles spent an estimated 8.1 hr/day and 11.7 hr/day feeding, respectively. Juveniles were apparently less efficient than adults in locating and extracting the stem bases of common cottongrass. Geese flew an average of 0.94 hrs/day with significantly more flying in the early morning (10.3%) when they were leaving night roost locations for feeding sites.

Effects of Aircraft Disturbance on Snow Geese

An energetics model was developed by USFWS-ANWR Biologist A.W. Brackney. Methods and results are summarized in ANWR Progress Report No. FY86-6-Impacts: Effects of aircraft disturbance on the energetics of staging lesser snow geese: a model (see Appendix V). The model estimated daily energy intake and expenditure from the estimated energy cost of tissue gain, thermoregulatory costs, activity costs, metabolic fecal and endogenous urinary energy costs, and specific dynamic effect. The model estimated the daily energy expenditures at 1759 kj/day and 1623 kj/day in male and female adults, respectively, and 1361 kj/day and 1302 kj/day in juvenile males and females, respectively. True metabolizable energy (TME) intake was estimated at 2969 kj/day in adult males and 2779.7 in adult females. For juveniles, the model predicted a TME intake of 1932 and 1930 in males and females, respectively. Estimated productive energy (cost of tissue gain) in adults (males = 1210 kj/day, females = 1156 kj/day) was close to twice that of juveniles (males = 570.8 kj/day, females = 627.9 kj/day).

The model was used to predict the effect of aircraft disturbance on the energetics and daily fat gain of the geese. In the model, it was assumed that the geese would respond to each aircraft disturbance with alert behavior for 3.4 min. and flight behavior for 2.3 min. (calculated from data of Davis and Wisely 1974). No flying, as a result of habituation, was assumed for 11% of the simulated aircraft overflights. As the number of aircrafts overflights increased, the percentage of time the geese took flight was decreased exponentially from 89% to 36%.

Behaviorial compensation, the substitution of feeding behavior for other behaviors, was examined at a compensation level of 0%, 50% and 100% of nonfeeding behaviors. The model predicted that juvenile fat gain would be cut in half at 25, 50, and 66 aircraft overflights/day at 0%, 50% and 100% compensation, respectively. Adult fat gain would be halved at 38, 78, and 98 overflights/day at 0%, 50% and 100% compensation. In general, the model clarifies the importance of various aspects of snow goose response to aircraft disturbance. Although the energetic costs of flight-escape and alert responses to disturbance were important without nonflight habituation and compensation, the loss of feeding time and reduced energy intake was the most critical aspect of disturbance.

Golden Eagle Distribution

In 1985, as in 1984, USFWS-ANWR biologist F.J. Mauer documented the distribution and relative abundance of golden eagles in relation to the Porcupine caribou (Rangifer tarandus) herd during the calving and post-calving period in 1985. Methods and results of these surveys are presented in ANWR Progress Report No. FY86-4: Distribution and relative abundance of golden eagles in relation to the Porcupine caribou herd during calving and post-calving periods, 1985 (see Appendix II). Observations were recorded by ground crews engaged in terrestrial bird studies at 8 locations, and by biologists conducting radio-tracking surveys, capture operations and other aerial operations associated with caribou, bear and wolf studies. New and previously known nest sites locations were surveyed from fixed wing aircraft, helicopter and ground access.

A total of 400 golden eagles were sighted, some of which were probably observed repeatedly during the study period of 7 April to 26 September 1985. Of the observed eagles which could be classified according to age (n=240), 79% were subadult and 22% were adult birds. Most observations (68%) were recorded in areas currently occupied by caribou or in areas where caribou had recently been observed. In areas unoccupied by large numbers of caribou, the frequency of reported golden eagle sightings was low and there was no indication of eagle concentrations in these areas. The frequency of golden eagle observations recorded in 1985 followed a pattern similar to that of 1984. Observations steadily increased after the caribou calving and peaked during the post-calving period (20-30 June). Three of 14 mortalities (21%) among 62 radio-collared calves were the result of golden eagle predation (Appendix III, ANWR Progress Report No. FY86-6: Calving distribution, initial productivity and neonatal mortaity of the Porcupine caribou herd).

A total of 19 golden eagle nests were investigated in 1985. Only 1 of 8 nests located adjacent to the caribou calving habitat contained young eagles. Three nests were occupied by adults; 2 of these contained an addled egg.

Raptor Surveys

During 7-20 June 1985, USFWS biologist M. Amaral (Endangered Species, Region 7), in the company of D. James (Endangered Species, Washington office), surveyed known and potential raptor nesting areas on the ANWR north slope. Due to lower than average water levels in many rivers, the investigators relied on helicopter support, and hiked portions of the Aichilik, Jago, Kekikuk, Sadlerochit, and Katakturuk, and Canning Rivers.

Peregrine falcons (Falcon peregrinus) were found at 3 nesting locations on ANWR north of the Brooks Range in 1985 (2 pairs and 1 single bird). On the Aichilik River the investigators observed 1 pair of nesting peregrine falcons and 4 pairs of golden eagles (1 nesting). At 4 sites on the Sadlerochit were found 1 active gyfalcon (Falco rusticolus) nest, 1 non-nesting pair of golden eagles, 1 pair of nesting rough-legged hawks (Buteo lagopus) and one unoccupied site. The Katakturuk supported 1 pair of nonnesting golden eagles, and 2 actively nesting pair of gyfalcons. Along the Canning river 1 active peregrine falcon nest, 2 active golden eagle nests, 1 active gyfalcon and 2 active rough-legged hawk nests were found. Two pairs of ravens were also observed with young in the nest. Altogether, 51 species of birds were tallied during the surveys.

Observations of peregrine falcons were made at 4 of 7 tundra bird camps on the coastal plain (Appendix II, ANWR Progress Report FY86-14: Territorial bird populations and habitat use on the coastal plain tundra of the Arctic National Wildlife Refuge). Of 23 peregrine observations reported during the period, June 11 through August 29, most were adults in flight. The presense of these individuals, which may have been nonbreeders or foothill nesting birds, indicate that recovery of the population in the region is underway.

Bird Use of Lagoons and Offshore Habitats

Lagoons Surveys

Standardized surveys of the ANWR lagoon system were completed by USFWS-ANWR biologists A.W. Brackney, R.M. Platte and J.M. Morton in 1985. Methods and results are reported in ANWR Progress Report No. FY86-15: Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1985 (see Appendix II). The major objective of these 1985 surveys was to obtain an index of relative numbers of migratory birds using coastal lagoons with emphasis on oldsquaw molting in selected lagoons. Four new lagoons were surveyed in 1984 and 1985 in addition to the 10 lagoons and an offshore transect flown in 1981-1983. Two aerial surveys were flown on 26 July, and 15 August 1985 along predetermined routes at an altitude of 30 m.

A total of 17 species of birds were observed during each survey with 21,478 birds observed on 26 July and 19,605 on 15 August. An average of 16.6 bird species per survey (N=15) have been sighted during 5 years of aerial lagoon surveys.

Estimated numbers of oldsquaw in the 10 select lagoons and 400 m offshore area were 19,885 on 26 July and 18,103 on 15 August 1985. Oldsquaw made up 92.3% to 92.6% of the total birds present in those lagoons. In all 14 lagoons surveyed, oldsquaw totaled 24,204 and 20,630 on 22 July and 15 August, respectively. The additional lagoons contained 17.8% of the oldsquaw in the lagoons on 22 July, and 12.3% on 15 August. Oldsquaw densities in the 10 select lagoons were consistent with past years and in the middle range of past surveys. Overall densities were 54.7 oldsquaw/km^2 on 26 July and 49.8 oldsquaw/km^2 on 15 August.

The 400 m offshore transect accounted for 18.7% and 15.0% of the oldsquaw along the coastline on 26 July and 15 August 1985. The number and proportions of oldsquaw in the offshore transect did not increase during the season as in past years, possibly due to mid-August departures of large numbers of oldsquaw.

In order to summarize the results of the 5 years of surveys and evaluate trends, weekly mean numbers of oldsquaw and all birds species were calculated for the 10 lagoons and the offshore transect. Total bird numbers increased early in the season with a peak in early to mid-August. The majority of birds observed in the lagoons and offshore were oldsquaw. Mean oldsquaw numbers peaked during early-August and then declined sharply from mid-August to September.

To compare the relative value of the 10 selected lagoons, an index was calculated from the density ratio (lagoon density/grand density), the proportion of birds xper lagoon, and the mean number of species present (Appendix II, ANWR Progress Report FY86-15, Table 6). This index was devised to compare the importance of the lagoons for waterbirds with respect to density, total population use, and species richness. Density ratio and proportion were used to make the index independent of temporal variations in total population size between aerial censuses. High species richness and a large proportion of the birds observed during surveys (primarily oldsquaw) placed a relatively higher value for all birds on Demarcation Bay, Jago, and Nuvagapak Lagoons. Medium value lagoons were Oruktalik, Tamayariak, and Simpson Cove. Tapkaurak, Arey, Brownlow, and Egaksrak lagoons rated low despite the high species richness in Egaksrak and Arey Lagoons. A similar measure of relative value for oldsquaw showed a high value for Oruktalik, Jago, Simpson Cove, and Demarcation Bay, medium value for Nuvagapak, Tamayariak, and Tapkaurak lagoons, and low values for Arey, Brownlow and Egaksrak lagoons.

The relative value measures were compared with the physical characteristics of the lagoons (Appendix II, ANWR Progress Report No. FY86-15, Table 7) by multiple regression. A positive association existed between the proportion of oldsquaw in a particular lagoon and water depth and lagoon area. The number of species in a lagoon was positively dependent on shoreline length. All other physical characteristics had little effect on species richness. Long shorelines length may have resulted in a higher probability that nontypical and semi-aquatic birds species entered the lagoon.

Several scenarios involving various combinations of the transects along the barrier islands, mid-lagoon, and shorelines were investigated to find a suitable estimator as an alternative to whole lagoon surveys. Areas within transects and corresponding numbers of oldsquaw observed were used to determine densities for each alternative. Regression estimators of the lagoon density were calculated. Only lagoons with more than 3 transects were used in the regression analysis. No combination of the transects proved to be an adequate estimator of oldsquaw density. The method of Johnson and Richardson (1981) was the most tenable (R^2=0.78). In this method the mid-lagoon and shoreline transects were used to estimate the number of oldsquaw in the lagoon outside of the barrier island area. This total was then added to the number inside the barrier island. The method worked best on lagoon surveys with less than 4300 birds per lagoon (R^2=0.806). However the regression failed to account for nearly 20% of the variance in the data. One problem with these estimates was the failure of the mid-lagoon and shoreline transects to adequately represent the density in the lagoon outside of the barrier island area.

Oldsquaw Habitat Use and Behavior.

In 1985, USFWS-ANWR biologist A.W. Brackney and R.M. Platte initiated a study to examine the dependance by oldsquaw on various lagoon habitats and available food resources during molt. Methods and results of the study are presented in ANWR Progess Report No. FY86-17: Habitat use and behavior of molting oldsquaw on the coast of the Arctic National Wildlife Refuge, Alaska, 1985 (see Appendix II). Objectives were to determine changes in oldsquaw body condition during molt, to determine behavioral changes with weather and between habitat types, and to quanitify the diet of molting oldsquaw and compare that information with other studies.

The study was conducted at Beaufort Lagoon, Angun Lagoon and Pokok Bay. Time budgets of oldsquaw in various habitat types were quantified and 100 oldsquaw were collected for analysis of diet and body condition. Wet weights of the specimen, (whole and plucked), dissected organs (heart, liver, gizzard), muscles (right breast, right leg) and body fat (abdominal, subcutaneous) were taken. Each oldsquaw was categorized by sex and placed in 1 of 4 molt classes based on the length of the 10th primary feather.

Foods in the oldsquaw esophagus (N=18) were composed primarily of crustaceans and mollusks (Appendix II, ANWR Progress Report No. FY86-17, Table 1). Specific taxa of importance were amphipods (30.3% of aggregate volume) gastropods (16.5%) and mysids (12.8%). The diet of oldsquaw collected in 1985 was substancially different than other studies along the Beaufort Sea coast where mysids were most important.

Of 4 independent variables (habitat, water depth, wave height, and time of day) only habitat had a significant influence on feeding behavior (Appendix II, ANWR Progress Report No. FY86-17, Table 2). Significantly higher proportions of oldsquaw in flocks were observed feeding while in passes (53.0%) than in other aquatic habitats. Likewise, significantly more oldsquaw were feeding while in the open water of lagoons (20.9%), in the ocean (27.1%), and along ocean mainland shorelines (34.3%), then along barrier islands of the lagoons (4.5%), ocean (4.5%), lagoon spits (3.1%), or along lagoon mainland shorelines (7.6%). Oldsquaw on land also exhibited significantly less feeding (0.1%) than in all other habitats (P 0.05). The increased feeding behavior by oldsquaw in open water habitats coincides with a higher biomass of epibenthic invertebrates in mid-lagoon areas (Griffith and Dillinger 1981).

Body weights were variable and not significantly different between molt stages despite a decrease (62.2 g in males, 9.5 g in females) from premolt to early molt. Males showed significant losses of 65.9 g plucked body weight from premolt to early molt. Male body weights increased from early to late molt but the differences were not significant. In males, a 91% decrease in abdominal fat weight occurred. Initially, both male and female oldsquaw had significant decreases in Protein Reserve Index (sum of breast, leg, gizzard and heart weights) from premolt to early molt followed by a significant gain in protein reserves in males from the mid to late molt stages. Theses changes were driven by a significant 52% drop in breast muscle weight from premolt to early molt and a gain (nonsignificant) in mean breast muscle weight from mid to late molt. Leg muscle weights varied in the opposite direction.

The fact that oldsquaw spent a majority of their time resting and preening while catabolizing body protein and fat reserves suggested that feeding behavior may have been attenuated for physiological or environmental reasons. Oldsquaw in all stages of primary feather molt were highly dependent on several lagoon habitats for food and shelter. Barrier islands and internal lagoon spits served as shelter from prevailing northeast winds and for basking/loafing sites. Loafing on islands and spits probably reduced thermoregulatory costs and such locations were less accessible to predators. Passes between barrier islands allowed temporally high food resources and access to the open ocean and lagoon habitats. Open water, under suitable conditions, provided the necessary food resources to meet the high energy and protein costs of molt. In their state of reduced mobility, molting oldsquaw may be highly susceptible to habitat alteration and perturbations of the food web.

Lagoon Invertebrates

Final analysis of a preliminary study by USFWS biologists M.A. Spindler, R.H. Meehan, and A.W. Brackney on the distribution and abundance of invertebrates and water quality in coastal lagoons of the refuge was completed. Methods and results are described in ANWR Progress Report No. FY86-24: A preliminary study of epibenthic invertebrates and water quality in coastal lagoons of the Arctic National Wildlife Refuge (see Appendix II). The objectives of the study were to document the abundance and distribution of invertebrate food sources in relation to oldsquaw lagoon use. In July-August 1981, invertebrate sampling was conducted in 9 lagoons with a modified cluster drop-net. A sampling station was set up at each of 3 habitat types (barrier island, mid lagoon, and shoreline) in each lagoon. Multiple stations were sampled at Brownlow and Tamayariak and stations in Jago, Kaktovik, and Arey Lagoons were sampled during 2 time periods. Five drop net samples were taken per station. Salinity, temperature, depth and visibility and bottom type were sampled concurrently.

No significant differences were found in numbers of mysids, amphipods, large amphipods (Onismus sp. & Gammarus sp.) or total invertebrates between lagoons or between habitat types.

Significant differences in total invertebrate numbers were found between stations in the same habitat types at Brownlow lagoon. At Tamayariak, large differences existed between barrier island stations in total numbers of invertebrates, amphipods, and total amphipods. Mid-lagoon stations were significantly different in total invertebrates and mysid numbers. Temporal variability in invertebrate abundance also occurred at stations in 3 lagoons that were sampled a second time in late August or early September. Measurements of surface temperature, bottom temperature, surface salinity, bottom salinity, depth, and visibility were not correlated with invertebrate abundance. Invertebrate abundance was not significantly different between bottom types (sand, mud, peat, mixed). No clear trends in invertebrate abundance with any lagoon, habitat, or water quality parameter were detectable at the level of sampling conducted in the study, therefore no association between lagoon-use by oldsquaw and invertebrate abundance could be examined. The high spatial and temporal variability in invertebrate numbers will necessitate a complex and intensive sampling plan before future studies can delineate trends in invertebrate distribution and abundance within and between lagoons.

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Chapter 5

MAMMALS

In 1985, ecological studies of ungulates, predators, and small mammal species were continued on the coastal plain of the Arctic National Wildlife Refuge (ANWR) by U.S. Fish and Wildlife Service (USFWS) biologists. Field work or data analysis on brown bear (Ursus arctos) food habits and behavior, muskox (Ovibos moschatus) habitat use, and the ecology of small mammals were continued by University of Alaska Fairbanks (UAF) graduate students. Caribou studies by other agencies were also completed.

Ungulates

Caribou (Rangifer tarandus)

Porcupine Caribou Herd

Fall and Winter Distribution, Movements, and Mortality: Results of radio-tracking surveys during the winter of 1984-1985 were summarized by Alaska Department of Fish and Game (ADFG) biologist K.R. Whitten, USFWF-ANWR biologists F.A. Mauer and G.W. Garner, and Canadian Wildlife Service (CWS) biologist D.D. Russell. Methods and results are presented in ANWR Progress Report No. FY86-21: Fall and winter movements, distribution, and annual mortality patterns of the Porcupine caribou herd, 1984-1985 (see Appendix III). In Alaska, surveys were flown once in August, September and November 1984, in February and April 1985 and also twice in May 1985. In Canada, surveys were flown numerous days in July and once in August, September, November and December 1984, and in May 1985. Southward migration of the Porcupine caribou herd through the Brooks Range occurred in July 1984, earlier than in previous years. Movements appeared to be influenced by weather. Snow storms in late August 1984 apparently stimulated a rapid southeasterly movement of caribou in Alaska to Canada north of Old Crow. During mild September weather, caribou drifted north with some animals moving back into Alaska by mid-November.

An estimated 50,000 caribou remained on traditional ranges in Alaska throughout the winter and about 90,000 caribou wintered in the northern Richardson mountains and Yukon north slope in Canada. Calves and adult cows were distributed similarly in these two areas, but the majority of bulls may have wintered in Canada. Spring migration in Alaska was underway up the Sheenjek River by mid-April 1985.

First year mortality was estimated to be 38%, based on observations of 58 radio-collared calves. Male calves had a higher first year mortality (53%) than female calves (23%). Mortality of calves apparently occurred in mid-winter as calves survived well into fall, after the brief period of mortality which occurred immediately after parturition. Annual mortality of caribou older than calves, based on observations of 70 radio-collared animals, was 11%. But mortality among animals older than 3 years was greater (32%, X2 = 6.07.,df =1, P< 0.05) than animals of age 1 to 3 years (5%).

Predation/scavenging was thought to be the major cause of mortality of both calves and adults. Wolves were the suspected predator in mortalities of calves and at least 2 adult cows. Three adult cows and a yearling bull were killed by brown bears. Hunting accounted for 11% of the adult mortality and 5% of the calf mortality. Relatively high calf survival and yearling recruitment as well as low to moderate adult mortality indicated that the Porcupine caribou herd was increasing.

Calving distribution, productivity, and mortality: In 1985, ADFG biologist K.R. Whitten and USFWS-ANWR biologist F.A. Mauer and Garner also completed the third year of a calving study of the Porcupine caribou herd. Methods and results of this study are reported in ANWR Progress Report Number FY86-6: Calving distribution, initial productivity, and neonatal mortality of the Porcupine caribou herd, 1985 (see Appendix III). Primary objectives of this study were to delineate calving distribution of the Porcupine caribou herd and describe the characteristics of calving areas, to determine initial productivity and mortality, and to measure variation in calf mortality and factors causing mortality between different locations or habitat types. Radio-collared adult cows were relocated in late May and early June 1985. Low level transects to count numbers of newborn calves and cows were flown across calving areas in Alaska on 30-31 May 1985. High altitude radio-tracking flights over northern winter ranges and areas adjacent to calving grounds were made to locate yearling and bull groups. A total of 59 calves were captures and collared on 2-3 June and 7 more calves were captured on 5-7 June. Collared calves were monitored at least daily and visually located every other day from 2 June through 7 July 1985. From July through December, calves were relocated monthly. Mortalities were investigated and retrieved with the use of a helicopter.

Spring migration in 1985 followed traditional routes with caribou wintering in Alaska moving north and east through the Sheenjek and Coleen drainages into the Firth River valley. In 1985, most caribou calved primarily in 2 locations: in northeastern ANWR from the Hulahula River to the Ekaluakat River,and in northwestern Canada in the hills south of Stokes Point (ANWR Progress Report FY86-6, Fig. 1). The peak of calving occurred between 31 May and 1 June for radio-collared cows (ANWR Progress Report FY86-6, Fig.4), earlier than other years. Initial productivity for these cows was 68% in 1985, not significantly different from 1982-1984.

Captured calves weighed an average of 7.75 kg and were estimated to be an average of 2.5 days old (ANWR Progress Report FY86-6, Table 2). Fourteen calf mortalities were recorded between 4 June and 3 September 1985 among the 66 collared calves (ANWR Progress Report FY86-6, Table 3). Two transmitters failed and 4 mortalities may have been study-induced. The natural mortality rate was 16.8%. Of the 10 natural mortalities, 7 were caused by predators (wolves/bears 3, golden eagles 3, unknown predator 1). Natural starvation and congenital disease were responsible for the mortality of 2 other calves and unknown causes killed 1 calf. Nine of these 10 mortalities occurred between 4 June and 1 July. Causes of mortality of 25 unmarked calves included 12 (48%) killed by predators (wolves 2, golden eagles 10). Nine (36%) died from starvation/pneumonia or undetermined disease and 4 (16%) died from other causes (exposure, trampling, low birth weight and unknown causes).

Natural mortality of radio-collared calves from 2 June - 1 July was 15%. This was not different from the 17.1% observed for control calves, born to radio-collared mothers. Most (80%) of the natural mortality among collared calves occurred in foothills and mountainous terrain (ANWR Progress Report No. FY86-6, Fig.6). Similar movements of nursery groups after calving (10-20 June) south into foothills and mountains also occurred in 1983 when mortality rates were 17.5% for collared calves and 27.8% for control calves. In 1984, when mortality of radio-collared calves and control calves was lower (7% and 4.4%), caribou moved northwesterly onto the coastal plain instead of into the mountains and foothills. This report speculates that greater numbers of predators in the foothills and mountains may have resulted in these higher mortality rates.

During this study, in 1985, collared calves remained near capture sites for 48-72 h after birth. Those born near the Jago River then moved gradually to the south, west or northwest and those born near the Aichilik River moved southwest or west. Post-calving distributions of caribou calving in Alaska extended as far west as the Sadlerochit River. In late June, these caribou turned east reaching the Kongakut River in a few days. Caribou calving in Canada moved west at about the same time so that all segments of the herd converged on the coastal plain and foothills south of Demarcation Bay on 26 June. Two days later, about 60% of the herd had moved southeast into Canada and about 40% moved southwest up the Kongakut, arriving in the upper Kongakut and upper Coleen River by 4 July. By mid-July, most groups reunited near Table Mountain, south of the Brooks Range in Alaska, where they continued to move southwest before fragmenting into smaller groups and dispersing eastward.

Distribution, Movements and Mortality in Canada: Studies of the Porcupine caribou herd in northwestern Canada were completed by CWS biologists D.E. Russell and W.A. Nixon. Methods and results of these studies are presented in a CWS report: Distribution, movements and juvenile mortality of the Porcupine caribou herd in northern Yukon, June 1982 - January 1986 (see Appendix VI). Distribution and movements were documented in brief narratives and maps which described the caribou surveys conducted from summer of 1982 to mid-winter 1986 in northwestern Canada.

Causes of juvenile mortality which occurred in about 37 short yearlings (35 females and 2 males) and 6 two year old cows radio-collared in March 1983 and monitored until June 1985 were also summarized. An overall mortality of 17.2% was calculated over the 28 months. The yearling (age 10-21 months) annual mortality rate was 8.2% compared to an annual mortality rate of 9.5% for two year olds (age 22-34 months).

An appendix of this report was a paper presented by CWS biologists A.M. Martell, W.A. Nixon and D. Russell at the 4th International Reindeer/Caribou Symposium (Whitehorse, Yukon, August 1985): Distribution, activity and range user of male caribou in early summer in northern Yukon, Canada. In this study, locations of radio-collared bulls and miscellaneous observations of bull caribou made from May to July in 1981-1983 were plotted on maps and activity and habitat use data were collected at three locations. Phenological data were collected at 8 tussock meadows, 6 habitat types were mapped on aerial photographs, and fecal samples were collected at 4 sites.

This study found that male caribou were segregated from females during spring migration and calving (May and June). Bulls from both Alaska and the Yukon followed essentially the same routes used by cows from wintering areas to calving grounds. By late June, bulls were moving westward and northward toward the coast near the Alaska-Yukon border. By early to mid-July, bull groups had met and mixed with cows and calves on the coastal plain and then turned eastward toward the Richardson mountains.

Band sizes of bull groups increased in late May and reached a maximum in mid-June (Appendix VI: CWS report, Appendix I, Table 1). Some activities differed between late May and late June: the proportions of time spend walking and the rate of movement was lower and the proportion of time spend lying was higher in mid-June (Appendix VI: CWS report, Appendix I, Table 2). The mean length of active and resting periods declined from late May to late June with the largest decrease occurring from mid to late June (Appendix VI: CWS report, Appendix I, Table 3).

In 1983, snow cover declined rapidly between 19 May and 3 June. All sites were essentially snow free by 17 June (Appendix VI: CWS report, Appendix I, Table 4). In late May and early June, caribou selected tussock tundra, and avoided wet sedge meadows and alluvial willow until mid and late June (Appendix VI: CWS report, Appendix I, Table 5). Fecal samples collected during this study contained Cladonia-type lichens and Vaccinium in late May and early June, although Eriophorum dominated the samples in early and mid-June, and declined in late June. Salix increased in early June and mid-June, dominating the samples in late June (Appendix VI: CWS report, Appendix I, Table 6). The report concluded that distribution of male caribou was related to snow melt and plant phenology and movements of male caribou appeared to follow a temporal pattern.

Population Status: ADFG biologist K.R. Whitten summarized recent population information about the Porcupine caribou herd in an ADFG report: Population status and trend of the Porcupine caribou herd, 1982-1985 (see Appendix VI). This report described historical information about the herd, and results of recent censuses. The herd was first censused in 1972 and 1977. In 1979, a modified photo-census method was used for the first time and this same technique was also used in 1982 and 1983. In 1983-1985, the availability of large numbers of radio-collared caribou permitted data on initial productivity, calf survival/yearling recruitment, and adult mortality to be collected.

In 1982, over 125,000 caribou were counted during the photocensus and an additional 12,000 calves were also estimated to be present indicating a population of about 137,000 caribou. Composition counts of almost 12,000 caribou showed 20% calves were present. In 1983, over 135,000 caribou were counted from photographs, but as the composition sample size was small, no effort was made to estimate number of calves. In 1984 and 1985, no censuses were conducted, but estimates based on productivity, mortality and herd composition data concluded that the Porcupine caribou population would have grown approximately to 149,000 in July 1984 and to 165,000 in 1985 based on an estimated rate of yearly increase of 10.3%.

Caribou Use of the 1002 Area: In 1985, biologists L.F. Pank, C.H. Curby and S.G. Fancy with the USFWS Alaska Fish and Wildlife Research Center (AFWRC) (formerly part of the Denver Wildlife Research Center (DWRC)) and ADFG biologist W.L. Regelin used satellite telemetry to systematically obtain detailed information on the locations and behavior of caribou within the ANWR and Yukon Territory. Methods and preliminary results are presented in AFWRC Progress Report Subwork Unit 4: Caribou use of potential oil and gas development areas in the 1002 region of the Arctic National Wildlife Refuge (see Appendix VI). The report presents preliminary analyses of the potential interaction between (1) caribou of the Porcupine Caribou Herd (PCH) and the Central Arctic Herd (CAH), and (2) potential developments within the 1002 area of the ANWR. In addition to the analyses described here, the detailed movement and behavioral data collected by satellite telemetry are being used to (1) identify critical habitats, including areas used for insect relief, (2) monitor the fidelity of individual caribou to specific calving areas, migration routes, and seasonal ranges, (3) provide detailed data on rates of movement and seasonal movement patterns, and (4) monitor activity patterns throughout the year. The movements of eight adult female caribou of the PCH and two CAH females were monitored daily by satellite between April 1985 and February 1986. Five of the collared females calved within the 1002 area; 3 of the other 5 calved in Canada, and 2 did not have calves. Five of the 8 PCH cows spent an average of 15 days within the eastern portion of the 1002 area. The 2 CAH females occurred within the 1002 area during all months except January and February 1986, when they were found in the Sadlerochit Mountains just south of the 1002 boundary.

<u>Sampling Caribou Use</u>: In 1985, AFWRC biologists L. Pank and P. Kuropat completed a study designed to sample caribou use of coastal tundra. Methods and results are presented in AFWRC Progress Report Subwork Unit 3: A sampling method to determine caribou use of coastal tundra on the Arctic National Wildlife Refuge: caribou use of the area surrounding the Kaktovik Inupiat Corporation (KIC) exploratory well No. 1 site (see Appendix VI). Objectives of this study were develop and evaluate a sampling method to assess caribou use of an area and to acquire site-specific information on caribou use on the KIC#1 exploratory well site and adjacent control sites. Four transect lines, with the same compass bearings relative to the coast, were set out from center points on a site at the KIC well No.1 and a control site. Both sites had similar land cover classes (based on LANDSAT imagery) and similar coastlines. Transects, 3 km in length divided into 1 km segments, were surveyed for caribou artifacts (hair, bone, antlers and tracks) and pellets. Maps derived from LANDSAT imagery were used for locating positions along the transects.

Eighty five caribou artifacts were found along control site transects and 25 artifacts were found along the well site transects. Numbers of artifacts were inadequate to estimate densities within strata along the transects. Hair was the most common artifact found. Antlers were old. Tracks were excluded from the sampling as old and new tracks could not be distinguished. There was no significant difference between densities of pellet groups found on well site and control site transects, although some comparisons of individual transects were significantly different. This report concluded that the use of pellet group densities in assess caribou use of an area was a relatively quick field sampling method and that trends in use over time may be quantifiable in local areas. But weathering and degradation rates of pellet groups need to be known. Within-site variation of topographic relief or land cover diversity may be greater than between site variations, requiring a larger number of transects.

<u>Insects</u>. In 1985, AFWRC biologists C.A. Benson, C.Curby, B. Zimot and E. Zozwiak completed a study on the spatial and temporal distributions of mosquitoes on the coastal plain and foothills of ANWR. Biting and parasitic insects are thought to influence caribou movements, energetics and habitat use. The methods and results of this study are described in AFWRC Progress Report Sub-work Unit 5: Spatial and temporal distribution of biting and parasitic insects on the coastal plain and adjoining foothills of the Arctic National Wildlife Refuge, 1985 (see Appendix VI). Sampling in 1983 found mosquitos to be the principle insect influencing caribou behavior in the study area. In 1985, objectives of the study were to contrast 1985 mosquito distributions with data from 1984 and 1983, and

to contrast extensively collected data on distribution of insects with data collected from intensively monitored trap locations. Sites within 3 geographic areas or "cells" (coastal, plains and foothills) were monitored. Site specific objectives were to determine the influence of various local factors on insect activity: in coastal locations, the distance from coastal and riparian habitats, in plains locations, the distance from riparian habitats and associated landcovers, and in foothill locations, the relationship with topography, aspect and associated landcovers.

Results of this report showed that mosquitoes appeared at approximately the same time in 1985 as in 1983, but later than 1984. Abundance appeared to be lower in 1985 than the two previous years. In 1985, the highest sweep net catch was at a plains site, although on days when direct comparisons could be made, mosquito activity was highest on the coast. Low wind speeds and warm air temperatures on the coast were conducive to mosquito activity on these days, however. A zone of insect relief habitat extending along the coastline of ANWR apparently exists, the width of which is dependent on weather factors. Distance from riparian areas may by another important factor. Mosquito sweepcatches in different moisture regimes were not different at coastal locations, but moist sites had more mosquitoes than dry or wet sites in the plains and foothill locations (Appendix IV: AFWRC Progress Report Sub-work Unit 5, Table 8). At foothill sites, mosquitos activity was also influenced by terrain: valley sites had the highest sweepnet captures of mosquitoes, as well as the greatest number of days with mosquitoes. Ridges had the lowest sweepnet captures and fewest days with mosquitoes (Appendix IV: AFWRC Progress Report Sub-work Unit 5, Table 9). Variation between days was thought be related to weather variables. Wind speeds increased and ambient air temperatures decreased from valleys to ridges (Appendix IV: AFWRC Progress Report Sub-work Unit 5, Fig.4, Table 10). At coast sites during 24 h sample periods, fewer mosquitoes were caught before 1400 h (Alaska Standard Time) than after. Wind speed was higher and temperatures lower before 1400 h, suggesting weather factors may influence mosquito activity. At plains locations, sweepnet catches peaked between 1000 and 1500 h, but windspeed and ambient air temperature were also higher during this same period. Foothills sweepnet catches peaked between 1000 and 1400 h, a period of decreased wind speed and high ambient air temperature.

This report concluded that levels of mosquitoes were usually highest on the plains and lowest on the coast, but high levels of mosquitoes may occur on the coast when high air temperatures and low wind speeds were present. These same conditions occurred most frequently on the plains and in valleys and slopes of the foothills. Land cover associated with mosquito activity also was present in valleys or less frequently on slopes. Flood plains and Dryas river terraces generally provided important corridors of insect relief. Weather variables influenced mosquito activity and confounded the relationship between land cover and mosquito activity. Mosquitoes emerged earlier on the plains and foothills than the coast. Non-attractant sticky traps were useful for detecting the appearance of mosquitoes, but could not measure relative numbers. Sweepnets were a more effective method for sampling the available population and provided the greatest agreement with other techniques. The report also concluded that human harassment and observed caribou harassment can be used to subjectively estimate mosquito activity, and stated that more quantification of factors which influence mosquito activity is needed.

Muskoxen (Ovibos moschatus)

Ecology: In 1985, work continued on the ecology of muskoxen by USFWS-ANWR biologists P.E. Reynolds, J.D. Herriges, and M.A. Masteller. Methods and results from 1982-1985 are described in ANWR Progress Report No. FY 86-2: Ecology of muskoxen in the Arctic National Wildlife Refuge, Alaska, 1982-1985 (see Appendix III). The objectives of this study were to determine population size, composition and herd dynamics, and to document seasonal distribution patterns, movements and habitat use.

During this study, 45 different muskoxen (19 bulls and 26 cows) were captured, measured and marked between 1982 and 1985. Pre-calving population surveys were flown in late March during all years except 1982 when the survey was in mid-April. Post-calving population surveys were made in late October-early November 1982-1985. Age composition counts were conducted in mid-June and late August 1983 and in late June-early July in 1984 and 1985. Survivors of the initial transplant of muskoxen to Barter Island in 1969 probably did not exceed 35 animals, but this transplanted population expanded rapidly, doubling every 3-4 years. In the fall of 1985, 476 muskoxen were counted between the Kavik River, west of the refuge and the Canadian border (ANWR Progress Report No. FY86-2, Table 9). In 1985, calf:cow ratios were 75 calves per 100 cows, the same as was seen in 1984 (ANWR Progress Report No. FY86-2, Table 12). An estimated total of 111 calves were produced in 1985 (ANWR Progress Report No. FY86-2, Table 13). Most radio-collared cows produced calves yearly or every other year. A mean reproductive interval of 1.6 years was calculated based on observations of 15 radio-collared cows. Calf:cow ratios for radio-collared cows were similar to ratios observed for the entire population in 1985 (ANWR Progress Report No. FY86-2, Table 16). Some young calves observed in late June suggested that some cows were bred in late September. Annual losses to the population (mortalities and dispersal), including the harvest of 4-5 bulls per year were calculated to be about 7-12% in 1983-1985 (ANWR Progress Report No. FY86-2, Table 18).

Most muskoxen in ANWR occurred in mixed-sex herds of 5-30 animals. Herd size reached a maximum in winter and minimum during the rut in mid-summer (ANWR Progress Report No. FY86-2, Fig. 6.). Bulls were also found in bull groups ranging in size from 2 to 10 animals or occurred as solitary animals. Small groups of cows and single cows were seen less frequently. Most muskoxen were concentrated in the same geographic areas from 1982-1985 and some of these areas apparently had been used since the animals were released near ANWR in 1969 and 1970. Some animals dispersed east and west of the study area and expanded their range within the study area. Seasonal use of specific areas was documented in 1982-1985. Changes in areas used during the peak of calving (mid May) occurred, but most variation was a shift in distribution to adjacent areas, or dispersal of some animals into new areas (ANWR Progress Report No. FY86-2, Table 19). Bull groups and solitary bulls were spatially segregated from mixed-sex herds and made relatively long movements between geographical areas, particularly during the rut in July and August. Muskoxen were most frequently associated with river or creek drainages except in winter and spring when some animals used ridges and hillsides blown partly free of snow (ANWR Progress Report No. FY 86-2, Fig. 23). Use of vegetation types appeared to follow a phenological progression with muskoxen using tussock and low vegetation in May and early June during calving, and riparian willows and associated low vegetation in summer after the emergence of leaves in late June . During the rut, habitat use was variable as herds spread out into more diverse areas. Willows and low riparian vegetation were used in fall as animals congregated on major river drainages. Snow covered most of the vegetation between October and May and low shrub-forb communities were used most frequently throughout the year (ANWR Progress Report No. FY 86-2, Fig. 24).

Satellite-telemetry: In 1984 and 1985, P.E. Reynolds conducted a study to test an experimental satellite collar on captive and wild muskoxen. Methods and results are reported in ANWR Progress Report No. FY 86-5: Movements and activity patterns of a satellite-collared muskox in the Arctic National Wildlife Refuge, 1984-1985 (see Appendix III). Objectives of this study were to document any problems with the physical configuration of the experimental collar, assess the accuracy of location and activity data, and determine any seasonal differences in distribution, movements, activity patterns and temperature. The collar, provided by Telonics (Mesa, AZ), was initially tested on a captive bull muskox at the University of Alaska, Fairbanks and then put onto a wild free-roaming cow muskox in northeastern ANWR. This study reported that the collar had no physical effects on the study animals. The wild cow carried it for almost 2 years, during which time it gave birth and successfully raised a calf. Over 300 locations were obtained from the satellite collar while it was on the wild cow (ANWR Progress Report No. FY 86-5, Fig. 1) and a mean accuracy of 1.3 km was calculated based on 10 visual observations of the animal which occurred within 5 min of a satellite fix. Seasonal differences in distribution and the size of use areas was also reported (ANWR Progress Report No. FY 86-5, Fig. 2). In late winter, the animal and the herd with which it was associated remained in an area of approximately 81 km2.

This report indicated that movements could be defined as short local movements within a high use area and longer movements between use areas (ANWR Progress Report No. FY 86-5, Fig.3). The satellite-collared muskox had a high fidelity to specific areas throughout the year. Rates of movement varied seasonally: in summer, mean movement rates were higher and more variable than in winter (ANWR Progress Report No. FY 86-5, Fig. 4). Seasonal differences in activity also occurred. Mean activity scores, based on counts from a tip-switch counter mounted on the collar, declined throughout the winter and increased during spring and summer, reaching a high in July (ANWR Progress Report No. FY 86-5, Fig. 6). Monthly mean temperatures from the satellite collar were correlated with temperatures from Barter Island (ANWR Progress Report No. FY 86-5, Fig. 8). The study concluded that this type of collar was an effective method of collecting information about muskox distribution, movements and activity patterns, especially during winter which visual observations were difficult to obtain.

Habitat use: In 1985, University of Alaska graduate student C. O'Brian continued with her field work for a Master of Science thesis project on muskox habitat use. O'Brian's study compared the vegetation in different river drainages used or not used by muskoxen.

Disturbance: In 1985, USFWS-ANWR biologist P.E. Reynolds completed a preliminary analysis of data collected on muskoxen responses to aircraft overflights. Methods and results of this study are presented in ANWR Progress Report No. FY86-5-Impacts: Responses of muskox groups to aircraft overflights in the Arctic National Wildlife Refuge 1982-1985 (see Appendix V). Objectives of this study were to determine the responses of muskox groups to small aircraft and helicopter overflights and to document differences in response to different aircraft types, altitude, season of the year and type of group. Over 1900 observed responses to small aircraft were recorded from 1982-1985. Muskoxen ran into groups more frequently in response to helicopter overflights than to fixed wing overflights (ANWR Progress Report No. FY86-5-Impacts, Fig. 1) Some of the difference observed was likely due to the lower flight altitude of helicopters. Bull groups, including single bulls, showed no response to fixed-wing overflights more often than did mixed-sex groups (ANWR Progress Report No. FY86-5-Impacts, Fig. 2). Muskoxen appeared to be more responsive to fixed wing overflights during winter and calving than during summer and fall (ANWR Progress Report No. FY86-5-Impacts, Fig. 3). Flight altitude of fixed wing aircraft over mixed sex groups in summer appeared to influence muskoxen response. (ANWR Progress Report No. FY86-5-Impacts, Fig. 4). Percentages of mixed-sex groups showing no response to fixed-wing aircraft in summer also increased from 1982 to 1985 suggesting that some animals had habituated to these fixed-wing overflights (ANWR Progress Report No. FY86-5-Impacts, Fig. 5). Muskoxen observed from the ground showed similar responses to aircraft overflights.

Moose (Alces alces)

In 1985, USFWS-ANWR biologists G.E. Muehlenhardt and G.W. Garner conducted aerial moose surveys in northern ANWR. Methods and results of these surveys are presented in ANWR Progress Report No. FY86-9: Population size, composition, and distribution of moose along the Canning and Kongakut Rivers within the Arctic National Wildlife Refuge, Alaska, spring and fall 1985 (see Appendix III).

Objectives of this study were to determine population size, composition, distribution, productivity and over-winter calf survival of moose herds within the Canning and Kongakut River drainages. Standardized surveys were flown in 1983, 1984 and 1985. In the Canning drainage, 159 moose were counted during the 1985 spring survey and 192 moose were counted during the fall survey (ANWR Progress Report No. FY86-9, Table 1). In spring, a smaller percentage of these were found in Cache and Eagle Creeks compared with percentages seen in 1984 and in 1980. But in fall, the proportion of the population found in Cache and Eagle Creeks was similar to other years. The proportion of calves showed a gradual increase between 1980 and 1985. Numbers of calves seen in the spring compared with numbers seen the previous fall were about the same in 1984-1985, but less in 1983-1984. The Marsh Fork of the Canning and the Kavik River were also surveyed in 1984 and 1985. The presence of some moose along the Marsh Fork indicated that this drainage should continue to be surveyed. Movements of moose between the Canning River and the Kavik River, where 96 moose were counted in April 1985, probably occurred, according to this report.

In the Kongakut drainage, 205 and 194 moose were counted during 1985 spring and fall surveys. The numbers of moose in this drainage increased since 1980. But the numbers of calves stayed about the same, indicating a decline in the proportion of calves (ANWR Progress Report No. FY86-9, Table 2) and suggesting that the increase in population was due to immigration. Numbers observed in fall were less than those seen during a 1984 fall survey but more than were seen in the fall of 1983. Proportions of calves in fall have remained relatively stable from 1983-1985, although the data indicated a higher overwinter loss for calves than for adults. In fall 1985, the bull/cow ratio within the Kongakut drainage was slightly higher than the same ratio for the Canning drainage. In 1983, the bull/cow ratio in the Kongakut was nearly double that of the Canning (ANWR Progress Report No. FY86-9, Table 3). Calves per 100 adult cows increased by

5% in the Kongakut population and 8% in the Canning population between 1983 and 1985.

Predators

Brown Bears (Ursus arctos)

Ecology: In 1985, work on brown bears by USFWS-ANWR biologist G.W. Garner, ADFG biologist H.V. Reynolds, and USFWS-ANWR technicians M.K. Phillips, G.E. Muehlenhardt and M.A. Masteller was continued. Methods and results are presented in ANWR Progress Report No. FY86-12: Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge (see Appendix III). Objectives of the study were to determine denning ecology and locations, to determine seasonal habitat use patterns, to determine seasonal interrelationships between brown bears and other wildlife species (especially caribou), and to determine the structure, size, status and reproductive biology of the brown bear population. A total of 145 brown bears were captured and marked from 1982-1985 (ANWR Progress Report No. FY86-12, Table 1) Of these, 113 were radio-collared. In 1985, 76 bears were marked. Bears were captured in May, June and July.

Age structure of the population in 1985, based on 115 captured bears and 23 accompanying offspring, showed that males predominated age classes of 5.5 years and younger, and females dominated age classes 6.5 years and older. Immature bears (4.5 years and younger) comprised 46.4% of the theoritical population in late winter 1984. Cubs were 18.8% of this group. Adults comprised 53.6% of the population. The sex ratio was 61 males and 54 females (ANWR Progress Report No. 12, Fig. 2).

Relatively good survival of young bears through age 4 was occurred for the 1982 cohort (ANWR Progress Report No. 12, Table 3). In 1982, cub survival was high: cubs born to 9 sows were still alive by denning time in fall. In 1982, 1983 and 1984, mortality rates for cubs and yearlings were 58.9%, 54.2%, and 45.0%, respectively. Causes of the high mortality rates were not known, but this report speculated that killings by adult bears was a factor. Four natural mortalities occurred in 1985. Two were killed by hunters, and 2 died from winter exposure.

Breeding pairs were commonly seen from May through early July. The peak of breeding apparently occurred in June. Most sows reproduced first at age 6.5 year of age. Eight sows losing cubs or yearlings early in the summer, bred that same year, and produced another litter of cubs the following year (ANWR Progress Report No. 12, Table 4).

Sex and age of 238 marked or associated unmarked bears indicated that the population had a relatively young age structure, which suggested a stable or increasing population. Ninety five bears (49 males and 46 females) were between 3.5 and 11.5 years of age. Forty one bears (20 males and 21 females) were in age classes 12.5 years and older (ANWR Progress Report No. 12, Table 5). Data were biased toward bears frequenting the ANWR coastal plain and adjacent foothills where most captures took place.

From 1982-1985, bears were observed 340 times in the vicinity of caribou. During most of these observations, interactions between the 2 species were not seen, but 28 chases and 1 successful kill were documented. Bears were seen feeding on caribou carcasses 72 times during 1982-1985. Thirty one of these were adult caribou and 22 were calves. Bears appeared to be using caribou during that time when caribou were present on the coastal plain and adjacent foothills. Preliminary analysis of movement data suggested that bears shifted their activity areas to the coastal plain when caribou were present. Bears were observed near moose and muskoxen on 28 and 32 occasions, respectively, during 1982-1985. Three unsuccessful chases of moose and 1 bear feeding on a moose calf were seen. Three instances of a bear feeding on a muskox carcass and 1 unsuccessful muskox chase were recorded.

In 1985, some bears had emerged from winter dens by 29 April (N = 6) and 19 May (N = 5). All bears emerged by early June (ANWR Progress Report No. 12, Table 6). A general pattern of early emergence by males and no-parturient females and later emergence of females with new cubs was seen.

Physical characteristics of 37 bear dens were measured in 1985 (ANWR Progress Report No. 12, Table 7). Mean elevations of dens ranged from 816-966 m in 1983-1985. Dens were predominately on southeast facing slopes. Three dens were located in coastal plain tundra habitats. The remainder were found in foothills or mountains. All but 1 dug dens collapsed by July. One den was a snow den with a bed of vegetation. Seven bears denned in rock caves. In general all radio-collared bears captured on the coastal plain or in the foothills denned south of their capture sites. In 1985, 36 bears denned by 16 October, 30 more denned by the end of October and 4 denned by early November (ANWR Progress Report No. 12, Table 8).

Behavior and Habitat Use: In 1985, University of Alaska graduate student M.K. Phillips completed analysis of data collected for a Master of Science thesis titled: Behavior and habitat use of grizzly bears in northeastern Alaska (Phillips 1986). Objectives of this study were to describe seasonal patterns of brown bear behavior and habitat use and the predatory relationship between brown bears and caribou. Methods included observing bears at 3 study sites and mapping vegetation at 1 of these sites. Almost 400 hours of observations of bears were obtained during this study. Phillips (1986) found that bears were least active during mid-day, showed patterns of crepuscular activity, and spent most of their time feeding and foraging. Caribou calves were a large part of brown bear kills and Phillip (1986) speculated that caribou were an important food source. In spring and early summer, bears found caribou in tussock tundra, and mat and cushion tundra in flat valleys and dry upland sites. They also dug for ground squirrels and roots in shrubland along floodplains. In mid-summer and early fall, lush areas of sedge-grass tundra, shrub tundra, tall shrubland, and herbaceous tundra were used as bears feed on Equisetum, grasses and sedges, and Boykinia richardsoni. In early fall, mat and cushion tundra in upland sites and shrub tundra used by bears feeding on berries. After the first snowfall, bears dug ground squirrels and roots, using low and tall shrubland along rivers (Phillips (1986).

Wolves (Canis lupus)

Ecology: In 1985, USFWS-ANWR biologists G.J. Weiler and G.W. Garner continued their study of wolf ecology in ANWR. Methods and results are reported in ANWR Progress Report No. FY86-7: Wolves of the Arctic National Wildlife Refuge: their seasonal movements and prey relationships (see Appendix III). Major objectives of this study were to define the seasonal ranges of individual wolves and associated packs in northern ANWR and to determine availability of potential prey. In 1985, 15 wolves were captured and radio-collared in the northern portion of ANWR to supplement the sample of 11 wolves captured in 1984. Captured wolves included members of 8 packs and 11 solitary individuals, 4 of which may have been members of a fragmented pack. A ninth pack of 2 wolves was located but both animals were killed by hunters. Male wolves weighed an average of 43.1 kg, females weighed an average of 36.7 kg. Average ages of captured wolves were estimated to be 2.6-3.2 years of age in 1984 and 2.7-3.5 years of age in 1985 (ANWR Progress Report No. FY86-7, Table 1). Most ANWR wolves were gray or brown, but black and tawny animals were also seen.

Locations and movements of collared animals associated with packs and solitary wolves indicated that movements of a radio-collared wolf may not reflect movements of an entire pack. Activities of packs observed during the study tended to be centered in and along major river drainages. Seasonal shifts in resident pack territories due to caribou movements were not detected. Only one pack appeared to have a large scale seasonal shift in territories. In 1984, most (9 of 11) collared wolves were either captured on or utilized the ANWR coastal plain. By contrast, in 1985, only 2 wolves (both lone animals) were captured on the coastal plain and 2 others, believed to be part of a fragmented pack, utilized the coastal plain. All of these animals were young, 3 years of age or less. Long distance movements by dispersing wolves were observed (ANWR Progress Report No. FY86-7, Table 2 and Fig. 4). One wolf moved 770 km, a record for Alaska.

Wolf densities reported in this study were 1 wolf/726 km2 in 1984 and 1 wolf/686 km2 in 1985 for an areas approximately 24,700 km2, which included the ANWR coastal plain. Minimum numbers of wolves were 27 adults and 7 pups (surviving until fall) in 1984 and 22 adults and 14 pups in 1985 (ANWR Progress Report No. FY86-7, Table 4). Litter sizes averaged 3.0 (n=2) in 1984 and 4.2-4.8 (n=4) in 1985. Estimated pup survival ratios were 50% in 1984 and 56% in 1985. Wolf productivity during this study in the northeastern Brooks Range was lower than other areas due to smaller litter sizes and lower survival rates. Pup survival was related to pack size. More pups survived in larger packs.

In northern ANWR, wolves ranged primarily in the mountains and foothills. All 7 dens found were along rivers with general exposures southeast to southwest with water nearby. Three were established dens with prior use and 4 were first year dens. Detailed drawings and photographs of the dens were presented in this report. Rabies was documented in this report as a factor causing mortalities in ANWR wolves. Between April and July 1985, 9 dead wolves were found: 5 tested positive for rabies and 2 others were possible victims. Two others may have died from effects of canine distemper. In 1984-1985, 10 wolves were taken by local resident hunters. Known mortalities in 1985 were 35% of the 1984 fall population.

This study concluded that ANWR wolves were a dynamic population in which dispersal and new pack formation occurred. Lone wolves and dispersing animals, which may travel long distances, apparently used the ANWR coastal plain, and followed caribou migrations. By contrast, pack wolves used mountains and foothills, and were resident animals with little seasonal change in use areas.

Food Habits: In 1985, USFWS-ANWR biologists G.J. Weiler and G.W. Garner continued work on the food habits of ANWR wolves. This study is described in Progress Report FY86-19: Food habits of denning wolves on the Arctic National Wildlife Refuge (see Appendix III). A total of 811 scats were collected at 6 den sites in late August (1 site in 1984, 5 sites in 1985) after wolves had abandoned the sites. Moose was the principle prey item (75%) found in scats collected in 1984 at the Canning den, but in 1985 caribou was the most important prey item (78%) (ANWR Progress Report FY86-19, Fig.1). Non-ungulate prey species comprised 19% of the remains in scats at the Canning den in 1985. These were primarily ground squirrels. Changes in pack size may have been a factor in the change in prey utilization at the Canning den, which had been used historically for many years.

A den on the Hulahula River was first used in 1985 by a single whelping bitch, who was later joined by another adult. Scats from this den contained a higher proportion of Dall sheep (35%) than fecal samples from any other den, but caribou was the principle species found (59%) (ANWR Progress Report FY86-19, Fig. 1). The den was located in an area near 4 sheep licks, but caribou were not commonly observed in the immediate area.

Scats collected at a den on the Aichilik River in 1984 also contained a predominance of caribou (68%) with some sheep (18%) and moose (12%)(ANWR Progress Report FY86-19, Fig.1). This den had been used prior to 1984 and the scats were probably from at least 2 year's occupation. Wolves did not use this den in 1985. Caribou were abundant in the area, sheep were common, but moose were scarce.

Caribou was also the most common prey item (63%) in scats collected at a first year den site on Drain Creek, in 1985, although moose (27%) and sheep (17%) were also found (ANWR Progress Report FY86-19, Fig 1). All 3 large ungulates were commonly observed in the area. Scats from another first year den on the Malcolm River contained similar proportions of caribou (57.5%) and an unexpectedly large proportion of sheep (26%) (ANWR Progress Report FY86-19, Fig. 1). Sheep were rarely observed in the area. All 3 ungulate species were found in scats from a den on the Kongakut River in 1983 and 1984, although there was a shift from caribou to moose in 1984. Moose were rarely seen in the area. The Kongakut den had been used for many years.

This report concluded that caribou was the dominant food item for all wolf packs observed in 1985, although moose and sheep were also eaten and moose were the most important prey species during some years. Annual variation in food habits was speculated to be related to prey availability and to pack size.

Den Site Behavior and Summer Diets: In 1985, UAF graduate student H. S. Haugen continued analysis of data collected as part of a Master of Science thesis titled: Den-site behavior, summer diet, and skull injuries of wolves in Alaska (Hagen 1987). Objectives for part of his thesis included determining patterns of den site attendance and behavior, and documenting diets of wolves in 3 different ANWR drainages (Haugen 1987). In 1983, preliminary observations were made along the Canning, Kongakut and Hulahula Rivers. In 1984, dens on the Kongakut and Canning Rivers were observed. Haugen (1987) presented descriptions of wolf behavior and pack composition at these 2 dens and concluded that the Canning wolves, which hunted moose, had a more cohesive pack and spent more time raising pups, although the den was not successful. The Kongakut pack, which hunted whatever prey was available, had a less cohesive pack and left pups alone for prolonged periods.

Haugen (1987) collected and analyzed wolf scats to obtain information on diet. Kongakut wolves ate more moose than caribou in 1984, but more caribou than moose in 1983. Dall sheep were eaten both years, but less frequently than moose and caribou. More Dall sheep and non-ungulate species were eaten in 1984, than 1983, especially lambs. Young ungulates of all 3 species were consumed both years (Haugen 1987, Fig 8). Canning River scats also collected in 1983 contained predominately caribou, some non-ungulate species and Dall sheep, but no moose. But the number of scats collected in 1983 was small (17). Moose was the principle prey items in Canning scats collected in 1984 (Haugen 1987, Fig. 9). Caribou and Dall sheep were the most important components of 24 scats collected along the Hulahula River in 1983. Young moose and non-ungulate species were also present (Haugen 1987, Fig. 10). Haugen (1987) observed all 3 ungulates near the Kongakut den, but thought caribou was most abundant species. He also observed Dall sheep on the Hulahula River, and few caribou or moose near the Canning den, although a large population of moose resided in drainages not far away.

Haugen (1987) concluded that Kongakut and Canning wolves appear to consume between 45 and 70% moose. Moose were important to the Canning wolves, Hulahula wolves focused on Dall sheep and non-ungulates, and Kongakut wolves appeared to eat primarily adult caribou, which were present when the Porcupine caribou herd moved through the area.

Arctic Foxes (Alopex lagopus)

In 1984, UAF graduate student R.M. Burgess completed a Master of Science degree titled: Investigations of patterns of vegetation, distribution and abundance of small mammals and nesting birds, and behavioral ecology of arctic foxes at Demarcation Bay, Alaska (Burgess 1984). The study, conducted in 1978 and 1979, focused on making detailed observations of the use and availability of food resources. To characterize important vegetation types, vegetation was sampled within the study plot, at small mammal capture locations and bird nests. Small mammals were live-trapped in 12 trap areas within the study plot in 1978. In 1979, trapping efforts were concentrated in areas which captures had been most frequent and areas south and east of the study plot were also sampled. Bird nesting success and nest density were monitored on the 30 ha study plot in 1978 and 1979. Six foxes were trapped, radio-collared, followed and observed in 1979.

Burgess (1984) described 17 vegetation/landform types in his study area which included 2 types of wet meadows, 3 each of low center polygon types, and upland vegetation types, 4 coastal vegetation types, and disturbed vegetation types which were limited in extent. Four species of small mammals were captured in the study area. Densities of small mammals were not high in either year, but were much higher in 1978, compared with 1979. The Lemmus sibericus population appeared to be productive and stable or increasing in 1978, when one active fox den was found in the study area, and declining in 1979, when foxes in the study area did not reproduce.

Burgess (1984) monitored over 40 nests of 7-12 avian species in 1978 and 1979. Weather (primarily snow during incubation) was responsible for the loss of most nests (10 of 17) in 1978 (Burgess 1984, Table 12). The largest cause of nest failure in 1979 was predation when 27 of 29 nests were lost to foxes. Lapland longspurs had the highest proportional loss in 1979 (21 of 22 nests lost), and were more vulnerable to fox predation than sandpipers. Many longspur nests failed at the nestling stage. The increase in fox predation in 1979 was attributed to the lack of alternate prey, primarily small mammals, according to Burgess (1986). One pair of foxes raised 9 pups in 1978, but no foxes bred successfully in 1979.

Burgess (1984) described arctic fox behaviors in 4 major categories. Arctic foxes were nocturnal throughout the summer, becoming active about 1800 h and ceasing activity at about 0800 or 0900. Short resting bouts sometimes occurred during the night and short activity bouts were frequently seen at mid-day. Resting bouts averaged 1.7 h and ranged from 1 min to 8.4 h. Activity bouts averaged 1.4 h and ranged from 3 min to 7.9 h. but did not change during the summer during fluctuating prey availability. Foxes spent over 70% of observed active behavior searching. Percentage of time spent foraging varied between June and August as foxes spent more time eating carrion later in the summer. Social activities were less than 3% of the total activity budget (Burgess 1986, Table 20).

Captures of prey by foxes decreased throughout the summer, in part because foxes fed on a large carcass in early to mid-August, but the rate of capture was greatest when food was most abundant in mid-June. Most (70%) of all captures at that time were avian eggs, when avian nest densities peaked. Birds were unavailable after mid-July, and small mammals were captured most frequently in June and early July. Although the rate of captures decreased, consumption rates remained stable (Burgess 1984, Table 21). Caching occurred most frequently when food was most abundant in mid-June and in August when portions of a carcass were cached. Food was retrieved from caches at an increasing rate through the summer and some cached food was re-cached. Over the summer, about 45% of captures were cached and eggs were the most frequently cached food item. Caches were used to regulate food availability through mid-August (Burgess 1984). Scent-marking rates for foxes were calculated by Burgess (1984, Table 23) who found scent marking may be related to foraging behaviors, in addition to having other functions. Observations of social behavior indicated that a pair bond was maintained through the summer of 1979 in spite of no successful reproduction and that the mated pair defended their relative large home range from other foxes.

Foxes rested in dry areas of vegetation, but did not travel to specific resting areas. Most frequently used vegetation types were also the most widely available, but one common vegetation type was apparently selected against, as were tussock slopes. Foxes selected gravel beaches and high relief high center polygons. High rates of capture were associated with the most common vegetation types, but no captures or meals were made on gravel beaches. Most captures in meadows took place on pond shores where avian prey, usually eggs, were found. The foxes's preferred prey, (L. sibericus) was most abundant in medium relief sites. Bird nest densities were highest in tussock slope, low relief and meadow sites.

Burgess (1984) found that avian species were apparently the most important food source for arctic foxes. Eggs were 85% of avian prey and chicks were another 12% (Burgess 1984, Table 21). Almost 60% of eggs taken by foxes were cached. Meals from small mammals declined after early July, and food availability from all live sources declined throughout the summer, requiring foxes to rely on carrion and caches. Caribou comprised the largest proportion of carrion in the foxes' diet. Radio-collared foxes moved distances ranging from 0 km to 29 km and average rates of movement per 10 d period were not different (Burgess 1984, Table 28). Home ranges of 2 radio-collared female foxes were 18 and 24 km2, and overlapped about 6 km. Burgess (1984) concluded that food caching (primarily eggs and carrion) provided a defendable resource through a season of low mammal availability.

Small Mammals

Microtine Rodents

1985 Population Status. A short study of microtine rodent densities and demographic status was conducted by USFWS-ANWR technician C.A. Babcock in 1985. Methods and results are reported in ANWR Progress Report No. FY86-1: A microtine rodent population increase in 1985 on the coastal plain of the Arctic National Wildlife Refuge, with notes on predator diversity (see Appendix III). Two study areas (Tamayariak and Niguanak) were selected because of unusually high brown bear (Ursus arctos) densities. A third study area (Marsh Creek), at approximately the same latitude on the coastal plain, had no high concentrations of bears. Microtine rodents were live-trapped at 96 station grids at each site and the presence of all predators were noted.

Similar total numbers of microtines were captured at all 3 sites. The Marsh Creek area had fewer Lemmus sibericus and more Microtus oeconomus than the other areas (ANWR Progress Report No. FY86-1, Table 1). Increasing densities of Lemmus were not indicated at any of the 3 sites. Sex ratios were skewed toward males and recruitment of juveniles appeared to be low. The demographic makeup of captured Lemmus at Niguanak and Tamayariak resembled those reported for populations in a decline phase following a density peak. By contrast, Microtus economus populations had a normal sex ratio, recruitment of juveniles, and evidence of reproductive and population density increase. Densities of microtines at all study areas were higher than those recorded during the 2 previous years.

Lemmus breed in winter and densities may have peaked in early spring 1985. Signs of intense grazing were found in scattered pockets at Tamayariak and Niguanak and several avian and mammalian predators were found at both these sites, indicating that locally high densities of Lemmus had occurred in the spring of 1985. At Marsh Creek, there was little sign of a Lemmus peak and predators were not as common or as diverse.

Bears and wolves (Canis lupus) may have been attracted to the Tamayariak and Niguanak areas by the presence of calving caribou and then switched to feeding on microtines after the caribou left the areas. This would only be energetically beneficial in certain years and in certain locations when microtine densities were high.

Habitat use: In 1985, UAF graduate student C.A. Babcock completed a Master of Science thesis titled: Vegetation patterns and microtine rodent use of tundra habitats in northeastern Alaska (Babcock 1986). The objective of this study was to examine the habitat use of microtine rodents in the heterogeneous environment of polygonized terrain, using a very fine scale assessment of vegetation. Three study sites were located in 3 physiographic areas across the ANWR coastal plain:

one in the foothills (Kongakut), one mid-way between the mountains and the coast (Katakturuk), and one on the coast (Okpilik). Quantitative vegetation sampling was done at live-trapping grids by estimating percent canopy cover in circular quadrats.

Babcock (1986, Table 1) found that the number of vascular plant species decreased from the mountain site to the coastal site and 41% of the species were found at all three sites. Adjacent areas were most similar. Similarity was greater between microhabitat types within a site than between sites, comparing the same types (Babcock 1986, Table 3). Moisture was a major condition for separating microhabitats, although a complex of physical and chemical gradients probably existed. Although large scale diversity of communities was found to decrease toward the coast, Babcock (1986) concluded that communities on the coast were packed more tightly into microsites of polygonal terrain than similar terrain further inland.

Babcock (1986) found 4 species of microtines in his study areas: 2 lemming species (*Lemmus sibericus* and *Dicrostonyx sp.)* and 2 vole species (*Microtus oeconomus* and *M. miurus*). All species differed widely in distribution in time and space. *Dicrostonyx* was trapped at all 3 sites but was uncommon at the mountainous Kongakut site and the inland Katakturuk site in both years and, in 1984, at the coastal Okpilik site. *Lemmus* was also uncommonly found during both years at Katakturk and in 1983 at Okpilik. *M. oeconomus* was the most frequently caught species at all 3 sites. *M. miurus* was captured infrequently at the Kongakut site. Fewer animals were caught in live-trap grids in 1984 than in 1983 (Babcock 1986, Table 4a). Trends indicated increasing populations at Kongakut and Katakturuk in 1983 (Babcock 1986, Fig.7). Snap-trapped captures of *M. oeconomus* showed no difference in sex ratios. Body weights of trapped and live-captured *M. oeconomus* differed between sexes, seasons and study sites (Babcock 1986, Table 6).

More *M. oeconomus* were trapped in wet microhabitat in 1983 at Kongakut, and in mesic sites at Katakturuk in 1984. Combining years, this species favored the wettest sites at Okpilik (Babcock 1986, Table 10). Weasel predation was highest at Okpilik and lowest at Katakturuk (Babcock 1986, Table 11). *Dicrostonyx* was more commonly found, and *M. oeconomus* was less commonly found than expected in raptor pellets (Babcock 1986, Table 12). Results of this study indicated that *Lemmus* was primarily coastal and *Dycrostonyx* also occurred more commonly toward the coast. *M. oeconomus* was widely distributed and *M. miurus* was restricted to the foothills. One species, *Clethrionomys rutilus*, found in mountain areas during other studies, was not captured during this study. The *M. oeconomus* populations in 1983 appeared to be increasing in 1983, but were at much lower densities in 1984. Other species were at low densities during the 2 years of the study. Babcock (1986) speculated that differences in litter sizes and animal weights of *M. oeconomus* at Okpilik and Kongakut may have been due to differences in population densities or differences in nutrients at the 2 sites. He also suggested that microtus populations either do not fluctuate or fluctuate out of synchrony with lemming species. Discussions of habitat use indicated that microhabitat selections of the 2 lemmings and *M. oeconomus* were similar to their selection of larger habitat patches reported by other studies: *Dicrostonyx* used polygon rims and high centers, *Lemmus* and *M. oeconomus* used the wetter polygon troughs.

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Chapter 6

FISH

Fairbanks Fishery Resources Station Studies

Six fisheries investigations were conducted in or near the Arctic National Wildlife Refuge (ANWR) coastal plain study area by the U.S. Fish and Wildlife Service, Fishery Resources office in 1985. Separate progress reports were completed for each investigation (Fairbanks Fishery Resources Progress Report No. FY86-1 through FY86-6) and are included in Appendix V.

Fishery Investigations in Beaufort Lagoon

In 1985, baseline sampling was continued in Beaufort lagoon following similar procedures used in 1984 (West and Wiswar 1985). Fish were caught in large directional fyke nets between July 7 and August 9, 1985. Nine species were captured, with Arctic char (Salvelinus alpinus) being the most numerous. Of the 2,161 char caught, 1,262 were tagged with numbered Floy tags. Of those, 29 (2.3 %) were recaptured within the lagoon during the summer sampling period. Tagged char were also recaptured by subsistence fisherman near Barter Island and by consultants working near Prudhoe Bay.

Other species caught in Beaufort Lagoon in 1985 included: fourhorn sculpin (Myoxocephalus quadricornis) (1,856), Arctic flounder (Liopsetta glacialis) (521), Arctic cisco (Coregonus autumnalis) (408), saffron cod (Eleginus gracialis) (29), least cisco (Coregonus sardinella) (20), Arctic grayling (Thymallus arcticus) (8), eelpout (Lycodes sp.), and rainbow smelt (Osmerus mordax) (1).

The majority of arctic char and Arctic cisco (80% and 90% respectively) were captured at the northeast side of the lagoon, immediately inside the barrier island. Most of these fish were moving in a westerly direction when captured.

Fall Movements and Overwintering of Arctic Grayling

The radio-telemetry study of fall migrations of grayling initiated in 1984 (West and Wiswar 1985) was continued in 1985. The study was repeated on the same river systems to compare results over 2 years. In 1985, 38 radio transmitters were surgically implanted in adult arctic grayling. Fifteen fish were implanted in the Akutoktak River, 14 in Itkilyariak Creek near its confluence with the Sadlerochit River, and 9 near the mouth of the Tamayariak River. Following the tagging in July and August, relocations from the air were made monthly through January. Overwintering locations were similar to those found in 1984. Grayling from the Okpilak River were found overwintering in the Hulahula River at "Fish Hole 1" or "Fish Hole 2." Overwintering locations for Itkilyariak Creek fish were deep pools in the Sadlerochit River adjacent to, but separate from, Sadlerochit Spring; in the Kekituk River; or in Peters or Shrader Lakes.

Grayling from the Tamayariak River moved into the lower Canning River or further upstream above the Canning River delta to overwinter.

Age, Growth, Distribution and Summer Feeding Habits of Arctic Flounder in Beaufort Lagoon.

Arctic flounder is an abundant marine species found nearshore in the Beaufort Sea in summer. Samples of flounder were taken in July and August 1985 in Beaufort Lagoon while other fisheries investigations were being undertaken. Flounder ranged in size from 55-298 mm, and age from 2 to 9 years. Fish 126-150 mm and 3 or 4 years old predominated. Arctic flounder were common throughout the sampling period, but a marked increase in their abundance was noted in mid-August. The major prey item documented for the flounder was the amphipod Gammarus setosus. Isopods and polychaetes also were found in the diet.

Baseline Histopathological and Contaminant Studies of Four Arctic Fish Species in Beaufort Lagoon.

Arctic char, Arctic cisco, Arctic flounder, and fourhorn sculpin were sampled from Beaufort Lagoon and were examined for histopathological abnormalities, parasites, and contaminant levels. Overall condition and health of the fish were good and disease rates appeared low. Arctic flounder were found to be the least infected with lesions or parasites of the species examined. Contaminant levels were generally low or below detection except for arsenic which was elevated in all species. The most common parasite observed was a cestode Bothrimonus sturionis which was found in the digestive tract of specimens in all species and which occurred in 100% of the Arctic char and 96% of the Arctic cisco samples.

Fisheries Investigations on the Kongakut River

Fish and invertebrate sampling was undertaken on the Kongakut River in June and July 1985. Arctic char and Arctic grayling were the only fish and species found. Spawning-age grayling and fry appeared to be distributed throughout much of the drainage; char were numerous in the middle and lower reaches. Ripening adult char were abundant but non-spawning adults had apparently left the river for summer feeding in the lagoons system. Twenty-two macroinvertebrate taxa were collected with Chironomidae, Nemouridae, and Oligochaeta being the most abundant.

The Freshwater Food Habits of Juvenile Arctic Char

The freshwater food habits of immature Arctic char were determined from samples taken from the Canning, Hulahula, Aichilik, and Kongakut Rivers. From the 189 stomachs examined, chironomids were the most commonly found prey organism. Plecopterans were second overall except in samples from the Canning River where Ephemeropterans were more commonly found.

Other Studies

In addition to Fish and Wildlife Service Fishery Resources investigations on the ANWR coastal plain, a study of domestic fishing effort and catch, along with monitoring of fish movements at Kaktovik was conducted in concert with the Endicott Environmental Monitoring Program (Envirosphere 1986). Fyke nets were deployed from late July to late August at Barter Island and questionnaires were used to poll residents of Kaktovik. The catch data was incorporated into a regional data base and tag returns from the Prudhoe Bay area were documented. Estimates of the summer catch of fish by residents of Kaktovik were 1,000 to 2,000 Arctic cisco and 2,000 to 4,000 Arctic char (Envirosphere 1986).

Sampling efforts by Entrix in the Colville River and by the Canadian Department of Fisheries and Oceans in the McKenzie River have resulted in several recaptures of Arctic cisco tagged in 1985 in Beaufort Lagoon and also cisco tagged near Prudhoe Bay.

A study of electophoretically separate stocks of Beaufort Sea Arctic char was started late in 1985. This study was funded by the Minerals Management Service as part of their support of studies on Arctic fish habitats and sensitivities. Juvenile char were taken from each of the major Beaufort Sea drainages which support anadromous char populations. The samples were shipped alive to the Fish and Wildlife Service laboratory in Anchorage where they were analysed. Preliminary results indicate that the river systems consist of unique stocks and that electrophoresis could be used as a method to distinquish stocks in a mixed sample (eg. from offshore), if a large enough sample size could be obtained (Everett and Wilmot 1987).

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Chapter 7

HUMAN HISTORY AND ARCHAEOLOGY

Subsistence

Kaktovik

In 1985, 2 technical papers containing information about subsistence use in the Arctic National Wildlife Refuge (ANWR) were completed by the Alaska Department of Fish and Game (ADG&G) Division of Subsistence. One report (Coffing and Pedersen 1985) was a summary of information on caribou hunting by Kaktovik residents in the 1983-84 regulatory year (30 June 1983-30 June 1984). The purpose of the study was to document: 1) land areas used by successful Kaktovik caribou hunters, 2) total numbers, sex composition, and herd source of animals harvested, 3) composition of caribou hunting groups, and 4) why some households did not harvest caribou.

Information was collected by interviewing members of 45 of 47 households in the community. Of these, 18 households took 102 caribou during 1983-84. Over 50% of the 27 non-harvesting households had work conflicts which prevented them from harvesting caribou. Another 37% were not in the community when caribou were available. A total of 80 caribou were harvested at 9 sites located near the coast from the Canning River delta to Griffin point. At 6 inland sites, a total of 22 caribou were harvested; 16 of these were taken at 4 sites near one another in the foothills near Sadlerochit Spring and the Hulahula River. Harvest was concentrated on the coast for the past 3 years.

The majority of the harvest took place in July, August and April when a total of 79 animals were taken. Inland sites were used only April. No caribou were harvested from December through February and in June and September in 1983-84. Harvest peaked from late June until August and from March through May based on information collected from 1981-1984. From December through February, hunting may be restricted by cold weather and darkness. In June, break-up limited both boat and snow mobile travel. Whaling activities took place in September. Boats, snow mobiles, and less frequently, three wheelers were used to hunt caribou. At least 24 hunting parties harvested caribou. About half of these contained individuals from 2 to 4 different households. It appeared that single household hunting parties were more mobile, but less successful, than multi-households hunting parties.

Only 1 animal was harvested out of season. The 1983-84 harvest of 102 was higher than the 43 animals taken in 1981-83. Caribou distribution apparently contributed to the fluctuation in harvest numbers. Bulls comprised the majority (58%) of the harvest in 1983-1984, as well as in the 2 previous years. Most males were taken in July and August in all 3 years. Females may have been selected in fall and spring. Both Porcupine herd and Central Arctic Herd caribou were taken by Kaktovik hunters, although numbers of animals taken from the latter herd were less variable over time.

Over 70% of Kaktovik's caribou harvest came from the ANWR coastal plain study area 1981-1984. All hunters traversed the area during hunting or enroute to hunting sites. Access to hunting sites was identified as an important land use issue.

A second study completed by ADF&G Division of Subsistence in 1985 focused on land use associated with residents of Kaktovik obtaining resources (Pedersen et al. 1985). Objectives of this study were to: 1) complete a literature review and compile a community socioeconomic profile, 2) map subsistence land use with data-base capabilities compatible with other existing systems, and 3) describe seasonal activities, document Inupiaq place names, and compile a subsistence land use atlas and overview of present land status. Twenty two map biographies representing the use of resources from 1923 to 1983 by 20 households were obtained in Kaktovik. As part of an over-view description of the environment, climate, fauna and flora, history of the community and economic factors were presented. The population in Kaktovik in April 1983 was 185 with males comprising of 55% and females comprising 45% of population . Eight three percent of the population was of Eskimo descent. The 46 households averaged 4.0 persons per household. Descriptions of historial and current employment patterns were presented. Median income was $24,167 in 1980.

Community resource use areas for the period 1923 to 1983 were calculated to be 11,406 square miles, with 23% of this area in coastal or near coastal waters. Maps of use areas for particular resources, for households and for all community resources were presented and discussed in this report. In addition, place names of significance to Kaktovik were recorded and mapped.

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Chapter 8

IMPACTS OF GEOPHYSICAL EXPLORATION

Impacts on Vegetation and Surface Stability

In 1985, the U.S. Fish and Wildlife Service (USFWS) continued studies to evaluate the impacts of winter seismic exploration on vegetation and surface stability in the study area. Three studies were conducted. The first utilized data from permanent study plots to evaluate impacts on visual resources, vegetation, and surface stability, while the second study utilized aerial photography to assess the impacts of vehicle trails over a wider variety of sites. In the third study, data was gathered on snow distribution across the coastal plain and its relationship to disturbance by winter seismic vehicles.

Impacts on Visual Resources, Vegetation, and Surface Stability

In 1985, studies to assess the impacts of the 1984 and 1985 winter seismic programs were continued by USFWS - Arctic National Wildlife Refuge (ANWR) botanists N.A. Felix, M.T. Jorgenson, M.K. Raynolds, and R. Lipkin, and biotechnicians D.L. Blank and B.K. Lance. Methods and results are reported in ANWR Progress Report No. FY 86-2-Impacts: Effects of winter seismic exploration on visual resources, vegetation and surface stability of the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985 (see Appendix V). The objectives of this study were to evaluate the impacts of winter seismic exploration on the vegetation, surface stability, and visual resources of the coastal plain, and to determine rates of recovery to predisturbance conditions.

Sixteen intensive study plots (30 m x 4 m) established in 1984 and 18 newly established plots were sampled to quantify the effects of disturbance and to study recovery rates. Fifty photo-trend plots (10 m x width of disturbance) established in 1984 plus an additional 16 plots were sampled less intensively to provide data from a wider variety of sites.

Seismic trails were generally visible in all vegetation types. Narrow trails, fuel spills, craters (blow outs at shotholes), and small radius vehicle turns were the most visible. Seismic vibrator trails were slightly more visible than dynamite trails. Trails showed either no change or slight improvement in visibility between 1984 and 1985. Reduced visibility of 2-year-old trails was due to the increase in standing dead leaves, the lighter color of weathered litter and drier soil, and the lack of standing water in 1985.

Plant cover decreased on most disturbed plots. Smaller decreases in plant cover in 1985 compared to 1984 occurred for some species at a few plots, but overall little recovery of plant cover was evident. Vegetative shoots and some seedlings were recolonizing bare patches on trails, but these covered very little ground area. Plant productivity of current year's growth, as measured by plant mass, twig length of shrubs, and numbers of leaves per sedge plant, were generally higher on 2-year-old plots. These factors indicate that recovery of vegetation is beginning to occur on trails in ANWR, but will take many years to reach predisturbance conditions.

Significantly greater thaw depths occurred on almost half of the disturbed plots compared to adjacent controls. Only 4 plots had greater changes between disturbed and control plots in 1985 than in 1984. Measurable track depressions occurred at 4 plots on narrow trials in moist sedge-shrub tundra. Summaries of disturbance on vehicle trails in each vegetation type are presented below. These vegetation types, modified from Walker et al. (1982) are described in detail in ANWR Report No. FY86-2-Impacts (see Appendix V).

Wet Graminoid and Moist Sedge-Shrub Tundra. Low level disturbances produced visible green trails due to knocking down of the lighter colored standing dead leaves. Trails were more visible at higher disturbance levels due to the obvious track depression or visible wetness of trails (especially when summer precipitation was high). Total plant cover decreased on plots with moderate and high disturbance levels. Soil was exposed only on plots with the highest level of disturbance.

Mosses were easily scuffed and compressed by vehicles, and thus were the most sensitive life form in this vegetation type. Mosses were rare recolonizers on bare patches in the moist sedge-shrub plots, but were important recolonizers in the 1 wet sedge plot (011).

Cover of willows (mostly Salix planifolia ssp. pulchra and S. lanata ssp. richardsonii) decreased on most disturbed plots. Vegetative shoots of S. planifolia were present recolonizing bare patches on a few plots. Productivity (mass and twig length) of current year's growth of S. planifolia was higher on 2-year-old disturbed plots than on adjacent controls. Nitrogen and phosphorus concentrations of new shoots were also higher on disturbed plots.

Sedges (Carex aquatilis and Eriophorum angustifolium) had no significant changes in cover in the first year after disturbance. In the second year, sedge cover increased above control levels at 4 disturbed plots, with a statistically significant increase at 1 plot. Mass of leaves and number of leaves per plant for these 2 sedges were significantly higher on 2-year-old plots. Nitrogen and phosphorus concentrations in the sedges (especially the below ground stems) were generally lower on disturbed plots. The total amount of nutrients in sedges on disturbed plots was similar to or greater than that on control plots, because the mass of sedges generally increased when the nutrient concentrations decreased. Vegetative shoots of E. angustifolium and C. aquatilis were the main recolonizers of bare patches; graminoid seedlings were also important as wet sedge plot 011. Sedge plants on trails had 1/3 the number of dead leaves as plants on control areas in the second year after disturbance. Two more growing seasons are expected to produce a full complement of standing dead leaves per plant resulting in reduced visibility of green trails. Forbs generally decreased in frequency and cover on disturbed plots.

Thaw depths (depth to permafrost) increased significantly on trails at all levels of disturbance. The decrease of lighter colored standing dead and increased moisture on trails caused decreases in energy reflection (albedo) and increases in energy absorption which led to deeper thaw. Four plots had greater differences in thaw depth between disturbed and control plots in 1985 than in 1984. Measurable track depression (5-12 cm) occurred on 4 plots which were all narrow trails made by multiple vehicle passes in moist sedge-shrub tundra. One photo-trend plot in wet graminoid tundra also had obvious track depression on the ground, but no measurements were made.

Moist Graminoid/Barren Tundra Complex. Trails were visible as discontinuous dark tracks due to exposed soil. Small patches of bare soil due to scuffing of mound tops and frost boils were common, but sometimes difficult to see due to the patchy nature of vegetation in the undisturbed habitat. Two-year-old trails were less visible, because standing dead increased in the trail and soil patches were drier and lighter, blending into surrounding vegetation.

Cover of the evergreen shrub *Dryas integrifolia*, the deciduous shrubs *Salix phlebophylla* and *S. reticulata*, mosses, and lichens was generally lower on trails. Little recovery of plant cover was evident on 2-year-old trails; only deciduous shrubs on O3 had a significant decrease in cover in 1984 but not in 1985. Bare patches changed little between 1984 and 1985, but some vegetative shoots of *Eriophorum angustifolium*, *Carex Bigelowii*, *Arctagrostis latifolia*, and *Salix phlebophylla* were recolonizing. Mosses and seedlings were rare or absent on bare patches.

Thaw depths were significantly greater on many level 2 and 3 disturbances in barren complex tundra. No track depression was evident in the field or in the surveyed elevational data. Small surface depression would be difficult to measure in this habitat due to the natural variation in micro-relief.

Moist Sedge Tussock Tundra. Trails appeared brown due to broken tillers and exposed peat cores of tussocks. Trails were less visible in the second year after disturbance, because the plant litter had weathered to a less noticeable gray and the exposed peat was drier and lighter in color. Disturbance ranged from scuffed tussocks (tillers broken) to tussock mound tops destroyed (peat cores exposed or tussocks cracked) to ruts starting to form (continuous mound top destruction). Total plant cover decreased significantly on most plots when compared to nearby controls. Small patches of exposed soil were common on disturbed plots due to disrupted tussocks.

Cover of the deciduous shrubs *Betula nana* s.l. and *Salix planifolia* ssp. *pulchra* and the evergreen shrubs *Ledum palustre* ssp. *decumbens* and *Vaccinium vitis-idaea* decreased on disturbed plots compared to adjacent controls. Little recovery in shrub cover was evident on 2-year-old plots. Vegetative shoots of *S. planifolia* and *V. vitis-idaea* were found on bare patches, but shrubs accounted for only a small percentage of recolonizing shoots. In some cases, *B. nana* and *S. planifolia* had more current year's growth (longer twigs and greater mass) and higher nitrogen concentrations on 2-year-old disturbed plots, but few changes in phosphorus concentrations. Current year's growth of *L. palustre* and *V. vitis-idaea* showed little change in mass, but some increases in nitrogen and phosphorus concentrations.

Cover of cottongrass (*Eriophorum vaginatum*) generally decreased due to disturbance. Tillers of *E. vaginatum* were commonly found recolonizing the edges of bare patches. Most retillering occurred in the first year after disturbance. *E. vaginatum* had some significant increases in mass and nitrogen concentration on 2-year-old disturbed plots, but no changes in phosphorus. The grass *Arctagrostis latifolia* was also an important recolonizer.

Mosses, including Hylocomium splendens and Tomenthypnum nitens, were sensitive to disturbance and decreased on all vehicle trails in tussock tundra. The mosses Aulacomnium turgidum, A. palustre, Pohlia sp., and Polytrichum juniperinum were important recolonizers on bare patches. Cover of lichens (mainly the foliose lichens Peltigera spp. and Nephroma arctica) decreased significantly on all 3 disturbed plots.

Increased thaw depths were present in some plots of all disturbance levels. No track depression was identified from surveyed elevational data. Track depression would be difficult to identify in this habitat due to the uneven surface of the tussocks. The Marsh Creek plots with ruts starting to form appeared to have track depressions. However without knowledge of the original surface height, depression in these narrow tracks could not be documented.

Moist Shrub Tundra. Visible trails resulted from removal of shrubs. The ericaceous shrubs Ledum palustre ssp. decumbens and Vaccinium vitis-idaea and deciduous shrubs (especially Betula nana s.l.) decreased due to disturbance. Vegetative shoots of V. vitis-idaea and Salix phlebophylla were present recolonizing bare patches, while shoots of L. palustre, B. nana, and Salix planifolia ssp. pulchra were rare or absent. Cover of mosses, including Hylocomium splendens and Dicranum spp. decreased significantly on the more disturbed plot (S6).

Exposed soil increased with increasing levels of disturbance. At 1 highly disturbed photo-trend plot (T29), soil exposed was 19% and the percent decrease in total plant cover was 77%. Bare patches changed little between 1984 and 1985 as recolonizing shoots covered very little ground area. Graminoid species, including Eriophorum vaginatum, Arctagrostis latifolia, Hierochloe alpina, and Luzula confusa, and various forb species were important colonizers. Some significant increases in thaw depth occurred on disturbed plots, but no track depression was found.

Riparian Shrubland. Trails were visible due to canopy removal. Disturbance to ground cover, especially mosses, increased the visibility of more highly disturbed trails. Two-year-old trails were often less visible due to the lighter color of litter and drier soil in 1985. Willows (Salix ssp.) and bearberry (Arctostaphylos rubra) were the main plants affected by disturbance. Cover of forbs, horsetails, and mosses also decreased on some disturbed plots. Fewer forb species were found in frequency quadrats on disturbed plots than control plots. No recovery was evident from plant cover data. Recolonizing shoots on bare patches included the shrubs Salix reticulata and Artostaphylos rubra and the forbs Oxytropis ssp. and Astragalus umbellatus. Seedlings, especially forb seedlings, were important recolonizers in this habitat.

Dryas Terrace. Disturbance was visible as a brown trail due to removal of the vegetative mat and exposure of soil. Visibility on 1 plot (06) increased in the second year after disturbance due to loss of the moss mat. Total plant cover decreased on all 3 disturbed plots sampled. Plot 06 had the largest decreases in plant cover of any disturbed plot with an average of 85% less cover in the disturbed plot than control in both 1984 and 1985. Dryas terrace plots had the largest amount of bare ground, because the vegetative mat was easily removed.

Cover of the evergreen shrub Dryas integrifolia, deciduous shrubs (especially Salix reticulata), horsetails (Equisetum variegatum), forbs, and mosses (especially Tomenthyphum nitens) decreased at disturbed plots. No recovery of plant cover was evident in 1985 on 06, the only plot with data from 2 years. However, Dryas integrifolia was frequently found sprouting from buried stems on the edges of bare patches. Horsetail (Equisetum variegatum) and forbs (mainly legumes) were also common recolonizers.

Airphoto Analysis of Winter Seismic Trails

In 1985, studies using aerial photography to assess the impacts of the 1984 and 1985 winter seismic trails were continued by USFWS - ANWR botanists N.A. Felix, M.T. Jorgenson, M.K. Raynolds, and R. Lipkin, and biotechnicians D.L. Blank and B.K. Lance. Methods and results are reported in ANWR Progress Report No. FY 86-1-Impacts: Airphoto analysis of seismic trails on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985. (see Appendix V). Color infrared aerial photographs (1:6000) of a portion of the 1984 and 1985 seismic lines and camp moves were taken to document disturbance in the first and second years after winter seismic activities. Airphoto interpretation of vegetation types and disturbance levels was used to assess the impacts of vehicle trails over a wide variety of sites, and to determine the relative sensitivity of vegetation types on the coastal plain of ANWR.

A photo interpretation key was developed which described 9 vegetation types and 4 levels of disturbance within most types. An accuracy assessment of photo interpretations made on trails in 1984 was conducted, and the results were used to improve the 1985 photo interpretation key. A detailed discussion of the development of the photo interpretation key, and efforts to improve consistency between interpreters is included.

Fifteen percent of the points on seismic trail were photo-interpreted as level 0 (none to slight disturbance), 57% were level 1 (low), 27% were level 2 (moderate), and 2% were level 3 (high). Moist graminoid/barren tundra complex, moist sedge tussock, and moist shrub tundra had higher levels of disturbance than other vegetation types, because tussocks and hummocks characteristic of these types were easily disturbed. Dryas terraces had a high number of points with level 2 and 3 disturbance indicating the high sensitivity of this vegetation type due to low snow cover and an easily disrupted vegetative mat. In contrast, trails in riparian shrubland had low disturbance, indicating good snow cover at the time of vehicle travel or recovery of damaged willows. The area west of the Sadlerochit River had higher disturbance levels than the area east of the Sadlerochit River due to differences in snow cover and vegetation types. Overlapping camp moves and seismic trails had higher levels of disturbance than either camp moves or seismic lines alone. Camp moves had more level 2 and 3 disturbance than seismic lines, and all level 3 camp moves were narrow trails. Camp moves also had more level 0 than seismic lines due to routing through less sensitive areas. 1985 camp moves had lower disturbance levels than 1984 camp moves due to improved routing and better snow cover in 1985. 1985 seismic trails had higher disturbance levels than 1984 seismic trails due to the use of the heavier vibrator trucks in 1985 and slight recovery of the 1984 trails. Final agreement checks between and within photo interpreters indicated that the interpreters were reasonably consistent, but some confusion still occurred between closely related vegetation types and disturbance levels. A ground check on the accuracy of the photo interpretations will be conducted during the 1986 field season.

Snow Distribution and Its Relationship to Disturbance

In 1985, the study of snow cover on the coastal plain and its ability to reduce disturbance due to winter seismic exploration was continued by USFWS - ANWR botanists N.A. Felix, M.T. Jorgenson, M.K. Raynolds, R. Lipkin, and biotechnicians D.L. Blank and B.K. Lance. Methods and results are reported in ANWR Progress Report No. FY 86-3-Impacts: Snow distribution on the arctic coastal plain and its relationship to disturbance caused by winter seismic exploration, Arctic National Wildlife Refuge, Alaska, 1985. (see Appendix V). The objectives of this study were to measure annual and seasonal variations in snow cover on Barter Island, to determine the distribution of snow across ANWR's coastal plain, and to assess the relationship between snow cover and the amount of disturbance caused by seismic vehicles traveling across the tundra.

Snow accumulation data from Wyoming snow gauges near the ANWR coastal plain were summarized for the period 1976-1986. Total snow accumulation was low in 1984 and closer to average in 1985 and 1986. Monthly snow measurements were made on 2 transects on Barter Island in 1985 and 1986. Snow depths gradually increased during both winters, while depth hoar increased early in the season and remained the same from January through May. Hardness of snow or the strength of bonding between crystals was measured using a Rammsonde penetrometer. The Rammsonde hardness increased during the first part of both winters, then decreased after March or April. Hardness was highly variable at individual points along the transects. Snow density averaged 0.30 g/cm^3 over both years.

Snow depths were measured as the seismic crews traveled across the coastal plain in 1984 and 1985. These snow depths averaged 23 cm in 1984 and 30 cm in 1985. Snow distribution across the coastal plain was highly variable due to wind transport of snow which resulted in little cover on hill crests or ridges and deep accumulations in basins and drainages. The area west of the Sadlerochit River had less snow than the eastern portion of the coastal plain. On the western side, moist sedge tussock tundra and moist graminoid/barren tundra complex had less snow than wet graminoid tundra. Overall, wet graminoid tundra and closed riparian shrubland had the highest snow depths while Dryas terrace and open riparian shrubland had the lowest snow depths. No significant differences in average snow depths were observed between terrain types, elevations, and aspects.

Ninety-six study plots were established on seismic lines and camp moves in tussock tundra and moist sedge-shrub tundra to study the relationship between snow cover and disturbance. Snow depth data were collected in the winter, and plant cover changes, tussock disturbance, and trail visibility were measured in the summer. In tussock tundra, plots with snow depths over 25 cm had significantly less disturbance than those with less than 25 cm. Moderate disturbance did not occur at snow depths over 25 cm or slab depths over 15 cm. Low level disturbance occurred at snow depths as high as 45 cm and slab depths as high as 39 cm. The relationship between snow cover and disturbance was less clear in moist sedge-shrub tundra, and in a number of cases, slab depth appeared to be a better measure of protective snow cover than total snow depth. Moist sedge-shrub tundra plots with greater snow or slab depth were also less disturbed, but the relationship between snow depth and disturbance was not as strong as with the tussock tundra plots, partly because of the difficulties in quantifying disturbance in this vegetation type. Moderate disturbance did not occur at snow depths over 35 cm or slab depths over 20 cm in moist sedge-shrub tundra.

Effects on Muskoxen

Muskoxen are one of the few terrestrial species which remain on the ANWR coastal plain throughout the winter and may be effected by winter seismic activities. In 1985, USFWS-ANWR biologists P.E. Reynolds and D.L. LaPlant summarized movement data and observations of muskoxen made during January - May 1985 when seismic crews were operating in the study area. These data were combined with similar information compiled by Reynolds and USFWS-ANWR biologist D.L. LaPlant in 1984. Methods and results are presented in ANWR Progress Report No. FY 86-4-Impacts: Effects of winter seismic exploration activities on muskoxen on the Arctic National Wildlife Refuge, January-May 1984-1985. (see Appendix V). The objective of this study was to document the effects of winter seismic exploration activities on distribution and movements of muskoxen in ANWR.

From January - May 1985, radio-collared muskoxen were relocated 5 times from fixed-wing aircraft. Miscellaneous observations from the air and ground were made by USFWS field monitors traveling with seismic crews. Responses of muskoxen to seismic vehicles were plotted on maps and movements of groups containing radio-collared muskoxen were determined.

Results showed that distribution of muskoxen was the same before, during, and after seismic exploration activities in 1985 and 1986. No long range movements of radio-collared muskoxen occurred. Responses of muskoxen to seismic vehicles were variable. Some animals showed no response to vehicles until they were within 100-300 m. Other animals grouped into defensive formations and ran in response to vehicles at distances of more than 3 km. Muskoxen encountered seismic vehicles infrequently during the seismic exploration program and effects on the muskox population were probably insignificant. In summers following winter seismic work in 1984 and 1985, 75 calves per 100 cows older than 3 years of age were recorded in the ANWR muskox population.

Chapter 9

IMPACTS OF FURTHER EXPLORATION, DEVELOPMENT AND PRODUCTION OF OIL AND GAS RESOURCES

In 1985, staff review of literature continued and no summaries were prepared for this interim report.

APPENDICES

Appendix I

VEGETATION

Appendix I Vegetation

Contents

Appendix I. Preliminary classification for a Landsat-derived land cover map of the coastal plain study area, Arctic National Wildlife Refuge, 1985.

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1. FOREST. This vegetation class is formed of tree species at least 5 m tall. Included within the concept of forest is secondary tree growth temporarily less than 5 m in height, i.e., intermediate succession stages.

   a. DECIDUOUS FOREST/TALL SHRUB has 25-100% tree cover. *Betula papyrifera*, *Populus tremuloides* and *P. balsamifera* are the dominant species occurring in this class. *Salix alaxensis* may also be classified in this class of alluvial terraces by itself or mixed with *P. balsamifera*. Also included are *Alnus crispa* and *Salix* spp., *Rosa acicularis*, *Shepherdia canadensis*, and *Calamagrostis canadensis*. This class is normally found on well drained to moist soils associated with hills and alluvial terraces south of the continental divide. North of the divide this type is rare, occurring mainly along the Canning River, and in a small area near Sadlerochit Springs.

2. SCRUB. This vegetation class is predominantly composed of shrubs (greater than 25 percent cover) up to 5 m in height.

   a. ALLUVIAL DECIDUOUS SCRUB occurs on frequently flooded gravel sites dominated by *Salix planifolia* ssp. *pulchra* and *S. alaxensis*. On some sites especially on the coastal plain, *Betula* spp. (dwarf birch) may occur with *Salix* in older alluvial terraces. The number of species occurring with the above species as co-dominants or as understory are many and may include: *Salix lanata* ssp. *richardsonii*, *S. glauca*, *S. brachycarpa*, *S. hastata*, *S. reticulata*, *Arctostaphylos rubra*, *Dryas integrifolia*, *Equisetum arvense*, *E. variegatum*, *E. scirpoides*, *Carex* spp., *Festuca* spp., *Juncus castaneus*, *Petasites* spp., *Hedysarum* spp., and *Hylocomium* spp. On the coastal plain, this class usually occurs in small patches which can not be distinguished on Landsat imagery, and is classified as scarcely vegetated floodplain.

   b. DRY PROSTRATE DWARF SCRUB formation occurs on river terraces, slightly elevated microsites on the coastal plain, and upper slope positions in the foothills. Bare soil is often an important component of the ground surface as a result of frost action. Because of the harsh environment, plants do not achieve heights greater than 10 cm. Some of the more commonly occurring shrubs are *Dryas integrifolia* (usually dominant) and *D. octopetala* with *Arctostaphylos rubra*, *Salix reticulata*, *S. rotundifolia* and *Cassiope tetragona*. Nonwoody species include *Saxifraga hirculus*, *S. oppositifolia*, *Polygonum bistorta*, *Petasites arctica*, *Polemonium* spp., *Equisetum arvense*, *Carex* spp., *Festuca* spp., *Hierochloe* spp., *Epilobium latifolium*, *Geum glaciale*, and the lichen *Cetraria* spp.

c. MOIST PROSTRATE DWARF SCRUB contains prostrate dwarf shrubs and sedges occupying mesic habitats on gentle to moderately steep slopes. In the foothills, these habitats are frequent on mid to lower slopes which receive subsurface drainage from adjacent terrain. *Dryas integrifolia* is often the dominant species. *Equisetum arvense* and the moss, *Tomenthypnum nitens*, are characteristic species of this land cover class. *Carex bigelowii* gives the habitat a hummocky surface. Moist habitats on slightly elevated microsites in the coastal plain, and alluvial terraces in the foothills and mountains are often drier, owing to greater exposure and lack of water from surrounding terrain. Lichens are more important than mosses in these drier habitats. These habitats are very similar to the moist microsites of the wet/moist dwarf shrub, graminoid land cover class. Other species important to this type include *Salix arctica*, *S. lanata*, *S. pulchra*, *Rubus chamaemorus*, *Saxifraga hirculus*, *S. punctata*, *Petasites frigidus*, *Eriophorum vaginatum*, and *Carex aquatilis*.

d. MESIC ERECT DWARF SCRUB contains dwarf shrubs, primarily from the taxa *Betula* spp., *Salix* spp., *Vaccinium uliginosum*, and *Cassiope tetragona*. These shrubs are usually 0.1 m to 0.5 m in height with interlocking branches. This type is common on low rolling hills. On hillsides at lower elevations (below 900 m), graminoid tussocks often occur with the dwarf shrubs. Major tussock producing plants include *Eriophorum vaginatum* and *Carex bigelowii*. Major shrub species include *Betula glandulosa*, *B. nana*, *Salix glauca*, *S. reticulata*, *S. planifolia* ssp. *pulchra*, *Ledum decumbens*, *Vaccinium vitis-idaea*, and *Empetrum nigrum*. Other species present may include *Carex lugens*, *Carex scirpoidea*, *Equisetum arvense*, *E. scirpoides*, *Hylocomium splendens*, *Tomenthypnum nitens*, and *Sphagnum* spp.

3. HERBACEOUS. Herbaceous plants are without significantly woody tissue and die back to the ground surface each year. There are two major growth forms: graminoids and forbs. Graminoids include all nonwoody grasses and grasslike plants such as *Carex* (sedges) and *Eriophorum* (cottongrass). Forbs are broad-leaved herbaceous plants such as *Petasites* (coltsfoot) and *Epilobium* (fireweed).

a. VERY WET GRAMINOID is a graminoid-dominated formation associated with aquatic habitats surrounding large, open bodies of fresh water; very wet habitats which contain numerous small bodies of open water; and coastal habitats frequently inundated with salt water. Surface forms include low-centered polygons with abundant standing water, thaw lake basins, the littoral zones of lakes and the coastline. *Arctophila fulva* is the primary species in deeper water, up to 1 m deep, with *Carex aquatilis*, *Eriophorum Scheuchzeri*, and *Eriophorum angustifolium* dominating areas where the water is less than 30 cm deep.

b. WET GRAMINOID formations are associated with wet habitats. These habitats often receive water by surface and subsurface flow from surrounding terrain. The habitats generally have standing water throughout the summer. Vegetative cover is continuous, as depth of water is not a limiting factor to plant establishment and growth. The habitat has few drained microsites associated with polygon rims, strangmoor, hummocks, etc. Landforms where these habitats occur are river deltas, drained lake basins, and river channels, where surface forms are low-centered polygons, and strangmoor. Primary taxa include numerous Carex spp. and Eriophorum spp. Common species occurring in this type include Carex aquatilis, C. microglochin, C. atrofusca, C. amblyorhyncha, C. scirpoidea, C. rostrata, C. bigelowii, C. physocarpa, C. misandra, Eriophorum vaginatum, E. angustifolium, E. russeolum, Equisetum fluviatile, Scirpus spp. Pedicularis spp., Valeriana capitata, Polygonum spp., Tomenthypnum nitens, and Drepanocladus spp. Some shrub species include Arctostaphylos rubra, Salix lanata ssp. richardsonii, and S. arctophila.

c. MOIST/WET TUNDRA COMPLEX is a type in which dwarf shrubs and graminoids occur together in habitats intermediate in moisture regime between the wet graminoid and moist dwarf shrub formations. Wet and moist microsites are often intermixed in a complex pattern in this habitat. High-centered and flat-centered polygons are common surface features in river delta and drained lake basin landforms. Along river drainages, disjunct string bogs are the most common surface form. Common species on these sites include Dryas integrifolia, Salix lanata ssp. richardsonii, S. reticulata, Cassiope tetragona, Vaccinium uliginosum, Eriophorum triste, E. vaginatum, Carex bigelowii, C. membranacea, Polygonum bistorta, Stellaria laeta, Senecio spp., Tomenthypnum nitens, and Hylocomium spp.

d. MOIST GRAMINOID TUSSOCK is a subclass related to part of the scrub subclass mesic erect dwarf scrub. Species dominating this class include the tussock producing Eriophorum vaginatum and Carex bigelowii. Also occurring are Betula nana, Salix planifolia ssp. pulchra, S. reticulata, Dryas integrifolia, Vaccinium uliginosum, V. vitis-idaea, Pyrola spp., Polygonum bistorta, P. viviparum, Cetraria spp., Tomenthypnum nitens, Hylocomium splendens, and Ptilidium ciliare.

4. SCARCELY VEGETATED AREAS. In this class plants are scattered or absent and bare mineral soil or rock determines the overall appearance of the landscape.

a. SCARCELY VEGETATED SCREE (5-20 % plant cover) comprises steep slopes of stones beneath weathering rocks. It is a very open fellfield and often grades into dry prostrate dwarf scrub. Some shrubs commonly found in this type, in prostrate or decumbent forms, are Betula.

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nana, Dryas integrifolia, D. octopetala, Vaccinium uliginosum, Cassiope tetragona, and Salix phlebophylla. Some other species found include Umbilcaria spp., Cystopteris spp., Diapensia lapponica, Cetraria spp., Lupinus arcticus, and Carex spp.

b. BARREN SCREE (less than 5% plant cover) is less vegetated than scarcely vegetated scree. It may form a type of lichen tundra dominated by blackish lichens, particularly the genera Umbilicaria, Cetraria, Cornicularia, and Pseudophebe. These plants are on the very limit of life's possibilities and the sites may be devoid of flowering plants.

c. SCARCELY VEGETATED FLOODPLAIN is a subclass that is a result of the initial invasion of plants on recent river alluvium. Plant cover averages 5-20 percent. Some of the more common species include Epilobium latifolium, Calamagrostis canadensis, Bromus spp., and Salix spp. On the coastal plain (below the 500 meter contour) this type includes alluvial deciduous scrub communities.

d. BARREN FLOODPLAIN is less vegetated than scarcely vegetated floodplain. It consists of alluvium and includes silt, sand, and rocks. Plant cover is less than 5 percent and includes the same species as scarcely vegetated floodplain if present.

5. OTHER CATEGORIES.

a. CLEAR WATER including lakes, pond, and rivers.

b. CLOUDS or ICE are dependent upon individual yearly weather patterns. Ice, in the form of pack ice and aufeis, may or may not be present on the ground or in the ocean as depicted on the map. Glacial ice in the mountains is probably stable and what is shown on the map could be found on the ground.

c. SHALLOW WATER includes riverine areas in which the water is shallow or when the satellite sensor received spectral data from both water and gravel bars and recorded them as one class.

d. OFFSHORE WATER is the Beaufort Sea shoreline as was digitized on the Flaxman Island, Barter Island, Demarcation Point, and Mount Michelson quads and applied to the land cover image. Those water areas north of the shoreline were labeled offshore water.

e. SHADOW--This type includes both terrain shadow (that is, mountain shadow) and cloud shadow.

Appendix II

BIRDS

Appendix II BIRDS

ANWR Progress Report Number FY86-14

TERRESTRIAL BIRD POPULATIONS AND HABITAT USE IN COASTAL PLAIN TUNDRA OF THE ARCTIC NATIONAL WILDLIFE REFUGE

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Key words: Anseriformes, Charadriiformes, Passeriformes, waterfowl, shorebirds, songbirds, tundra, wetlands, breeding bird census, populations, habitat use, community structure, status and distribution, Arctic-Beaufort north slope.

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3 February 1987

ANWR Progress Report No. FY86-14

Terrestrial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge, Alaska.

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Abstract: Five breeding season and 3 post-breeding season bird censuses were conducted on 119 10-ha plots representing 7 habitat types at 8 study sites on the coastal plain of the Arctic National Wildlife Refuge in 1985. Six of these sites were sampled in previous years. Plant flowering and bird breeding phenologies were similar among years for most species. Lapland longspurs were most common in Riparian and upland habitats during reproductive and post-reproductive seasons and primarily nested in upland habitats, with differences in habitat use among locations. Pectoral sandpipers preferred Flooded and other wet habitats for foraging and nesting during the reproductive season, and Flooded and upland (except Tussock) habitats during the post-reproductive season with large density variations within habitats among locations. Semipalmated sandpipers were seen most often in Riparian habitat during the breeding season. No significant differences among habitats in nest densities and bird densities in the post-reproductive season were observed. Densities varied up to 20-fold among locations within habitats. Lesser golden-plovers were found in significant numbers in all habitats through the summer but densities were highest in Riparian habitats. Location was a significant factor in relative use of Flooded and Tussock habitats. Red-necked phalaropes strongly preferred Flooded habitat for foraging and nesting during reproductive and post-reproductive seasons, but use of Flooded (and most other) habitats declined during the post-reproductive season. Riparian and Flooded habitats had the highest densities of total birds and the greatest numbers of species during the reproductive and post-reproductive seasons. Significant annual variability was observed. Lapland longspur densities at Okpilak and in some habitats at Aichilik, Sadlerochit and Jago Delta, and nest densities at Jago Delta changed yearly. Densities of pectoral sandpipers declined significantly in all habitats at Jago Bitty and in some habitats at Aichilik, but increased in some habitats and decreased in others at Okpilak. Pectoral sandpiper nest densities fluctuated among years independently of bird densities. Semipalmated sandpiper densities annually fluctuated at Okpilak but generally declined at Katakturuk and Aichilik. Lesser golden-plover densities changed yearly in Moist Sedge-Shrub habitat at Okpilak and in Tussock habitat at Sadlerochit, and declined at Aichilik, but nest densities increased in Tussock habitat at Sadlerochit and in all habitats at Jago Delta where no nests had been found previously. Red-necked phalarope densities increased among years at Jago Bitty and decreased in Moist Sedge-Shrub at Aichilik. No consistent patterns of total bird use were observed among years. Variation among censuses within study plots was often the highest source of variation for bird densities during the reproductive and post-reproductive seasons. Variation in nest densities among replicate plots within habitats was usually higher than variation among locations within habitats.

Terrestrial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge.

A prerequisite for the assessment and minimization of impacts due to increased energy exploration and development activity is a thorough knowledge of terrestrial bird populations and the relative importance of the habitat types which they occupy (Brooks et al. 1971, Bergman et al. 1977, Myers and Pitelka 1980, Derksen et al. 1981). Prior to this study several terrestrial bird census projects were undertaken by the U.S. Fish and Wildlife Service (USFWS) and other researchers to document status, distribution, population levels, and habitat use by birds in various (mostly coastal) locations, on the Arctic National Wildlife Refuge (ANWR) north slope. Studies by Schmidt (1970) at Beaufort Lagoon and Magoun and Robus (1977) of the area between the Jago and Katakturuk Rivers were extensive in sample coverage, and were followed by several more intensive site-specific studies: Spindler (1978) at the Okpilak River delta, Burgess (1984) at Demarcation Bay in 1978 and 1979, and Martin and Moitoret (1981) at the Canning River delta. Synthesis of data from these studies indicated that habitat use patterns by nesting and transient populations of common species varied spatially between differing habitats and within the same habitat types, and varied seasonally and annually within the same habitat type (U.S. Fish and Wildlife Service 1982). Major data gaps identified were: 1) insufficient intensive coverage for inland and riparian habitats and 2) insufficient sample size for several of the habitat types that would allow ranking of habitats according to levels of bird use (U.S. Fish and Wildlife Service 1982). To assess seasonal and annual variation in habitat use with statistical validity, geographically dispersed replicates within each habitat over several years are desirable (Bell et al. 1973, States et al. 1978, Myers and Pitelka 1980, Anderson et al. 1981, Hilden 1981, Martin and Moitoret 1981, Svensson 1981, Wiens 1981).

In 1982, an intensive bird census study was initiated to provide multi-year population data for 4 habitats on 2 sites (one coastal and one inland) on the coastal plain of the refuge (Spindler and Miller 1983). Primary objectives were to determine annual and seasonal changes in populations of key tundra-nesting bird species on inland and coastal tundra habitats as defined by recent Landsat habitat mapping efforts (Walker et al. 1982) and to compare the sampling efficiency of small (10 ha) plots vs. larger (25 or 50 ha) plots. Findings of the 1982 study showed that breeding densities varied between habitat types and that the highest densities were found in the Riparian[a] and Mosaic (Moist/Wet Sedge Tundra)[a] types (Spindler and Miller 1983). Additionally, variability of bird densities within a habitat type differed among habitat types, with Wet Sedge and Tussock being the most variable. The 1982 study also indicated that 10 ha was the more efficient plot size for determining bird density given the observed variation between plots.

The study design in 1983 was expanded to include an additional study site and a total of seven habitats. Primary objectives were to:

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[a] Habitat type names adapted from Walker et al. (1982) (see Table 1).

1. Determine and compare densities of breeding, resident, and transient birds in the major habitat classes defined by recent Landsat mapping of the ANWR coastal plain, as modified by Spindler et al. (1984).

2. Determine breeding, resident, and transient population density estimates of quality sufficient to make total population extrapolations for the ANWR coastal plain.

3. Determine baseline levels of annual and seasonal variation for the most abundant species (pectoral sandpiper and Lapland longspur) and less abundant, but conspicuous, species (red-necked phalarope, lesser golden-plover, and semipalmated sandpiper).

Three replicate census plots were established in each Landsat-identified habitat type (Walker et al. 1982) at each study site. Based on the habitat classification of the Landsat map, it was anticipated that estimates of bird densities derived from sample plots could be extrapolated to areas of like Landsat classes elsewhere on the coastal plain of the Refuge.

Numerous problems of misclassification or overlap of habitat types on the Landsat map, as documented in Spindler et al. (1984), created difficulties in addressing objectives 1 and 2. Objective 1 was modified to estimate and compare breeding, resident, and transient bird densities for habitats that could be identified on the ground using a modified Landsat classification scheme (Table 1). The modifications in methods included adding the Riparian habitat type and dividing Landsat class IV into two types: Mosaic (which included subcategories of Landsat classes III and IV) and Moist Sedge (which was not defined by Landsat). Problems associated with population extrapolations for the ANWR coastal plain were not resolved. Estimates of bird densities by habitat could still be applied on a site-specific basis in order to assess potential impacts of a particular activity.

The results of the 1983 analyses indicated that three habitats (Flooded, Riparian, and Mosaic) had significantly higher bird densities and greater diversity of species than the other four habitats. Riparian habitat had significantly higher nest densities than all other habitats. Significant differences in bird densities due to location were primarily attributed to differences in habitat types available and their quality at inland versus coastal sites. Significant seasonal variability (which varied between habitats) suggested that certain habitats, such as Wet Sedge, were more important for staging and feeding by migrating flocks than for breeding birds during the post-breeding season. Analysis of annual variability for 1978, 1982, and 1983 at a single site (Okpilak) indicated that there were significant population changes between years which were not consistent for each habitat.

Experimental design for the 1984 season was similar to the 1983 design. However, three different study sites were censused to provide more information on locational variation of avian habitat use, and additional censuses were conducted during the post-breeding season to provide more data on seasonal habitat use. Levels of annual variability could not be addressed with three new study sites, and this analysis was deferred until 1985.

Table 1. Habitat classes of 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.

Habitat class		Landsat cover unit	Dominant cover types not recognized by Landsat
No.[a]	Abbreviated name		
II	Flooded	Pond/Sedge Tundra Complex (IIa) Aquatic Tundra (IIb) Wet Sedge Tundra - Very wet complex (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 (*Dryas* River Terraces-IVb) Partially Vegetated Areas-River Bars (IX) Barren Gravel or Rock (X) Barren Mud or Wet Gravel (XI)	low willow[c]

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[a] Number generally corresponds with dominant Landsat cover unit number

[b] Homogenous moist sedge meadow with little or no micro-relief (Spindler et al. 1984)

[c] Vegetation type described by Viereck et al. (1982)

Analyses of 1984 data revealed that different habitats generally had higher bird densities at each of the three study locations: Moist Sedge-Shrub at Aichilik; Riparian at Sadlerochit; and Mosaic at Jago Delta (Moitoret et al. 1985). However, Mosaic habitat had significantly higher total nest densities than other habitats at both locations (Sadlerochit, Jago Delta) at which it occurred. Total bird densities were higher in Wet Sedge habitat at coastal locations than at the inland site throughout the summer. Densities of total birds increased from reproductive to post-reproductive season in three habitats: Wet Sedge (primarily at Jago Delta), Moist Sedge (at Aichilik), and Riparian (primarily at coastal locations). Spatial and temporal variability of bird densities also increased during the post-breeding season, largely due to movements of migratory flocks (Moitoret et al. 1985).

A clustering and ordination analysis (TWINSPAN) of 1983 and 1984 reproductive season census data showed Flooded and Riparian plots were distinct from all other habitats, with higher and more diverse bird use (Moitoret et al. 1985). The remaining five plot-types were separated into those with very wet habitats or high interspersion of habitats (all Mosaic plots, most Wet Sedge plots, and Moist Sedge-Shrub and Tussock plots with interspersions of ponds) versus those with more uniform and generally drier habitats (all Moist Sedge plots, most Tussock plots, Moist Sedge-Shrub plots without ponds, and a few marginally wet Wet Sedge plots). The former category had higher and more diverse bird use than the latter.

Materials and Methods

Study Area

The study was conducted on the ANWR coastal plain from 31 May to 30 August 1985. The arctic coastal plain is a relatively flat 790,000 ha portion of the 7,300,000 ha refuge, extending from the northern foothills of the Brooks Range to the Beaufort Sea coastline. It contains four major landform types described by Walker et al. (1982): thaw-lake plain near the coast in the vicinity of the larger river deltas, floodplain extending along the major river and creek drainages, hilly coastal plain areas, and foothills. Ten study sites were established for the project (Fig. 1), but only eight were censused in 1985 (Table 2).

Study sites for the project were selected primarily on the basis of representation of major modified Landsat habitat types (Table 3a) and landform types (Table 3b), geographic distribution throughout the study area, and representation of both coastal and inland areas. Other significant considerations included proximity to several (4-5) habitats within walking distance of a central camp location, availability of data from previous studies (Okpilak Delta), and likely areas of high impact from potential oil development (Marsh Creek, Niguanak).

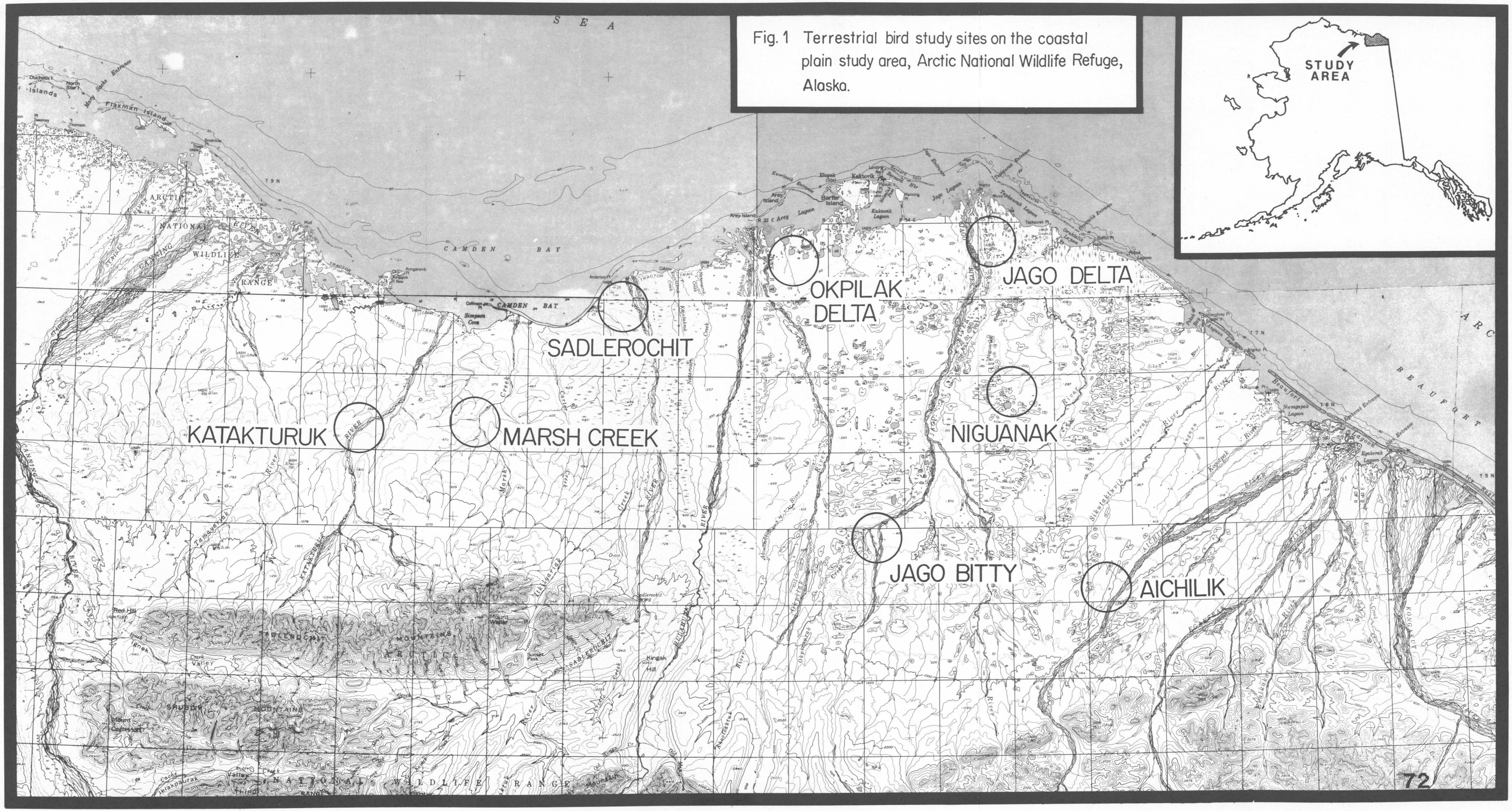

Fig. 1 Terrestrial bird study sites on the coastal plain study area, Arctic National Wildlife Refuge, Alaska.

Table 2. Terrestrial bird study sites on the coastal plain study area, Arctic National Wildlife Refuge, Alaska, 1982-1985.

Study site name	Abbrieviation[a]	Years censused			
		1982	1983	1984	1985
Coastal sites:					
Okpilik	OKP	X	X		X
Jago Delta	JDE			X	X
Sadlerochit	SAD			X	X
Inland sites:					
Katakturuk	KAT	X	X		X
Jago Bitty	JBI		X		X
Aichilik	AIC			X	X
Marsh Creek	MCR				X
Niguanak	NIG				X

[a] Study site names are abbreviated in some figures and tables.

The Okpilak (OKP) study area was located 1-6 km inland from marine waters of the Beaufort Sea and 11-16 km southwest of the village of Kaktovik on Barter Island (Fig. 2). This study area included large lake and wetland areas.

The Sadlerochit (SAD) study site, located at the mouth of the Sadlerochit River on the west bank, extended 0.5-6 km inland from the Beaufort Sea and was approximately 34 km southwest of Kaktovik (Fig. 3). It was the only study site in an area where the foothills landform type extends to the Beaufort Sea coast. The Sadlerochit site therefore differed from other coastal sites in the presence of drier inland-type habitats and the absence of large lakes or wetlands.

The Jago Delta (JDE) site was located on the east side of the Jago River, 2-7 km from the Beaufort Sea and about 14-19 km east-southeast of Kaktovik (Fig. 4). It differed from the Sadlerochit Delta site by the presence of extensive shallow ponds. While the Okpilak Delta site was in the thaw-lake plain landform, the Jago Delta site consisted of floodplain and hilly coastal plain in which there were relatively few large lakes.

The Katakturuk (KAT) study area was an inland site about 75 km west-southwest of Kaktovik (Fig. 5). It was located 15-17 km south of the Beaufort Sea and 22-24 km north of the Sadlerochit Mountains, along the Katakturuk River. The Katakturuk River study area differed from the Okpilak River delta study area by the presence of more extensive prostrate shrub ground cover in Moist Sedge-Shrub Tundra, presence of Tussock Dwarf Shrub Tundra, absence of extensive wetlands, and greater topographic relief (Spindler and Miller 1983).

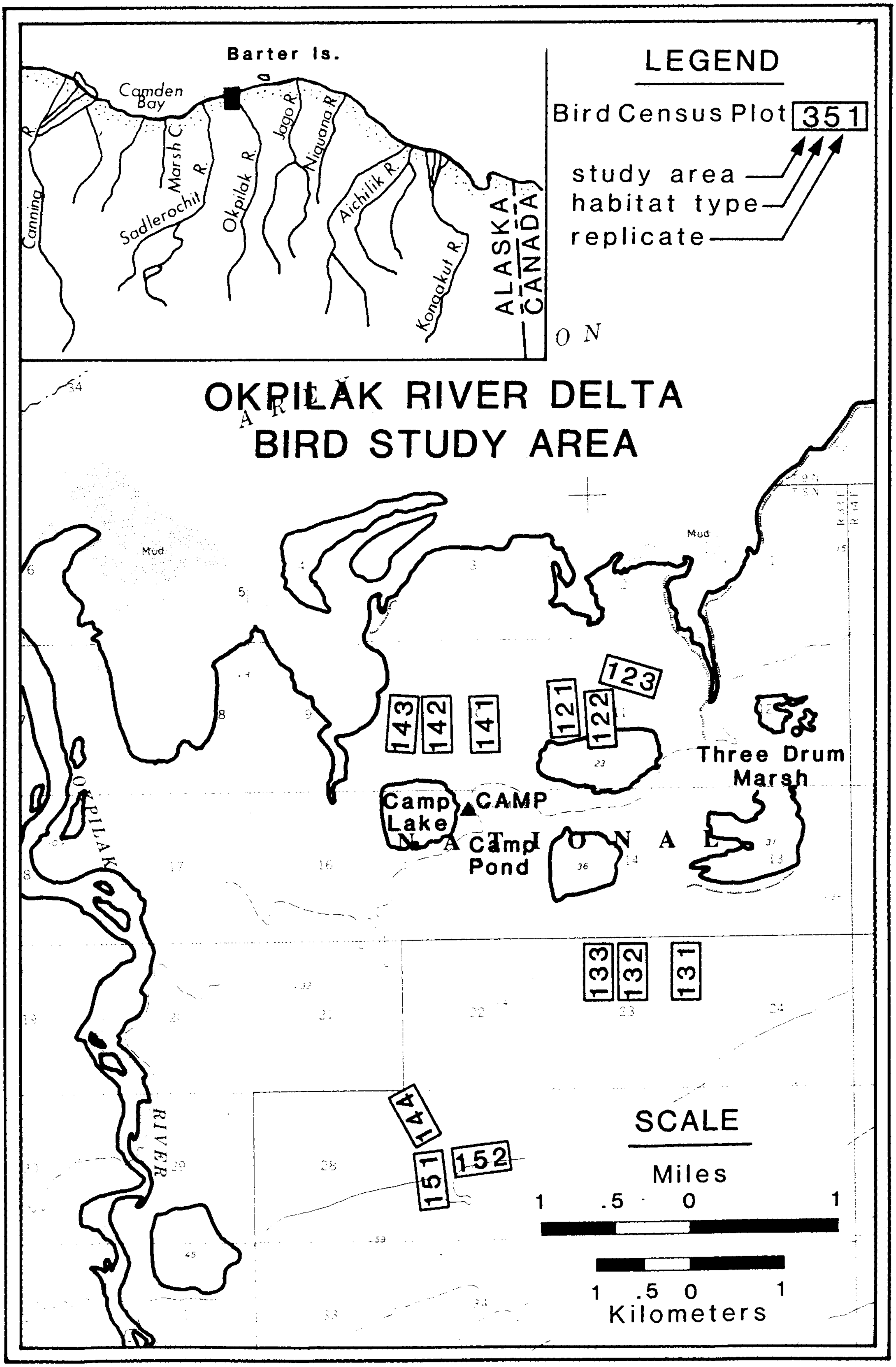

Fig. 2. Okpilak River Delta study area, Arctic National Wildlife Refuge, Alaska.

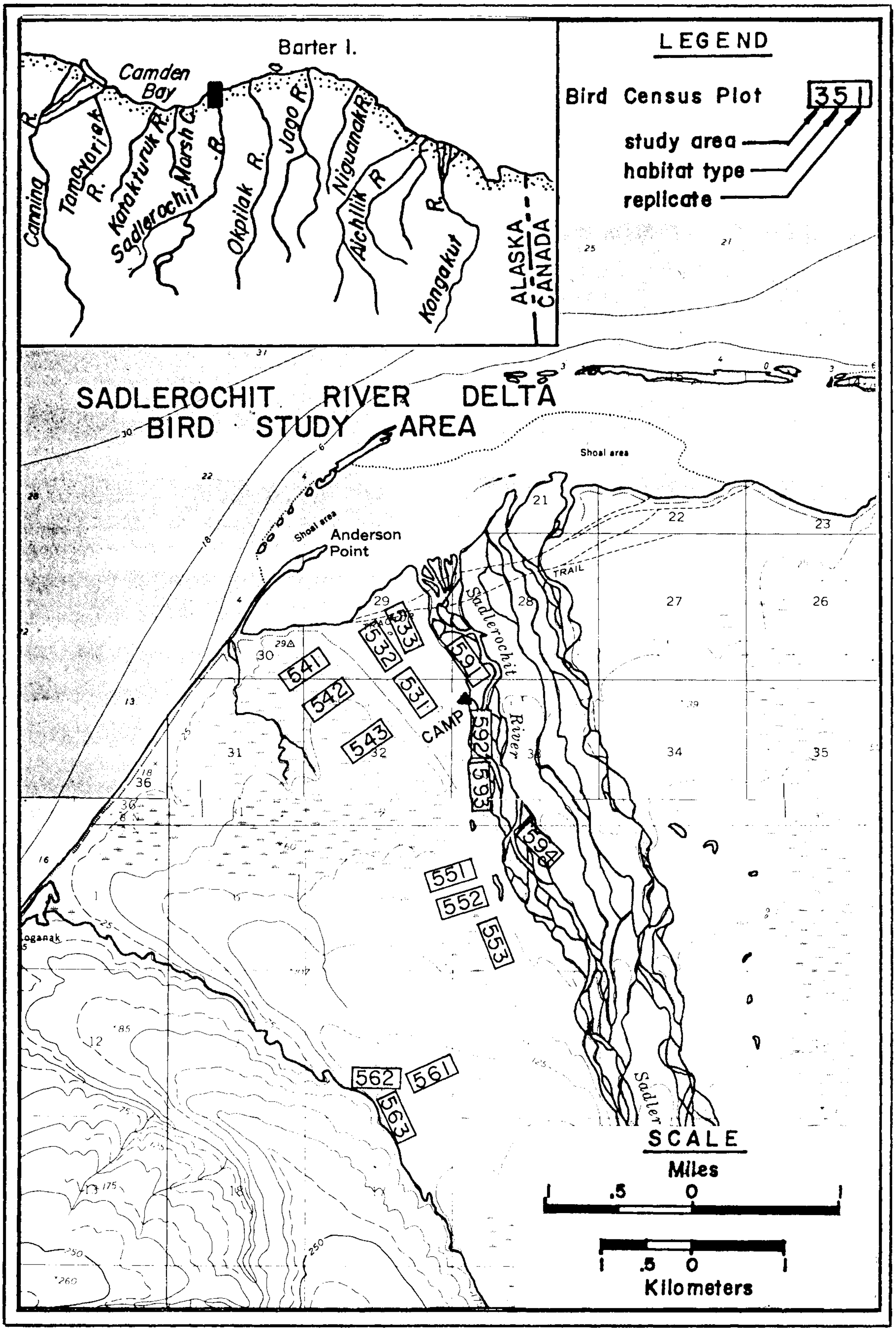

Fig. 3. Sadlerochit River study area, Arctic National Wildlife Refuge, Alaska.

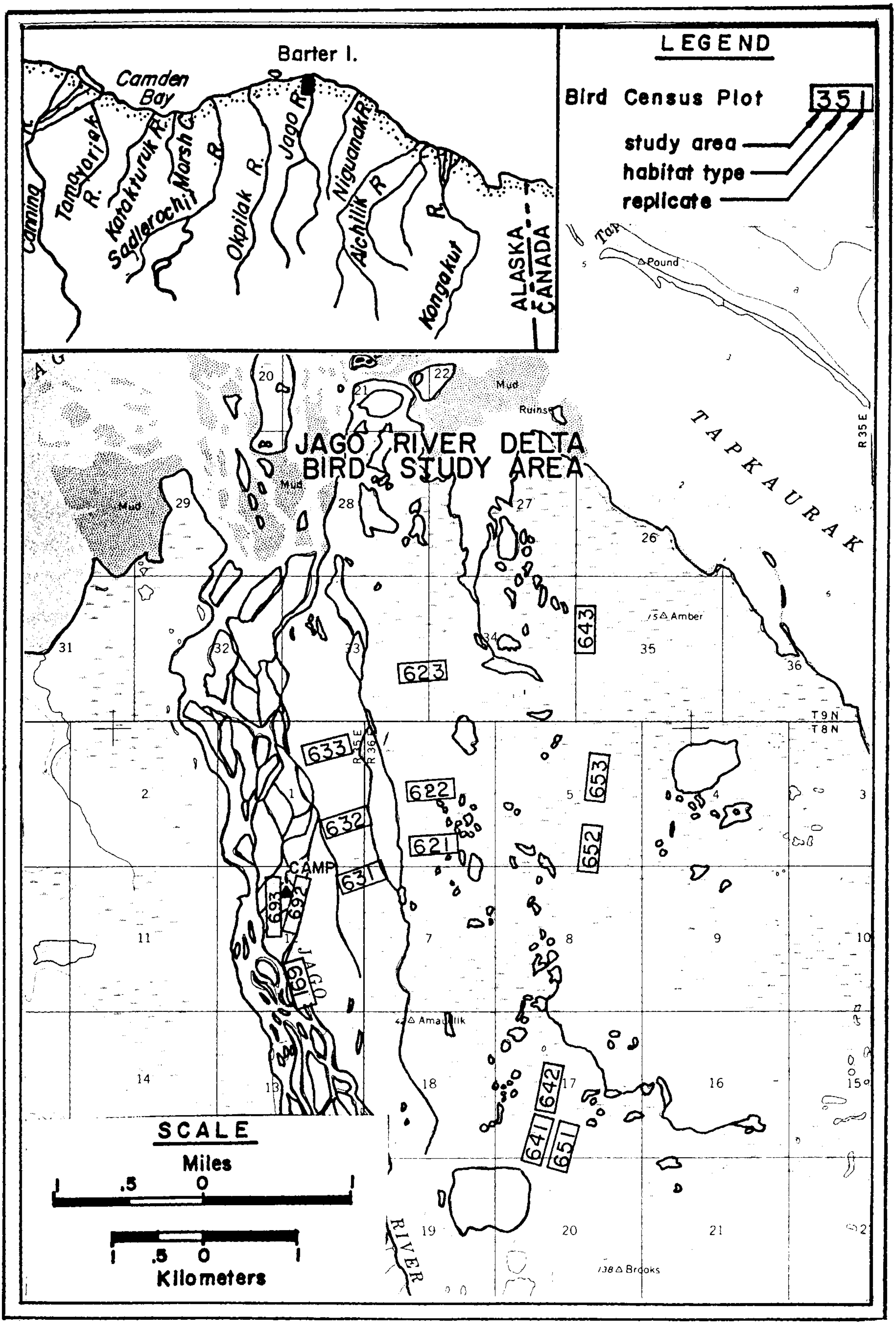

Fig. 4. Jago River Delta study area, Arctic National Wildlife Refuge, Alaska.

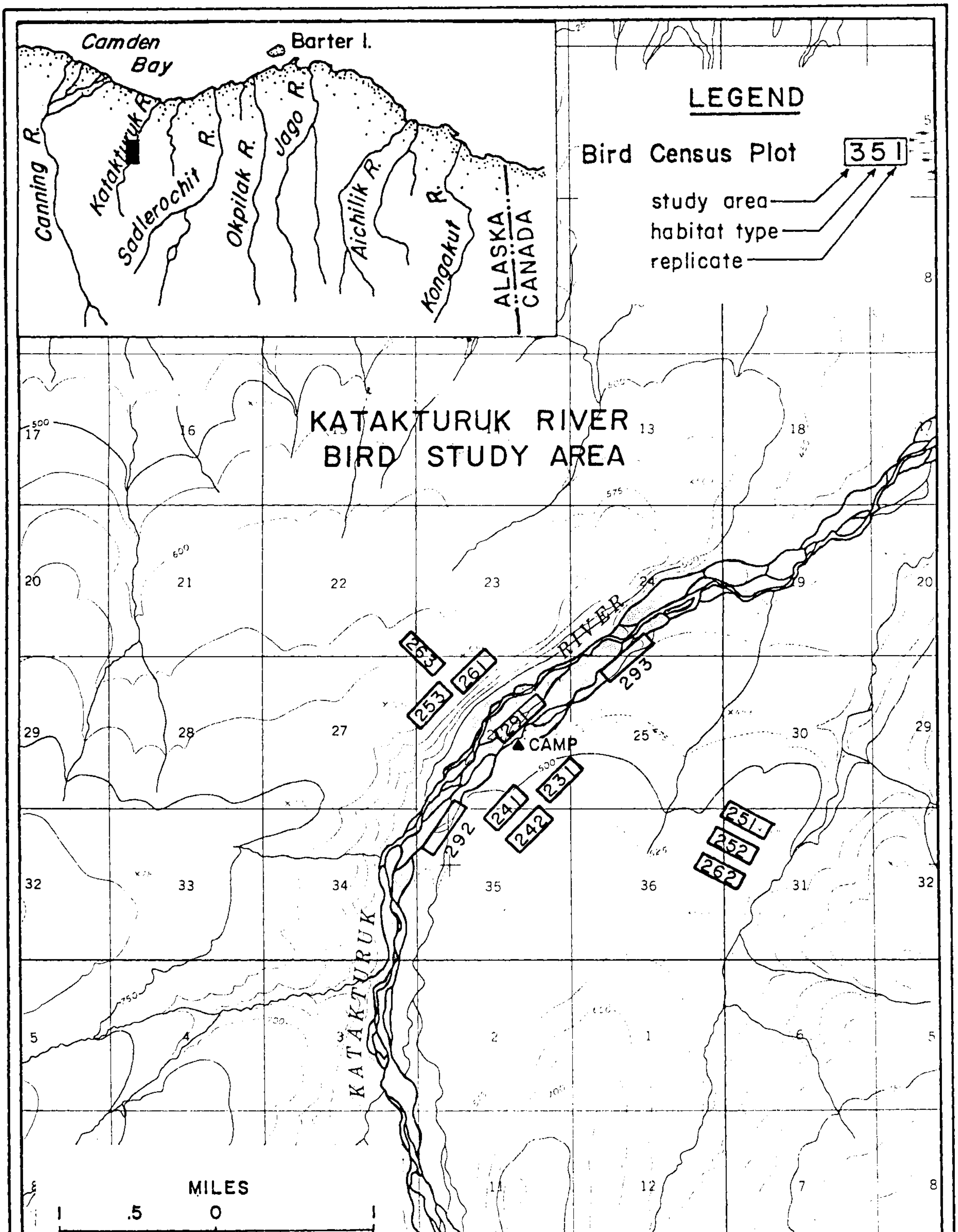

Fig. 5. Katakturuk River study area, Arctic National Wildlife Refuge, Alaska.

Table 3a. *Number of 10-ha plots of each habitat type at each bird study site, coastal plain, Arctic National Wildlife Refuge, Alaska, 1985*

	Habitat (Class No.)						
Study areas (census years)	Flooded (II)	Wet Sedge (III)	Moist Sedge (IV)	Mosaic (IVa)	Moist Sedge-Shrub (V)	Tussock (VI)	Riparian (IX)
Coastal sites:							
Okpilak (82[a], 83, 85)	3	3		4	2		2
Jago Delta (84, 85)	3	3		3	3		3
Sadlerochit (84, 85)		3		3	3	3	3
Inland sites:							
Katakturuk (82[a], 83, 85)		1	2		3	3	3
Jago Bitty (83, 85)		3	3		3	3	3
Aichilik (84, 85)		3	3		3	3	3
Marsh Creek (85)		1	3		4	3	3
Niguanak (85)	3	3			3	3	

[a] Not all habitats censused; see Spindler and Miller (1983) for sampling design

Table 3b. Landform types represented at each bird study site, coastal plain, Arctic National Wildlife Refuge, Alaska, 1985.

	Landform type[a]			
Study area	Floodplain	Thaw-lake plain	Hilly coastal plain	Foothills
Coastal sites:				
Okpilak	X	X	X	
Jago Delta	X		X	
Sadlerochit	X		X	X
Inland sites:				
Katakturuk	X			X
Jago Bitty	X		X	X
Aichilik	X			
Marsh Creek	X			X
Niguanak			X	

[a] Walker et al. (1982)

The Jago Bitty (JBI) study area was an inland site situated 45 km south of Kaktovik. It was located 37-43 km south of the Beaufort Sea and 30-36 km north of the Brooks Range, on the Jago River and was approximately 13 km northeast of VABM Bitty (Fig. 6). It was similar to the Katakturuk study area in extent of willow cover in the Riparian habitat, extent of shrub cover in the Moist Sedge-Shrub and Tussock habitats, absence of wetlands, and amount of topographic relief. It differed from the Katakturuk River study area in that the area included some large lakes and extensive Wet Sedge habitat nearby. Moist Sedge habitats contained more erect willow cover than Katakturuk, yet willows in the Riparian habitats at Jago-Bitty were shorter than at Katakturuk.

The Aichilik (AIC) study site, located about 60 km southeast of the village of Kaktovik, was approximately 32-37 km inland from the Beaufort Sea and 10-15 km from the Brooks Range (Fig. 7). This site differed from Katakturuk and Jago Bitty study areas by having less topographic relief. The Aichilik study site was entirely within the floodplain, whereas the inland sites additionally represented foothills and hilly coastal plain landforms.

The Marsh Creek (MCR) site was located 58 km southwest of Kaktovik and 13 km inland from the Beaufort Sea, on Marsh Creek (Fig. 8). This area was characterized by lush, riparian willows and sedge meadows along the creek, and dense tussocks on the surrounding hills. Riparian shrub cover was generally taller and more extensive than in the other study areas, and extensive wetlands and lakes were absent. The area was primarily within the foothills landform type, and a narrow strip of floodplain was present along the creek.

The Niguanak (NIG) site, 30 km southeast of Kaktovik, was located adjacent to a large lake between the Jago and Niguanak Rivers (Fig. 9). It was 24 km inland from the Beaufort Sea coast and 42 km from the Brooks Range. This was the only site located exclusively within the hilly coastal plain landform, and it differed from other inland sites by the presence of extensive wetlands. Drier ridges were interspersed throughout the wetlands, and rolling hills dissected by steep drainages were present in the northern part of the study site.

Plot Selection and Surveying

Generally, 3 replicate plots were chosen randomly within each habitat at each location whenever sufficient habitat existed (Table 2). When available habitat precluded random selection, plots and their orientation were selected to fit within available habitat, with plots no closer than 100 m to another replicate in the same habitat.

Bird census plots were 10 ha, and generally were 200 m by 500 m. Plots of 150 m by 667 m were established in habitats (particularly riparian willow) which were too linear for 200 m wide plots.

Study plots at Sadlerochit, Katakturuk, and Jago Bitty were surveyed using a Silva Ranger hand-held compass and 50 m surveyor's chain. All other plots were surveyed using an Ushikata transit and 50 m chain. All plots were marked on a 50 m x 100 m grid system using numbered wooden surveyor's stakes

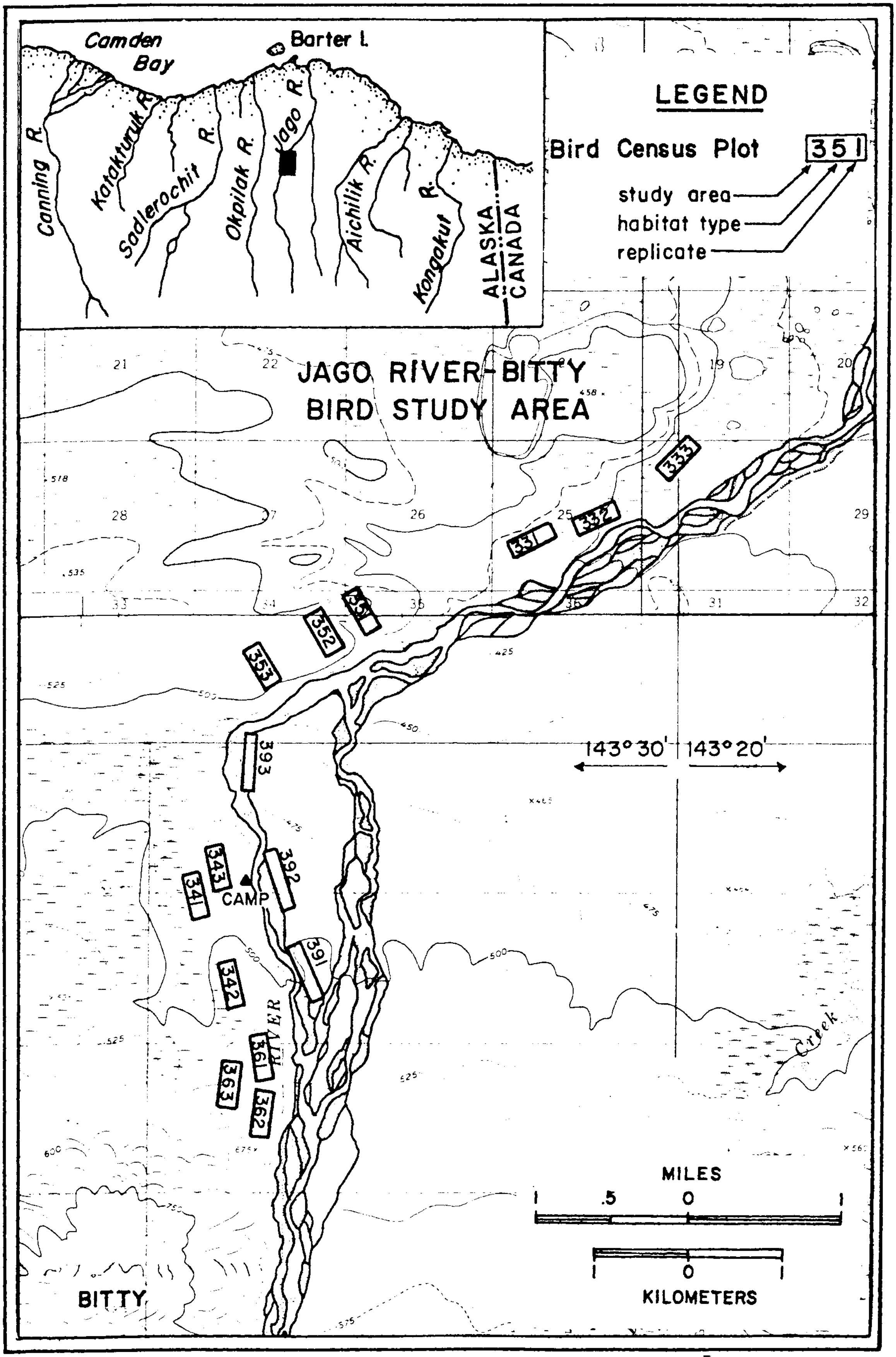

Fig. 6. Jago River-Bitty study area, Arctic National Wildlife Refuge, Alaska.

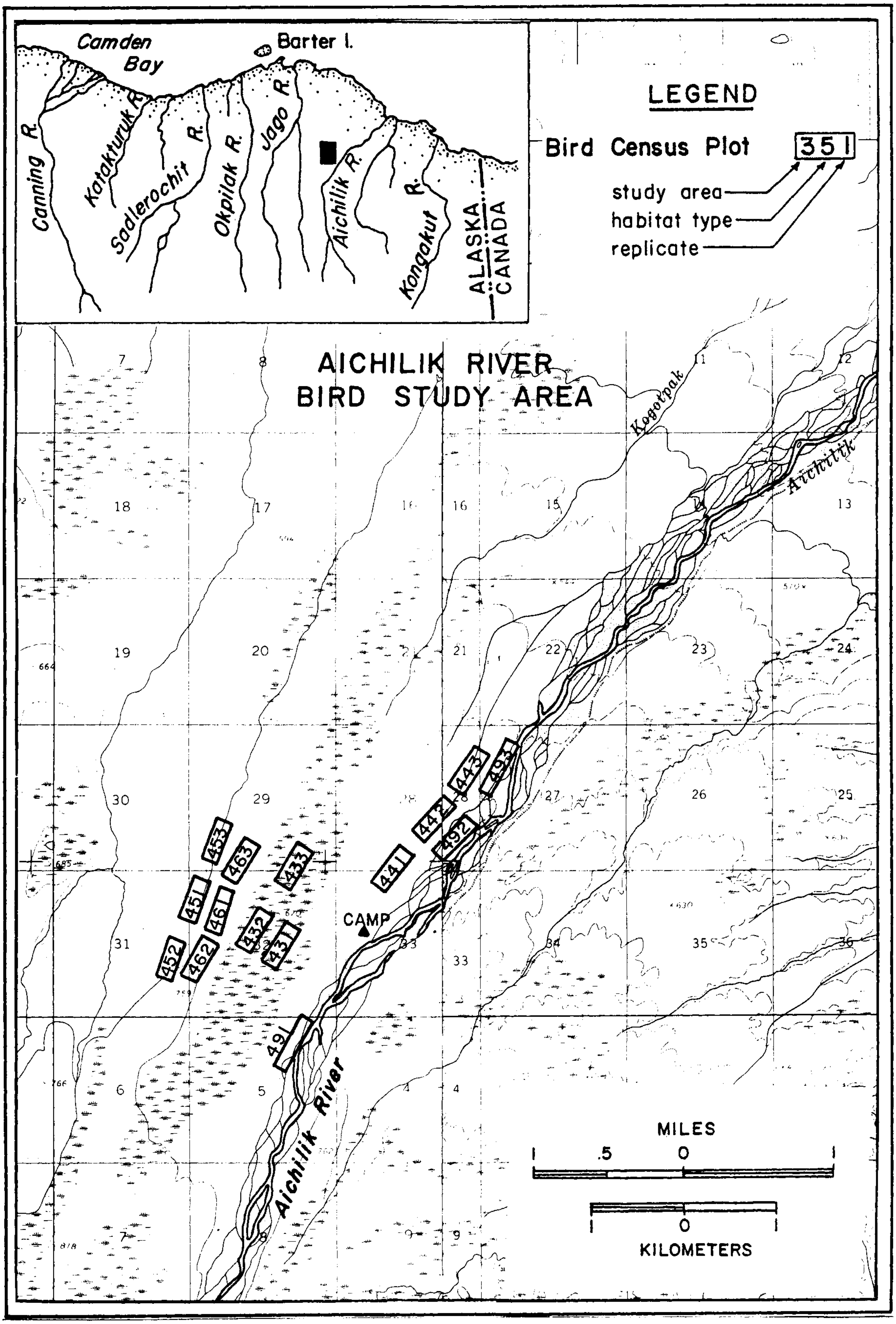

Fig. 7. Aichilik River study area, Arctic National Wildlife Refuge, Alaska.

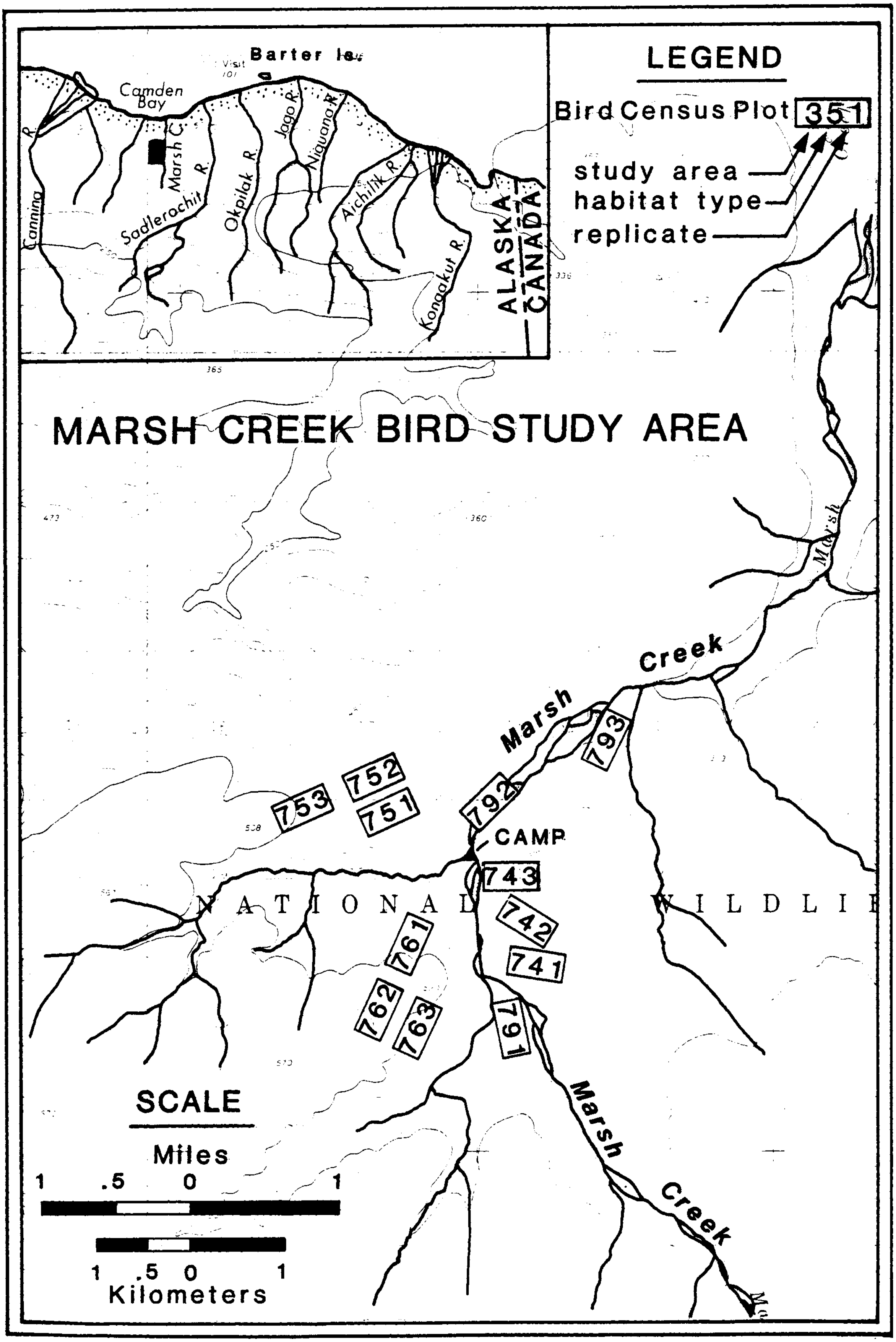

Fig. 8. Marsh Creek study area, Arctic National Wildlife Refuge, Alaska.

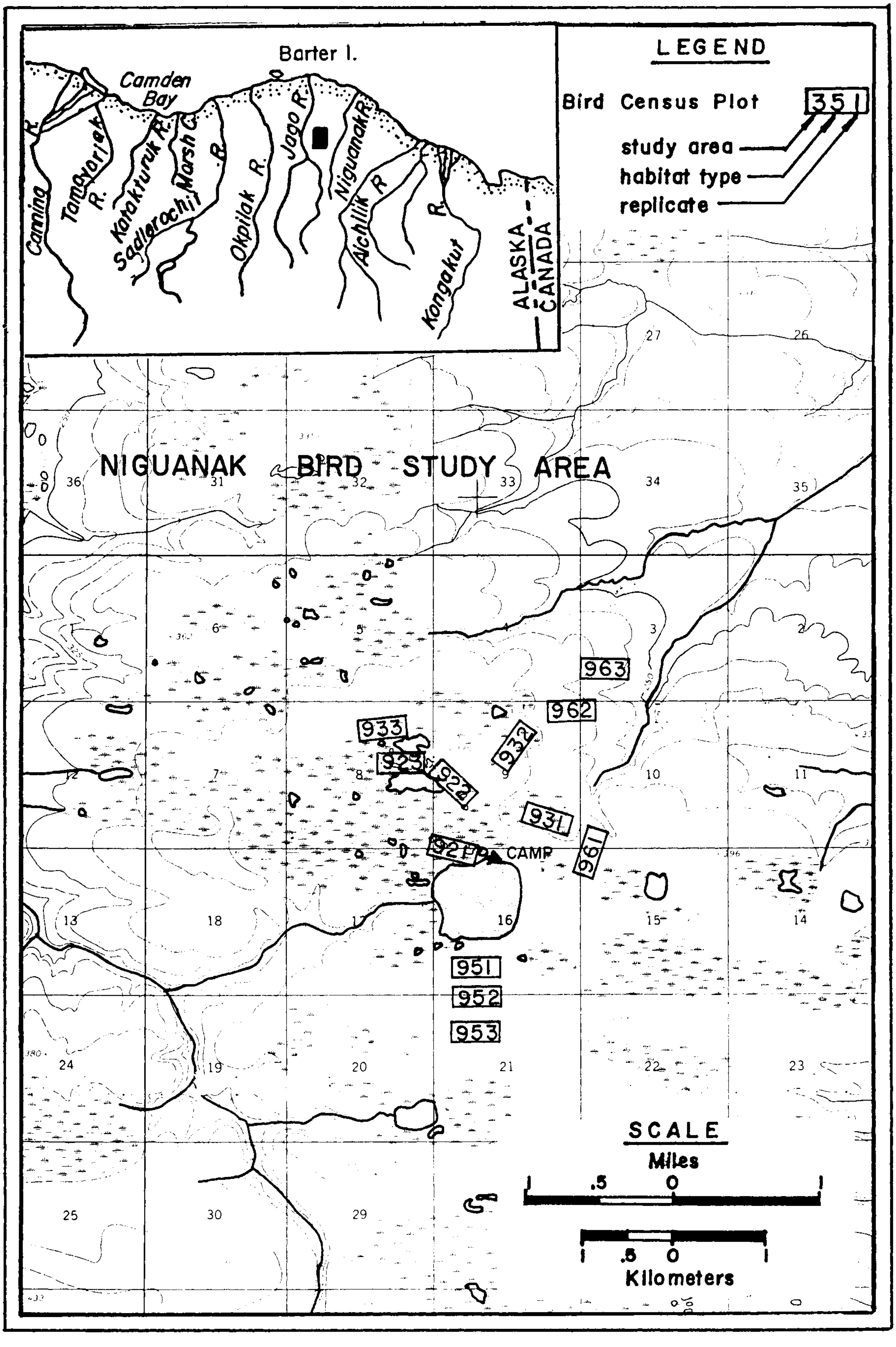

Fig. 9. Niguanak study area, Arctic National Wildlife Refuge, Alaska.

at each intersection. Plot corners were also marked with 46 cm long steel concrete reinforcement bar labeled with aluminum tags. Plot locations were documented on aerial photographs of 1:18,000 scale and are on file at the ANWR office, Fairbanks, Alaska.

Plot Census

Censuses consisted of: 1) counting all birds present to estimate total bird populations and 2) intensive search for nests and mapping of birds to estimate breeding bird density. All plots at the 1985 study sites were censused weekly during the last three weeks of June and first two weeks of July. Nesting habitat data were collected during the third week in July. The sixth census was conducted during the fourth week in July and seventh and eighth censuses were conducted on the second and third weeks in August. The field season then ended at all locations except Niguanak and Jago Delta, where crews remained and conducted 2 more censuses ending on 30 August.

Census methods, consistent with those described by Spindler (1978), Martin and Moitoret (1981), and Spindler and Miller (1983), were an adaptation of the spot mapping method (Williams 1936, IBCC 1970). Each census was performed by three or four people walking abreast, evenly spaced between the grid lines. When only 2 people were available for censusing, a zig-zag pattern was followed to insure complete coverage of plots. Species, sex, direction of flight, and location of all birds were recorded on a scaled map of the plot. Notes were made of any behavior suggesting a nearby nest, and extra effort was made to find nests in such situations. Eggs in unoccupied nests were identified using Harrison (1978). Censuses were not initiated during adverse weather conditions of strong wind (greater than 24 km/h), precipitation, or fog. If weather conditions deteriorated, censuses already initiated were completed, but no new censuses were begun until conditions improved.

Each nest was marked with a numbered tongue depressor placed in the ground 1 m from the nest in the direction of the nearest stake. Nest number, plot number, coordinate location of nest within plot, compass bearing in degrees and distance from nearest plot stake, species, date, sex of bird flushed from nest, and any hatching success/predation information were recorded on North American Nest Record Cards provided by Cornell University, Ithaca, N.Y. for each nest. Bird names and phylogenetic order follow the American Ornithologists' Union (1983).

Censuses were generally conducted on all plots of the same habitat at all study sites on the same day. Habitats were censused in the same order each week, but the order in which replicate plots within a habitat were censused was varied. A different starting point within each plot was chosen for each census.

Bird and Nest Density

Population density for each species (including breeders, transients, and migrants) in each habitat type, was estimated by averaging the total number of birds, excluding unfledged young, observed in each replicate plot, for each of the five censuses in the breeding season. Post-breeding population density was estimated in the same way using data from the last three censuses. Breeding bird population estimates were based on number of nests found in intensive nest searches of plots. Bird densities from the 10 ha plots were expressed as birds/km^2. Total counts on each census of each plot comprised the raw data used in statistical tests.

Data Analysis

Plant phenology data were compared among locations with Friedmans tests (Sokal and Rohlf 1981). Bird nesting phenology data were tested among locations and among years with chi-square contingency tests (Snedecor and Cochran 1967).

Bird and nest densities were analyzed with analysis of variance tests (ANOVA) utilizing SAS General Linear Models procedures (SAS Institute 1985). Censuses were grouped into two seasons (reproductive and post-reproductive) based on the breeding phenology of key bird species. Reproductive season was defined as the period beginning with the initiation of observations in early June and ending two weeks after 90 percent of observed nests of key species had hatched (this allowed time for chicks to fledge and gain some degree of independence from their parents). Post-reproductive season was defined as the period beginning at the end of the reproductive season and ending at the termination of observations in August.

Variables tested included means for total birds, total species, Lapland longspurs, pectoral sandpipers, semipalmated sandpipers, lesser golden-plovers, red-necked phalaropes, and nests for these species and groups. Means for a species in a habitat type at a location during a season of one year were derived from means of numbers of that species seen on all replicate plots in that habitat at that location for all the censuses during the season during that year. Variance due to replicate plots was partitioned out in the ANOVA (Snedecor and Cochran 1967). Three primary analyses were conducted: tests for differences in habitat, location, and season for 1985 data; tests of habitat and year for all four years' data; and the derivation of variance components for 1985 data to facilitate the examination of sampling variability.

In the 1985 analyses, initial tests were conducted for differences in bird densities and number of species due to habitat, season and their interaction. Locations were pooled and season was treated as a repeated measure (Winer 1971). Tests were then conducted to determine differences within habitats due to location, and season and their interaction. Season was again treated as a repeated measure.

Annual variability was examined with tests for habitat, year, and their interaction within a given location. Year was treated as a repeated measure.

The Least Significant Difference test (Steele and Torrie 1980) was used to determine significant differences between mean bird and nest densities of individual habitats, of individual locations within habitats, of individual habitats within each location, of seasons within habitats, and of years within habitats, when statistical significance (at P=0.05) was indicated by the ANOVA analyses.

Results and Discussion

Phenology

Snow melt

Snow melt on the ANWR coastal plain in 1985 occurred at approximately the same time as in 1984 but was earlier than in 1983. Over 90% of the coastal plain was snow free by 22 May and the Jago River began flowing at the Delta on 23 May. Most small ponds and lakes were free of surface ice by 1 June although some large lakes had surface ice until late June. Aichilik retained some snow in Tussock plots until the first week of June. Snow cover was 80% complete on 1 June in 1983 and melted suddenly between 1 and 3 June.

Plant flowering

First flowering dates for common plant species were compared to assess phenological differences between the 8 study sites censused in 1985 and between years (Appendix Table I). There were no significant differences among the 8 study sites censused in 1985 for first flowering dates of 5 common species (Friedman Test, $P > 0.05$). In addition, when Marsh Creek was omitted (which doubled the number of species common to locations) there were also no significant differences between first flowering dates observed (Friedman Test, $P > 0.05$).

Comparisons between 1985 and previous years were confined to the locations which were common among years. Comparisons between 1984 and 1985 were further confined to Sadlerochit as sampling methods were different at Aichilik and Jago Delta in 1984 and 1985. Phenologically, 1985 was slightly, but not significantly, earlier than 1983 based on a comparison of 11 species and slightly, but not significantly, later than 1984 based on a comparison of 18 species.

Bird Nesting

Distributions among census periods of numbers of nests containing eggs were statistically similar for locations for all 5 key species in 1985 (Table 4). Therefore, nest phenology data were pooled across locations (Fig. 10). Similarly, breeding phenology was statistically similar among locations within years in 1984 and 1983 and locations were pooled within years for comparison with common locations censused in 1985.

Lesser golden-plover was the only key species in which temporal distributions of nests with eggs were statistically different between 1984 and 1985 (Table 5). Apparently, golden-plover nesting phenology was slightly earlier in 1985 than in 1984 (Table 6). In addition, plovers nested in a greater variety of habitats and in higher densities in 1985 (Table 7).

Distributions of nests containing eggs among census periods were statistically similar in 1983 and 1985 for all 5 key species (Table 8).

The 1985 breeding season, based on breeding phenology of the 5 key species, was considered to be census periods 1-5 (5 June - 7 July) and the post-breeding season consisted of censuses 6-8 (8 July - 15 August).

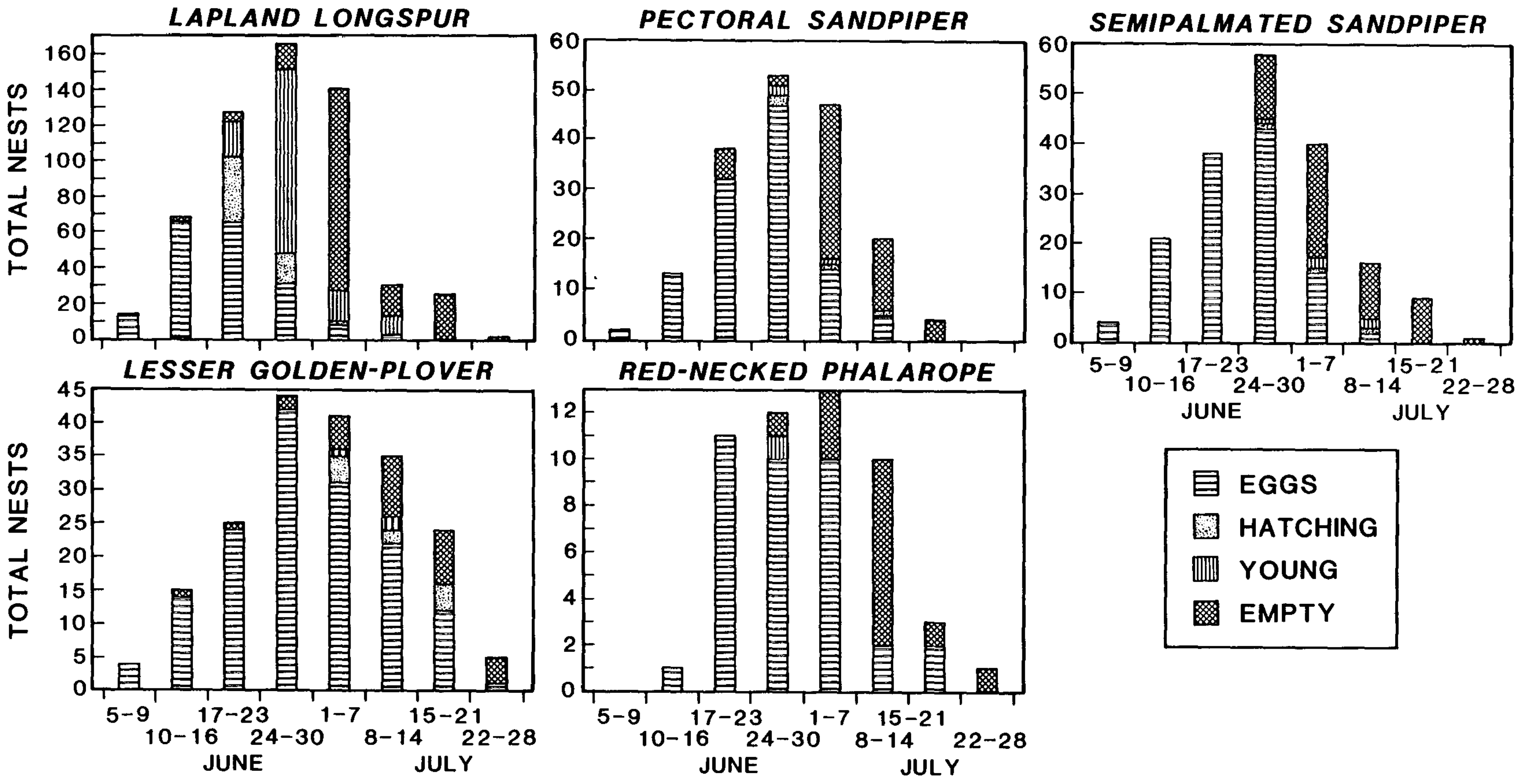

Fig. 10. Nesting chronology of 5 bird species at 8 locations (pooled) on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Table 4. Chi-square values for tests of distributions of nests of 5 bird species among census periods for 8 study sites on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Species	Chi-square Value	d.f.	P
Lapland longspur	46.52	35	$0.05 < P < 0.10$
Pectoral sandpiper	35.78	35	$0.10 < P < 0.50$
Semipalmated sandpiper	32.37	35	$0.50 < P < 0.90$
Lesser golden-plover	47.89	35	$0.05 < P < 0.10$
Red-necked phalarope	20.97	35	$0.90 < P < 0.975$

Table 5. Chi-square values for tests of distributions of nests of 5 bird species among census periods at Aichilik, Sadlerochit, and Jago Delta (locations pooled within years) on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1984 and 1985.

Species	Chi-square Value	d.f.	P
Lapland longspur	10.45	5	$0.05 < P < 0.10$
Pectoral sandpiper	4.32	5	$0.50 < P < 0.90$
Semipalmated sandpiper	7.84	5	$0.10 < P < 0.50$
Lesser golden-plover	12.29	5	$0.025 < P < 0.05$
Red-necked phalarope[a]	n.a.	5	n.a.

[a] Red-necked phalaropes were not tested due to insufficient sample sizes.

Table 6. Distributions among census periods of total numbers of lesser golden-plover nests with eggs at Aichilik, Sadlerochit, and Jago Delta (locations pooled within years) on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1984 and 1985.

Year	Sample Period					
	0	1	2	3	4	5
1984	0[a]	0	1	8	6	0
1985	4	7	7	12	3	0

[a] Indicates time period before censuses were initiated.

Table 7. Total numbers of lesser golden-plover nests observed in 7 habitats at Aichilik, Sadlerochit, and Jago Delta (locations pooled within years) on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1984 and 1985.

Year	Habitat						
	II	III	IV	IVa	V	VI	IX
1984	0	0	3	2	0	3	4
1985	0	2	2	3	3	8	6

Table 8. Chi-square values for tests of distributions of nests of 5 bird species among census periods at Okpilak, Katakturuk, and Jago Bitty (locations pooled within years) on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1983 and 1985.

Species	Chi-square value	d.f.	P
Lapland longspur	3.22	4	$0.75 > p > 0.50$
Pectoral sandpiper	6.47	4	$0.25 > p > 0.10$
Semipalmated sandpiper	2.56	4	$0.75 > p > 0.50$
Lesser golden-plover	5.69	4	$0.25 > p > 0.10$
Red-necked phalarope[a]	n.a.	4	n.a.

[a] Red-necked phalaropes were not tested due to insufficient sample sizes.

Bird Use of Tundra Habitats

This section is divided into three primary sections: "Differences Due to Habitat, Season, and Location in 1985", "Annual Variability", and "Sampling Variability: Location, Study Plot, and Census." The first section examines data collected in 1985 by presenting the results of statistical tests for differences in habitat, seasonal, and locational use by each of the 5 key species individually. Total birds and total species are then considered together and discussed by individual habitats. The "Annual Variability" section also considers the five key species individually. These sections, the results of tests for differences in year, habitat, and location, are further divided into discussions of locations sampled in each of two different annual sample cycles (1982, 1983, 1985 and 1984, 1985).

Total birds and total species are again considered together but results are presented by individual locations. The "Sampling Variability" section details documented and suspected sources of sampling variability, discusses the relative importance of the various sources, and provides a means for evaluating sufficiency of sample size for the 1985 results.

Differences In Bird Use Due to Habitat, Season, and Location in 1985

Lapland longspurs

Lapland longspurs were most common in Riparian and upland habitats (Table 9). In addition, they were also common in Wet Sedge habitat where they foraged and nested on raised polygon rims and strangs (McWhorter et al. 1987). Although highest densities of longspurs were observed in Riparian habitat when locations and seasons were pooled in 1985, nest density in Riparian was significantly lower than in Moist Sedge-Shrub, Tussock, and Mosaic (Table 10).

Overall, densities of longspurs declined significantly during the post-reproductive season, however, slight (nonsignificant) increases were observed in Riparian and Moist Sedge-Shrub habitats. Longspurs near Barrow fed heavily on Tenthredenid (sawfly) larvae during the late July through August period (Custer and Pitelka 1978). As sawfly larvae feed on willows (Holmes 1966), willow-rich habitats (Riparian and Moist Sedge-Shrub) may have supported higher densities of sawflies and therefore higher densities of longspurs during the post-reproductive period. Riparian habitat seemed to offer fewer high quality nesting sites but better foraging and brood-rearing areas than some other habitats. Flooded and Moist Sedge habitats were among the lowest in densities of longspurs and their nests.

Sadlerochit had significantly higher densities of longspurs in Riparian habitat for pooled seasons than all other locations except Katakturuk (Table 11). Nest densities were statistically similar among locations and there appeared to be no strong correlation ($r=0.2554$, $P > 0.05$) between bird and nest densities among locations for Riparian habitat. Although no overall significant increase occurred during the post-reproductive season, longspur density appeared to increase at all locations except Sadlerochit and Katakturuk.

Table 9. Mean densities of Lapland longspurs (birds/km^2) during the reproductive and post-reproductive seasons[a] observed in 7 habitats pooled by location on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Mean Lapland Longspurs/km^2

(Habitat $P<0.001$; Season $P=0.030$; Habitat x Season $P=0.053$)

IX	IVa	V	III	VI	II	IV	
216	139	107	91	87	80	59	Reproductive Season - A
235	114	117	66	63	45	48	Post-Reproductive Season - B

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[a] Sample sizes; reproductive: II n=45, III n=95, IV n=55, IVa n=50, V n=115, VI n=89, IX n=93; post-reproductive: II n=27, III n=56, IV n=31, IVa n=30, V n=69, VI n=54, IX n=55. Underlining indicates habitat means which are not significantly different at $P=0.05$; seasons followed by the same letter are not significantly different at $P=0.05$.

Table 10. Mean densities of Lapland longspur nests (nests/km^2) observed in 7 habitats[a] pooled by location on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Mean Lapland Longspur Nests/km^2

(Habitat $P<0.002$)

V	VI	IVa	IV	IX	III	II
24	21	16	13	13	12	7

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[a] Sample sizes: II n=9, III n=19, IV n=11, IVa n=10, V n=23, VI n=18, IX n=19. Underlining indicates habitat means that are not significantly different at $P=0.05$.

Table 11. Mean densities of Lapland longspurs (birds/km^2) observed in 7 habitats at different locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985^a. Sample sizes were 15 and 9 for reproductive and post-reproductive seasons except where noted.

Mean Lapland Longspurs/km^2

RIPARIAN HABITAT^b

(Location P=0.006; Season P=0.265; Location x Season P=0.122)

SAD	KAT	JBI	JDE	AIC	MCR		
429	308	153	81	101	140	Reproductive Season	- A
383	259	167	217	193	149	Post-Reproductive Season	- A

FLOODED HABITAT

(Location P=0.707; Season P=0.001; Location x Season P=0.558)

NIG	JDE	OKP		
79	84	76	Reproductive Season	- A
54	43	38	Post-Reproductive Season	- B

WET SEDGE HABITAT^c

(Location P=0.001; Season P=0.001; Location x Season P=0.165)

SAD	OKP	KAT	NIG	JBI	JDE	AIC		
179	114	88	83	61	65	44	Reproductive Season	- A
158	70	45	39	58	49	31	Post-Reproductive Season	- B

MOSAIC HABITAT^d

(Location P=0.399; Season P=0.087; Location x Season P=0.728)

SAD	OKP	JDE		
170	139	109	Reproductive Season	- A
133	127	77	Post-Reproductive Season	- A

MOIST SEDGE HABITAT^e

(Location P=0.040; Season P=0.322; Location x Season P=0.215)

KAT	JBI	AIC	MCR		
74	85	38	43	Reproductive Season	- A
75	52	58	16	Post-Reproductive Season	- A

Table 11. (continued).

MOIST SEDGE-SHRUB HABITAT[f]

(Location P=0.025; Season P=0.476; Location x Season P=0.182)

SAD	NIG	OKP	MCR	AIC	JDE	JBI	KAT		
			---				---[g]		
158	101	142	93	102	109	73	74	Reproductive Season	-A
178	171	113	157	118	82	58	61	Post-Reproductive Season	-A

TUSSOCK HABITAT[h]

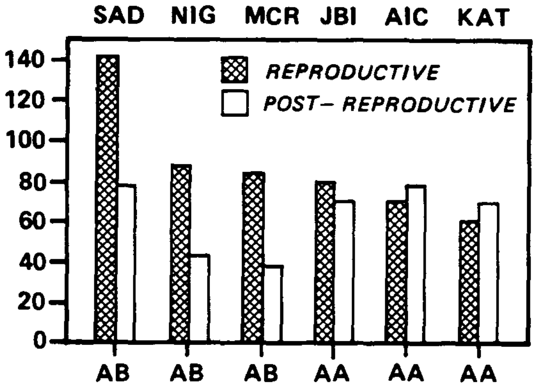
(Location P=0.006; Season P=0.003; Location x Season P=0.028)

Reproductive Season

SAD	NIG	MCR	JBI	AIC	KAT
142	87	84	79	70	60

Post-Reproductive Season

SAD	AIC	JBI	KAT	NIG	MCR
78	78	70	69	43	38



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[a] Underlining indicates location means which are not significantly different at p=0.05; seasons followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sadlerochit: reproductive season n=18, post-reproductive season n=12, and Katakturuk: post-reproductive season n=7.

[c] Katakturuk: reproductive season n=5, post-reproductive season n=2.

[d] Okpilak: reproductive season n=20, post-reproductive season n=12.

[e] Katakturuk: reproductive season n=10, post-reproductive season n=4.

[f] Okpilak: reproductive season n=10, post-reproductive season n=6.

[g] Katakturuk was significantly different from Marsh Creek, but was not significantly different from Okpilak.

[h] Katakturuk: reproductive season n=14.

Sadlerochit also had significantly higher densities of longspurs in Wet Sedge habitat than all other locations (Table 11). Nest densities were statistically similar among locations despite the relatively high numbers observed at Sadlerochit (Appendix Table IV). Wet Sedge plots at Sadlerochit had an extensive network of Moist Sedge-Shrub strangs that were heavily utilized by longspurs and which probably influenced bird and nest densities. Longspur densities declined during the post-reproductive season (Table 11).

Lapland longspur densities also declined significantly at Sadlerochit, Niguanak, and Marsh Creek in Tussock habitat during the post-reproductive season (Table 11). However, they appeared to increase in Moist Sedge-Shrub at these locations (and to a lesser extent, at Aichilik) suggesting a possible shift in habitat use across seasons.

Pectoral Sandpipers

Mean pectoral sandpiper density in Flooded habitat was significantly higher than in other habitats during the reproductive and post-reproductive seasons (Table 12). Densities increased significantly during the post-reproductive season in Flooded habitat, largely due to congregations of local females with young and high influxes of fall migrants (McWhorter et al. 1987). Among other habitats, pectoral sandpipers occurred most frequently in mesic types (Wet Sedge) or those interspersed with small ponds (Mosaic and sometimes Moist Sedge-Shrub), while Riparian, Tussock, and Moist Sedge habitats received relatively little use.

Mean nest densities did not differ statistically across habitat types (Table 13), probably as a result of high variability among sampling locations within several habitats (Table 14). For example, in Moist Sedge-Shrub habitat, pectoral sandpiper nest densities were 33/km^2 at Niguanak, 20/km^2 at Aichilik, and 0/km^2 at all other locations.

Inter-location variability was also significant within Flooded and Wet Sedge habitats. The relationships between habitat types and pectoral sandpiper nest densities often varied depending upon the sampling location. Mean pectoral nest density in Wet Sedge habitat at Sadlerochit was significantly higher than that at Niguanak, yet the relationship was reversed in Moist Sedge-Shrub habitat (Table 14).

Mean population densities also varied extensively between locations (Table 15). Although there were no differences among locations within Flooded habitat during the reproductive season, densities at Okpilak increased significantly over Niguanak and Jago Delta during the post-reproductive period. As nest densities were relatively low at Okpilak, the area probably was occupied primarily by non-breeding birds and staging fall migrants. Evidence also suggested that pectoral sandpipers utilized the more mesic habitats available at a given location during the post-reproductive season. Densities increased in both Flooded and Mosaic habitat but decreased in Wet Sedge habitat (which dried during the summer), particularly at Sadlerochit where the decrease in Wet Sedge was accompanied by a substantial increase in Mosaic habitat (Table 15). Pectoral sandpiper numbers decreased significantly across seasons in Moist Sedge-Shrub habitat at Niguanak. Although nesting density was very high at Niguanak, males left the area after breeding and females moved their young to the surrounding Flooded habitat soon after hatching.

Table 12. Mean densities of pectoral sandpipers (birds/km²) observed in 7 habitats[a] pooled over locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Mean Pectoral Sandpipers/km²

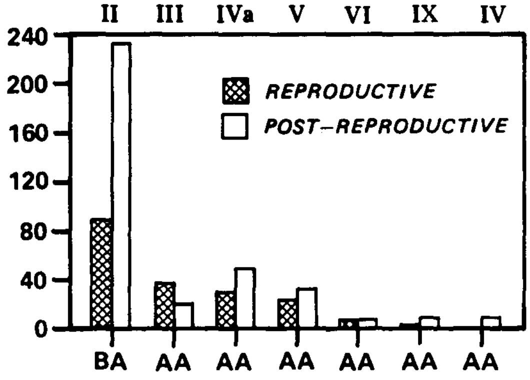
(Habitat $P<0.001$; Season $P<0.001$; Habitat x Season $P<0.001$)

Reproductive Season

II	III	IVa	V	VI	IC	IV
90	37	30	23	6	3	1

Post Reproductive Season

II	IVa	V	III	IX	IV	VI
232	49	32	20	8	8	7



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[a] Sample sizes; reproductive: II n=45, III n=95, IV n=55, IVa n=50, V n=115, VI n=89, IX n=93; post-reproductive: II n=27, III n=56, IV n=31, IVa n=30, V n=69, VI n=54, IX n=55; underlining indicates habitat means which are not significantly different at p=0.05; seasons within habitats subtended by the same letter are not significantly different at p=0.05.

Table 13. Mean densities of pectoral sandpiper nests (nests/km²) observed in 7 habitats pooled over locations on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[b].

Mean Pectoral Sandpiper Nests/km²

(Habitat P=0.1232)

II	III	V	VIa	VI	IX	IV
9	8	7	5	3	2	1

---

[a] Sample sizes: II n=9, III n=19, IV n=11, IVa n=10, V n=23, VI n=18, IX n=19.

[b] Underlining indicates habitat means that are not significantly different at p=0.05.

Table 14. Mean densities of pectoral sandpiper nests (nests/km^2) observed in 3 habitats at 8 locations on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a]. Sample size is 3 for all locations except where noted below.

Mean Pectoral Sandpiper Nests/km^2								
FLOODED HABITAT	NIG	JDE	OKP					
(P=0.027)	20	7	0					
WET SEDGE HABITAT[b]	SAD	JBI	AIC	NIG	KAT	JDE	OKP	
(P=0.040)	20	16	10	3	0	0	0	
MOIST SEDGE-SHRUB HABITAT[c]	NIG	AIC	OKP	KAT	JBI	SAD	JDE	MCR
(P=0.0001)	33	20	0	0	0	0	0	0

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[a] Underlining indicates location means that are not significantly different at p=0.05.

[b] Katakturuk: n=1.

[c] Okpilak: n=2.

Table 15. Mean densities of pectoral sandpipers observed in 7 habitats at 8 locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a]. Sample sizes were 15 and 9 for reproductive and post-reproductive seasons, except where noted.

Mean Pectoral Sandpipers/km^2

RIPARIAN HABITAT[b]

(Location p=0.001; Season p=0.329; Location x Season p=0.968)

SAD	MCR	AIC	JBI	JDE	KAT		
14	0	3	0	0	1	Reproductive Season	- A
21	10	2	4	4	0	Post Reproductive Season	- A

FLOODED HABITAT

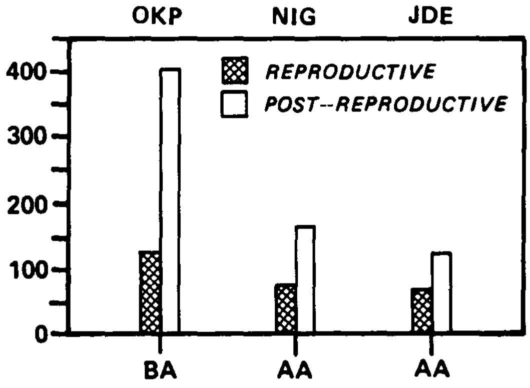
(Location P=0.014; Season P=0.001; Location x Season P=0.015)

Reproductive Season

OKP	NIG	JDE
126	76	68

Post-Reproductive Season

OKP	NIG	JDE
404	164	127



WET SEDGE HABITAT[c]

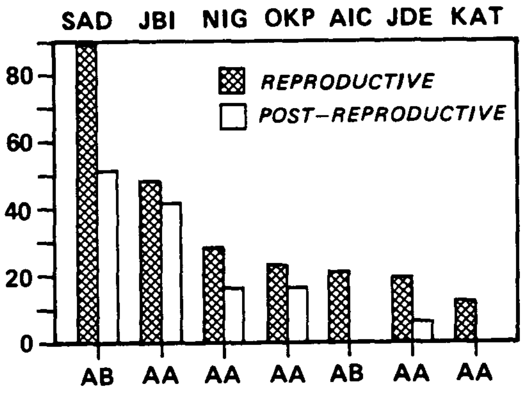
(Location P=0.056; Season P=0.001; Location x Season P=0.015)

Reproductive Season

SAD	JBI	NIG	OKP	AIC	JDE	KAT
89	48	28	23	21	19	12

Post-Reproductive Season

SAD	JBI	NIG	OKP	JDE	AIC	KAT
51	41	16	16	6	0	0[d]



MOSAIC HABITAT[e]

(Location P=0.015; Season P=0.021; Location x Season P=0.174)

JDE	SAD	OKP		
46	23	23	Reproductive Season	- B
57	64	32	Post-Reproductive Season	- A

Table 15. (continued).

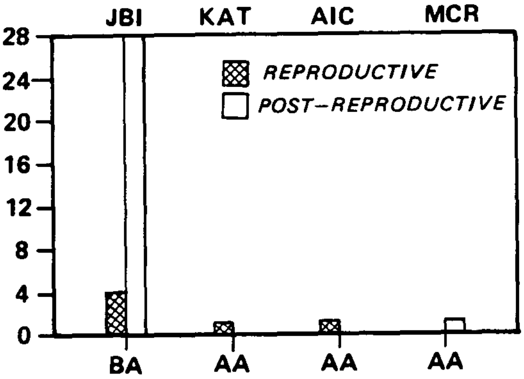
MOIST SEDGE HABITAT[f]
(Location P=0.007; Season P=0.055; Location x Season P=0.023)

Reproductive Season

JBI	KAT	AIC	MCR
4	1	1	0

Post-Reproductive Season

JBI	MCR	KAT	AIC
28	1	0	0



MOIST SEDGE-SHRUB HABITAT[g]
(Location P=0.001; Season P=0.012; Location x Season P=0.001)

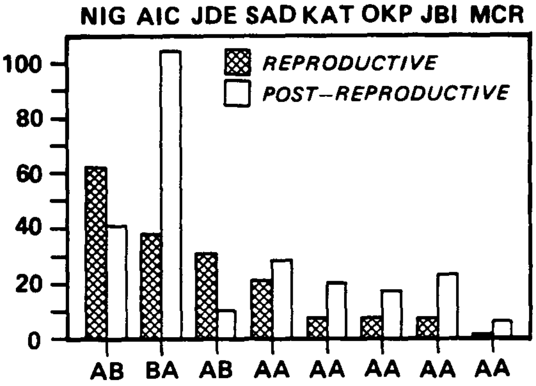
Reproductive Season

NIG	AIC	JDE	SAD	KAT	OKP	JBI	MCR
62	38	31	21	7	7	7	1

— —   — —[1]

Post-Reproductive Season

AIC	NIG	SAD	JBI	KAT	OKP	JDE	MCR
104	41	28	23	20	17	10	6



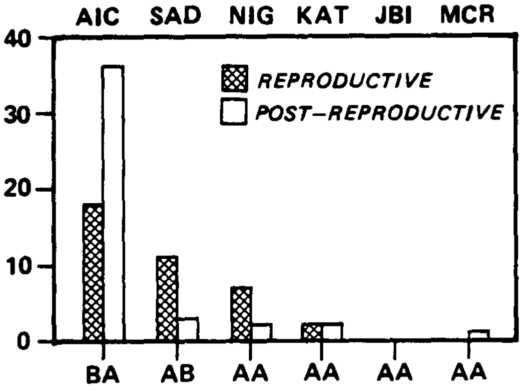
TUSSOCK HABITAT[i]
(Location P=0.006; Season P=0.369; Location x Season P=0.002)

Reproductive Season

AIC	SAD	NIG	KAT	JBI	MCR
18	11	7	2	0	0

Post-Reproductive Season

AIC	SAD	NIG	KAT	MCR	JBI
36	3	2	2	1	0



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[a] Underlining indicates location means which are not significantly different at P=0.05; seasons followed or subtended by the same letter are not significantly different at P=0.05.

[b] Sadlerochit: reproductive season n=18, post-reproductive season n=12, and Katakturuk: post-reproductive n=7.

[c] Katakturuk: reproductive season n=5, post-reproductive season n=2.

[d] Katakturuk was not significantly different from any other location.

[e] Okpilak: reproductive season n=20, post-reproductive n=12.

[f] Katakturuk: reproductive season n=10, post-reproductive season n=4.

[g] Okpilak: reproductive season n=10, post-reproductive season n=6.

[h] Katakturuk and Jago Bitty were significantly different from Sadlerochit, but Okpilak was not significantly different from Sadlerochit.

[i] Katakturak: reproductive season n=14.

Distributions and habitat associations were extremely variable across the inland foothill locations. Overall densities were very low at Katakturuk and Marsh Creek, the two most westerly locations. Pectoral sandpipers were more abundant at Aichilik and Jago Bitty, but habitat use between the two locations was very different. Densities in Moist Sedge-Shrub and Tussock habitat were higher at Aichilik, while densities in Wet Sedge and Moist Sedge were greater at Jago Bitty. Use of these habitats at both locations appeared to be related to the presence of mesic inclusions, particularly during the post-reproductive season. Similarly, Myers and Pitelka (1980) found that local breeders of most shorebird species moved into lowland and ponded areas after chicks hatched.

Variations in habitat use between locations may have been due, in part, to differences in food availability or to topographic variation that was not delineated by the Landsat classification. Opportunistic sandpipers, such as the pectoral sandpiper (Pitelka et al. 1974), have clumped dispersion patterns and nest at intermittently high densities. The opportunistic strategy is to "pack" small territories into productive habitats. Very successful breeding is risked against possible failure in the event of bad weather conditions; however, pectoral sandpipers minimize this risk by accumulating large fat reserves during the late stages of northward migration (MacLean 1969). Nesting in high densities increases vulnerability of nests to predators as well as increases the number of birds consuming the food resource. Male pectoral sandpipers leave the breeding grounds after copulation which aids in reducing activity around the nests and reducing competition for food (Pitelka et al. 1974). Females leave the nesting areas later, but before the young, further augmenting food availability for the growing juveniles (Pitelka 1959).

Pectoral sandpiper densities not only varied between habitat types and between locations within a habitat, but relative habitat use often differed between locations. Additionally, densities and patterns of habitat use at a particular location often varied between years (see Annual Variation section). Near Barrow, Alaska, similar variability was observed and related to weather-induced differences in timing of spring melt and in availability of food (Holmes and Pitelka 1968). During the post-reproductive season, when chironomids were the dominant prey base (Holmes and Pitelka 1968), distributions of pectoral sandpipers on the ANWR coastal plain were most closely associated with Flooded habitat. But at locations without Flooded habitat, densities were highest in the more mesic habitats or those interspersed with ponds or water-filled polygon troughs. Populations and nesting densities were very patchy during the breeding period, and were possibly related to the abundance of tipulids, the primary early-summer prey (Holmes and Pitelka 1968).

The pectoral sandpiper's opportunistic strategy to concentrate in areas of high food supply may have superceded affinities to particular habitats. Prey availability data could potentially provide a more definite understanding of pectoral sandpiper distribution on the coastal plain.

Semipalmated sandpiper

Mean semipalmated sandpiper density in Riparian habitat was significantly higher than all other habitat types during the reproductive season (Table 16). Densities decreased in all habitats except Flooded during the post-reproductive season, with a large significant drop in the use of

Riparian habitat (Table 16). Females left the nesting areas after eggs hatched (Ashkenazie and Safriel 1979a), and possibly moved to better foraging areas since their daily energy expenditure was 15% greater than that of males during the egg laying and incubation period (Ashkenazie and Safriel 1979b). Later, males and young juveniles also departed from most tundra habitats, however; the sustained densities in Flooded habitat may have been related to the use of wetland shorelines as important feeding sites (Derksen et al. 1981). At the Canning River delta, upland study plots were deserted while lowland densities increased, but the most massive shift was to marine littoral habitat (Martin and Moitoret 1981). Semipalmated sandpipers were one of the earliest shorebirds to leave in migration (Holmes and Pitelka 1968), and post-breeding movements to coastal shoreline environments were reflected by the relatively low densities observed in tundra habitats across all locations (Table 16).

Table 16. Mean densities of semipalmated sandpipers (birds/km^2) observed in 7 habitats pooled over locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].

Mean Semipalmated Sandpipers/km^2

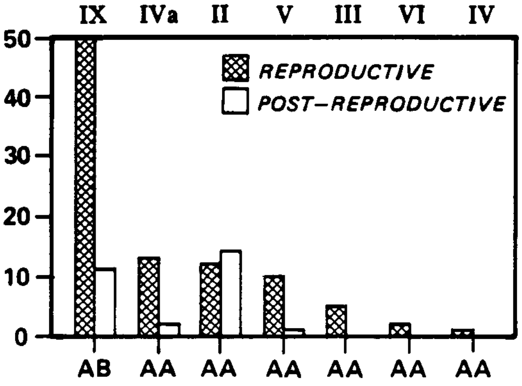
(Habitat $P < 0.001$; Season $P < 0.001$; Habitat x Season $P < 0.001$)

Reproductive Season

IX	IVa	II	V	III	VI	IV
50	13	12	10	5	2	1

Post-Reproductive Season

II	IX	IVa	V	III	VI	IV
14	11	2	1	0	0	0



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[a] Sample sizes; reproductive: II n=45, III n=95, IV n=55, IVa n=50, V n=115, VI n=89, IX n=93; post-reproductive: II n=27, III n=56, IV n=31, IVa n=30, V n=69, VI n=54, IX n=55;uUnderlining indicates habitat means which are not significantly different at p=0.05; seasons within habitats subtended by the same letter are not significantly different at p=0.05.

Riparian, Mosaic, and Moist Sedge-Shrub were the 3 primary nesting habitats of semipalmated sandpipers (Table 17), and within each habitat there was considerable variability between locations (Table 18). Sadlerochit and Jago Bitty had particularly high nest densities relative to other locations. Population densities also varied extensively between locations (Table 19). Riparian habitat at Sadlerochit and Katakturuk supported mean densities that were at least 3-times higher than all other locations. Sadlerochit also recorded the highest densities in Wet Sedge, Mosaic, and Moist Sedge-Shrub habitats. Concurrent with this study, Holmes and Pitelka (1968) reported semipalmated sandpiper distributions as locally common, especially near the coast and extending along rivers into the foothills. The concentrated densities at the coastal Sadlerochit site and the high inland numbers in Riparian habitat at Katakturuk (Table 19) and Jago Bitty (Table 18) were indicative of their patchy distribution.

Table 17. Mean densities of semipalmated sandpiper nests (nests/km^2) observed in 7 habitats pooled over locations on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Mean Semipalmated Sandpiper Nests/km^2

(Habitat P=0.0679)

IX	IVa	V	III	VI	II	III
7	6	6	2	1	0	0

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[a] Sample sizes: II n=9, III n=19, IV n=11, IVa n=10, I n=23, VI n=18, IX n=19. Underlining indicates habitat means that are not significantly different at P=0.05.

Table 18. Mean densities of semipalmated sandpiper nests (nests/km^2) observed in 3 habitats at 8 locations on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].

Mean Semipalmated Sandpiper Nests/km^2

RIPARIAN HABITAT[b]	JBI	SAD	KAT	AIC	JDE	MCR		
(Location P=0.09)	23	18	0	0	0	0		
MOSAIC HABITAT[c]	SAD	JDE	OKP					
(Location P=0.0966)	17	3	1					
MOIST SEDGE-SHRUB HABITAT[d]	SAD	JBI	AIC	JDE	OKP	KAT	MCR	NIG
(Location P=0.0347)	23	13	3	3	0	0	0	0

---

[a] Underlining indicates location means that are not significantly different at p=0.05.

[b] Sample size = 3 except Sadlerochit n=4.

[c] Sample size = 3, except Okpilak n=4.

[d] Sample size = 3 except Okpilak n=2.

Table 19. Mean densities of semipalmated sandpipers observed in 7 habitats at 8 locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a]. Samples sizes were 15 and 9 for reproductive and post-reproductive seasons, except where noted.

Mean Semipalmated Sandpipers/km^2

RIPARIAN HABITAT[b]

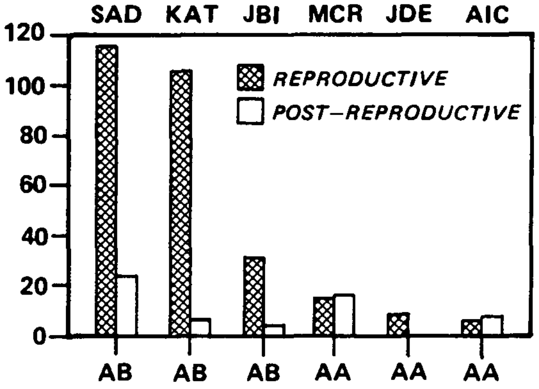
(Location $P<0.001$; Season $P<0.001$; Location x Season $P<0.001$)

Reproductive Season

SAD	KAT	JBI	MCR	JDE	AIC
115	106	31	15	9	6

Post-Reproductive Season

SAD	MCR	AIC	KAT	JBI	JDE
24	16	8	6	4	2



FLOODED HABITAT

(Location P=0.254; Season P=0.496; Location x Season P=0.130)

OKP	JDE	NIG	
13	13	9	Reproductive Season - A
24	17	1	Post-Reproductive Season - B

WET SEDGE HABITAT[c]

(Location P=0.052; Season P=0.011; Location x Season P=0.052)

SAD	NIG	KAT	JDE	JBI	OKP	AIC	
19	5	4	3	2	1	0	Reproductive Season - A
0	0	0	0	0	0	0	Post-Reproductive Season - B

MOSAIC HABITAT[d]

(Location P=0.013; Season P=0.003; Location x Season P=0.007)

Reproductive Season

SAD	OKP	JDE
31	5	4

Post-Reproductive Season

OKP	SAD	JDE
3	2	0

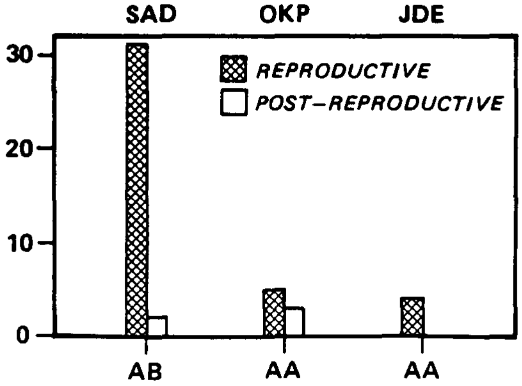


Table 19. (continued).

MOIST SEDGE HABITAT[e]

(Location P=0.637; Season P=2.275; Location x Season P=0.639)

MCR	JBI	KAT	AIC		
1	1	0	0	Reproductive Season	- A
0	0	0	0	Post-Reproductive Season	- A

MOIST SEDGE-SHRUB HABITAT [f]

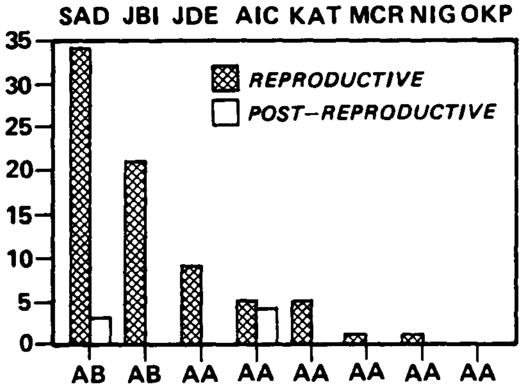
(Location P=0.013; Season P=0.004; Location x Season P=0.041)

Reproductive Season

SAD	JBI	AIC	KAT	MCR	NIG	OKP
34	21	9	5	1	1	0

Post-Reproductive Season

AIC	SAD	JDE	JBI	KAT	MCR	NIG	OKP
4	3	0	0	0	0	0	0



TUSSOCK HABITAT[g]

(Location P=0.460; Season P=0.097; Location x Season P=0.460)

KAT	SAD	AIC	JBI	MCR	NIG		
8	3	3	0	0	0	Reproductive Season	- A
0	0	0	0	0	0	Post-Reproductive Season	- A

---

[a] Underlining indicates location means which are not significantly different at P=0.05; seasons followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sadlerochit: reproductive season n=18, post-reproductive season n=12, and Katakturak: post-reproductive season n=7.

[c] Katakturak: reproductive season n=5, post-reproductive season n=2.

[d] Okpilak: reproductive season n=20, post-reproductive season n=12.

[e] Katakturak: reproductive season n=10, post-reproductive season n=4.

[f] Okpilak: reproductive season n=10, post-reproductive n=6.

[g] Katakturak: reproductive season n=14.

Semipalmated sandpipers are monogamous and considered a conservative species in terms of social organization (Pitelka et al. 1974). Conservative species produce a moderate number of surviving offspring each breeding season on maintained, defended territories that are large enough to sustain reproductive efforts under adverse conditions. Spacing of territories helps to reduce predation pressures, but in productive food-rich areas, sandpipers may concentrate within smaller territories and communally forage in adjacent habitats (Pitelka et al. 1974). The high localized densities of semipalmated sandpipers at Sadlerochit, Katakturuk, and Jago Bitty, and the relatively low densities at other areas, may have been influenced by differential prey availability.

Lesser Golden-plover

Mean densities of lesser golden-plovers were significantly higher in Riparian than other habitats when locations were pooled (Table 20). Surprisingly, densities of plovers in Flooded and Moist Sedge habitats were similar to densities in the more upland habitats due to an apparent increase in use of the wetter habitats during the post-reproductive season. Lesser golden-plovers were primarily reported in upland habitats during summer, but in some years were observed to use wet areas in late summer (Myers and Pitelka 1980), probably as brooding habitat (Martin and Moitoret 1981, McWhorter et al. 1987). Although most nests were found in Riparian or upland habitats, nest densities were statistically similar among habitats. Plovers nested in dry sites with low or no vegetation; frost boils and polygon rims provided suitable microsites in wet habitats (McWhorter et al. 1987).

Table 20. Mean densities of lesser golden-plovers (birds/km^2) observed in 7 habitats pooled over locations during the reproductive and post-reproductive seasons[a] on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985. Sample sizes were 15 and 9 for reproductive and post-reproductive seasons except where noted.

Mean Lesser Golden-plovers/km^2

(Habitat $P<0.001$; Season $P=0.356$; Habitat x Season $P=0.127$)

IX	II	IV	VI	I	IVa	III		
24	8	6	10	6	7	4	Reproductive Season	- A
24	16	16	7	7	1	2	Post-Reproductive Season	- A

---

[a] Sample sizes; reproductive: II n=45, III n=95, IV n=55, IVa n=50, V n=115, VIn=89, IX n=93, post-reproductive: II n=27, III n=56, IV n=31, IVa n=30, V n=69, VI n=54, IX n=55; underlining indicates habitat means which are not significantly different at p=0.05.

Changes in plover densities from reproductive to post-reproductive seasons indicated that shifts occurred in use of some habitats at several locations. Higher densities of plovers were observed in Flooded habitat inland (Niguanak) than coastally (Jago Delta and Okpilak) during the reproductive season (Table 21). However, during the post-reproductive season, densities declined at Niguanak and increased at Okpilak and Jago Delta suggesting a possible coastal shift in use of Flooded habitat. In addition, plover densities declined in Wet Sedge at Jago Delta and Niguanak but increased at Jago Bitty during the post-reproductive season (Table 21). Wet Sedge plots contained substantial standing water at Jago Bitty during the post-reproductive season but there was little or no standing water in Wet Sedge at Jago Delta and Niguanak. Although some plovers apparently moved to wetter areas during the post-reproductive season of 1985, others continued to utilize upland and drier Riparian habitats. Densities were statistically similar for reproductive and post-reproductive seasons in Moist Sedge-Shrub, Tussock and Riparian habitats.

Red-necked Phalarope

Red-necked phalaropes were closely tied to Flooded habitat during the reproductive season and were found in much lower densities in other habitats (Table 22). Significantly more nests were found in Flooded than other habitats (Table 23). Phalarope densities were statistically similar among locations in Flooded habitat despite substantially lower numbers observed at Jago Delta (Table 24). Flooded plots at Okpilak and Niguanak had deeper, more persistent lakes and ponds apparently preferred by red-necked phalaropes while plots at Jago Delta were of the less-preferred "marshy" type (Martin and Moitoret 1981). Similarly, phalarope use of Mosaic habitat was largely confined to the small, relatively deep, ice-wedge ponds. Densities in Flooded habitat, and at most locations in Wet Sedge habitat, decreased significantly during the post-reproductive season (Table 24) as females and later, males and young moved to the coast and flocked prior to migration (Shamel 1978, Divoky 1978, Martin and Moitoret 1981).

Total Birds, Total Species

Riparian and Flooded habitats had the highest densities of birds and the greatest numbers of species observed during the reproductive and post-reproductive seasons (Tables 25 and 26). Total bird densities increased significantly in Riparian and appeared to increase in Flooded habitat while numbers of species decreased significantly in both habitats during the post-reproductive season. Ptarmigan and/or Lapland longspurs increased substantially at most locations in Riparian habitat as the result of immigration and recruitment and more than offset the decreases of early migrating species. Flooded habitats, particularly coastal, were important staging and migrating areas for shorebirds and possibly waterfowl and large numbers of several species, particularly pectoral sandpipers, surged through in flocks during the post-reproductive season.

Riparian. Large variations were observed in bird density and numbers of species among locations in Riparian habitat. Sadlerochit, Katakturuk, and Marsh Creek had the highest bird densities observed during the reproductive season. These results were largely due to the relatively high densities of Lapland longspurs, semipalmated sandpipers, redpolls, and savannah sparrows

Table 21. Mean densities of lesser golden-plovers (birds/km^2) observed on 7 habitats at different locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a]. Sample sizes were 15 and 9 for reproductive and post-reproductive seasons except where noted.

Mean Lesser Golden-plovers/km^2

RIPARIAN HABITAT[b]

(Location P=0.393; Season P=0.877; Location x Season P=0.633)

SAD	AIC	KAT	JDE	MCR	JBI		
45	27	17	20	15	13	Reproductive Season	- A
29	34	34	22	18	4	Post-Reproductive Season	- A

FLOODED HABITAT

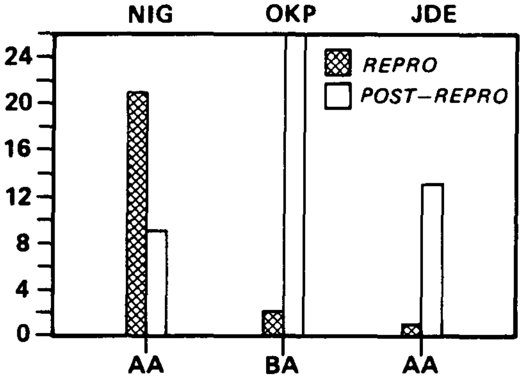
(Location P=0.352; Season P=0.099; Location x Season P=0.034)

Reproductive Season

NIG	OKP	JDE
21	2	1

Post-Reproductive Season

OKP	JDE	NIG
26	13	9



WET SEDGE HABITAT[c]

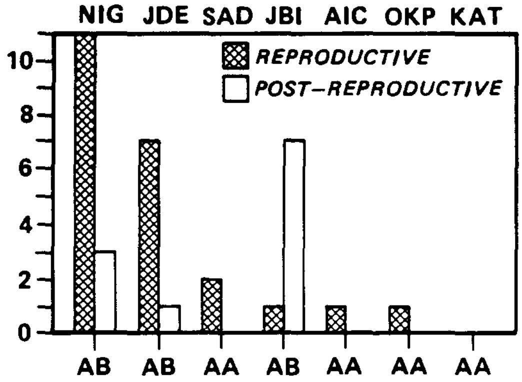
(Location P=0.175; Season P=0.135; Location x Season P=0.049)

Reproductive Season

NIG	JDE	SAD	JBI	AIC	OKP	KAT
11	7	2	1	1	1	0

Post-Reproductive Season

JBI	NIG	JDE	SAD	AIC	OKP	KAT
7	3	1	0	0	0	0



MOSAIC HABITAT[d]

(Location P=0.180; Season P=0.012; Location x Season P=0.523)

JDE	SAD	OKP		
9	6	6	Reproductive Season	- A
1	3	0	Post-Reproductive Season	- B

Table 21. (continued).

MOIST SEDGE HABITAT[e]

(Location P=0.275; Season P=0.147; Location x Season P=0.272

JBI	AIC	KAT	MCR		
10	4	6	3	Reproductive Season	- A
31	27	0	2	Post-Reproductive Season	- A

MOIST SEDGE-SHRUB HABITAT [f]

(Location P=0.080; Season P=.823; Location x Season P=0.667)

AIC	JBI	KAT	JDE	SAD	OKP	MCR	NIG		
15	5	4	10	4	5	4	1	Reproductive Season	-A
22	11	11	2	4	2	0	0	Post-Reproductive Season	-A

TUSSOCK HABITAT[g]

(Location P = 0.031; Season P = 0.243; Location x Season P = 0.243)

AIC	KAT	SAD	NIG	JBI	MCR		
21	9	15	5	4	4	Reproductive Season	- A
23	9	0	7	2	2	Post-Reproductive Season	- A

---

[a] Underlining indicates location means which are not significantly different at p=0.05; seasons followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sadlerochit: reproductive season n=18, post-reproductive season n=12, and Katakturak: post-reproductive n=7.

[c] Katakturak: reproductive season n=5, post-reproductive season n=2.

[d] Okpilak: reproductive season n=20, post-reproductive season n=12.

[e] Katakturak: reproductive season n=10, post-reproductive season n=4.

[f] Okpilak: reproductive season n=10, post-reproductive season n=6.

[g] Katakturuk: reproductive season n=14.

Table 22. Mean densities of red-necked phalaropes (birds/km^2) observed in 7 habitats pooled over location during the reproductive and post-reproductive season on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].

Mean Red-necked Phalaropes/km^2

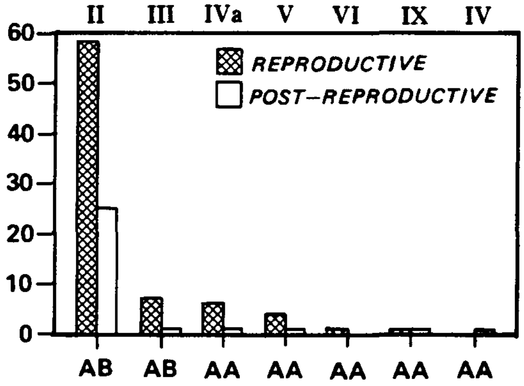
(Habitat $P<0.001$; Season $P<0.001$; Location x Season $P<0.001$)

Reproductive Season

II	III	IVa	V	VI	IX	IV
58	7	6	4	1	1	0

Post-Reproductive Season

II	IVa	V	III	IV	IX	VI
25	1	1	1	1	1	0



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[a] Sample sizes: reproductive: II n=45, III n=95, IV n=55, IVa n=50, V N=115, VI n=89, IX n=93; post-reproductive: II n=27, III n=56, IV n=31, V n=30, VI n=54, IX n=55; underlining indicates habitat means which are not significantly different at P=0.05; seasons with habitats subtended by the same letter are not significantly different at p=0.05.

Table 23. Mean densities of red-necked phalarope nests (nests/km^2) observed in 7 habitats[a] pooled over location on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Mean Red-necked Phalarope Nests/km^2

(Habitat $P<0.001$)

II	III	V	VI	IVa	IV	IX
8	2	1	1	0	0	0

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[a] Sample sizes: II n=9, III n=19, IV n=11, IVa n=10, V n=23, VI n=18, IX n=19; underlining indicates habitat means that are not significantly different at p=0.05.

Table 24. Mean densities of red-necked phalaropes (birds/km^2) observed in 7 habitats and 8 locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a]. Sample sizes are 15 and 9 for reproductive and post-reproductive seasons, except where noted.

Mean Red-necked Phalaropes/km^2

RIPARIAN HABITAT[b]

(Location P=0.409; Season P=0.614; Location x Season P=0.733)

AIC	SAD	KAT	JBI	JDE	MCR		
1	1	0	0	0	0	Reproductive Season	- A
0	1	0	0	0	0	Post-Reproductive Season	- A

FLOODED HABITAT

(Location P=0.122; Season P=0.016; Location x Season P=0.150)

OKP	NIG	JDE		
93	77	5	Reproductive Season	- A
41	29	4	Post-Reproductive Season	- B

WET SEDGE HABITAT[c]

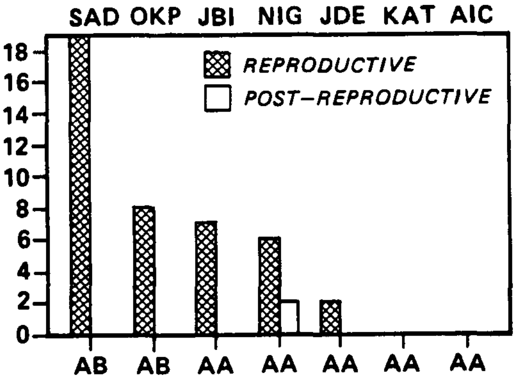
(Location P=0.075; Season P=0.004; Location x Season P=0.045)

Reproductive Season

SAD	OKP	JBI	NIG	JDE	KAT	AIC
19	8	7	6	2	0	0

Post-Reproductive Season

NIG	SAD	OKP	JBI	JDE	KAT	AIC
2	0	0	0	0	0	0



MOSAIC HABITAT[d]

(Location P=0.865; Season P 0.001; Location x Season P=0.072)

SAD	OKP	JDE		
8	7	5	Reproductive Season	- A
3	0	0	Post-Reproductive Season	- B

Table 24. (continued).

MOIST SEDGE HABITAT[e]

(Location P=0.510; Season P=0.407; Location x Season P=0.510)

JBI	KAT	AIC	MCR		
0	0	0	0	Reproductive Season	- A
1	0	0	0	Post-Reproductive Season	- B

MOIST SEDGE-SHRUB HABITAT[f]

(Location P=0.149; Season P=0.006; Location x Season P=0.117)

JBI	AIC	NIG	SAD	KAT	OKP	MCR		
9	8	7	3	3	0	0	Reproductive Season	- A
0	0	1	3	0	0	0	Post-Reproductive Season	- B

TUSSOCK HABITAT[g]

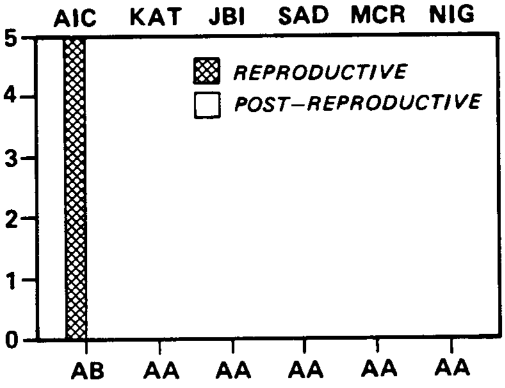
(Location P=0.039; Season P=0.091; Location x Season P=0.039)

Reproductive Season

AIC	KAT	JBI	SAD	MCR	NIG
5	0	0	0	0	0

Post-Reproductive Season

AIC	KAT	JBI	SAD	MCR	NIG
0	0	0	0	0	0



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[a] Underlining indicates location means which are not significantly different at p=0.05; seasons followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sadlerochit: reproductive season n=18, post-reproductive season n=12, and Katakturak: post-reproductive season n=7.

[c] Katakturak: reproductive season n=5, post-reproductive season n=2.

[d] Okpilak: reproductive season n=20, post-reproductive season n=12.

[e] Katakturak: reproductive season n=10, post-reproductive season n=4.

[f] Okpilak: reproductive season n=10, post-reproductive season n=6.

[g] Katakturuk: reproductive season n=14.

Table 25. Mean densities of total birds (birds/km^2) observed in 7 habitats pooled over locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].

Mean Total Birds/km^2

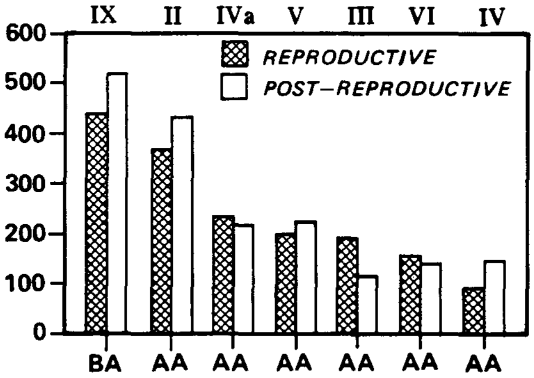
(Habitat $P<0.001$; Season $P=0.125$; Habitat x Season $P<0.001$)

Reproductive Season

IX	II	IVa	V	III	VI	IV
439	369	233	197	189	155	91

Post-Reproductive Season

IX	II	V	IVa	IV	VI	III
515	429	222	216	143	140	115



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[a] Sample sizes; reproductive: II n=45, III n=95, IV n=55, IVa n=50, V n=115, VI n=89, IX n=93; post-reproductive: II n=27, III n=56, IV n=31, IVa n=30, V n=69, VI n=54, IX n=55. Underlining indicates habitat means which are not significantly different at P=0.05; seasons within habitats subtended by the same letter are not significantly different at p=0.05.

Table 26. Mean densities of total species (species/0.1 km^2) observed in 7 habitats pooled over locations during the reproductive and post-reproductive seasons[a] on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Mean Total Species/0.1 km^2

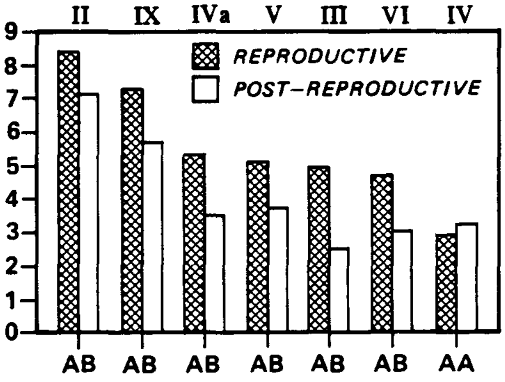
(Habitat $P<0.001$; Season $P<0.001$; Habitat x Season $P<0.001$)

Reproductive Season

II	IX	IVa	V	III	VI	IV
8.4	7.3	5.3	5.1	4.9	4.7	2.9

Post-Reproductive Season

II	IX	V	IVa	IV	VI	II
7.1	5.7	3.7	3.5	3.2	3.0	2.5



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[a] Sample sizes; reproductive: II n=45, III n=95, IV n=55, IVa n=55, V n=115, VI n=89, IX n=93; post-reproductive: II n=27, III n=56 IV n=31, IVa n=30, V n=69, VI n=54, IX n=55. Underlining indicates habitat means which are not significantly different at P=0.05; seasons within habitats subtended by the same letter are not significantly different at P=0.05.

seen at these locations. In addition, these three locations also supported the greatest numbers of species observed and, with the addition of Jago Bitty, the greatest numbers of nesting species (Table 27). Marsh Creek and Katakturuk had the highest densities and most consistent observations of yellow wagtails, American tree sparrows, white-crowned sparrows, and redpolls. These birds were primarily associated with the relatively extensive tall willow stands present at these locations. Fewer species of passerines were consistently present at Sadlerochit but low densities of several species less common in Riparian plots were observed (red-throated loon, mallard, northern pintail, common eider, oldsquaw). Riparian plots at Jago Delta were relatively low in vegetative diversity and significantly fewer species were observed there than at other locations (Table 27).

Several less common species were regularly or predominantly observed in Riparian habitat during the reproductive season. Jaegers were present in low densities at virtually all locations in all habitats and parasitic and long-tailed jaegers were probably important predators of birds (Maher 1974). Although no patterns in distribution were apparent, long-tailed jaegers appeared to be the most common of the 3 species. Observations of ruddy turnstones and Baird's sandpipers were mostly confined to Riparian habitat and both species appeared to be dependent on gravel or mud bars. Turnstones and their nests were most evident at coastal locations but nesting was also observed inland. Buff-breasted sandpipers were apparently quite localized in distribution. They were observed in all habitats but appeared to use Riparian (often Dryas terraces) most consistently.

Significant increases in total bird density observed in Riparian habitat at Jago Bitty during the post-reproductive season (Table 27) resulted from increases in ptarmigan, while increases at Marsh Creek reflected substantial increases in ptarmigan and savannah sparrows and minor increases in pectoral and Baird's sandpipers (Appendix Table III). Despite increased ptarmigan densities, total bird densities declined significantly at Sadlerochit (Table 27) as a result of substantial reductions in densities of semipalmated sandpipers, ruddy turnstones, lesser golden-plovers, and redpolls (Appendix Table III).

Flooded. Physical characteristics of Flooded habitat varied considerably among locations. Flooded plots at Jago Delta were located in a coastal wetland and included numerous shallow ephemeral ponds with emergent vegetation, while plots at another coastal site, Okpilak, were in an area of deep, open, permanent ponds having marginal or no emergent vegetation and surrounded primarily by Wet Sedge. Plots at Niganak were in an inland wetland with deep, open, permanent ponds surrounded by Wet Sedge and upraised polygons and polygon rims.

Mean total bird densities were significantly lower at Jago Delta than at Okpilak during the reproductive season (Table 28). Niguanak ranked intermediate and statistically similar to both locations. Numbers of species and total nests were statistically similar among locations (Table 28). Despite apparent similarities in bird communities at the three locations, differences in species composition and numbers were observed. Red-throated loons, Canada geese, brant, and spectacled eiders were observed nesting in close association with ponds at Okpilak. These species are typically observed breeding in arctic coastal thaw-lake areas, although breeding Canada geese and red-throated loons were discovered considerable

Table 27. Mean total birds (birds/km^2), mean number of species (species/0.1km^2), and mean number of nesting species (species/0.1km^2) observed in Riparian habitat at 6 locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].

Riparian Habitat

MEAN TOTAL BIRDS/km^2 [b]

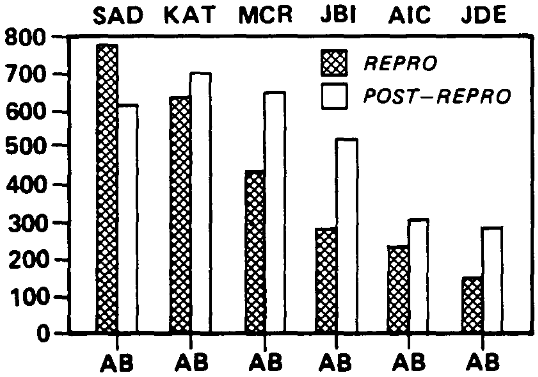
(Location P=0.004; Season P=0.005; Location x Season P=0.015)

Reproductive Season

SAD	KAT	MCR	JBI	AIC	JDE
755	635	429	279	231	146

Post-Reproductive Season

KAT	MCR	SAD	JBI	AIC	JDE
698	647	613	514	302	281



MEAN TOTAL SPECIES/0.1km^2 [b]

(Location P< 0.001; Season P=0.001; Location x Season P=0.075)

MCR	KAT	SAD	AIC	JBI	JDE	
9.3	7.9	9.0	7.1	6.2	3.5	Reproductive Season - A
9.1	7.7	5.8	4.1	4.4	3.0	Post-Reproductive Season - B

MEAN TOTAL NESTING SPECIES/0.1km^2 [c]
(Location P=0.0454)

MCR	JBI	SAD	KAT	AIC	JDE
5.7	4.3	4.3	3.7	2.7	2.0

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[a] Underlining indicates location means which are not significantly different at P=0.05; seasons followed or subtended by the same letter are not significantly different at P=0.05.

[b] Sample sizes: reproductive season n=15, post-reproductive season n=9, except Katakturak: post-reproductive season n=7 and Sadlerochit: reproductive season n=18, post-reproductive season n=12.

[c] Sample size: n=3, except Sadlerochit: n=4.

Table 28. Mean total birds (birds/km^2), mean number of species (species/0.1km^2), and mean number of nesting species (species/0.1km^2) observed in Flooded habitat at 3 locations[a] during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Flooded Habitat

TOTAL BIRDS/km^2 [b]

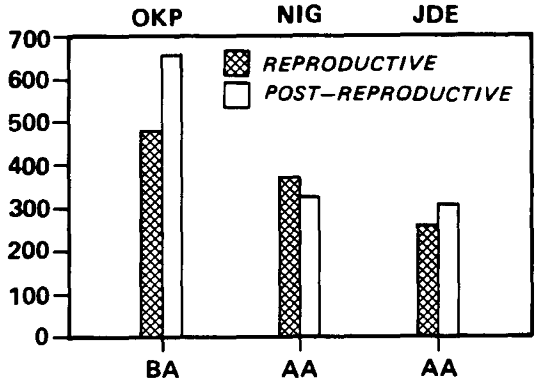
(Location P=0.009; Season P=0.074; Location x Season P=0.047)

Reproductive Season

OKP	NIG	JDE
479	368	260

Post-Reproductive Season

OKP	NIG	JDE
656	326	306



MEAN TOTAL SPECIES/0.1 km^2 [b]

(Location P=0.153; Season P=0.090; Location x Season P=0.430)

OKP	NIG	JDE		
9.5	8.9	6.8	Reproductive Season	- A
8.1	6.7	6.7	Post-Reproductive Season	- A

MEAN TOTAL NESTING SPECIES/0.1km^2 [c]
(Location P=0.2739)

OKP	NIG	JDE
67	63	20

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[a] Underlining indicates location means which are not significantly different at p=0.05; seasons followed or subtended by the same letter are not significantly different at p=0.5.

[b] Sample sizes: reproductive season n=15, post reproductive season n=9.

[c] Sample size: n=3.

distances inland on NPRA (Derksen et al. 1981). Higher mean densities of pectoral sandpipers, glaucous gulls, and red phalaropes were observed at Okpilak than at Jago Delta or Niguanak and higher densities of red-necked phalaropes were observed at Okpilak and Niguanak. Highest densities of oldsquaw and pomarine jaegers in Flooded plots were seen at Niguanak. Parasitic and long-tailed jaegers were not observed at Niguanak but were seen in Flooded plots at Okpilak and Jago Delta. Densities of stilt sandpipers and long-billed dowitchers were high in Flooded relative to other habitats and these species were evident at all three locations.

Pectoral sandpipers increased in Flooded habitat at all locations during the post-reproductive season, but most substantially at Okpilak. Lesser golden-plovers and semipalmated sandpipers increased coastally and decreased inland and dunlin (probably early migrants) appeared at coastal locations. Red phalaropes declined at Okpilak and Niguanak and increased at Jago Delta. Stilt sandpipers and long-billed dowitchers continued to use Flooded habitat in relatively high numbers through the post-reproductive season. Pintail densities increased in Flooded habitat at Okpilak and Niguanak during the post-reproductive season as birds utilized ponds for molting and brooding areas (Derksen et al. 1981, McWhorter et al. 1987). Lapland longspurs and jaegers appeared to decline in Flooded habitat at all locations.

Wet Sedge. Mean total bird densities in Wet Sedge were significantly higher at Sadlerochit than at other locations during the reproductive season (Table 29). Much of this difference was due to the presence of exceptional numbers of savannah sparrows and Lapland longspurs. Both species were closely associated with the unusually high density of willow-dominated strangs present in the plots at Sadlerochit. In addition, high densities of longspur nests, comparable to densities typical in more preferred habitats, were observed. Highest densities of parasitic jaegers in Wet Sedge were also observed at Sadlerochit, possibly in response to the high number of passerines, a major food source for breeding parasitic jaegers (Maher 1974). Pectoral and semipalmated sandpipers and red-necked phalaropes were also present in higher densities than at other locations.

Total bird density declined significantly during the post-reproductive season at Sadlerochit, Okpilak, Niguanak and Jago Delta. Decreases in Lapland longspurs, pectoral sandpipers, and jaegers were observed at all four locations. Red-necked phalaropes declined at Sadlerochit and Okpilak, and lesser golden-plovers declined at Niguanak and Jago Delta. In addition, a substantial decrease in savannah sparrows occurred at Sadlerochit. Rock ptarmigan increased at Aichilik, Katakturuk, and Sadlerochit during the post-reproductive season.

Mosaic. No significant differences in mean total birds were observed among locations or between seasons in Mosaic habitat (Table 30). Lapland longspurs were the most abundant species at all locations and nested in relatively high densities. Oldsquaw and northern pintail were present in low densities at all locations and were observed nesting on polygon rims or high center polygons near water at Jago Delta (McWhorter et al. 1987). Lesser golden-plovers, long-billed dowitchers and red-necked phalaropes were also present in relatively low densities at all locations. However, significant location differences in densities of pectoral and semipalmated

Table 29. Mean total birds (birds/km^2) and mean number of species (species/0.1km^2) observed in Wet Sedge habitat at 7 locations during the post-reproductive and reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].

Wet Sedge Habitat

MEAN TOTAL BIRDS/km^2 [b]

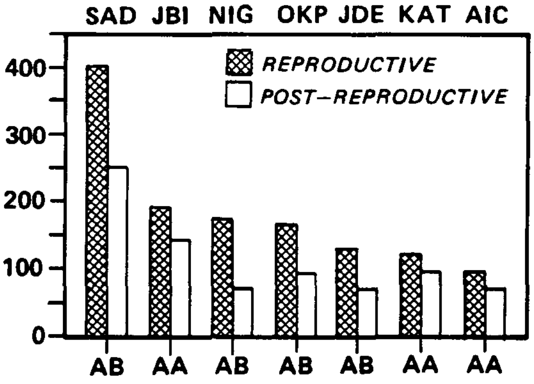
(Location $P<0.001$; Season $P<0.001$; Location x Season $P=0.037$)

Reproductive Season

SAP	JBI	NIG	OKP	JDE	KAT	AIC
401	191	172	167	131	122	95

Post-Reproductive Season

SAP	JBI	KAT	OKP	AIC	NIG	JDE
250	142	95	93	72	71	69



MEAN TOTAL SPECIES/0.1 km^2 [b]

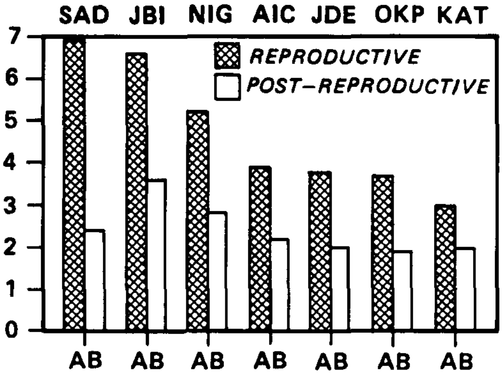
(Location $P<0.001$; Season $P<0.001$; Location x Season $P=0.34$)

Reproductive Season

SAD	JBI	NIG	AIC	JDE	OKP	KAT
6.9	6.6	5.2	3.9	3.8	3.7	3.0

Post-Reproductive Season

JBI	NIG	SAD	AIC	JDE	KAT	OKP
3.6	2.8	2.4	2.2	2.0	2.0	1.9



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[a] Underlining indicates location means which are not significantly different at p=0.05; seasons subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes: reproductive season n=15, post-reproductive season n=9, except Katakturak: reproductive season n=5, post reproductive season n=2.

sandpipers were observed (see previous sections), and densities of rock ptarmigan appeared to be greater at Jago Delta.

There was a significant decline in the mean number of species present in Mosaic habitat at all locations during the post-reproductive season (Table 30). However, species composition was not consistent among locations and the declines resulted from the reduction or absence of different species at different locations (Appendix Tables II and III). The greatest change in bird density observed was a five-fold increase in rock ptarmigan at Jago Delta. Although no increases were observed in Mosaic habitat at Sadlerochit or Okpilak, a four-fold increase in rock ptarmigan density occurred in Riparian habitat at Sadlerochit.

Table 30. Mean total birds (birds/km^2) and mean number of species (species/0.1km^2) observed in Mosaic habitat at 3 locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic national Wildlife Refuge, Alaksa, 1985[a].

Mosaic Habitat

MEAN TOTAL BIRDS/km^2 [b]

(Location P=0.457; Season P=0.701; Location x Season P=0.696)

JDE	SAD	OKP		
239	262	201	Reproductive Season	- A
269	231	166	Post-Reproductive Season	- A

MEAN TOTAL SPECIES/0.1km^2 [b]

(Location P=0.172; Season P=0.001; Location x Season P=0.930)

JDE	SAD	OKP		
6.1	5.5	4.6	Reproductive Season	- A
4.2	3.9	2.6	Post-Reproductive Season	- B

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[a] Underlining indicates location means which are not significantly different at p=0.05; seasons followed by the same letter are not significantly different at p=0.05.

[b] Sample sizes: reproductive season n=15, post-reproductive season n=9, except Okpilak: reproductive season n=20, post-reproductive season n=12.

Moist Sedge. Jago Bitty had the highest density of total birds observed in Moist Sedge habitat during the reproductive season (Table 31) as a result of generally higher densities of species common to all locations and due to the presence of additional species that were absent at other locations (Appendix Table II). Moist Sedge plots at Jago Bitty appeared relatively more diverse than plots at other locations and had substantial inclusions of Wet Sedge as well as limited areas of ponds and stands of erect willows. The most common species were Lapland longspur, lesser golden-plover, rock ptarmigan, and long-tailed jaeger.

Table 31. Mean total birds (birds/km^2) and mean number of species (species/0.1km^2) observed in Moist Sedge habitat at 4 locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].

Moist Sedge Habitat

MEAN TOTAL BIRDS/km^2 [b]

(Location P=0.046; Season P=0.024; Location x Season P=0.093)

JBI	KAT	AIC	MCR		
131	90	69	72	Reproductive Season	- B
268	105	107	81	Post-Reproductive Season	- A

MEAN TOTAL SPECIES/0.1km^2 [b]

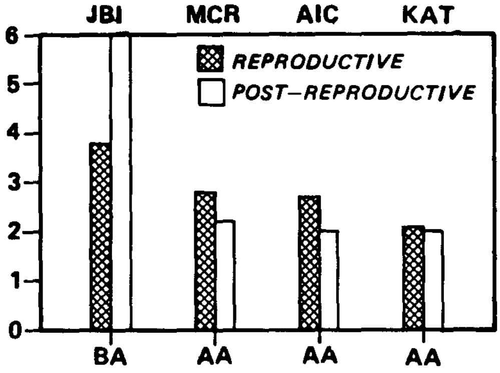
(Location P=0.044; Season P=0.486; Locations x Season P=0.023)

Reproductive Season

JBI	MCR	AIC	KAT
3.8	2.8	2.7	2.1

Post-Reproductive Season

JBI	MCR	AIC	KAT
6.0	2.2	2.0	2.0



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[a] Underlining indicates location means which are not significantly different at p=0.05; seasons followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes: reproductive season n=15, post-reproductive season n=9, except Katakturak: reproductive season n=10, post-reproductive season n=6.

Total bird densities increased significantly in Moist Sedge during the post-reproductive season as a result of increases in rock ptarmigan at all locations and increases in densities of willow ptarmigan, lesser golden-plovers, pectoral sandpipers, and savannah sparrows at some locations (Appendix Table III). Bird densities doubled at Jago Bitty and the mean number of species observed rose to the highest levels observed at any of the four locations in either season as a result of substantial increases in willow and rock ptarmigan, lesser golden-plovers, pectoral sandpipers, savannah sparrows, redpolls, and small increases in several species not found in Moist Sedge at other locations (Appendix Tables II and III).

Moist Sedge-Shrub. Differences in total bird densities and total species among locations were not well defined statistically for Moist Sedge-Shrub habitat (Table 32). However, examination of densities of individual species revealed some apparent differences and similarities among locations within seasons and within locations among seasons.

During the reproductive season, willow ptarmigan were observed in higher densities in Moist Sedge-Shrub at inland locations. Rock ptarmigan were present at all locations and highest densities were seen at Sadlerochit. Greatest numbers of semipalmated sandpipers were observed at Sadlerochit and Jago Bitty and pectoral sandpipers were most common at Aichilik, Sadlerochit, Jago Delta, and Niguanak. Savannah sparrows were most abundant at Marsh Creek, Aichilik, Katakturuk, and Jago Bitty. Several species were evident at most or all locations in similar numbers. These included northern pintail (all locations except Marsh Creek), lesser golden-plover, pomarine jaeger, parasitic jaeger, long-tailed jaeger, and Lapland longspur (the most abundant species).

Significantly higher densities of nests (primarily Lapland longspur and pectoral sandpiper) were observed in Moist Sedge-Shrub at Niguanak. Lapland longspur was the only species whose nests were found in this habitat at all locations. Several species, including pectoral sandpiper, lesser golden-plover, and semipalmated sandpiper, exhibited either high nesting densities or were absent.

Although total bird densities were statistically similar among seasons, the number of total species declined significantly in Moist Sedge-Shrub at all locations during the post-reproductive season. This decline was primarily the result of movement by several species of shorebirds which were present during the reproductive season in moderate to low densities (particularly semipalmated and buff-breasted sandpipers, and red-necked phalaropes) into other habitats prior to migration. Lesser golden-plovers and pectoral sandpipers were notable exceptions to the shorebird decline.

During the post-reproductive period, Lapland longspurs exhibited density increases at Aichilik, Sadlerochit, Marsh Creek, and Niguanak and declined at Okpilak, Katakturuk, Jago Bitty, and Jago Delta. Willow ptarmigan increased at Jago Bitty, Katakturuk, Aichilik, Sadlerochit, and Marsh Creek, and rock ptarmigan increased at Katakturuk, Jago Bitty, Sadlerochit, Marsh Creek, and Niguanak. Pectoral sandpipers increased at all locations except Jago Delta and Niguanak.

Table 32. Mean total birds (birds/km^2), mean number of species (species/0.1km^2) and mean number of nesting species (species/0.1km^2) observed in Moist Sedge-Shrub habitat at 8 locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].

Moist Sedge-Shrub Habitat

MEAN TOTAL BIRDS/km^2 [b]

(Location P=0.019; Season P=0.230; Location x Season P=0.136)

SAD	AIC	NIG	JBI	MCR	OKP	JDE	KAT		
———	———	———	———	———					
		———	———	———	———	———			
			———	———	———	———	———		
272	227	225	198	137	180	203	127	Reproductive Season	- A
290	328	260	221	256	140	110	141	Post-Reproductive Season	- A

MEAN TOTAL SPECIES/0.1km^2 [b]

(Location P=0.002; Season $P < 0.001$; Location x Season P=0.136)

AIC	JBI	SAD	NIG	JDE	KAT	MCR	OKP		
———	———	———	———						
	———	———	———	———	———				
				———	———	———	———		
7.0	5.9	5.7	5.5	5.2	4.3	3.7	3.3	Reproductive Season	- A
5.1	4.2	4.2	4.1	2.8	3.6	2.7	2.2	Post-Reproductive Season	- B

MEAN TOTAL NESTS/km^2 [c]

(Location P=0.002)

NIG	SAD	AIC	JBI	JDE	OKP	KAT	MCR
90	57	53	47	47	30	27	20
———	———	———	———	———	———		
		———	———	———	———	———	
			———	———	———	———	———

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[a] Underlining indicates location means which are not significantly different at p=0.05; seasons followed by the same letter are not significantly different at p=0.05.

[b] Sample sizes: reproductive season n=15, post-reproductive season n=9, except Okpilak: reproductive season n=10, post-reproductive season n=4.

[c] Sample size: n=3, except Okpilak: n=2.

Tussock. Total bird numbers in Tussock habitat at the four locations with highest densities were statistically similar during the reproductive season but significantly more total species were observed at Aichilik (Table 33). This was probably due to the presence of several species of shorebirds (long-billed dowitchers, red-necked phalaropes, whimbrels) which were not seen on Tussock plots at other locations and which are typically found in wetter habitats. Lapland longspur was the most abundant species at all locations and at most locations comprised over half the total bird observations. Substantial numbers of willow and rock ptarmigan were also observed at most locations (Appendix Table II).

No significant differences between locations were detected for total nests or total nesting species in Tussock habitat. Willow ptarmigan nests were found at Jago Bitty, Marsh Creek, and Niguanak and, although none were observed, were probably present at Katakturuk and Aichilik. Rock ptarmigan nests were found at all locations except Marsh Creek.

There was a significant decline in total bird species observed in Tussock habitat at all locations during the post-reproductive season (Table 33). Total bird densities increased significantly at Katakturuk and declined significantly at Sadlerochit and Niguanak. The increase at Katakturuk resulted from increases in ptarmigan plus a slight increase in longspurs which more than compensated for the departures of semipalmated sandpipers, pomarine and parasitic jaegers, yellow wagtails, savannah sparrows, and redpolls. Sadlerochit and Niguanak were the only locations at which rock ptarmigan did not increase. Lapland longspurs exhibited substantial decreases at both locations.

Lesser golden-plovers were present on Tussock plots during the post-reproductive season in numbers similar to those observed during the reproductive season but were absent at Sadlerochit. Pomarine and parasitic jaegers were absent and long-tailed jaegers declined at all locations except Niguanak. Yellow wagtails, savannah sparrows, and redpolls moved out of Tussock habitat during the post-reproductive season. Substantial reductions in Lapland longspurs were observed at Sadlerochit, Marsh Creek, and Niguanak and a slight decline occurred at Jago Bitty. Longspurs increased slightly at Katakturuk and Aichilik.

Annual Variability

Annual variability in bird density was observed for at least some locations in every species or group tested. Although in most instances it was beyond the scope of this study to define causes for observed variation, some enlightenment can be gained from examining where annual variation occurred and comparing general results with those of other researchers. Direct comparison of density values with other studies was avoided due to possible biases caused by different censusing methods, but comparisons of the observed magnitudes of annual changes were made.

Very few cases of annual variability in nest densities were detected. This was probably the result of high variability among plots within a location. Further discussion appears in "Sampling Variability".

Table 33. Mean total birds (birds/km^2) and mean number of species (species/0.1km^2) observed in Tussock habitat at 6 locations during the reproductive and post-reproductive seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].

Tussock Habitat

MEAN TOTAL BIRDS/km^2 [b]

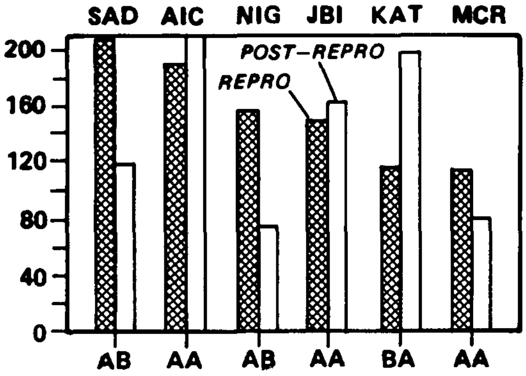
(Location P=0.005; Season P=0.229; Location x Season P=0.006)

Reproductive Season

SAD	AIC	NIG	JBI	KAT	MCR
207	189	156	148	115	113

Post-Reproductive Season

AIC	KAT	JBI	SAD	MCR	NIG
210	198	163	117	80	74



MEAN TOTAL SPECIES/0.1 km^2 [b]

(Location $P < 0.001$; Season $P < 0.001$; Location x Season P=0.064)

AIC	NIG	SAD	JBI	KAT	MCR	
7.4	4.5	5.0	4.5	4.1	2.9	Reproductive Season - A
4.4	3.1	2.6	2.7	3.0	2.1	Post-Reproductive Season - B

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[a] Underlining indicates location means which are not significantly different at P=0.05; seasons followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes: reproductive season n=15, post-reproductive season n=9, except Katakturak: reproductive season n=14.

Lapland Longspur

Significantly fewer Lapland longspurs were observed at Okpilak in 1982 than in 1983 or 1985 (Table 34). Numbers of longspurs were statistically similar from 1983 to 1985 at Okpilak, Katakturuk, and Jago Bitty. However, significant differences in longspur density existed among years in at least some habitats at all three locations sampled in 1984 and 1985 (Aichilik, Sadlerochit, and Jago Delta). Fewer longspurs were observed during 1985 at Aichilik in Riparian, Moist Sedge-Shrub, and Moist Sedge. Similarly, longspur densities at Jago Delta declined in Riparian, Mosaic, and Wet Sedge and nest density declined over all habitats from 1984 to 1985 (Table 35). In contrast, numbers of longspurs at Sadlerochit increased from 1984 to 1985 in Riparian and Wet Sedge.

Multi-year studies of tundra birds near Barrow and Atkasook (Myers and Pitelka 1980) revealed that some plots exhibited 2-fold or greater changes in Lapland longspur density (Atkasook plot, Barrow plots 2 and 3) between some pairs of consecutive years and not others. In contrast, one plot (Barrow plot 1) maintained relatively similar densities over 5 consecutive years. Exact causes of the observed annual variability were unknown but the authors stressed the need for understanding these factors and suggested some general areas for continued investigation: annual changes in weather, inter and intra-specific competition, and changes in predator densities.

Food availability is probably a major factor in nesting habitat selection by Lapland longspurs (Seastedt and MacLean 1979) but its impact on annual variability is speculative. Seastedt and MacLean (1979) found that longspur territory size (and therefore probably density) was inversely related to "expected" prey density. They derived "expected" prey density from the mean of several years of data and found a stronger relationship between this mean and territory size than between prey density of the current year and territory size. They hypothesized that longspurs preferred or selected habitats which likely had higher prey densities. This hypothesis is further supported by the fact that the majority of the longspur diet during the period of territory establishment was seeds (Custer and Pitelka 1978), suggesting relatively low arthropod availability during this period (Holmes 1966, Seastedt and MacLean 1979).

Pectoral Sandpiper

Numbers of pectoral sandpipers observed from 1982 to 1985 varied somewhat within habitats, but relative ranks of habitats were quite similar and overall densities were statistically similar within locations among years at Katakturuk, Sadlerochit and Jago Delta (Table 36). However, there was a significant increase in nest density in Wet Sedge habitat at Sadlerochit (from 1984 to 1985) and a significant decline in nest density in Mosaic habitat at Jago Delta from 1984 to 1985 (Table 37). Nest densities were statistically similar among years at Katakturuk. Pectoral sandpiper densities declined in all habitats at Jago Bitty from 1983 to 1985 but nest densities were similar in both years. Pectoral sandpiper numbers at Okpilak were statistically similar in all habitats from 1982 to 1983. However, higher densities were observed in Flooded habitat and lower densities were observed in Mosaic and Wet Sedge habitats in 1985 than in 1982 or 1983. No significant differences among years were detected in nest densities at Okpilak. Significant declines in pectoral sandpipers were also observed in

Table 34. Mean densities of Lapland longspurs (birds/km^2) observed in 5 habitats and 6 locations during the reproductive season on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1982 - 1985[a].

Mean Lapland Longspurs/km^2

OKPILAK[b]

(Habitat P=0.007; Year P=0.001; Year x Habitat P=0.244)

V	IVa	III	II	
98	113	81	20	1982 - A
158	148	101	54	1983 - B
163	124	115	77	1985 - B

KATAKTURUK[c]

(Habitat $P<0.001$; Year P=0.242; Year x Habitat P=0.142)

IX	III	VI	V	IV	
247	63	84	58	53	1983 - A
325	95	50	68	56	1985 - A

JAGO BITTY[d]

(Habitat $P<0.001$; Year P=0.295; Year x Habitat P=0.132)

IX	V	IV	VI	III	
173	95	83	60	42	1983 - A
157	96	81	79	66	1985 - A

AICHILIK[e]

(Habitat $P<0.001$; Year $P<0.001$: Year x Habitat P=0.027)

1984

V	IX	VI	IV	III
231	182	167	62	51

1985

IX	V	VI	III	IV
108	99	82	41	31

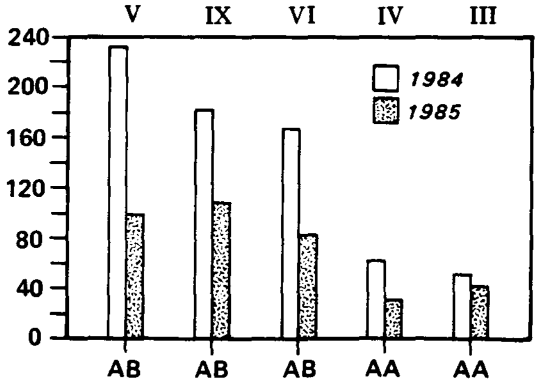
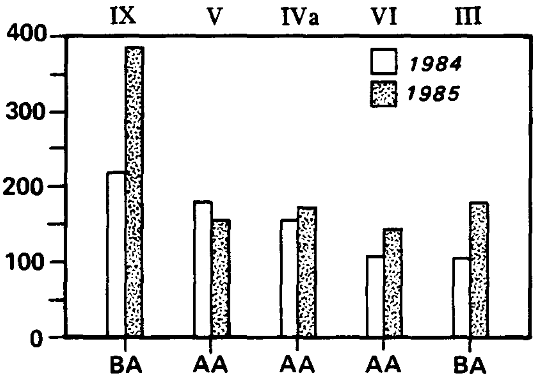


Table 34. (continued).

SADLEROCHIT[f]

(Habitat P=0.045; Year P<0.001; Year x Habitat P=0.003)

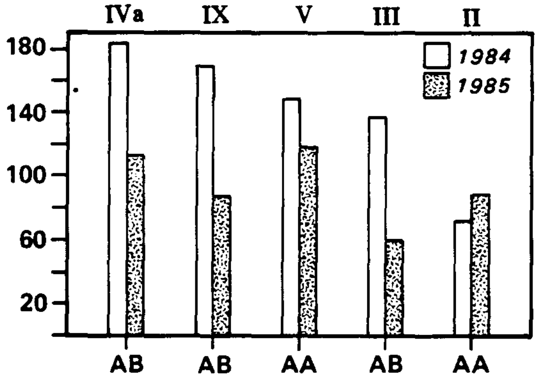
1984				
IX	V	IVa	VI	III
218	178	154	106	103
—	—	—	—	—
1985				
IX	III	IVa	V	VI
384	178	171	154	143
—	—	—	—	—



JAGO DELTA[e]

(Habitat P=0.002; Year P<0.001; Year x Habitat P=0.002)

1984				
IVa	IX	V	III	II
183	169	148	137	71
—	—	—		
	—	—	—	—
1985				
V	IVa	II	IX	III
118	113	88	87	59
—	—	—	—	
		—	—	—



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[a] Underlining indicates habitat means which are not significantly different at P=0.05; years followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes; V: 1982 n=4, 1983 n=8, 1985 n=10; IVa: 1982 n=16, 1983 n=16, 1985 n=20; III: 1982 n=12, 1983 n=12, 1985 n=15; II: 1982 n=12, 1983 n=12, 1985 n=15.

[c] Sample sizes; IX: 1983 n=12, 1985 n=15; III: 1983 n=4, 1985 n=5; VI: 1983 n=12, 1985 n=14, V: 1983 n=12, 1985 n=15; IV: 1983 n=8, 1985 n=10.

[d] Sample sizes for all habitats: 1983 n=12; 1985 n=15.

[e] Sample sizes for all habitats and both years: n=15.

[f] Sample sizes for all habitats and both years: n=15, except 1985 IX: n=18.

Table 35. Mean densities of Lapland longspur nests (nests/km^2) observed in 5 habitats at Jago Delta during the reproductive seasons of 1984 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Mean Lapland Longspur Nests/km^2

JAGO DELTA[b]

(Habitat P=0.261; Year P=0.006; Year x Habitat P=0.221)

V	IVa	III	II	IX	
27	33	23	23	7	1984 - A
27	10	10	3	3	1985 - B

---

[a] Underlining indicates habitat means which are not significantly different at p=0.05; years followed by the same letter are not significantly different at P=0.05.

[b] Sample sizes for all habitats and both years: n=3.

Table 36. Mean densities of pectoral sandpipers (birds/km^2) observed in 5 habitats and 6 locations during the reproductive seasons of 1982, 1983, 1984 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Mean Pectoral Sandpipers/km^2

OKPILAK[b]

(Habitat P=0.006; Year P=0.340; Year x Habitat P=0.007)

1982

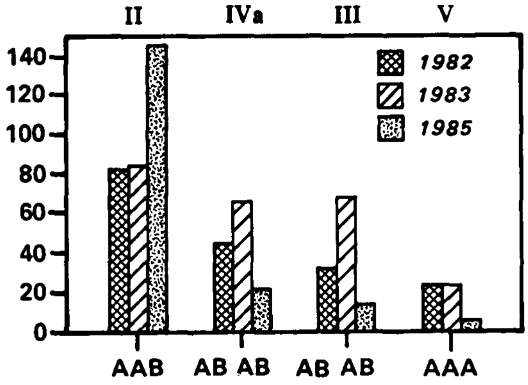
II	IVa	III	V
82	45	32	23[c]

1983

II	III	IVa	V
84	68	66	23

1985

II	IVa	III	V
145	21	13	5



KATAKTURUK[d]

(Habitat P=0.144; Year P=0.242; Year x Habitat P=0.689)

III	V	VI	IV	IX	
18	15	6	0	0	1983 - A
13	8	3	1	0	1985 - A

JAGO BITTY[e]

(Habitat P$<$0.001; Year P=0.003; Year x Habitat P=0.094)

III	V	IV	IX	VI	
64	23	10	7	0	1983 - A
39	4	4	0	0	1985 - B

Table 36. (continued).

AICHILIK[f]

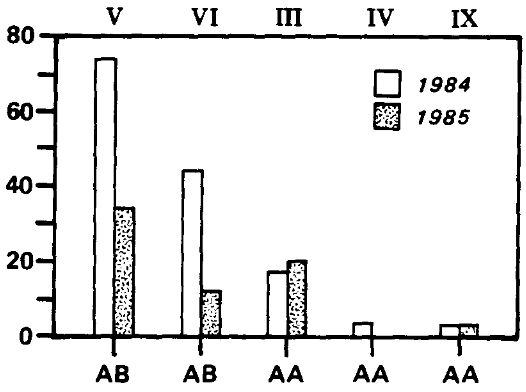
(Habitat $P < 0.001$; Year $P < 0.001$; Year x Habitat $P < 0.001$)

1984

V	VI	III	IV	IX
73	44	17	3	3

1985

V	III	VI	IX	IV
34	20	12	3	0



SADLEROCHIT[g]

(Habitat P=0.001; Year P=0.734; Year x Season P=0.328)

III	IVa	V	IX	VI	
63	39	27	10	10	1984 - A
90	19	20	23	8	1985 - A

JAGO DELTA[f]

(Habitat P=0.001; Year P=0.119; Year x Habitat P=0.380)

II	IVa	V	III	IX	
51	51	14	8	0	1984 - A
72	45	25	18	0	1985 - A

---

[a] Underlining indicates habitat means which are not significantly different at p=0.05; years followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes; V: 1982 n=4, 1983 n=8, 1985 n=10; IVa: 1982 n=16, 1983 n=16, 1985 n=20; III: 1982 n=12, 1983 n=12, 1985 n=15; II: 1982 n=12, 1983 n=12, 1985 n=15.

[c] Wet Sedge was significantly different from Flooded, but Moist Sedge-Shrub was not significantly different from Flooded.

[d] Sample sizes; IX: 1983 n=12, 1985 n=15; III: 1983 n=4, 1985 n=5; VI: 1983 n=12, 1985 n=14; V: 1983 n=12, 1985 n=15: IV: 1983 n=8, 1985 n=10.

[e] Sample sizes for all habitats: 1983 n=12, 1985 n=15.

[f] Sample sizes for all habitats and both years: n=15.

[g] Sample sizes for all habitats and both years: n=15, except 1985 IX: n=18.

Table 37. Mean densities of pectoral sandpiper nests (nests/km^2) observed in 5 habitats and 3 locations during the reproductive seasons of 1984 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Mean Pectoral Sandpiper Nests/km^2

AICHILIK[b]

(Habitat P=0.159; Year P=0.033; Habitat x Year P=0.072)

V	VI	III	IV	IX	
3	10	3	0	0	1984 - B
20	10	10	0	0	1985 - A

SADLEROCHIT[c]

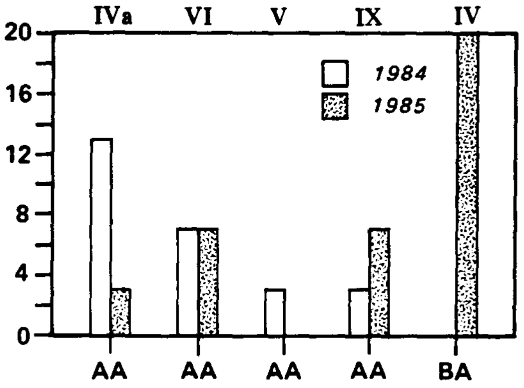
(Habitat P=0.357; Year P=0.387; Habitat x Year P=0.016)

1984

IVa	VI	V	IX	III
13	7	3	3	0

1985

III	VI	IX	IVa	V
20	7	7	3	0



JAGO DELTA[b]

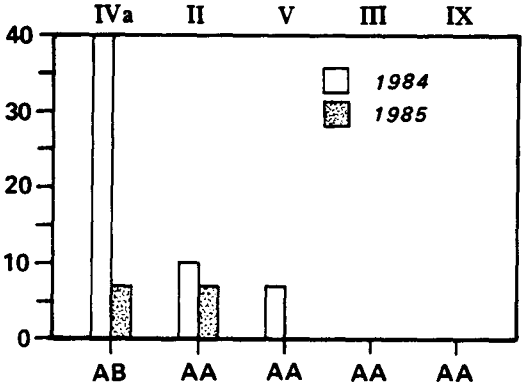
(Habitat $P<0.001$; Year P=0.002; Year x Habitat P=0.002)

1984

IVa	II	V	III	IX
40	10	7	0	0

1985

IVa	II	V	III	IX
7	7	0	0	0



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[a] Underlining indicates habitat means which are not significantly different at p=0.05; years followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes for all habitats and both years: n=3.

[c] Sample sizes for all habitats and both years: n=3, except 1985 IX: n=4.

Moist Sedge-Shrub and Tussock habitats at Aichilik from 1984 to 1985. Numbers of nests declined significantly in Mosaic habitat at Jago Delta.

Researchers have found that densities of pectoral sandpipers typically varied among locations within a year and often among years at a given location (Pitelka 1959, Holmes 1966). Pitelka et al. (1974) felt that variations in breeding density could be related to food availability. Myers and Pitelka (1980) examined shorebird use of three habitat gradients (polygonization, pondiness, vegetation density) over three years at Atkasook (inland) and four years at Barrow (coastal). Pectoral sandpipers exhibited significant annual variation in use of polygonization and vegetation density gradients at Atkasook and of all three gradients at Barrow.

Pitelka (1959) suggested that the inland location (Umiat) experienced less annual variability than coastal areas in local pectoral sandpiper densities. Umiat is located considerably further inland (and further west) than the inland locations censused on ANWR and may not be comparable. However, the areas are similar in that they have Riparian habitats and associated wetlands in close proximity to foothills. The two coastal locations censused on ANWR in 1984 and 1985 lacked significant annual variability which was observed in two habitats at Aichilik, the inland site. Okpilak, the coastal location censused in 1982, 1983, and 1985 exhibited annual variation in 3 of 4 habitats and Jago Bitty, an inland site, demonstrated significantly lower overall densities in 1985 than 1983. Katakturuk, also an inland site, showed no significant difference among years. Thus, on ANWR, no consistent coastal/inland differences in annual variability were observed.

Semipalmated sandpiper

No significant annual variations in semipalmated sandpiper densities were observed at Jago Bitty, Sadlerochit, or Jago Delta (Table 38). Densities of semipalmated sandpipers at Okpilak were significantly higher in Mosaic habitat during 1982 than in 1983 or 1985 and significantly higher in Flooded habitat during 1985 than in 1982 or 1983 (Table 38). Sandpiper numbers increased more than two-fold during 1985 over 1983 densities in Riparian habitat at Katakturuk and were lower at Aichilik than in 1984.

Pitelka et al. (1974) stated that semipalmated sandpipers tended not to undergo "large" population fluctuations but that this species could achieve high densities in very favorable habitats. Myers and Pitelka (1980) observed two-fold density changes and significant shifts in semipalmated sandpiper habitat use among years along a polygonization gradient at Atkasook (inland). Annual variations in density at Barrow (coastal) were similar but shifts in habitat use occurred along polygonization, pondiness, and vegetation density gradients.

Lesser Golden-plover

Lesser golden-plover densities were statistically similar among years at Katakturuk and Jago Bitty (1983 to 1985) and Aichilik and Jago Delta (1984 to 1985) despite apparent declines at the inland locations and an apparent increase at the coastal site (Table 39). Significant increases, however, were observed in plover nests at Jago Delta (Table 40). At Okpilak, plover densities increased significantly in Moist Sedge-Shrub (where they were not

Table 38. Mean densities of semipalmated sandpipers (birds/km^2) observed in 5 habitats and 6 locations during the reproductive seasons of 1982, 1983, 1984 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Mean Semipalmated Sandpipers/km^2

OKPILAK[b]

(Habitat P=0.280; Year P=0.334; Year x Habitat P=0.007)

1982

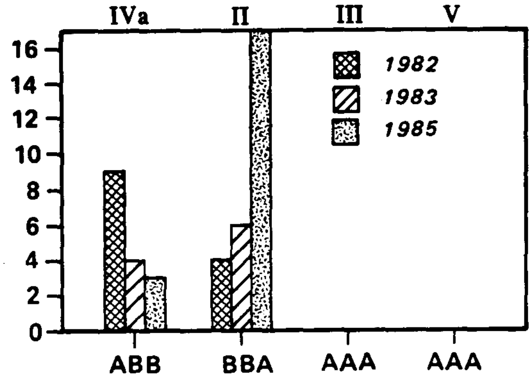
IVa	II	III	V
9	4	0	0

1983

II	IVa	III	V
6	4	0	0

1985

II	IVa	III	V
17	3	0	0



KATAKTURUK[c]

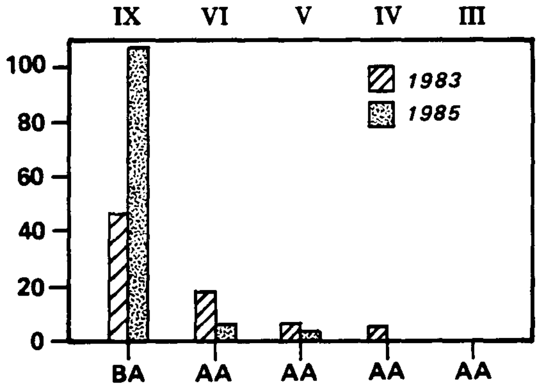
(Habitat P<0.001; Year P=0.149; Year x Habitat P=0.005)

1983

IX	VI	V	IV	III
46	18	6	5	0

1985

IX	VI	V	IV	III
107	6	3	0	0



JAGO BITTY[d]

(Habitat P=0.025; Year P=0.120; Year x Habitat P=0.404)

IX	V	VI	III	IV	
23	20	3	0	0	1983 - A
33	20	0	2	0	1985 - A

Table 38. (continued).

AICHILIK[e]

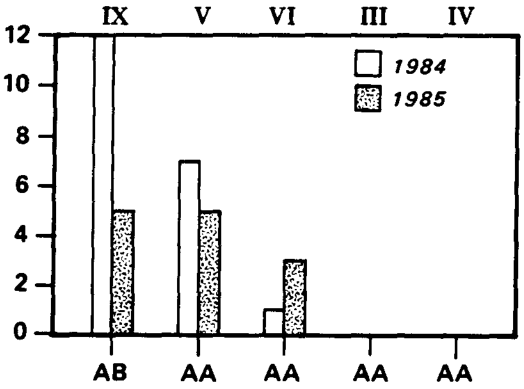
(Habitat P=0.434; Year P=0.120; Year x Habitat P=0.019)

1984

IX	V	VI	III	IV
12	7	1	0	0

1985

IX	V	VI	III	IV
5	5	3	0	0



SADLEROCHIT[f]

(Habitat P$<$0.001; Year P=0.300; Year x Habitat P=0.853)

IX	V	IVa	III	VI	
88	31	29	3	2	1984 - A
104	34	29	18	2	1985 - A

JAGO DELTA[e]

(Habitat P=0.646; Year P=0.749; Year x Habitat P=0.120)

IX	II	IVa	V	III	
13	6	13	7	7	1984 - A
12	14	4	11	2	1985 - A

---

[a] Underlining indicates habitat means which are not significantly different at p=0.05; years followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes; V: 1982 n=4, 1983 n=8, 1985 n=10; IVa: 1982 n=16, 1983 n=16, 1985 n=20; III: 1982 n=12, 1983 n=12, 1985 n=15; II: 1982 n=12, 1983 n=12, 1985 n=15.

[c] Sample sizes; IX: 1983 n=12, 1985 n=15; III: 1983 n=4, 1985 n=5; VI: 1983 n=12, 1985 n=14; V: 1983 n=12, 1985 n=15; IV: 1983 n=8, 1985 n=10.

[d] Sample sizes for all habitats: 1983 n=12; 1985 n=15.

[e] Sample sizes for all habitats and both years: n=15.

[f] Sample sizes for all habitats and both years: n=15, except 1985 IX: n=18.

Table 39. Mean densities of lesser golden-plovers (birds/km^2) observed in 5 habitats and 6 locations during the reproductive seasons of 1982, 1983, 1984 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Mean Lesser Golden-plovers/km^2

OKPILAK[b]

(Habitat P=0.001; Year P=0.068; Year x Habitat P=0.044)

1982

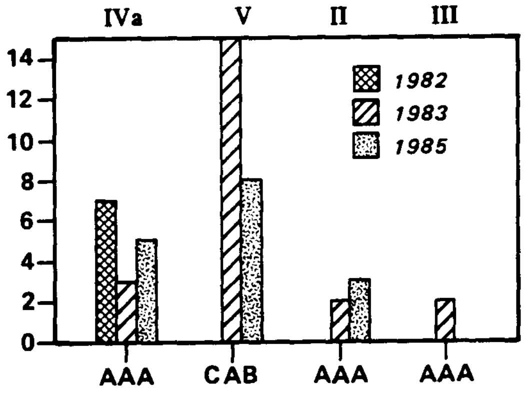
IVa	V	II	III
7	0	0	0

1983

V	IVa	II	III
15	3	2	2

1985

V	IVa	II	III
8	5	3	0



KATAKTURUK[c]

(Habitat P=0.230; Year P=0.248; Year x Habitat P=0.954)

VI	IX	V	IV	III	
16	12	7	9	3	1983 - A
9	9	5	1	0	1985 - A

JAGO BITTY[d]

(Habitat P=0.121; Year P=0.721; Year x Habitat P=0.882)

IX	IV	V	IV	III	
16	8	7	5	3	1983 - A
12	12	6	3	2	1985 - A

AICHILIK[e]

(Habitat P=0.001; Year P=0.051; Year x Habitat P=0.845)

IX	IV	V	IV	III	
33	23	11	10	2	1984 - A
28	18	10	5	0	1985 - A

Table 39. (continued).

SADLEROCHIT[f]

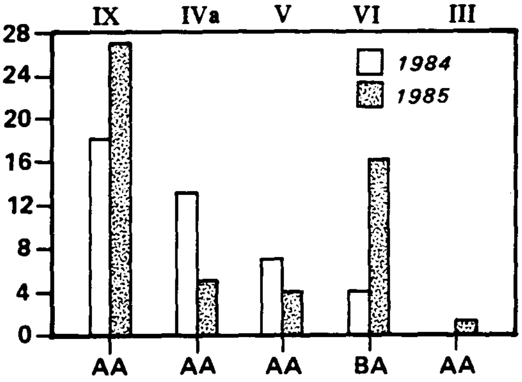
(Habitat P=0.015; Year P=0.289; Year x Habitat P=0.032)

1984

IX	IVa	V	VI	III
18	13	7	4	0

1985

IX	VI	IVa	V	III
27	16	5	4	1



JAGO DELTA[e]

(Habitat P=0.351; Year P=0.152; Year x Habitat P=0.402)

IX	IVa	II	V	III	
5	3	9	0	2	1984 - A
25	11	1	9	7	1985 - A

---

[a] Underlining indicates habitat means which are not significantly different at P=0.05; years followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes; V: 1982 n=4, 1983 n=8, 1985 n=10, IVa: 1982 n=16, 1983 n=16, 1985 n=20; III: 1982 n=12, 1983 n=12, 1985 n=15; II: 1982 n=12, 1983 n=12, 1985 n=15.

[c] Sample sizes; IX: 1983 n=12, 1985 n=15; III: 1983 n=4, 1985 n=5; VI: 1983 n=12, 1985 n=14; V: 1983 n=12, 1985 n=15; IV: 1983 n=8, 1985 n=10.

[d] Sample sizes for all habitats: 1983 n=12; 1985 n=15.

[e] Sample sizes for all habitats and both years: n=15.

[f] Sample sizes for all habitats and both years: n=15, except 1985 IX: n=18.

Table 40. Mean densities of lesser golden-plover nests (nests/km^2) observed in 5 habitats and 2 locations during the reproductive seasons of 1984 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Mean Lesser Golden-plover nests/km^2

SADLEROCHIT[b]

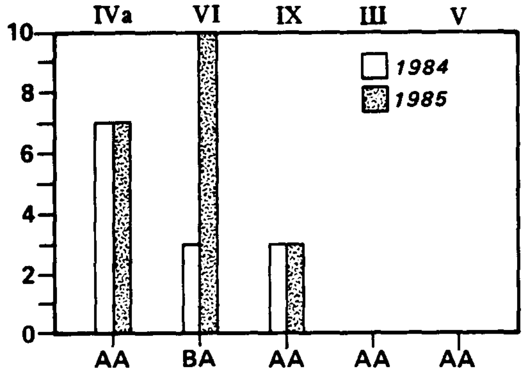
(Habitat P=0.139; Year P=0.073; Habitat x Year P=0.034)

1984

IVa	VI	IX	III	V
7	3	3	0	0

1985

VI	IVa	IX	III	V
10	7	3	0	0



JAGO DELTA[c]

(Habitat P=0.415; Year P=0.017; Habitat x Year P=0.415)

V	III	IVa	IX	II	
0	0	0	0	0	1984 - B
10	7	3	3	0	1985 - A

---

[a] Underlining indicates habitat means which are not significantly different at P=0.05; years followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes for all habitats and both years: n=3, except 1985 IX: n=4.

[c] Sample sizes for all habitats and both years: n=3.

observed in 1982) from 1982 to 1983 and declined by half in 1985. Densities in other habitats at Okpilak varied but were statistically similar among years. Plover and nest densities increased significantly in Tussock habitat at Sadlerochit from 1984 to 1985. Plovers also appeared to increase in Riparian and decline in Mosaic and Moist Sedge-Shrub at Sadlerochit during this period.

Very low densities of golden-plovers were observed at Atkasook (Myers and Pitelka 1980). Over the three years the area was censused, plovers were present at identical densities for two years and absent the third year. Golden-plover densities at Barrow varied as much as four-fold among years on a given plot (Myers and Pitelka 1980). Habitat use did not vary along any of the measured habitat gradients at Atkasook but plover use of habitats varied along gradients of pondiness and vegetation density at Barrow (Myers and Pitelka 1980). During some years golden-plovers confined their activities to upland sites while in other years they moved into heavily ponded areas. Observations of Martin and Moitoret (1981) and McWhorter et al. (1987) suggested that wet areas were used as brood-rearing habitat.

Red-necked Phalarope

No significant annual variation was observed in red-necked phalarope densities at the three coastal locations (Okpilak, Sadlerochit, and Jago Delta) or at Katakturuk (which had extremely low densities) (Table 41). Nevertheless, a three-fold decrease from 1982 to 1983 and a four-fold increase from 1983 to 1985 were observed in phalarope densities in Flooded habitat at Okpilak. Significant increases in phalarope density were recorded from 1983 to 1985 in Moist Sedge-Shrub and Wet Sedge habitats at Jago Bitty. In addition, phalarope densities at Aichilik declined significantly in Moist Sedge-Shrub from 1984 to 1985. No significant annual variability was observed in red-necked phalarope nest densities.

Although red-necked phalaropes were absent from study plots at Barrow and Atkasook during most years, they were present in very low densities on one plot at Barrow and at a moderately high density on the Atkasook plot in 1979 (Myers and Pitelka 1980). Martin (1983) also reported annual variation in red-necked phalarope densities on the Canning River Delta.

Total Birds, Total Species

Significant annual variation was observed for mean total bird density and mean number of species in at least some habitats at virtually all locations. Annual changes in total birds were usually heavily influenced by changes in one or several abundant species for a given habitat and location. Very few locations exhibited significant annual variation in nest densities or numbers of nesting species. Locations are discussed individually and species which made major contributions to annual variability are identified. In addition, less abundant species which exhibited substantial annual variations (increase of 100% or more, decrease of 50% or more) in density are often listed by habitat.

Okpilak. Significant increases in total bird densities and total species were observed in Flooded habitat at Okpilak from 1982 and 1983 to 1985 (Table 42). Species which contributed substantially to the increase included brant, pectoral sandpiper, red-necked phalarope, red phalarope, and Lapland longspur (Appendix Table V).

Table 41. Mean densities of red-necked phalaropes (birds/km^2) observed in 5 habitats and 6 locations during the reproductive seasons of 1982, 1983, 1984, and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Mean Red-necked phalaropes/km^2

OKPILAK[b]

(Habitat P=0.021; Year P=0.327; Year x Habitat P=0.323)

II	IVa	III	V	
72	16	9	28	1982 - A
26	8	9	0	1983 - A
101	6	9	0	1985 - A

KATAKTURUK[c]

(Habitat P=0.641; Year P=0.517; Year x Habitat P=0.641)

V	III	IV	VI	IX	
0	0	0	0	0	1983 - A
3	0	0	0	0	1985 - A

JAGO BITTY[d]

(Habitat P=0.076; Year P=0.034; Year x Habitat P=0.132)

V	III	IV	VI	IX	
6	2	0	0	0	1983 - B
12	7	0	0	0	1985 - A

AICHILIK[e]

(Habitat P$<$0.001; Year P=0.090; Year x Habitat P=0.016)

1984

V	VI	IX	III	IV
21	6	0	0	0

1985

V	VI	IX	III	IV
9	6	2	0	0

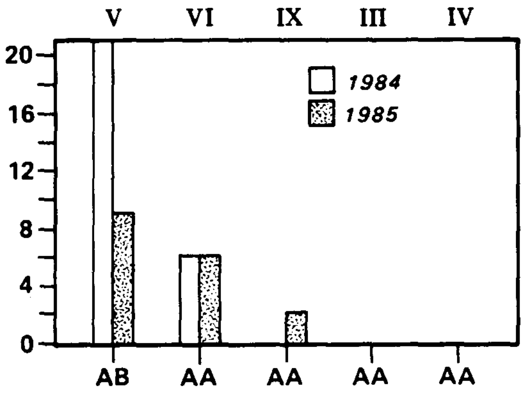


Table 41. (continued).

SADLEROCHIT[f]

(Habitat P=0.042; Year P=0.900; Year x Habitat P=0.598)

III	IVa	V	IX	VI	
12	10	4	3	0	1984 - A
19	4	3	1	0	1985 - A

JAGO DELTA[e]

(Habitat P=0.002; Year P=0.301; Year x Habitat P=0.331)

IVa	II	V	III	IX	
8	3	0	0	0	1984 - A
7	7	1	0	0	1985 - A

---

[a] Underlining indicates habitat means which are not significantly different at p=0.05; years followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes; V: 1982 n=4, 1983 n=8, 1985 n=10; IVa: 1982 n=16, 1983 n=16, 1985 n=20; III: 1982 n=12, 1983 n=12, 1985 n=15, II: 1982 n=12, 1983 n=12, 1985 n=15.

[c] Sample sizes; IX: 1983 n=12, 1985 n=15; III: 1983 n=4, 1985 n=5; VI: 1983 n=12, 1985 n=14; V: 1983 n=12, 1985 n=15; IV: 1983 n=8, 1985 n=10.

[d] Sample sizes for all habitats: 1983 n=12; 1985 n=15.

[e] Sample sizes for all habitats and both years: n=15.

[f] Sample sizes for all habitats and both years: n=15, except 1985 IX: n=18.

Table 42. Mean total birds (birds/km^2) and mean number of species (species/0.1km^2) observed in 4 habitats at Okpilak during the reproductive seasons of 1982, 1983 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Okpilak

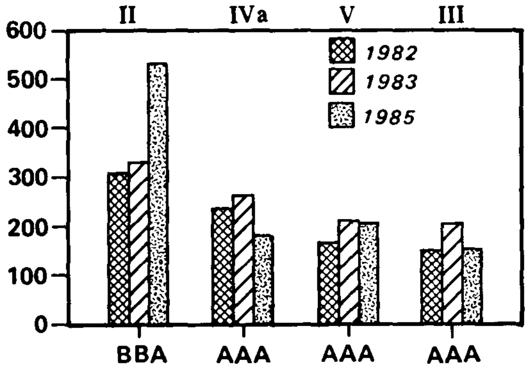
MEAN TOTAL BIRDS/km^2 [b]

(Habitat P=0.004; Year P=0.333; Year x Habitat P=0.030)

1982			
II	IVa	V	III
309	236	165	150

1983			
II	IVa	V	III
328	264	210	203

1985			
II	V	IVa	III
529	203	182	153



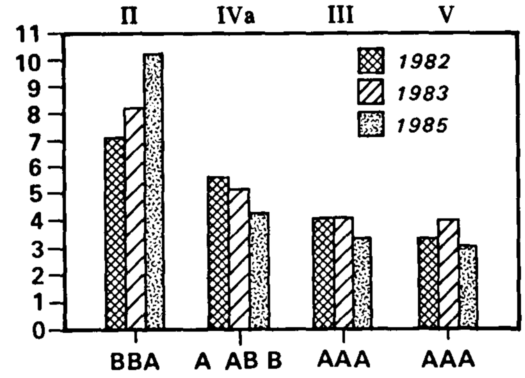
MEAN TOTAL SPECIES/0.1km^2 [b]

(Habitat P=0.004; Year P=0.709; Year x Habitat P=0.004)

1982			
II	IVa	III	V
7.1	5.6	4.1	3.3

1983			
II	IVa	III	V
8.2	5.1	4.1	4.0

1985			
II	IVa	III	V
10.2	4.2	3.3	3.0



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[a] Underlining indicates habitat means which are not significantly different at p=0.05; years subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes; II: 1982 n=12, 1983 n=12, 1985 n=15; IVa: 1982 n=16, 1983 n=16, 1985 n=20; V: 1982 n=4, 1983 n=8, 1985 n=10; III: 1982 n=12, 1983 n=12, 1985 n=15.

Observed annual changes in nest density were largely the result of the presence or absence of one or two nests of several species (Appendix Table VII). In addition, a small nesting colony of brant and glaucous gulls not observed in 1982 or 1983 was present in 1985 (McWhorter et al. 1987). Red-throated loons, which nested all three years, appeared to increase in 1985. Mosaic, Moist Sedge-Shrub, and Wet Sedge habitats all exhibited relatively low annual variability. Most fluctuations in bird and nest densities were confined to species which were present in relatively low densities.

Katakturuk. Substantial increases in densities of semipalmated sandpipers, Lapland longspurs, and redpolls and slight increases in semipalmated plovers, Baird's, pectoral and buff-breasted sandpipers, and long-billed dowitchers resulted in a significant increase in total bird densities in Riparian habitat at Katakturuk from 1983 to 1985 (Table 43). Nest densities declined due to the absence of nesting semipalmated sandpipers, lesser golden-plovers, ruddy turnstones and a nearly 50% decline in nesting by Lapland longspurs in 1985 (Appendix Table VII).

Although more species of shorebirds were present in Moist Sedge-Shrub at Katakturuk in 1985, most of the slight increase in observed total bird density was due to higher Lapland longspur densities. Nest densities more than doubled as species composition changed among years and Lapland longspur nest density increased substantially (Appendix Table VII).

Species composition was quite similar among years in Wet Sedge habitat and the observed density increase resulted from higher Lapland longspur densities. No nests were observed during either year. Total bird densities were identical among years in Moist Sedge. Although more total species were observed in 1985 than 1983 (Table 43), several species were observed only rarely in 1985 and sightings were more consistent in 1983. Nesting species composition was identical for both years and Lapland longspur nest density declined slightly in 1985.

Several species declined in Tussock habitat from 1983 to 1985 but Lapland longspurs were the largest contributors to the overall decline in total bird densities. Numbers of species observed increased in 1985 due to the presence of willow ptarmigan, pomarine jaegers, short-eared owls and redpolls at very low densities (Appendix Table V). Nest density declined in 1985 due to the absence of nesting pectoral sandpipers and fewer nesting semipalmated sandpipers (Appendix Table VII).

Jago Bitty. Total bird and nest densities increased significantly overall from 1983 to 1985 at Jago Bitty (Table 44). Greatest increases in bird density were observed in Wet Sedge and Tussock habitats which also experienced significant increases in total species (Table 44). Higher bird densities in Wet Sedge resulted from substantial increases in densities of willow and rock ptarmigans, Lapland longspurs, and smaller increases in northern pintails, oldsquaws, stilt sandpipers, long-billed dowitchers, red-necked phalaropes, pomarine and long-tailed jaegers, short-eared owls, and redpolls. Also, 6 additional species nested in Wet Sedge in 1985: northern pintail, willow and rock ptarmigan, stilt sandpiper, red-necked phalarope, and long-tailed jaeger. Increased bird densities in Tussock habitat primarily resulted from higher ptarmigan densities. Fewer total species nested in Tussock in 1985 and the slight increase in nest density

Table 43. Mean total birds (birds/km^2) and mean number of species (species/0.1km^2) observed in 5 habitats at Katakturak during the reproductive seasons of 1983 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Katakturuk

MEAN TOTAL BIRDS/km^2 [b]

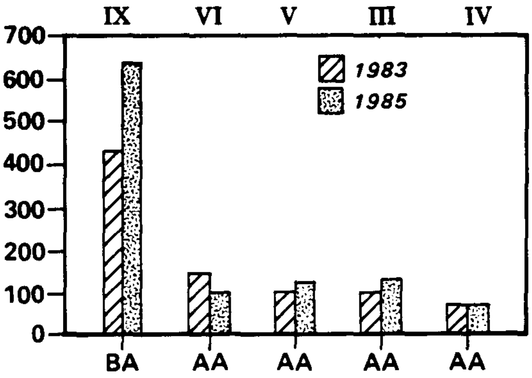
(Habitat $P<0.001$; Year $P=0.120$; Year x Habitat $P=0.033$)

1983

IX	VI	V	III	IV
428	145	102	100	71

1985

IX	III	V	VI	IV
633	130	123	99	71



MEAN TOTAL SPECIES/0.1km^2 [b]

(Habitat $P=0.010$; Year $P=0.234$; Year x Habitat $P=0.652$)

IX	V	VI	III	IV	
6.8	3.3	3.4	2.8	2.3	1983 - A
7.4	4.5	2.0	3.0	2.0	1985 - A

---

[a] Underlining indicates habitat means which are not significantly different at p=0.05; years followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes; IX: 1983 n=12, 1985 n=15; VI: 1983 n=12, 1985 n=14; V: 1983 n=12, 1985 n=15; III: 1983 n=4, 1985 n=5; IV: 1983 n=8, 1985 n=10.

Table 44. Mean total birds (birds/km^2), mean number of species (species/0.1km^2) and mean number of nesting species (species/0.1km^2) observed in 5 habitats at Jago Bitty during the reproductive seasons of 1983 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Jago Bitty

MEAN TOTAL BIRDS/km^2 [b]

(Habitat $P<0.001$; Year $P=0.029$; Year x Habitat $P=0.233$)

IX	V	III	VI	IV	
260	189	121	90	110	1983 - A
267	187	180	144	120	1985 - B

MEAN TOTAL SPECIES/0.1 km^2 [b]

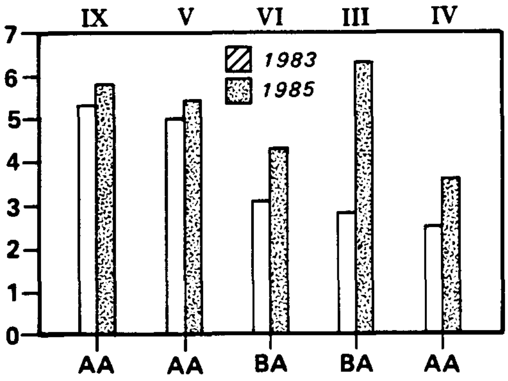
(Habitat $P=0.011$; Year $P<0.001$; Year x Habitat $P=0.014$)

1983

IX	V	VI	III	IV
5.3	5.0	3.1	2.8	2.5

1985

III	IX	V	VI	IV
6.3	5.8	5.4	4.3	3.6



MEAN TOTAL NESTING SPECIES/0.1 km^2 [c]

(Habitat $P=0.582$; Year $P=0.047$; Year x Habitat $P=0.510$)

IX	III	V	IV	VI	
3.0	2.0	2.7	2.0	2.0	1983 - B
4.3	4.0	3.0	2.7	2.0	1985 - A

---

[a] Underlining indicates habitat means which are not significantly different at p=0.05; years followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes for all habitats: 1983 n=12; 1985 n=15.

[c] Sample size for all habitats and both years: n=3.

observed in 1985 resulted from higher numbers of longspur nests (Appendix Table VII).

Although bird density increased only slightly in Riparian habitat in 1985, nest density nearly doubled as a result of higher nesting densities of semipalmated sandpipers, Lapland longspurs, rock and willow ptarmigan, short-eared owls, and American tree sparrows (Appendix Table VII). No nests were detected for the latter four species in 1983 and savannah sparrows, which nested in 1983, were not observed nesting in 1985.

Bird and nest densities were similar among years in Moist Sedge but several additional species were present (rock and willow ptarmigan, semipalmated and buff-breasted sandpipers, long-tailed jaeger). In addition, rock ptarmigan, stilt sandpipers, and buff-breasted sandpipers nested in 1985. Bird densities were similar and species richness was greater in Moist Sedge-Shrub in 1985. Additional species included northern pintail, rock ptarmigan, semipalmated plover, pomarine jaeger, glaucous gull, yellow wagtail, and redpoll. Lower densities of semipalmated sandpiper and Lapland longspur nests resulted in lowered total nest densities in 1985 despite the addition of rock ptarmigan and pectoral sandpiper as nesting species.

Aichilik. Several species (semipalmated plover, Baird's and stilt sandpipers, red-necked phalarope, and arctic tern) not observed on censuses in 1984 were observed at low densities in Riparian habitat at Aichilik in 1985; but total bird densities declined significantly from 1984 as a result of substantial declines in densities of lesser golden-plovers, ruddy turnstones, pomarine and long-tailed jaegers, and Lapland longspurs (Table 45, Appendix Table V). In contrast, total nest densities increased (primarily redpolls and Lapland longspurs) but the number of nesting species decreased slightly from 1984 to 1985 (Appendix Table VII).

Significant declines in total bird density were also observed in Moist Sedge-Shrub habitat from 1984 to 1985. Greatest declines were observed in pectoral sandpipers, savannah sparrows and Lapland longspurs although several other species of shorebirds, as well as long-tailed jaegers and redpolls, were less evident. Surprisingly, nest densities increased among years (primarily pectoral and semipalmated sandpipers).

Tussock, Moist Sedge, and Wet Sedge habitats exhibited relatively small annual declines in total bird density. However, significantly higher mean numbers of species were observed on Tussock plots in 1985 than in 1984. This represented only one more species seen in 1985 and the higher mean computed for 1985 resulted from the more even distribution of species across replicate plots. Declines in total bird and nest densities in Moist Sedge were due to reductions in Lapland longspurs and lesser golden-plovers.

Sadlerochit. Major increases in total bird densities were observed from 1984 to 1985 in Riparian and Wet Sedge habitats at Sadlerochit (Table 46). The majority of the change in Riparian habitat resulted from increases in lesser golden-plovers, semipalmated sandpipers and Lapland longspurs. Smaller increases were observed in rock ptarmigan, ruddy turnstones, Baird's sandpipers, buff-breasted sandpipers, and long-tailed jaegers (Appendix Table V). Eight species (red-throated loon, mallard, northern pintail, willow ptarmigan, semipalmated plover, whimbrel, glaucous gull, and yellow wagtail) were observed on Riparian plots in 1985 but not in 1984. In Wet

Table 45. Mean total birds (birds/km^2) and mean number of species (species/0.1km^2) observed in 5 habitats at Aichilik during the reproductive seasons of 1984 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Aichilik

MEAN TOTAL BIRDS/km^2 [b]

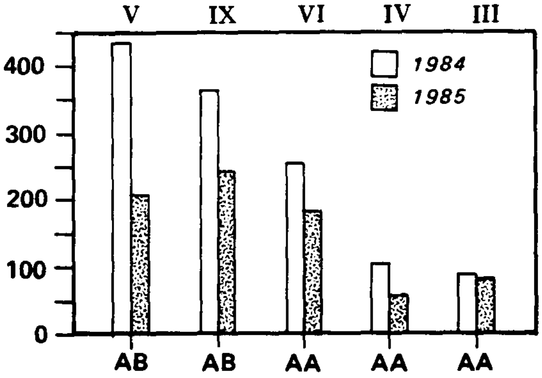
(Habitat $P<0.001$; Year $P<0.001$; Year x Habitat $P=0.003$)

1984

V	IX	VI	IV	III
431	362	253	105	87

1985

IX	V	VI	III	IV
241	207	183	83	58



MEAN TOTAL SPECIES /0.1km^2 [b]

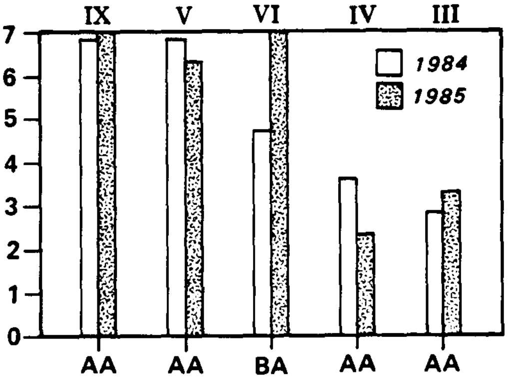
(Habitat $P<0.001$; Year $P=0.457$; Year x Habitat $P=0.035$)

1984

IX	V	VI	IV	III
6.8	6.8	4.7	3.6	2.8

1985

IX	VI	V	III	IV
7.0	7.0	6.3	3.3	2.3



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[a] Underlining indicates habitat means which are not significantly different at p=0.05; years subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes for all habitats and both years: n=15.

Table 46. Mean total birds (birds/km^2) and mean number of species (species/0.1 km^2) observed in 5 habitats at Sadlerochit during the reproductive seasons of 1984 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Sadlerochit

MEAN TOTAL BIRDS/km^2 [b]

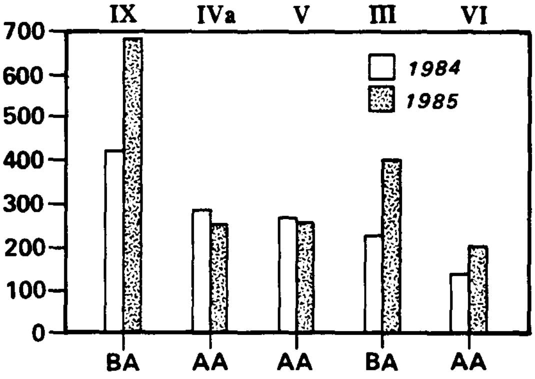
(Habitat P=0.017; Year P<0.001; Year x Habitat P<0.001)

1984

IX	IVa	V	III	VI
421	284	266	225	138

1985

IX	III	V	IVa	VI
680	401	257	251	204



MEAN TOTAL SPECIES/0.1km^2 [b]

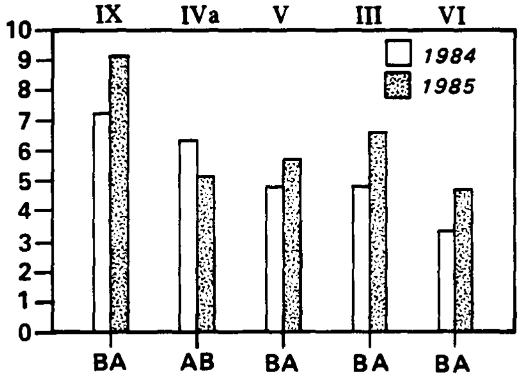
(Habitat P<0.001; Year P<0.001; Year x Habitat P=0.002)

1984

IX	IVa	V	III	VI
7.2	6.3	4.8	4.8	3.3

1985

IX	III	V	IVa	VI
9.1	6.6	5.7	5.1	4.7



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[a] Underlining indicates habitat means which are not significantly different at p=0.05; years subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes for all habitats and both years: n=15, except 1985 IX: n=18.

Sedge, large increases occurred in pectoral sandpipers, savannah sparrows and Lapland longspurs and smaller increases were seen in densities of semipalmated sandpipers, red-necked phalaropes, and parasitic jaegers (Appendix Table V). Redpolls, pomarine jaegers and long-tailed jaegers (present in 1985) were not observed on Wet Sedge plots in 1984. Nest densities were similar among years in Riparian habitat due to compensating increases and decreases among species (Appendix Table VII). No pectoral sandpiper nests were recorded in Wet Sedge in 1984, and the high density of pectoral sandpiper nests in 1985 produced a 50% increase in total nest density (Appendix Table VII).

A moderate increase in total bird and total nest densities occurred in Tussock habitat in 1985 (Table 46) that primarily resulted from increased densities of Lapland longspur, rock ptarmigan, and lesser golden-plover nests (Appendix Table VII). Total species also increased (Table 46) due to the presence of buff-breasted sandpipers, all three jaeger species, short-eared owls, and savannah sparrows.

Bird densities were similar among years for Mosaic and Moist Sedge-Shrub habitats but total species decreased in Mosaic and increased in Moist Sedge-shrub in 1985 (Table 46). Nest densities were similar in 1984 and 1985 in Moist Sedge-Shrub but declined in Mosaic as a result of declines in nests of oldsquaw, and pectoral and semipalmated sandpipers (Appendix Table VII).

Jago Delta. Total bird densities increased significantly in Flooded habitat and moderately in Moist Sedge-Shrub habitat at Jago Delta from 1984 to 1985 (Table 47). Changes in Flooded habitat were due to moderate or small increases in densities of several species (particularly pectoral sandpiper, long-billed dowitcher, and pomarine jaeger). Surprisingly, a substantial decline in total nest densities on Flooded plots occurred from 1984 to 1985 (Table 47) as a result of large decreases in nests of pectoral sandpipers, red phalaropes, and Lapland longspurs (Appendix Table VII). In Moist Sedge-Shrub habitat increases also occurred in several species (notably lesser golden-plover, pectoral sandpiper and pomarine jaeger) but the overall increase was small due to the compensating affect of a substantial reduction in Lapland longspur density. Nest densities were statistically similar among years for both habitats (Table 47).

Total bird densities declined in Riparian, Mosaic and Wet Sedge from 1984 to 1985. However, higher mean numbers of species were observed in all habitats except Riparian in 1985. Major declines in Lapland longspur densities far exceeded increases observed in some species in all three habitats (Appendix Table V). Buff-breasted sandpipers, ruddy turnstones, and redpolls also exhibited substantial declines in Riparian habitat while lesser golden-plovers and parasitic jaegers were among the species which increased (Appendix Table V). Ruddy turnstones made a large contribution to the overall increase in nest density in Riparian habitat from 1984 to 1985 (Appendix Table VII).

Densities of buff-breasted sandpipers, pomarine jaegers, and pectoral sandpipers increased in Wet Sedge habitat in 1985 (Appendix Table V). Total nest densities were identical for 1984 and 1985 as a result of compensating declines in nests of semipalmated sandpipers, stilt sandpipers and Lapland longspurs and increases in nests of lesser golden-plovers and buff-breasted sandpipers. (Appendix Table VII).

Table 47. Mean total birds (birds/km^2), mean number of species (species/0.1 km^2) and mean number of nesting species (species/0.1km^2) observed in 5 habitats at Jago Delta during the reproductive seasons of 1984 and 1985 on the coastal plain of the Arctic National Wildlife Refuge, Alaska[a].

Jago Delta

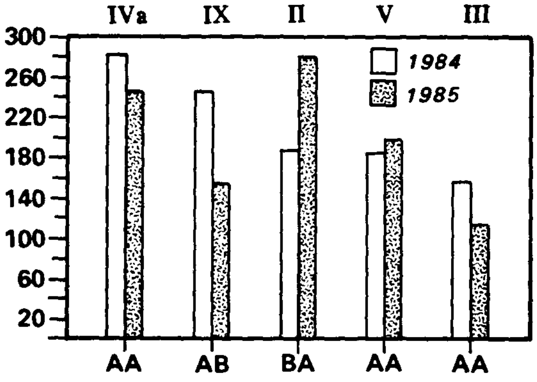
MEAN TOTAL BIRDS/km^2 [b](Habitat P=0.012; Year P=0.278; Year x Habitat P=0.003)

1984

IVa	IX	II	V	III
281	244	186	184	156

1985

II	IVa	V	IX	III
279	245	197	154	114



MEAN TOTAL SPECIES/0.1km^2 [b] (Habitat P=0.001; Year P=0.013; Year x Habitat P=0.496)

II	IVa	V	IX	III	
5.6	4.7	3.6	3.8	2.3	1984 - B
6.8	6.0	5.0	3.6	3.4	1985 - A

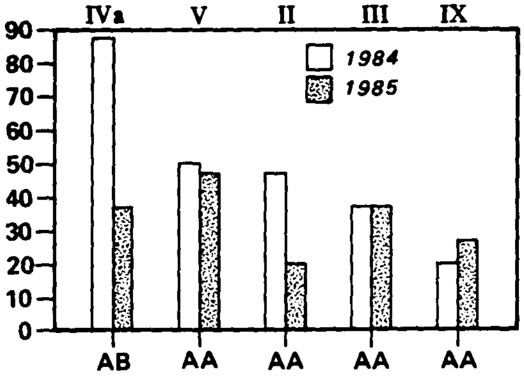
MEAN TOTAL NESTING SPECIES/0.1km^2 [c] (Habitat P=0.017; Year P=0.024; Habitat x Year P=0.047)

1984

IVa	V	II	III	IX
87	50	47	37	20

1985

V	IVa	III	IX	II
47	37	37	27	20



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[a] Underlining indicates habitat means which are not significantly different at p=0.05; years followed or subtended by the same letter are not significantly different at p=0.05.

[b] Sample sizes for all habitats and both years: n=15.

[c] Sample sizes for all habitats and both years: n=3.

Lower densities of semipalmated and pectoral sandpipers were observed in 1985 than in 1984 in Mosaic habitat. Conversely, densities of northern pintails, oldsquaws, rock ptarmigan, lesser golden-plovers, semipalmated sandpipers, buff-breasted sandpipers and pomarine jaegers increased. Nesting density declined over 50% in Mosaic habitat (Table 47) principally because of lower nest densities of semipalmated sandpipers, pectoral sandpipers, and Lapland longspurs.

Sampling Variability: Location, Study Plot, Census

Common to many avian-habitat studies are the questions: How many locations to survey? How many study plots to establish? How many censuses to conduct? The experimental design of the 1002 Tundra Bird project established replicate study plots within locations and conducted avian censuses within study plots. Variation was introduced at each level of the sampling hierarchy. Knowing the relative amounts of sampling variation attributable to locations, plots within locations, and censuses within plots provides information addressing the aforementioned questions.

Variance component analyses calculated the relative percentage of the total variation that was associated with each level of the sampling hierarchy (Table 48). Variability among censuses within study plots was often the highest source of variation during both the reproductive and post-reproductive seasons. This demonstrated the importance of conducting several censuses at a given study plot to more accurately estimate mean seasonal density. A single census would likely produce an estimate that was not representative of the overall seasonal mean. Pitelka (1959) suggested that 5 to 10 surveys within an area would yield a high level of accuracy in estimating breeding densities of pectoral sandpipers.

Various patterns of increasing and decreasing avian densities were observed during a given season depending on the habitat, location, and species considered. Lapland longspur abundance in Tussock habitat at Sadlerochit during the reproductive season displayed inconsistent trends across the 3 replicate plots during the 5-week sampling period (Fig. 11). In Moist Sedge-Shrub habitat at Niguanak, where high Lapland longspur nest density was recorded, population density peaked midway through the reproductive season (Fig. 11). Pectoral sandpiper abundance in Flooded habitat at Okpilak fluctuated variably during the reproductive season (Fig. 11), while in Moist Sedge-Shrub habitat at Niguanak (an area of high nest density, Table 14), pectoral sandpiper abundance peaked during the second week of censusing (Fig. 11).

These examples typify the variability associated with avian censusing during the reproductive season. In most instances, the variability between censuses increased during the post-reproductive season. Because of high variability, a single "point-in-time" estimate of avian density was usually not indicative of mean seasonal density, and the accuracy of estimating the mean was improved through repeated sampling.

If the dynamics of tundra bird populations had been evaluated on a weekly rather than a seasonal basis, the relationships between habitats, locations, and avian distributions would have probably varied depending on the census week being considered. In other words, interactions between census week and avian distributions would be likely. They would be similar to the

Table 48. Relative proportions (expressed as percentages) of the total variation attributed to locations, plots within locations, and censuses within plots, for several avian parameters within each Landsat habitat, for both the reproductive (R) and post-reproductive (PR) seasons on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].

Habitat Variance Component	Lapland longspur		Pectoral sandpiper		Semipalmated sandpiper		Red-necked phalarope		Lesser golden-plover		Total birds		Total species	
	R	PR	R	PR	R	PR	R	PR	R	PR	R	PR	R	PR
Riparian:														
Location	44	27	4	7	67	1	0	0	4	0	63	29	58	64
Plot within location	18	14	14	0	3	14	16	1	15	5	22	19	10	6
Census within plot	38	59	82	93	30	85	84	99	81	95	15	52	32	30
Flooded:														
Location	0	0	19	31	0	15	23	17	42	3	20	32	21	0
Plot within location	20	24	0	0	7	0	21	34	9	0	16	0	7	20
Census within plot	80	76	81	69	93	85	56	49	49	97	64	68	72	80
Wet Sedge:														
Location	57	22	31	9	17	--	16	13	14	4	64	21	36	15
Plot within location	0	0	29	0	7	--	7	0	27	0	8	0	15	15
Census within plot	43	78	40	91	76	--	77	87	59	86	28	79	49	70
Mosaic:														
Location	6	0	17	16	51	0	0	26	2	0	4	0	9	12
Plot within location	25	30	7	0	7	44	0	0	1	32	6	47	17	44
Census within plot	69	61	76	84	42	56	100	74	97	68	90	53	74	44
Moist Sedge:														
Location	31	21	11	27	0	--	--	0	5	11	21	36	8	58
Plot within location	0	30	8	0	18	--	--	0	4	44	7	8	14	23
Census within plot	69	49	81	73	82	--	--	100	91	45	72	56	78	19

Table 48. continued.

Habitat Variance Component	Lapland longspur		Pectoral sandpiper		Semipalmated sandpiper		Red-necked phalarope		Lesser golden-plover		Total birds		Total species	
	R	PR	R	PR	R	PR	R	PR	R	PR	R	PR	R	PR
Moist Sedge-Shrub:														
Location	27	15	52	48	35	2	9	14	15	3	33	18	30	20
Plot within location	2	12	15	0	34	0	14	9	0	0	5	16	0	30
Census within plot	71	73	33	52	31	98	77	77	85	97	62	66	70	50
Tussock:														
Location	33	9	19	53	0	--	25	--	30	15	29	28	44	28
Plot within location	1	0	22	7	62	--	21	--	16	2	14	0	7	0
Census within plot	69	91	59	40	38	--	54	--	54	83	57	72	49	72

[a] A component attributed with 0% of the total variation reflects computations of a negative variance component, and indicates no real evidence of significant variation due to that component relative to the other components. Species not observed within a given habitat and season are denoted by hyphens (-).

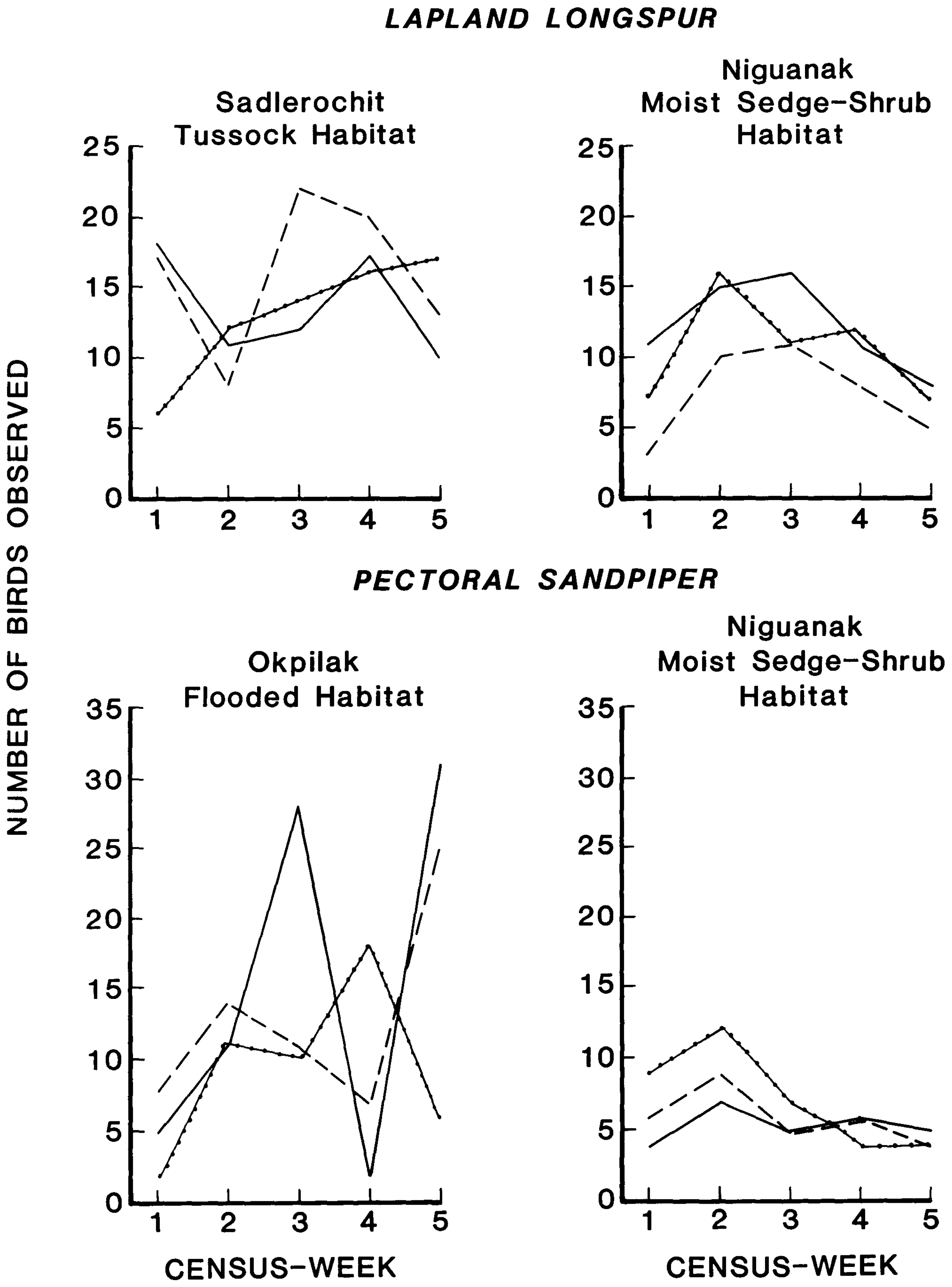

Fig. 11. Densities (birds/km^2) of Lapland longspurs and pectoral sandpipers on replicate plots in 3 habitats at 3 locations on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

season-by-location and season-by-habitat interactions reported previously, but potentially very complex, difficult to interpret, and cumbersome to present because the interactions would incorporate 8 census weeks rather than 2 seasons.

The relative proportions of sampling variation attributable to locations and plots within locations varied between bird species, habitats, and seasons (Table 48). Location variability may reflect site-specific differences in habitat quality that were not delineated by the Landsat classification, such as differences in microrelief or food availability. Other possibilities include non-uniform breeding or migratory ranges across the study area, or the "chance" sampling of random aggregations of a bird population inhabiting an unsaturated environment (Wiens 1981).

The environment surrounding a location or the composition of habitat types within a location could also influence avian densities and species composition. Distances to major landforms, such as the ocean or mountains, or the proximity of critical habitats such as coastal lagoons, tundra wetlands, or river systems could strongly affect the suitability of a particular area. The locations surveyed by the 1002 project were intentionally placed in areas with high interspersions of habitat types. Sampling protocol was thus facilitated, but it was also biased toward areas with inherently more habitat edge and diversity, and extrapolating the results across large expanses of homogeneous habitat could introduce serious error.

In Riparian habitat, location was the highest source of variation for Lapland longspurs, semipalmated sandpipers, total birds, and total species during the reproductive season (Table 48). Estimating seasonal means for these parameters, across the coastal plain, would be best improved by sampling more locations. The relative proportion of lesser golden-plover variability was higher among plots within locations than between locations, in Riparian habitat (Table 48). This contributed to location having an insignificant treatment effect, even though the location means appeared different (Table 21). Better estimates of lesser golden-plover density in Riparian habitat would be achieved by sampling more plots at each location.

Differences among replicate plots within a location may have resulted for reasons similar to those affecting overall location variability: differences in habitat physiognomy such as microrelief or small inclusions of other habitat types; localized differences in food availability: the character or quality of surrounding habitat (edge effects); or "patchy", non-uniform bird distributions at a local scale. Inter-specific competition presents another possible factor influencing avian distributions both across and within locations.

Several potential factors that may have affected the variability associated with location and study plots within locations have been presented, but their actual operative influence in terms of this study remains speculative. However, site-specific differences in habitat quality were probably an important factor due to limitations of the Landsat habitat classification system. High-resolution features of micro-relief, such as the degree of polygonization, shrubiness, and pondiness, were not well delineated by the habitat classification, yet they probably influenced avian distributions (Myers and Pitelka 1980).

Table 49. Relative proportions (expressed as percentages) of the total variation attributed to locations and plots within locations for several avian nest parameters within each landsat habitat, Arctic National Wildlife Refuge, Alaska, 1985[a].

Habitat Variance Component	Lapland longspur	Pectoral sandpiper	Semipalmated sandpiper	Red-necked phalarope	Lesser golden-plover	Total nests	Total species
Riparian:							
Location	28	10	31	--	0	33	40
Plot within location	72	90	69	--	100	67	60
Flooded:							
Location	14	67	--	31	--	17	32
Plot within location	86	33	--	69	--	83	68
Wet Sedge:							
Location	26	45	23	6	32	26	11
Plot within location	74	55	77	94	68	74	89
Mosaic:							
Location	0	0	41	--	0	7	34
Plot within location	100	100	59	--	100	93	66
Moist Sedge:							
Location	62	0	--	--	0	31	41
Plot within location	38	100	--	--	100	69	59
Moist Sedge-Shrub:							
Location	44	78	41	0	36	62	17
Plot within location	56	22	59	100	64	38	83
Tussock:							
Location	43	6	0	0	27	17	40
Plot within location	57	94	100	100	73	83	60

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[a] A component attributed with 0% of the total variation reflects computations of a negative variance component, and indicates no real evidence of significant variation due to that component relative to the other components. Species not observed within a given habitat and season are denoted by hyphens (-).

Locations were rarely significantly different from one another in terms of mean nest densities (see previous sections). In many cases, location means appeared to be different, but a large proportion of the variability was attributable to study plots within locations (Table 49) and this restricted statistical significance. Sampling more replicate study plots would improve the estimates of location means, and given a large enough sample size, the means would probably be determined statistically different. Using estimates of the within-location variation from the 1985 data (Appendix Table IX), the number of replications needed to detect a difference between means was calculated (Sokal and Rohlf 1981:263). For example, mean total nest density varied extensively across locations in all habitat types, but statistical differences were only detected in Moist Sedge-Shrub (Table 32). The number of replicate plots needed at each location to detect significant ($P > 0.05$) differences between the highest and lowest observed locations (1985) are presented in Table 50. The relatively large number of plots needed in Flooded and Mosaic habitats was partially due to the small number of sample locations. Analyses concluding insignificant location effects do not imply that the true location means were equivalent, but rather, that there was insufficient evidence to declare the means statistically different. As shown in Table 50, given the same within-location variability, location differences would have been detected if a greater number of replicate study plots had been surveyed (except for Moist Sedge-Shrub habitat). Sample sizes needed to detect differences between location means (across any magnitude) can be calculated for nest and bird density parameters using the error mean squares presented in Appendices VIII and IX, and the computational formulas in Sokal and Rohlf (1981:263).

Conclusions

Numerous differences in bird and nest densities due to habitat, season, year, and location were detected through the use of ANOVA techniques. Although Riparian and Flooded habitats consistently had the highest bird densities observed during reproductive and post-reproductive seasons, few other consistent patterns of habitat use emerged. Variance component analyses revealed that, in many instances, variance of bird densities among censuses within study plots was often the greatest source of variation measured. This emphasized the need for temporal replication of censuses to provide more representative measures of bird use. In addition, variation in nest densities among replicate plots within a habitat type was typically higher than the variation observed among locations. Although no definite conclusions could be reached, it was suspected that habitat differences were greater among replicates than among locations. Moitoret et al. (1985) suggested that other more specific habitat variables (such as microrelief, moisture level, size and type of water bodies, height and density of shrubs, and interspersion of microhabitats) could be used to better define bird use of tundra habitats. In addition, seasonal quantification of local food supplies, an important factor in tundra bird distribution (Pitelka et al. 1974, Holmes and Pitelka 1968), could potentially result in significant understanding of variability observed within habitat types.

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Table 50. Minimum number of replicate study plots needed at each location to be 90% certain of detecting a significant (P 0.05) difference between the location with the highest mean total nest density and the location with the lowest mean total nest density.

Habitat	Location means								Error mean square (plots within location)	Minimum number of study plots per location
Riparian	JBI[a]	MCR	SAD	AIC	KAT	JDE			472.6	4
(IX)	83	70	63	53	43	27				
Flooded	OKP	NIG	JDE						1255.3	13
(II)	67	63	20							
Wet Sedge	SAD	JBI	JDE	NIG	OKP	AIC	KAT		511.2	4
(III)	60	57	37	37	23	17	0			
Mosaic	SAD	JDE	OKP						423.1	15
(IVa)	50	37	25							
Moist Sedge	JBI	KAT	AIC	MCR					133.4	6
(IV)	37	20	20	13						
Moist Sedge-	NIG	SAD	AIC	JBI	JDE	OKP	KAT	MCR	249.0	2
Shrub (V)	90	57	53	47	47	30	27	20		
Tussock	SAD	AIC	NIG	JBI	KAT	MCR			427.7	6
(VI)	57	53	47	37	30	17				

[a] Abbreviations for locations defined in text.

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APPENDIX

ANWR Progress Report Number FY86-14

Appendix Table I. Julian dates of first observed flowering for plant species found at eight study sites on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Species	Earliest Date	Okpilak	Katakturuk	Jago Bitty	Aichilik	Sadlerochit	Jago Delta	Marsh Creek	Niguanak
Eriophorum vaginatum	152	156	158	156	-	153	-	153	152
Saxifraga oppositifolia	(152)[a]153	154	158	158	160	156	155	153	(152)153
Thlaspi arcticum	153	-	(158)	-	-	-	-	153	-
Salix lanata	153	168	158	-	160	161	153	153	(170)171
Salix phlebophylla	153	-	-	-	-	-	-	153	(159)169
Anemone parviflora	155	(167)	158	-	160	164	162	155	(171)
Ranunculus nivalis	155	161	(172)	169	168	156	156	155	(159)163
Pedicularis Kanei	156	156	158	168	169	169	162	171	169
Minuartia stricta	156	-	156	-	-	-	-	-	-
Geum glaciale	157	-	-	160	163	-	177	-	157
Oxytropis nigrescens	160	167	167	-	170	169	160	165	(166)176
Anemone Richardsonii	161	-	-	161	-	-	-	-	-
Salix planifolia pulchra	161	-	-	-	-	169	-	161	(163)164
Salix arctica	161	161	-	-	-	-	-	-	(169)176
Salix glauca	161	(175)	-	-	-	161	-	-	-
Oxyria digyna	(159)162	(159)174	-	-	-	(171)	162	171	(172)177
Arctostaphylos rubra	162	-	-	164	169	-	-	162	-
Parrya nudicaulis	167	175	172	170	171	171	173	167	(170)176
Arctostaphylos uva-ursi	167	-	167	-	-	-	-	-	-
Petasites frigidus	167	170	172	168	173	169	176	167	171
Lupinus arcticus	168	(178)	(172)	175	176	-	-	168	(176)183
Silene acaulis	169	177	179	180	179	186	169	-	(176)183
Cassiope tetragona	169	175	180	175	-	175	173	169	(171)175
Lagotis glauca	169	175	172	175	179	176	178	169	(174)176
Potentilla uniflora	(170)	(170)	-	-	-	-	-	-	-
Dryas integrifolia	171	174	172	171	176	172	171	-	(171)175
Betula nana	171	175	-	-	171	-	-	-	(180)182
Caltha palustris	172	175	172	172	173	175	176	-	(175)176
Lloydia serotina	172	-	179	-	-	181	172	-	-
Androsace chamaejasme	172	(191)	-	-	-	-	172	-	-
Astragalus umbellatus	172	174	172	-	-	177	176	-	182
Draba caesia	172	(177)	172	-	-	176	-	-	-
Oxytropis Maydelliana	(171)172	183	186	179	177	172	192	-	(171)172
Salix ovalifolia	172	-	-	-	-	-	172	-	-
Draba nivalis	173	-	-	-	178	173	-	-	-
Pedicularis Langsdorffii arctica	173	-	-	186	182	173	-	-	(176)182
Draba cinerea	174	174	-	-	-	-	-	-	-
Andromeda polifolia	174	-	-	180	182	-	-	174	178
Stellaria longipes	174	174	179	-	-	(183)	-	-	-
Stellaria laeta	174	174	194	-	-	-	184	-	-
Draba lactea	175	175	-	-	-	-	-	-	-
Draba eutrema Edwardsii	(175)	(175)	-	-	-	-	-	-	-
Draba pilosa	175	175	-	-	-	-	-	-	-
Eriophorum angustifolium	(171)175	-	-	-	-	-	-	-	(171)175
Eriophorum russeolum	175	-	-	-	-	-	-	-	175
Rubus chamaemorus	175	175	-	179	176	177	-	-	(175)182
Hierochloe alpina	175	175	-	-	-	-	-	-	-
Carex Bigelowii	(170)175	175	180	-	-	-	-	-	(170)175
Ledum palustre decumbens	175	175	180	175	-	177	-	-	176
Senecio atropurpureus frigidus	175	175	180	-	-	182	183	-	182
Hedysarum Mackenzii	175	-	179	175	185	191	-	-	-
Salix reticulata	175	(175)	179	-	177	181	-	-	175
Salix rotundifolia	(172)175	(175)	-	-	-	-	-	-	(172)177
Carex aquatilis	176	183	-	-	176	-	-	-	-
Carex scirpoidea	176	176	-	-	-	-	-	-	-
Papaver Macounii	176	(177)	180	182	180	176	(176)	-	(179)183
Polygonum bistorta	(175)176	(175)	180	179	176	184	187	-	(180)183
Pedicularis capitata	(175)176	177	179	176	182	178	186	-	(175)176
P. sudetica albolabiata	176	(178)	180	176	-	177	183	-	(179)182
Draba pseudopilosa	176	176	-	-	-	-	179	-	-
Minuartia arctica	(170)176	175	-	182	-	186	187	-	(170)183
Polemonium boreale	176	176	179	177	179	178	178	-	-
Rhododendron lapponicum	176	-	179	179	182	-	-	176	-
Dryas octopetala	177	-	-	177	-	-	-	-	-
Oxytropis campestris	177	-	194	179	177	178	-	-	-
Potentilla hyparctica	(176)177	(191)	-	-	-	182	177	-	(176)
Astragalus alpinus	177	204	179	-	-	182	177	-	(180)
Ranunculus Pallasii	177	184	-	-	-	191	-	-	177
Primula borealis	178	181	-	-	-	(178)	178	-	-
Cochlearia officinalis	178	-	-	-	178	(207)	-	-	-
Papaver lapponicum	179	-	179	-	-	-	-	-	-
Papaver alboroseum	179	-	179	-	-	-	-	-	-
Erigeron purpuratus	179	-	179	-	-	-	-	-	-

Appendix Table I. Continued.

Species	Earliest Date	Okpilak	Katakturuk	Jago Bitty	Aichilik	Sadlerochit	Jago Delta	Marsh Creek	Niguanak
Hedysarum alpinum	179	-	-	179	-	-	-	-	-
Ranunculus pedatifidus affinis	179	-	-	-	180	-	179	-	-
Saxifraga punctata Nelsoniana	(177)180	(177)	-	180	182	182	183	-	(183)
Cardamine hyperborea	180	(189)	180	-	-	182	-	-	-
Valeriana capitata	180	182	187	182	191	182	194	-	(190)196
Saxifraga hieracifolia	(180)181	182	-	189	-	181	196	-	(180)182
Eritrichium aretioides	181	-	-	181	-	-	-	-	-
Dodecatheon frigidum	(176)181	-	-	193	182	-	-	181	(176)
Boykinia Richardsonii	181	-	-	-	190	-	-	181	(190)
Stellaria Edwardsii	182	-	-	-	-	182	-	-	-
Senecio fuscatus	(182)	-	-	-	-	-	-	-	(182)
Saxifraga tricuspidata	182	-	(195)	-	182	-	-	-	-
Castelleja caudata	182	-	186	182	186	191	199	-	-
Pedicularis verticillata	182	-	194	-	182	-	-	-	-
Parnassia kotzebuei	182	-	-	182	-	-	-	-	-
Pyrola grandiflora	182	-	187	182	-	186	192	-	190
Senecio yukonensis	(172)182	182	-	-	-	182	-	-	(172)
Calamagrostis inexpansa	182	182	-	-	-	-	-	-	-
Vaccinium uliginosum	(179)183	190	-	-	-	-	-	-	(179)183
Corydalis pauciflora	(183)	(183)	-	-	-	-	-	-	-
Senecio lugens	183	-	-	183	-	-	-	-	-
Saxifraga hirculus	184	184	194	197	-	195	184	-	(187)189
Taraxacum ceratophorum	184	184	-	-	-	188	-	-	-
Melandrium apetalum	184	191	-	-	186	184	(191)	-	(190)191
Pedicularis labradorica	184	-	-	184	186	-	-	-	-
Stellaria monantha	(185)	-	-	-	-	-	(185)	-	-
Taraxacum lacerum	185	-	-	-	185	-	-	-	-
Artemisia arctica comata	185	-	186	185	-	-	-	-	-
Astragalus aboriginum	186	-	-	-	186	-	-	-	-
Carex misandra	(186)	-	-	-	-	-	-	-	(186)
Luzula confusa	(186)	-	-	-	-	-	-	-	(186)
Crepis nana	186	-	186	187	-	-	-	-	-
Arabis lyrata kamchatica	186	-	186	-	-	-	-	-	-
Minuartia rossii	186	-	-	-	-	-	186	-	-
Tofieldia pusilla	186	-	186	(197)	-	-	-	-	-
Saxifraga reflexa	186	-	186	-	-	-	-	-	-
Epilobium latifolium	186	-	194	186	186	195	198	-	(204)
Arnica alpina angustifolia	186	-	186	-	-	-	190	-	-
Erigeron eriocephalus	186	-	-	-	186	188	199	-	-
Artemisia furcata	187	-	-	187	-	-	-	-	-
Rumex arcticus	187	-	187	-	-	-	-	-	-
Senecio conterminus	187	-	187	-	-	-	-	-	-
Potentilla biflora	(182)189	-	194	191	-	-	-	-	(182)189
Ranunculus Gmelini	189	-	-	-	-	(204)	-	-	189
Chrysanthemum integrifolium	189	-	-	-	-	-	-	-	189
Oxytropis borealis	190	-	194	190	-	-	178	-	-
Vaccinium vitus-idaea	190	-	-	-	-	190	-	-	(195)
Polemonium acutiflorum	(183)190	(183)	-	-	-	-	-	-	190
Saxifraga cernua	(184)190	190	194	-	-	(184)	-	-	-
Senecio congestus	191	-	-	-	-	-	-	-	191
Erigeron humilis	(190)191	-	-	191	-	-	-	-	(190)
Cardamine bellidifolia	(192)	(192)	-	-	-	-	-	-	-
Taraxacum alaskanum	193	-	-	-	-	-	193	-	-
Polygonum viviparum	193	219	-	-	-	-	193	-	-
Senecio resedifolius	(183)194	-	194	-	-	(183)	-	-	-
Myosotis alpestris	(194)	-	(194)	-	-	-	-	-	-
Sedum rosea	(194)	-	-	-	-	(194)	(200)	-	-
Aconitum delphinifolium	194	(202)	194	-	194	194	-	-	(194)
Saussurea angustifolia	194	217	194	-	-	-	-	-	(215)217
Campanula lasiocarpa	195	-	195	-	-	-	-	-	-
Aster sibericus	195	-	195	(200)	-	-	-	-	-
Potentilla fruticosa	195	-	-	195	-	-	-	-	-
Cardamine pratensis	(201)	(201)	-	-	-	-	-	-	-
Saxifraga caespitosa	(202)	(202)	-	-	-	-	-	-	-
Saxifraga exilis	(202)	(202)	-	-	-	-	-	-	-
Delphinium brachycentrum	203	219	-	-	-	203	-	-	-
Saxifraga bronchialis funstonii	204	-	-	-	-	204	-	-	-
Delphinium spp.	(204)	-	-	-	-	-	-	-	(204)
Potentilla palustris	219	-	-	-	-	-	-	-	219
Saxifraga rivularis	(221)	-	-	-	-	(221)	-	-	-
Achillea borealis	221	-	221	-	-	-	-	-	-
Saussurea viscida yukonenis	224	-	-	-	-	224	-	-	-

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[a] Dates in parentheses were for plants first or only observed flowering off bird study plots.

Appendix Table II. Mean densities (birds/km^2) and mean number of species (species/0.1km^2)[a] of birds observed on 10 ha study plots during the reproductive season in different habitats on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1982-1985, sorted by location and year.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		II Flooded			
Okpilak	1982	Total birds	12	30.92	19.28
		Total species (17)[b]	12	7.08	1.78
		Red-throated loon	12	0.58	0.79
		Pacific loon	12	0.75	1.14
		Northern pintail	12	0.50	1.73
		Oldsquaw	12	0.92	0.90
		Whimbrel	12	0.58	2.02
		Semipalmated sandpiper	12	0.42	1.00
		Pectoral sandpiper	12	8.17	7.98
		Long-billed dowitcher	12	1.42	1.88
		Red-necked phalarope	12	7.17	5.89
		Red phalarope	12	3.83	4.80
		Parasitic jaeger	12	0.42	0.67
		Long-tailed jaeger	12	0.75	2.30
		Herring gull	12	0.08	0.29
		Glaucous gull	12	2.42	3.85
		Arctic tern	12	0.17	0.58
		Snowy owl	12	0.17	0.39
		Lapland longspur	12	2.00	1.41
	1983	Total birds	12	32.83	13.29
		Total species (17)	12	8.17	2.48
		Red-throated loon	12	1.17	1.11
		Pacific loon	12	0.33	0.65
		Brant	12	0.25	0.62
		Northern pintail	12	1.17	1.95
		Oldsquaw	12	1.25	1.60
		Lesser golden-plover	12	0.17	0.39
		Semipalmated sandpiper	12	0.67	0.98
		Pectoral sandpiper	12	8.42	5.28
		Stilt sandpiper	12	0.08	0.29
		Long-billed dowitcher	12	2.42	2.71
		Red-necked phalarope	12	2.58	2.84
		Red phalarope	12	2.58	2.43
		Parasitic jaeger	12	0.67	0.89
		Long-tailed jaeger	12	0.08	0.29
		Glaucous gull	12	5.50	7.42
		Short-eared owl	12	0.08	0.29
		Lapland longspur	12	5.42	4.54
	1985	Total birds	15	47.93	27.07
		Total species (22)	15	9.47	2.59
		Red-throated loon	15	0.47	0.64
		Pacific loon	15	0.33	0.62
		Brant	15	2.60	5.10
		Canada goose	15	0.33	0.62
		Northern pintail	15	1.53	2.47
		Spectacled eider	15	0.60	1.06
		Oldsquaw	15	0.60	0.91
		Rock ptarmigan	15	0.07	0.26
		Lesser golden-plover	15	0.20	0.41
		Semipalmated sandpiper	15	1.33	2.02
		Pectoral sandpiper	15	12.60	9.08

Appendix Table II. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		II Flooded Continued.			
Okpilak	1985	Stilt sandpiper	15	1.07	1.53
		Long-billed dowitcher	15	1.20	1.57
		Red-necked phalarope	15	9.27	10.32
		Red phalarope	15	4.53	5.87
		Pomarine jaeger	15	0.53	1.06
		Parasitic jaeger	15	0.60	0.83
		Long-tailed jaeger	15	0.13	0.52
		Glaucous gull	15	2.67	2.92
		Common raven	15	0.07	0.26
		Lapland longspur	15	7.60	1.92
		Redpoll spp.	15	0.13	0.52
Jago Delta	1984	Total birds	15	18.93	6.15
		Total species (14)	15	5.33	1.50
		Common eider	15	0.07	0.26
		Oldsquaw	15	0.13	0.52
		Black-bellied plover	15	0.07	0.26
		Lesser golden-plover	15	1.00	0.93
		Semipalmated sandpiper	15	0.47	0.83
		Pectoral sandpiper	15	5.20	2.76
		Dunlin	15	0.13	0.52
		Stilt sandpiper	15	1.13	1.51
		Long-billed dowitcher	15	0.47	0.92
		Red-necked phalarope	15	0.53	0.99
		Red phalarope	15	1.60	1.45
		Parasitic jaeger	15	0.13	0.35
		Long-tailed jaeger	15	0.20	0.56
		Lapland longspur	15	7.80	4.16
	1985	Total birds	15	26.00	8.24
		Total species (17)	15	6.80	1.82
		Northern pintail	15	0.40	1.12
		King eider	15	0.33	0.90
		Oldsquaw	15	0.20	0.56
		Rock ptarmigan	15	0.40	0.74
		Black-bellied plover	15	0.20	0.56
		Lesser golden-plover	15	0.07	0.26
		Semipalmated sandpiper	15	1.33	1.40
		Pectoral sandpiper	15	6.80	3.36
		Stilt sandpiper	15	1.07	1.44
		Buff-breasted sandpiper	15	0.47	0.92
		Long-billed dowitcher	15	2.47	4.31
		Red-necked phalarope	15	0.53	0.92
		Red phalarope	15	1.93	1.44
		Pomarine jaeger	15	0.73	0.88
		Parasitic jaeger	15	0.60	0.83
		Long-tailed jaeger	15	0.07	0.26
		Lapland longspur	15	8.40	2.69
Niguanak	1985	Total birds	15	36.80	10.43
		Total species (18)	15	8.87	2.45
		Pacific loon	15	0.13	0.52
		Tundra swan	15	0.13	0.35
		Northern pintail	15	0.33	0.72
		King eider	15	0.07	0.26
		Oldsquaw	15	2.47	1.64
		Rock ptarmigan	15	0.60	0.83
		Lesser golden-plover	15	2.07	2.02
		Semipalmated sandpiper	15	0.87	1.13
		Pectoral sandpiper	15	7.60	3.11
		Stilt sandpiper	15	1.87	1.73
		Buff-breasted sandpiper	15	0.07	0.26
		Long-billed dowitcher	15	1.67	2.09
		Red-necked phalarope	15	7.73	5.42

Appendix Table II. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		II Flooded Continued.			
Niguanak	1985	Red phalarope	15	0.80	1.15
		Pomarine jaeger	15	2.33	1.18
		Glaucous gull	15	0.07	0.26
		Arctic tern	15	0.07	0.26
		Lapland longspur	15	7.93	3.67
		III Wet Sedge			
Okpilak	1982	Total birds	12	15.00	7.99
		Total species (13)	12	4.08	1.62
		King eider	12	0.17	0.58
		Oldsquaw	12	0.08	0.29
		Sandhill crane	12	0.25	0.87
		Pectoral sandpiper	12	3.17	3.33
		Buff-breasted sandpiper	12	0.17	0.58
		Long-billed dowitcher	12	0.67	1.37
		Red-necked phalarope	12	0.92	0.90
		Red phalarope	12	0.25	0.62
		Parasitic jaeger	12	0.42	0.67
		Long-tailed jaeger	12	0.50	0.80
		Snowy owl	12	0.17	0.58
		Short eared owl	12	0.17	0.39
		Lapland longspur	12	8.08	4.01
Okpilak	1983	Total birds	12	20.33	6.39
		Total species (11)	12	4.08	1.31
		Northern pintail	12	0.17	0.39
		Lesser golden-plover	12	0.17	0.39
		Pectoral sandpiper	12	6.75	3.91
		Stilt sandpiper	12	0.08	0.29
		Long-billed dowitcher	12	1.50	2.91
		Red-necked phalarope	12	0.92	1.16
		Red phalarope	12	0.08	0.29
		Pomarine jaeger	12	0.08	0.29
		Parasitic jaeger	12	0.33	0.49
		Long-tailed jaeger	12	0.17	0.39
		Lapland longspur	12	10.08	2.15
	1985	Total birds	15	16.53	8.16
		Total species (12)	15	3.67	1.35
		Northern pintail	15	0.13	0.52
		Rock ptarmigan	15	0.33	0.72
		Lesser golden-plover	15	0.07	0.26
		Semipalmated sandpiper	15	0.07	0.26
		Pectoral sandpiper	15	2.27	2.87
		Stilt sandpiper	15	0.13	0.35
		Long-billed dowitcher	15	0.60	0.99
		Red-necked phalarope	15	0.80	1.01
		Pomarine jaeger	15	0.47	0.74
		Long-tailed jaeger	15	0.33	0.72
		Snowy owl	15	0.07	0.26
		Lapland longspur	15	11.40	5.00
Katakturuk	1983	Total birds	4	10.00	3.92
		Total species (5)	4	2.75	0.96
		Lesser golden-plover	4	0.25	0.50
		Pectoral sandpiper	4	1.75	0.96
		Long-tailed jaeger	4	1.00	2.00
		Lapland longspur	4	6.25	2.22
		Redpoll spp.	4	0.75	1.50

Appendix Table II. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean ±	S.D.
		III Wet Sedge Continued.			
Katakturuk	1985	Total birds	5	12.20	5.81
		Total species (6)	5	3.00	1.00
		Rock ptarmigan	5	0.20	0.45
		Semipalmated sandpiper	5	0.40	0.89
		Pectoral sandpiper	5	1.20	0.45
		Long-tailed jaeger	5	1.40	1.52
		Lapland longspur	5	8.80	5.81
		Redpoll spp.	5	0.20	0.45
Jago Bitty	1983	Total birds	12	12.08	4.96
		Total species (8)	12	2.83	1.19
		Rock ptarmigan	12	0.08	0.29
		Lesser golden-plover	12	0.25	0.62
		Pectoral sandpiper	12	6.42	4.56
		Stilt sandpiper	12	0.08	0.29
		Red necked phalarope	12	0.17	0.39
		Parasitic jaeger	12	0.50	0.80
		Savannah sparrow	12	0.42	1.00
		Lapland longspur	12	4.17	2.98
	1985	Total birds	15	19.13	5.69
		Total species (17)	15	6.60	1.88
		Northern pintail	15	0.07	0.26
		Oldsquaw	15	0.13	0.52
		Willow ptarmigan	15	1.07	1.03
		Rock ptarmigan	15	2.33	3.13
		Lesser golden-plover	15	0.13	0.35
		Semipalmated sandpiper	15	0.20	0.56
		Pectoral sandpiper	15	4.80	2.31
		Stilt sandpiper	15	1.00	1.00
		Long-billed dowitcher	15	0.20	0.41
		Red-necked phalarope	15	0.67	0.90
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.47	0.74
		Long-tailed jaeger	15	1.13	1.30
		Short-eared owl	15	0.13	0.35
		Savannah sparrow	15	0.47	0.64
		Lapland longspur	15	6.13	3.11
		Redpoll spp.	15	0.13	0.52
Aichilik	1984	Total birds	15	9.60	5.72
		Total species (7)	15	2.87	1.30
		Rock ptarmigan	15	0.20	0.56
		Lesser golden-plover	15	0.33	0.62
		Pectoral sandpiper	15	1.80	1.86
		Pomarine jaeger	15	0.33	1.29
		Long-tailed jaeger	15	1.13	1.60
		Lapland longspur	15	5.47	4.03
		Redpoll spp.	15	0.27	0.80
	1985	Total birds	15	9.47	4.73
		Total species (13)	15	3.93	1.75
		Northern pintail	15	0.07	0.26
		Gyrfalcon	15	0.07	0.26
		Willow ptarmigan	15	0.13	0.35
		Rock ptarmigan	15	0.73	1.28
		Lesser golden-plover	15	0.07	0.26
		Pectoral sandpiper	15	2.13	1.60
		Stilt sandpiper	15	0.27	0.59
		Buff-breasted sandpiper	15	0.07	0.26
		Pomarine jaeger	15	0.40	0.51
		Parasitic jaeger	15	0.13	0.35
		Long-tailed jaeger	15	0.87	0.92
		Lapland longspur	15	4.40	1.84
		Redpoll spp.	15	0.13	0.52

Appendix Table II. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		III Wet Sedge Continued.			
Sadlerochit	1984	Total birds	15	21.07	7.95
		Total species (9)	15	4.40	1.12
		Northern pintail	15	0.07	0.26
		Oldsquaw	15	0.07	0.26
		Semipalmated sandpiper	15	0.27	0.46
		Pectoral sandpiper	15	5.47	6.76
		Long-billed dowitcher	15	0.73	0.70
		Red-necked phalarope	15	0.93	1.28
		Parasitic jaeger	15	0.93	0.88
		Savannah sparrow	15	2.20	2.18
		Lapland longspur	15	10.40	5.78
	1985	Total birds	15	40.07	11.04
		Total species (15)	15	6.87	1.13
		Red-throated loon	15	0.13	0.52
		Northern pintail	15	0.27	0.59
		Oldsquaw	15	0.53	0.83
		Rock ptarmigan	15	0.20	0.41
		Lesser golden-plover	15	0.20	0.56
		Semipalmated sandpiper	15	1.93	2.84
		Pectoral sandpiper	15	8.93	6.13
		Long-billed dowitcher	15	0.67	0.82
		Red-necked phalarope	15	1.93	2.46
		Pomarine jaeger	15	0.13	0.35
		Parasitic jaeger	15	1.33	1.11
		Long-tailed jaeger	15	0.40	0.51
		Savannah sparrow	15	5.33	4.06
		Lapland longspur	15	17.93	5.75
		Redpoll spp.	15	0.13	0.52
Jago Delta	1984	Total birds	15	16.40	10.49
		Total species (7)	15	2.60	1.40
		Lesser golden-plover	15	0.27	0.70
		Semipalmated sandpiper	15	1.07	1.10
		Pectoral sandpiper	15	1.00	1.46
		Stilt sandpiper	15	0.33	0.62
		Buff-breasted sandpiper	15	0.13	0.52
		Long-tailed jaeger	15	0.07	0.26
		Lapland longspur	15	13.53	8.63
	1985	Total birds	15	13.13	6.37
		Total species (10)	15	3.80	1.61
		Rock ptarmigan	15	0.07	0.26
		Lesser golden-plover	15	0.73	1.10
		Semipalmated sandpiper	15	0.33	0.62
		Pectoral sandpiper	15	1.87	2.23
		Buff-breasted sandpiper	15	2.00	2.00
		Red-necked phalarope	15	0.20	0.77
		Pomarine jaeger	15	1.00	1.46
		Parasitic jaeger	15	0.33	0.49
		Long-tailed jaeger	15	0.13	0.35
		Lapland longspur	15	6.47	2.20
Niguanak	1985	Total birds	15	17.20	6.28
		Total species (13)	15	5.20	2.31
		King eider	15	0.07	0.26
		Oldsquaw	15	0.07	0.26
		Rock ptarmigan	15	0.47	1.06
		Lesser golden-plover	15	1.07	1.10
		Semipalmated sandpiper	15	0.53	0.99
		Pectoral sandpiper	15	2.80	1.57
		Stilt sandpiper	15	0.67	0.90

Appendix Table II. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
III Wet Sedge Continued.					
Niguanak	1985	Long-billed dowitcher	15	0.27	0.59
		Red-necked phalarope	15	0.60	1.12
		Pomarine jaeger	15	1.80	1.08
		Parasitic jaeger	15	0.20	0.77
		Short eared owl	15	0.40	0.83
		Lapland longspur	15	8.27	3.71
IV Moist Sedge					
Katakturuk	1982	Total birds	5	7.20	4.15
		Total species (8)	5	3.40	1.95
		Rough-legged hawk	5	0.20	0.45
		Rock ptarmigan	5	0.60	0.89
		Pectoral sandpiper	5	0.20	0.45
		Parasitic jaeger	5	0.80	0.84
		Long-tailed jaeger	5	0.60	0.55
		Short eared owl	5	0.20	0.45
		Lapland longspur	5	4.20	2.68
		Redpoll spp.	5	0.40	0.55
	1983	Total birds	8	7.13	6.88
		Total species (4)	8	2.25	1.28
		Lesser golden-plover	8	0.88	0.83
		Semipalmated sandpiper	8	0.50	0.76
		Long-tailed jaeger	8	0.50	0.76
		Lapland longspur	8	5.25	5.47
	1985	Total birds	10	9.00	5.94
		Total species (7)	10	2.10	0.99
		Rock ptarmigan	10	0.20	0.42
		Lesser golden-plover	10	0.60	1.07
		Ruddy turnstone	10	0.10	0.32
		Pectoral sandpiper	10	0.10	0.32
		Parasitic jaeger	10	0.20	0.63
		Long-tailed jaeger	10	0.40	0.70
		Lapland longspur	10	7.40	4.93
Jago Bitty	1983	Total birds	12	11.00	5.31
		Total species (9)	12	2.50	0.67
		Lesser golden-plover	12	0.83	1.34
		Pectoral sandpiper	12	1.00	1.28
		Pomarine jaeger	12	0.08	0.29
		Parasitic jaeger	12	0.08	0.29
		Long-tailed jaeger	12	0.42	0.79
		Short eared owl	12	0.08	0.29
		Savannah sparrow	12	0.08	0.29
		Lapland longspur	12	8.33	4.25
		Redpoll spp.	12	0.08	0.29
	1985	Total birds	15	13.13	5.04
		Total species (11)	15	3.80	1.15
		Willow ptarmigan	15	0.33	0.62
		Rock ptarmigan	15	1.07	1.28
		Lesser golden-plover	15	1.00	1.07
		Semipalmated sandpiper	15	0.07	0.26
		Pectoral sandpiper	15	0.40	0.63
		Buff-breasted sandpiper	15	0.33	0.62
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.93	1.62
		Savannah sparrow	15	0.07	0.26
		Lapland longspur	15	8.53	2.92
		Redpoll spp.	15	0.33	0.62

Appendix Table II. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		IV Moist Sedge Continued.			
Aichilik	1984	Total birds	15	10.93	7.66
		Total species (12)	15	3.53	1.41
		Rock ptarmigan	15	0.53	0.74
		Lesser golden-plover	15	1.00	0.93
		Whimbrel	15	0.27	1.03
		Pectoral sandpiper	15	0.27	0.46
		Buff-breasted sandpiper	15	0.13	0.35
		Pomarine jaeger	15	0.13	0.35
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	1.47	1.60
		Glaucous gull	15	0.07	0.26
		Common raven	15	0.07	0.26
		Lapland longspur	15	6.80	6.17
		Redpoll spp.	15	0.13	0.52
	1985	Total birds	15	6.93	4.22
		Total species (11)	15	2.67	1.54
		Rock ptarmigan	15	0.60	1.80
		Lesser golden-plover	15	0.40	0.63
		Whimbrel	15	0.27	1.03
		Pectoral sandpiper	15	0.07	0.26
		Buff-breasted sandpiper	15	0.53	1.13
		Long-billed dowitcher	15	0.13	0.52
		Pomarine jaeger	15	0.33	0.82
		Long-tailed jaeger	15	0.40	0.51
		Glaucous gull	15	0.07	0.26
		Lapland longspur	15	3.80	2.43
		Redpoll spp.	15	0.20	0.77
Marsh Creek	1985	Total birds	15	7.20	4.66
		Total species (10)	15	2.80	1.90
		Willow ptarmigan	15	0.33	0.62
		Rock ptarmigan	15	0.47	0.64
		Lesser golden-plover	15	0.27	0.80
		Semipalmated sandpiper	15	0.13	0.35
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.20	0.41
		Long-tailed jaeger	15	0.13	0.35
		Savannah sparrow	15	0.80	1.37
		Lapland longspur	15	4.33	2.89
		Redpoll spp.	15	0.47	1.13
		IVa Mosaic			
Okpilak	1982	Total birds	16	23.62	8.77
		Total species (17)	16	5.63	2.13
		Northern pintail	16	0.19	0.75
		Oldsquaw	16	0.38	1.09
		Rock ptarmigan	16	0.31	0.60
		Lesser golden-plover	16	0.69	0.87
		Semipalmated sandpiper	16	0.88	0.96
		Pectoral sandpiper	16	4.50	2.97
		Buff-breasted sandpiper	16	1.44	3.42
		Long-billed dowitcher	16	0.63	1.54
		Red-necked phalarope	16	1.63	2.83
		Red phalarope	16	0.81	1.22
		Pomarine jaeger	16	0.50	1.10
		Parasitic jaeger	16	0.31	0.79
		Long-tailed jaeger	16	0.38	0.81
		Glaucous gull	16	0.13	0.34
		Snowy owl	16	0.06	0.25
		Short-eared owl	16	0.06	0.25
		Lapland longspur	16	11.31	3.36

Appendix Table II. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		IVa Mosaic Continued.			
Okpilak	1983	Total birds	16	26.37	7.88
		Total species (14)	16	5.06	1.73
		Northern pintail	16	1.19	2.17
		Oldsquaw	16	0.25	0.58
		Lesser golden-plover	16	0.31	0.48
		Semipalmated sandpiper	16	0.38	0.50
		Pectoral sandpiper	16	6.56	3.29
		Stilt sandpiper	16	0.19	0.54
		Long-billed dowitcher	16	0.56	0.73
		Red-necked phalarope	16	0.75	1.13
		Red phalarope	16	0.25	0.77
		Pomarine jaeger	16	0.06	0.25
		Parasitic jaeger	16	0.25	0.45
		Long-tailed jaeger	16	0.75	1.18
		Glaucous gull	16	0.06	0.25
		Lapland longspur	16	14.81	5.04
	1985	Total birds	20	20.70	8.75
		Total species (16)	20	4.55	1.76
		Northern pintail	20	0.15	0.49
		Oldsquaw	20	0.45	1.23
		Rock ptarmigan	20	0.20	0.41
		Lesser golden-plover	20	0.55	0.69
		Semipalmated sandpiper	20	0.50	0.95
		Pectoral sandpiper	20	2.25	2.77
		Stilt sandpiper	20	0.55	0.89
		Long-billed dowitcher	20	0.40	1.23
		Red-necked phalarope	20	0.75	1.02
		Pomarine jaeger	20	0.25	0.55
		Parasitic jaeger	20	0.05	0.22
		Long-tailed jaeger	20	0.30	0.57
		Glaucous gull	20	0.05	0.22
		Short-eared owl	20	0.05	0.22
		Lapland longspur	20	13.90	5.88
		Redpoll spp.	20	0.20	0.62
Sadlerochit	1984	Total birds	15	30.33	10.91
		Total species (14)	15	6.40	1.45
		Northern pintail	15	0.67	1.11
		Oldsquaw	15	0.20	0.56
		Rock ptarmigan	15	0.33	0.72
		Lesser golden-plover	15	1.53	1.73
		Semipalmated sandpiper	15	3.20	2.01
		Pectoral sandpiper	15	4.87	2.95
		Long-billed dowitcher	15	1.00	1.31
		Red-necked phalarope	15	0.80	0.94
		Pomarine jaeger	15	0.40	0.91
		Parasitic jaeger	15	0.27	0.46
		Long-tailed jaeger	15	0.33	0.62
		Savannah sparrow	15	0.13	0.35
		Lapland longspur	15	15.73	5.73
		Redpoll spp.	15	0.80	1.78
	1985	Total birds	15	26.20	8.27
		Total species (18)	15	5.53	1.55
		Northern pintail	15	0.07	0.26
		Oldsquaw	15	0.13	0.52
		Northern harrier	15	0.07	0.26
		Golden eagle	15	0.07	0.26
		Rock ptarmigan	15	0.33	0.62
		Lesser golden-plover	15	0.60	0.74
		Ruddy turnstone	15	0.13	0.52
		Semipalmated sandpiper	15	3.13	2.20

Appendix Table II. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		IVa Mosaic Continued.			
Sadlerochit	1985	Pectoral sandpiper	15	2.27	2.02
		Long-billed dowitcher	15	0.67	1.11
		Red-necked phalarope	15	0.47	0.74
		Red phalarope	15	0.07	0.26
		Pomarine jaeger	15	0.40	0.74
		Parasitic jaeger	15	0.33	0.49
		Long-tailed jaeger	15	0.33	0.62
		Sabine's gull	15	0.07	0.26
		Short eared owl	15	0.07	0.26
		Lapland longspur	15	17.00	8.02
Jago Delta	1984	Total birds	15	31.40	12.71
		Total species (15)	15	4.73	1.67
		Northern pintail	15	0.33	0.62
		Oldsquaw	15	0.40	0.91
		Rock ptarmigan	15	0.20	0.56
		Lesser golden-plover	15	0.33	0.62
		Semipalmated sandpiper	15	1.73	1.91
		Pectoral sandpiper	15	6.67	4.94
		Stilt sandpiper	15	0.07	0.26
		Long-billed dowitcher	15	0.20	0.41
		Red-necked phalarope	15	0.60	0.74
		Red phalarope	15	0.27	0.80
		Parasitic jaeger	15	0.27	1.03
		Long-tailed jaeger	15	0.27	0.80
		Glaucous gull	15	0.13	0.52
		Lapland longspur	15	19.73	7.82
		Redpoll spp.	15	0.27	1.03
	1985	Total birds	15	23.93	7.93
		Total species (16)	15	6.07	1.79
		Northern pintail	15	0.67	1.11
		King eider	15	0.13	0.52
		Oldsquaw	15	0.80	1.26
		Rock ptarmigan	15	1.93	3.22
		Lesser golden-plover	15	0.93	0.80
		Semipalmated sandpiper	15	0.40	0.63
		Pectoral sandpiper	15	4.60	2.32
		Dunlin	15	0.07	0.26
		Buff-breasted sandpiper	16	0.27	0.59
		Long-billed dowitcher	15	0.33	1.29
		Red-necked phalarope	15	0.67	0.82
		Red phalarope	15	0.27	0.70
		Pomarine jaeger	15	0.93	1.28
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.47	0.83
		Lapland longspur	15	10.93	5.59
		V Moist Sedge-Shrub			
Okpilak	1982	Total birds	4	16.50	8.27
		Total species (8)	4	3.25	1.71
		Northern pintail	4	0.25	0.50
		Willow ptarmigan	4	0.25	0.50
		Rock ptarmigan	4	0.25	0.50
		Pectoral sandpiper	4	2.25	3.86
		Red-necked phalarope	4	2.75	5.50
		Pomarine jaeger	4	0.50	1.00
		Long-tailed jaeger	4	0.50	0.58
		Lapland longspur	4	9.75	4.92

Appendix Table II. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		V Moist Sedge-Shrub Continued.			
Okpilak	1983	Total birds	8	17.50	8.47
		Total species (8)	8	3.50	1.20
		Northern pintail	8	0.13	0.35
		Lesser golden-plover	8	0.75	0.89
		Pectoral sandpiper	8	2.50	1.41
		Long-billed dowitcher	8	0.13	0.35
		Red-necked phalarope	8	0.13	0.35
		Pomarine jaeger	8	0.13	0.35
		Long-tailed jaeger	8	1.13	1.46
		Lapland longspur	8	12.62	9.24
	1985	Total birds	10	18.00	4.32
		Total species (9)	10	3.30	1.42
		Northern pintail	10	0.20	0.63
		Willow ptarmigan	10	0.40	0.70
		Rock ptarmigan	10	0.30	0.48
		Lesser golden-plover	10	0.50	0.85
		Pectoral sandpiper	10	0.70	0.82
		Pomarine jaeger	10	0.50	0.97
		Parasitic jaeger	10	0.40	0.70
		Long-tailed jaeger	10	0.30	0.67
		Lapland longspur	10	14.20	3.05
Katakturuk	1982	Total birds	3	16.33	8.74
		Total species (8)	3	5.33	1.53
		Rough legged hawk	3	0.33	0.58
		Rock ptarmigan	3	0.67	1.15
		Semipalmated sandpiper	3	5.33	2.52
		Red-necked phalarope	3	0.33	0.58
		Short-eared owl	3	1.00	1.00
		Yellow wagtail	3	0.67	0.58
		Savannah sparrow	3	1.67	0.58
		Lapland longspur	3	6.33	4.51
	1983	Total birds	12	10.17	4.61
		Total species (12)	12	3.33	1.15
		Willow ptarmigan	12	0.08	0.29
		Rock ptarmigan	12	0.25	0.45
		Lesser golden-plover	12	0.67	1.23
		Semipalmated sandpiper	12	0.58	0.79
		Pectoral sandpiper	12	1.50	1.31
		Parasitic jaeger	12	0.08	0.29
		Long-tailed jaeger	12	0.25	0.45
		Short-eared owl	12	0.08	0.29
		Savannah sparrow	12	0.67	1.23
		Lapland longspur	12	5.75	3.82
		Smith's longspur	12	0.08	0.29
		Redpoll spp.	12	0.17	0.58
	1985	Total birds	15	12.73	4.64
		Total species (15)	15	4.33	1.11
		Northern pintail	15	0.13	0.35
		Willow ptarmigan	15	0.93	1.39
		Rock ptarmigan	15	0.80	0.54
		Lesser golden-plover	15	0.40	0.63
		Semipalmated sandpiper	15	0.47	0.92
		Pectoral sandpiper	15	0.73	1.03
		Buff-breasted sandpiper	15	0.27	0.46
		Long-billed dowitcher	15	0.07	0.26
		Red-necked phalarope	15	0.27	0.46
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.07	0.26

Appendix Table II. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		V Moist Sedge-Shrub Continued.			
Katakturuk	1982	Long-tailed jaeger	15	0.27	0.59
		Yellow wagtail	15	0.07	0.26
		Savannah sparrow	15	0.80	1.61
		Lapland longspur	15	7.40	3.96
Jago Bitty	1983	Total birds	12	18.92	6.92
		Total species (10)	12	5.00	1.41
		Oldsquaw	12	0.08	0.29
		Willow ptarmigan	12	1.00	0.85
		Lesser golden-plover	12	0.67	1.07
		Semipalmated sandpiper	12	2.00	2.13
		Pectoral sandpiper	12	2.33	2.06
		Red-necked phalarope	12	0.58	1.24
		Parasitic jaeger	12	0.33	0.89
		Long-tailed jaeger	12	0.42	0.79
		Savannah sparrow	12	1.67	1.83
		Lapland longspur	12	9.50	3.73
	1985	Total birds	15	19.80	4.39
		Total species (17)	15	5.87	1.36
		Northern pintail	15	0.07	0.26
		Oldsquaw	15	0.07	0.26
		Willow ptarmigan	15	1.93	1.49
		Rock ptarmigan	15	0.87	1.13
		Lesser golden-plover	15	0.53	0.74
		Semipalmated plover	15	0.07	0.26
		Semipalmated sandpiper	15	2.13	2.42
		Pectoral sandpiper	15	0.67	1.11
		Red-necked phalarope	15	0.93	1.53
		Pomarine jaeger	15	0.87	1.92
		Parasitic jaeger	15	0.47	0.74
		Long-tailed jaeger	15	0.53	0.99
		Glaucous gull	15	0.13	0.52
		Yellow wagtail	15	0.13	0.35
		Savannah sparrow	15	0.73	0.96
		Lapland longspur	15	9.27	1.98
		Redpoll spp.	15	0.40	0.91
Aichilik	1984	Total birds	15	42.40	12.43
		Total species (15)	15	7.00	1.56
		Northern pintail	15	0.27	0.59
		Willow ptarmigan	15	0.40	0.51
		Lesser golden-plover	15	1.00	1.25
		Semipalmated sandpiper	15	0.93	1.79
		Pectoral sandpiper	15	7.60	4.82
		Long-billed dowitcher	15	1.47	3.02
		Red-necked phalarope	15	1.87	1.88
		Pomarine jaeger	15	0.60	1.30
		Parasitic jaeger	15	0.47	0.92
		Long-tailed jaeger	15	1.87	1.88
		Glaucous gull	15	0.07	0.26
		Short-eared owl	15	0.07	0.26
		Savannah sparrow	15	4.20	4.07
		Lapland longspur	15	21.40	8.26
		Redpoll spp.	15	0.40	1.12
	1985	Total birds	15	22.73	6.51
		Total species (17)	15	7.00	2.17
		Green-winged teal	15	0.07	0.26
		Northern pintail	15	0.40	0.63
		Golden eagle	15	0.07	0.26
		Gyrfalcon	15	0.13	0.52

Appendix Table II. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		V Moist Sedge-Shrub Continued.			
Aichilik	1985	Willow ptarmigan	15	0.73	0.80
		Rock ptarmigan	15	0.20	0.56
		Lesser golden-plover	15	1.47	1.77
		Whimbrel	15	0.33	0.90
		Semipalmated sandpiper	15	0.47	0.74
		Pectoral sandpiper	15	3.80	2.65
		Long-billed dowitcher	15	0.47	1.13
		Red-necked phalarope	15	0.80	0.77
		Pomarine jaeger	15	0.60	1.12
		Parasitic jaeger	15	0.40	0.63
		Long-tailed jaeger	15	1.00	1.07
		Savannah sparrow	15	1.60	1.18
		Lapland longspur	15	10.20	3.32
Sadlerochit	1984	Total birds	15	26.67	9.55
		Total species (14)	15	4.87	1.36
		Northern pintail	15	0.20	0.56
		Willow ptarmigan	15	0.07	0.26
		Lesser golden-plover	15	0.53	1.06
		Ruddy turnstone	15	0.07	0.26
		Semipalmated sandpiper	15	2.93	2.49
		Pectoral sandpiper	15	2.80	1.97
		Long-billed dowitcher	15	0.13	0.52
		Red-necked phalarope	15	0.67	0.98
		Parasitic jaeger	15	0.20	0.41
		Long-tailed jaeger	15	0.87	1.19
		Glaucous gull	15	0.07	0.26
		Savannah sparrow	15	0.33	0.62
		Lapland longspur	15	17.67	6.11
		Redpoll spp.	15	0.13	0.35
	1985	Total birds	15	27.20	7.84
		Total species (15)	15	5.67	1.76
		Northern pintail	15	0.33	1.05
		Peregrine falcon	15	0.07	0.26
		Willow ptarmigan	15	0.27	0.59
		Rock ptarmigan	15	3.20	2.93
		Lesser golden-plover	15	0.40	0.51
		Semipalmated sandpiper	15	3.40	1.92
		Pectoral sandpiper	15	2.07	1.53
		Long-billed dowitcher	15	0.07	0.26
		Red-necked phalarope	15	0.27	0.59
		Pomarine jaeger	15	0.13	0.35
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	1.07	1.03
		Snowy owl	15	0.07	0.26
		Savannah sparrow	15	0.07	0.26
		Lapland longspur	15	15.80	5.33
Jago Delta	1984	Total birds	15	19.80	10.54
		Total species (14)	15	4.07	1.87
		Northern pintail	15	0.27	0.70
		Rock ptarmigan	15	0.27	0.46
		Lesser golden-plover	15	0.33	0.90
		Semipalmated sandpiper	15	0.87	1.13
		Pectoral sandpiper	15	2.00	1.51
		Dunlin	15	0.27	0.70
		Buff-breasted sandpiper	16	0.33	0.49
		Red phalarope	15	0.13	0.35
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.27	0.59
		Long-tailed jaeger	15	0.20	0.41
		Glaucous gull	15	0.07	0.26
		Lapland longspur	15	14.73	8.42
		Redpoll spp.	15	0.07	0.26

Appendix Table II. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		V Moist Sedge-Shrub Continued.			
Jago Delta	1985	Total birds	15	20.27	8.30
		Total species (14)	15	5.20	1.37
		Northern pintail	15	0.27	1.03
		Rock ptarmigan	15	0.60	0.74
		Lesser golden-plover	15	1.00	0.85
		Semipalmated sandpiper	15	0.93	1.28
		Pectoral sandpiper	15	3.13	2.64
		Dunlin	15	0.47	0.92
		Buff-breasted sandpiper	15	0.53	0.99
		Long-billed dowitcher	15	0.33	0.72
		Red-necked phalarope	15	0.07	0.26
		Pomarine jaeger	15	1.47	2.00
		Parasitic jaeger	15	0.20	0.41
		Long-tailed jaeger	15	0.13	0.35
		Short-eared owl	15	0.20	0.56
		Lapland longspur	15	10.93	5.04
Marsh Creek	1985	Total birds	15	13.67	5.98
		Total species (12)	15	3.67	1.88
		Rough-legged hawk	15	0.07	0.26
		Golden eagle	15	0.07	0.26
		Willow ptarmigan	15	1.40	1.68
		Rock ptarmigan	15	0.47	0.64
		Lesser golden-plover	15	0.40	0.74
		Semipalmated sandpiper	15	0.07	0.26
		Pectoral sandpiper	15	0.13	0.35
		Pomarine jaeger	15	0.20	0.41
		Parasitic jaeger	15	0.13	0.35
		Long-tailed jaeger	15	0.40	0.63
		Savannah sparrow	15	1.00	1.46
		Lapland longspur	15	9.27	4.59
Niguanak	1985	Total birds	15	22.53	6.57
		Total species (15)	15	5.53	1.96
		Northern pintail	15	0.53	0.92
		Oldsquaw	15	0.20	0.56
		Willow ptarmigan	15	0.47	0.64
		Rock ptarmigan	15	0.60	0.99
		Lesser golden-plover	15	0.13	0.35
		Semipalmated sandpiper	15	0.07	0.26
		Pectoral sandpiper	15	6.20	2.31
		Stilt sandpiper	15	0.13	0.35
		Long-billed dowitcher	15	0.33	0.49
		Red-necked phalarope	15	0.67	1.05
		Pomarine jaeger	15	2.60	1.92
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.07	0.26
		Short-eared owl	15	0.40	0.63
		Lapland longspur	15	10.07	3.83
		VI Tussock			
Katakturuk	1982	Total birds	3	23.33	12.66
		Total species (10)	3	6.00	2.65
		Northern pintail	3	0.33	0.58
		Rough-legged hawk	3	0.33	0.58
		Rock ptarmigan	3	0.33	0.58
		Semipalmated sandpiper	3	3.00	2.65
		Pectoral sandpiper	3	2.00	1.00
		Buff-breasted sandpiper	3	0.33	0.58
		Long-tailed jaeger	3	0.67	0.58
		Short-eared owl	3	0.33	0.58
		Savannah sparrow	3	4.33	0.58
		Lapland longspur	3	11.67	8.50

Appendix Table II. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean ±	S.D.
		VI Tussock Continued.			
Katakturuk	1983	Total birds	12	14.50	13.96
		Total species (9)	12	3.42	2.23
		Rock ptarmigan	12	0.25	0.45
		Lesser golden-plover	12	1.58	1.68
		Semipalmated sandpiper	12	1.83	3.21
		Pectoral sandpiper	12	0.58	0.79
		Parasitic jaeger	12	0.08	0.29
		Long-tailed jaeger	12	0.17	0.39
		Yellow wagtail	12	0.50	1.17
		Savannah sparrow	12	1.08	1.98
		Lapland longspur	12	8.42	7.40
	1985	Total birds	14	11.00	7.80
		Total species (13)	14	3.93	1.90
		Willow ptarmigan	14	0.79	1.05
		Rock ptarmigan	14	0.79	0.89
		Lesser golden-plover	14	0.93	0.83
		Semipalmated sandpiper	14	0.71	1.20
		Pectoral sandpiper	14	0.21	0.58
		Pomarine jaeger	14	0.14	0.36
		Parasitic jaeger	14	0.29	0.61
		Long-tailed jaeger	14	0.14	0.36
		Short-eared owl	14	0.07	0.27
		Yellow wagtail	14	0.36	0.93
		Savannah sparrow	14	0.64	1.74
		Lapland longspur	14	5.86	4.31
		Redpoll spp.	14	0.07	0.27
Jago Bitty	1983	Total birds	12	9.00	5.70
		Total species (9)	12	3.08	1.38
		Willow ptarmigan	12	0.25	0.62
		Rock ptarmigan	12	0.42	0.67
		Lesser golden-plover	12	0.50	0.80
		Semipalmated sandpiper	12	0.25	0.45
		Buff-breasted sandpiper	12	0.08	0.29
		Parasitic jaeger	12	0.08	0.29
		Long-tailed jaeger	12	0.33	0.49
		Savannah sparrow	12	1.08	1.16
		Lapland longspur	12	6.00	4.73
	1985	Total birds	15	14.80	3.05
		Total species (10)	15	4.53	1.51
		Willow ptarmigan	15	2.73	1.16
		Rock ptarmigan	15	1.60	1.55
		Lesser golden-plover	15	0.40	0.51
		Pomarine jaeger	15	0.33	0.72
		Parasitic jaeger	15	0.20	0.41
		Long-tailed jaeger	15	0.73	0.88
		Yellow wagtail	15	0.07	0.26
		Savannah sparrow	15	0.73	1.03
		Lapland longspur	15	7.93	1.83
		Redpoll spp.	15	0.07	0.26
Aichilik	1984	Total birds	15	25.93	10.98
		Total species (15)	15	5.27	2.02
		Willow ptarmigan	15	0.40	0.63
		Rock ptarmigan	15	0.80	1.15
		Lesser golden-plover	15	2.07	1.71
		Semipalmated sandpiper	15	0.07	0.26
		Pectoral sandpiper	15	4.73	2.60
		Buff-breasted sandpiper	15	0.07	0.26
		Long-billed dowitcher	15	0.60	0.91

Appendix Table II. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		VI Tussock Continued.			
Aichilik	1984	Red-necked phalarope	15	0.53	0.83
		Pomarine jaeger	15	0.33	0.82
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.93	1.39
		Glaucous gull	15	0.07	0.26
		Savannah sparrow	15	0.27	0.70
		Lapland longspur	15	15.87	7.63
		Redpoll spp.	15	0.13	0.52
	1985	Total birds	15	18.93	4.01
		Total species (16)	15	7.40	1.68
		Northern pintail	15	0.27	0.59
		Willow ptarmigan	15	1.47	0.83
		Rock ptarmigan	15	2.47	1.55
		Lesser golden-plover	15	2.13	1.25
		Whimbrel	15	0.07	0.26
		Semipalmated sandpiper	15	0.27	0.46
		Pectoral sandpiper	15	1.80	2.04
		Long-billed dowitcher	15	0.07	0.26
		Red-necked phalarope	15	0.53	0.74
		Pomarine jaeger	15	0.60	1.12
		Parasitic jaeger	15	0.53	0.64
		Long-tailed jaeger	15	0.60	0.63
		Short-eared owl	15	0.47	0.74
		Common raven	15	0.07	0.26
		Lapland longspur	15	7.00	2.70
		Redpoll spp.	15	0.60	1.18
Sadlerochit	1984	Total birds	15	13.87	5.25
		Total species (10)	15	3.47	1.25
		Northern pintail	15	0.07	0.26
		Willow ptarmigan	15	0.07	0.26
		Rock ptarmigan	15	0.93	1.10
		Lesser golden-plover	15	0.47	0.64
		Semipalmated sandpiper	15	0.13	0.35
		Pectoral sandpiper	15	1.13	0.92
		Long-billed dowitcher	15	0.07	0.26
		Parasitic jaeger	15	0.20	0.56
		Long-tailed jaeger	15	0.60	0.91
		Lapland longspur	15	10.20	4.44
	1985	Total birds	15	20.87	4.78
		Total species (13)	15	5.00	1.69
		Northern pintail	15	0.07	0.26
		Willow ptarmigan	15	0.13	0.35
		Rock ptarmigan	15	2.07	1.28
		Lesser golden-plover	15	1.47	1.19
		Semipalmated sandpiper	15	0.33	0.62
		Pectoral sandpiper	15	1.07	1.22
		Buff-breasted sandpiper	15	0.07	0.26
		Pomarine jaeger	15	0.20	0.41
		Parasitic jaeger	15	0.27	0.46
		Long-tailed jaeger	15	0.67	0.82
		Short-eared owl	15	0.13	0.52
		Savannah sparrow	15	0.20	0.56
		Lapland longspur	15	14.20	4.48
Marsh Creek	1985	Total birds	15	11.27	5.35
		Total species (8)	15	2.87	0.92
		Willow ptarmigan	15	1.40	1.12
		Rock ptarmigan	15	0.20	0.41
		Lesser golden-plover	15	0.40	0.63

Appendix Table II. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		VI Tussock Continued.			
Marsh Creek	1985	Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.40	1.06
		Savannah sparrow	15	0.33	0.62
		Lapland longspur	15	8.40	4.66
Niguanak	1985	Total birds	15	15.60	5.77
		Total species (11)	15	4.53	1.60
		Northern pintail	15	0.20	0.56
		Willow ptarmigan	15	0.33	0.82
		Rock ptarmigan	15	1.67	1.35
		Lesser golden-plover	15	0.53	0.83
		Pectoral sandpiper	15	0.67	1.18
		Buff-breasted sandpiper	15	0.07	0.26
		Pomarine jaeger	15	2.33	2.26
		Parasitic jaeger	15	0.53	0.74
		Long-tailed jaeger	15	0.40	0.63
		Short-eared owl	15	0.20	0.56
		Lapland longspur	15	8.73	4.42
		IX Riparian			
Okpilak	1983	Total birds	8	36.12	9.86
		Total species (14)	8	6.50	1.85
		Northern pintail	8	0.38	1.06
		Oldsquaw	8	0.25	0.71
		Lesser golden-plover	8	0.88	1.13
		Ruddy turnstone	8	0.25	0.71
		Semipalmated sandpiper	8	6.75	2.60
		Baird's sandpiper	8	0.63	1.41
		Pectoral sandpiper	8	2.13	3.04
		Red-necked phalarope	8	0.50	0.76
		Parasitic jaeger	8	0.50	0.53
		Long-tailed jaeger	8	0.38	0.52
		Arctic tern	8	0.13	0.35
		Savannah sparrow	8	1.25	1.39
		Lapland longspur	8	17.37	5.76
		Redpoll spp.	8	4.75	6.07
Katakturuk	1982	Total birds	6	41.50	8.83
		Total species (15)	6	8.17	0.41
		Rough-legged hawk	6	0.17	0.41
		Rock ptarmigan	6	0.33	0.82
		Lesser golden-plover	6	2.17	1.33
		Semipalmated plover	6	0.67	0.52
		Ruddy turnstone	6	0.50	0.55
		Semipalmated sandpiper	6	8.00	3.69
		Baird's sandpiper	6	0.33	0.52
		Buff-breasted sandpiper	6	0.50	1.22
		Long-tailed jaeger	6	1.33	1.51
		Horned lark	6	0.33	0.82
		Yellow wagtail	6	2.33	1.21
		Water pipit	6	0.50	1.22
		American tree sparrow	6	2.17	2.71
		Lapland longspur	6	17.83	5.64
		Redpoll spp.	6	4.83	2.23
	1983	Total birds	12	42.75	11.81
		Total species (16)	12	6.75	1.36
		Willow ptarmigan	12	0.17	0.58
		Rock ptarmigan	12	0.42	0.79
		Lesser golden-plover	12	1.17	1.40

Appendix Table II. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean ±	S.D.
		IX Riparian Continued.			
Katakturuk	1983	Semipalmated plover	12	0.33	0.65
		Spotted sandpiper	12	0.08	0.29
		Ruddy turnstone	12	0.42	0.79
		Semipalmated sandpiper	12	4.58	2.54
		Baird's sandpiper	12	0.17	0.39
		Long-tailed jaeger	12	0.92	1.00
		American robin	12	0.08	0.29
		Yellow wagtail	12	2.50	1.73
		American tree sparrow	12	2.83	2.66
		Savannah sparrow	12	0.08	0.29
		White-crowned sparrow	12	0.25	0.87
		Lapland longspur	12	24.67	10.62
		Redpoll spp.	12	4.25	3.70
	1985	Total birds	15	63.47	8.97
		Total species (17)	15	7.93	1.83
		Rock ptarmigan	15	0.53	0.92
		Lesser golden-plover	15	1.67	2.19
		Semipalmated plover	15	1.33	1.80
		Ruddy turnstone	15	0.67	1.59
		Semipalmated sandpiper	15	10.60	3.74
		Baird's sandpiper	15	1.13	1.64
		Pectoral sandpiper	15	0.07	0.26
		Buff-breasted sandpiper	15	0.33	0.49
		Long-billed dowitcher	15	0.07	0.26
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.40	0.74
		Yellow wagtail	15	2.47	2.07
		American tree sparrow	15	1.60	1.24
		Savannah sparrow	15	0.07	0.26
		White-crowned sparrow	15	0.13	0.35
		Lapland longspur	15	30.80	9.96
		Redpoll spp.	15	10.80	6.28
Jago Bitty	1983	Total birds	12	26.00	9.44
		Total species (11)	12	5.25	1.60
		Willow ptarmigan	12	0.08	0.29
		Rock ptarmigan	12	0.25	0.62
		Lesser golden-plover	12	1.58	1.78
		Ruddy turnstone	12	0.33	0.65
		Semipalmated sandpiper	12	2.25	1.76
		Pectoral sandpiper	12	0.67	1.44
		Parasitic jaeger	12	0.33	0.89
		Long-tailed jaeger	12	0.42	0.67
		Savannah sparrow	12	1.92	1.24
		Lapland longspur	12	17.25	7.97
		Redpoll spp.	12	0.92	1.24
	1985	Total birds	15	27.87	6.81
		Total species (16)	15	6.20	1.42
		Northern pintail	15	0.07	0.26
		Willow ptarmigan	15	0.80	1.15
		Rock ptarmigan	15	0.93	0.88
		Lesser golden-plover	15	1.27	1.67
		Ruddy turnstone	15	0.13	0.52
		Semipalmated sandpiper	15	3.07	2.79
		Buff-breasted sandpiper	15	0.07	0.26
		Pomarine jaeger	15	0.27	0.80
		Parasitic jaeger	15	0.53	0.74
		Long-tailed jaeger	15	0.60	1.30
		Short-eared owl	15	0.40	0.63

Appendix Table II. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		IX Riparian Continued.			
Jago Bitty	1985	Yellow wagtail	15	0.07	0.26
		American tree sparrow	15	0.13	0.52
		Savannah sparrow	15	2.00	1.81
		Lapland longspur	15	16.27	5.91
		Redpoll spp.	15	1.27	2.15
Aichilik	1984	Total birds	15	37.67	12.53
		Total species (15)	15	7.27	1.94
		Rock ptarmigan	15	0.73	1.03
		Lesser golden-plover	15	3.60	1.96
		Whimbrel	15	0.13	0.52
		Ruddy turnstone	15	2.47	2.64
		Semipalmated sandpiper	15	1.20	1.93
		Buff-breasted sandpiper	15	0.47	0.92
		Pomarine jaeger	15	1.47	1.41
		Parasitic jaeger	15	1.33	3.13
		Long-tailed jaeger	15	0.13	0.35
		Mew gull	15	3.67	3.20
		Glaucous gull	15	0.07	0.26
		Arctic tern	15	0.40	1.30
		Savannah sparrow	15	1.73	2.71
		Lapland longspur	15	16.00	8.98
		Redpoll spp.	15	4.47	3.81
	1985	Total birds	15	23.13	6.56
		Total species (20)	15	7.13	1.81
		Rock ptarmigan	15	1.67	2.29
		Lesser golden-plover	15	2.67	1.59
		Semipalmated plover	15	0.13	0.52
		Whimbrel	15	0.07	0.26
		Ruddy turnstone	15	0.40	0.74
		Semipalmated sandpiper	15	0.60	1.12
		Baird's sandpiper	15	0.60	0.91
		Pectoral sandpiper	15	0.27	0.59
		Stilt sandpiper	15	0.07	0.26
		Buff-breasted sandpiper	15	1.33	1.45
		Red-necked phalarope	15	0.13	0.35
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.13	0.35
		Long-tailed jaeger	15	0.53	0.83
		Mew gull	15	0.20	0.56
		Glaucous gull	15	0.20	0.41
		Arctic tern	15	0.20	0.56
		Savannah sparrow	15	0.67	1.45
		Lapland longspur	15	10.07	6.12
		Redpoll spp.	15	3.13	1.92
Sadlerochit	1984	Total birds	15	40.47	19.88
		Total species (21)	15	7.27	1.33
		Common eider	15	0.07	0.26
		Oldsquaw	15	0.20	0.41
		Rock ptarmigan	15	0.07	0.26
		Lesser golden-plover	15	2.13	2.26
		Ruddy turnstone	15	1.20	1.08
		Semipalmated sandpiper	15	8.47	5.72
		Baird's sandpiper	15	0.73	1.16
		Pectoral sandpiper	15	0.93	1.03
		Dunlin	15	0.07	0.26
		Buff-breasted sandpiper	15	0.13	0.52
		Long-billed dowitcher	15	0.07	0.26
		Red-necked phalarope	15	0.27	1.03
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.33	0.62

Appendix Table II. Continued.

Location	Year	Species	Sample Size	Mean	± S.D.
		IX Riparian Continued.			
Sadlerochit	1984	Long-tailed jaeger	15	0.40	0.63
		Arctic tern	15	0.47	0.64
		Short-eared owl	15	0.07	0.26
		Savannah sparrow	15	1.60	2.41
		Lapland longspur	15	20.27	11.92
		Snow bunting	15	0.07	0.26
		Redpoll spp.	15	2.87	3.44
	1985	Total birds	18	71.89	30.99
		Total species (26)	18	9.06	1.89
		Red-throated loon	18	0.11	0.47
		Mallard	18	0.06	0.24
		Northern pintail	18	0.06	0.24
		Common eider	18	0.11	0.47
		Oldsquaw	18	0.11	0.32
		Willow ptarmigan	18	0.06	0.24
		Rock ptarmigan	18	1.56	2.06
		Lesser golden-plover	18	4.11	3.55
		Semipalmated plover	18	0.06	0.24
		Whimbrel	18	0.06	0.24
		Ruddy turnstone	18	2.67	2.30
		Semipalmated sandpiper	18	11.06	5.62
		Baird's sandpiper	18	1.56	2.57
		Pectoral sandpiper	18	1.56	3.71
		Dunlin	18	0.17	0.51
		Buff-breasted sandpiper	18	1.33	2.68
		Red-necked phalarope	18	0.06	0.24
		Pomarine jaeger	18	0.33	0.69
		Parasitic jaeger	18	0.39	0.70
		Long-tailed jaeger	18	1.00	1.24
		Glaucous gull	18	0.22	0.55
		Arctic tern	18	0.17	0.51
		Yellow wagtail	18	0.83	1.10
		Savannah sparrow	18	1.28	1.96
		Lapland longspur	18	39.94	25.56
		Redpoll spp.	18	3.00	4.23
Jago Delta	1984	Total birds	15	22.20	11.40
		Total species (10)	15	3.73	1.10
		Northern pintail	15	0.07	0.26
		Lesser golden-plover	15	0.40	0.63
		Semipalmated plover	15	0.20	0.41
		Ruddy turnstone	15	2.07	2.09
		Semipalmated sandpiper	15	1.20	1.66
		Dunlin	15	0.07	0.26
		Buff-breasted sandpiper	15	2.20	3.05
		Pomarine jaeger	15	0.07	0.26
		Lapland longspur	15	15.20	9.33
		Redpoll spp.	15	0.67	1.45
	1985	Total birds	15	14.60	8.36
		Total species (12)	15	3.53	1.41
		Tundra swan	15	0.07	0.26
		Oldsquaw	15	0.07	0.26
		Lesser golden-plover	15	2.00	4.64
		Ruddy turnstone	15	1.53	1.85
		Semipalmated sandpiper	15	0.93	1.44
		Baird's sandpiper	15	0.13	0.35
		Dunlin	15	0.07	0.26
		Buff-breasted sandpiper	15	0.67	1.18
		Pomarine jaeger	15	0.53	1.06
		Long-tailed jaeger	15	0.33	0.62
		Snowy owl	15	0.13	0.35
		Lapland longspur	15	8.13	5.66

Appendix Table II. Continued.

Location	Year	Species	Sample Size	Mean	± S.D.
		IX Riparian Continued.			
Marsh Creek	1985	Total birds	15	42.93	9.09
		Total species (19)	15	9.27	1.67
		Willow ptarmigan	15	0.07	0.26
		Rock ptarmigan	15	1.33	1.29
		Lesser golden-plover	15	1.53	1.06
		Semipalmated plover	15	0.07	0.26
		Spotted sandpiper	15	0.13	0.35
		Ruddy turnstone	15	0.80	0.94
		Semipalmated sandpiper	15	1.47	2.59
		Baird's sandpiper	15	0.07	0.26
		Buff-breasted sandpiper	15	0.07	0.26
		Pomarine jaeger	15	0.13	0.52
		Parasitic jaeger	15	0.40	0.63
		Long-tailed jaeger	15	1.60	0.99
		Glaucous gull	15	0.07	0.26
		Yellow wagtail	15	4.00	2.00
		American tree sparrow	15	3.13	2.26
		Savannah sparrow	15	4.93	4.33
		White-crowned sparrow	15	1.60	2.23
		Lapland longspur	15	14.00	7.12
		Redpoll spp.	15	7.47	4.78

Habitat

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[a] Mean densities and mean number of species were means of counts from all replicate plots in each habitat at each location during all census periods during the reproductive season (see text).

[b] Value in parentheses refers to total number of species observed in all replicate plots during the reproductive season.

Appendix Table III. Mean densities (birds/km^2) and mean number of species (species/0.1km^2)[a] of birds observed on 10 ha study plots during the post-reproductive season in different habitats on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1982-1985, sorted by location and year.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		II Flooded			
Okpilak	1982	Total birds	3	49.33	26.63
		Total species (13)[b]	3	7.33	2.52
		Red-throated loon	3	0.33	0.58
		Pacific loon	3	0.33	0.58
		Northern pintail	3	0.67	1.15
		Black-bellied plover	3	1.33	1.53
		Lesser golden-plover	3	1.33	2.31
		Pectoral sandpiper	3	21.67	21.13
		Long-billed dowitcher	3	13.33	8.14
		Red-necked phalarope	3	0.67	0.58
		Red phalarope	3	0.33	0.58
		Parasitic jaeger	3	0.67	1.15
		Glaucous gull	3	1.33	1.53
		Arctic tern	3	1.33	2.31
		Lapland longspur	3	6.00	1.73
	1983	Total birds	3	60.67	27.15
		Total species (12)	3	7.67	1.53
		Red-throated loon	3	3.00	1.00
		Northern pintail	3	0.33	0.58
		Black-bellied plover	3	0.33	0.58
		Lesser golden-plover	3	1.33	2.31
		Semipalmated sandpiper	3	0.33	0.58
		Pectoral sandpiper	3	42.33	19.66
		Long-billed dowitcher	3	4.00	3.00
		Red-necked phalarope	3	2.00	2.00
		Red phalarope	3	0.67	1.15
		Parasitic jaeger	3	0.67	1.15
		Glaucous gull	3	3.67	2.89
		Lapland longspur	3	1.33	1.53
	1985	Total birds	9	65.56	37.89
		Total species (19)	9	8.11	3.44
		Red-throated loon	9	1.44	0.88
		Pacific loon	9	0.33	0.71
		Northern pintail	9	4.00	7.30
		Spectacled eider	9	0.11	0.33
		Rock ptarmigan	9	0.11	0.33
		Black-bellied plover	9	0.33	1.00
		Lesser golden-plover	9	2.56	4.61
		Semipalmated sandpiper	9	2.44	3.32
		Pectoral sandpiper	9	40.44	29.18
		Dunlin	9	0.11	0.33
		Stilt sandpiper	9	0.56	1.67
		Long-billed dowitcher	9	1.22	1.48
		Red-necked phalarope	9	4.11	3.55
		Red phalarope	9	1.67	1.87
		Pomarine jaeger	9	0.33	0.50
		Parasitic jaeger	9	0.33	0.50
		Glaucous gull	9	1.67	2.78
		Snowy owl	9	0.11	0.33
		Lapland longspur	9	3.78	2.28
Jago Delta	1984	Total birds	6	18.67	6.83
		Total species (7)	6	3.50	1.05
		Pectoral sandpiper	6	6.83	5.15
		Stilt sandpiper	6	0.33	0.82
		Long-billed dowitcher	6	0.83	1.33
		Red phalarope	6	1.67	2.34
		Parasitic jaeger	6	0.50	1.22
		Glaucous gull	6	0.17	0.41
		Lapland longspur	6	8.17	7.03

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		II Flooded Continued.			
Jago Delta	1985	Total birds	9	30.56	7.28
		Total species (15)	9	6.67	1.50
		King eider	9	0.11	0.33
		Black-bellied plover	9	0.78	1.99
		Lesser golden-plover	9	1.33	1.73
		Semipalmated sandpiper	9	1.67	1.87
		Pectoral sandpiper	9	12.67	3.94
		Dunlin	9	0.56	1.13
		Stilt sandpiper	9	1.44	1.51
		Buff-breasted sandpiper	9	0.11	0.33
		Long-billed dowitcher	9	1.89	2.52
		Red-necked phalarope	9	0.44	1.01
		Red phalarope	9	4.11	4.54
		Pomarine jaeger	9	0.44	0.53
		Parasitic jaeger	9	0.33	1.00
		Snowy owl	9	0.33	1.00
		Lapland longspur	9	4.33	1.94
Niguanak	1985	Total birds	9	32.56	19.09
		Total species (13)	9	6.67	1.32
		Pacific loon	9	0.22	0.67
		Northern pintail	9	1.78	3.49
		Rock ptarmigan	9	0.11	0.33
		Lesser golden-plover	9	0.89	1.36
		Semipalmated sandpiper	9	0.11	0.33
		Pectoral sandpiper	9	16.44	17.21
		Stilt sandpiper	9	0.89	1.05
		Long-billed dowitcher	9	1.78	1.48
		Red-necked phalarope	9	2.89	3.02
		Red phalarope	9	0.33	0.50
		Pomarine jaeger	9	1.56	0.53
		Short-eared owl	9	0.11	0.33
		Lapland longspur	9	5.44	2.56
		III Wet Sedge			
Okpilak	1982	Total birds	3	12.33	5.03
		Total species (5)	3	3.33	0.58
		Pectoral sandpiper	3	1.67	2.08
		Long-billed dowitcher	3	1.33	1.53
		Red-necked phalarope	3	0.33	0.58
		Parasitic jaeger	3	1.33	1.15
		Lapland longspur	3	7.67	4.04
	1983	Total birds	3	9.67	3.06
		Total species (6)	3	3.33	1.15
		Black-bellied plover	3	0.33	0.58
		Pectoral sandpiper	3	4.33	2.52
		Red-necked phalarope	3	0.33	0.58
		Long-tailed jaeger	3	0.33	0.58
		Glaucous gull	3	0.33	0.58
		Lapland longspur	3	4.00	1.73
	1985	Total birds	9	9.33	8.66
		Total species (5)	9	1.89	0.78
		Northern pintail	9	0.56	1.67
		Pectoral sandpiper	9	1.56	1.81
		Long-billed dowitcher	9	0.11	0.33
		Lapland longspur	9	7.00	6.04
		Smith's longspur	9	0.11	0.33

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		III Wet Sedge Continued.			
Katakturuk	1983	Total birds	1	11.00	.
		Total species (5)	1	5.00	.
		Rock ptarmigan	1	2.00	.
		Lesser golden-plover	1	3.00	.
		Pectoral sandpiper	1	2.00	.
		Long-tailed jaeger	1	1.00	.
		Lapland longspur	1	3.00	.
	1985	Total birds	2	9.50	0.71
		Total species (3)	2	2.00	0.00
		Rock ptarmigan	2	4.00	5.66
		Long-tailed jaeger	2	1.00	0.00
		Lapland longspur	2	4.50	6.36
Jago Bitty	1983	Total birds	3	9.67	4.16
		Total species (6)	3	3.67	0.58
		Rock ptarmigan	3	0.33	0.58
		Pectoral sandpiper	3	5.00	2.00
		Long-billed dowitcher	3	0.33	0.58
		Parasitic jaeger	3	0.67	1.15
		Long-tailed jaeger	3	1.00	1.00
		Lapland longspur	3	2.33	1.15
	1985	Total birds	9	14.22	5.49
		Total species (10)	9	3.56	0.88
		Northern pintail	9	0.33	1.00
		Rock ptarmigan	9	1.44	2.88
		Lesser golden-plover	9	0.67	1.00
		Pectoral sandpiper	9	4.11	3.33
		Long-billed dowitcher	9	0.22	0.44
		Parasitic jaeger	9	0.89	1.54
		Long-tailed jaeger	9	0.56	1.01
		Short-eared owl	9	0.11	0.33
		Lapland longspur	9	5.78	2.49
		Redpoll spp.	9	0.11	0.33
Aichilik	1984	Total birds	6	19.50	8.02
		Total species (4)	6	1.67	0.52
		Willow ptarmigan	6	2.50	6.12
		Lesser golden-plover	6	0.67	1.63
		Pectoral sandpiper	6	3.50	6.12
		Lapland longspur	6	12.83	6.74
	1985	Total birds	9	7.22	4.27
		Total species (6)	9	2.22	1.09
		Willow ptarmigan	9	0.11	0.33
		Rock ptarmigan	9	3.33	4.64
		Whimbrel	9	0.11	0.33
		Pomarine jaeger	9	0.33	0.50
		Long-tailed jaeger	9	0.22	0.44
		Lapland longspur	9	3.11	2.47
Sadlerochit	1984	Total birds	6	26.83	8.45
		Total species (3)	6	2.33	0.52
		Pectoral sandpiper	6	21.00	9.25
		Parasitic jaeger	6	0.50	0.84
		Lapland longspur	6	5.33	2.73
	1985	Total birds	9	25.00	25.98
		Total species (8)	9	2.44	1.24
		Northern pintail	9	0.33	1.00
		Willow ptarmigan	9	1.67	5.00

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean ±	S.D.
		III Wet Sedge Continued.			
Sadlerochit	1985	Pectoral sandpiper	9	5.11	10.45
		Long-billed dowitcher	9	0.33	0.50
		Parasitic jaeger	9	0.11	0.33
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	1.56	1.88
		Lapland longspur	9	15.78	15.83
Jago Delta	1984	Total birds	6	39.83	18.86
		Total species (9)	6	4.17	1.17
		Lesser golden-plover	6	2.33	3.50
		Semipalmated sandpiper	6	1.00	1.10
		Pectoral sandpiper	6	17.33	20.29
		Dunlin	6	0.17	0.41
		Stilt sandpiper	6	0.17	0.41
		Buff-breasted sandpiper	6	0.33	0.52
		Red phalarope	6	0.17	0.41
		Long-tailed jaeger	6	0.17	0.41
		Lapland longspur	6	18.00	8.72
	1985	Total birds	9	6.89	2.76
		Total species (7)	9	2.00	0.87
		Rock ptarmigan	9	0.67	2.00
		Lesser golden-plover	9	0.11	0.33
		Pectoral sandpiper	9	0.56	1.33
		Buff-breasted sandpiper	9	0.22	0.67
		Pomarine jaeger	9	0.33	0.50
		Snowy owl	9	0.11	0.33
		Lapland longspur	9	4.89	1.76
Niguanak	1985	Total birds	9	7.12	2.62
		Total species (6)	9	2.78	1.20
		Lesser golden-plover	9	0.33	0.71
		Pectoral sandpiper	9	1.56	1.59
		Red-necked phalarope	9	0.22	0.44
		Pomarine jaeger	9	1.11	0.78
		Long-tailed jaeger	9	0.11	0.33
		Lapland longspur	9	3.89	2.71
		IV Moist Sedge			
Katakturuk	1982	Total birds	2	17.00	5.66
		Total species (2)	2	2.00	0.00
		Pectoral sandpiper	2	11.50	10.61
		Lapland longspur	2	5.50	4.95
	1983	Total birds	2	6.00	7.07
		Total species (4)	2	2.00	1.41
		Pectoral sandpiper	2	0.50	0.71
		Parasitic jaeger	2	1.00	1.41
		Long-tailed jaeger	2	0.50	0.71
		Lapland longspur	2	4.00	5.66
	1985	Total birds	4	10.50	9.33
		Total species (3)	4	2.00	0.82
		Rock ptarmigan	4	1.75	3.50
		Long-tailed jaeger	4	1.25	0.96
		Lapland longspur	4	7.50	5.45
Jago Bitty	1983	Total birds	3	5.33	1.53
		Total species (2)	3	1.33	0.58
		Parasitic jaeger	3	0.33	0.58
		Lapland longspur	3	5.00	2.00

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		IV Moist Sedge Continued.			
Jago Bitty	1985	Total birds	9	26.78	15.11
		Total species (13)	9	6.00	2.12
		Northern Pintail	9	0.11	0.33
		Willow Ptarmigan	9	4.67	6.98
		Rock ptarmigan	9	7.22	6.59
		Lesser golden-plover	9	3.11	1.76
		Pectoral sandpiper	9	2.78	3.73
		Long-billed dowitcher	9	0.11	0.33
		Red-necked phalarope	9	0.11	0.33
		Parasitic jaeger	9	0.67	1.00
		Long-tailed jaeger	9	0.44	0.53
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	1.11	1.76
		Lapland longspur	9	5.22	3.23
		Redpoll spp.	9	1.11	1.54
Aichilik	1984	Total birds	6	32.50	25.19
		Total species (5)	6	2.50	1.05
		Rock ptarmigan	6	2.50	6.12
		Lesser golden-plover	6	1.67	4.08
		Pectoral sandpiper	6	10.50	8.46
		Long-tailed jaeger	6	0.50	0.84
		Lapland longspur	6	17.33	14.33
	1985	Total birds	9	10.67	7.25
		Total species (6)	9	2.22	1.39
		Rock ptarmigan	9	1.33	2.40
		Black-bellied plover	9	0.44	1.33
		Lesser golden-plover	9	2.67	4.09
		Buff-breasted sandpiper	9	0.22	0.67
		Long-tailed jaeger	9	0.22	0.44
		Lapland longspur	9	5.78	2.59
Marsh Creek	1985	Total birds	9	8.11	8.33
		Total species (8)	9	2.00	1.00
		Willow ptarmigan	9	1.56	2.35
		Rock ptarmigan	9	4.11	7.80
		Lesser golden-plover	9	0.22	0.67
		Pectoral sandpiper	9	0.11	0.33
		Long-tailed jaeger	9	0.22	0.44
		Short-eared owl	9	0.22	0.67
		Savannah sparrow	9	0.11	0.33
		Lapland longspur	9	1.56	2.96
		IVa Mosaic			
Okpilak	1982	Total birds	4	27.75	11.24
		Total species (6)	4	3.50	0.58
		Lesser golden-plover	4	2.50	4.36
		Pectoral sandpiper	4	4.25	1.71
		Long-billed dowitcher	4	4.25	4.92
		Red-necked phalarope	4	0.50	1.00
		Long-tailed jaeger	4	0.25	0.50
		Lapland longspur	4	16.00	12.70
	1983	Total birds	4	22.75	7.41
		Total species (8)	4	5.00	1.41
		Black-bellied plover	4	0.50	0.58
		Lesser golden-plover	4	1.50	2.38
		Pectoral sandpiper	4	11.00	2.94
		Long-billed dowitcher	4	0.25	0.50
		Parasitic jaeger	4	0.25	0.50

Appendix Table III. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		IVa Mosaic Continued.			
Okpilak	1983	Long-tailed jaeger	4	0.50	0.58
		Glaucous gull	4	0.75	0.50
		Lapland longspur	4	7.75	4.27
	1985	Total birds	12	16.58	10.36
		Total species (8)	12	2.58	0.79
		Rock ptarmigan	12	0.17	0.58
		Semipalmated sandpiper	12	0.25	0.62
		Pectoral sandpiper	12	3.17	1.95
		Pomarine jaeger	12	0.08	0.29
		Parasitic jaeger	12	0.08	0.29
		Long-tailed jaeger	12	0.08	0.29
		Snowy owl	12	0.08	0.29
		Lapland longspur	12	12.67	10.62
Sadlerochit	1984	Total birds	6	19.83	17.78
		Total species (7)	6	3.17	1.17
		Northern pintail	6	1.33	3.27
		Rock ptarmigan	6	2.83	6.01
		Lesser golden-plover	6	1.17	1.60
		Pectoral sandpiper	6	3.00	2.37
		Long-billed dowitcher	6	0.17	0.41
		Long-tailed jaeger	6	0.17	0.41
		Lapland longspur	6	11.17	7.00
	1985	Total birds	9	23.11	8.43
		Total species (11)	9	3.89	1.27
		Northern pintail	9	0.33	0.71
		Rock ptarmigan	9	0.11	0.33
		Lesser golden-plover	9	0.33	0.71
		Semipalmated sandpiper	9	0.22	0.44
		Pectoral sandpiper	9	6.44	5.41
		Long-billed dowitcher	9	0.33	0.71
		Red-necked phalarope	9	0.33	0.50
		Parasitic jaeger	9	0.22	0.44
		Long-tailed jaeger	9	0.11	0.33
		Snowy owl	9	0.22	0.44
		Lapland longspur	9	13.33	6.75
Jago Delta	1984	Total birds	6	32.67	11.41
		Total species (7)	6	4.00	1.26
		Northern pintail	6	0.33	0.52
		Oldsquaw	6	0.17	0.41
		Rock ptarmigan	6	1.00	2.45
		Lesser golden-plover	6	1.33	1.97
		Pectoral sandpiper	6	12.67	8.85
		Long-billed dowitcher	6	1.33	1.97
		Lapland longspur	6	14.83	7.57
	1985	Total birds	9	26.89	22.67
		Total species (12)	9	4.22	2.17
		Northern pintail	9	0.44	1.33
		Oldsquaw	9	0.56	1.67
		Rough-legged hawk	9	0.11	0.33
		Rock ptarmigan	9	10.22	23.90
		Lesser golden-plover	9	0.11	0.33
		Pectoral sandpiper	9	5.67	2.18
		Buff-breasted sandpiper	9	0.11	0.33
		Long-billed dowitcher	9	0.67	1.12
		Pomarine jaeger	9	0.67	0.71
		Long-tailed jaeger	9	0.56	1.01
		Snowy owl	9	0.11	0.33
		Lapland longspur	9	7.67	4.09

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		V Moist Sedge-Shrub			
Okpilak	1982	Total birds	1	7.00	.
		Total species (3)	1	3.00	.
		Pectoral sandpiper	1	1.00	.
		Red-necked phalarope	1	1.00	.
		Lapland longspur	1	5.00	.
	1985	Total birds	9	26.78	15.11
		Total species (13)	9	6.00	2.12
		Northern pintail	9	0.11	0.33
		Willow ptarmigan	9	4.67	6.98
		Rock ptarmigan	9	7.22	6.59
		Lesser golden-plover	9	3.11	1.76
		Pectoral sandpiper	9	2.78	3.73
		Long-billed dowitcher	9	0.11	0.33
		Red-necked phalarope	9	0.11	0.33
		Parasitic jaeger	9	0.67	1.00
		Long-tailed jaeger	9	0.44	0.53
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	1.11	1.76
		Lapland longspur	9	5.22	3.23
		Redpoll spp.	9	1.11	1.54
Aichilik	1984	Total birds	6	32.50	25.19
		Total species (5)	6	2.50	1.05
		Rock ptarmigan	6	2.50	6.12
		Lesser golden-plover	6	1.67	4.08
		Pectoral sandpiper	6	10.50	8.46
		Long-tailed jaeger	6	0.50	0.84
		Lapland longspur	6	17.33	14.33
	1985	Total birds	9	10.67	7.25
		Total species (6)	9	2.22	1.39
		Rock ptarmigan	9	1.33	2.40
		Black-bellied plover	9	0.44	1.33
		Lesser golden-plover	9	2.67	4.09
		Buff-breasted sandpiper	9	0.22	0.67
		Long-tailed jaeger	9	0.22	0.44
		Lapland longspur	9	5.78	2.59
Marsh Creek	1985	Total birds	9	8.11	8.33
		Total species (8)	9	2.00	1.00
		Willow ptarmigan	9	1.56	2.35
		Rock ptarmigan	9	4.11	7.80
		Lesser golden-plover	9	0.22	0.67
		Pectoral sandpiper	9	0.11	0.33
		Long-tailed jaeger	9	0.22	0.44
		Short-eared owl	9	0.22	0.67
		Savannah sparrow	9	0.11	0.33
		Lapland longspur	9	1.56	2.96
	1983	Total birds	2	28.00	2.83
		Total species (4)	2	3.00	0.00
		Pectoral sandpiper	2	7.50	3.54
		Long-billed dowitcher	2	0.50	0.71
		Parasitic jaeger	2	1.00	1.41
		Lapland longspur	2	19.00	1.41
	1985	Total birds	6	14.00	6.87
		Total species (6)	6	2.17	0.98
		Rock ptarmigan	6	0.17	0.41
		Lesser golden-plover	6	0.17	0.41
		Pectoral sandpiper	6	1.67	2.07

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		V Moist Sedge-Shrub Continued.			
Marsh Creek	1985	Stilt sandpiper	6	0.50	1.22
		Long-tailed jaeger	6	0.17	0.41
		Lapland longspur	6	11.33	5.79
Katakturuk	1982	Total birds	1	12.00	.
		Total species (1)	1	1.00	.
		Lapland longspur	1	12.00	.
	1983	Total birds	3	23.67	25.42
		Total species (4)	3	2.00	0.00
		Pectoral sandpiper	3	1.00	1.73
		Parasitic jaeger	3	0.33	0.58
		Savannah sparrow	3	1.00	1.73
		Lapland longspur	3	21.33	24.83
	1985	Total birds	9	14.11	8.67
		Total species (9)	9	3.56	1.01
		Willow ptarmigan	9	1.89	2.98
		Rock ptarmigan	9	1.56	4.30
		Lesser golden-plover	9	1.11	2.09
		Pectoral sandpiper	9	2.00	2.74
		Parasitic jaeger	9	0.33	0.71
		Long-tailed jaeger	9	0.44	0.53
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	0.22	0.44
		Lapland longspur	9	6.11	4.34
Jago Bitty	1983	Total birds	3	9.67	4.62
		Total species (4)	3	3.00	0.00
		Willow ptarmigan	3	1.67	1.15
		Lesser golden-plover	3	1.67	1.53
		Pectoral sandpiper	3	0.33	0.58
		Lapland longspur	3	6.00	3.61
	1985	Total birds	9	22.11	15.10
		Total species (12)	9	4.22	1.39
		Northern pintail	9	0.22	0.67
		Northern harrier	9	0.11	0.33
		Willow ptarmigan	9	9.56	11.02
		Rock ptarmigan	9	1.56	3.24
		Lesser golden-plover	9	1.11	2.98
		Pectoral sandpiper	9	2.33	1.50
		Long-billed dowitcher	9	0.67	0.87
		Parasitic jaeger	9	0.11	0.33
		Long-tailed jaeger	9	0.44	0.73
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	0.11	0.33
		Lapland longspur	9	5.78	1.92
Aichilik	1984	Total birds	6	46.67	5.75
		Total species (6)	6	3.33	0.82
		Northern pintail	6	0.33	0.82
		Willow ptarmigan	6	4.67	7.47
		Pectoral sandpiper	6	19.50	3.62
		Parasitic jaeger	6	0.50	0.84
		Long-tailed jaeger	6	0.50	0.55
		Lapland longspur	6	21.17	3.87
	1985	Total birds	9	32.78	10.81
		Total species (12)	9	5.11	2.32
		Northern harrier	9	0.11	0.33
		Willow ptarmigan	9	4.56	6.82
		Lesser golden-plover	9	2.22	4.15

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		V Moist Sedge-Shrub Continued.			
Aichilik	1985	Whimbrel	9	0.11	0.33
		Semipalmated sandpiper	9	0.44	1.01
		Pectoral sandpiper	9	10.44	5.85
		Long-billed dowitcher	9	0.56	0.73
		Parasitic jaeger	9	0.56	0.73
		Long-tailed jaeger	9	0.22	0.67
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	1.33	1.73
		Lapland longspur	9	11.78	3.99
Sadlerochit	1984	Total birds	6	17.67	13.35
		Total species (5)	6	2.67	0.82
		Northern pintail	6	0.17	0.41
		Lesser golden-plover	6	0.67	1.63
		Pectoral sandpiper	6	4.17	5.23
		Long-tailed jaeger	6	0.67	0.52
		Lapland longspur	6	12.00	9.86
	1985	Total birds	9	29.00	11.32
		Total species (12)	9	4.22	1.39
		Northern pintail	9	0.33	0.71
		Willow ptarmigan	9	1.56	4.67
		Rock ptarmigan	9	4.00	9.29
		Lesser golden-plover	9	0.44	0.73
		Semipalmated sandpiper	9	0.33	1.00
		Pectoral sandpiper	9	2.78	2.77
		Buff-breasted sandpiper	9	0.44	1.33
		Long-billed dowitcher	9	0.11	0.33
		Red-necked phalarope	9	0.33	0.50
		Parasitic jaeger	9	0.11	0.33
		Long-tailed jaeger	9	0.78	0.83
		Lapland longspur	9	17.78	6.53
Jago Delta	1984	Total birds	6	35.83	9.60
		Total species (6)	6	3.33	0.82
		Rock ptarmigan	5	0.33	0.52
		Lesser golden-plover	6	2.83	3.19
		Pectoral sandpiper	6	7.67	5.92
		Parasitic jaeger	6	0.17	0.41
		Long-tailed jaeger	6	0.17	0.41
		Lapland longspur	6	24.67	15.42
	1985	Total birds	9	11.00	6.28
		Total species (6)	9	2.78	0.97
		Lesser golden-plover	9	0.22	0.44
		Pectoral sandpiper	9	1.00	2.29
		Buff-breasted sandpiper	9	0.22	0.44
		Pomarine jaeger	9	1.22	0.67
		Snowy owl	9	0.11	0.33
		Lapland longspur	9	8.22	6.10
Marsh Creek	1985	Total birds	9	25.56	16.39
		Total species (8)	9	2.67	0.87
		Willow ptarmigan	9	6.67	7.79
		Rock ptarmigan	9	1.44	4.33
		Pectoral sandpiper	9	0.56	1.33
		Pomarine jaeger	9	0.44	1.33
		Parasitic jaeger	9	0.11	0.33
		Long-tailed jaeger	9	0.44	0.53
		Savannah sparrow	9	0.22	0.67
		Lapland longspur	9	15.67	13.34

Appendix Table III. Continued.

Location	Year	Species	Sample Size	Mean	± S.D.
		V Moist Sedge-Shrub Continued.			
Niguanak	1985	Total birds	9	26.00	16.90
		Total species (7)	9	4.11	1.27
		Rock ptarmigan	9	1.89	3.22
		Pectoral sandpiper	9	4.11	3.10
		Stilt sandpiper	9	0.56	1.13
		Red-necked phalarope	9	0.11	0.33
		Pomarine jaeger	9	1.44	0.73
		Short-eared owl	9	0.78	1.30
		Lapland longspur	9	17.11	14.79
		VI Tussock			
Katakturuk	1982	Total birds	1	24.00	.
		Total species (4)	1	4.00	.
		Willow ptarmigan	1	2.00	.
		Rock ptarmigan	1	1.00	.
		Water pipit	1	6.00	.
		Lapland longspur	1	15.00	.
	1983	Total birds	3	12.67	12.50
		Total species (5)	3	2.67	1.15
		Rock ptarmigan	3	0.33	0.58
		Pectoral sandpiper	3	0.33	0.58
		Long-tailed jaeger	3	1.33	1.53
		Savannah sparrow	3	1.00	1.73
		Lapland longspur	3	9.67	10.69
	1985	Total birds	9	19.78	12.36
		Total species (10)	9	3.00	0.87
		Willow ptarmigan	9	2.00	6.00
		Rock ptarmigan	9	8.78	11.30
		Lesser golden-plover	9	0.89	1.27
		Whimbrel	9	0.22	0.67
		Pectoral sandpiper	9	0.22	0.44
		Long-tailed jaeger	9	0.22	0.44
		Short-eared owl	9	0.22	0.67
		Common raven	9	0.11	0.33
		Water pipit	9	0.22	0.67
		Lapland longspur	9	6.89	3.62
Jago Bitty	1983	Total birds	3	6.00	1.00
		Total species (4)	3	2.00	1.00
		Lesser golden-plover	3	0.33	0.58
		Pectoral sandpiper	3	1.00	1.73
		Long-tailed jaeger	3	0.33	0.58
		Lapland longspur	3	4.33	1.15
	1985	Total birds	9	16.33	12.02
		Total species (7)	9	2.67	1.41
		Willow ptarmigan	9	5.67	6.46
		Rock ptarmigan	9	2.44	4.30
		Lesser golden-plover	9	0.22	0.44
		Long-tailed jaeger	9	0.11	0.33
		Common raven	9	0.33	1.00
		Lapland longspur	9	7.00	6.26
		Redpoll spp.	9	0.56	1.33
Aichilik	1984	Total birds	6	32.00	11.05
		Total species (6)	6	3.33	1.21
		Willow ptarmigan	6	4.33	6.83
		Lesser golden-plover	6	0.50	0.84
		Pectoral sandpiper	6	8.83	4.02

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean ±	S.D.
		VI Tussock Continued.			
Aichilik	1984	Parasitic jaeger	6	0.17	0.41
		Long-tailed jaeger	6	0.50	0.55
		Lapland longspur	6	17.67	6.06
	1985	Total birds	9	21.00	6.18
		Total species (10)	9	4.44	1.13
		Green-winged teal	9	0.11	0.33
		Willow ptarmigan	9	4.22	4.52
		Rock ptarmigan	9	2.00	2.69
		Lesser golden-plover	9	2.33	3.35
		Pectoral sandpiper	9	3.56	2.74
		Stilt sandpiper	9	0.11	0.33
		Long-billed dowitcher	9	0.22	0.44
		Pomarine jaeger	9	0.22	0.44
		Long-tailed jaeger	9	0.44	1.01
		Lapland longspur	9	7.78	4.27
Sadlerochit	1984	Total birds	6	23.67	17.04
		Total species (6)	6	2.33	1.03
		Willow ptarmigan	6	4.17	6.65
		Rock ptarmigan	6	7.67	12.03
		Lesser golden-plover	6	0.17	0.41
		Pectoral sandpiper	6	0.17	0.41
		Long-tailed jaeger	6	0.33	0.52
		Lapland longspur	6	11.17	5.85
	1985	Total birds	9	11.67	5.27
		Total species (7)	9	2.56	1.13
		Willow ptarmigan	9	0.22	0.44
		Rock ptarmigan	9	2.78	4.41
		Pectoral sandpiper	9	0.33	0.71
		Stilt sandpiper	9	0.11	0.33
		Long-tailed jaeger	9	0.33	0.71
		Short-eared owl	9	0.11	0.33
		Lapland longspur	9	7.78	4.38
Marsh Creek	1985	Total birds	9	8.00	5.68
		Total species (6)	9	2.11	1.05
		Willow ptarmigan	9	3.44	5.22
		Rock ptarmigan	9	0.11	0.33
		Lesser golden-plover	9	0.22	0.44
		Pectoral sandpiper	9	0.11	0.33
		Long-tailed jaeger	9	0.33	0.50
		Lapland longspur	9	3.78	2.39
Niguanak	1985	Total birds	9	7.44	2.24
		Total species (10)	9	3.11	1.05
		Willow ptarmigan	9	0.22	0.67
		Rock ptarmigan	9	0.56	1.33
		Lesser golden-plover	9	0.67	1.32
		Pectoral sandpiper	9	0.22	0.44
		Long-billed dowitcher	9	0.11	0.33
		Pomarine jaeger	9	0.33	0.50
		Long-tailed jaeger	9	0.67	1.00
		Short-eared owl	9	0.22	0.44
		Common raven	9	0.11	0.33
		Lapland longspur	9	4.33	1.87
Okpilak	1983	Total birds	2	23.50	12.02
		Total species (6)	2	4.50	2.12
		Pectoral sandpiper	2	2.50	0.71
		Parasitic jaeger	2	0.50	0.71

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		VI Tussock Continued.			
Okpilak	1983	Glaucous gull	2	1.00	0.00
		Savannah sparrow	2	1.50	2.12
		Lapland longspur	2	17.00	8.49
		Redpoll spp.	2	1.00	1.41
Katakturuk	1982	Total birds	2	35.00	9.90
		Total species (8)	2	5.50	0.71
		Northern harrier	2	0.50	0.71
		Lesser golden-plover	2	0.50	0.71
		Pectoral sandpiper	2	0.50	0.71
		Water pipit	2	6.00	8.49
		American tree sparrow	2	4.00	5.66
		Savannah sparrow	2	0.50	0.71
		Lapland longspur	2	16.50	2.12
		Redpoll spp.	2	5.00	4.24
	1983	Total birds	3	59.67	12.66
		Total species (9)	3	6.33	0.58
		Rock ptarmigan	3	1.67	2.08
		Lesser golden-plover	3	0.33	0.58
		Pectoral sandpiper	3	0.33	0.58
		Long-tailed jaeger	3	1.67	0.58
		Yellow wagtail	3	4.33	5.13
		American tree sparrow	3	18.00	7.00
		Savannah sparrow	3	0.67	0.58
		Lapland longspur	3	25.67	11.59
		Redpoll spp.	3	7.00	10.44
Katakturuk	1985	Total birds	7	70.71	16.03
		Total species (13)	7	7.57	1.27
		Willow ptarmigan	7	1.14	2.61
		Rock ptarmigan	7	21.43	16.06
		Lesser golden-plover	7	3.00	4.62
		Semipalmated sandpiper	7	0.71	1.89
		Buff-breasted sandpiper	7	0.29	0.76
		Long-tailed jaeger	7	0.71	0.95
		American robin	7	0.29	0.49
		Yellow wagtail	7	3.00	1.63
		American tree sparrow	7	3.71	2.63
		Savannah sparrow	7	3.14	3.08
		White-crowned sparrow	7	0.71	1.25
		Lapland longspur	7	27.71	15.74
		Redpoll spp.	7	4.86	3.58
Jago Bitty	1983	Total birds	3	13.67	5.51
		Total species (7)	3	4.33	0.58
		Lesser golden-plover	3	0.67	1.15
		Ruddy turnstone	3	3.33	5.77
		Pectoral sandpiper	3	0.67	0.58
		Parasitic jaeger	3	0.67	1.15
		Long-tailed jaeger	3	1.00	0.00
		Savannah sparrow	3	1.33	1.15
		Lapland longspur	3	6.00	3.46
	1985	Total birds	9	51.44	29.76
		Total species (12)	9	4.44	1.67
		Willow ptarmigan	9	22.44	20.45
		Rock ptarmigan	9	8.33	11.05
		Lesser golden-plover	9	0.44	1.01
		Semipalmated sandpiper	9	0.44	1.33
		Pectoral sandpiper	9	0.44	1.01
		Long-tailed jaeger	9	0.44	0.73

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		VI Tussock Continued.			
Jago Bitty	1985	Short-eared owl	9	0.22	0.44
		Yellow wagtail	9	0.11	0.33
		American tree sparrow	9	0.33	1.00
		Savannah sparrow	9	1.22	1.92
		Lapland longspur	9	16.67	5.10
		Redpoll spp.	9	0.33	0.71
Aichilik	1984	Total birds	6	29.67	16.74
		Total species (10)	6	3.67	1.21
		Rock ptarmigan	6	5.67	13.40
		Lesser golden-plover	6	1.50	1.76
		Ruddy turnstone	6	1.00	1.67
		Semipalmated sandpiper	6	1.50	2.81
		Pectoral sandpiper	6	1.33	1.97
		Long-tailed jaeger	6	0.33	0.82
		American tree sparrow	6	0.33	0.82
		Savannah sparrow	6	0.17	0.41
		Lapland longspur	6	17.67	5.43
		Redpoll spp.	6	0.17	0.41
Aichilik	1985	Total birds	9	30.22	17.30
		Total species (16)	9	4.11	1.83
		Red-breasted merganser	9	0.33	1.00
		Rock ptarmigan	9	2.22	3.46
		Lesser golden-plover	9	3.44	6.46
		Ruddy turnstone	9	0.11	0.33
		Semipalmated sandpiper	9	0.78	1.39
		Baird's sandpiper	9	0.44	1.01
		Pectoral sandpiper	9	0.22	0.67
		Stilt sandpiper	9	0.11	0.33
		Buff-breasted sandpiper	9	0.33	0.71
		Parasitic jaeger	9	0.33	0.71
		Long-tailed jaeger	9	0.11	0.33
		Mew gull	9	0.11	0.33
		Northern wheatear	9	0.11	0.33
		Savannah sparrow	9	1.89	3.10
		Lapland longspur	9	19.33	8.00
		Redpoll spp.	9	0.33	0.71
Sadlerochit	1984	Total birds	6	58.00	20.01
		Total species (16)	6	6.67	1.03
		Lesser golden-plover	6	2.17	2.14
		Ruddy turnstone	6	0.83	0.98
		Semipalmated sandpiper	6	3.67	3.83
		Pectoral sandpiper	6	22.83	16.81
		Dunlin	6	5.67	4.80
		Stilt sandpiper	6	0.17	0.41
		Buff-breasted sandpiper	6	0.17	0.41
		Long-billed dowitcher	6	0.33	0.82
		Red-necked phalarope	6	0.17	0.41
		Parasitic jaeger	6	0.83	1.33
		Long-tailed jaeger	6	0.17	0.41
		Arctic tern	6	0.17	0.41
		Yellow wagtail	6	0.67	1.63
		American tree sparrow	6	0.17	0.41
		Savannah sparrow	6	0.33	0.82
		Lapland longspur	6	19.17	10.52
	1985	Total birds	12	61.33	29.35
		Total species (17)	12	5.83	1.64
		Willow ptarmigan	12	2.67	6.24
		Rock ptarmigan	12	7.92	12.05

Appendix Table III. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		VI Tussock Continued.			
Sadlerochit	1985	Black-bellied plover	12	0.08	0.29
		Lesser golden-plover	12	2.92	2.35
		Ruddy turnstone	12	0.50	1.17
		Semipalmated sandpiper	12	2.42	3.68
		Baird's sandpiper	12	0.08	0.29
		Pectoral sandpiper	12	2.08	4.14
		Buff-breasted sandpiper	12	0.75	1.29
		Red-necked phalarope	12	0.08	0.29
		Parasitic jaeger	12	0.50	1.17
		Long-tailed jaeger	12	1.08	0.79
		Arctic tern	12	0.08	0.29
		Short-eared owl	12	0.08	0.29
		Yellow wagtail	12	0.08	0.29
		Savannah sparrow	12	0.92	1.62
		Lapland longspur	12	38.33	20.85
Jago Delta	1984	Total birds	6	41.67	25.87
		Total species (10)	6	4.83	1.60
		Lesser golden-plover	6	5.17	9.39
		Ruddy turnstone	6	1.50	1.64
		Semipalmated sandpiper	6	1.67	2.66
		Baird's sandpiper	6	0.17	0.41
		Pectoral sandpiper	6	6.33	6.15
		Dunlin	6	8.50	7.34
		Buff-breasted sandpiper	6	0.17	0.41
		Red phalarope	6	0.17	0.41
		Parasitic jaeger	6	0.33	0.82
		Lapland longspur	6	17.67	8.73
	1985	Total birds	9	28.11	11.99
		Total species (8)	9	3.00	0.87
		Lesser golden-plover	9	2.22	4.27
		Semipalmated sandpiper	9	0.22	0.44
		Baird's sandpiper	9	0.22	0.67
		Pectoral sandpiper	9	0.44	0.73
		Buff-breasted sandpiper	9	3.11	3.89
		Parasitic jaeger	9	0.11	0.33
		Snowy owl	9	0.11	0.33
		Lapland longspur	9	21.67	8.53
Marsh Creek	1985	Total birds	9	64.67	21.52
		Total species (18)	9	9.11	1.90
		Green-winged teal	9	0.78	1.99
		Willow ptarmigan	9	5.44	7.14
		Rock ptarmigan	9	10.00	12.51
		Lesser golden-plover	9	1.78	3.19
		Ruddy turnstone	9	0.11	0.33
		Semipalmated sandpiper	9	1.56	2.35
		Baird's sandpiper	9	1.78	4.97
		Pectoral sandpiper	9	1.00	1.12
		Buff-breasted sandpiper	9	0.22	0.67
		Parasitic jaeger	9	0.44	0.88
		Long-tailed jaeger	9	1.22	0.97
		Short-eared owl	9	0.11	0.33
		Yellow wagtail	9	2.78	2.05
		American tree sparrow	9	4.22	4.21
		Savannah sparrow	9	15.33	8.99
		White-crowned sparrow	9	0.22	0.67
		Lapland longspur	9	14.89	6.15
		Redpoll spp.	9	3.00	2.29

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[a] Mean densities and mean number of species were means of counts from all replicate plots in each habitat at each location during the post-reproductive season (see text).

[b] Value in parentheses refers to total number of species observed on all replicate plots during the post-reproductive season.

Appendix Table IV. Mean densities (nests/km^2) of nests and mean number of nesting bird species (species/0.1km^2)[a] observed on study plots in different habitats on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1982-1985, sorted by location and year.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		II Flooded			
Okpilak	1982	Total nests	3	36.67	5.77
		Total species (5)[b]	3	2.33	0.58
		Red-throated loon	3	3.33	5.77
		Pacific loon	3	3.33	5.77
		Northern pintail	3	20.00	0.00
		Pectoral sandpiper	3	6.67	11.55
		Glaucous gull	3	3.33	5.77
	1983	Total nests	3	40.00	0.00
		Total species (7)	3	3.00	1.00
		Red-throated loon	3	3.33	5.77
		Pectoral sandpiper	3	6.67	11.55
		Red-necked phalarope	3	6.67	5.77
		Red phalarope	3	3.33	5.77
		Parasitic jaeger	3	3.33	5.77
		Glaucous gull	3	3.33	5.77
		Lapland longspur	3	13.33	11.55
	1985	Total nests	3	66.67	55.08
		Total species (8)	3	4.00	1.00
		Red-throated loon	3	13.33	5.77
		Brant	3	20.00	34.64
		Canada goose	3	3.33	5.77
		Spectacled eider	3	3.33	5.77
		Red-necked phalarope	3	6.67	5.77
		Red phalarope	3	10.00	10.00
		Glaucous gull	3	6.67	11.55
		Lapland longspur	3	3.33	5.77
Jago Delta	1984	Total nests	3	46.67	5.77
		Total species (4)	3	3.00	1.00
		Oldsquaw	3	3.33	5.77
		Pectoral sandpiper	3	10.00	10.00
		Red phalarope	3	10.00	0.00
		Lapland longspur	3	23.33	5.77
	1985	Total nests	3	20.00	10.00
		Total species (5)	3	2.00	1.00
		Northern pintail	3	3.33	5.77
		Oldsquaw	3	3.33	5.77
		Pectoral sandpiper	3	6.67	5.77
		Long-billed dowitcher	3	3.33	5.77
		Lapland longspur	3	3.33	5.77
Niguanak	1985	Total nests	3	63.33	25.17
		Total species (7)	3	3.67	1.53
		Oldsquaw	3	3.33	5.77
		Rock ptarmigan	3	3.33	5.77
		Pectoral sandpiper	3	20.00	10.00
		Long-billed dowitcher	3	3.33	5.77
		Red-necked phalarope	3	16.67	15.28
		Red phalarope	3	3.33	5.77
		Lapland longspur	3	13.33	11.55

Appendix Table IV. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		III Wet Sedge			
Okpilak	1982	Total nests	3	26.67	15.28
		Total species (3)	3	1.67	1.15
		Pectoral sandpiper	3	6.67	5.77
		Long-billed dowitcher	3	3.33	5.77
		Lapland longspur	3	16.67	20.82
	1983	Total nests	3	40.00	20.00
		Total species (2)	3	1.67	0.58
		Pectoral sandpiper	3	23.33	20.82
		Lapland longspur	3	16.67	5.77
	1985	Total nests	3	23.33	11.55
		Total species (3)	3	1.67	0.58
		Long-billed dowitcher	3	6.67	11.55
		Red-necked phalarope	3	6.67	5.77
		Lapland longspur	3	10.00	10.00
Katakturuk	1983	Total nests	1	0	.
		Total species (0)	1	0	.
	1985	Total nests	1	0	.
		Total species (0)	1	0	.
Jago Bitty	1983	Total nests	3	26.67	11.55
		Total species (3)	3	2.00	1.00
		Pectoral sandpiper	3	13.33	5.77
		Parasitic jaeger	3	3.33	5.77
		Lapland longspur	3	10.00	10.00
	1985	Total nests	3	56.67	40.41
		Total species (8)	3	4.00	2.65
		Northern pintail	3	3.33	5.77
		Willow ptarmigan	3	10.00	10.00
		Rock ptarmigan	3	3.33	5.77
		Pectoral sandpiper	3	16.67	15.28
		Stilt sandpiper	3	3.33	5.77
		Red-necked phalarope	3	3.33	5.77
		Long-tailed jaeger	3	3.33	5.77
		Lapland longspur	3	13.33	5.77
Aichilik	1984	Total nests	3	23.33	5.77
		Total species (3)	3	1.67	0.58
		Pectoral sandpiper	3	3.33	5.77
		Long-tailed jaeger	3	3.33	5.77
		Lapland longspur	3	16.67	5.77
	1985	Total nests	3	16.67	11.55
		Total species (3)	3	1.67	1.55
		Pectoral sandpiper	3	10.00	0.00
		Stilt sandpiper	3	3.33	5.77
		Lapland longspur	3	3.33	5.77
Sadlerochit	1984	Total nests	3	40.00	20.00
		Total species (4)	3	2.33	0.58
		Long-billed dowitcher	3	3.33	5.77
		Parasitic jaeger	3	3.33	5.77
		Savannah sparrow	3	6.67	5.77
		Lapland longspur	3	26.67	15.28
	1985	Total nests	3	60.00	0.00
		Total species (6)	3	3.33	0.58
		Pectoral sandpiper	3	20.00	10.00
		Long-billed dowitcher	3	3.33	5.77
		Red-necked phalarope	3	3.33	5.77

Appendix Table IV. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		III Wet Sedge Continued.			
Sadlerochit	1985	Parasitic jaeger	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	26.67	11.55
Jago Delta	1984	Total nests	3	36.67	15.28
		Total species (3)	3	2.33	0.58
		Semipalmated sandpiper	3	10.00	0.00
		Stilt sandpiper	3	3.33	5.77
		Lapland longspur	3	23.33	11.55
	1985	Total nests	3	36.67	11.55
		Total species (4)	3	2.67	0.58
		Lesser golden-plover	3	6.67	5.77
		Semipalmated sandpiper	3	6.67	5.77
		Buff-breasted sandpiper	3	13.33	15.28
		Lapland longspur	3	10.00	10.00
Niguanak	1985	Total nests	3	36.67	32.15
		Total species (6)	3	2.67	2.31
		Lesser golden-plover	3	10.00	10.00
		Semipalmated sandpiper	3	3.33	5.77
		Pectoral sandpiper	3	3.33	5.77
		Stilt sandpiper	3	3.33	5.77
		Short-eared owl	3	3.33	5.77
		Lapland longspur	3	13.33	11.55
		IV Moist Sedge			
Katakturuk	1982	Total nests	2	10.00	14.14
		Total species (2)	2	1.00	1.41
		Rock ptarmigan	2	5.00	7.07
		Lapland longspur	2	5.00	7.07
	1983	Total nests	2	25.00	7.07
		Total species (2)	2	1.50	0.71
		Lesser golden-plover	2	5.00	7.07
		Lapland longspur	2	20.00	0.00
	1985	Total nests	2	20.00	14.14
		Total species (2)	2	1.50	0.71
		Lesser golden-plover	2	5.00	7.07
		Lapland longspur	2	15.00	7.07
Jago Bitty	1983	Total nests	3	33.33	5.77
		Total species (3)	3	2.00	1.00
		Lesser golden-plover	3	3.33	5.77
		Pectoral sandpiper	3	10.00	10.00
		Lapland longspur	3	20.00	17.32
	1985	Total nests	3	36.67	5.77
		Total species (6)	3	2.67	0.58
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Pectoral sandpiper	3	3.33	5.77
		Stilt sandpiper	3	3.33	5.77
		Buff-breasted sandpiper	3	3.33	5.77
		Lapland longspur	3	20.00	0.00
Aichilik	1984	Total nests	3	30.00	17.32
		Total species (2)	3	1.67	0.58
		Lesser golden-plover	3	10.00	10.00
		Lapland longspur	3	20.00	10.00

Appendix Table IV. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		IV Moist Sedge Continued.			
Aichilik	1985	Total nests	3	20.00	10.00
		Total species (2)	3	1.33	0.58
		Lesser golden-plover	3	6.67	11.55
		Lapland longspur	3	13.33	5.77
Marsh Creek	1985	Total nests	3	13.33	15.28
		Total species (2)	3	1.00	1.00
		Willow ptarmigan	3	3.33	5.77
		Lapland longspur	3	10.00	10.00
		IVa Mosaic			
Okpilak	1982	Total nests	4	42.50	9.57
		Total species (4)	4	2.50	0.58
		Lesser golden-plover	4	2.50	5.00
		Pectoral sandpiper	4	15.00	12.91
		Red phalarope	4	5.00	5.77
		Lapland longspur	4	20.00	11.55
	1983	Total nests	4	40.00	8.16
		Total species (4)	4	2.00	1.15
		Canada goose	4	2.50	5.00
		Lesser golden-plover	4	2.50	5.00
		Pectoral sandpiper	4	12.50	15.00
		Lapland longspur	4	22.50	15.00
	1985	Total nests	4	25.00	19.15
		Total species (4)	4	1.75	0.96
		Lesser golden-plover	4	2.50	5.00
		Pectoral sandpiper	4	5.00	5.77
		Stilt sandpiper	4	2.50	5.00
		Lapland longspur	4	15.00	12.91
Sadlerochit	1984	Total nests	3	70.00	10.00
		Total species (5)	3	4.00	1.00
		Oldsquaw	3	3.33	5.77
		Lesser golden-plover	3	6.67	5.77
		Semipalmated sandpiper	3	23.33	11.55
		Pectoral sandpiper	3	13.33	5.77
		Lapland longspur	3	23.33	5.77
	1985	Total nests	3	50.00	26.46
		Total species (4)	3	2.67	0.58
		Lesser golden-plover	3	6.67	5.77
		Semipalmated sandpiper	3	16.67	15.28
		Pectoral sandpiper	3	3.33	5.77
		Lapland longspur	3	23.33	23.09
Jago Delta	1984	Total nests	3	86.67	30.55
		Total species (5)	3	3.33	0.58
		Northern pintail	3	3.33	5.77
		Semipalmated sandpiper	3	6.67	5.77
		Pectoral sandpiper	3	40.00	10.00
		Red-necked phalarope	3	3.33	5.77
		Lapland longspur	3	33.33	25.17
	1985	Total nests	3	36.67	15.28
		Total species (7)	3	3.67	1.53
		Northern pintail	3	6.67	5.77
		Oldsquaw	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Semipalmated sandpiper	3	3.33	5.77
		Pectoral sandpiper	3	6.67	5.77
		Long-tailed jaeger	3	3.33	5.77
		Lapland longspur	3	10.00	0.00

Appendix Table IV. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		V Moist Sedge-Shrub			
Okpilak	1982	Total nests	1	10.00	.
		Total species (1)	1	1.00	.
		Lapland longspur	1	10.00	.
	1983	Total nests	2	40.00	14.14
		Total species (4)	2	2.50	0.71
		Northern pintail	2	5.00	7.07
		Lesser golden-plover	2	5.00	7.07
		Pectoral sandpiper	2	5.00	7.07
		Lapland longspur	2	25.00	21.21
	1985	Total nests	2	30.00	14.14
		Total species (1)	2	1.00	0.00
		Lapland longspur	2	30.00	14.14
Katakturuk	1982	Total nests	1	20.00	.
		Total species (2)	1	2.00	.
		Semipalmated sandpiper	1	10.00	.
		Lapland longspur	1	10.00	.
	1983	Total nests	3	10.00	10.00
		Total species (3)	3	1.00	1.00
		Pectoral sandpiper	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	3.33	5.77
	1985	Total nests	3	26.67	11.55
		Total species (4)	3	2.67	1.15
		Willow ptarmigan	3	3.33	5.77
		Buff-breasted sandpiper	3	6.67	5.77
		Red-necked phalarope	3	3.33	5.77
		Lapland longspur	3	10.00	0.00
Jago Bitty	1983	Total nests	3	56.67	46.19
		Total species (4)	3	2.67	1.53
		Willow ptarmigan	3	3.33	5.77
		Semipalmated sandpiper	3	10.00	10.00
		Pectoral sandpiper	3	20.00	26.46
		Lapland longspur	3	23.33	11.55
	1985	Total nests	3	46.67	5.77
		Total species (5)	3	3.00	1.00
		Willow ptarmigan	3	6.67	5.77
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	6.67	5.77
		Semipalmated sandpiper	3	13.33	15.28
		Lapland longspur	3	16.67	15.28
Aichilik	1984	Total nests	3	30.00	17.32
		Total species (3)	3	1.67	0.58
		Pectoral sandpiper	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	23.33	15.28
	1985	Total nests	3	53.33	20.82
		Total species (4)	3	2.33	0.58
		Semipalmated sandpiper	3	3.33	5.77
		Pectoral sandpiper	3	20.00	17.32
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	26.67	11.55

Appendix Table IV. Continued.

Location	Year	Species	Sample Size	Mean	± S.D.
		V Moist Sedge-Shrub			
Sadlerochit	1984	Total nests	3	56.67	11.55
		Total species (4)	3	2.33	1.15
		Semipalmated sandpiper	3	16.67	15.28
		Pectoral sandpiper	3	3.33	5.77
		Red-necked phalarope	3	3.33	5.77
		Lapland longspur	3	33.33	15.28
	1985	Total nests	3	56.67	11.55
		Total species (4)	3	2.67	0.58
		Rock ptarmigan	3	6.67	11.55
		Semipalmated sandpiper	3	23.33	15.28
		Long-tailed jaeger	3	3.33	5.77
		Lapland longspur	3	23.33	5.77
Jago Delta	1984	Total nests	3	50.00	10.00
		Total species (6)	3	3.33	1.15
		Northern pintail	3	3.33	5.77
		Semipalmated sandpiper	3	6.67	5.77
		Pectoral sandpiper	3	6.67	5.77
		Dunlin	3	3.33	5.77
		Buff-breasted sandpiper	3	3.33	5.77
		Lapland longspur	3	26.67	20.82
	1985	Total nests	3	46.67	15.28
		Total species (5)	3	2.67	0.58
		Northern pintail	3	3.33	5.77
		Lesser golden-plover	3	10.00	10.00
		Semipalmated sandpiper	3	3.33	5.77
		Short-eared owl	3	3.33	5.77
		Lapland longspur	3	26.67	15.28
Marsh Creek	1985	Total nests	3	20.00	10.00
		Total species (3)	3	1.67	1.15
		Willow ptarmigan	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	13.33	5.77
Niguanak	1985	Total nests	3	90.00	26.46
		Total species (5)	3	3.00	1.00
		Oldsquaw	3	3.33	5.77
		Willow ptarmigan	3	3.33	5.77
		Pectoral sandpiper	3	33.33	5.77
		Red-necked phalarope	3	3.33	5.77
		Lapland longspur	3	46.67	11.55
		VI Tussock			
Katakturuk	1982	Total nests	1	20.00	.
		Total species (1)	1	1.00	.
		Lapland longspur	1	20.00	.
	1983	Total nests	3	36.67	37.86
		Total species (4)	3	2.00	1.73
		Lesser golden-plover	3	3.33	5.77
		Semipalmated sandpiper	3	10.00	17.32
		Pectoral sandpiper	3	6.67	5.77
		Lapland longspur	3	16.67	15.28
	1985	Total nests	3	36.67	37.86
		Total species (4)	3	2.00	1.73
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	10.00	17.32
		Savannah sparrow	3	6.67	5.77
		Lapland longspur	3	16.67	15.28

Appendix Table IV. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		VI Tussock Continued.			
Jago Bitty	1983	Total nests	3	30.00	20.00
		Total species (6)	3	2.00	1.00
		Willow ptarmigan	3	3.33	5.77
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Semipalmated sandpiper	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	13.33	23.09
	1985	Total nests	3	36.67	23.09
		Total species (4)	3	2.00	1.00
		Willow ptarmigan	3	3.33	5.77
		Rock ptarmigan	3	6.67	11.55
		Lesser golden-plover	3	3.33	5.77
		Lapland longspur	3	23.33	11.55
Aichilik	1984	Total nests	3	36.67	30.55
		Total species (4)	3	2.00	1.73
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	6.67	11.55
		Pectoral sandpiper	3	10.00	10.00
		Lapland longspur	3	16.67	15.28
	1985	Total nests	3	53.33	23.09
		Total species (7)	3	4.33	0.58
		Rock ptarmigan	3	6.67	5.77
		Lesser golden-plover	3	16.67	11.55
		Semipalmated sandpiper	3	3.33	5.77
		Pectoral sandpiper	3	10.00	10.00
		Red-necked phalarope	3	3.33	5.77
		Short-eared owl	3	3.33	5.77
		Lapland longspur	3	10.00	0.00
Sadlerochit	1984	Total nests	3	36.67	20.82
		Total species (6)	3	2.67	1.53
		Northern pintail	3	3 33	5 77
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Pectoral sandpiper	3	6.67	5.77
		Long-tailed jaeger	3	3.33	5.77
		Lapland longspur	3	16.67	15.28
	1985	Total nests	3	56.67	20.82
		Total species (4)	3	2.67	1.15
		Rock ptarmigan	3	6.67	11.55
		Lesser golden-plover	3	10.00	0.00
		Pectoral sandpiper	3	6.67	11.55
		Lapland longspur	3	33.33	5.77
Marsh Creek	1985	Total nests	3	16.67	11.55
		Total species (3)	3	1.33	0.58
		Willow ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Lapland longspur	3	10.00	10.00
Niguanak	1985	Total nests	3	46.67	15.28
		Total species (5)	3	2.33	0.58
		Willow ptarmigan	3	3.33	5.77
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Pectoral sandpiper	3	3.33	5.77
		Lapland longspur	3	33.33	11.55

Appendix Table IV. Continued.

		Habitat			
Location	Year	Species	Sample Size	Mean	± S.D.
		IX Riparian			
Okpilak	1983	Total nests	2	45.00	21.21
		Total species (4)	2	2.00	1.41
		Ruddy turnstone	2	5.00	7.07
		Semipalmated sandpiper	2	15.00	21.21
		Lapland longspur	2	15.00	21.21
		Redpoll spp.	2	10.00	14.14
Katakturuk	1982	Total nests	2	100.00	14.14
		Total species (6)	2	4.50	0.71
		Lesser golden-plover	2	10.00	0.00
		Semipalmated sandpiper	2	25.00	21.21
		Yellow wagtail	2	5.00	7.07
		American tree sparrow	2	10.00	14.14
		Lapland longspur	2	30.00	28.28
		Redpoll spp.	2	20.00	28.28
	1983	Total nests	3	53.33	30.55
		Total species (6)	3	3.67	1.53
		Lesser golden-plover	3	3.33	5.77
		Ruddy turnstone	3	3.33	5.77
		Semipalmated sandpiper	3	13.33	5.77
		American tree sparrow	3	3.33	5.77
		Lapland longspur	3	16.67	5.77
		Redpoll spp.	3	13.33	11.55
Katakturuk	1985	Total nests	3	43.33	11.55
		Total species (5)	3	3.67	1.15
		Semipalmated plover	3	3.33	5.77
		Buff-breasted sandpiper	3	3.33	5.77
		American tree sparrow	3	3.33	5.77
		Lapland longspur	3	6.67	5.77
		Redpoll spp.	3	13.33	5.77
Jago Bitty	1983	Total nests	3	43.33	5.77
		Total species (5)	3	3.00	1.00
		Northern pintail	3	6.67	5.77
		Semipalmated plover	3	10.00	10.00
		Savannah sparrow	3	13.33	15.28
		Lapland longspur	3	10.00	10.00
		Redpoll spp.	3	3.33	5.77
	1985	Total nests	3	83.33	28.87
		Total species (8)	3	4.33	2.52
		Northern pintail	3	3.33	5.77
		Willow ptarmigan	3	6.67	11.55
		Rock ptarmigan	3	10.00	10.00
		Semipalmated sandpiper	3	23.33	15.28
		Short-eared owl	3	6.67	11.55
		American tree sparrow	3	3.33	5.77
		Lapland longspur	3	26.67	5.77
		Redpoll spp.	3	3.33	5.77
Aichilik	1984	Total nests	3	33.33	15.28
		Total species (6)	3	3.00	1.73
		Lesser golden-plover	3	10.00	10.00
		Ruddy turnstone	3	3.33	5.77
		Semipalmated sandpiper	3	3.33	5.77
		Buff-breasted sandpiper	3	6.67	5.77
		Lapland longspur	3	6.67	5.77
		Redpoll spp.	3	3.33	5.77

Appendix Table IV. Continued.

Habitat					
Location	Year	Species	Sample Size	Mean	± S.D.
		IX Riparian Continued.			
Aichilik	1985	Total nests	3	53.33	25.17
		Total species (5)	3	2.67	1.53
		Lesser golden-plover	3	10.00	10.00
		Baird's sandpiper	3	3.33	5.77
		Buff-breasted sandpiper	3	6.67	5.77
		Lapland longspur	3	10.00	17.32
		Redpoll spp.	3	23.33	20.82
Sadlerochit	1984	Total nests	3	63.33	68.07
		Total species (6)	3	3.00	1.73
		Common eider	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Semipalmated sandpiper	3	30.00	43.59
		Pectoral sandpiper	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	20.00	17.32
	1985	Total nests	4	62.50	26.30
		Total species (9)	4	4.25	0.50
		Rock ptarmigan	4	2.50	5.00
		Lesser golden-plover	4	5.00	5.77
		Ruddy turnstone	4	5.00	5.77
		Semipalmated sandpiper	4	17.50	22.17
		Baird's sandpiper	4	2.50	5.00
		Pectoral sandpiper	4	5.00	5.77
		Long-billed dowitcher	4	2.50	5.00
		Lapland longspur	4	17.50	9.57
		Redpoll spp.	4	5.00	10.00
Jago Delta	1984	Total nests	3	20.00	17.32
		Total species (4)	3	1.67	1.53
		Northern pintail	3	3.33	5.77
		Semipalmated plover	3	3.33	5.77
		Ruddy turnstone	3	6.67	5.77
		Lapland longspur	3	6.67	11.55
	1985	Total nests	3	26.67	11.55
		Total species (4)	3	2.00	0.00
		Lesser golden-plover	3	3.33	5.77
		Ruddy turnstone	3	16.67	11.55
		Baird's sandpiper	3	3.33	5.77
		Lapland longspur	3	3.33	5.77
Marsh Creek	1985	Total nests	3	70.00	17.32
		Total species (11)	3	5.67	0.58
		Willow ptarmigan	3	3.33	5.77
		Rock ptarmigan	3	6.67	5.77
		Lesser golden-plover	3	6.67	11.55
		Ruddy turnstone	3	10.00	10.00
		Pectoral sandpiper	3	3.33	5.77
		Long-tailed jaeger	3	3.33	5.77
		Yellow wagtail	3	3.33	5.77
		American tree sparrow	3	3.33	5.77
		White-crowned sparrow	3	10.00	10.00
		Lapland longspur	3	10.00	10.00
		Redpoll spp.	3	10.00	0.00

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[a] Mean densities and mean number of nesting species were means of counts from all replicate plots in each habitat at each location (see text).

[b] Value in parentheses refers to total number of species observed nesting on all replicate plots.

Appendix Table V. Mean densities (birds/km^2) and mean number of species (species/km^2)[a] of birds observed on 10 ha study plots during the reproductive season in different locations on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1982-1985, sorted by habitat and year.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Okpilak			
Flooded	1982	Total birds	12	30.92	19.28
		Total species (17)[b]	12	7.08	1.78
		Red-throated loon	12	0.58	0.79
		Pacific loon	12	0.75	1.14
		Northern pintail	12	0.50	1.73
		Oldsquaw	12	0.92	0.90
		Whimbrel	12	0.58	2.02
		Semipalmated sandpiper	12	0.42	1.00
		Pectoral sandpiper	12	8.17	7.98
		Long-billed dowitcher	12	1.42	1.88
		Red-necked phalarope	12	7.17	5.89
		Red phalarope	12	3.83	4.80
		Parasitic jaeger	12	0.42	0.67
		Long-tailed jaeger	12	0.75	2.30
		Herring gull	12	0.08	0.29
		Glaucous gull	12	2.42	3.85
		Arctic tern	12	0.17	0.58
		Snowy owl	12	0.17	0.39
		Lapland longspur	12	2.00	1.41
	1983	Total birds	12	32.83	13.29
		Total species (17)	12	8.17	2.48
		Red-throated loon	12	1.17	1.11
		Pacific loon	12	0.33	0.65
		Brant	12	0.25	0.62
		Northern pintail	12	1.17	1.95
		Oldsquaw	12	1.25	1.60
		Lesser golden-plover	12	0.17	0.39
		Semipalmated sandpiper	12	0.67	0.98
		Pectoral sandpiper	12	8.42	5.28
		Stilt sandpiper	12	0.08	0.29
		Long-billed dowitcher	12	2.42	2.71
		Red-necked phalarope	12	2.58	2.84
		Red phalarope	12	2.58	2.43
		Parasitic jaeger	12	0.67	0.89
		Long-tailed jaeger	12	0.08	0.29
		Glaucous gull	12	5.50	7.42
		Short-eared owl	12	0.08	0.29
		Lapland longspur	12	5.42	4.54
	1985	Total birds	15	47.93	27.07
		Total species (22)	15	9.47	2.59
		Red-throated loon	15	0.47	0.64
		Pacific loon	15	0.33	0.62
		Brant	15	2.60	5.10
		Canada goose	15	0.33	0.62
		Northern pintail	15	1.53	2.47
		Spectacled eider	15	0.60	1.06
		Oldsquaw	15	0.60	0.91
		Rock ptarmigan	15	0.07	0.26
		Lesser golden-plover	15	0.20	0.41
		Semipalmated sandpiper	15	1.33	2.02
		Pectoral sandpiper	15	12.60	9.08
		Stilt sandpiper	15	1.07	1.53
		Long-billed dowitcher	15	1.20	1.57
		Red-necked phalarope	15	9.27	10.32
		Red phalarope	15	4.53	5.87
		Pomarine jaeger	15	0.53	1.06
		Parasitic jaeger	15	0.60	0.83
		Long-tailed jaeger	15	0.13	0.52
		Glaucous gull	15	2.67	2.92

Appendix Table V. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Okpilak Continued.			
Flooded	1985	Common raven	15	0.07	0.26
		Lapland longspur	15	7.60	1.92
		Redpoll spp	15	0.13	0.52
Wet Sedge	1982	Total birds	12	15.00	7.99
		Total species (13)	12	4.08	1.62
		King eider	12	0.17	0.58
		Oldsquaw	12	0.08	0.29
		Sandhill crane	12	0.25	0.87
		Pectoral sandpiper	12	3.17	3.33
		Buff-breasted sandpiper	12	0.17	0.58
		Long-billed dowitcher	12	0.67	1.37
		Red-necked phalarope	12	0.92	0.90
		Red phalarope	12	0.25	0.62
		Parasitic jaeger	12	0.42	0.67
		Long-tailed jaeger	12	0.50	0.80
		Snowy owl	12	0.17	0.58
		Short-eared owl	12	0.17	0.39
		Lapland longspur	12	8.08	4.01
	1983	Total birds	12	20.33	6.39
		Total species (11)	12	4.08	1.31
		Northern pintail	12	0.17	0.39
		Lesser golden-plover	12	0.17	0.39
		Pectoral sandpiper	12	6.75	3.91
		Stilt sandpiper	12	0.08	0.29
		Long-billed dowitcher	12	1.50	2.91
		Red-necked phalarope	12	0.92	1.16
		Red phalarope	12	0.08	0.29
		Pomarine jaeger	12	0.08	0.29
		Parasitic jaeger	12	0.33	0.49
		Long-tailed jaeger	12	0.17	0.39
		Lapland longspur	12	10.08	2.15
	1985	Total birds	15	16.53	8.16
		Total species (12)	15	3.67	1.35
		Northern pintail	15	0.13	0.52
		Rock ptarmigan	15	0.33	0.72
		Lesser golden-plover	15	0.07	0.26
		Semipalmated sandpiper	15	0.07	0.26
		Pectoral sandpiper	15	2.27	2.87
		Stilt sandpiper	15	0.13	0.35
		Long-billed dowitcher	15	0.60	0.99
		Red-necked phalarope	15	0.80	1.01
		Pomarine jaeger	15	0.47	0.74
		Long-tailed jaeger	15	0.33	0.72
		Snowy owl	15	0.07	0.26
		Lapland longspur	15	11.40	5.00
Mosaic	1982	Total birds	16	23.62	8.77
		Total species (17)	16	5.63	2.13
		Northern pintail	16	0.19	0.75
		Oldsquaw	16	0.38	1.09
		Rock ptarmigan	16	0.31	0.60
		Lesser golden-plover	16	0.69	0.87
		Semipalmated sandpiper	16	0.88	0.96
		Pectoral sandpiper	16	4.50	2.97
		Buff-breasted sandpiper	16	1.44	3.42
		Long-billed dowitcher	16	0.63	1.54
		Red-necked phalarope	16	1.63	2.83
		Red phalarope	16	0.81	1.22
		Pomarine jaeger	16	0.50	1.10
		Parasitic jaeger	16	0.31	0.79
		Long-tailed jaeger	16	0.38	0.81

Appendix Table V. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Okpilak Continued.			
Mosaic	1982	Glaucous gull	16	0.13	0.34
		Snowy owl	16	0.06	0.25
		Short-eared owl	16	0.06	0.25
		Lapland longspur	16	11.31	3.36
	1983	Total birds	16	26.37	7.88
		Total species (14)	16	5.06	1.73
		Northern pintail	16	1.19	2.17
		Oldsquaw	16	0.25	0.58
		Lesser golden-plover	16	0.31	0.48
		Semipalmated sandpiper	16	0.38	0.50
		Pectoral sandpiper	16	6.56	3.29
		Stilt sandpiper	16	0.19	0.54
		Long-billed dowitcher	16	0.56	0.73
		Red-necked phalarope	16	0.75	1.13
		Red phalarope	16	0.25	0.77
		Pomarine jaeger	16	0.06	0.25
		Parasitic jaeger	16	0.25	0.45
		Long-tailed jaeger	16	0.75	1.18
		Glaucous gull	16	0.06	0.25
		Lapland longspur	16	14.81	5.04
	1985	Total birds	20	20.70	8.75
		Total species (16)	20	4.55	1.76
		Northern pintail	20	0.15	0.49
		Oldsquaw	20	0.45	1.23
		Rock ptarmigan	20	0.20	0.41
		Lesser golden-plover	20	0.55	0.69
		Semipalmated sandpiper	20	0.50	0.95
		Pectoral sandpiper	20	2.25	2.77
		Stilt sandpiper	20	0.55	0.89
		Long-billed dowitcher	20	0.40	1.23
		Red-necked phalarope	20	0.75	1.02
		Pomarine jaeger	20	0.25	0.55
		Parasitic jaeger	20	0.05	0.22
		Long-tailed jaeger	20	0.30	0.57
		Glaucous gull	20	0.05	0.22
		Short-eared owl	20	0.05	0.22
		Lapland longspur	20	13.90	5.68
		Redpoll spp	20	0.20	0.62
Moist Sedge-Shrub	1982	Total birds	4	16.50	8.27
		Total species (8)	4	3.25	1.71
		Northern pintail	4	0.25	0.50
		Willow ptarmigan	4	0.25	0.50
		Rock ptarmigan	4	0.25	0.50
		Pectoral sandpiper	4	2.25	3.86
		Red-necked phalarope	4	2.75	5.50
		Pomarine jaeger	4	0.50	1.00
		Long-tailed jaeger	4	0.50	0.58
		Lapland longspur	4	9.75	4.92
	1983	Total birds	8	17.50	8.47
		Total species (8)	8	3.50	1.20
		Northern pintail	8	0.13	0.35
		Lesser golden-plover	8	0.75	0.89
		Pectoral sandpiper	8	2.50	1.41
		Long-billed dowitcher	8	0.13	0.35
		Red-necked phalarope	8	0.13	0.35
		Pomarine jaeger	8	0.13	0.35
		Long-tailed jaeger	8	1.13	1.46
		Lapland longspur	8	12.62	9.24

Appendix Table V. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Okpilak Continued.			
Moist Sedge-Shrub	1985	Total birds	10	18.00	4.32
		Total species (9)	10	3.30	1.42
		Northern pintail	10	0.20	0.63
		Willow ptarmigan	10	0.40	0.70
		Rock ptarmigan	10	0.30	0.48
		Lesser golden-plover	10	0.50	0.85
		Pectoral sandpiper	10	0.70	0.82
		Pomarine jaeger	10	0.50	0.97
		Parasitic jaeger	10	0.40	0.70
		Long-tailed jaeger	10	0.30	0.67
		Lapland longspur	10	14.20	3.05
Riparian	1983	Total birds	8	36.12	9.86
		Total species (14)	8	6.50	1.85
		Northern pintail	8	0.38	1.06
		Oldsquaw	8	0.25	0.71
		Lesser golden-plover	8	0.88	1.13
		Ruddy turnstone	8	0.25	0.71
		Semipalmated sandpiper	8	6.75	2.60
		Baird's sandpiper	8	0.63	1.41
		Pectoral sandpiper	8	2.13	3.04
		Red-necked phalarope	8	0.50	0.76
		Parasitic jaeger	8	0.50	0.53
		Long-tailed jaeger	8	0.38	0.52
		Arctic tern	8	0.13	0.35
		Savannah sparrow	8	1.25	1.39
		Lapland longspur	8	17.37	5.76
		Redpoll spp	8	4.75	6.07
		Katakturuk			
Wet Sedge	1983	Total birds	4	10.00	3.92
		Total species (5)	4	2.75	0.96
		Lesser golden-plover	4	0.25	0.50
		Pectoral sandpiper	4	1.75	0.96
		Long-tailed jaeger	4	1.00	2.00
		Lapland longspur	4	6.25	2.22
		Redpoll spp	4	0.75	1.50
	1985	Total birds	5	12.20	5.81
		Total species (6)	5	3.00	1.00
		Rock ptarmigan	5	0.20	0.45
		Semipalmated sandpiper	5	0.40	0.89
		Pectoral sandpiper	5	1.20	0.45
		Long-tailed jaeger	5	1.40	1.52
		Lapland longspur	5	8.80	5.81
		Redpoll spp	5	0.20	0.45
Moist Sedge	1982	Total birds	5	7.20	4.15
		Total species (8)	5	3.40	1.95
		Rough-legged hawk	5	0.20	0.45
		Rock ptarmigan	5	0.60	0.89
		Pectoral sandpiper	5	0.20	0.45
		Parasitic jaeger	5	0.80	0.84
		Long-tailed jaeger	5	0.60	0.55
		Short-eared owl	5	0.20	0.45
		Lapland longspur	5	4.20	2.68
		Redpoll spp	5	0.40	0.55

Appendix Table V. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Katakturuk Continued.			
Moist Sedge	1983	Total birds	8	7.13	6.88
		Total species (4)	8	2.25	1.28
		Lesser golden-plover	8	0.88	0.83
		Semipalmated sandpiper	8	0.50	0.76
		Long-tailed jaeger	8	0.50	0.76
		Lapland longspur	8	5.25	5.47
	1985	Total birds	10	9.00	5.94
		Total species (7)	10	2.10	0.99
		Rock ptarmigan	10	0.20	0.42
		Lesser golden-plover	10	0.60	1.07
		Ruddy turnstone	10	0.10	0.32
		Pectoral sandpiper	10	0.10	0.32
		Parasitic jaeger	10	0.20	0.63
		Long-tailed jaeger	10	0.40	0.70
		Lapland longspur	10	7.40	4.93
Moist Sedge-Shrub	1982	Total birds	3	16.33	8.74
		Total species (8)	3	5.33	1.53
		Rough-legged hawk	3	0.33	0.58
		Rock ptarmigan	3	0.67	1.15
		Semipalmated sandpiper	3	5.33	2.52
		Red-necked phalarope	3	0.33	0.58
		Short-eared owl	3	1.00	1.00
		Yellow wagtail	3	0.67	0.58
		Savannah sparrow	3	1.67	0.58
		Lapland longspur	3	6.33	4.51
	1983	Total birds	12	10.17	4.61
		Total species (12)	12	3.33	1.15
		Willow ptarmigan	12	0.08	0.29
		Rock ptarmigan	12	0.25	0.45
		Lesser golden-plover	12	0.67	1.23
		Semipalmated sandpiper	12	0.58	0.79
		Pectoral sandpiper	12	1.50	1.31
		Parasitic jaeger	12	0.08	0.29
		Long-tailed jaeger	12	0.25	0.45
		Short-eared owl	12	0.08	0.29
		Savannah sparrow	12	0.67	1.23
		Lapland longspur	12	5.75	3.82
		Smith's longspur	12	0.08	0.29
		Redpoll spp	12	0.17	0.58
	1985	Total birds	15	12.73	4.64
		Total species (15)	15	4.33	1.11
		Northern pintail	15	0.13	0.35
		Willow ptarmigan	15	0.93	1.39
		Rock ptarmigan	15	0.80	0.94
		Lesser golden-plover	15	0.40	0.63
		Semipalmated sandpiper	15	0.47	0.92
		Pectoral sandpiper	15	0.73	1.03
		Buff-breasted sandpiper	15	0.27	0.46
		Long-billed dowitcher	15	0.07	0.26
		Red-necked phalarope	15	0.27	0.46
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.27	0.59
		Yellow wagtail	15	0.07	0.26
		Savannah sparrow	15	0.80	1.61
		Lapland longspur	15	7.40	3.96

Appendix Table V. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Katakturuk Continued.			
Tussock	1982	Total birds	3	23.33	12.66
		Total species (10)	3	6.00	2.65
		Northern pintail	3	0.33	0.58
		Rough-legged hawk	3	0.33	0.58
		Rock ptarmigan	3	0.33	0.58
		Semipalmated sandpiper	3	3.00	2.65
		Pectoral sandpiper	3	2.00	1.00
		Buff-breasted sandpiper	3	0.33	0.58
		Long-tailed jaeger	3	0.67	0.58
		Short-eared owl	3	0.33	0.58
		Savannah sparrow	3	4.33	0.58
		Lapland longspur	3	11.67	8.50
	1983	Total birds	12	14.50	13.96
		Total species (9)	12	3.42	2.23
		Rock ptarmigan	12	0.25	0.45
		Lesser golden-plover	12	1.58	1.68
		Semipalmated sandpiper	12	1.83	3.21
		Pectoral sandpiper	12	0.58	0.79
		Parasitic jaeger	12	0.08	0.29
		Long-tailed jaeger	12	0.17	0.39
		Yellow wagtail	12	0.50	1.17
		Savannah sparrow	12	1.08	1.98
		Lapland longspur	12	8.42	7.40
	1985	Total birds	14	11.00	7.80
		Total species (13)	14	3.93	1.90
		Willow ptarmigan	14	0.79	1.05
		Rock ptarmigan	14	0.79	0.89
		Lesser golden-plover	14	0.93	0.83
		Semipalmated sandpiper	14	0.71	1.20
		Pectoral sandpiper	14	0.21	0.58
		Pomarine jaeger	14	0.14	0.36
		Parasitic jaeger	14	0.29	0.61
		Long-tailed jaeger	14	0.14	0.36
		Short-eared owl	14	0.07	0.27
		Yellow wagtail	14	0.36	0.93
		Savannah sparrow	14	0.64	1.74
		Lapland longspur	14	5.86	4.31
		Redpoll spp	14	0.07	0.27
Riparian	1982	Total birds	6	41.50	8.83
		Total species (15)	6	8.17	0.41
		Rough-legged hawk	6	0.17	0.41
		Rock ptarmigan	6	0.33	0.82
		Lesser golden-plover	6	2.17	1.33
		Semipalmated plover	6	0.67	0.52
		Ruddy turnstone	6	0.50	0.55
		Semipalmated sandpiper	6	8.00	3.69
		Baird's sandpiper	5	0.33	0.52
		Buff-breasted sandpiper	6	0.50	1.22
		Long-tailed jaeger	6	1.33	1.51
		Horned lark	6	0.33	0.82
		Yellow wagtail	6	2.33	1.21
		Water pipit	6	0.50	1.22
		American tree sparrow	6	2.17	2.71
		Lapland longspur	6	17.83	5.64
		Redpoll spp	6	4.83	2.23
	1983	Total birds	12	42.75	11.81
		Total species (16)	12	6.75	1.36
		Willow ptarmigan	12	0.17	0.58
		Rock ptarmigan	12	0.42	0.79
		Lesser golden-plover	12	1.17	1.40

Appendix Table V. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean ±	S.D.
		Jago Bitty Continued.			
Riparian	1983	Semipalmated plover	12	0.33	0.65
		Spotted sandpiper	12	0.08	0.29
		Ruddy turnstone	12	0.42	0.79
		Semipalmated sandpiper	12	4.58	2.54
		Baird's sandpiper	12	0.17	0.39
		Long-tailed jaeger	12	0.92	1.00
		American robin	12	0.08	0.29
		Yellow wagtail	12	2.50	1.73
		American tree sparrow	12	2.83	2.66
		Savannah sparrow	12	0.08	0.29
		White-crowned sparrow	12	0.25	0.87
		Lapland longspur	12	24.67	10.62
		Redpoll spp	12	4.25	3.70
	1985	Total birds	15	63.47	8.97
		Total species (17)	15	7.93	1.83
		Rock ptarmigan	15	0.53	0.92
		Lesser golden-plover	15	1.67	2.19
		Semipalmated plover	15	1.33	1.80
		Ruddy turnstone	15	0.67	1.59
		Semipalmated sandpiper	15	10.60	3.74
		Baird's sandpiper	15	1.13	1.64
		Pectoral sandpiper	15	0.07	0.26
		Buff-breasted sandpiper	15	0.33	0.49
		Long-billed dowitcher	15	0.07	0.26
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.40	0.74
		Yellow wagtail	15	2.47	2.07
		American tree sparrow	15	1.60	1.24
		Savannah sparrow	15	0.07	0.26
		White-crowned sparrow	15	0.13	0.35
		Lapland longspur	15	30.80	9.96
		Redpoll spp	15	10.80	6.28
Wet Sedge	1983	Total birds	12	12.08	4.96
		Total species (8)	12	2.83	1.19
		Rock ptarmigan	12	0.08	0.29
		Lesser golden-plover	12	0.25	0.62
		Pectoral sandpiper	12	6.42	4.56
		Stilt sandpiper	12	0.08	0.29
		Red-necked phalarope	12	0.17	0.39
		Parasitic jaeger	12	0.50	0.80
		Savannah sparrow	12	0.42	1.00
		Lapland longspur	12	4.17	2.98
	1985	Total birds	15	19.13	5.69
		Total species (17)	15	6.60	1.88
		Northern pintail	15	0.07	0.26
		Oldsquaw	15	0.13	0.52
		Willow ptarmigan	15	1.07	1.03
		Rock ptarmigan	15	2.33	3.13
		Lesser golden-plover	15	0.13	0.35
		Semipalmated sandpiper	15	0.20	0.56
		Pectoral sandpiper	15	4.80	2.31
		Stilt sandpiper	15	1.00	1.00
		Long-billed dowitcher	15	0.20	0.41
		Red-necked phalarope	15	0.67	0.90
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.47	0.74
		Long-tailed jaeger	15	1.13	1.30
		Short-eared owl	15	0.13	0.35
		Savannah sparrow	15	0.47	0.64
		Lapland longspur	15	6.13	3.11
		Redpoll spp	15	0.13	0.52

Appendix Table V. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Jago Bitty Continued.			
Moist Sedge	1983	Total birds	12	11.00	5.31
		Total species (9)	12	2.50	0.67
		Lesser golden-plover	12	0.83	1.34
		Pectoral sandpiper	12	1.00	1.28
		Pomarine jaeger	12	0.08	0.29
		Parasitic jaeger	12	0.08	0.29
		Long-tailed jaeger	12	0.42	0.79
		Short-eared owl	12	0.08	0.29
		Savannah sparrow	12	0.08	0.29
		Lapland longspur	12	8.33	4.25
		Redpoll spp	12	0.08	0.29
	1985	Total birds	15	13.13	5.04
		Total species (11)	15	3.80	1.15
		Willow ptarmigan	15	0.33	0.62
		Rock ptarmigan	15	1.07	1.28
		Lesser golden-plover	15	1.00	1.07
		Semipalmated sandpiper	15	0.07	0.26
		Pectoral sandpiper	15	0.40	0.63
		Buff-breasted sandpiper	15	0.33	0.62
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.93	1.62
		Savannah sparrow	15	0.07	0.26
		Lapland longspur	15	8.53	2.92
		Redpoll spp	15	0.33	0.62
Moist Sedge-Shrub	1983	Total birds	12	18.92	6.92
		Total species (10)	12	5.00	1.41
		Oldsquaw	12	0.08	0.29
		Willow ptarmigan	12	1.00	0.85
		Lesser golden-plover	12	0.67	1.07
		Semipalmated sandpiper	12	2.00	2.13
		Pectoral sandpiper	12	2.33	2.06
		Red-necked phalarope	12	0.58	1.24
		Parasitic jaeger	12	0.33	0.89
		Long-tailed jaeger	12	0.42	0.79
		Savannah sparrow	12	1.67	1.83
		Lapland longspur	12	9.50	3.73
	1985	Total birds	15	19.80	4.39
		Total species (17)	15	5.87	1.36
		Northern pintail	15	0.07	0.26
		Oldsquaw	15	0.07	0.26
		Willow ptarmigan	15	1.93	1.49
		Rock ptarmigan	15	0.87	1.13
		Lesser golden-plover	15	0.53	0.74
		Semipalmated plover	15	0.07	0.26
		Semipalmated sandpiper	15	2.13	2.42
		Pectoral sandpiper	15	0.67	1.11
		Red-necked phalarope	15	0.93	1.53
		Pomarine jaeger	15	0.87	1.92
		Parasitic jaeger	15	0.47	0.74
		Long-tailed jaeger	15	0.53	0.99
		Glaucous gull	15	0.13	0.52
		Yellow wagtail	15	0.13	0.35
		Savannah sparrow	15	0.73	0.96
		Lapland longspur	15	9.27	1.98
		Redpoll spp	15	0.40	0.91
Tussock	1983	Total birds	12	9.00	5.70
		Total species (9)	12	3.08	1.38
		Willow ptarmigan	12	0.25	0.62
		Rock ptarmigan	12	0.42	0.67
		Lesser golden-plover	12	0.50	0.80
		Semipalmated sandpiper	12	0.25	0.45

Appendix Table V. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Jago Bitty Continued.			
Tussock	1983	Buff-breasted sandpiper	12	0.08	0.29
		Parasitic jaeger	12	0.08	0.29
		Long-tailed jaeger	12	0.33	0.49
		Savannah sparrow	12	1.08	1.16
		Lapland longspur	12	6.00	4.73
	1985	Total birds	15	14.80	3.05
		Total species (10)	15	4.53	1.51
		Willow ptarmigan	15	2.73	1.16
		Rock ptarmigan	15	1.60	1.55
		Lesser golden-plover	15	0.40	0.51
		Pomarine jaeger	15	0.33	0.72
		Parasitic jaeger	15	0.20	0.41
		Long-tailed jaeger	15	0.73	0.88
		Yellow wagtail	15	0.07	0.26
		Savannah sparrow	15	0.73	1.03
		Lapland longspur	15	7.93	1.83
		Redpoll spp	15	0.07	0.26
Riparian	1983	Total birds	12	26.00	9.44
		Total species (11)	12	5.25	1.60
		Willow ptarmigan	12	0.08	0.29
		Rock ptarmigan	12	0.25	0.62
		Lesser golden-plover	12	1.58	1.78
		Ruddy turnstone	12	0.33	0.65
		Semipalmated sandpiper	12	2.25	1.76
		Pectoral sandpiper	12	0.67	1.44
		Parasitic jaeger	12	0.33	0.89
		Long-tailed jaeger	12	0.42	0.67
		Savannah sparrow	12	1.92	1.24
		Lapland longspur	12	17.25	7.97
		Redpoll spp	12	0.92	1.24
	1985	Total birds	15	27.87	6.81
		Total species (16)	15	6.20	1.42
		Northern pintail	15	0.07	0.26
		Willow ptarmigan	15	0.80	1.15
		Rock ptarmigan	15	0.93	0.88
		Lesser golden-plover	15	1.27	1.67
		Ruddy turnstone	15	0.13	0.52
		Semipalmated sandpiper	15	3.07	2.79
		Buff-breasted sandpiper	15	0.07	0.26
		Pomarine jaeger	15	0.27	0.80
		Parasitic jaeger	15	0.53	0.74
		Long-tailed jaeger	15	0.60	1.30
		Short-eared owl	15	0.40	0.63
		Yellow wagtail	15	0.07	0.26
		American tree sparrow	15	0.13	0.52
		Savannah sparrow	15	2.00	1.81
		Lapland longspur	15	16.27	5.91
		Redpoll spp	15	1.27	2.15
		Aichilik			
Wet Sedge	1984	Total birds	15	9.60	5.72
		Total species (7)	15	2.87	1.30
		Rock ptarmigan	15	0.20	0.56
		Lesser golden-plover	15	0.33	0.62
		Pectoral sandpiper	15	1.80	1.86
		Pomarine jaeger	15	0.33	1.29
		Long-tailed jaeger	15	1.13	1.60
		Lapland longspur	15	5.47	4.03
		Redpoll spp	15	0.27	0.80

Appendix Table V. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Aichilik Continued.			
Wet Sedge	1985	Total birds	15	9.47	4.73
		Total species (13)	15	3.93	1.75
		Northern pintail	15	0.07	0.26
		Gyrfalcon	15	0.07	0.26
		Willow ptarmigan	15	0.13	0.35
		Rock ptarmigan	15	0.73	1.28
		Lesser golden-plover	15	0.07	0.26
		Pectoral sandpiper	15	2.13	1.60
		Stilt sandpiper	15	0.27	0.59
		Buff-breasted sandpiper	15	0.07	0.26
		Pomarine jaeger	15	0.40	0.51
		Parasitic jaeger	15	0.13	0.35
		Long-tailed jaeger	15	0.87	0.92
		Lapland longspur	15	4.40	1.84
		Redpoll spp	15	0.13	0.52
Moist Sedge	1984	Total birds	15	10.93	7.66
		Total species (12)	15	3.53	1.41
		Rock ptarmigan	15	0.53	0.74
		Lesser golden-plover	15	1.00	0.93
		Whimbrel	15	0.27	1.03
		Pectoral sandpiper	15	0.27	0.46
		Buff-breasted sandpiper	15	0.13	0.35
		Pomarine jaeger	15	0.13	0.35
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	1.47	1.60
		Glaucous gull	15	0.07	0.26
		Common raven	15	0.07	0.26
		Lapland longspur	15	6.80	6.17
		Redpoll spp	15	0.13	0.52
	1985	Total birds	15	6.93	4.22
		Total species (11)	15	2.67	1.54
		Rock ptarmigan	15	0.60	1.80
		Lesser golden-plover	15	0.40	0.63
		Whimbrel	15	0.27	1.03
		Pectoral sandpiper	15	0.07	0.26
		Buff-breasted sandpiper	15	0.53	1.13
		Long-billed dowitcher	15	0.13	0.52
		Pomarine jaeger	15	0.33	0.82
		Long-tailed jaeger	15	0.40	0.51
		Glaucous gull	15	0.07	0.26
		Lapland longspur	15	3.80	2.43
		Redpoll spp	15	0.20	0.77
Moist Sedge-Shrub	1984	Total birds	15	42.40	12.43
		Total species (15)	15	7.00	1.56
		Northern pintail	15	0.27	0.59
		Willow ptarmigan	15	0.40	0.51
		Lesser golden-plover	15	1.00	1.25
		Semipalmated sandpiper	15	0.93	1.79
		Pectoral sandpiper	15	7.60	4.82
		Long-billed dowitcher	15	1.47	3.02
		Red-necked phalarope	15	1.87	1.88
		Pomarine jaeger	15	0.60	1.30
		Parasitic jaeger	15	0.47	0.92
		Long-tailed jaeger	15	1.87	1.88
		Glaucous gull	15	0.07	0.26
		Short-eared owl	15	0.07	0.26
		Savannah sparrow	15	4.20	4.07
		Lapland longspur	15	21.40	8.26
		Redpoll spp	15	0.40	1.12

Appendix Table V. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Aichilik Continued.			
Moist Sedge-Shrub	1985	Total birds	15	22.73	6.51
		Total species (17)	15	7.00	2.17
		Green-winged teal	15	0.07	0.26
		Northern pintail	15	0.40	0.63
		Golden eagle	15	0.07	0.26
		Gyrfalcon	15	0.13	0.52
		Willow ptarmigan	15	0.73	0.80
		Rock ptarmigan	15	0.20	0.56
		Lesser golden-plover	15	1.47	1.77
		Whimbrel	15	0.33	0.90
		Semipalmated sandpiper	15	0.47	0.74
		Pectoral sandpiper	15	3.80	2.65
		Long-billed dowitcher	15	0.47	1.13
		Red-necked phalarope	15	0.80	0.77
		Pomarine jaeger	15	0.60	1.12
		Parasitic jaeger	15	0.40	0.63
		Long-tailed jaeger	15	1.00	1.07
		Savannah sparrow	15	1.60	1.18
		Lapland longspur	15	10.20	3.32
Tussock	1984	Total birds	15	25.93	10.98
		Total species (15)	15	5.27	2.02
		Willow ptarmigan	15	0.40	0.63
		Rock ptarmigan	15	0.80	1.15
		Lesser golden-plover	15	2.07	1.71
		Semipalmated sandpiper	15	0.07	0.26
		Pectoral sandpiper	15	4.73	2.60
		Buff-breasted sandpiper	15	0.07	0.26
		Long-billed dowitcher	15	0.60	0.91
		Red-necked phalarope	15	0.53	0.83
		Pomarine jaeger	15	0.33	0.82
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.93	1.39
		Glaucous gull	15	0.07	0.26
		Savannah sparrow	15	0.27	0.70
		Lapland longspur	15	15.87	7.63
		Redpoll spp	15	0.13	0.52
	1985	Total birds	15	18.93	4.01
		Total species (16)	15	7.40	1.68
		Northern pintail	15	0.27	0.59
		Willow ptarmigan	15	1.47	0.83
		Rock ptarmigan	15	2.47	1.55
		Lesser golden-plover	15	2.13	1.25
		Whimbrel	15	0.07	0.26
		Semipalmated sandpiper	15	0.27	0.46
		Pectoral sandpiper	15	1.80	2.04
		Long-billed dowitcher	15	0.07	0.26
		Red-necked phalarope	15	0.53	0.74
		Pomarine jaeger	15	0.60	1.12
		Parasitic jaeger	15	0.53	0.64
		Long-tailed jaeger	15	0.60	0.63
		Short-eared owl	15	0.47	0.74
		Common raven	15	0.07	0.26
		Lapland longspur	15	7.00	2.70
		Redpoll spp	15	0.60	1.18
Riparian	1984	Total birds	15	37.67	12.53
		Total species (15)	15	7.27	1.94
		Rock ptarmigan	15	0.73	1.03
		Lesser golden-plover	15	3.60	1.96
		Whimbrel	15	0.13	0.52
		Ruddy turnstone	15	2.47	2.64

Appendix Table V. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Aichilik Continued.			
Riparian	1984	Semipalmated sandpiper	15	1.20	1.93
		Pectoral sandpiper	15	0.47	0.92
		Buff-breasted sandpiper	15	1.47	1.41
		Pomarine jaeger	15	1.33	3.13
		Parasitic jaeger	15	0.13	0.35
		Long-tailed jaeger	15	3.67	3.20
		Mew gull	15	0.07	0.26
		Glaucous gull	15	0.40	1.30
		Savannah sparrow	15	1.73	2.71
		Lapland longspur	15	16.00	8.98
		Redpoll spp	15	4.47	3.81
	1985	Total birds	15	23.13	6.56
		Total species (20)	15	7.13	1.81
		Rock ptarmigan	15	1.67	2.29
		Lesser golden-plover	15	2.67	1.59
		Semipalmated plover	15	0.13	0.52
		Whimbrel	15	0.07	0.26
		Ruddy turnstone	15	0.40	0.74
		Semipalmated sandpiper	15	0.60	1.12
		Baird's sandpiper	15	0.60	0.91
		Pectoral sandpiper	15	0.27	0.59
		Stilt sandpiper	15	0.07	0.26
		Buff-breasted sandpiper	15	1.33	1.45
		Red-necked phalarope	15	0.13	0.35
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.13	0.35
		Long-tailed jaeger	15	0.53	0.83
		Mew gull	15	0.20	0.56
		Glaucous gull	15	0.20	0.41
		Arctic tern	15	0.20	0.56
		Savannah sparrow	15	0.67	1.45
		Lapland longspur	15	10.07	6.12
		Redpoll spp	15	3.13	1.92
		Sadlerochit			
Wet Sedge	1984	Total birds	15	21.07	7.95
		Total species (9)	15	4.40	1.12
		Northern pintail	15	0.07	0.26
		Oldsquaw	15	0.07	0.26
		Semipalmated sandpiper	15	0.27	0.46
		Pectoral sandpiper	15	5.47	6.76
		Long-billed dowitcher	15	0.73	0.70
		Red-necked phalarope	15	0.93	1.28
		Parasitic jaeger	15	0.93	0.88
		Savannah sparrow	15	2.20	2.18
		Lapland longspur	15	10.40	5.78
	1985	Total birds	15	40.07	11.04
		Total species (15)	15	6.87	1.13
		Red-throated loon	15	0.13	0.52
		Northern pintail	15	0.27	0.59
		Oldsquaw	15	0.53	0.83
		Rock ptarmigan	15	0.20	0.41
		Lesser golden-plover	15	0.20	0.56
		Semipalmated sandpiper	15	1.93	2.84
		Pectoral sandpiper	15	8.93	6.13
		Long-billed dowitcher	15	0.67	0.82
		Red-necked phalarope	15	1.93	2.46
		Pomarine jaeger	15	0.13	0.35
		Parasitic jaeger	15	1.33	1.11
		Long-tailed jaeger	15	0.40	0.51
		Savannah sparrow	15	5.33	4.06
		Lapland longspur	15	17.93	5.75
		Redpoll spp	15	0.13	0.52

Appendix Table V. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Sadlerochit Continued.			
Mosaic	1984	Total birds	15	30.33	10.91
		Total species (14)	15	6.40	1.45
		Northern pintail	15	0.67	1.11
		Oldsquaw	15	0.20	0.56
		Rock ptarmigan	15	0.33	0.72
		Lesser golden-plover	15	1.53	1.73
		Semipalmated sandpiper	15	3.20	2.01
		Pectoral sandpiper	15	4.87	2.95
		Long-billed dowitcher	15	1.00	1.31
		Red-necked phalarope	15	0.80	0.94
		Pomarine jaeger	15	0.40	0.91
		Parasitic jaeger	15	0.27	0.46
		Long-tailed jaeger	15	0.33	0.62
		Savannah sparrow	15	0.13	0.35
		Lapland longspur	15	15.73	5.73
		Redpoll spp	15	0.80	1.78
	1985	Total birds	15	26.20	8.27
		Total species (18)	15	5.53	1.55
		Northern pintail	15	0.07	0.26
		Oldsquaw	15	0.13	0.52
		Northern harrier	15	0.07	0.26
		Golden eagle	15	0.07	0.26
		Rock ptarmigan	15	0.33	0.62
		Lesser golden-plover	15	0.60	0.74
		Ruddy turnstone	15	0.13	0.52
		Semipalmated sandpiper	15	3.13	2.20
		Pectoral sandpiper	15	2.27	2.02
		Long-billed dowitcher	15	0.67	1.11
		Red-necked phalarope	15	0.47	0.74
		Red phalarope	15	0.07	0.26
		Pomarine jaeger	15	0.40	0.74
		Parasitic jaeger	15	0.33	0.49
		Long-tailed jaeger	15	0.33	0.62
		Sabine's gull	15	0.07	0.26
		Short-eared owl	15	0.07	0.26
		Lapland longspur	15	17.00	8.02
Moist Sedge-Shrub	1984	Total birds	15	26.67	9.55
		Total species (14)	15	4.87	1.36
		Northern pintail	15	0.20	0.56
		Willow ptarmigan	15	0.07	0.26
		Lesser golden-plover	15	0.53	1.06
		Ruddy turnstone	15	0.07	0.26
		Semipalmated sandpiper	15	2.93	2.49
		Pectoral sandpiper	15	2.80	1.97
		Long-billed dowitcher	15	0.13	0.52
		Red-necked phalarope	15	0.67	0.98
		Parasitic jaeger	15	0.20	0.41
		Long-tailed jaeger	15	0.87	1.19
		Glaucous gull	15	0.07	0.26
		Savannah sparrow	15	0.33	0.62
		Lapland longspur	15	17.67	6.11
		Redpoll spp	15	0.13	0.35
	1985	Total birds	15	27.20	7.84
		Total species (15)	15	5.67	1.76
		Northern pintail	15	0.33	1.05
		Peregrine falcon	15	0.07	0.26
		Willow ptarmigan	15	0.27	0.59
		Rock ptarmigan	15	3.20	2.93
		Lesser golden-plover	15	0.40	0.51
		Semipalmated sandpiper	15	3.40	1.92

Appendix Table V. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Sadlerochit Continued.			
Moist Sedge-Shrub	1985	Pectoral sandpiper	15	2.07	1.53
		Long-billed dowitcher	15	0.07	0.26
		Red-necked phalarope	15	0.27	0.59
		Pomarine jaeger	15	0.13	0.35
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	1.07	1.03
		Snowy owl	15	0.07	0.26
		Savannah sparrow	15	0.07	0.26
		Lapland longspur	15	15.80	5.33
Tussock	1984	Total birds	15	13.87	5.25
		Total species (10)	15	3.47	1.25
		Northern pintail	15	0.07	0.26
		Willow ptarmigan	15	0.07	0.26
		Rock ptarmigan	15	0.93	1.10
		Lesser golden-plover	15	0.47	0.64
		Semipalmated sandpiper	15	0.13	0.35
		Pectoral sandpiper	15	1.13	0.92
		Long-billed dowitcher	15	0.07	0.26
		Parasitic jaeger	15	0.20	0.56
		Long-tailed jaeger	15	0.60	0.91
		Lapland longspur	15	10.20	4.44
	1985	Total birds	15	20.87	4.78
		Total species (13)	15	5.00	1.69
		Northern pintail	15	0.07	0.26
		Willow ptarmigan	15	0.13	0.35
		Rock ptarmigan	15	2.07	1.28
		Lesser golden-plover	15	1.47	1.19
		Semipalmated sandpiper	15	0.33	0.62
		Pectoral sandpiper	15	1.07	1.22
		Buff-breasted sandpiper	15	0.07	0.26
		Pomarine jaeger	15	0.20	0.41
		Parasitic jaeger	15	0.27	0.46
		Long-tailed jaeger	15	0.67	0.82
		Short-eared owl	15	0.13	0.52
		Savannah sparrow	15	0.20	0.56
		Lapland longspur	15	14.20	4.48
Riparian	1984	Total birds	15	40.47	19.88
		Total species (21)	15	7.27	1.33
		Common eider	15	0.07	0.26
		Oldsquaw	15	0.20	0.41
		Rock ptarmigan	15	0.07	0.26
		Lesser golden-plover	15	2.13	2.26
		Ruddy turnstone	15	1.20	1.08
		Semipalmated sandpiper	15	8.47	5.72
		Baird's sandpiper	15	0.73	1.16
		Pectoral sandpiper	15	0.93	1.03
		Dunlin	15	0.07	0.26
		Buff-breasted sandpiper	15	0.13	0.52
		Long-billed dowitcher	15	0.07	0.26
		Red-necked phalarope	15	0.27	1.03
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.33	0.62
		Long-tailed jaeger	15	0.40	0.63
		Arctic tern	15	0.47	0.64
		Short-eared owl	15	0.07	0.26
		Savannah sparrow	15	1.60	2.41
		Lapland longspur	15	20.27	11.92
		Snow bunting	15	0.07	0.26
		Redpoll spp	15	2.87	3.44

Appendix Table V. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Sadlerochit Continued.			
Riparian	1985	Total birds	18	71.89	30.99
		Total species (26)	18	9.06	1.89
		Red-throated loon	18	0.11	0.47
		Mallard	18	0.06	0.24
		Northern pintail	18	0.06	0.24
		Common eider	18	0.11	0.47
		Oldsquaw	18	0.11	0.32
		Willow ptarmigan	18	0.06	0.24
		Rock ptarmigan	18	1.56	2.06
		Lesser golden-plover	18	4.11	3.55
		Semipalmated plover	18	0.06	0.24
		Whimbrel	18	0.06	0.24
		Ruddy turnstone	18	2.67	2.30
		Semipalmated sandpiper	18	11.06	5.62
		Baird's sandpiper	18	1.56	2.57
		Pectoral sandpiper	18	1.56	3.71
		Dunlin	18	0.17	0.51
		Buff-breasted sandpiper	18	1.33	2.68
		Red-necked phalarope	18	0.06	0.24
		Pomarine jaeger	18	0.33	0.69
		Parasitic jaeger	18	0.39	0.70
		Long-tailed jaeger	18	1.00	1.24
		Glaucous gull	18	0.22	0.55
		Arctic tern	18	0.17	0.51
		Yellow wagtail	18	0.83	1.10
		Savannah sparrow	18	1.28	1.96
		Lapland longspur	18	39.94	25.56
		Redpoll spp	18	3.00	4.23
		Jago Delta			
Flooded	1984	Total birds	15	18.93	6.15
		Total species (14)	15	5.33	1.50
		Common eider	15	0.07	0.26
		Oldsquaw	15	0.13	0.52
		Black-bellied plover	15	0.07	0.26
		Lesser golden-plover	15	1.00	0.93
		Semipalmated sandpiper	15	0.47	0.83
		Pectoral sandpiper	15	5.20	2.76
		Dunlin	15	0.13	0.52
		Stilt sandpiper	15	1.13	1.51
		Long-billed dowitcher	15	0.47	0.92
		Red-necked phalarope	15	0.53	0.99
		Red phalarope	15	1.60	1.45
		Parasitic jaeger	15	0.13	0.35
		Long-tailed jaeger	15	0.20	0.56
		Lapland longspur	15	7.80	4.16
	1985	Total birds	15	26.00	8.24
		Total species (17)	15	6.80	1.82
		Northern pintail	15	0.40	1.12
		King eider	15	0.33	0.90
		Oldsquaw	15	0.20	0.56
		Rock ptarmigan	15	0.40	0.74
		Black-bellied plover	15	0.20	0.56
		Lesser golden-plover	15	0.07	0.26
		Semipalmated sandpiper	15	1.33	1.40
		Pectoral sandpiper	15	6.80	3.36
		Stilt sandpiper	15	1.07	1.44
		Buff-breasted sandpiper	15	0.47	0.92
		Long-billed dowitcher	15	2.47	4.31
		Red-necked phalarope	15	0.53	0.92
		Red phalarope	15	1.93	1.44

Appendix Table V. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Jago Delta Continued.			
Flooded	1985	Pomarine jaeger	15	0.73	0.88
		Parasitic jaeger	15	0.60	0.83
		Long-tailed jaeger	15	0.07	0.26
		Lapland longspur	15	8.40	2.69
Wet Sedge	1984	Total birds	15	16.40	10.49
		Total species (7)	15	2.60	1.40
		Lesser golden-plover	15	0.27	0.70
		Semipalmated sandpiper	15	1.07	1.10
		Pectoral sandpiper	15	1.00	1.46
		Stilt sandpiper	15	0.33	0.62
		Buff-breasted sandpiper	15	0.13	0.52
		Long-tailed jaeger	15	0.07	0.26
		Lapland longspur	15	13.53	8.63
	1985	Total birds	15	13.13	6.37
		Total species (10)	15	3.80	1.61
		Rock ptarmigan	15	0.07	0.26
		Lesser golden-plover	15	0.73	1.10
		Semipalmated sandpiper	15	0.33	0.62
		Pectoral sandpiper	15	1.87	2.23
		Buff-breasted sandpiper	15	2.00	2.00
		Red-necked phalarope	15	0.20	0.77
		Pomarine jaeger	15	1.00	1.46
		Parasitic jaeger	15	0.33	0.49
		Long-tailed jaeger	15	0.13	0.35
		Lapland longspur	15	6.47	2.20
Mosaic	1984	Total birds	15	31.40	12.71
		Total species (15)	15	4.73	1.67
		Northern pintail	15	0.33	0.62
		Oldsquaw	15	0.40	0.91
		Rock ptarmigan	15	0.20	0.56
		Lesser golden-plover	15	0.33	0.62
		Semipalmated sandpiper	15	1.73	1.91
		Pectoral sandpiper	15	6.67	4.94
		Stilt sandpiper	15	0.07	0.26
		Long-billed dowitcher	15	0.20	0.41
		Red-necked phalarope	15	0.60	0.74
		Red phalarope	15	0.27	0.80
		Parasitic jaeger	15	0.27	1.03
		Long-tailed jaeger	15	0.27	0.80
		Glaucous gull	15	0.13	0.52
		Lapland longspur	15	19.73	7.82
		Redpoll spp	15	0.27	1.03
	1985	Total birds	15	23.93	7.93
		Total species (16)	15	6.07	1.79
		Northern pintail	15	0.67	1.11
		King eider	15	0.13	0.52
		Oldsquaw	15	0.80	1.26
		Rock ptarmigan	15	1.93	3.22
		Lesser golden-plover	15	0.93	0.80
		Semipalmated sandpiper	15	0.40	0.63
		Pectoral sandpiper	15	4.60	2.32
		Dunlin	15	0.07	0.26
		Buff-breasted sandpiper	15	0.27	0.59
		Long-billed dowitcher	15	0.33	1.29
		Red-necked phalarope	15	0.67	0.82
		Red phalarope	15	0.27	0.70
		Pomarine jaeger	15	0.93	1.28
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.47	0.83
		Lapland longspur	15	10.93	5.59

Appendix Table V. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Jago Delta Continued.			
Moist Sedge-Shrub	1984	Total birds	15	19.80	10.54
		Total species (14)	15	4.07	1.87
		Northern pintail	15	0.27	0.70
		Rock ptarmigan	15	0.27	0.46
		Lesser golden-plover	15	0.33	0.90
		Semipalmated sandpiper	15	0.87	1.13
		Pectoral sandpiper	15	2.00	1.51
		Dunlin	15	0.27	0.70
		Buff-breasted sandpiper	15	0.33	0.49
		Red phalarope	15	0.13	0.35
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.27	0.59
		Long-tailed jaeger	15	0.20	0.41
		Glaucous gull	15	0.07	0.26
		Lapland longspur	15	14.73	8.42
		Redpoll spp	15	0.07	0.26
	1985	Total birds	15	20.27	8.30
		Total species (14)	15	5.20	1.37
		Northern pintail	15	0.27	1.03
		Rock ptarmigan	15	0.60	0.74
		Lesser golden-plover	15	1.00	0.85
		Semipalmated sandpiper	15	0.93	1.28
		Pectoral sandpiper	15	3.13	2.64
		Dunlin	15	0.47	0.92
		Buff-breasted sandpiper	15	0.53	0.99
		Long-billed dowitcher	15	0.33	0.72
		Red-necked phalarope	15	0.07	0.26
		Pomarine jaeger	15	1.47	2.00
		Parasitic jaeger	15	0.20	0.41
		Long-tailed jaeger	15	0.13	0.35
		Short-eared owl	15	0.20	0.56
		Lapland longspur	15	10.93	5.04
Riparian	1984	Total birds	15	22.20	11.40
		Total species (10)	15	3.73	1.10
		Northern pintail	15	0.07	0.26
		Lesser golden-plover	15	0.40	0.63
		Semipalmated plover	15	0.20	0.41
		Ruddy turnstone	15	2.07	2.09
		Semipalmated sandpiper	15	1.20	1.66
		Dunlin	15	0.07	0.26
		Buff-breasted sandpiper	15	2.20	3.05
		Pomarine jaeger	15	0.07	0.26
		Lapland longspur	15	15.20	9.33
		Redpoll spp	15	0.67	1.45
	1985	Total birds	15	14.60	8.36
		Total species (12)	15	3.53	1.41
		Tundra swan	15	0.07	0.26
		Oldsquaw	15	0.07	0.26
		Lesser golden-plover	15	2.00	4.64
		Ruddy turnstone	15	1.53	1.85
		Semipalmated sandpiper	15	0.93	1.44
		Baird's sandpiper	15	0.13	0.35
		Dunlin	15	0.07	0.26
		Buff-breasted sandpiper	15	0.67	1.18
		Pomarine jaeger	15	0.53	1.06
		Long-tailed jaeger	15	0.33	0.62
		Snowy owl	15	0.13	0.35
		Lapland longspur	15	8.13	5.66

Appendix Table V. Continued.

Habitat	Year	Species	Sample Size	Mean	± S.D.
		Marsh Creek			
Moist Sedge	1985	Total birds	15	7.20	4.66
		Total species (10)	15	2.80	1.90
		Willow ptarmigan	15	0.33	0.62
		Rock ptarmigan	15	0.47	0.64
		Lesser golden-plover	15	0.27	0.80
		Semipalmated sandpiper	15	0.13	0.35
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.20	0.41
		Long-tailed jaeger	15	0.13	0.35
		Savannah sparrow	15	0.80	1.37
		Lapland longspur	15	4.33	2.89
		Redpoll spp	15	0.47	1.13
Moist Sedge-Shrub	1985	Total birds	15	13.67	5.98
		Total species (12)	15	3.67	1.88
		Rough-legged hawk	15	0.07	0.26
		Golden eagle	15	0.07	0.26
		Willow ptarmigan	15	1.40	1.68
		Rock ptarmigan	15	0.47	0.64
		Lesser golden-plover	15	0.40	0.74
		Semipalmated sandpiper	15	0.07	0.26
		Pectoral sandpiper	15	0.13	0.35
		Pomarine jaeger	15	0.20	0.41
		Parasitic jaeger	15	0.13	0.35
		Long-tailed jaeger	15	0.40	0.63
		Savannah sparrow	15	1.00	1.46
		Lapland longspur	15	9.27	4.59
Tussock	1985	Total birds	15	11.27	5.35
		Total species (8)	15	2.87	0.92
		Willow ptarmigan	15	1.40	1.12
		Rock ptarmigan	15	0.20	0.41
		Lesser golden-plover	15	0.40	0.63
		Pomarine jaeger	15	0.07	0.26
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.40	1.06
		Savannah sparrow	15	0.33	0.62
		Lapland longspur	15	8.40	4.66
Riparian	1985	Total birds	15	42.93	9.09
		Total species (19)	15	9.27	1.67
		Willow ptarmigan	15	0.07	0.26
		Rock ptarmigan	15	1.33	1.29
		Lesser golden-plover	15	1.53	1.06
		Semipalmated plover	15	0.07	0.26
		Spotted sandpiper	15	0.13	0.35
		Ruddy turnstone	15	0.80	0.94
		Semipalmated sandpiper	15	1.47	2.59
		Baird's sandpiper	15	0.07	0.26
		Buff-breasted sandpiper	15	0.07	0.26
		Pomarine jaeger	15	0.13	0.52
		Parasitic jaeger	15	0.40	0.63
		Long-tailed jaeger	15	1.60	0.99
		Glaucous gull	15	0.07	0.26
		Yellow wagtail	15	4.00	2.00
		American sparrow	15	3.13	2.26
		Savannah sparrow	15	4.93	4.33
		White-crowned sparrow	15	1.60	2.23
		Lapland longspur	15	14.00	7.12
		Redpoll spp	15	7.47	4.78

Appendix Table V. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Niguanak			
Flooded	1985	Total birds	15	36.80	10.43
		Total species (18)	15	8.87	2.45
		Pacific loon	15	0.13	0.52
		Tundra Swan	15	0.13	0.35
		Northern pintail	15	0.33	0.72
		King eider	15	0.07	0.26
		Oldsquaw	15	2.47	1.64
		Rock ptarmigan	15	0.60	0.83
		Lesser golden-plover	15	2.07	2.02
		Semipalmated sandpiper	15	0.87	1.13
		Pectoral sandpiper	15	7.60	3.11
		Stilt sandpiper	15	1.87	1.73
		Buff-breasted sandpiper	15	0.07	0.26
		Long-billed dowitcher	15	1.67	2.09
		Red-necked phalarope	15	7.73	5.42
		Red phalarope	15	0.80	1.15
		Pomarine jaeger	15	2.33	1.18
		Glaucous gull	15	0.07	0.26
		Arctic tern	15	0.07	0.26
		Lapland longspur	15	7.93	3.67
Wet Sedge	1985	Total birds	15	17.20	6.28
		Total species (13)	15	5.20	2.31
		King eider	15	0.07	0.26
		Oldsquaw	15	0.07	0.26
		Rock ptarmigan	15	0.47	1.06
		Lesser golden-plover	15	1.07	1.10
		Semipalmated sandpiper	15	0.53	0.99
		Pectoral sandpiper	15	2.80	1.57
		Stilt sandpiper	15	0.67	0.90
		Long-billed dowitcher	15	0.27	0.59
		Red-necked phalarope	15	0.60	1.12
		Pomarine jaeger	15	1.80	1.08
		Parasitic jaeger	15	0.20	0.77
		Short-eared owl	15	0.40	0.83
		Lapland longspur	15	8.27	3.71
Moist Sedge-Shrub	1985	Total birds	15	22.53	6.57
		Total species (15)	15	5.53	1.96
		Northern pintail	15	0.53	0.92
		Oldsquaw	15	0.20	0.56
		Willow ptarmigan	15	0.47	0.64
		Rock ptarmigan	15	0.60	0.99
		Lesser golden-plover	15	0.13	0.35
		Semipalmated sandpiper	15	0.07	0.26
		Pectoral sandpiper	15	6.20	2.31
		Stilt sandpiper	15	0.13	0.35
		Long-billed dowitcher	15	0.33	0.49
		Red-necked phalarope	15	0.67	1.05
		Pomarine jaeger	15	2.60	1.92
		Parasitic jaeger	15	0.07	0.26
		Long-tailed jaeger	15	0.07	0.26
		Short-eared owl	15	0.40	0.63
		Lapland longspur	15	10.07	3.83
Tussock	1985	Total birds	15	15.60	5.77
		Total species (11)	15	4.53	1.60
		Northern pintail	15	0.20	0.56
		Willow ptarmigan	15	0.33	0.82
		Rock ptarmigan	15	1.67	1.35
		Lesser golden-plover	15	0.53	0.83
		Pectoral sandpiper	15	0.67	1.18
		Buff-breasted sandpiper	15	0.07	0.26

Appendix Table V. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Niguanak Continued.			
Tussock	1985	Pomarine jaeger	15	2.33	2.26
		Parasitic jaeger	15	0.53	0.74
		Long-tailed jaeger	15	0.40	0.63
		Short-eared owl	15	0.20	0.56
		Lapland longspur	15	8.73	4.42

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[a] Mean densities and mean number of species were means of counts from all replicate plots at each location in each habitat during all census periods during the reproductive season. (see text)

[b] Value in parentheses refers to total number of species observed on all replicate plots during the reproductive season.

Appendix Table VI. Mean densities (birds/km^2) and mean number of species (species/0.1km^2)[a] of birds observed on 10 ha study plots during the post-reproductive season in different locations on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1982-1985, sorted by habitat and year.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Okpilak			
Flooded	1982	Total birds	3	49.33	26.63
		Total species (13)[b]	3	7.33	2.52
		Red-throated loon	3	0.33	0.58
		Pacific loon	3	0.33	0.58
		Northern pintail	3	0.67	1.15
		Black-bellied plover	3	1.33	1.53
		Lesser golden-plover	3	1.33	2.31
		Pectoral sandpiper	3	21.67	21.13
		Long-billed dowitcher	3	13.33	8.14
		Red-necked phalarope	3	0.67	0.58
		Red phalarope	3	0.33	0.58
		Parasitic jaeger	3	0.67	1.15
		Glaucous gull	3	1.33	1.53
		Arctic tern	3	1.33	2.31
		Lapland longspur	3	6.00	1.73
	1983	Total birds	3	60.67	27.15
		Total species (12)	3	7.67	1.53
		Red-throated loon	3	3.00	1.00
		Northern pintail	3	0.33	0.58
		Black-bellied plover	3	0.33	0.58
		Lesser golden-plover	3	1.33	2.31
		Semipalmated sandpiper	3	0.33	0.58
		Pectoral sandpiper	3	42.33	19.66
		Long-billed dowitcher	3	4.00	3.00
		Red-necked phalarope	3	2.00	2.00
		Red phalarope	3	0.67	1.15
		Parasitic jaeger	3	0.67	1.15
		Glaucous gull	3	3.67	2.89
		Lapland longspur	3	1.33	1.53
	1985	Total birds	9	65.56	37.89
		Total species (19)	9	8.11	3.44
		Red-throated loon	9	1.44	0.88
		Pacific loon	9	0.33	0.71
		Northern pintail	9	4.00	7.30
		Spectacled eider	9	0.11	0.33
		Rock ptarmigan	9	0.11	0.33
		Black-bellied plover	9	0.33	1.00
		Lesser golden-plover	9	2.56	4.61
		Semipalmated sandpiper	9	2.44	3.32
		Pectoral sandpiper	9	40.44	29.18
		Dunlin	9	0.11	0.33
		Stilt sandpiper	9	0.56	1.67
		Long-billed dowitcher	9	1.22	1.48
		Red-necked phalarope	9	4.11	3.55
		Red phalarope	9	1.67	1.87
		Pomarine jaeger	9	0.33	0.50
		Parasitic jaeger	9	0.33	0.50
		Glaucous gull	9	1.67	2.78
		Snowy owl	9	0.11	0.33
		Lapland longspur	9	3.78	2.28
Wet Sedge	1982	Total birds	3	12.33	5.03
		Total species (5)	3	3.33	0.58
		Pectoral sandpiper	3	1.67	2.08
		Long-billed dowitcher	3	1.33	1.53
		Red-necked phalarope	3	0.33	0.58
		Parasitic jaeger	3	1.33	1.15
		Lapland longspur	3	7.67	4.04

Appendix Table VI. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Okpilak Continued.			
Wet Sedge	1983	Total birds	3	9.67	3.06
		Total species (6)	3	3.33	1.15
		Black-bellied plover	3	0.33	0.58
		Pectoral sandpiper	3	4.33	2.52
		Red-necked phalarope	3	0.33	0.58
		Long-tailed jaeger	3	0.33	0.58
		Glaucous gull	3	0.33	0.58
		Lapland longspur	3	4.00	1.73
	1985	Total birds	9	9.33	8.66
		Total species (5)	9	1.89	0.78
		Northern pintail	9	0.56	1.67
		Pectoral sandpiper	9	1.56	1.81
		Long-billed dowitcher	9	0.11	0.33
		Lapland longspur	9	7.00	6.04
		Smith's longspur	9	0.11	0.33
Mosaic	1982	Total birds	4	27.75	11.24
		Total species (6)	4	3.50	0.58
		Lesser golden-plover	4	2.50	4.36
		Pectoral sandpiper	4	4.25	1.71
		Long-billed dowitcher	4	4.25	4.92
		Red-necked phalarope	4	0.50	1.00
		Parasitic jaeger	4	0.25	0.50
		Lapland longspur	4	16.00	12.70
	1983	Total birds	4	22.75	7.41
		Total species (8)	4	5.00	1.41
		Black-bellied plover	4	0.50	0.58
		Lesser golden-plover	4	1.50	2.38
		Pectoral sandpiper	4	11.00	2.94
		Long-billed dowitcher	4	0.25	0.50
		Parasitic jaeger	4	0.25	0.50
		Long-tailed jaeger	4	0.50	0.58
		Glaucous gull	4	0.75	0.50
		Lapland longspur	4	7.75	4.27
	1985	Total birds	12	16.58	10.36
		Total species (8)	12	2.58	0.79
		Rock ptarmigan	12	0.17	0.58
		Semipalmated sandpiper	12	0.25	0.62
		Pectoral sandpiper	12	3.17	1.95
		Pomarine jaeger	12	0.08	0.29
		Parasitic jaeger	12	0.08	0.29
		Long-tailed jaeger	12	0.08	0.29
		Snowy owl	12	0.08	0.29
		Lapland longspur	12	12.67	10.62
Moist Sedge-Shrub	1982	Total birds	1	7.00	.
		Total species (3)	1	3.00	.
		Pectoral sandpiper	1	1.00	.
		Red-necked phalarope	1	1.00	.
		Lapland longspur	1	5.00	.
	1983	Total birds	2	28.00	2.83
		Total species (4)	2	3.00	0.00
		Pectoral sandpiper	2	7.50	3.54
		Long-billed dowitcher	2	0.50	0.71
		Parasitic jaeger	2	1.00	1.41
		Lapland longspur	2	19.00	1.41
	1985	Total birds	6	14.00	6.87
		Total species (6)	6	2.17	0.98
		Rock ptarmigan	6	0.17	0.41
		Lesser golden-plover	6	0.17	0.41

Appendix Table VI. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Okpilak Continued.			
Moist Sedge-Shrub	1985	Pectoral sandpiper	6	1.67	2.07
		Stilt sandpiper	6	0.50	1.22
		Long-tailed jaeger	6	0.17	0.41
		Lapland longspur	6	11.33	5.79
Riparian	1983	Total birds	2	23.50	12.02
		Total species (6)	2	4.50	2.12
		Pectoral sandpiper	2	2.50	0.71
		Parasitic jaeger	2	0.50	0.71
		Glaucous gull	2	1.00	0.00
		Savannah sparrow	2	1.50	2.12
		Lapland longspur	2	17.00	8.49
		Redpoll spp	2	1.00	1.41
		Katakturuk			
Wet Sedge	1983	Total birds	1	11.00	.
		Total species (5)	1	5.00	.
		Rock ptarmigan	1	2.00	.
		Lesser golden-plover	1	3.00	.
		Pectoral sandpiper	1	2.00	.
		Long-tailed jaeger	1	1.00	.
		Lapland longspur	1	3.00	.
	1985	Total birds	2	9.50	0.71
		Total species (3)	2	2.00	0.00
		Rock ptarmigan	2	4.00	5.66
		Long-tailed jaeger	2	1.00	0.00
		Lapland longspur	2	4.50	6.36
Moist Sedge	1982	Total birds	2	17.00	5.66
		Total species (2)	2	2.00	0.00
		Pectoral sandpiper	2	11.50	10.61
		Lapland longspur	2	5.50	4.95
	1983	Total birds	2	6.00	7.07
		Total species (4)	2	2.00	1.41
		Pectoral sandpiper	2	0.50	0.71
		Parasitic jaeger	2	1.00	1.41
		Long-tailed jaeger	2	0.50	0.71
		Lapland longspur	2	4.00	5.66
	1985	Total birds	4	10.50	9.33
		Total species (3)	4	2.00	0.82
		Rock ptarmigan	4	1.75	3.50
		Long-tailed jaeger	4	1.25	0.96
		Lapland longspur	4	7.50	5.45
Moist Sedge-Shrub	1982	Total birds	1	12.00	.
		Total species (1)	1	1.00	.
		Lapland longspur	1	12.00	.
	1983	Total birds	3	23.67	25.42
		Total species (4)	3	2.00	0.00
		Pectoral sandpiper	3	1.00	1.73
		Parasitic jaeger	3	0.33	0.58
		Savannah sparrow	3	1.00	1.73
		Lapland longspur	3	21.33	24.83
	1985	Total birds	9	14.11	8.67
		Total species (9)	9	3.56	1.01
		Willow ptarmigan	9	1.89	2.98
		Rock ptarmigan	9	1.56	4.30

Appendix Table VI. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Katakturuk Continued.			
Moist Sedge-Shrub	1985	Lesser golden-plover	9	1.11	2.09
		Pectoral sandpiper	9	2.00	2.74
		Parasitic jaeger	9	0.33	0.71
		Long-tailed jaeger	9	0.44	0.53
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	0.22	0.44
		Lapland longspur	9	6.11	4.34
Tussock	1982	Total birds	1	24.00	.
		Total species (4)	1	4.00	.
		Willow ptarmigan	1	2.00	.
		Rock ptarmigan	1	1.00	.
		Water pipit	1	6.00	.
		Lapland longspur	1	15.00	.
	1983	Total birds	3	12.67	12.50
		Total species (5)	3	2.67	1.15
		Rock ptarmigan	3	0.33	0.58
		Pectoral sandpiper	3	0.33	0.58
		Long-tailed jaeger	3	1.33	1.53
		Savannah sparrow	3	1.00	1.73
		Lapland longspur	3	9.67	10.69
	1985	Total birds	9	19.78	12.36
		Total species (10)	9	3.00	0.87
		Willow ptarmigan	9	2.00	6.00
		Rock ptarmigan	9	8.78	11.30
		Lesser golden-plover	9	0.89	1.27
		Whimbrel	9	0.22	0.67
		Pectoral sandpiper	9	0.22	0.44
		Long-tailed jaeger	9	0.22	0.44
		Short-eared owl	9	0.22	0.67
		Common raven	9	0.11	0.33
		Water pipit	9	0.22	0.67
		Lapland longspur	9	6.89	3.62
Riparian	1982	Total birds	2	35.00	9.90
		Total species (8)	2	5.50	0.71
		Northern harrier	2	0.50	0.71
		Lesser golden-plover	2	0.50	0.71
		Pectoral sandpiper	2	0.50	0.71
		Water pipit	2	6.00	8.49
		American tree sparrow	2	4.00	5.66
		Savannah sparrow	2	0.50	0.71
		Lapland longspur	2	16.50	2.12
		Redpoll spp	2	5.00	4.24
	1983	Total birds	3	59.67	12.66
		Total species (9)	3	6.33	0.58
		Rock ptarmigan	3	1.67	0.58
		Lesser golden-plover	3	0.33	0.58
		Pectoral sandpiper	3	0.33	0.58
		Long-tailed jaeger	3	1.67	0.58
		Yellow wagtail	3	4.33	5.13
		American tree sparrow	3	18.00	7.00
		Savannah sparrow	3	0.67	0.58
		Lapland longspur	3	25.67	11.59
		Redpoll spp	3	7.00	10.44
	1985	Total birds	7	70.71	16.03
		Total species (13)	7	7.57	1.27
		Willow ptarmigan	7	1.14	2.61
		Rock ptarmigan	7	21.43	16.06
		Lesser golden-plover	7	3.00	4.62

Appendix Table VI. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Katakturuk Continued.			
Riparian	1985	Semipalmated sandpiper	7	0.71	1.89
		Buff-breasted sandpiper	7	0.29	0.76
		Long-tailed jaeger	7	0.71	0.95
		American robin	7	0.29	0.49
		Yellow wagtail	7	3.00	1.63
		American tree sparrow	7	3.71	2.63
		Savannah sparrow	7	3.14	3.08
		White-crowned sparrow	7	0.71	1.25
		Lapland longspur	7	27.71	15.74
		Redpoll spp	7	4.86	3.58
		Jago Bitty			
Wet Sedge	1983	Total birds	3	9.67	4.16
		Total species (6)	3	3.67	0.58
		Rock ptarmigan	3	0.33	0.58
		Pectoral sandpiper	3	5.00	2.00
		Long-billed dowitcher	3	0.33	0.58
		Parasitic jaeger	3	0.67	1.15
		Long-tailed jaeger	3	1.00	1.00
		Lapland longspur	3	2.33	1.15
	1985	Total birds	9	14.22	5.49
		Total species (10)	9	3.56	0.88
		Northern pintail	9	0.33	1.00
		Rock ptarmigan	9	1.44	2.88
		Lesser golden-plover	9	0.67	1.00
		Pectoral sandpiper	9	4.11	3.33
		Long-billed dowitcher	9	0.22	0.44
		Parasitic jaeger	9	0.89	1.54
		Long-tailed jaeger	9	0.56	1.01
		Short-eared owl	9	0.11	0.33
		Lapland longspur	9	5.78	2.49
		Redpoll spp	9	0.11	0.33
Moist Sedge	1983	Total birds	3	5.33	1.53
		Total species (2)	3	1.33	0.58
		Parasitic jaeger	3	0.33	0.58
		Lapland longspur	3	5.00	2.00
	1985	Total birds	9	26.78	15.11
		Total species (13)	9	6.00	2.12
		Northern pintail	9	0.11	0.33
		Willow ptarmigan	9	4.67	6.98
		Rock ptarmigan	9	7.22	6.59
		Lesser golden-plover	9	3.11	1.76
		Pectoral sandpiper	9	2.78	3.73
		Long-billed dowitcher	9	0.11	0.33
		Red-necked phalarope	9	0.11	0.33
		Parasitic jaeger	9	0.67	1.00
		Long-tailed jaeger	9	0.44	0.53
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	1.11	1.76
		Lapland longspur	9	5.22	3.23
		Redpoll spp	9	1.11	1.54
Moist Sedge-Shrub	1983	Total birds	3	9.67	4.62
		Total species (4)	3	3.00	0.00
		Willow ptarmigan	3	1.67	1.15
		Lesser golden-plover	3	1.67	1.53
		Pectoral sandpiper	3	0.33	0.58
		Lapland longspur	3	6.00	3.61

Appendix Table VI. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Jago Bitty Continued.			
Moist Sedge-Shrub	1985	Total birds	9	22.11	15.10
		Total species (12)	9	4.22	1.39
		Northern pintail	9	0.22	0.67
		Northern harrier	9	0.11	0.33
		Willow ptarmigan	9	9.56	11.02
		Rock ptarmigan	9	1.56	3.24
		Lesser golden-plover	9	1.11	2.98
		Pectoral sandpiper	9	2.33	1.50
		Long-billed dowitcher	9	0.67	0.87
		Parasitic jaeger	9	0.11	0.33
		Long-tailed jaeger	9	0.44	0.73
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	0.11	0.33
		Lapland longspur	9	5.78	1.92
Tussock	1983	Total birds	3	6.00	1.00
		Total species (4)	3	2.00	1.00
		Lesser golden-plover	3	0.33	0.58
		Pectoral sandpiper	3	1.00	1.73
		Long-tailed jaeger	9	0.33	0.58
		Lapland longspur	3	4.33	1.15
	1985	Total birds	9	16.33	12.02
		Total species (7)	9	2.67	1.41
		Willow ptarmigan	9	5.67	6.46
		Rock ptarmigan	9	2.44	4.30
		Lesser golden-plover	9	0.22	0.44
		Long-tailed jaeger	9	0.11	0.33
		Common raven	9	0.33	1.00
		Lapland longspur	9	7.00	6.26
		Redpoll spp	9	0.56	1.33
Riparian	1983	Total birds	3	13.67	5.51
		Total species (7)	3	4.33	0.58
		Lesser golden-plover	3	0.67	1.15
		Ruddy turnstone	3	3.33	5.77
		Pectoral sandpiper	3	0.67	0.58
		Parasitic jaeger	3	0.67	1.15
		Long-tailed jaeger	3	1.00	0.00
		Savannah sparrow	3	1.33	1.15
		Lapland longspur	3	6.00	3.46
	1985	Total birds	9	51.44	29.76
		Total species (12)	9	4.44	1.67
		Willow ptarmigan	9	22.44	20.45
		Rock ptarmigan	9	8.33	11.05
		Lesser golden-plover	9	0.44	1.01
		Semipalmated sandpiper	9	0.44	1.33
		Pectoral sandpiper	9	0.44	1.01
		Long-tailed jaeger	9	0.44	0.73
		Short-eared owl	9	0.22	0.44
		Yellow wagtail	9	0.11	0.33
		American tree sparrow	9	0.33	1.00
		Savannah sparrow	9	1.22	1.92
		Lapland longspur	9	16.67	5.10
		Redpoll spp	9	0.33	0.71
		Aichilik			
Wet Sedge	1984	Total birds	6	19.50	8.02
		Total species (4)	6	1.67	0.52
		Willow ptarmigan	6	2.50	6.12
		Lesser golden-plover	6	0.67	1.63
		Pectoral sandpiper	6	3.50	6.12
		Lapland longspur	6	12.83	6.74

Appendix Table VI. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Aichilik Continued.			
	1985	Total birds	9	7.22	4.27
		Total species (6)	9	2.22	1.09
		Willow ptarmigan	9	0.11	0.33
		Rock ptarmigan	9	3.33	4.64
		Whimbrel	9	0.11	0.33
		Pomarine jaeger	9	0.33	0.50
		Long-tailed jaeger	9	0.22	0.44
		Lapland longspur	9	3.11	2.47
Moist Sedge	1984	Total birds	6	32.50	25.19
		Total species (5)	6	2.50	1.05
		Rock ptarmigan	6	2.50	6.12
		Lesser golden-plover	6	1.67	4.08
		Pectoral sandpiper	6	10.50	8.46
		Long-tailed jaeger	6	0.50	0.84
		Lapland longspur	6	17.33	14.33
	1985	Total birds	9	10.67	7.25
		Total species (6)	9	2.22	1.39
		Rock ptarmigan	9	1.33	2.40
		Black-bellied plover	9	0.44	1.33
		Lesser golden-plover	9	2.67	4.09
		Buff-breasted sandpiper	9	0.22	0.67
		Long-tailed jaeger	9	0.22	0.44
		Lapland longspur	9	5.78	2.59
Moist Sedge-Shrub	1984	Total birds	6	46.67	5.75
		Total species (6)	6	3.33	0.82
		Northern pintail	6	0.33	0.82
		Willow ptarmigan	6	4.67	7.47
		Pectoral sandpiper	6	19.50	3.62
		Parasitic jaeger	6	0.50	0.84
		Long-tailed jaeger	6	0.50	0.55
		Lapland longspur	6	21.17	3.87
	1985	Total birds	9	32.78	10.81
		Total species (12)	9	5.11	2.32
		Northern harrier	9	0.11	0.33
		Willow ptarmigan	9	4.56	6.82
		Lesser golden-plover	9	2.22	4.15
		Whimbrel	9	0.11	0.33
		Semipalmated sandpiper	9	0.44	1.01
		Pectoral sandpiper	9	10.44	5.85
		Long-billed dowitcher	9	0.56	0.73
		Parasitic jaeger	9	0.56	0.73
		Long-tailed jaeger	9	0.22	0.67
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	1.22	1.73
		Lapland longspur	9	11.78	3.99
Tussock	1984	Total birds	6	32.00	11.05
		Total species (6)	6	3.33	1.21
		Willow ptarmigan	6	4.33	5.83
		Lesser golden-plover	6	0.50	0.84
		Pectoral sandpiper	6	8.83	4.02
		Parasitic jaeger	6	0.17	0.41
		Long-tailed jaeger	6	0.50	0.55
		Lapland longspur	6	17.67	6.06
	1985	Total birds	9	21.00	6.18
		Total species (10)	9	4.44	1.13
		Green-winged teal	9	0.11	0.33
		Willow ptarmigan	9	4.22	4.52
		Rock ptarmigan	9	2.00	2.69
		Lesser golden-plover	9	2.33	3.35

Appendix Table VI. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Jago Bitty Continued.			
Tussock	1985	Pectoral sandpiper	9	3.56	2.74
		Stilt sandpiper	9	0.11	0.33
		Long-billed dowitcher	9	0.22	0.44
		Pomarine jaeger	9	0.22	0.44
		Long-tailed jaeger	9	0.44	1.01
		Lapland longspur	9	7.78	4.27
Riparian	1984	Total birds	6	29.67	16.74
		Total species (10)	6	3.67	1.21
		Rock ptarmigan	6	5.67	13.40
		Lesser golden-plover	6	1.50	1.76
		Ruddy turnstone	6	1.00	1.67
		Semipalmated sandpiper	6	1.50	2.81
		Pectoral sandpiper	6	1.33	1.97
		Long-tailed jaeger	6	0.33	0.82
		American tree sparrow	6	0.33	0.82
		Savannah sparrow	6	0.17	0.41
		Lapland longspur	6	17.67	5.43
		Redpoll spp	6	0.17	0.41
	1985	Total birds	9	30.22	17.30
		Total species (16)	9	4.11	1.83
		Red-breasted merganser	9	0.33	1.00
		Rock ptarmigan	9	2.22	3.46
		Lesser golden-plover	9	3.44	6.46
		Ruddy turnstone	9	0.11	0.33
		Semipalmated sandpiper	9	0.78	1.39
		Baird's sandpiper	9	0.44	1.01
		Pectoral sandpiper	9	0.22	0.67
		Stilt sandpiper	9	0.11	0.33
		Buff-breasted sandpiper	9	0.33	0.71
		Parasitic jaeger	9	0.33	0.71
		Long-tailed jaeger	9	0.11	0.33
		Mew gull	9	0.11	0.33
		Northern wheatear	9	0.11	0.33
		Savannah sparrow	9	1.89	3.10
		Lapland longspur	9	19.33	8.00
		Redpoll spp	9	0.33	0.71
		Sadlerochit			
Wet Sedge	1984	Total birds	6	26.83	8.45
		Total species (3)	6	2.33	0.52
		Pectoral sandpiper	6	21.00	9.25
		Parasitic jaeger	6	0.50	0.84
		Lapland longspur	6	5.33	2.73
	1985	Total birds	9	25.00	25.98
		Total species (8)	9	2.44	1.24
		Northern pintail	9	0.33	1.00
		Willow ptarmigan	9	1.67	5.00
		Pectoral sandpiper	9	5.11	10.45
		Long-billed dowitcher	9	0.33	0.50
		Parasitic jaeger	9	0.11	0.33
		Short-eared owl	9	0.11	0.33
		Savannah sparrow	9	1.56	1.88
		Lapland longspur	9	15.78	15.83
Mosaic	1984	Total birds	6	19.83	17.78
		Total species (7)	6	3.17	1.17
		Northern pintail	6	1.33	3.27
		Rock ptarmigan	6	2.83	6.01
		Lesser golden-plover	6	1.17	1.60
		Pectoral sandpiper	6	3.00	2.37
		Long-billed dowitcher	6	0.17	0.41
		Long-tailed jaeger	6	0.17	0.41
		Lapland longspur	6	11.17	7.00

Appendix Table VI. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Sadlerochit Continued.			
Mosaic	1985	Total birds	9	23.11	8.43
		Total species (11)	9	3.89	1.27
		Northern pintail	9	0.33	0.71
		Rock ptarmigan	9	0.11	0.33
		Lesser golden-plover	9	0.33	0.71
		Semipalmated sandpiper	9	0.22	0.44
		Pectoral sandpiper	9	6.44	5.41
		Long-billed dowitcher	9	0.33	0.71
		Red-necked phalarope	9	0.33	0.50
		Parasitic jaeger	9	0.22	0.44
		Long-tailed jaeger	9	0.11	0.33
		Snowy owl	9	0.22	0.44
		Lapland longspur	9	13.33	6.75
Moist Sedge-Shrub	1984	Total birds	6	17.67	13.35
		Total species (5)	6	2.67	0.82
		Northern pintail	6	0.17	0.41
		Lesser golden-plover	6	0.67	1.63
		Pectoral sandpiper	6	4.17	5.23
		Long-tailed jaeger	6	0.67	0.52
		Lapland longspur	6	12.00	9.86
	1985	Total birds	9	29.00	11.32
		Total species (12)	9	4.22	1.39
		Northern pintail	9	0.33	0.71
		Willow ptarmigan	9	1.56	4.67
		Rock ptarmigan	9	4.00	9.29
		Lesser golden-plover	9	0.44	0.73
		Semipalmated sandpiper	9	0.33	1.00
		Pectoral sandpiper	9	2.78	2.77
		Buff-breasted sandpiper	9	0.44	1.33
		Long-billed dowitcher	9	0.11	0.33
		Red-necked phalarope	9	0.33	0.50
		Parasitic jaeger	9	0.11	0.33
		Long-tailed jaeger	9	0.78	0.83
		Lapland longspur	9	17.78	6.53
Tussock	1984	Total birds	6	23.67	17.04
		Total species (6)	6	2.33	1.03
		Willow ptarmigan	6	4.17	6.65
		Rock ptarmigan	6	7.67	12.03
		Lesser golden-plover	6	0.17	0.41
		Pectoral sandpiper	6	0.17	0.41
		Long-tailed jaeger	6	0.33	0.52
		Lapland longspur	6	11.17	5.85
	1985	Total birds	9	11.67	5.27
		Total species (7)	9	2.56	1.13
		Willow ptarmigan	9	0.22	0.44
		Rock ptarmigan	9	2.78	4.41
		Pectoral sandpiper	9	0.33	0.71
		Stilt sandpiper	9	0.11	0.33
		Long-tailed jaeger	9	0.33	0.71
		Short-eared owl	9	0.11	0.33
		Lapland longspur	9	7.78	4.38
Riparian	1984	Total birds	6	58.00	20.01
		Total species (16)	6	6.67	1.03
		Lesser golden-plover	6	2.17	2.14
		Ruddy turnstone	6	0.83	0.98
		Semipalmated sandpiper	6	3.67	3.83
		Pectoral sandpiper	6	22.83	16.81
		Dunlin	6	5.67	4.80
		Stilt sandpiper	6	0.17	0.41

Appendix Table VI. Continued.

Habitat	Year	Species	Sample Size	Mean	± S.D.
		LOCATION			
		Sadlerochit Continued.			
Riparian	1984	Buff-breasted sandpiper	6	0.17	0.41
		Long-billed dowitcher	6	0.33	0.82
		Red-necked phalarope	6	0.17	0.41
		Parasitic jaeger	6	0.83	1.33
		Long-tailed jaeger	6	0.17	0.41
		Arctic tern	6	0.17	0.41
		Yellow wagtail	6	0.67	1.63
		American tree sparrow	6	0.17	0.41
		Savannah sparrow	6	0.33	0.82
		Lapland longspur	6	19.17	10.52
	1985	Total birds	12	61.33	29.35
		Total species (17)	12	5.83	1.64
		Willow ptarmigan	12	2.67	6.24
		Rock ptarmigan	12	7.92	12.05
		Black-bellied plover	12	0.08	0.29
		Lesser golden-plover	12	2.92	2.35
		Ruddy turnstone	12	0.50	1.17
		Semipalmated sandpiper	12	2.42	3.68
		Baird's sandpiper	12	0.08	0.29
		Pectoral sandpiper	12	2.08	4.14
		Buff-breasted sandpiper	12	0.75	1.29
		Red-necked phalarope	12	0.08	0.29
		Parasitic jaeger	12	0.50	1.17
		Long-tailed jaeger	12	1.08	0.79
		Arctic tern	12	0.08	0.29
		Short-eared owl	12	0.08	0.29
		Yellow wagtail	12	0.08	0.29
		Savannah sparrow	12	0.92	1.62
		Lapland longspur	12	38.33	20.85
		Jago Delta			
Flooded	1984	Total birds	6	18.67	6.83
		Total species (7)	6	3.50	1.05
		Pectoral sandpiper	6	6.83	5.15
		Stilt sandpiper	6	0.33	0.82
		Long-billed dowitcher	6	0.83	1.33
		Red phalarope	6	1.67	2.34
		Parasitic jaeger	6	0.50	1.22
		Glaucous gull	6	0.17	0.41
		Lapland longspur	6	8.17	7.03
	1985	Total birds	9	30.56	7.28
		Total species (15)	9	6.67	1.50
		King eider	9	0.11	0.33
		Black-bellied plover	9	0.78	1.99
		Lesser golden-plover	9	1.33	1.73
		Semipalmated sandpiper	9	1.67	1.87
		Pectoral sandpiper	9	12.67	3.94
		Dunlin	9	0.56	1.13
		Stilt sandpiper	9	1.44	1.51
		Buff-breasted sandpiper	9	0.11	0.33
		Long-billed dowitcher	9	1.89	2.52
		Red-necked phalarope	9	0.44	1.01
		Red phalarope	9	4.11	4.54
		Pomarine jaeger	9	0.44	0.53
		Parasitic jaeger	9	0.33	1.00
		Snowy owl	9	0.33	1.00
		Lapland longspur	9	4.33	1.94
Wet Sedge	1984	Total birds	6	39.83	18.86
		Total species (9)	6	4.17	1.17
		Lesser golden-plover	6	2.33	3.50
		Semipalmated sandpiper	6	1.00	1.10
		Pectoral sandpiper	6	17.33	20.29

Appendix Table VI. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Jago Delta Continued.			
Wet Sedge	1984	Dunlin	6	0.17	0.41
		Stilt sandpiper	6	0.17	0.41
		Buff-breasted sandpiper	6	0.33	0.52
		Red phalarope	6	0.17	0.41
		Long-tailed jaeger	6	0.17	0.41
		Lapland longspur	6	18.00	8.72
	1985	Total birds	9	6.89	2.76
		Total species (7)	9	2.00	0.87
		Rock ptarmigan	9	0.67	2.00
		Lesser golden-plover	9	0.11	0.33
		Pectoral sandpiper	9	0.56	1.33
		Buff-breasted sandpiper	9	0.22	0.67
		Pomarine jaeger	9	0.33	0.50
		Snowy owl	9	0.11	0.33
		Lapland longspur	9	4.89	1.76
Mosaic	1984	Total birds	6	32.67	11.41
		Total species (7)	6	4.00	1.26
		Northern pintail	6	0.33	0.52
		Oldsquaw	6	0.17	0.41
		Rock ptarmigan	6	1.00	2.45
		Lesser golden-plover	6	1.33	1.97
		Pectoral sandpiper	6	12.67	8.85
		Long-billed dowitcher	6	1.33	1.97
		Lapland longspur	6	14.83	7.57
	1985	Total birds	9	26.89	22.67
		Total species (12)	9	4.22	2.17
		Northern pintail	9	0.44	1.33
		Oldsquaw	9	0.56	1.67
		Rough-legged hawk	9	0.11	0.33
		Rock ptarmigan	9	10.22	23.90
		Lesser golden-plover	9	0.11	0.33
		Pectoral sandpiper	9	5.67	2.18
		Buff-breasted sandpiper	9	0.11	0.33
		Long-billed dowitcher	9	0.67	1.12
		Pomarine jaeger	9	0.67	0.71
		Long-tailed jaeger	9	0.56	1.01
		Snowy owl	9	0.11	0.33
		Lapland longspur	9	7.67	4.09
Moist Sedge-Shrub	1984	Total birds	6	35.83	9.60
		Total species (6)	6	3.33	0.82
		Rock ptarmigan	6	0.33	0.52
		Lesser golden-plover	6	2.83	3.19
		Pectoral sandpiper	6	7.67	5.92
		Parasitic jaeger	6	0.17	0.41
		Long-tailed jaeger	6	0.17	0.41
		Lapland longspur	6	24.67	15.42
	1985	Total birds	9	11.00	6.28
		Total species (6)	9	2.78	0.97
		Lesser golden-plover	9	0.22	0.44
		Pectoral sandpiper	9	1.00	2.29
		Buff-breasted sandpiper	9	0.22	0.44
		Pomarine jaeger	9	1.22	0.67
		Snowy owl	9	0.11	0.33
		Lapland longspur	9	8.22	6.10
Riparian	1984	Total birds	6	41.67	25.87
		Total species (10)	6	4.83	1.60
		Lesser golden-plover	6	5.17	9.39
		Ruddy turnstone	6	1.50	1.64

Appendix Table VI. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Jago Delta Continued.			
Riparian	1984	Semipalmated sandpiper	6	1.67	2.66
		Baird's sandpiper	6	0.17	0.41
		Pectoral sandpiper	6	6.33	6.15
		Dunlin	6	8.50	7.34
		Buff-breasted sandpiper	6	0.17	0.41
		Red phalarope	6	0.17	0.41
		Parasitic jaeger	6	0.33	0.82
		Lapland longspur	6	17.67	8.73
	1985	Total birds	9	28.11	11.99
		Total species (8)	9	3.00	0.87
		Lesser golden-plover	9	2.22	4.27
		Semipalmated sandpiper	9	0.22	0.44
		Baird's sandpiper	9	0.22	0.67
		Pectoral sandpiper	9	0.44	0.73
		Buff-breasted sandpiper	9	3.11	3.89
		Parasitic jaeger	9	0.11	0.33
		Snowy owl	9	0.11	0.33
		Lapland longspur	9	21.67	8.53
		Marsh Creek			
Moist Sedge	1985	Total birds	9	8.11	8.33
		Total species (8)	9	2.00	1.00
		Willow ptarmigan	9	1.56	2.35
		Rock ptarmigan	9	4.11	7.80
		Lesser golden-plover	9	0.22	0.67
		Pectoral sandpiper	9	0.11	0.33
		Long-tailed jaeger	9	0.22	0.44
		Short-eared owl	9	0.22	0.67
		Savannah sparrow	9	0.11	0.33
		Lapland longspur	9	1.56	2.96
Moist Sedge-Shrub	1985	Total birds	9	25.56	16.39
		Total species (8)	9	2.67	0.87
		Willow ptarmigan	9	6.67	7.79
		Rock ptarmigan	9	1.44	4.33
		Pectoral sandpiper	9	0.56	1.33
		Pomarine jaeger	9	0.44	1.33
		Parasitic jaeger	9	0.11	0.33
		Long-tailed jaeger	9	0.44	0.53
		Savannah sparrow	9	0.22	0.67
		Lapland longspur	9	15.67	13.34
Tussock	1985	Total birds	9	8.00	5.68
		Total species (6)	9	2.11	1.05
		Willow ptarmigan	9	3.44	5.22
		Rock ptarmigan	9	0.11	0.33
		Lesser golden-plover	9	0.22	0.44
		Pectoral sandpiper	9	0.11	0.33
		Long-tailed jaeger	9	0.33	0.50
		Lapland longspur	9	3.78	2.39
Riparian	1985	Total birds	9	64.67	21.52
		Total species (18)	9	9.11	1.90
		Green-winged teal	9	0.78	1.99
		Willow ptarmigan	9	5.44	7.14
		Rock ptarmigan	9	10.00	12.51
		Lesser golden-plover	9	1.78	3.19
		Ruddy turnstone	9	0.11	0.33
		Semipalmated sandpiper	9	1.56	2.35
		Baird's sandpiper	9	1.78	4.97
		Pectoral sandpiper	9	1.00	1.12

Appendix Table VI. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Marsh Creek Continued.			
Riparian	1985	Buff-breasted sandpiper	9	0.22	0.67
		Parasitic jaeger	9	0.44	0.88
		Long-tailed jaeger	9	1.22	0.97
		Short-eared owl	9	0.11	0.33
		Yellow wagtail	9	2.78	2.05
		American tree sparrow	9	4.22	4.21
		Savannah sparrow	9	15.33	8.99
		White-crowned sparrow	9	0.22	0.67
		Lapland longspur	9	14.89	6.15
		Redpoll spp	9	3.00	2.29
		Niguanak			
Flooded	1985	Total birds	9	32.56	19.09
		Total species (13)	9	6.67	1.32
		Pacific loon	9	0.22	0.67
		Northern pintail	9	1.78	3.49
		Rock ptarmigan	9	0.11	0.33
		Lesser golden-plover	9	0.89	1.36
		Semipalmated sandpiper	9	0.11	0.33
		Pectoral sandpiper	9	16.44	17.21
		Stilt sandpiper	9	0.89	1.05
		Long-billed dowitcher	9	1.78	1.48
		Red-necked phalarope	9	2.89	3.02
		Red phalarope	9	0.33	0.50
		Pomarine jaeger	9	1.56	0.53
		Short-eared owl	9	0.11	0.33
		Lapland longspur	9	5.44	2.65
Wet Sedge	1985	Total birds	9	7.11	2.62
		Total species (6)	9	2.78	1.20
		Lesser golden-plover	9	0.33	0.71
		Pectoral sandpiper	9	1.56	1.59
		Red-necked phalarope	9	0.22	0.44
		Pomarine jaeger	9	1.11	0.78
		Long-tailed jaeger	9	0.11	0.33
		Lapland longspur	9	3.89	2.71
Moist Sedge-Shrub	1985	Total birds	9	26.00	16.90
		Total species (7)	9	4.11	1.27
		Rock ptarmigan	9	1.89	3.22
		Pectoral sandpiper	9	4.11	3.10
		Stilt sandpiper	9	0.56	1.13
		Red-necked phalarope	9	0.11	0.33
		Pomarine jaeger	9	1.44	0.73
		Short-eared owl	9	0.78	1.30
		Lapland longspur	9	17.11	14.79
Tussock	1985	Total birds	9	7.44	2.24
		Total species (10)	9	3.11	1.05
		Willow ptarmigan	9	0.22	0.67
		Rock ptarmigan	9	0.56	1.33
		Lesser golden-plover	9	0.67	1.32
		Pectoral sandpiper	9	0.22	0.44
		Long-billed dowitcher	9	0.11	0.33
		Pomarine jaeger	9	0.33	0.50
		Long-tailed jaeger	9	0.67	1.00
		Short-eared owl	9	0.22	0.44
		Common raven	9	0.11	0.33
		Lapland longspur	9	4.33	1.87

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[a] Mean densities and mean number of species were means of counts from all replicate plots at each location in each habitat during th post-reproductive season (see text).

[b] Value in parentheses refers to total number of species observed on all replicate plots during the post-reproductive season.

Appendix Table VII. Mean densities (nests/km^2) of nests and mean number of nesting bird species (species/0.1km^2)[a] observed on study plots in different locations, on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1982-1985, sorted by habitat and year.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Okpilak			
Flooded	1982	Total nests	3	36.67	5.77
		Total species (5)[b]	3	2.33	0.58
		Red-throated loon	3	3.33	5.77
		Pacific loon	3	3.33	5.77
		Northern pintail	3	20.00	0.00
		Pectoral sandpiper	3	6.67	11.55
		Glaucous gull	3	3.33	5.77
	1983	Total nests	3	40.00	0.00
		Total species (7)	3	3.00	1.00
		Red-throated loon	3	3.33	5.77
		Pectoral sandpiper	3	6.67	11.55
		Red-necked phalarope	3	6.67	5.77
		Red phalarope	3	3.33	5.77
		Parasitic jaeger	3	3.33	5.77
		Glaucous gull	3	3.33	5.77
		Lapland longspur	3	13.33	11.55
	1985	Total nests	3	66.67	55.08
		Total species (8)	3	4.00	1.00
		Red-throated loon	3	13.33	5.77
		Brant	3	20.00	34.64
		Canada goose	3	3.33	5.77
		Spectacled eider	3	3.33	5.77
		Red-necked phalarope	3	6.67	5.77
		Red phalarope	3	10.00	10.00
		Glaucous gull	3	6.67	11.55
		Lapland longspur	3	3.33	5.77
Wet Sedge	1982	Total nests	3	26.67	15.28
		Total species (3)	3	1.67	1.15
		Pectoral sandpiper	3	6.67	5.77
		Long-billed dowitcher	3	3.33	5.77
		Lapland longspur	3	16.67	20.82
	1983	Total nests	3	40.00	20.00
		Total species (2)	3	1.67	0.58
		Pectoral sandpiper	3	23.33	20.82
		Lapland longspur	3	16.67	5.77
	1985	Total nests	3	23.33	11.55
		Total species (3)	3	1.67	0.58
		Long-billed dowitcher	3	6.67	11.55
		Red-necked phalarope	3	6.67	5.77
		Lapland longspur	3	10.00	10.00
Mosaic	1982	Total nests	4	42.50	9.57
		Total species (4)	4	2.50	0.58
		Lesser golden-plover	4	2.50	5.00
		Pectoral sandpiper	4	15.00	12.91
		Red phalarope	4	5.00	5.77
		Lapland longspur	4	20.00	11.55
	1983	Total nests	4	40.00	8.16
		Total species (4)	4	2.00	1.15
		Canada goose	4	2.50	5.00
		Lesser golden-plover	4	2.50	5.00
		Pectoral sandpiper	4	12.50	15.00
		Lapland longspur	4	22.50	15.00

Appendix Table VII. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Okpilak Continued.			
Mosaic	1985	Total nests	4	25.00	19.15
		Total species (4)	4	1.75	0.96
		Lesser golden-plover	4	2.50	5.00
		Pectoral sandpiper	4	5.00	5.77
		Stilt sandpiper	4	2.50	5.00
		Lapland longspur	4	15.00	12.91
Moist Sedge-Shrub	1982	Total nests	1	10.00	.
		Total species (1)	1	1.00	.
		Lapland longspur	1	10.00	.
	1983	Total nests	2	40.00	14.14
		Total species (4)	2	2.50	0.71
		Northern pintail	2	5.00	7.07
		Lesser golden-plover	2	5.00	7.07
		Pectoral sandpiper	2	5.00	7.07
		Lapland longspur	2	25.00	21.21
	1985	Total nests	2	30.00	14.14
		Total species (1)	2	1.00	0.00
		Lapland longspur	2	30.00	14.14
Riparian	1983	Total nests	2	45.00	21.21
		Total species (4)	2	2.00	1.41
		Ruddy turnstone	2	5.00	7.07
		Semipalmated sandpiper	2	15.00	21.21
		Lapland longspur	2	15.00	21.21
		Redpoll spp	2	10.00	14.14
		Katakturuk			
Wet Sedge	1983	Total nests	1	0	.
		Total species (0)	1	0	.
	1985	Total nests	1	0	.
		Total species (0)	1	0	.
Moist Sedge	1982	Total nests	2	10.00	14.14
		Total species (2)	2	1.00	1.41
		Rock ptarmigan	2	5.00	7.07
		Lapland longspur	2	5.00	7.07
	1983	Total nests	2	25.00	7.07
		Total species (2)	2	1.50	0.71
		Lesser golden-plover	2	5.00	7.07
		Lapland longspur	2	20.00	0.00
	1985	Total nests	2	20.00	14.14
		Total species (2)	2	1.50	0.71
		Lesser golden-plover	2	5.00	7.07
		Lapland longspur	2	15.00	7.07
Moist Sedge-Shrub	1982	Total nests	1	20.00	.
		Total species (2)	1	2.00	.
		Semipalmated sandpiper	1	10.00	.
		Lapland longspur	1	10.00	.
	1983	Total nests	3	10.00	10.00
		Total species (3)	3	1.00	1.00
		Pectoral sandpiper	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	3.33	5.77

Appendix Table VII. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Katakturuk Continued.			
Moist Sedge-Shrub	1985	Total nests	3	26.67	11.55
		Total species (4)	3	2.67	1.15
		Willow ptarmigan	3	3.33	5.77
		Buff-breasted sandpiper	3	6.67	5.77
		Red-necked phalarope	3	3.33	5.77
		Lapland longspur	3	10.00	0.00
Tussock	1982	Total nests	1	20.00	.
		Total species (1)	1	1.00	.
		Lapland longspur	1	20.00	.
	1983	Total nests	3	36.67	37.86
		Total species (4)	3	2.00	1.73
		Lesser golden-plover	3	3.33	5.77
		Semipalmated sandpiper	3	10.00	17.32
		Pectoral sandpiper	3	6.67	5.77
		Lapland longspur	3	16.67	15.28
	1985	Total nests	3	30.00	26.46
		Total species (4)	3	2.00	1.73
		Rock ptarmigan	3	6.67	5.77
		Lesser golden-plover	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	16.67	15.28
Riparian	1982	Total nests	2	100.00	14.14
		Total species (6)	2	4.50	0.71
		Lesser golden-plover	2	10.00	0.00
		Semipalmated sandpiper	2	25.00	21.21
		Yellow wagtail	2	5.00	7.07
		American tree sparrow	2	10.00	14.14
		Lapland longspur	2	30.00	28.28
		Redpoll spp	2	20.00	28.28
	1983	Total nests	3	53.33	30.55
		Total species (6)	3	3.67	1.53
		Lesser golden-plover	3	3.33	5.77
		Ruddy turnstone	3	3.33	5.77
		Semipalmated sandpiper	3	13.33	5.77
		American tree sparrow	3	3.33	5.77
		Lapland longspur	3	16.67	5.77
		Redpoll spp	3	13.33	11.55
	1985	Total nests	3	43.33	11.55
		Total species (5)	3	3.67	1.15
		Semipalmated sandpiper	3	3.33	5.77
		Buff-breasted sandpiper	3	3.33	5.77
		American tree sparrow	3	3.33	5.77
		Lapland longspur	3	6.67	5.77
		Redpoll spp	3	13.33	5.77
		Jago Bitty			
Wet Sedge	1983	Total nests	3	26.67	11.55
		Total species (3)	3	2.00	1.00
		Pectoral sandpiper	3	13.33	5.77
		Parasitic jaeger	3	3.33	5.77
		Lapland longspur	3	10.00	10.00
	1985	Total nests	3	56.67	40.41
		Total species (8)	3	4.00	2.65
		Northern pintail	3	3.33	5.77
		Willow ptarmigan	3	10.00	10.00

Appendix Table VII. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Jago Bitty Continued.			
Wet Sedge	1985	Rock ptarmigan	3	3.33	5.77
		Pectoral sandpiper	3	16.67	15.28
		Stilt sandpiper	3	3.33	5.77
		Red-necked phalarope	3	3.33	5.77
		Long-tailed jaeger	3	3.33	5.77
		Lapland longspur	3	13.33	5.77
Moist Sedge	1983	Total nests	3	33.33	5.77
		Total species (3)	3	2.00	1.00
		Lesser golden-plover	3	3.33	5.77
		Pectoral sandpiper	3	10.00	10.00
		Lapland longspur	3	20.00	17.32
	1985	Total nests	3	36.67	5.77
		Total species (6)	3	2.67	0.58
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Pectoral sandpiper	3	3.33	5.77
		Stilt sandpiper	3	3.33	5.77
		Buff-breasted sandpiper	3	3.33	5.77
		Lapland longspur	3	20.00	0.00
Moist Sedge-Shrub	1983	Total nests	3	56.67	46.19
		Total species (4)	3	2.67	1.53
		Willow ptarmigan	3	3.33	5.77
		Semipalmated sandpiper	3	10.00	10.00
		Pectoral sandpiper	3	20.00	26.46
		Lapland longspur	3	23.33	11.55
	1985	Total nests	3	46.67	5.77
		Total species (5)	3	3.00	1.00
		Willow ptarmigan	3	6.67	5.77
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	6.67	5.77
		Semipalmated sandpiper	3	13.33	15.28
		Lapland longspur	3	16.67	15.28
Tussock	1983	Total nests	3	30.00	20.00
		Total species (6)	3	2.00	1.00
		Willow ptarmigan	3	3.33	5.77
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Semipalmated sandpiper	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	13.33	23.09
	1985	Total nests	3	36.67	23.09
		Total species (4)	3	2.00	1.00
		Willow ptarmigan	3	3.33	5.77
		Rock ptarmigan	3	6.67	11.55
		Lesser golden-plover	3	3.33	5.77
		Lapland longspur	3	23.33	11.55
Riparian	1983	Total nests	3	43.33	5.77
		Total species (5)	3	3.00	1.00
		Northern pintail	3	6.67	5.77
		Semipalmated sandpiper	3	10.00	10.00
		Savannah sparrow	3	13.33	15.28
		Lapland longspur	3	10.00	10.00
		Redpoll spp	3	3.33	5.77

Appendix Table VII. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Aichilik Continued.			
Riparian	1985	Total nests	3	83.33	28.87
		Total species (8)	3	4.33	2.52
		Northern pintail	3	3.33	5.77
		Willow ptarmigan	3	6.67	11.55
		Rock ptarmigan	3	10.00	10.00
		Semipalmated sandpiper	3	23.33	15.28
		Short-eared owl	3	6.67	11.55
		American tree sparrow	3	3.33	5.77
		Lapland longspur	3	26.67	5.77
		Redpoll spp	3	3.33	5.77
Wet Sedge	1984	Total nests	3	23.33	5.77
		Total species (3)	3	1.67	0.58
		Pectoral sandpiper	3	3.33	5.77
		Long-tailed jaeger	3	3.33	5.77
		Lapland longspur	3	16.67	5.77
	1985	Total nests	3	16.67	11.55
		Total species (3)	3	1.67	1.15
		Pectoral sandpiper	3	10.00	0.00
		Stilt sandpiper	3	3.33	5.77
		Lapland longspur	3	3.33	5.77
Moist Sedge	1984	Total nests	3	30.00	17.32
		Total species (2)	3	1.67	0.58
		Lesser golden-plover	3	10.00	10.00
		Lapland longspur	3	20.00	10.00
	1985	Total nests	3	20.00	10.00
		Total species (2)	3	1.33	0.58
		Lesser golden-plover	3	6.67	11.55
		Lapland longspur	3	13.33	5.77
Moist Sedge-Shrub	1984	Total nests	3	30.00	17.32
		Total species (3)	3	1.67	0.58
		Pectoral sandpiper	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	23.33	15.28
	1985	Total nests	3	53.33	20.82
		Total species (4)	3	2.33	0.58
		Semipalmated sandpiper	3	3.33	5.77
		Pectoral sandpiper	3	20.00	17.32
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	26.67	11.55
Tussock	1984	Total nests	3	36.67	30.55
		Total species (4)	3	2.00	1.73
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	6.67	11.55
		Pectoral sandpiper	3	10.00	10.00
		Lapland longspur	3	16.67	15.28
	1985	Total nests	3	53.33	23.09
		Total species (7)	3	4.33	0.58
		Rock ptarmigan	3	6.67	5.77
		Lesser golden-plover	3	16.67	11.55
		Semipalmated sandpiper	3	3.33	5.77
		Pectoral sandpiper	3	10.00	10.00
		Red-necked phalarope	3	3.33	5.77
		Short-eared owl	3	3.33	5.77
		Lapland longspur	3	10.00	0.00

Appendix Table VII. Continued.

LOCATION					
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Aichilik Continued.			
Riparian	1984	Total nests	3	33.33	15.28
		Total species (6)	3	3.00	1.73
		Lesser golden-plover	3	10.00	10.00
		Ruddy turnstone	3	3.33	5.77
		Semipalmated sandpiper	3	3.33	5.77
		Buff-breasted sandpiper	3	6.67	5.77
		Lapland longspur	3	6.67	5.77
		Redpoll spp	3	3.33	5.77
	1985	Total nests	3	53.33	25.17
		Total species (5)	3	2.67	1.53
		Lesser golden-plover	3	10.00	10.00
		Baird's sandpiper	3	3.33	5.77
		Buff-breasted sandpiper	3	6.67	5.77
		Lapland longspur	3	10.00	17.32
		Redpoll spp	3	23.33	20.82
		Sadlerochit			
Wet Sedge	1984	Total nests	3	40.00	20.00
		Total species (4)	3	2.33	0.58
		Long-billed dowitcher	3	3.33	5.77
		Parasitic jaeger	3	3.33	5.77
		Savannah sparrow	3	6.67	5.77
		Lapland longspur	3	26.67	15.28
	1985	Total nests	3	60.00	0.00
		Total species (6)	3	3.33	0.58
		Pectoral sandpiper	3	20.00	10.00
		Long-billed dowitcher	3	3.33	5.77
		Red-necked phalarope	3	3.33	5.77
		Parasitic jaeger	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	26.67	11.55
Mosaic	1984	Total nests	3	70.00	10.00
		Total species (5)	3	4.00	1.00
		Oldsquaw	3	3.33	5.77
		Lesser golden-plover	3	6.67	5.77
		Semipalmated sandpiper	3	23.33	11.55
		Pectoral sandpiper	3	13.33	5.77
		Lapland longspur	3	23.33	5.77
	1985	Total nests	3	50.00	26.46
		Total species (4)	3	2.67	0.58
		Lesser golden-plover	3	6.67	5.77
		Semipalmated sandpiper	3	16.67	15.28
		Pectoral sandpiper	3	3.33	5.77
		Lapland longspur	3	23.33	23.09
Moist Sedge-Shrub	1984	Total nests	3	56.67	11.55
		Total species (4)	3	2.33	1.15
		Semipalmated sandpiper	3	16.67	15.28
		Pectoral sandpiper	3	3.33	5.77
		Red-necked phalarope	3	3.33	5.77
		Lapland longspur	3	33.33	15.28
	1985	Total nests	3	56.67	11.55
		Total species (4)	3	2.67	0.58
		Rock ptarmigan	3	6.67	11.55
		Semipalmated sandpiper	3	23.33	15.28
		Long-tailed jaeger	3	3.33	5.77
		Lapland longspur	3	23.33	5.77

Appendix Table VII. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Sadlerochit Continued.			
Tussock	1984	Total nests	3	36.67	20.82
		Total species (6)	3	2.67	1.53
		Northern pintail	3	3.33	5.77
		Rock ptarmigan	3	3 33	5.77
		Lesser golden-plover	3	3.33	5.77
		Pectoral sandpiper	3	6.67	5.77
		Long-tailed jaeger	3	3.33	5.77
		Lapland longspur	3	16.67	15.28
	1985	Total nests	3	56.67	20.82
		Total species (4)	3	2.67	1.15
		Rock ptarmigan	3	6.67	11.55
		Lesser golden-plover	3	10.00	0.00
		Pectoral sandpiper	3	6.67	11.55
		Lapland longspur	3	33.33	5.77
Riparian	1984	Total nests	3	63.33	68.07
		Total species (6)	3	3.00	1.73
		Common eider	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Semipalmated sandpiper	3	30.00	43.59
		Pectoral sandpiper	3	3.33	5.77
		Savannah longspur	3	3.33	5.77
		Lapland longspur	3	20.00	17.32
	1985	Total nests	4	62.50	26.30
		Total species (9)	4	4.25	0.50
		Rock ptarmigan	4	2.50	5.00
		Lesser golden-plover	4	5.00	5.77
		Ruddy turnstone	4	5.00	5.77
		Semipalmated sandpiper	4	17.50	22.17
		Baird's sandpiper	4	2.50	5.00
		Pectoral sandpiper	4	5.00	5.77
		Long-billed dowitcher	4	2.50	5.00
		Lapland longspur	4	17.50	9.57
		Redpoll spp.	4	5.00	10.00
		Jago Delta			
Flooded	1984	Total nests	3	46.67	5.77
		Total species (4)	3	3.00	1.00
		Oldsquaw	3	3.33	5.77
		Pectoral sandpiper	3	10.00	10.00
		Red phalarope	3	10.00	0.00
		Lapland longspur	3	23.33	5.77
	1985	Total nests	3	20.00	10.00
		Total species (5)	3	2.00	1.00
		Northern pintail	3	3.33	5.77
		Oldsquaw	3	3.33	5.77
		Pectoral sandpiper	3	6.67	5.77
		Long-billed dowitcher	3	3.33	5.77
		Lapland longspur	3	3.33	5.77
Wet Sedge	1984	Total nests	3	36.67	15.28
		Total species (3)	3	2.33	0.58
		Semipalmated sandpiper	3	10.00	0.00
		Stilt sandpiper	3	3.33	5.77
		Lapland longspur	3	23.33	11.55
	1985	Total nests	3	36.67	11.55
		Total species (4)	3	2.67	0.58
		Lesser golden-plover	3	6.67	5.77
		Semipalmated sandpiper	3	6.67	5.77
		Buff-breasted sandpiper	3	13.33	15.28
		Lapland longspur	3	10.00	10.00

Appendix Table VII. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Jago Delta Continued.			
Mosaic	1984	Total nests	3	86.67	30.55
		Total species (5)	3	3.33	0.58
		Northern pintail	3	3.33	5.77
		Semipalmated sandpiper	3	6.67	5.77
		Pectoral sandpiper	3	40.00	10.00
		Red-necked phalarope	3	3.33	5.77
		Lapland longspur	3	33.33	25.17
	1985	Total nests	3	36.67	15.28
		Total species (7)	3	3.67	1.53
		Northern pintail	3	6.67	5.77
		Oldsquaw	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Semipalmated sandpiper	3	3.33	5.77
		Pectoral sandpiper	3	6.67	5.77
		Long-tailed jaeger	3	3.33	5.77
		Lapland longspur	3	10.00	0.00
Moist Sedge-Shrub	1984	Total nests	3	50.00	10.00
		Total species (6)	3	3.33	1.15
		Northern pintail	3	3.33	5.77
		Semipalmated sandpiper	3	6.67	5.77
		Pectoral sandpiper	3	6.67	5.77
		Dunlin	3	3.33	5.77
		Buff-breasted sandpiper	3	3.33	5.77
		Lapland longspur	3	26.67	20.82
	1985	Total nests	3	46.67	15.28
		Total species (5)	3	2.67	0.58
		Northern pintail	3	3.33	5.77
		Lesser golden-plover	3	10.00	10.00
		Semipalmated sandpiper	3	3.33	5.77
		Short-eared owl	3	3.33	5.77
		Lapland longspur	3	26.67	15.28
Riparian	1984	Total nests	3	20.00	17.32
		Total species (4)	3	1.67	1.53
		Northern pintail	3	3.33	5.77
		Semipalmated sandpiper	3	3.33	5.77
		Ruddy turnstone	3	6.67	5.77
		Lapland longspur	3	6.67	11.55
	1985	Total nests	3	26.67	11.55
		Total species (4)	3	2.00	0.00
		Lesser golden-plover	3	3.33	5.77
		Ruddy turnstone	3	16.67	11.55
		Baird's sandpiper	3	3.33	5.77
		Lapland longspur	3	3.33	5.77
		Marsh Creek			
Moist Sedge	1985	Total nests	3	13.33	15.28
		Total species (2)	3	1.00	1.00
		Willow ptarmigan	3	3.33	5.77
		Lapland longspur	3	10.00	10.00
Moist Sedge-Shrub	1985	Total nests	3	20.00	10.00
		Total species (3)	3	1.67	1.15
		Willow ptarmigan	3	3.33	5.77
		Savannah sparrow	3	3.33	5.77
		Lapland longspur	3	13.33	5.77

Appendix Table VII. Continued.

		LOCATION			
Habitat	Year	Species	Sample Size	Mean	± S.D.
		Marsh Creek Continued.			
Tussock	1985	Total nests	3	16.67	11.55
		Total species (3)	3	1.33	0.58
		Willow ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Lapland longspur	3	10.00	10.00
Riparian	1985	Total nests	3	70.00	17.32
		Total species (11)	3	5.67	0.58
		Willow ptarmigan	3	3.33	5.77
		Rock ptarmigan	3	6.67	5.77
		Lesser golden-plover	3	6.67	11.55
		Ruddy turnstone	3	10.00	10.00
		Pectoral sandpiper	3	3.33	5.77
		Long-tailed jaeger	3	3.33	5.77
		Yellow wagtail	3	3.33	5.77
		American tree sparrow	3	3.33	5.77
		White-crowned sparrow	3	10.00	10.00
		Lapland longspur	3	10.00	10.00
		Redpoll spp	3	10.00	0.00
		Niguanak			
Flooded	1985	Total nests	3	63.33	25.17
		Total species (7)	3	3.67	1.53
		Oldsquaw	3	3.33	5.77
		Rock ptarmigan	3	3.33	5.77
		Pectoral sandpiper	3	20.00	10.00
		Long-billed dowitcher	3	3.33	5.77
		Red-necked phalarope	3	16.67	15.28
		Red phalarope	3	3.33	5.77
		Lapland longspur	3	13.33	11.55
Wet Sedge	1985	Total nests	3	36.67	32.15
		Total species (6)	3	2.67	2.31
		Lesser golden-plover	3	10.00	10.00
		Semipalmated sandpiper	3	3.33	5.77
		Pectoral sandpiper	3	3.33	5.77
		Stilt sandpiper	3	3.33	5.77
		Short-eared owl	3	3.33	5.77
		Lapland longspur	3	13.33	11.55
Moist Sedge-Shrub	1985	Total nests	3	90.00	26.46
		Total species (5)	3	3.00	1.00
		Oldsquaw	3	3.33	5.77
		Willow ptarmigan	3	3.33	5.77
		Pectoral sandpiper	3	33.33	5.77
		Red-necked phalarope	3	3.33	5.77
		Lapland longspur	3	46.67	11.55
Tussock	1985	Total nests	3	46.67	15.28
		Total species (5)	3	2.33	0.58
		Willow ptarmigan	3	3.33	5.77
		Rock ptarmigan	3	3.33	5.77
		Lesser golden-plover	3	3.33	5.77
		Pectoral sandpiper	3	3.33	5.77
		Lapland longspur	3	33.33	11.55

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[a] Mean densities and mean number of nesting species were means of counts from all replicate plots at each location in each habitat (see text).

[b] Value in parentheses refers to total number of species observed nesting on all replicate plots.

Appendix Table VIII. Error mean squares (plots within locations) by habitat and season for bird density data collected on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Season	Variable	Habitat[a]	Error Mean Square
Reproductive	Total birds	II	114.74
		III	22.08
		IV	6.74
		IVa	17.99
		V	10.78
		VI	11.36
		IX	225.06
	Total species	II	1.49
		III	1.18
		IV	0.73
		IVa	1.09
		VI	0.85
		IX	1.19
	Lapland longspur	II	3.12
		III	2.42
		IV	1.33
		IVa	18.78
		V	3.60
		VI	3.14
		IX	108.31
	Pectoral sandpiper	II	4.11
		III	5.98
		IV	0.04
		IVa	1.60
		V	1.58
		VI	0.56
		IX	0.97
	Semipalmated sandpiper	II	0.64
		III	0.44
		IV	0.02
		IVa	0.64
		V	1.23
		VI	0.31
		IX	3.51
	Lesser golden-plover	II	0.48
		III	0.24
		IV	0.19
		IVa	0.11
		V	0.11
		VI	0.34
		IX	3.03
	Red-necked phalarope	II	20.33
		III	0.43
		IV	0
		IVa	0.09
		V	0.21
		VI	0.04
		IX	0.01

Appendix Table VIII. Continued.

Season	Variable	Habitat	Error Mean Square
Post-reproductive	Total Birds	II	38.70
		III	17.95
		IV	51.42
		IVa	156.19
		V	75.13
		VI	13.81
		IX	279.53
	Total species	II	2.60
		III	0.49
		IV	1.83
		IVa	1.59
		V	1.20
		VI	0.19
		IX	1.16
	Lapland longspur	II	2.80
		III	8.22
		IV	8.10
		IVa	42.10
		V	30.86
		VI	4.12
		IX	80.91
	Pectoral sandpiper	II	71.06
		III	4.62
		IV	0.66
		IVa	2.09
		V	1.93
		VI	0.64
		IX	0.93
	Semipalmated sandpiper	II	1.62
		III	0
		IV	0
		IVa	0.15
		V	0.08
		VI	0
		IX	2.22
	Lesser golden-plover	II	1.17
		III	0.06
		IV	4.40
		IVa	0.10
		V	1.35
		VI	0.87
		IX	6.37
	Red-necked phalarope	II	5.11
		III	0.01
		IV	0.01
		IVa	0.12
		V	0.02
		VI	0
		IX	0.01

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[a] II = Flooded, III = Wet Sedge, IV = Moist Sedge, IVa = Mosaic, V = Moist Sedge-Shrub, VI = Tussock, X = Riparian

Appendix Table IX. Error mean squares (plots within location) by season and habitat for nest density data collected on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Variable	Habitat[a]	Error Mean Square
Total nests	II	1255.56
	III	511.11
	IV	133.33
	IVa	423.81
	V	248.89
	VI	427.78
	IX	472.44
Total species	II	1.44
	III	2.44
	IV	0.55
	IVa	1.15
	V	0.76
	VI	1.06
	IX	1.65
Lapland longspur	II	66.67
	III	88.89
	IV	26.19
	IVa	223.81
	V	120.00
	VI	105.56
	IX	98.08
Pectoral sandpiper	II	44.44
	III	61.11
	IV	9.52
	IVa	33.33
	V	44.44
	VI	44.44
	IX	12.82
Semipalmated sandpiper	II	0
	III	11.11
	IV	0
	IVa	76.19
	V	71.11
	VI	5.56
	IX	149.36
Lesser golden-plover	II	0
	III	22.22
	IV	54.76
	IVa	29.76
	V	17.78
	VI	44.44
	IX	48.72
Red-necked phalarope	II	88.89
	III	16.67
	IV	0
	IVa	0
	V	8.89
	VI	5.56
	IX	0

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[a] II = Flooded, III = Wet Sedge, IV = Moist Sedge, IVa = Mosaic, V = Moist Sedge-Shrub, VI = Tussock, IX = Riparian.

Appendix Table X. Significance levels of ANOVA's testing differences among habitats, seasons, and their interactions over pooled locations for bird data and among habitats over pooled locations for nest density data collected on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Bird Variable	TREATMENT EFFECT Habitat	Season	Interaction (Hab x Seas)
Total birds	$P < 0.001$	$P = 0.125$	$P < 0.001$
Total species	$P < 0.001$	$P < 0.001$	$P < 0.001$
Lapland longspur	$P < 0.001$	$P = 0.030$	$P = 0.053$
Pectoral sandpiper	$P < 0.001$	$P < 0.001$	$P < 0.001$
Semipalmated sandpiper	$P < 0.001$	$P < 0.001$	$P < 0.001$
Lesser golden-plover	$P < 0.001$	$P = 0.356$	$P = 0.127$
Red-necked phalarope	$P < 0.001$	$P < 0.001$	$P < 0.001$
Nest Variable			
Total nests	$P = 0.016$	-	-
Total species	$P = 0.002$	-	-
Lapland longspur	$P = 0.002$	-	-
Pectoral sandpiper	$P = 0.123$	-	-
Semipalmated sandpiper	$P = 0.068$	-	-
Lesser golden-plover	$P = 0.145$	-	-
Red-necked phalarope	$P < 0.001$	-	-

Appendix Table XI. Significance levels for ANOVA's testing differences among locations, seasons, and their interactions within habitats for bird density data collected on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Variable	Habitat[a]	Location	Season	Location x Season
Total birds	II	P = 0.009	P = 0.074	P = 0.047
	III	P < 0.001	P < 0.001	P = 0.037
	IV	P = 0.046	P = 0.024	P = 0.093
	IVa	P = 0.457	P = 0.701	P = 0.696
	V	P = 0.019	P = 0.230	P = 0.136
	VI	P = 0.005	P = 0.229	P = 0.006
	IX	P = 0.004	P = 0.005	P = 0.015
Total species	II	P = 0.153	P = 0.090	P = 0.430
	III	P = 0.015	P < 0.001	P = 0.034
	IV	P = 0.044	P = 0.486	P = 0.023
	IVa	P = 0.172	P = 0.001	P = 0.930
	V	P = 0.002	P < 0.001	P = 0.693
	VI	P < 0.001	P < 0.001	P = 0.064
	IX	P < 0.001	P = 0.001	P = 0.075
Lapland longspur	II	P = 0.707	P = 0.001	P = 0.558
	III	P < 0.001	P < 0.001	P = 0.165
	IV	P = 0.040	P = 0.322	P = 0.215
	IVa	P = 0.399	P = 0.087	P = 0.728
	V	P = 0.025	P = 0.476	P = 0.182
	VI	P = 0.006	P = 0.003	P = 0.028
	IX	P = 0.006	P = 0.265	P = 0.122
Pectoral sandpiper	II	P = 0.014	P < 0.001	P = 0.015
	III	P = 0.056	P < 0.001	P = 0.047
	IV	P = 0.007	P = 0.055	P = 0.023
	IVa	P = 0.015	P = 0.021	P = 0.174
	V	P < 0.001	P = 0.012	P < 0.001
	VI	P = 0.006	P = 0.369	P = 0.002
	IX	P = 0.001	P = 0.329	P = 0.968
Semipalmated sandpiper	II	P = 0.254	P = 0.496	P = 0.130
	III	P = 0.052	P = 0.011	P = 0.052
	IV	P = 0.639	P = 0.275	P = 0.639
	IVa	P = 0.013	P = 0.003	P = 0.008
	V	P = 0.013	P = 0.004	P = 0.041
	VI	P = 0.460	P = 0.097	P = 0.460
	IX	P < 0.001	P < 0.001	P < 0.001
Lesser golden-plover	II	P = 0.352	P = 0.099	P = 0.034
	III	P = 0.175	P = 0.135	P = 0.049
	IV	P = 0.275	P = 0.147	P = 0.272
	IVa	P = 0.180	P = 0.020	P = 0.523
	V	P = 0.080	P = 0.823	P = 0.667
	VI	P = 0.031	P = 0.244	P = 0.243
	IX	P = 0.393	P = 0.877	P = 0.633
Red-necked phalarope	II	P = 0.122	P = 0.016	P = 0.150
	III	P = 0.075	P = 0.004	P = 0.045
	IV	P = 0.510	P = 0.407	P = 0.510
	IVa	P = 0.865	P = 0.001	P = 0.072
	V	P = 0.149	P = 0.006	P = 0.117
	VI	P = 0.039	P = 0.091	P = 0.039
	IX	P = 0.409	P = 0.614	P = 0.733

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[a] II = Flooded, III = Wet Sedge, IV = Moist Sedge, IVa = Mosaic, V = Moist Sedge-Shrub, VI = Tussock, IX = Riparian

Appendix Table XII. Significance levels of ANOVA's testing differences among habitats, years, and their interactions for bird density data collected during the reproductive season[a] at seven locations on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1982-1985.

Variable	Treatment Effect	Okpilak	Katakturuk	Jago Bitty	Aichilik	Sadlerochit	Jago Delta
Total birds	Habitat	$P = 0.004$	$P < 0.001$	$P = 0.001$	$P < 0.001$	$P = 0.017$	$P = 0.012$
	Year	$P = 0.333$	$P = 0.120$	$P = 0.029$	$P < 0.001$	$P < 0.000$	$P = 0.278$
	Hab x Year	$P = 0.030$	$P = 0.033$	$P = 0.233$	$P < 0.003$	$P < 0.001$	$P = 0.003$
Total species	Habitat	$P = 0.004$	$P = 0.010$	$P = 0.011$	$P < 0.001$	$P < 0.001$	$P = 0.001$
	Year	$P = 0.709$	$P = 0.239$	$P < 0.001$	$P = 0.457$	$P < 0.001$	$P = 0.013$
	Hab x Year	$P = 0.004$	$P = 0.652$	$P = 0.014$	$P = 0.035$	$P = 0.002$	$P = 0.496$
Lapland longspur	Habitat	$P = 0.007$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P = 0.045$	$P = 0.002$
	Year	$P = 0.001$	$P = 0.242$	$P = 0.295$	$P < 0.001$	$P < 0.001$	$P < 0.001$
	Hab x Year	$P = 0.244$	$P = 0.142$	$P = 0.132$	$P = 0.027$	$P = 0.003$	$P = 0.002$
Pectoral sandpiper	Habitat	$P = 0.006$	$P = 0.144$	$P < 0.001$	$P = 0.001$	$P < 0.001$	$P < 0.001$
	Year	$P = 0.340$	$P = 0.242$	$P = 0.003$	$P < 0.001$	$P = 0.734$	$P = 0.119$
	Hab x Year	$P = 0.007$	$P = 0.689$	$P = 0.094$	$P < 0.001$	$P = 0.328$	$P = 0.380$
Semipalmated sandpiper	Habitat	$P = 0.280$	$P = 0.001$	$P = 0.025$	$P = 0.434$	$P < 0.001$	$P = 0.646$
	Year	$P = 0.334$	$P = 0.149$	$P = 0.340$	$P = 0.120$	$P = 0.300$	$P = 0.749$
	Hab x Year	$P = 0.007$	$P = 0.005$	$P = 0.404$	$P = 0.019$	$P = 0.853$	$P = 0.120$
Lesser golden-plover	Habitat	$P = 0.001$	$P = 0.230$	$P = 0.121$	$P = 0.001$	$P = 0.015$	$P = 0.351$
	Year	$P = 0.068$	$P = 0.248$	$P = 0.721$	$P = 0.051$	$P = 0.289$	$P = 0.152$
	Hab x Year	$P = 0.044$	$P = 0.954$	$P = 0.882$	$P = 0.845$	$P = 0.032$	$P = 0.402$
Red-necked phalarope	Habitat	$P = 0.021$	$P = 0.641$	$P = 0.076$	$P < 0.001$	$P = 0.042$	$P = 0.002$
	Year	$P = 0.327$	$P = 0.517$	$P = 0.034$	$P = 0.090$	$P = 0.900$	$P = 0.301$
	Hab x Year	$P = 0.323$	$P = 0.641$	$P = 0.132$	$P = 0.016$	$P = 0.598$	$P = 0.331$

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[a] Reproductive season included censuses 2-5: those common at all locations in all years.

Appendix Table XIII. Significance levels of ANOVA's testing differences among habitats, years, and their interactions for nest density data collected at 7 locations on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1982-1985.

Variable	Treatment Effect	Okpilak	Katakturuk	Jago Bitty	Aichilik	Sadlerochit	Jago Delta
Total nests	Habitat	P = 0.466	P = 0.267	P = 0.271	P = 0.287	P = 0.828	P = 0.017
	Year	P = 0.377	P = 0.896	P = 0.129	P = 0.099	P = 0.526	P = 0.024
	Hab x year	P = 0.266	P = 0.672	P = 0.380	P = 0.144	P = 0.532	P = 0.047
Total species	Habitat	P = 0.082	P = 0.095	P = 0.582	P = 0.130	P = 0.457	P = 0.063
	Year	P = 0.713	P = 0.559	P = 0.047	P = 0.215	P = 0.403	P = 0.739
	Hab x year	P = 0.188	P = 0.719	P = 0.510	P = 0.168	P = 0.129	P = 0.698
Lapland longspur	Habitat	P = 0.062	P = 0.387	P = 0.673	P = 0.145	P = 0.911	P = 0.261
	Year	P = 0.189	P = 0.459	P = 0.387	P = 0.314	P = 0.739	P = 0.006
	Hab x year	P = 0.580	P = 0.138	P = 0.666	P = 0.589	P = 0.362	P = 0.221
Pectoral sandpiper	Habitat	P = 0.278	P = 0.389	P = 0.138	P = 0.159	P = 0.357	P < 0.001
	Year	P = 0.317	P = 0.191	P = 0.244	P = 0.033	P = 0.387	P = 0.002
	Hab x year	P = 0.763	P = 0.389	P = 0.362	P = 0.072	P = 0.016	P = 0.002
Semipalmated sandpiper	Habitat		P = 0.421	P = 0.026	P = 0.737	P = 0.288	P = 0.055
	Year	no nests	P = 0.174	P = 0.368	P = 0.577	P = 0.569	P = 0.114
	Hab x year		P = 0.421	P = 0.439	P = 0.382	P = 0.591	P = 0.737
Lesser golden-plover	Habitat	P = 0.290	P = 0.546	P = 0.452	P = 0.245	P = 0.139	P = 0.415
	Year	P = 0.197	P = 0.743	P = 0.341	P = 0.467	P = 0.073	P = 0.017
	Hab x year	P = 0.430	P = 0.950	P = 0.452	P = 0.239	P = 0.034	P = 0.415
Red-necked phalarope	Habitat	P = 0.025	P = 0.641	P = 0.452	P = 0.452	P = 0.580	P = 0.452
	Year	P = 0.161	P = 0.517	P = 0.341	P = 0.341	P = 0.999	P = 0.341
	Hab x year	P = 0.226	P = 0.641	P = 0.452	P = 0.452	P = 0.351	P = 0.452

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SPECIES ACCOUNTS OF BIRDS OBSERVED AT EIGHT STUDY AREAS ON THE COASTAL PLAIN OF THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1985

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Key words: Anseriformes, Charadriiformes, Passeriformes, Falconiformes, Strigiformes, Galliformes, waterfowl, shorebirds, songbirds, ptarmigan, raptors, tundra, wetlands, species accounts, habitat use, status and distribution, Arctic-Beaufort, north slope

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15 December 1986

Species accounts of birds observed at eight study areas on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

The following species accounts describe status, breeding chronology, migration, and habitat use of bird species at 8 locations (Figs. 1-9) on the coastal plain of the Arctic National Wildlife Refuge (ANWR) where intensive investigations of terrestrial bird populations and habitat use occurred during June-August 1985 (Oates et al. 1987).

Study area maps and descriptions were presented in Spindler and Miller (1983) Spindler et al. (1984), Moitoret et al. (1985), Oates et al. (1987). Bird breeding chronology, behavior, status, and distribution data were recorded daily during the field season. Field work in the study areas was carried out between 1 June and 30 August. First and last dates of observations and first dates of hatching of young may not be all inclusive.

The following status and abundance categories (Kessel and Gibson 1978) were used: resident, migrant, breeder, visitant and abundant, common, fairly common, uncommon, rare, casual, accidental. Species accounts are presented in phylogenetic order, and use nomenclature of the American Ornithologist's Union (1983). Two redpoll species (common redpoll and hoary redpoll) were lumped for purposes of this report because of difficult field identification and because several investigators have considered them to be conspecific (Williamson 1961, Troy 1980). Habitat types used in this report were described by Walker et al. (1982) with modifications described in Moitoret et al. (1985, Table 1); the classification categories are capitalized in the text.

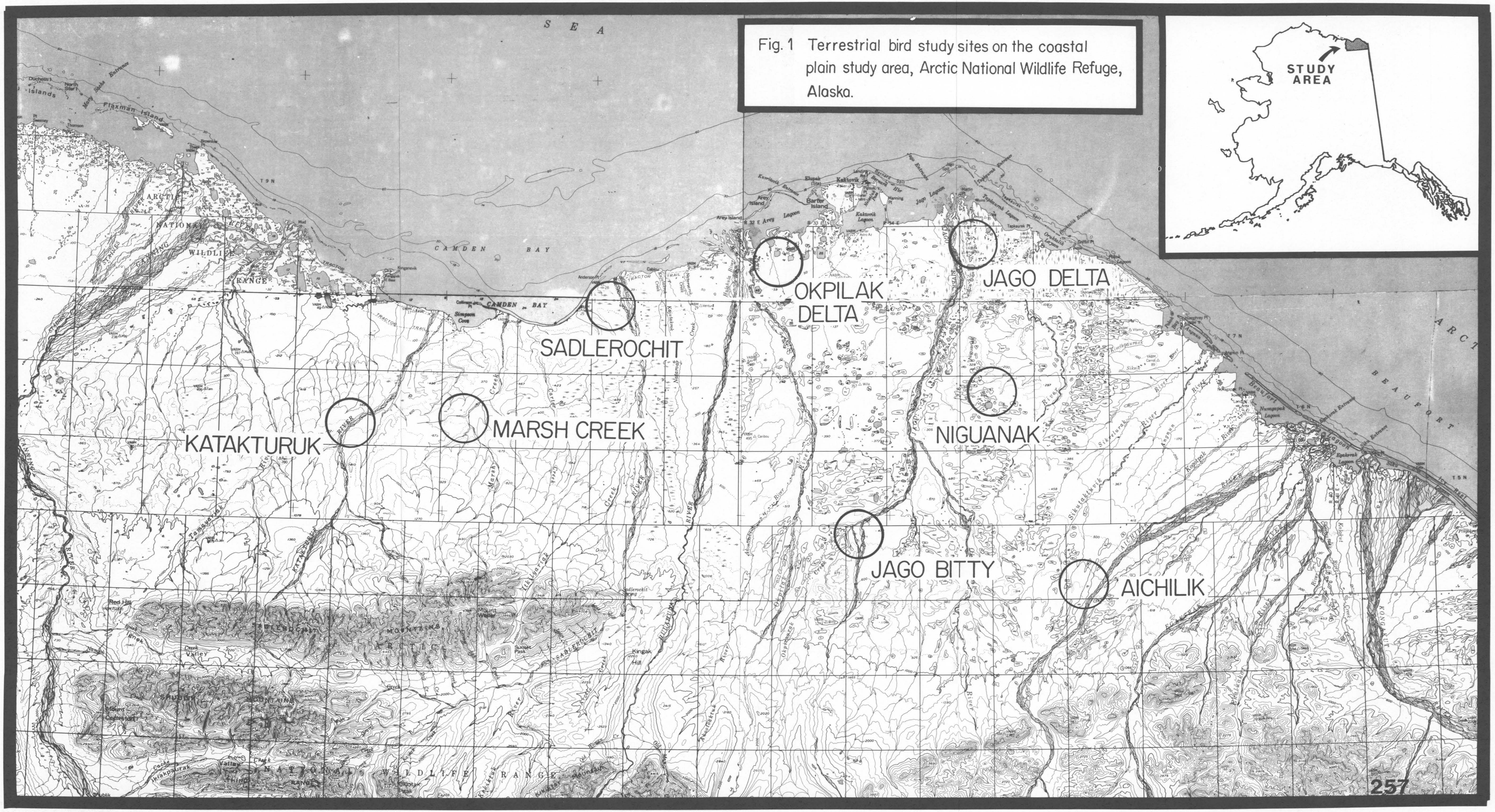

Fig. 1 Terrestrial bird study sites on the coastal plain study area, Arctic National Wildlife Refuge, Alaska.

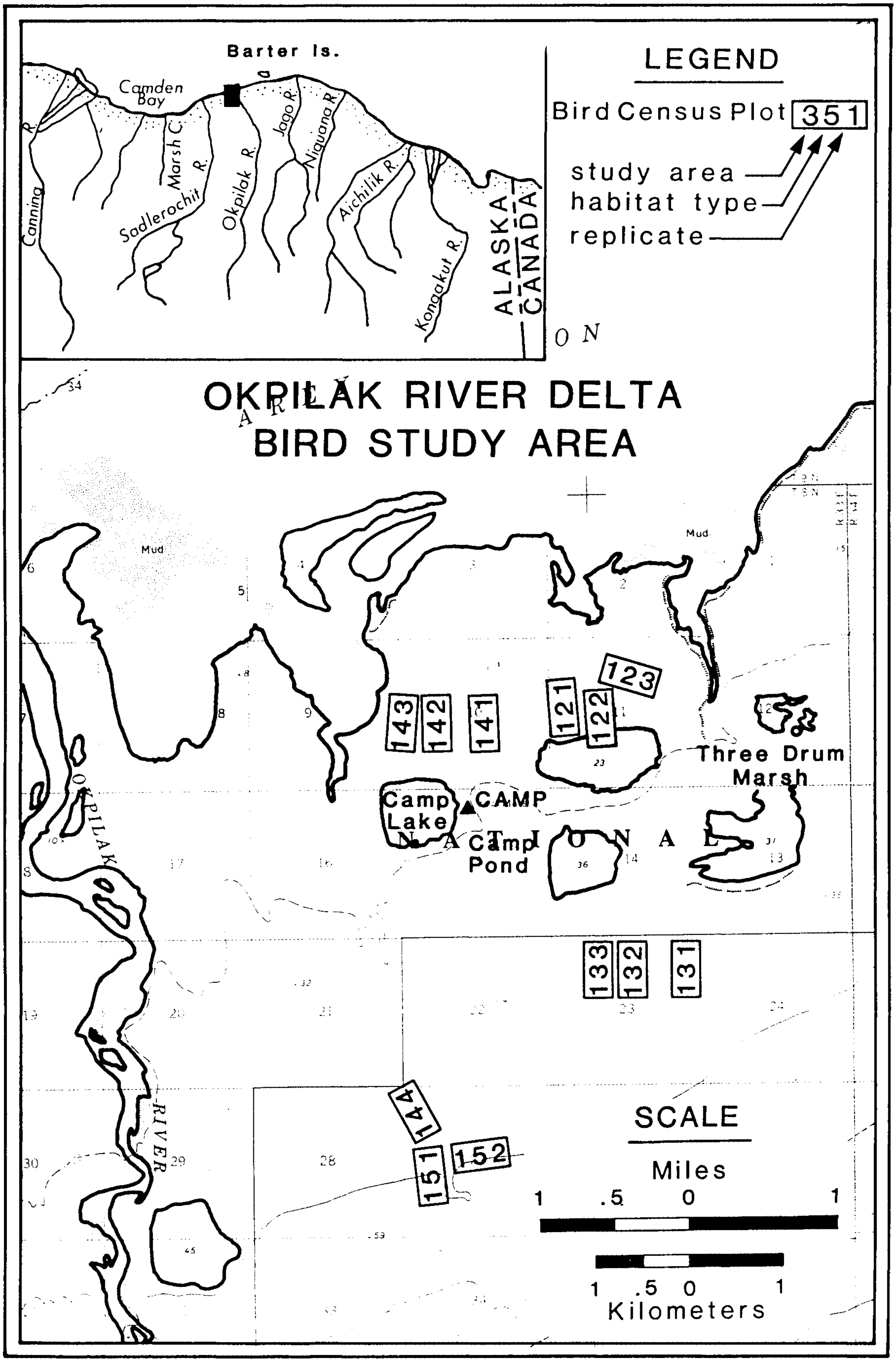

Fig. 2. Okpilak River Delta study area, Arctic National Wildlife Refuge, Alaska.

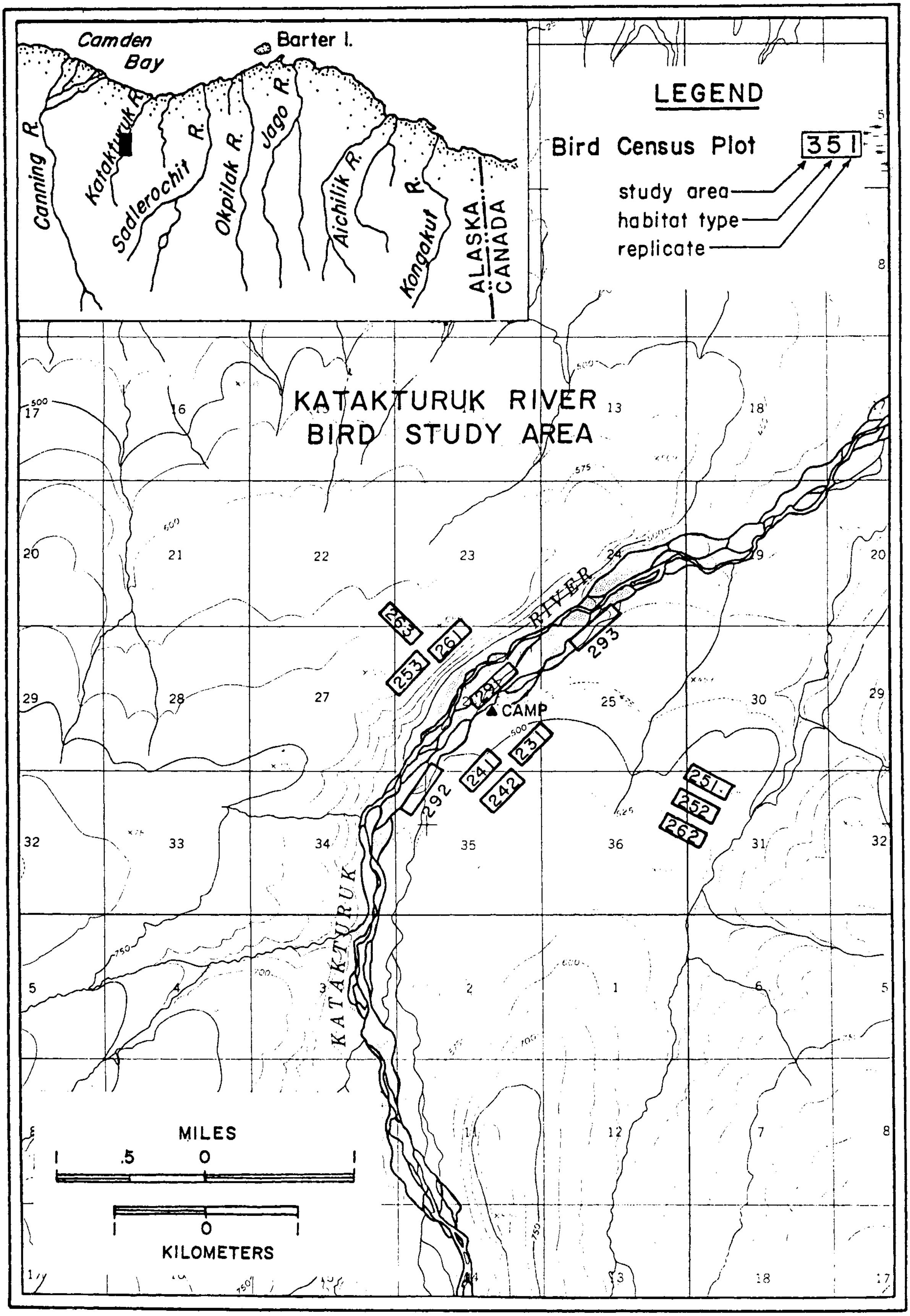

Fig. 3. Katakturuk River study area, Arctic National Wildlife Refuge, Alaska.

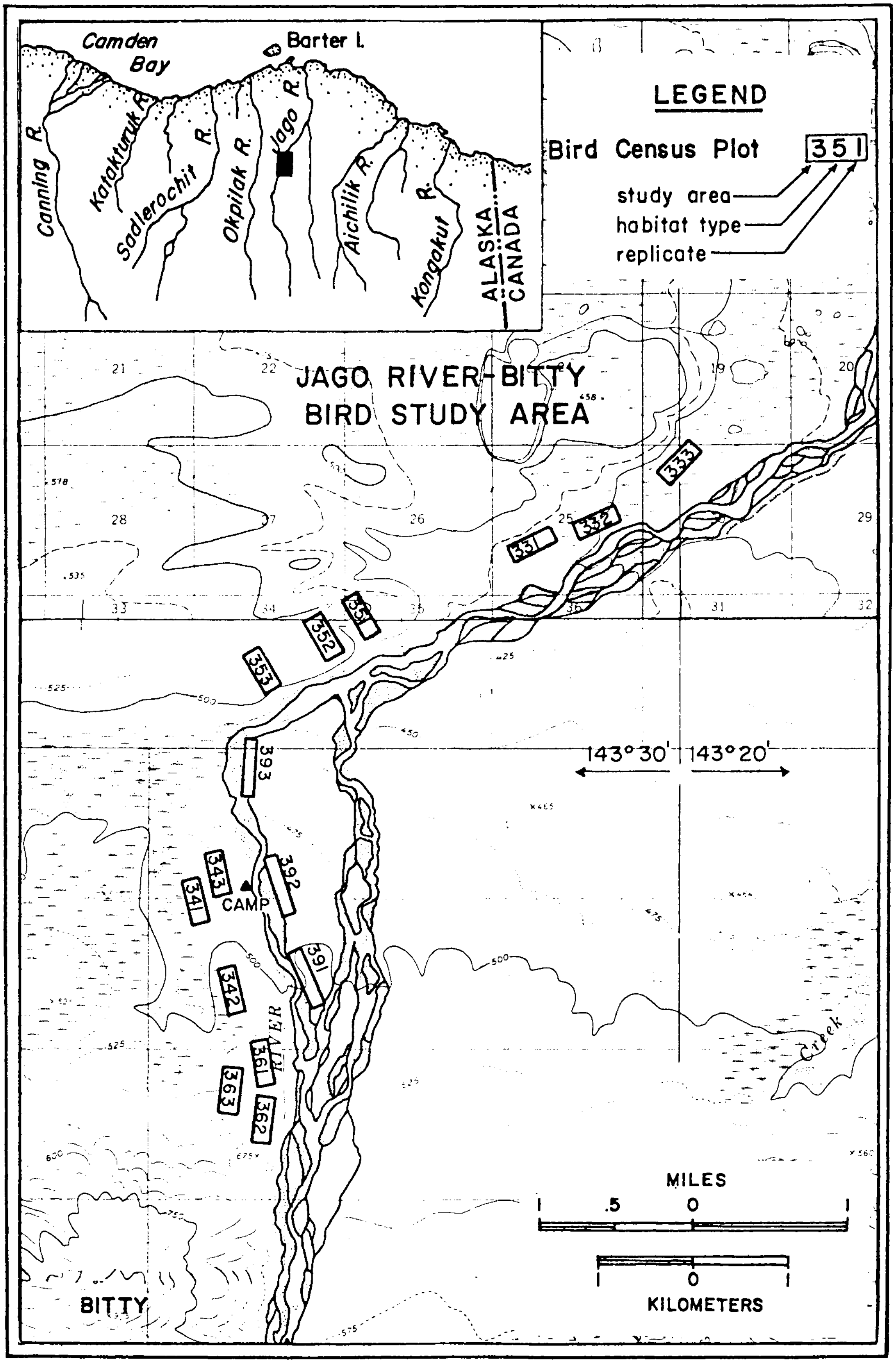

Fig. 4. Jago River-Bitty study area, Arctic National Wildlife Refuge, Alaska.

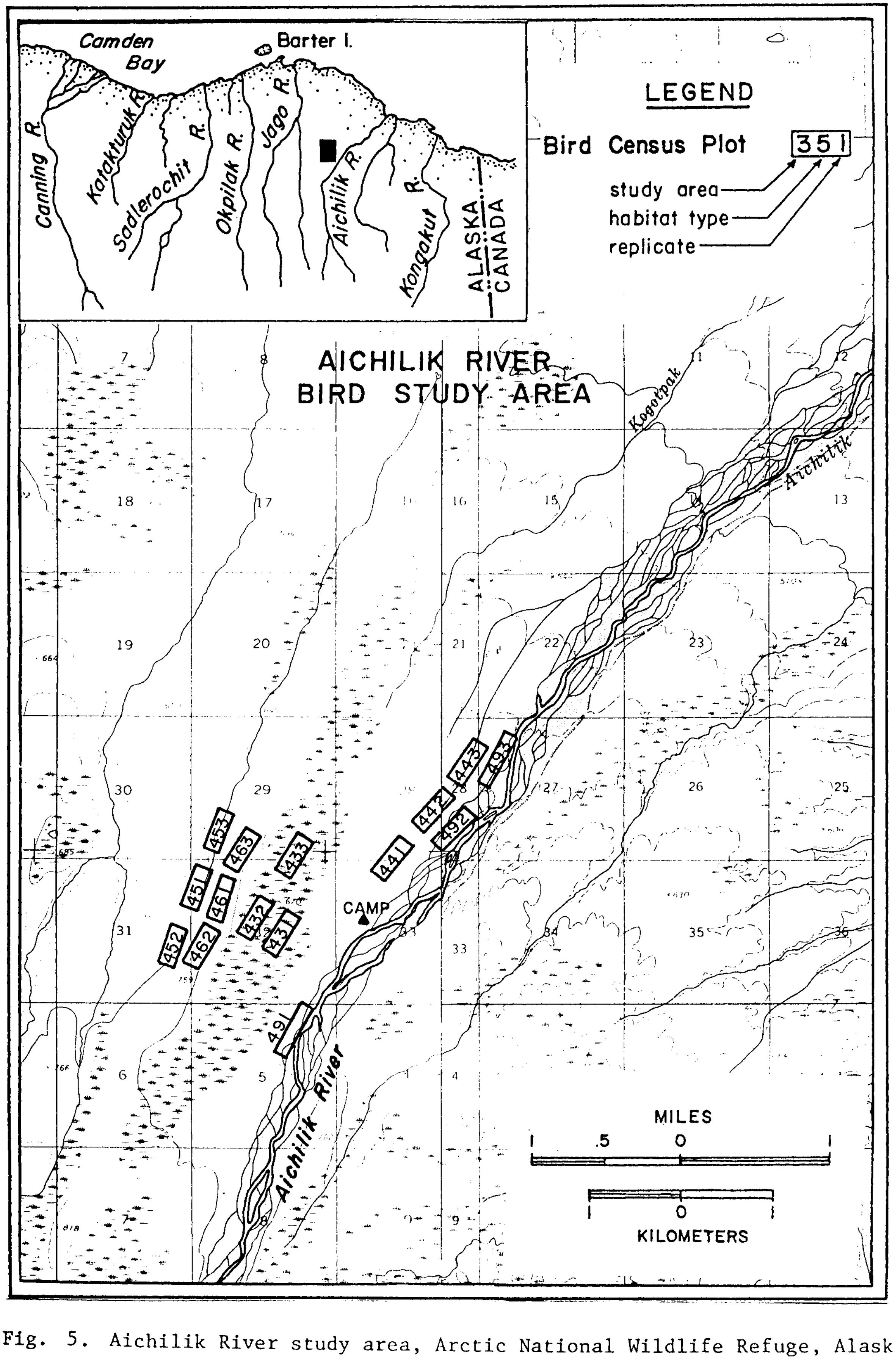

Fig. 5. Aichilik River study area, Arctic National Wildlife Refuge, Alaska.

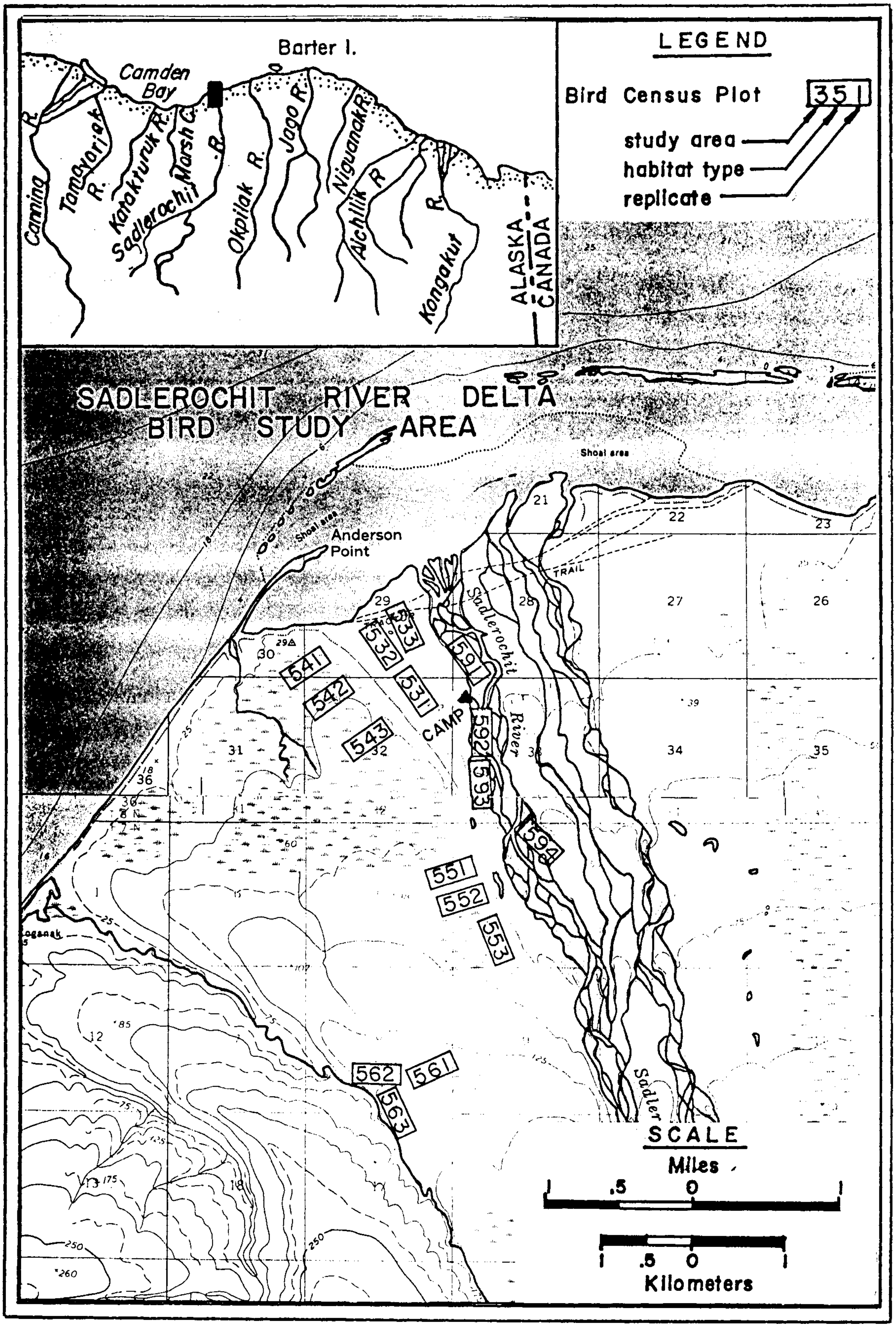

Fig. 6. Sadlerochit River study area, Arctic National Wildlife Refuge, Alaska.

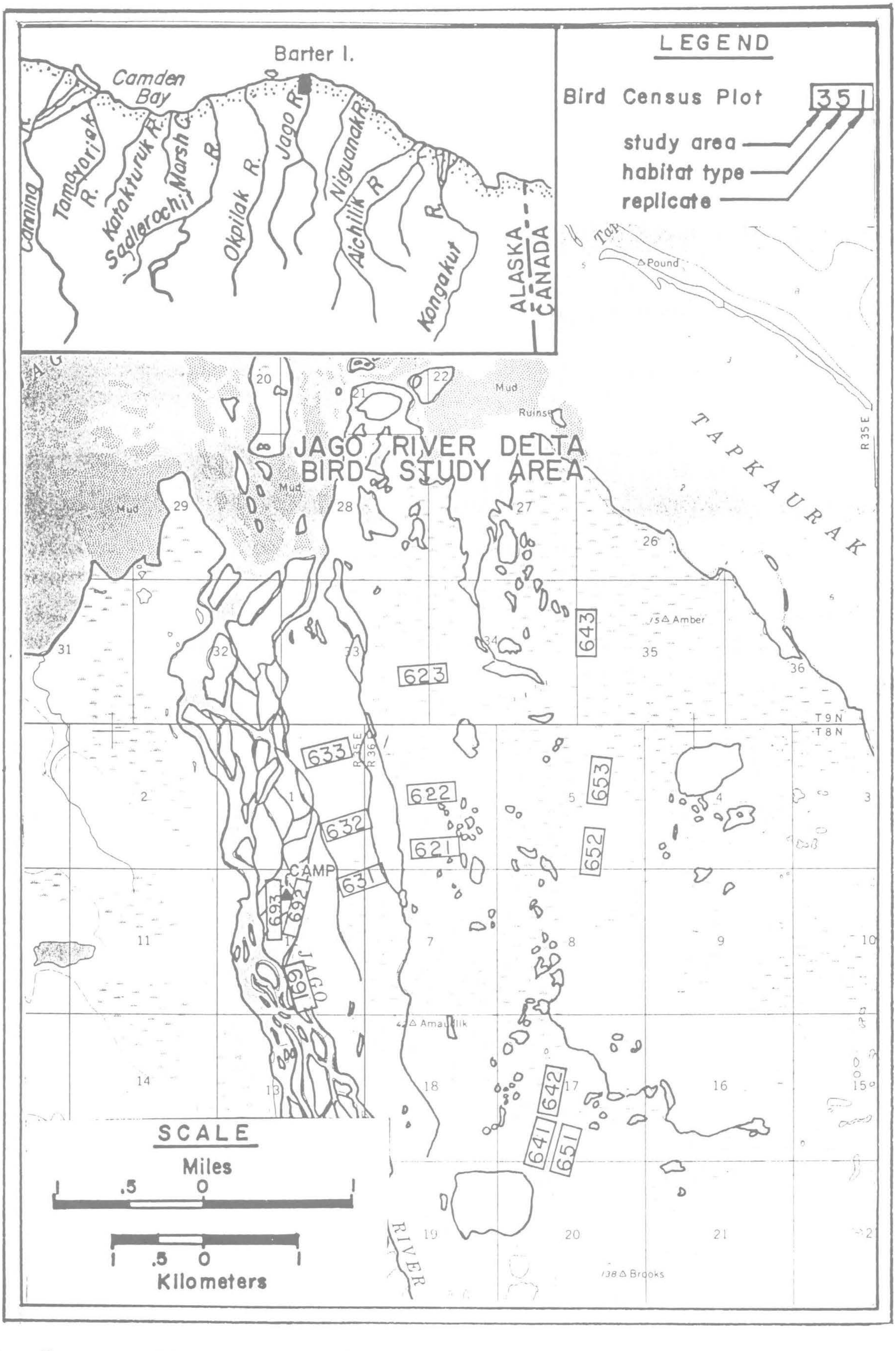

Fig. 7. Jago River Delta study area, Arctic National Wildlife Refuge, Alaska.

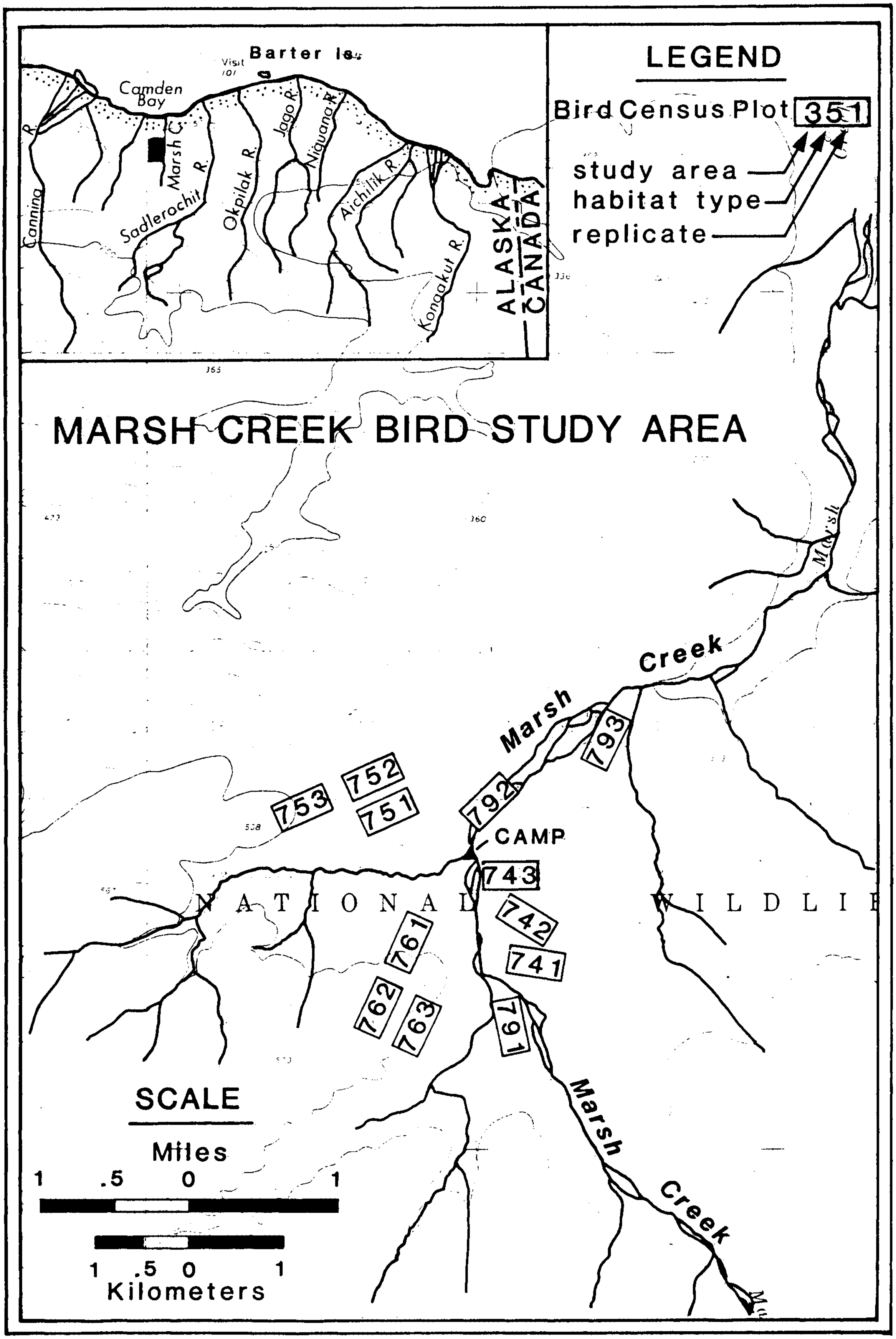

Fig. 8. Marsh Creek study area, Arctic National Wildlife Refuge, Alaska.

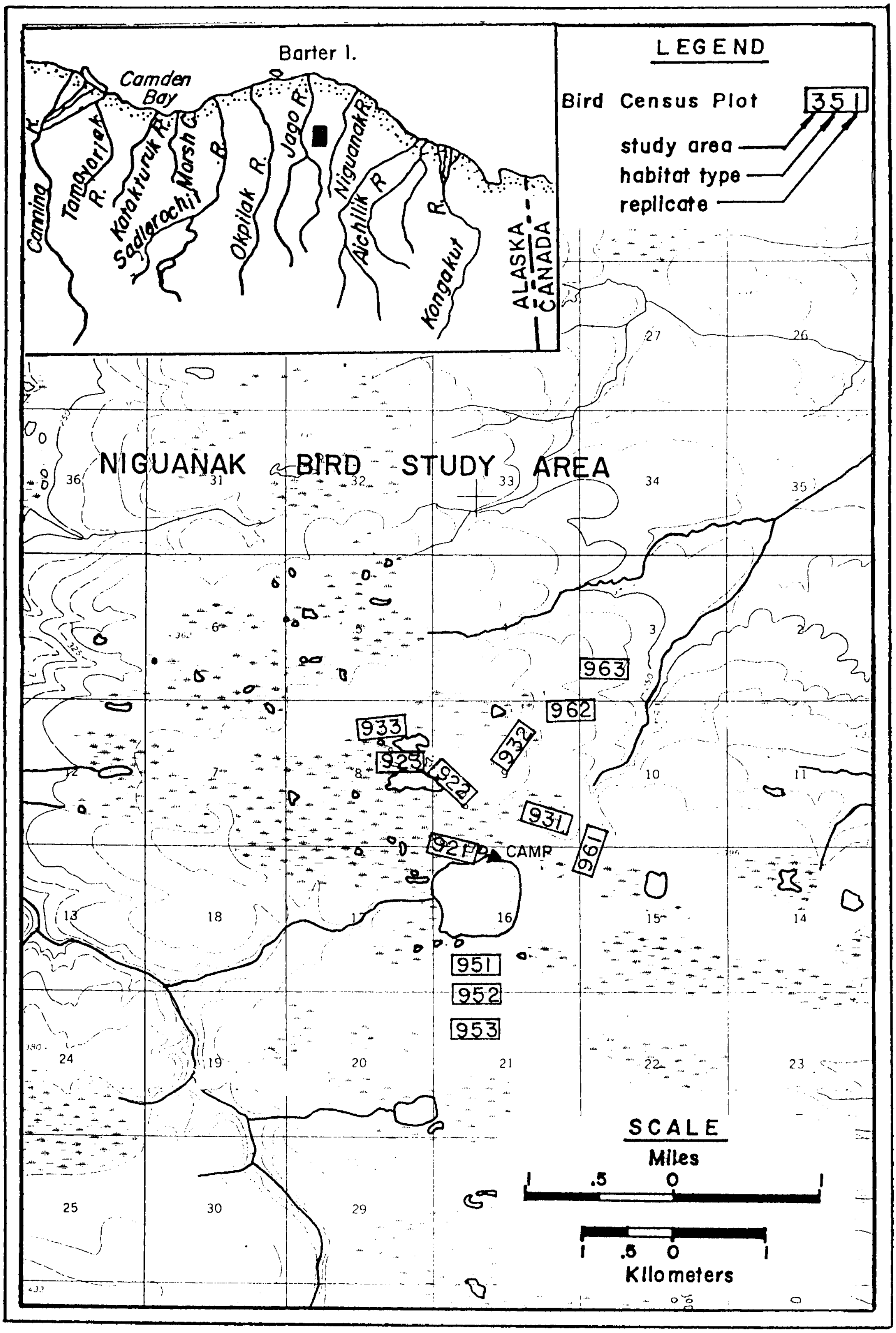

Fig. 9. Niguanak study area, Arctic National Wildlife Refuge, Alaska.

Species Accounts

RED-THROATED LOON

Okpilak - Common breeder. Red-throated loons were regularly observed from 10 June until 14 August. Five nests were found in Flooded habitat: the first on 19 June with 1 egg, the last on 24 July with 2 eggs. First hatching occurred during the week of 10-17 July. As in 1983, red-throated loons were more commonly seen or heard in August as they vocalized during flights between brooding areas and coastal feeding areas.

Aichilik - Uncommon migrant. One or 2 birds were observed weekly, beginning 16 June and continuing throughout the field season.

Sadlerochit - Uncommon breeder; fairly common summer visitant. Single loons and small flocks were frequently seen flying eastward along the coast and over camp from 4-7 June and then irregularly through July. Two pairs were observed flying south along the river and swimming in Wet Sedge ponds from 9-11 June. One pair was seen regularly in a Wet Sedge pond 1.5 km south of camp and was observed attending 1 chick on 5 August. Estimating the age of the chick and assuming a 24-29 day incubation period (Harrison 1978), egg-laying probably occurred during the first week of July. From 18 July through 16 August, singles, pairs, and groups (3-10 loons) were observed flying eastward or swimming, feeding, and vocalizing in lagoons and coastal Wet Sedge ponds.

Jago Delta - Fairly common breeder and summer visitant. A few individuals and pairs of red-throated loons were seen flying in various directions near camp and swimming on lagoons, rivers, and ponds in Flooded and Mosaic habitats throughout June and July. No nests were discovered, but adults with chicks were seen on coastal lakes and ponds on 5 August. During late August small groups of adults and several pairs with chicks were seen almost daily near the coast, with a maximum of 24 adults seen in flight on 21 August. Young were full-grown and flight-capable by 26 August, but apparently were not yet independent.

PACIFIC LOON

Okpilak - Common spring migrant: fairly common breeder. Pacific loons were present from 2 June through 14 August. Several large flocks of 10-25+ were observed flying northeast between 7 and 11 June. By 13 June, vocalizations were heard regularly in aquatic areas. One nest containing 2 eggs was found on 8 July in Flooded habitat. On 17 July, 2 adults with 2 chicks were observed on Camp Lake.

Sadlerochit - Uncommon migrant and summer visitant. Four flocks of 5-7 Pacific loons were seen flying along the coast from 5-22 June. From 17 June through 25 July, pairs were infrequently seen flying east along the coast, and a single loon was sighted on 9 days, either flying along the river or coastline or swimming in the lagoon. Pacific loon vocalizations were first heard on 19 July along the coast. Single loons were subsequently observed flying eastward between 5 and 14 August.

Jago Delta - Uncommon breeder; fairly common summer visitant. Pacific loons were observed from 5 June through 30 August. Two migrant flocks of 8 loons were seen flying north-northeast toward the coast on 5 and 7 June, but the remaining June observations were of singles or pairs flying in various directions over camp or swimming in ponds in Flooded and Mosaic tundra. Through July and August, loons were observed more frequently in the lagoon and river as well as in ponds near the coast in Flooded, Mosaic, and Wet Sedge habitats. Chicks were first observed on 19 July near the coast. A maximum of 3 pairs, each with 1 chick, were seen on a coastal lake on 7 August. Pacific loons gathered in flocks of 3-9 with resident family groups through the end of August, at which time the young were still incapable of flight.

Niguanak - Common breeder. Pacific loons inhabited the large water bodies from 12 June through 30 August. Vocalizations were heard frequently during the latter half of June and active nests were first observed on 26 and 28 June. All nests (n=3) were located on small islands in larger lakes and ponds. At least 2 nests were successful: each produced 1 chick that was first observed on 24 July. During the latter weeks of August, congregations of 5-11 adults were frequently observed feeding and vocalizing on Niguanak Lake. Chicks had not fledged by 30 August.

YELLOW-BILLED LOON

Okpilak - Uncommon migrant. Yellow-billed loons were observed on 5 occasions, beginning 1 June when a pair and a flock of 7 were seen flying southeast. Individuals or pairs flying east and northeast were noted on 8 June, 23 July, and 4 August.

Sadlerochit - Fairly common migrant; uncommon summer visitant. Single yellow-billed loons and groups of 3-8 were observed daily from 5-18 June and during 5 days between 5 and 26 July. Loons were typically flying eastward along the coast or swimming and feeding in the lagoon. From 7-16 August, several groups of 1-7 adult loons were seen daily, flying eastward along the coast. Vocalizations were frequently heard from the bay west of Anderson Spit, indicating a possible resting area.

Jago Delta - Rare fall migrant. One adult was observed at Jago Lagoon on 7 August.

Niguanak - Uncommon migrant. Seven sightings were made of single individuals feeding or resting on the large Niguanak Lake between 9 July and 29 August. Visiting loons generally stayed at the lake for less than 6 hours.

TUNDRA SWAN

Okpilak - Fairly common breeder. Singles and pairs were seen almost daily from 1 June through 14 August. Pairs were first observed when camp was established on 1 June. On 16 July, a pair with 2 cygnets was observed at 3-Drum Marsh, a successful 1984 nesting area. Another pair with 2 cygnets was seen 3 km west of Okpilak camp on 17 July. On 5 August, a third pair with 2 young was seen 2.5 km north of camp.

Jago Bitty - Rare summer visitant. Swans were observed on 3 occasions: a lone adult flying southeast on 6 June; an adult on a gravel bar along the Jago River 3.2 km north of camp on 21 June; and a pair of adults on a small pond in Moist Sedge habitat on 2 July.

Sadlerochit - Fairly common summer visitant; probable uncommon breeder. Sightings of either one or two pairs, or a group of 3-5 swans occurred almost daily from 5 June through 19 July. Swans utilized Wet Sedge, Moist Sedge-Shrub, Mosaic, and Riparian habitats, as well as coastal lagoons and river delta areas. Evidence of breeding in the vicinity occurred on 5 August when a pair was seen leading 2 large cygnets by a bluff melt-water pond 1.5 km south of camp.

Jago Delta - Fairly common breeder. Pairs were first observed on 1 June and 1-4 adults were seen regularly during July on Flooded tundra lakes and in Riparian habitat. No nests were discovered, but 2 pairs with cygnets were frequently observed in Flooded and Wet Sedge habitats from 9 July through 15 August. Additional adults with cygnets were observed at coastal lakes and in Tapkaurak Bay between 22 July and 27 August, with a high of 16 birds (11 adults and 5 cygnets) observed on 23 August. Cygnets were nearly full-grown but still incapable of flight on 27 August.

Niguanak - Fairly common spring migrant; uncommon summer resident and breeder. During June, small groups of 3-5 individuals moved through the area, occasionally stopping on large lakes and ponds. Throughout July and early August, a non-breeding pair occupied Flooded habitat near the Niguanak camp. A pair that produced 3 cygnets inhabited an area of Flooded tundra 6 km south of Niguanak Lake. The male swan was observed aggressively chasing greater white-fronted and snow geese that were staging in the swan's brooding area during late August.

GREATER WHITE-FRONTED GOOSE

Okpilak - Fairly common migrant. Single individuals were seen on 3 occasions flying east during the first week of June. Four birds fed at a small pond on 10 June, and a flock of 39 was sighted moving west on 24 June. On 15 July, geese were seen flying west, on 15 August a flock of 35 flew eastward 5 km south of camp.

Jago Bitty - Rare migrant. Five geese were seen flying southeast on 15 June, and a group of 8 geese were seen 8 km northeast of camp on 15 August.

Aichilik - Rare fall migrant. A single individual was seen flying south over camp on 11 August.

Sadlerochit - Common spring migrant; uncommon summer visitant; fairly common fall migrant. Several flocks of 10-100 geese were observed flying eastward over camp on 31 May. From 1-27 June, migration movements decreased with flocks of 3-20 geese seen on 14 occasions. A group of 3 geese grazed briefly along a river bank on 3 June. Geese visited lagoon areas during July and several were observed on Anderson Spit on 7 August. Small flocks were seen flying eastward along the coast between 7 and 18 August.

Jago Delta - Uncommon spring migrant; fairly common fall migrant. Singles and pairs of greater white-fronted geese were observed flying in various directions over camp or loafing near lakes on 8 days during June. No geese were subsequently observed until 15 August when a group of 8 flew over Riparian habitat. Through the end of August, geese were observed more frequently and in larger flocks (12-29 birds) flying and feeding in Moist Sedge and Dryas habitats along the river and delta, occaisionally with snow geese. Flight directions were generally random, indicating local staging movements. By 29 August, ratios of juveniles to adults in flocks were nearly equal.

Marsh Creek - Rare spring migrant. A single goose was flushed from Marsh Creek approximately 5 km downstream from camp on 5 June.

Niguanak - Uncommon spring migrant; common fall migrant. Between 1 and 27 June, a single pair utilized Flooded habitat in the Niguanak area, particularly along the banks of the large lake and areas of emergent vegetation. On 22 June, approximately 15 geese were observed in Wet Sedge areas along lake banks 6 km south of camp. Beginning 16 August, several flocks migrated eastward over the area. Over 3150 geese passed across the Niguanak area in flocks of 3-100 during the last 4 days of observations (27-30 August). The relatively low numbers observed at the coastal Jago Delta camp during the same time period suggested that the major flux of fall migrants occurred inland, at least across the portion of ANWR between Camden Bay and Beaufort Lagoon. Greater white-fronted geese frequently foraged in the Niguanak area and primarily utilized Wet Sedge habitats along lake shores and beaded streams.

SNOW GOOSE

Okpilak - Rare spring migrant. A mixed flock of 10 snow geese and several brant flew northeast along the coast on 8 June. A flock of 12 was observed flying eastward on 11 June.

Jago Bitty - Rare spring migrant. A flock of 12 geese was observed flying west-southwest on 15 June.

Sadlerochit - Rare spring migrant. On 5 June, flocks of 35 and 17 snow geese (with one blue-phase individual) were observed flying westward along coast.

Jago Delta - Common fall migrant. Flocks of 9-37 geese were observed from 15-30 August resting and feeding on river Dryas benches near camp and by the lakes south of Martin Point. Flocks were composed of up to 50% juveniles with a maximum of 8 observed.

Niguanak - Rare spring migrant; common fall migrant. On 5 June, a flock of approximately 150 geese flew northeast over camp, and on 19 June, 50+ geese flew southwest over the area. Beginning 13 August and increasing until observations terminated 30 August, numerous flocks of snow geese passed over the Niguanak area. Numbers peaked during the last 3 days of observations when approximately 3,090, 2,900, and 1,940 were counted on 28, 29, and 30 August, respectively. Several congregations of snow geese foraged in Wet Sedge and Moist Sedge habitats, particularly along gently sloping lake shores.

BRANT

Okpilak - Abundant spring migrant; fairly common breeder. Between 2 and 11 June, numerous flocks of 25-100 brant moved eastward over the coastal areas. A small colony of glaucous gulls and brant had initiated incubation in Flooded habitat prior to 11 June. Four nests were found in the area on 11 June. One nest had 3 eggs, another had 5 eggs, and the others were not disturbed. On 19 June, a fifth nest was found with 5 eggs. Full clutches averaged 4.6 (n=5). Laying and incubation took place primarily during the week of 11-19 June. Earliest completion of a full clutch occurred on or before 11 June. All eggs apparently hatched between 25 June and 3 July but no broods were observed, possibly reflecting post-hatching seaward movements. No brant were observed after 18 July.

Sadlerochit - Abundant spring migrant; common fall migrant. Brant flying eastward on spring migration were observed from 31 May through 20 June. Many flocks of 10-200 geese (average of 50-70 geese per flock) were sighted daily, with numbers peaking by 9 June. Brant were almost exclusively seen flying along the coastline with only a few observed up to 2 km inland.

Jago Delta - Common migrant; rare breeder. Flocks of 3-25 brant were observed flying northward towards the coast from 1-11 June. A pair with 2 goslings was seen at Martin Point Lake on 23 July. The first sighting of fall migrants was a flock of 110 geese resting and feeding on the west shore of Tapkaurak Bay on 16 August. Many flocks of 10-450 geese (average 25-50) were seen flying west along the coast through the end of August, with a maximum of 2,000 birds moving through the area on 23 August. Geese flew over Jago Lagoon apparently following the coastline, and small flocks stopped to feed and rest on Jago Delta and Tapkaurak Bay.

Niguanak - Rare spring and fall migrant. On 1 June, a flock of brant (75+) flew southeast over camp and 2 individuals were seen flying with a large flock of snow geese on 28 August.

CANADA GOOSE

Okpilak - Uncommon spring and fall migrant; rare breeder. A pair was first observed flying east on 2 June, and other pairs were observed on 14 and 15 June. A flock of 12 was seen in the area on 17 and 18 June. One nest with an incubating adult was found in Flooded habitat on 11 June. The nest contained 6 eggs on 25 June and 4 eggs on 30 June and 3 July. Status of the 2 missing eggs remained unknown. On 8 July, the nest was empty, apparently a successful hatch. A flock of 30-50 geese was observed feeding in Moist Sedge-Shrub habitat on 7 August.

Jago Bitty - Rare migrant. Two birds were seen flying southeast on 29 June.

Aichilik - Rare summer visitant. Three Canada geese were seen on 16 July, flying south along the Aichilik River.

Sadlerochit - Uncommon spring migrant. On 14 June, a flock of 7 geese flew north over camp, calling in flight. A flock of 7 flew west along the coast on 19 June, and on 27 June a group of 4 flew eastward over the river.

Jago Delta - Fairly common breeder; common fall migrant and visitant. First observation of Canada geese was of a large flock flying northeast on 2 June. Flocks of 5 geese were observed during 3 days at the end of June, flying over the river and Flooded tundra and singles or pairs were seen swimming in the river or standing by large lakes on 6 occasions between 11 June and 2 July. Two broods of 2 and 3 goslings were first observed on a large lake near the coast on 19 July. Single adults were observed flying over Mosaic and Riparian habitats through July. By 27 August, the 2 resident family groups were still utilizing the lake area and the goslings were full-grown. Flocks of 6-27 geese (including up to 6 juveniles) joined the resident geese during late August; the largest group was seen on 29 August.

GREEN-WINGED TEAL

Okpilak - Rare spring migrant; rare breeder. On 8 June, a flock of six males flew northeast over a coastal lagoon. On 11 June, a female was flushed from a nest containing 2 eggs. Two days later the nest could not be relocated. On 13 June, a pair was flushed from Flooded habitat, and on 16 June, a pair was observed on a small pond in Moist Sedge-Shrub habitat.

Jago Bitty - Rare summer visitant. Two males were observed along the Jago River on 21 June, and a lone female on Okpirourak Creek, near the confluence with the Jago River, was seen on 5 July.

Aichilik - Rare migrant. A pair was observed in Moist Sedge-Shrub habitat on 4 June, and a single individual was seen on 10 June. One male was sighted on 22 June, and a female was observed in Moist Sedge-Shrub habitat on 13 August.

Marsh Creek - Rare breeder. A female exhibiting agitated behavior in Riparian habitat on 24 July was thought to be protecting young, and on 12 August, a female with 5 ducklings was observed in the same vicinity.

Niguanak - Rare fall migrant. One female was observed on Niguanak Lake on 27 August.

MALLARD

Sadlerochit - Rare migrant. A male mallard in partial eclipse plumage was observed swimming in the Sadlerochit River on 10 July. On 21 July a female (or possible male in full eclipse plumage) circled briefly over observers near the river. A flock of 12 mallards flew east over a shoreline lagoon on 12 August.

Jago Delta - Rare fall migrant. Two mallards were seen on the river near the coast on 12 August.

Niguanak - Rare spring migrant. A pair flushed from a small pond in Moist Sedge-Shrub habitat on 10 June.

NORTHERN PINTAIL

Okpilak - Fairly common summer resident; uncommon breeder. Small groups, pairs, and singles were seen regularly from 2 June through 14 August. One nest with 7 eggs was found in Mosaic habitat on 8 June. A molting female was observed on 18 July, with a brood of 4 ducklings in Flooded habitat. On 11 August, several flocks (150 birds total) were seen flying east over camp.

Katakturuk - Uncommon spring migrant. Pintails were observed on 3 occasions in June.

Jago Bitty - Uncommon breeder. Singles and small groups of up to 4 were observed regularly from 2-21 June in all habitat types except Tussock. Approximately 90% of these birds were males. A pintail nest containing 7 eggs was located in Riparian habitat on 8 June. It was empty and intact on 28 June and believed to represent a successful hatching. A second nest with 5 eggs was found in Wet Sedge habitat on 21 June and was apparently depredated by 29 June. Sightings of adult females (6 lone birds and 1 pair) occurred sporadically between 22 June and 7 August. Three fully grown juveniles were observed in Wet Sedge habitat on 9 August, and several more lone pintails were sighted through 17 August.

Aichilik - Fairly common spring visitant; rare breeder. Males were seen frequently in groups of 1-5 during early June in Moist Sedge-Shrub, Tussock, and Wet Sedge habitats. On 17 July, a hen with a duckling estimated to be one week old was observed in Moist Sedge-Shrub habitat. The estimated date of clutch completion was approximately 14-15 June.

Sadlerochit - Uncommon breeder; fairly common summer visitant. Pintails were observed daily from 31 May through 16 August. Groups of 5-40 individuals flew over all habitats and coastal wetlands from 31 May to 19 June. Pairs and small predominantly male groups were observed through June in all habitats, but most frequently in small ponds of Mosaic, Moist Sedge-Shrub, and Wet Sedge tundra types. One nest was located on 23 June in Wet Willow-Sedge habitat along a river bank. The nest was empty and intact on 22 July, and a female with 4 young was seen in the vicinity on 4 occasions through 11 August. Additional females with flight-capable young were observed on Wet Sedge, Mosaic melt-water and ponds through July and more frequently in coastal Wet Sedge during early August. Fall flocking of adults and juveniles was noted from 14-16 August when small groups of up to 10 and one group of 150 pintails flew eastward along the coast.

Jago Delta - Fairly common breeder. Pairs and small groups of pintails were observed flying over all habitats through June. Several "chases" involving 2 males and one female occurred during early June and pairs were most frequently observed by ponds and among sedges in Flooded, Mosaic and Moist Sedge-Shrub habitats. Three nests were located: one in Moist Sedge-Shrub habitat on 10 June, and one each in Mosaic tundra on 11 and 22 June. Large flocks of females and juveniles (up to 37 birds) were observed congregating at coastal lakes and Tapkaurak Bay from 5 August through 30 August.

Marsh Creek - Uncommon migrant and summer visitant. Two flocks of approximately 30 males were observed in flight on 7 June. Between 4 and 10 July, a female was seen irregularly in the vicinity of camp. On 12 August, 3 pintails were observed flying east.

Niguanak - Fairly common spring and fall migrant; uncommon breeder. Male pintails were seen as early as 2 June, and were subsequently observed competing for females that began arriving during the second week of June. Most early observations were associated with small ponds scattered in Moist Sedge-Shrub habitat. Males were rarely observed after 1 July. Two nests containing 5 and 7 eggs were found within 100 m of Niguanak Lake. The first chicks were seen on 12 July, and at least one brood was observed on Niguanak Lake; however, broods were more commonly associated with small, shallow ponds. During August, small groups of females began congregating on ponds and lakes in Flooded habitat. Molting birds were noted between 13 and 21 August, and pintail observations continued through 29 August.

NORTHERN SHOVELER

Okpilak - Rare spring migrant. A pair was seen on the water in Flooded habitat on 4 June, and on 16 June a pair flew over camp.

Jago Delta - Rare spring migrant. A pair was flushed from a small flooded area near Mosaic habitat on 12 June.

AMERICAN WIGEON

Okpilak - Rare spring migrant. One bird was observed on 10 June, 2.5 km northwest of the Okpilak camp.

Jago Bitty - Rare visitant; possible breeder. Wigeon were observed on 4 occasions between 3 and 16 June. Pairs were seen 3 times: once along the Jago River and twice on Okpirourak Creek 2.4 km north of camp. The fourth sighting was of a lone bird along the Jago River near camp.

GREATER SCAUP

Okpilak - Rare spring migrant. One scaup was observed on a lake near camp on 4 June, and a flock was seen on a coastal lagoon on 9 June.

Sadlerochit - Rare spring migrant. A male scaup was seen swimming alone in the lagoon each day from 1-3 June. On 6 July, a male was observed swimming in the lagoon with a flock of 50 oldsquaw.

Jago Delta - Rare migrant. A pair of scaup was observed swimming and then resting on an island 2 km northeast of camp on 4 June. On 25 August, a lone female was seen swimming on Tapkaurak Bay.

COMMON EIDER

Okpilak - Uncommon spring migrant. Common eider were observed on 3, 7, 8, and 13 June. On the latter date, a flock of 25+ males and females was seen flying 1.5 km north of camp.

Sadlerochit - Rare breeder; common summer resident. Large flocks of up to 250 eiders were seen swimming among sea ice flows and in lagoons from 2-22 June. From 4-27 June, pairs and groups of up to 6 pairs flew along the river and through the study area, often pausing to swim on the river for short periods. One nest was located on a river bank near camp on 7 July. The female was still incubating on 21 July. On 13 July, a female with brood of 3 chicks was observed along the river near the coast. Groups of 3-12 females were frequently seen flying and resting or foraging together off gravel bars in lagoons, along rivers, and on river deltas through July. Possibly these were failed breeders or non-nesting individuals. Large groups of females used barrier islands and rocky shoals through 16 August, apparently during post-breeding season molt.

Jago Delta - Fairly common fall migrant. A group of 25 female eiders was seen swimming at the Jago River delta by Martin Point on 19 July, and on 22 July a flock of 25 flew west off the coast. On 5 August, 35 drakes were seen flying west over Jago Lagoon, and a female was sighted in a pond near the coast.

Niguanak - Rare spring migrant. One male was observed flying north on 6 June, and 4 males and 1 female were seen on Niguanak Lake, 8 June.

KING EIDER

Okpilak - Rare spring migrant. A flock of 12 flew west along Arey Lagoon on 2 June, and a single individual flew east over camp on 19 June.

Jago Delta - Common summer visitant; uncommon breeder. Mixed-sex flocks of 10 and 25 eiders were seen flying northwest toward the coast on 10 and 13 June, respectively. A few king eider pairs were repeatedly observed resting on ponds in Flooded tundra and on islands and by ponds in Mosaic habitat from 4-25 June. Groups of single females and females with broods aggregated by small ponds and lakes near the coast and at Tapkaurak Bay from 15 July through 20 August. First observations of full-grown young occurred on 7 August. From 21-30 August, most sightings consisted of small flocks of females flying along the coast, but a few individuals were seen resting in coastal lakes.

Niguanak - Uncommon breeder. Two king eider pairs were frequently observed between 9 and 18 June in Flooded habitat. One nest was found on 21 June atop a small hummock 15 m from the shoreline of a large lake. Males were not observed after 18 June. A female with 3 young was seen on a shallow pond in Flooded habitat on 15 July. Two females resided with oldsquaw on the banks of Niguanak Lake between 7 and 24 July, and 4 adult females were observed together in Flooded habitat on 21 July. King eiders were not observed after 24 July.

SPECTACLED EIDER

Okpilak - Uncommon breeder. Spectacled eiders were infrequently observed between 11 June and 24 July. Pairs were noted in Flooded habitat on 11, 13, and 16 June. One nest containing 4 eggs was discovered in Flooded habitat on 19 June. The nest contained 5 eggs on 25 June and was incubated through at least 10 July. A female with 5 young was observed 16 July in the same vicinity. During late June, groups of 3 and 4 females were seen in Flooded habitat.

HARLEQUIN DUCK

Katakturuk - Rare spring migrant. A lone harlequin duck was sighted on the Katakturuk River, 16 June.

Jago Bitty - Rare visitant; probable breeder. A pair swam by camp on the Jago River on 4 occasions between 9 and 20 June. A lone female was observed near camp 4 additional times between 27 June and 4 August.

Marsh Creek - Uncommon resident; rare breeder. Between 10 June and 10 July, individuals and pairs were occasionally seen flying up and down Marsh Creek. One male and 5 females fed near camp on 10 July. On 11 and 12 August, a female with 5 young was observed on Marsh Creek.

OLDSQUAW

Okpilak - Common resident; fairly common breeder. Oldsquaw were observed daily from 2 June through 14 August. Between 2 and 7 June, several flocks of 6-12 birds were seen flying eastward over the tundra. By 13 June, males were displaying and vocalizing regularly, and male-male interactions were frequent. A female with 6 ducklings was observed on 17 July, and a second female with 7 young was seen on 20 July. A late clutch of 6 eggs (a seventh egg was buried) placed in Flooded habitat was observed hatching on 12 August. Also on 12 August, a brood of 4 well-developed juveniles with one female was observed on Camp Lake. A flock of 17 juveniles and 2 females was also seen on Camp Lake.

Jago Bitty - Uncommon breeder. Pairs were observed regularly from 6 through 16 June in Moist Sedge-Shrub and Wet Sedge habitats and on Okpirourak Creek. The last observation of a male occurred on 21 June. From 21 June through 22 July, lone females were sighted on 6 occasions. It was suspected that nests were present in Moist Sedge-Shrub and Wet Sedge habitats, although none were found.

Aichilik - Uncommon spring migrant. Oldsquaw were seen several times in June, usually associated with a small lake south of the Wet Sedge study plots. Both males and females were observed, but there was no evidence of nesting.

Sadlerochit - Uncommon breeder; common summer resident. Oldsquaw were present in the area from 31 May through 14 August. Flocks of 10-100 birds flew eastward along the coast through 19 June, and on 2 June the first large flocks were observed in the lagoon. At least 2 pairs were already present on 31 May and remained until 3 July, swimming and feeding on the river and Wet Sedge ponds and once in Mosaic habitat. Fewer observations of singles and pairs occurred through July; these birds increased their use of ponds below bluffs as snow melted. No nests were located, but 2 were suspected in Riparian habitat and by shallow ponds in Wet Sedge tundra approximately 1.5 km south of camp. A female with estimated 6 week-old ducklings was observed in this area in a melt-water pond on 5 August. Rafts of primarily male oldsquaw swam and fed in the lagoon and outer Camden Bay throughout the season. Total numbers through June ranged from 50-200 and increased to 300 in July. A large influx occurred in August, with many flocks of 200-400 (up to 1,600 total at one time) observed swimming or resting on barrier islands.

Jago Delta - Fairly common breeder; common summer resident. Many small flocks of 10-25 oldsquaw flew eastward through the area from 2-7 June. Several pairs were observed swimming in lakes and ponds of Flooded and Mosaic habitats and along the river through 6 July. Males (of pairs) were visible in the area through 15 July. One nest under construction was discovered in Flooded habitat on 11 June, but was depredated by 18 June. Another nest containing 7 eggs was located in Mosaic habitat on 22 June. Outcome of the nest was unknown, but on 8 August a female with 7 ducklings was seen on a small lake close to the nest site. When we first visited the coast on 19 July, flocks of males were seen in Jago Lagoon and along the river. Females with broods were first observed on 20 July near dunes along the coast and on 24 July on a lake near camp. Several sightings were made of females with broods of up to 7 young on small ponds and in coastal bays through 23 August. Single females began to form small flocks in these areas also, sometimes aggregating with brood-rearing individuals. A major influx of oldsquaw (primarily males) occurred on 23 July when approximately 1,750 flew westward along the coast in flocks of 50-200. After this date, flocks using coastal lagoons generally did not exceed 6-12 birds through 30 August.

Marsh Creek - Rare spring migrant. A flock of 8 males flushed from a small pond in Moist Sedge-Shrub habitat on 3 June.

Niguanak - Fairly common breeder. Paired oldsquaw were present on 2 June (during the establishment of camp). Throughout June, territorial chasing, vocalizations, and additional pairing were observed on Niguanak Lake. Numbers and activity increased as lake-ice receded. Lakes and ponds in Flooded habitat were also utilized as were, to a lesser extent, the small ponds interspersed in Moist Sedge-Shrub habitat. One apparently successful nest with 7 eggs was placed near a small pond in Moist Sedge-Shrub habitat. The clutch hatched prior to 14 July. A second nest was situated atop strangmoor in Flooded habitat 30 m from a large lake. It was apparently destroyed by jaegers. After 9 July, males were no longer seen. During mid-July, females and broods began congregating on Niguanak Lake. On 21 July, 61 individuals were seen on the lake, and on 3 August, 5 broods of 9, 6, 5, 5, and 7 chicks were recorded. During the latter half of August, oldsquaw numbers began decreasing on Niguanak Lake and females began more extensive utilization of adjacent Flooded habitats.

SURF SCOTER

Okpilak - Rare spring migrant. Five surf scoters were seen flying west on 19 June.

Sadlerochit - Rare spring migrant. Seven surf scoters were observed on 21 and 22 June, and two were seen on 26 June, swimming and feeding in lagoon.

Jago Delta - Rare fall migrant. Two flocks of 30 and 40 scoters swam and fed in Jago Lagoon on 25 August. At least a small percentage of these were adult females.

Niguanak - Uncommon summer migrant. Surf scoters were observed exclusively on Niguanak Lake. The first sighting was a single bird on 19 June. Flocks of 30, 38, and 25 rested and fed at the lake on 30 June, 2 and 15 July, respectively. One individual was seen on 22 July, the last surf scoter observation.

WHITE-WINGED SCOTER

Jago Bitty - Rare spring migrant. Three and 2 scoters were observed flying south-southeast on 15 and 18 June, respectively.

Sadlerochit - Uncommon spring migrant. White-winged scoters were first observed on 3 June when one flew westward over the lagoon. Three small groups of scoters (up to 7 birds) were observed swimming with flocks of up to 50 oldsquaw on three occasions between 5 and 23 June. Eight scoters flew eastward low over the lagoon on 26 July.

Niguanak - Rare summer migrant. Four individuals were observed with a flock of 38 surf scoters on Niguanak Lake on 2 July.

COMMON MERGANSER

Jago Bitty - Rare summer visitant. On 10 June, a male was seen flying north along the Jago River, and on 1 July, a female was observed on Okpirourak Creek approximately 2.4 km north of camp. These were the first records of this species occurring on the north slope of ANWR.

RED-BREASTED MERGANSER

Okpilak - Rare spring migrant. A group of 6 was observed flying north on 12 June.

Jago Bitty - Rare spring visitant. A lone female was observed flying north along the Jago River on 11 June.

Aichilik - Uncommon summer resident. Two and 3 individuals, including 1 or 2 males, were seen frequently from 9 to 13 June on the Aichilik River near camp. Throughout the remainder of the study period, 1 to 4 females were seen every 4 or 5 days. Although they were present on the river near camp all summer, there was no evidence of local reproduction.

Sadlerochit - Fairly common summer visitant; probable breeder. Sightings of a single pair of mergansers occurred on 7 occasions from 8 June to 1 July. Birds were observed either flying along the river, or swimming in the lagoon and river. A few groups of 3-5 females were first observed on 30 June and were infrequently sighted flying along the river or swimming in the lagoon through July. No nests were discovered, but a female leading a brood of 6 chicks was observed near the mouth of the river on 13 and 14 August.

Jago Delta - Rare summer visitant. Two female mergansers were observed in Tapkaurak Bay on 22 July.

Marsh Creek - Rare migrant. A single female was observed flying upriver on 5 June and 9 July.

Niguanak - Rare migrant. One male flew west over Flooded habitat on 26 June.

NORTHERN HARRIER

Okpilak - Uncommon visitant. Six sightings of a single individual hunting and flying over Mosaic, Wet Sedge, and Moist Sedge-Shrub habitats occurred between 2 June and 22 July.

Katakturuk - Rare spring visitant. One harrier was observed flying and hunting in the study area on 15 and 16 June.

Jago Bitty - Rare breeder. One or 2 birds were observed almost daily from 5 June to 3 July, typically hunting over Moist Sedge or Riparian habitats near camp. These observations were believed to represent a single, mated pair. Harriers were observed only twice after 3 July (on 11 and 22 July) and no evidence of breeding was ascertained.

Aichilik - Rare summer visitant. Brown-plumaged northern harriers (females or possibly immatures) were seen 4 times between 9 June and 5 August in Wet Sedge and Moist Sedge-Shrub habitats. Sightings were possibly of the same individual.

Sadlerochit - Uncommon summer visitant. A female northern harrier was first observed hunting near camp and by the bluff on 2 and 3 June. A male hunted along the bluff on 4 June, but was not sighted again. From 10 June to 13 July the female was seen on 9 dates. In June she typically hunted over Moist Sedge-Shrub habitat and along the bluff, but was also seen in Wet Sedge and Mosaic tundra. In July she was observed in Tussock upland tundra and hunting over Moist Sedge habitat east of the river. The last observation occurred on 15 August when a brown-plumaged harrier was seen flying west near camp.

Marsh Creek - Uncommon resident. Two pairs were regularly observed during early June over the bluffs and river north of camp. Individual birds were sighted occasionally between 11 June and 26 July. On 6 and 11 August, an individual harrier in Riparian habitat became very vocal and agitated at the presence of observers.

Niguanak - Uncommon resident. Northern harriers were infrequently observed from 15 June to the end of study on 31 August. Hunting was generally associated with Flooded and Moist Sedge-Shrub habitats.

ROUGH-LEGGED HAWK

Okpilak - Uncommon summer visitant. Rough-legged hawks were observed on 15 occasions, beginning 2 June and ending 11 August. It was unlikely that any breeding occurred in the Okpilak area, although a pair was observed on 16 July.

Katakturuk - Uncommon breeder. Rough-legged hawks were first observed on 7 June when an active nest was discovered on Katakturuk bluffs. The female was a light phase individual. Incubation was underway on 7 June, and on 15 June a clutch of 4 eggs was observed. Hatching was in process on 28 June when 2 young and 2 eggs were observed, and 4 downy young were seen in the nest on 14 July (probably hatched by 30 June). By 19 July, one chick had apparently died and was put on the ledge outside of the nest by adults. Last sighting of adults was on 10 August. When the site was next visited on 18 August, rough-legged hawks were absent from the area. Assuming a 41 day period to fledging (Harrison 1978) it is probable that the young had gained independence by this date.

Jago Bitty - Rare visitant. Rough-legged hawks were observed only twice on the study area: a single adult was seen over Moist Sedge habitat south of camp on 2 and 4 June. Seven pairs of rough-legged hawks were known to nest along an 8.5 km section of Igilatvik Creek, along the west side of Pilak, approximately 6.5-13.0 km southeast of camp.

Aichilik - Uncommon visitant. A light-phase bird was seen soaring west of the Aichilik River on 17 June and 9 July. A dark-phase hawk was seen from camp on 9 June and from the foothills on 7 July.

Sadlerochit - Uncommon summer visitant. A male rough-legged hawk hunted over Tussock habitat on 2 June. Between 4 June and 13 July, single hawks were seen on 7 days hunting over Moist Sedge habitat east of the river, along the camp bluff and over Wet Sedge, Mosaic, and Moist Sedge-Shrub habitats. On 3 occasions the hawk was positively identified as a female. A hawk circling over Wet Sedge tundra on 28 June was harassed at length by a pair of nesting parasitic jaegers. A final sighting occurred on 9 August when one hawk hunted over Wet Sedge by the lagoon and was attacked vigorously by a long-tailed jaeger.

Jago Delta - Fairly common summer visitant. Adult rough-legged hawks were observed on 9 days from 12 June through 16 August. On 3 occasions during June and early July hawks were mobbed by pomarine jaegers. Hawks hunted over all habitats, but were seen most frequently over Mosaic and Riparian areas. A female was observed perched on the ground in a Mosaic tundra plot on 22 July, feeding on an unknown prey item. Two adults (possibly a pair) were sighted flying together on 26 June and 18 July. A juvenile hawk was seen hunting near camp with an adult on 27 August, and alone near Martin Point on 29 and 30 August.

Marsh Creek - Uncommon spring visitant. Single individuals were seen in Marsh Creek drainage on 4 occasions between 2 and 9 June. On 11 June, 1 hawk hunted over Moist Sedge-Shrub habitat.

Niguanak - Fairly common spring resident; uncommon fall visitant. Between 6 June and 12 July, 1-4 rough-legged hawks were regularly observed hunting and soaring over the ridges of a deep ravine 3 km northeast of camp. No sightings were made from 13 July to 8 August. During the latter weeks of August, 1-4 individuals were observed soaring over the general Niguanak area.

GOLDEN EAGLE

Katakturuk - Rare summer visitant. Solitary golden eagles were sighted on 21 June and 5 July soaring high above the study area.

Jago Bitty - Fairly common summer visitant. Golden eagles were sighted on 16 occasions from 13 June through 23 July. Eleven of these were believed to be repeat observations of a single subadult eagle. Eagles were seen hunting over Tussock, Moist Sedge, Moist Sedge-Shrub, and Riparian habitats from 6 km south to 10 km northeast of camp.

Aichilik - Fairly common summer resident. Immatures were seen regularly throughout the study period: 4 times in June, twice in July, and once on 7 August. Mature individuals were seen 4 times in June; on 17 June, a nesting short-eared owl drove an intruding eagle from its territory. Additional sightings involved individuals too distant to age.

Sadlerochit - Uncommon summer visitant. An adult golden eagle was observed hunting over Tussock upland tundra over an area from 6 to 15 km southwest of camp on 2 June. From 13 June through 23 July, a subadult was sighted on 5 days hunting and flying over a wide area including all habitat types. These may have been repeat sightings of the same individual which appeared to be a 2-3 year old from the degree of white coloration on tail and wings. On 3 occasions the eagle was harassed by long-tailed and parasitic jaegers and short-eared owls when it flew near nest territories along the river and the bluff south of camp.

Jago Delta - Uncommon summer visitant. A subadult eagle was sighted on 14 June flying north along the river, and on 26 June flying over Moist Sedge-Shrub habitat while being mobbed by a parasitic and a pomarine jaeger. A subadult was observed on two occasions along the coast: on 19 July flying across sand dunes and on 16 August hunting over the mud flats. The last observation was of an immature eagle flying near camp on 22 August.

Marsh Creek - Uncommon summer visitant. Frequent sightings of an immature, believed to be the same individual, were made during the last 2 weeks of June. Immatures were seen occasionally between 25 June and 26 July, and were often harassed by long-tailed or parasitic jaegers.

Niguanak - Fairly common summer resident. Solitary golden eagles were observed frequently between 3 June and 16 August across the greater Niguanak area. Regular sightings of a single individual were made at the mouth of a ravine 6 km northeast of camp. Sightings of immatures were 3 times more frequent than those for mature birds when age determination was possible.

MERLIN

Niguanak - Rare fall visitant. One female was seen repeatedly around the Okerokovik River ice field 13 km southwest of the Niguanak camp on 9 August. A female was observed circling a ravine 3 km northeast of camp on 16 August.

PEREGRINE FALCON

Okpilak - Uncommon visitant. Five sightings of solitary falcons were made between 11 June and 23 July. All birds were seen in flight except for an adult that was perched on a hummock in Flooded habitat along the Okpilak River on 12 June.

Sadlerochit - Uncommon summer visitant; rare fall migrant. Peregrine falcons were sighted passing through area on 6 days from 17 June through 15 August. On 17 June, an adult was chased by an arctic tern from the river near camp to a distance approximately 6 km southwest of camp. Two adults were observed circling over upland Tussock tundra on 5 July. They passed very close to each other and one half-rolled over to briefly present its talons to the other; then both flew rapidly to the south. A peregrine of unidentified age was chased by several long-tailed and pomarine jaegers over Moist Sedge habitat east of the river on 7 July, and on 14 July a very large falcon (possibly female) flew rapidly westward along the coast. In late season (11 and 15 August), two sightings of solitary, immature falcons being chased to the southwest by parasitic and long-tailed jaegers were made near camp.

Jago Delta - Rare summer visitant; fairly common fall migrant. A small, dark falcon flew east along the coast on 23 July, and a similar plumaged bird was observed flying north along the river drainage near camp on 26 July. Solitary falcons were sighted 3 times from 21-27 August. A subadult with light-colored plumage was seen on 21 August flying south upriver, and again on 27 August circling the study area, then flying toward the coast. On 25 August a large adult female was sighted flying over Tapkaurak Bay.

Niguanak - Uncommon visitant. Single individuals were sighted on 11 occasions between 16 June and 29 August. Two of the falcons were hunting in ravines, and the remaining individuals were flying quickly through the area, often pursued by pomarine jaegers.

GYRFALCON

Katakturuk - Rare summer visitant. Two sightings of adult gyrfalcons were made on 16 June and 5 July. A pair was observed at the northern mouth of Katakturuk River gorge (Sadlerochit Mtns) on 28 July near what appeared to be highly suitable nesting habitat.

Jago Bitty - Rare fall visitant. A single gyrfalcon was observed on 13 August flying over upland Tussock habitat.

Aichilik - Rare summer visitant. Two light-gray gyrfalcons were seen hunting together over Moist Sedge-Shrub habitat on 1 July. One of the falcons was in pursuit of a willow ptarmigan. A third, solitary dark-gray individual hunted over Wet Sedge habitat on 6 July.

Sadlerochit - Rare fall visitant. A light gray-phase adult gyrfalcon was observed on 15 August flying north toward the coast over river drainage while being chased by a long-tailed jaeger. The observation was made 20 min after a peregrine falcon passed through the area.

Jago Delta - Rare fall visitant. One immature, brown-plumaged gyrfalcon was observed flying low over mudflats near Tapkaurak Bay on 25 August.

Marsh Creek - Uncommon resident. A gray-phase gyrfalcon was frequently observed hunting over the Marsh Creek area during June. Two sightings were made in July, and individuals observed on 7 and 11 August were harassed by both long-tailed and parasitic jaegers. An immature falcon flew through the camp area and perched briefly on the west river bluff on 18 August.

Niguanak - Rare fall visitant. Solitary gyrfalcons were seen on the last days of field observations, 29 and 30 August.

WILLOW PTARMIGAN

Okpilak - Uncommon summer resident. Willow ptarmigan were infrequently observed between 5 June and 11 August. All sightings were in Moist Sedge-Shrub habitat.

Katakturuk - Fairly common breeder; common summer resident. Willow ptarmigan were frequently observed in Tussock habitat on 7 of 9 weekends; the area was surveyed from 15 June through 17 August. Although only 1 nest was located, the number of adult ptarmigans seen in June suggests that more may have nested. The nest containing 9 eggs was discovered in Tussock tundra on 21 June and was successfully hatched by 29 June.

Jago Bitty - Abundant breeder. Birds were observed daily from 2 June through 16' August. Willow ptarmigan occurred in all habitat types, but were most abundant in Riparian, Moist Sedge-Shrub, and Tussock tundra types. Males performed courtship displays from 2-12 June and defended territories throughout most of the month. Females became more conspicuous after clutches hatched (1-15 July) and by 22 July large numbers of pairs and females with broods were observed. Four nests each were found in Riparian and Wet Sedge habitats, three were discovered in Moist Sedge-Shrub, and one in Tussock habitat. Mean clutch size was 9.7 (n=10). Data suggested that nests were initiated in early June and that hatching occurred by early July. Willow ptarmigan chicks (1-2 days old) were first observed on 29 June, and fledglings were first seen on 9 July. By 15 July, the majority of young observed were flight-capable. Beginning 22 July, juveniles were abundant in Riparian and Moist Sedge-Shrub habitats. Molting males were first noted on 8 June, and by 1 July the first complete summer plumages were observed. The majority of males seen after 8 July had fully molted. Females were in summer plumage when observers arrived on the study area on 2 June.

Aichilik - Common resident; fairly common breeder. Willow ptarmigan were seen daily throughout the study period. They were most common in Moist Sedge-Shrub and Tussock habitats away from the Aichilik River, but were also observed frequently in Wet Sedge habitat. Males were molting into summer plumage by 2 June, and some males had completed molt by 24 June. A nest with 9 eggs was discovered in Tussock habitat on 11 June, and a second nest in Tussock habitat with 8 eggs hatched by 17 July. Flight-capable juveniles were seen as early as 17 July.

Sadlerochit - Fairly common breeder. Willow ptarmigan were observed from 2 June to 16 August. Males performed courtship and territorial displays through 17 June in Tussock, Moist Sedge-Shrub, and Mosaic habitats, and along the edge of the bluff. They were noticeably secretive after this point. No nests were located; however, chicks (several days old) were first observed on 8 July in Moist Sedge-Shrub vegetation and from 9 to 17 July in Tussock and closed Riparian shrub habitats. On 21 July, the first group of adult male ptarmigans was observed. From 8 to 16 August, multiple family groups were noted in Riparian shrub, Moist Sedge-Shrub, and Wet Sedge habitats. Female willow ptarmigan were in summer plumage on 2 June. Males were partially molted (head and neck) by this date and some were in full summer plumage by 8 July.

Marsh Creek - Fairly common breeder. Males frequently displayed and engaged in territorial confrontations with rock ptarmigan between 2 and 11 June. Willow ptarmigan tended to occur in shrubbier habitats compared to the more abundant rock ptarmigan. Two nests contained 10 and 11 eggs that hatched in late June. Following hatch, family groups were frequently observed in Riparian habitat. Flight-capable chicks were seen by 14 July.

Niguanak - Fairly common breeder. Willow ptarmigan pairs were observed during early June in Tussock and Moist Sedge-Shrub habitats. Males frequently had non-aggressive, highly vocal, territorial disputes with male rock ptarmigan. On 11 June, a male was observed "popping" straight off the ground and making contact with a low flying pomarine jaeger. Chicks, barely able to fly, were first observed on 9 July. During mid-August, family groups congregated with large numbers of rock ptarmigan in a ravine 3 km northeast of camp.

ROCK PTARMIGAN

Okpilak - Fairly common breeder. Rock ptarmigan were observed frequently from 2 June through 11 August. Males displayed and vocalized during early June. By 2 July, male molting appeared complete. On 16 July, a flock of 11 adult males was flushed as it moved towards the Okpilak River. A female with a brood of 8 was flushed on 17 July, and one with a brood of 6 was observed in Moist Sedge-Shrub habitat on 7 August.

Katakturuk - Fairly common breeder; common summer resident. Rock ptarmigan were frequently observed in Riparian habitat (less often in Tussock and Moist Sedge habitats) every weekend the area was surveyed from 7 June through 17 August. Two nests located in Tussock habitat were apparently successful, as broods were observed in the vicinity. Large flocks began appearing in Riparian habitat by 9 August and even greater numbers were present by 16 August.

Jago Bitty - Abundant breeder. Rock ptarmigan were observed daily from 2 June to 16 August. From 10 June to 11 July, sightings were fairly uniform across habitat types. Thereafter, females congregated with broods predominantly in Moist Sedge and Riparian habitats, and concentrations of males were occasionally observed in Wet Sedge tundra. Males displayed and defended territories from 2-19 June. Nests were found in all habitat types: 4 in Riparian, 3 in Moist Sedge, 2 in Tussock, and one each in Moist Sedge-Shrub and Wet Sedge. Mean clutch size was 8.0 eggs (n=10). Data suggested that initiation of incubation occurred in early June and that hatching began in late June. Clutches from 8 of 10 successful nests observed hatched between 25 June and 6 July. Rock ptarmigan chicks (1-2 days old) were first observed on 1 July and most young were fledged by 13 July. Juveniles with adults were most commonly observed in riparian zones adjacent to Wet Sedge; a maximum of 6 adults and 41 juveniles were sighted here on 9 August. A few male ptarmigan had begun to molt into summer plumage by 7 June, and by 6 July most were fully molted. Females were in summer plumage when observers arrived at the study area on 2 June.

Aichilik - Common summer resident; fairly common breeder. Rock ptarmigan were seen daily throughout the summer, usually in Wet Sedge, Riparian, and Tussock habitats. Males entered summer molt in mid-June and the molt was completed by 9 July. Male territorial displays were common until 26 June. An incomplete 4-egg clutch was found on *Dryas* bench 12 June, and a long-tailed jaeger was believed responsible for its depredation. Few rock ptarmigan broods were positively identified, but broods of 6, 9, and 7 juveniles were seen respectively on 24 July, 26 July, and 6 August. Flocking males were observed as early as 4 July, and sightings continued through 8 August.

Sadlerochit - Common breeder. Rock ptarmigan were observed daily from 31 May to 15 August. Males displayed in all habitats, but were observed most in Moist Sedge and Moist Sedge-Shrub habitats along river flood plain and uplands, and in Tussock tundra. Ten nests were located: 1 in Riparian habitat, and 3 each in Tussock tundra, Moist Sedge-Shrub of uplands, and Moist Sedge-Shrub in river flood plain. Initiation of incubation varied widely from 10-29 June. Chicks (1-2 days old) were first observed on 7 July and latest known hatching occurred on 24 July. Most young were observed to fly by 22 July. In July, greatest numbers of family groups were seen along the river bank in Moist Sedge and open Riparian shrub habitats, although birds frequently were observed in upland Moist Sedge-Shrub and Tussock tundra. In early July, male groups were seen in Riparian, Moist Sedge-Shrub, and Tussock habitats, and multiple family groups began aggregating in Riparian habitats and flood plain shrublands frequently after 22 July. Fewer ptarmigan were observed in Tussock habitat in August, although they were abundant in a willow drainage that coursed through uplands. Male rock ptarmigan were observed molting into summer plumage on 11 June and many were fully molted by 27 June. Females were already in summer plumage when first seen on 5 June. On 6 August one male was beginning to molt from summer into winter plumage.

Jago Delta - Common breeder. Rock ptarmigan were observed daily through 29 August. Pairs and displaying males were observed frequently in all habitats through 7 June, and males continued to defend territories through 27 June. A nest with 2 eggs was discovered on 2 June in Riparian habitat. No other nests were discovered, but frequency of male and female sightings and flushings of females during June suggested that several other nests existed in Riparian, Mosaic, and Moist Sedge-Shrub habitats. Chicks (1-2 days old) were first seen in Riparian habitat on 10 July, and fledged young were present on Mosaic tundra on 8 August. Aggregates of family groups were observed most frequently in Mosaic habitat with a maximum of 72 individuals sighted on 14 August. Rock ptarmigan were less abundant in the study area in late season, and only a few adults and single family groups were seen in Mosaic and Riparian areas from 21-29 August. Male ptarmigan were beginning to molt into summer plumage by 13 June and the first completely molted individual was seen on 23 June.

Marsh Creek - Common breeder. During the first 2 weeks of June, males engaged in display flights and territorial disputes (particularly with willow ptarmigan) throughout various habitats. Females apparently began to nest and brood eggs during this time. Male displays tapered off from 15-25 June. Eggs hatched early in July and family groups were seen more frequently in Riparian habitat. Flight-capable chicks were first seen on 9 July. Male display flights were again noted during late July and August.

Niguanak - Common breeder. Rock ptarmigan pairs were present when field study initiated on 1 June. Territorial display flights by males were frequent through 26 June in Tussock habitat, including Tussock communities interspersed within other habitat types. Males showed signs of summer molt by 8 June, and fall molt was apparent by 23 July. The first chicks were observed, with a very defensive female, on 3 July. Family groups congregated in ravines during mid-August. On 14 August, over 125 ptarmigan were observed actively feeding during late-night hours in a ravine 3 km northeast of camp.

SANDHILL CRANE

Okpilak - Uncommon summer resident. Sandhill cranes were heard or observed on 28 days during the field season. Birds were usually heard vocalizing in the distance. First and last observations were on 2 June and 14 August, respectively.

Aichilik - Rare summer visitant. A single sandhill crane was seen on 16 June on the tussock ridge west of camp. The bird was not seen again but was heard in the same location almost daily through 22 June.

Sadlerochit - Rare spring migrant. On 5 and 6 June a single adult crane foraged in Wet Sedge tundra near the lagoon and by camp. Two adults were seen foraging together in Wet Sedge by the lagoon on 13 June, and on 15 June, crane vocalizations were heard east of the river across from camp.

Jago Delta - Fairly common summer visitant. Sandhill cranes were observed almost daily through June. A solitary crane was first seen displaying on a dry bluff south of camp on 4 June. Generally, observations were of single birds foraging or vocalizing loudly in Mosaic habitat and by the river, small tributaries and lakes. Flooded habitat was infrequently utilized by cranes. During mid-summer, cranes were observed or heard on 4 days from 1-25 July. Staging individuals, pairs, and small groups were seen feeding and vocalizing off plots and on mudflats and bluffs of the coast from 21-30 August.

BLACK-BELLIED PLOVER

Okpilak - Uncommon spring and fall migrant. Observations were made of a single bird foraging in Wet and Moist Sedge habitats on 2 and 3 June. Three birds were sighted in Flooded habitat on 24 July. Six sightings occurred between 6 and 13 August when lesser golden-plovers and black-bellied plovers appeared to be initiating fall migration.

Aichilik - Rare spring and fall migrant. A single bird was seen in flight on 15 June, and 4 were seen in Moist Sedge habitat on 14 August.

Sadlerochit - Rare spring migrant; fairly common fall migrant. Single male plovers in full breeding plumage were sighted flying over and perched in Riparian or Mosaic habitat on 3 occasions between 2 and 5 June. Small flocks of 2-11 adults flew eastward along the coast and foraged on mudflats of the delta and the river from 7 August through 15 August; several of these birds had begun to molt into winter plumage.

Jago Delta - Fairly common spring and summer visitant; possible breeder; common fall migrant. Plovers were sighted regularly from 2 June through 30 August. Three birds were observed flying together in a circular pattern and "squawking" loudly on 5 June. Individuals and pairs seen through June and July were primarily in Flooded and Wet Sedge habitats. Frequent sightings of adults vocalizing and chasing jaegers in this area suggested the presence of a nest, but no evidence of young was discovered. Pairs were first noted foraging on coastal mudflats and flying eastward on 19 July. Flocks of 3-20 adults began congregating at the coast and moving eastward on 11 August, and reached a maximum observed number of 66 on 25 August. The first juveniles of the season were observed on 28 August after adults had apparently moved through the area. On 30 August a total of 75 immatures in flocks were observed flying eastward and feeding on delta mudflats.

Niguanak - Rare spring and fall migrant. One pair was observed feeding around snow-free tussocks near camp on 1 and 2 June. Two birds were seen flying east on both 29 and 30 August.

LESSER GOLDEN-PLOVER

Okpilak - Fairly common breeder and fall migrant. Birds were observed regularly from 2 June to 14 August. Copulation was first noted on 11 June and distraction display occurred on 24 June. Two nests were discovered on 14 and 19 June; both were in Mosaic habitat and both contained 4 eggs. Initial fall migration movements were recorded on 23 July as flocks were observed flying east and northeast.

Katakturuk - Fairly common breeder. Plovers were observed frequently in all habitats on all weekends from 7 June - 17 August. One nest each was located in Tussock (15 June) and Moist Sedge (16 June) habitats, and 2 were found on Dryas riparian terraces (9 and 28 June). Mean clutch size was 3.75 (n=4). Hatching was observed at 2 nests on 6 and 12 July, and assuming a incubation period of 27-28 days (Harrison 1978), nest initiation occured during the second week of June.

Jago Bitty - Fairly common breeder. Birds were observed regularly from 2 June through 16 August. Lesser golden-plovers were observed in all habitat types, with greatest densities of adults occurring in Riparian and Moist Sedge habitats. Courtship activities (displaying, vocalizing, flying together, aggressive interactions) were noted from 2-19 June. Seven nests were located between 17 June and 5 July and were found in all habitats except Wet Sedge. Two nests each were located in Moist Sedge-Shrub, Moist Sedge and Riparian types, and one was found in Tussock habitat. Mean clutch size was 3.4 eggs (n=7). Chronology data suggested the occurrence of two general nesting patterns within the breeding season. Two of 7 clutches hatched by 5 July, indicating initiation at the beginning of June, assuming a 27-28 day incubation period (Harrison 1978). The 5 remaining clutches hatched between 10 and 23 July and were apparently initiated during the last 2 weeks of June. Juvenile plovers were observed in all habitats; however, concentrations of juveniles were seen only in Moist Sedge and Moist Sedge-Shrub. Juveniles began to form into groups after 6 August, although some young plovers were still less than half grown and attended by adults at that time. Adults congregated with other shorebirds in Riparian and Wet Sedge habitats from 15-19 July. From 22-25 July, relatively large numbers (53 birds in 11 flocks) of plovers migrated eastward through the study area.

Aichilik - Common breeder and fall migrant. Probably the most conspicuous bird species at Aichilik. In June, male territorial display flights and aggressive interactions were common. Nineteen nests were found: 9 in Riparian Dryas bench, 5 in Tussock, 3 in Moist Sedge, 1 in Moist Sedge-Shrub, and 1 in Wet Sedge habitat. The first nest was found on 7 June and contained 4 eggs. All nests had 4 eggs except for one that contained 2 eggs layed on approximately 25 June, possibly a renest attempt. Known hatch dates ranged between 4 and 21 July, with the majority occurring between 14-16 July. By the second week of August, all young birds were in juvenile plumage. Beginning as early as 15 July, small flocks (6-15 birds) were seen flying eastward. On 23 July, five separate flocks flying east were seen during a 4-hour period.

Sadlerochit - Fairly common breeder. Plovers were observed from 31 May through 16 August. Pairs were seen as early as 1 June, and displays (calling in-flight, flying together) were noted from 2-15 June. Copulation was first observed on 8 June. Nests were located in all habitats exclusive of Wet Sedge from 11-30 June. Three nests each were located in Mosaic and Tussock habitats and 2 were found in Riparian dry barren/forb complex. Evidence of probable nesting (highly defensive adults or adults with chicks) was seen in Moist Sedge habitat along the river flood plain and in Moist Sedge-Shrub upland zones. Chronology data suggested an extended breeding season for plovers, with actual and estimated (from age of observed chicks) hatching dates ranging from early July through the beginning of August. Two nests found depredated during June suggested that some of the later hatching nests in the vicinity may have been renest attempts. Soon after hatching, adults were observed most frequently with chicks in Riparian habitat and by bluff melt-water ponds where they were seen through the end of July. Beginning 16 July, flocks of juveniles (3-12 birds) staged and foraged in these habitats as well. From 22-31 July, small groups of adults were observed flying eastward through the study area. By early August, adults were absent from the area except those that raised late broods. A few juvenile groups were seen moving eastward and foraging by the river on 16 August. Lesser golden-plovers were already in summer plumage when they arrived in spring. Some plovers were molting into winter plumage on 14 July and several adults were fully molted by 11 August.

Jago Delta - Fairly common breeder. Lesser golden-plovers were observed daily from 4 June through 30 August. Pairs were first seen on 7 June and the first observation of nest building occurred on 13 June. Five active nests, each containing 4 eggs, were located between 10 June and 6 July: 4 in Moist Sedge-Shrub tundra, and 1 in Mosaic habitat. Chicks (1-2 days old) were first observed on 2 July, and were last noted on 3 August. Adults with chicks, and juveniles moving through the area, were observed most frequently foraging in Riparian, Flooded, and Wet Sedge habitats through the latter part of July. Through August, plover observations consisted primarily of small juvenile flocks (3-10 birds) flying eastward through the area, or foraging on Riparian Dryas benches and mudflats of the river and coast. A maximum count of 25 birds was noted on 30 August. First observations of adults molting into winter plumage were made on 5 July.

Marsh Creek - Common breeder and fall migrant. During the first 10 days of June, male display flights were especially common in the evenings, but after 11 June the activity was no longer observed. A nest containing a single egg was found on Riparian Dryas terrace on 5 June. Pipping eggs were first noted on 2 July, and adults entered molt shortly after hatch. Eastward migration was first observed on 22 July.

Niguanak - Common breeder and fall migrant. Vocal males flying with deep, slow wingbeats displayed over the tundra between 2 and 9 June. The first active nest was found on 11 June, where the adults were observed performing intense distraction displays. Frost scars, frost boils, and other sparsely vegetated microsites interspersed within a variety of habitat types were used as nesting areas. Another pair was observed copulating on 20 June. Hatching began in early July and continued through the middle of the month. Both adults attended chicks and were often observed in Wet Sedge communities around pond peripheries. Numerous low-flying flocks comprised of 3-20 adult plovers migrated eastward between 23 July and 3 August, particularly during the morning hours. The major juvenile migration occurred during the last two weeks of August.

SEMIPALMATED PLOVER

Katakturuk - Rare breeder; fairly common summer resident. Semipalmated plovers were observed in Riparian habitat on 9 of 10 surveys, beginning 7 June and ending 17 August. One nest containing 4 eggs was found in Riparian habitat on 16 June. The nest may have been subjected to flooding during heavy early-July rains; it contained 3 eggs on 28 June and was empty by 5 July. One chick was observed nearby on 5 July.

Jago Bitty - Rare visitant. Plovers were observed on 8 occasions from 2 to 16 June; 2 birds were observed in Moist Sedge habitat, one in Moist Sedge-Shrub, and the remaining were seen on gravel bars along the Jago River. Semipalmated plovers also were sighted along the river approximately 6 km south of camp on 12 and 26 July.

Aichilik - Uncommon spring migrant. First sighting consisted of 3 birds on 9 June. Two were observed in Riparian habitat 13 June, and one individual was seen 3 km upriver on 29 June.

Sadlerochit - Rare breeder. A single adult plover was sighted on 4 days from 6 through 27 June; on 3 occasions a male was observed foraging and displaying on a Riparian mudflat near camp, and a male was seen displaying at the tip of Anderson Spit. On 8 July, a nest containing 4 newly hatched chicks was discovered on a bare-ground scrape among pebbles on the river bank near camp. Observers had walked frequently through this area during June without flushing an incubating adult. After hatching, no plovers were observed until 14 August when a single adult was sighted foraging on the lagoon shore.

Jago Delta - Rare migrant. Two single adults were observed on 2 June: one flew in a circular pattern through camp area "cackling" loudly, and one flew eastward, approximately 5 km south of coast. Two juvenile plovers fed with juvenile dunlin and semipalmated sandpipers on Riparian mudflats on 15 August, and 3 juveniles were observed in this habitat on 16 August. An individual of unknown age vocalized from the river area on 19 August.

Marsh Creek - Rare visitant. Semipalmated plovers were seen south of camp in Riparian habitat on 19 and 20 June.

Niguanak - Rare migrant. Two juveniles were seen on 9 August 13 km southwest of the Niguanak camp on a gravel bar along the Okerokovik River.

WANDERING TATTLER

Katakturuk - Rare visitant. A single wandering tattler was sighted in Riparian habitat on 21 June.

Marsh Creek - Rare breeder. On 6 June, 1 bird was seen foraging along Marsh Creek on gravel and sand bars. Between 30 June and 3 July, a single adult was again observed foraging, and on 8 July 3 adults with at least 3 chicks were seen in the Riparian habitat. One adult with 1 chick was sighted on 24 July.

SPOTTED SANDPIPER

Katakturuk - Rare visitant. Sightings of solitary spotted sandpipers occurred on 7, 21, and 28 June in Riparian habitat.

Jago Bitty - Rare visitant. Several birds were observed in Riparian habitat approximately 6 km south of camp on 13 July.

Marsh Creek - Rare breeder. A pair, first seen on 10 June, successfully nested in Riparian habitat. The nest was discovered on 19 June and contained 4 eggs. Both adults were observed attending chicks near the nest site on 24 July.

WHIMBREL

Katakturuk - Rare summer visitant; possible breeder. A pair of whimbrels was observed in an area of high center polygons near Tussock habitat on 26 July. One individual flew and perched repeatedly in the area, while scolding and acting defensively, as if chicks were present.

Jago Bitty - Rare visitant; possible breeder. Whimbrels were sighted on 5 occasions between 16 June and 21 July; three sightings were of lone birds and two sightings were of a pair. On 21 July, a whimbrel in Riparian habitat performed distractive displays, suggesting that eggs or young were nearby. A final pair of whimbrels was observed flying over Moist Sedge-Shrub habitat on 12 August.

Aichilik - Rare breeder; uncommon to fairly common visitant. Throughout June, whimbrels were seen in small groups of 2-4 in Moist Sedge and Wet Sedge habitats about once every 5 days. During July, sightings of larger flocks (3-18 individuals) occurred daily. A whimbrel nest was found on 16 June on a low hummock in Wet Sedge habitat. There were 2 eggs, markedly unequal in size, indicating a possible renest attempt. Harrison (1978) reported a normal clutch-size range of 3-5. The eggs hatched between 7 and 12 July; backdating (Harrison 1978) indicated egg laying between 10-15 June. This was the first confirmed nesting by whimbrels on the ANWR coastal plain. On 20 July, a fledgling was seen with an adult about 300 m from the nest site. The last whimbrel observation consisted of 2 birds in Moist Sedge-Shrub habitat on 5 August.

Sadlerochit - Rare summer visitant. Whimbrels were sighted on 5 days between 13 June and 21 July. On 13 June and 15 July, sightings were of solitary adults flying into Riparian and over Mosaic habitats respectively, calling in flight. Four adults were again observed foraging in Moist Sedge vegetation along the river bank on 13 July. A final sighting on 21 July, was of 2 adults flying over the lagoon.

Marsh Creek - Rare spring migrant. On 5 June, one whimbrel was seen in Moist Sedge-Shrub habitat 5 km north of camp.

Niguanak - Rare migrant. Two whimbrels were observed flying together on 5 July.

BLACK-TAILED GODWIT

Jago Delta - Casual fall migrant. One godwit in juvenile plumage was observed (with a flock of long-billed dowitchers) flying eastward over Flooded habitat on 27 August.

RUDDY TURNSTONE

Okpilak - Uncommon summer resident; possible breeder. The first sighting was of a single bird flying eastward over a coastal lagoon on 2 June. Almost all observations were either in Riparian habitat or along coastal peripheries. The last ruddy turnstone observation was on 4 August at the coast.

Katakturuk - Fairly common summer resident; probable breeder. Ruddy turnstones were observed in Riparian habitat during 7 surveys from 7 June through 19-20 July. A pair was suspected of nesting along the river drainage.

Jago Bitty - Fairly common breeder. Birds were seen regularly between 2 June and 25 July, mainly in Riparian areas near camp and between camp and Wet Sedge plots 9 km northeast of camp. Although no nests were found, a pair probably nested on a gravel bar near camp, and at least 2 additional pairs probably nested along the Jago River, approximately 3-7 km northeast of camp. Ruddy turnstones frequently used Dryas terraces adjacent to river from 24 June to 13 July. Adults performed distraction displays and behaved as if young were nearby; however, no juvenile turnstones were observed during the field season.

Aichilik - Fairly common breeder. Ruddy turnstones were conspicuous residents of Riparian gravel bars throughout the study period. During the first 3 weeks of June, aerial displays and aggressive flights against jaegers occurred frequently. Three nests found on 7 June each contained 4 eggs and were located on a gravel bar near camp. One of the nests was depredated within a week. A nest found on 6 July was 30 m from the earlier depredated nest, and contained only a 3-egg clutch. This was suspected to be a renest attempt by the same pair and was empty when rechecked 13 July. No fledglings were seen in the Aichilik area.

Sadlerochit - Fairly common breeder; common summer resident. Ruddy turnstones were frequently sighted near the Sadlerochit River from 31 May to 16 August. Pairs were first seen in Riparian habitat on 1 June, and 4 nests were discovered on sparsely vegetated mudflats of river channels between 8 and 13 June. All nests contained 4-egg clutches. Turnstones frequently vocalized at jaegers and chased them through the area. By 20 June, 2 nests were found empty, apparently depredated. At least 2 groups of adults with chicks less than one week old were seen foraging along the river on 27 June and 7 July. Turnstone adults were fiercely defensive of their young against jaegers, gulls, owls, and foxes; "patrols" of 3-7 birds flew constantly through the area to harass all intruders during the brood rearing period of July. The first juvenile was seen on 21 July, and a group of 4 juveniles was sighted on 8 August. Most observations through 15 August were of single juveniles or juveniles and adults foraging in Moist Sedge vegetation along river banks or on mudflats. Turnstone adults were present in the area with fledgling young for longer periods than other shorebird species. No adults were observed to be molting into winter plumage.

Jago Delta - Fairly common breeder; common summer resident. Ruddy turnstones were seen daily in Riparian habitat from 2 June through 6 August. One observation of a turnstone perched in Wet Sedge tundra occurred on 5 June. Pairs were not observed until 7 July when the first nest was discovered. Four additional nests (all with 4-egg clutches) were located in sparsely vegetated Riparian habitat through 6 July. The latest observation of incubation was on 12 July, although young chicks accompanied by adults were already present in Riparian habitat on 6 July. Through July, most observations were of single adults and family groups foraging along the river. An individual was observed foraging with a flock of semipalmated sandpipers on coastal mudflats on 19 July. Only juveniles were observed during August; single birds were seen in Riparian habitat on 15 and 16 August, and on 25 August one was sighted on mudflats west of the delta feeding with a mixed flock of shorebirds.

Marsh Creek - Fairly common breeder. Ruddy turnstones were obvious and common inhabitants of the Marsh Creek drainage. Two nests, found 11 and 12 June, contained 4 eggs each and were located on gravelly substrates in Riparian habitat. The first eggs pipped on 25 June; after 6 July, adults with young were seen in various locations along the river. First fall migration movements were noted on 22 July, and no turnstones were seen after 7 August.

Niguanak - Rare summer migrant. Two ruddy turnstones were seen flying through the Niguanak area on 18 June. One bird was seen briefly mingling with a flock of 18 pectoral sandpipers on 20 August. Pairs and small flocks were seen during the summer in Riparian habitat outside the immediate Niguanak camp area: Jago River, Niguanak River, and Okerokovik River.

SANDERLING

Sadlerochit - Rare spring migrant. On 6 June, a flock of 15 sanderlings foraged with Baird's, stilt, and semipalmated sandpipers on lagoon mudflats. Several were in full breeding plumage, while others were in various stages of molt.

Jago Delta - Common fall migrant. Juvenile sanderlings were observed feeding on mudflats at the coast in mixed shorebird groups on 8 occasions between 22 July and 29 August. Through 21 August, observations consisted primarily of scattered individuals. Migrational staging increased from 23-29 August, when total numbers of sanderlings observed at the coast reached 70, 75, and 156 during 3 days. Average flock size was 10-40 birds.

SEMIPALMATED SANDPIPER

Okpilak - Fairly common breeder and fall migrant. Birds were observed daily from 2 June to 14 August. On 2 June, aerial displays were common and birds were abundant in all habitat types. By 13 June, display flights had diminished. Nest sites were in Mosaic habitat and the earliest hatching was recorded on 26 June. Chicks were seen in Flooded habitat on 3 July. Small flocks were first observed on 9 July and numbers peaked on 24 July in Flooded habitat. Densities soon diminished across tundra habitats, but on 11 August approximately 300 semipalmated sandpipers were observed on the Okpilak River mudflats.

Katakturuk - Fairly common breeder. Semipalmated sandpipers were frequently observed on 8 of 10 weekends Katakturuk was surveyed (7 June to 20 July; 16 to 17 August). Three nests were discovered between 16 and 22 June: 2 in Riparian habitat, and 1 in Tussock tundra. Mean clutch size was 3.75 (n=4). At one rest hatching was in progress on 5 July, suggesting nest initiation began during the third week of June (Harrison 1978). Adults and chicks were observed in Riparian habitat on 14 July.

Jago Bitty - Abundant breeder. Birds were seen almost daily from 2 June through 24 July; 95% of birds counted during censuses were observed in Riparian (58%) and Moist Sedge-Shrub (37%) habitat types. Courtship displays and aggressive interactions among males were observed from 4-21 June. Nineteen nests were located between 11 June and 1 July. Nests were found in Riparian (n=10), Moist Sedge (n=5), and Moist Sedge-Shrub (n=4) habitat types. Nests in Moist Sedge type were located on slightly elevated, drier areas near the Jago River that more closely resembled Riparian habitat. Mean clutch size was 3.7 (n=19). Chronology data suggested that nearly 80% of clutches hatched between 28 June and 10 July. Hatching was known to occur on 29 June and 2, 7, 8, and 10 July; therefore, most nests were probably initiated during mid to late June (Harrison 1978). Within 2 weeks after the hatching period, most semipalmated sandpipers left the area. Fairly large numbers of adults performed distractive displays in Riparian and Moist Sedge habitats between 15 and 18 July; only 6 birds were observed thereafter.

Aichilik - Fairly common breeder and fall migrant. The majority of observations occurred in Riparian habitat during June when males were engaged in flight displays. Three nests were found: 2 in Moist Sedge-Shrub and 1 in Tussock habitat. All were well hidden in tall sedge. A nest with 3 eggs on 1 July contained 1 egg on 8 July and an agitated adult was nearby. Egg laying probably occurred between 13 and 24 June (Harrison 1978). During early August, flocks of 10-15 were seen flying east.

Sadlerochit - Abundant breeder; and common fall migrant. Birds were observed daily from 31 May through 16 July. A flock of 120 semipalmated sandpipers, apparently in migration, foraged on a lagoon mudflat with a flock of other shorebirds on 6 June. Pairs were seen together from 31 May through mid June, and courtship displays were performed by males from 31 May to 23 June. Territorial displays, aggressive interactions between males and other intruders, and distraction displays extended through incubation and early brood periods.

Through June, sandpipers were most frequently seen in Moist Sedge tundra near the river drainage, and Mosaic, Moist Sedge-Shrub, and Riparian habitats. Twenty-four nests were located between 8 and 27 June: 7 each in Moist Sedge-Shrub and Riparian habitats, and 5 each in Mosaic habitat and Moist Sedge vegetation along the river bank. Mean clutch size was 3.8 (n=24). Earliest evidence of hatching was 26 June (Mosaic), and all nests were hatched or abandoned by 10 July. Several adults with chicks (1-5 days old) were observed along the river bank in Moist Sedge vegetation on 30 June. Adults with broods appeared to concentrate in Riparian associated habitats, in wet upland swales near the bluff, and in Moist Sedge-Shrub tundra. Adults gradually left the area during July and were absent after 5 August. From mid-July through mid-August, juvenile semipalmated sandpiper groups were seen feeding primarily in Riparian river channels and melt-water ponds near the bluff. Large flocks of up to 50 birds were noted in August on lagoon mudflats. On several occasions beginning in late July, parasitic jaegers were observed to capture juvenile sandpipers in flight.

Jago Delta - Common breeder and fall migrant. Semipalmated sandpipers were observed daily from 4 June to 30 August. Pairs were seen on 4 June, and males performed courtship and territorial displays from 4-20 June in all habitats. Eight nests were located between 14 and 30 June: 3 in Wet Sedge, 2 each in Flooded and Mosaic, and 1 in Moist Sedge-Shrub habitat. Hatching was suspected at several nests during the first week of July because of "group defensive" behavior of adults (flying in flocks of 3-7 birds to chase away or distract observers, aerial predators, and foxes); chicks were first observed on 10 July. Individuals and groups of adults, as well as parents with broods, fed primarily in Riparian, Flooded, and Wet Sedge habitats through July. Mixed-aged flocks of 28 and 20 birds were sighted on coastal mudflats on 19 and 23 June, respectively. Adults were observed in the area until early August, after which only migratory and/or staging juvenile groups were seen. Flocks of 5-100 birds fed along coastal mudflats with mixed flocks of Calidris sandpipers through 30 August. Greatest numbers seen at the coast were 220 (12 August), 210 (19 August), and 166 (20 August).

Marsh Creek - Fairly common summer resident; probable breeder. Observations were most common in Riparian habitat along Marsh Creek. Display flights were frequent during early June, then tapered off and ended by the last week of June. No nests were found but flight-capable chicks were seen in Riparian habitat on 24 July.

Niguanak - Uncommon breeder. No more than 6 individuals were seen during any day during the breeding season. Display flights were observed from 13-26 June. Two nests, each containing 4 eggs, were found in Wet Sedge habitat. One nest hatched between 29 June and 5 July, the other between 11 and 14 July. Semipalmated sandpipers were seldom observed after mid-July. A flock of 12 was seen flying east on 3 August. On 9 and 10 August, several small flocks were observed outside the immediate Niguanak area in Riparian habitat along the Okerokovik and Niguanak River.

WESTERN SANDPIPER

Okpilak - Fairly common fall migrant. Approximately 400 western sandpipers were observed on Okpilak River mudflats on 11 August.

Sadlerochit - Rare fall migrant. A single western sandpiper was observed foraging on a mudflat near the mouth of Sadlerochit River on 13 August.

Jago Delta - Common fall migrant. Juvenile flocks of western sandpipers were regularly seen feeding on mudflats at the coast (some in mixed shorebird groups) from 11-30 August. Highest total numbers (maximum of 105 birds) and flock sizes (maximum of 55) were noted during 11 and 12 August. Throughout the remainder of August, daily observations were typically of 2-13 western sandpipers foraging or flying eastward along the coast. One individual in winter plumage was sighted on 23 August and several other sandpipers were noted as molting juveniles.

LEAST SANDPIPER

Katakturuk - Casual spring migrant. An adult least sandpiper was sighted in Riparian habitat on 21 June. This was the first record of the species occurring on the inner coastal plain of ANWR.

WHITE-RUMPED SANDPIPER

Aichilik - Rare fall migrant. A single white-rumped sandpiper was seen in a mixed flock of *Calidris* sandpipers on 11 August. The flock was moving north along a *Dryas* bench.

Jago Delta - Rare fall migrant. A solitary, juvenile white-rumped sandpiper was observed feeding on coastal mudflats with mixed flocks of shorebirds on 12 and 27 August.

Niguanak - Rare fall migrant. One juvenile was observed with 3 semipalmated sandpipers and a red-necked phalarope at a gravel bar pool on the Niguanak River 8 km southeast of camp on 10 August.

BAIRD'S SANDPIPER

Katakturuk - Rare breeder; fairly common summer visitant. Baird's sandpipers were observed on 7 of 10 weekends at Katakturuk, on 7-8 June, and from 16 June through 20 July. Large numbers of Baird's sandpipers sighted in Riparian habitat on 28-29 June were probably flocks of post-breeding males. One nest was found on Katakturuk bluffs; it contained 4 eggs on 21 June and was empty on 13 July.

Jago Bitty - Rare visitant. Birds were observed on 6 occasions between 2 June and 15 August. Several Baird's sandpipers utilized Moist Sedge habitat near camp in early June, several more birds were in the Riparian zone 6 km south of camp in mid-July, and birds were observed feeding on a gravel bar 3 km north of camp on 12 and 15 August.

Aichilik - Fairly common spring migrant; rare breeder. Baird's sandpipers were seen daily on Riparian gravel bars until 10 June. Aerial displays and vocalizations were frequent. Observations then diminished, and by 20 June, only 1 pair was present in the area. A nest was found on 20 June in a grass clump on a Riparian gravel bar. Four eggs were present, but were gone by 27 June. A second nest with 3 eggs was found on 6 July only 10 m from the first nest site. Two nestlings hatched on 20 July; the third egg was infertile. Back-dating placed the initiation of incubation at 30 June (Harrison 1978); this was likely a renesting attempt.

Sadlerochit - Uncommon breeder and migrant. Baird's sandpipers were observed from 6 June - 15 August. A group of 7 adults was seen feeding with a mixed flock of shorebirds on coastal mudflats on 6 June. Two nests were discovered on barren/shrub-forb Riparian tundra on 8 and 20 June; each nest contained 4 eggs. The only other sighting during June was of 9 adult Baird's sandpipers and 1 chick present in Riparian habitat on 27 June. This observation suggested the likelihood of at least one additional nest in the study area. Adults with broods were sighted near the first 2 nests on 10 July, and were seen foraging on river bars through mid-July. Juveniles were first seen on 15 July, and were observed foraging on lagoon mudflats and stony beaches through 15 August. No adults were seen after 5 August.

Jago Delta - Rare breeder and fall migrant. Solitary Baird's sandpipers were observed foraging in wet Riparian habitat on 2, 4, and 8 June. A bird vocalized and displayed briefly over a gravel bar on 16 June, and single Baird's Sandpipers were subsequently seen on 18 and 21 June. One nest containing 4 eggs was discovered in sparsely vegetated Riparian tundra on 5 July. Hatching was in progress on 15 July, and 4 chicks were banded at the nest the next day. Chicks were observed in the area on 18 July, after which single adult sandpipers were sighted near the river on 4 days through 13 August. At the coast, an adult with 4 chicks foraged on a mudflat near Martin Point on 20 July. From 11-30 August, single juveniles and small flocks (3-6 birds) were seen on 9 occasions feeding on river and delta mudflats.

Marsh Creek - Uncommon visitant. An apparently transient individual was observed foraging in Riparian habitat from 1-3 and 7-10 July. Two individuals were seen in Riparian habitat on 12 August.

Niguanak - Rare breeder. On 2 July, 2 adults and 3 chicks (approximately 3 days old) were seen on ravine gravel bottoms. A single nervous adult was noted in the same area on 16 July, and a juvenile was seen on 23 July.

PECTORAL SANDPIPER

Okpilak - Common breeder; abundant fall migrant. Pectoral sandpipers were seen daily from 2 June - 14 August. Males displayed frequently in Wet Sedge and Mosaic habitats during early June and less frequently during mid-June. Three nests were discovered; all were in Mosaic habitat and each contained 4 eggs. Laying and incubation were recorded between 20 June and 8 July, and hatching occurred between 1 and 18 July. Flocks flying eastward and birds congregating in Flooded habitat were observed as early as 9-10 July, but the most extensive migratory movements were noted on 22 and 23 July.

Katakturuk - Fairly common summer visitant. Pectoral sandpipers were observed on 7 of 10 surveys of the study area. Birds were first seen on 7 and 8 June, and last observed on 17 August. No nests were located.

Jago Bitty - Common breeder. Birds were observed regularly from 4 June - 16 August. Courtship displays and aggressive interactions among males were observed from 7-26 June. Seven nests were located between 15 June and 5 July in Wet Sedge habitat types. Mean clutch size was 3.7 (n=5). Three nests hatched on 29 June, another hatched between 26 and 30 June, and one more hatched between 5 and 10 July. With the assumption of a 21-23 day incubation period (Harrison 1978), this data suggested most nests were initiated in the first or second week of June. Juvenile pectorals were first observed on 22 July, and the greatest numbers were present in Wet Sedge and Moist Sedge habitats thereafter. Juvenile predominated groups were first seen during the 6-9 August period. Flocking behavior among adults was observed between 6 and 19 July, mainly in Wet Sedge tundra where groups of up to 9 birds congregated. Flocks of migrating adults (up to 12 birds) were sighted moving eastward on 24 and 25 July.

Aichilik - Common breeder and fall migrant. Pectoral sandpipers were present throughout the study period in all habitats, although use of Riparian and Moist Sedge habitats was rare prior to fall migration. Moist Sedge-Shrub had the highest density of birds and nests (6 nests found), followed by Wet Sedge (5 nests), and Tussock (3 nests). Use of Tussock habitat may have reflected its proximity to Moist Sedge-Shrub since few pectoral sandpipers were seen in pure Tussock stands. Male courtship displays were noted from the time of observer's arrival (2 June), although by the last week of June display frequency was declining. Most of the males had departed by mid-July. The first eggs were found on 10 June, and some nests found on that date had full clutches. Laying largely occurred during the first three weeks of June, with only a few nests initiated in the last week of that month (Harrison 1978). Flightless fledglings were commonly seen in the second and third weeks of July, and the last were seen on 5 August. By 3 August, small flocks began to assemble and birds were seen more frequently in Riparian and Moist Sedge habitats.

Sadlerochit - Common breeder. Pectoral sandpipers were present in the study area from 31 May through 16 August. Small flocks of males flew together, and courtship displays and aggressive male interactions were frequently observed through 15 June in all habitat types. Thirteen nests were located between 11 and 20 June. Nests were found in Wet Sedge (n=6), Tussock (n=3), Riparian (n=2), Mosaic (n=1), and Moist Sedge-Shrub (n=1) habitats; several more may have been present in Moist Sedge tundra along the river bank north of camp. Nestlings were first observed on 28 June in Wet Sedge tundra and on 3 July in Mosaic habitat. Highly defensive attitude and vigorous distraction displays of pectoral sandpipers along the bluff through mid-July suggested that most adults from upland tundra types moved broods to forage in Wet Sedge and melt-water ponds soon after hatching. Juveniles were first observed on 14 July and were seen regularly as singles or in small groups in Wet Sedge and Mosaic habitats through the end of July. Flocks of adult sandpipers were noticed flying eastward in groups of up to 50 from 4-26 July, with peak numbers observed on 23 July. During August, sightings were primarily of small flocks of juveniles flying and feeding in Riparian habitat and on coastal mudflats. Observations of juveniles being chased or depredated by a parasitic jaeger pair occurred during the later part of the season.

Jago Delta - Common breeder; abundant fall migrant. Birds were seen frequently and regularly from 2 June - 30 August. Displaying males were very prominent through mid-June in all habitat types. An unsuccessful attempt at copulation was observed on 5 June. Four nests were located between 11 and 26 June: 2 each were found in Flooded and Mosiac tundra. Hatching occurred at most nests during the first week of July and chicks were first seen on 10 July. Flocks of up to 5 adult pectoral sandpipers "patrolled" flooded tundra where the majority of young were observed through approximately 24 July. The latest observations of chicks occurred in mid-August when two 8-9 day old young were seen in Flooded habitat (13 August), and one 10 day old chick was seen in Mosiac tundra (14 August). These may have been chicks from renest attempts. Juveniles, or flight-capable young, were first seen on 20 July, foraging singly or in small groups in Flooded, Wet Sedge, Mosaic, and Riparian habitats. From 11-26 July many flocks of up to 30 adults were sighted flying eastward through the area and feeding in primarily Flooded habitat. On 24 July, 300 birds were seen flying from inland areas in flocks of up to 175 birds to forage on coastal mudflats. Through August, many juvenile flocks of up to 50 birds were sighted daily flying eastward or foraging on inland Flooded habitat and coastal mudflats. Peak migration was observed on 25 August when a total of 1,027 birds congregated in mixed shorebird feeding flocks at Tapkaurak Bay.

Marsh Creek - Uncommon summer visitant; fairly common fall migrant. Pectoral sandpipers were seen infrequently during the breeding season. No nesting activities were observed. Flocks were first noted flying eastward on 22 July and after that date pectoral sandpipers were more common in all habitats.

Niguanak - Abundant breeder and fall migrant. Pectoral sandpipers were seen daily from 2 June - 30 August. During June, the species was most abundant in Moist Sedge-Shrub habitat and fairly common in Flooded. Males patrolled territories and frequently displayed from 3-23 June, after which activity diminished through the end of the month. The first active nest was found on 8 June, and the last nest containing eggs was noted on 8 July. The average clutch size was 3.9 (n=23). All but 3 nests were in Moist Sedge-Shrub or Flooded habitat. Chicks were abundant after 1 July, and females attended broods in Flooded habitats where several family groups of various shorebird species gathered to forage in the saturated soils. Flocking tendencies were noted as early as 10 July. Between 21 July and 3 August, numerous flocks of 4-24 were regularly observed flying eastward. Migrating juveniles surged eastward in flocks of 15-20 between 20 and 30 August. Migrants often stopped to forage in the muck soils around receding ponds in Flooded habitat.

SHARP-TAILED SANDPIPER

Niguanak - Rare fall migrant. One was observed foraging along the edge of Niguanak Lake on 27 August.

DUNLIN

Okpilak - Uncommon visitant. Two birds foraged in Wet Sedge habitat on 9 June. Subsequently, single birds in Mosaic and Flooded habitats were observed 5 times during the summer, the last on 12 August.

Sadlerochit - Rare breeder and migrant. A single male was observed in Mosiac habitat on 5 June, and a flock of 10 dunlin foraged with a mixed flock of shorebirds on lagoon mudflats the next day. From 13-30 June, a single adult or a pair was observed on 5 occasions foraging in wet mud and Moist Sedge habitat along the river. No nest was located, but a pair was highly defensive of a dry, elevated site in Moist Sedge tundra near camp on 5 July. The next day an adult was observed brooding 4 downy chicks (approximately 24 hours old) in this area. Through July, the adults and young were infrequently observed in the Riparian area. Three partially molted individuals (presumably juveniles) rested on a gravel bar near camp on 11 August, and on 15 August, 4 adults in full breeding plumage foraged on lagoon mudflats.

Jago Delta - Uncommon breeder; common fall migrant. Two dunlins, possibly a pair, were observed foraging in Flooded and Wet Sedge tundra, and near a lake by Mosaic habitat on 4, 10, and 17 June, respectively. A male displayed and called from Mosaic habitat on 17 June. On 4 days between 2 and 9 July, single dunlins, and a pair, were observed in Moist Sedge-Shrub and Riparian habitats. No nests were located, but one bird of a pair acted defensively near a pond in Mosaic habitat, as if chicks might have been present. Five adults flew in a defensive, vocalizing flock at a lake near camp on 16 July. On 22 July, 2 adults with broods of 1 and 2 young were sighted in Flooded tundra; a juvenile was first observed in Flooded habitat the next day. Individuals and small groups of 2-4 birds were seen in Flooded tundra near camp through August. Single dunlins were first observed on coastal mudflats on 19 and 22 July. Small adult and juvenile flocks foraged on mudflats of the lagoon and delta, often in mixed shorebird flocks, from 23 July through August. Peak migration occurred after this point with daily totals of 140 and 210 birds seen on mudflats on 25 and 30 August, respectively. About one-third of these were adults in breeding plumage, or partially molted into winter plumage, while the remainder were in juvenile plumage, or juveniles molting into first winter plumage.

STILT SANDPIPER

Okpilak - Fairly common breeder. Birds were frequently observed between 7 June and 13 August. Aerial displays were noted on 19 June. Three nests were found: 2 in Mosaic and 1 in Moist Sedge-Shrub habitat. Three nestlings were banded on 27 June, and a banded juvenile was seen in Moist Sedge-Shrub on 22 July. Chicks were observed in Flooded habitat on 3 July. One nest containing 2 eggs on 13 June was still attended by an adult on 9 July, but was found abandoned on 17 July with 2 unhatched eggs.

Jago Bitty - Uncommon breeder. Stilt sandpipers from several pairs were observed regularly in Wet Sedge habitat, and 1 pair was seen occasionally in Moist Sedge tundra. Males performed courtship display flights from 15-29 June. Two pairs nested in Wet Sedge, and a third nest was located in Moist Sedge habitat. Four chicks (1 day old) were observed near 1 nest in Wet Sedge on 29 June, and clutches from the other 2 nests hatched between 3 and 10 July. Mean clutch size was 4.0 (n=3). Assuming an incubation period of 19 to

21 days (Harrison 1978), nests were probably initiated during second and third weeks of June. Males were observed incubating eggs at 2 nests. Shortly after clutches hatched, stilt sandpipers either moved to different habitat types or became extremely secretive in their habits; only 2 birds were seen after 3 July. On 19 July, a lone adult was observed by the river approximately 7 km north of camp, and a second bird was seen in Wet Sedge habitat on 25 July.

Aichilik - Uncommon breeder. A pair was seen in Wet Sedge habitat from 5 June through 6 July. During 5-21 June, the male (presumably) frequently called in a high flight display. On 6 July, an adult was observed incubating 4 eggs on a small hummock in Wet Sedge habitat. The eggs were not pipping, so when the nest was found empty 2 days later, it had likely been depredated. An adult was observed calling and circling defensively on 16 July, and a flight-capable juvenile was seen in the same area on 22 July. One suspected juvenile was noted in Riparian habitat on 15 August.

Sadlerochit - Uncommon migrant. Twenty stilt sandpipers foraged with a mixed flock of sanderling, Baird's, and semipalmated sandpipers on lagoon mudflats on 6 June. Between 5 and 9 August, single and paired juveniles were seen on 3 occasions foraging along the coast on mudflats and by a small pond.

Jago Delta - Uncommon breeder and fall migrant. From 1-4 stilt sandpipers were seen regularly through the breeding season between 4 June and 26 July. A pair was first observed on 4 June, and sightings of 1 or 2 adults were made on 7 more occasions between 11 June and 2 July. Observations of stilt sandpipers occurred exclusively in Flooded habitat. No nests were located, but on 3 and 10 July adults with chicks (less than 1 week old) were seen in Flooded tundra. On 17 July, a flight-capable young and an adult were observed, and juveniles (independent group) were first sighted foraging in Flooded tundra on 23 July. Observations of juvenile stilt sandpipers continued from the end of July through mid-August in Flooded tundra (4-6 birds regularly seen) and along the coast (flocks of 1-10 individuals). Maximum numbers of stilt sandpipers observed at the coast reached 42 on 12 August and 31 on 21 August.

Niguanak - Fairly common breeder. Stilt sandpipers were observed regularly from 7 June through July and infrequently during August. Males displayed in high aerial flights between 16 June and 6 July. One nest with 4 eggs was found on a small hummock in Wet Sedge habitat on 13 June. During early July, up to 8 adults in Flooded habitat vocalized nervously and circled observers in defense of nearby chicks. The first flight-capable juvenile was seen on 17 July, and adults in winter plumage were noted on 7 August.

BUFF-BREASTED SANDPIPER

Okpilak - Uncommon spring and fall visitant. One sandpiper was observed in Wet Sedge habitat on 12 June. Two males displayed in Riparian habitat at the Okpilak River on 14 June. Five birds were seen again at the Okpilak River on 16 June, but no displaying was observed. On 11 August, buff-breasted sandpipers were sighted in the same general area.

Katakturuk - Uncommon breeder. Buff-breasted sandpipers were observed frequently on 8 of 10 surveys. First observations were on 7 and 8 June, and the last were on 16 and 17 August. Three nests were found: 2 in Riparian habitat on 16 and 21 June, and 1 on 6 July in Tussock tundra. Each nest contained 4 eggs. Chicks were present in 1 Riparian nest on 6 July. Juvenile birds were first seen foraging on *Dryas* Riparian benches on 10 August.

Jago Bitty - Rare breeder. Buff-breasted sandpipers were observed regularly between 7 June and 12 July: all sightings except one were believed to represent members of a single family group. The pair's nest with 4 eggs was located in Moist Sedge habitat on 12 June and was watched relatively closely thereafter. During the incubation period, the female foraged in Moist Sedge and Riparian habitats near the nest site. A male was seen foraging in Riparian areas on several occasions. The eggs began pipping on 6 July, and were hatched by late 7 July, indicating a minimum incubation period of 26 days. The female and 4 chicks were observed foraging along the Jago River near camp on 8, 10, and 12 July, and were not seen thereafter.

Aichilik - Fairly common breeder. This species was common at the time observers arrived on 2 June, and remained conspicuous through 15 June. Lek courting males were seen in groups of 2-5 in Riparian Dryas-shrub bench and Moist Sedge. From 16-22 June, courtship displays declined in frequency and often only single birds were seen "wing raising". From 23 June through July, no more than 5 solitary individuals were seen; apparently all males had departed. Nearly all observations were in Riparian Dryas-shrub and Moist Sedge habitats. Four nests were found: 2 were in Dryas-willow complex (near gravel bars) and 2 were in Moist Sedge with scattered willow within a few meters of Riparian Dryas bench. One nest found on 16 June with 4 eggs was depredated the following week. A second nest containing 3 eggs on 20 June hatched a nestling on 10 or 11 July: the remaining 2 eggs were infertile. A third nest with 4 eggs was empty when examined 6 July, and on 12 July an agitated adult nearby indicated the presence of young. A fourth nest hatched 4 nestlings on 13 or 14 July. Harrison (1978) reported the incubation period for this species as unknown. The nest found with a complete clutch on 20 June and with a nestling on 11 July suggested a minimum incubation of 21 days (See Jago Bitty account for further estimations).

Sadlerochit - Fairly common breeder. Birds were observed regularly from 1 June through 16 August. Small "leks" of males (2-5 birds) foraged and flew together, and performed elaborate wing displays in Moist Sedge and Riparian habitat from 6-19 June. A pair was seen together on 2 June, but after this date males were most often seen in groups. Four nests, each containing 4 eggs, were located between 20 June and 1 July: 3 were found in Moist Sedge vegetation within 30 m of the river bank, and 1 was located in a sedge/forb area of Riparian habitat. A female and 4 chicks were first observed on 5 July in a Moist Sedge-Shrub margin of Tussock habitat, suggesting the presence of an upland tundra nest. In Riparian habitat small chicks (1-4 days old) were observed foraging with an accompanying adult on 14 and 25 July, and 2 nests along the river bank hatched during the periods of 14-15, and 18-20 July, respectively. Through the first week of August, adults and young foraged primarily in Riparian, Moist Sedge, Tussock, and Moist Sedge-Shrub habitats. Only juvenile birds were observed after 6 August; from 1-4 were seen most often in Riparian habitat and by melt-water ponds, but were also noted in Moist Sedge-Shrub tundra. Buff-breasted sandpipers were observed displaying at Sadlerochit study area in June 1984, but were never observed to nest.

Jago Delta - Fairly common breeder. Buff-breasted sandpipers were observed through the season to 30 August. Single birds were initially sighted on river mudflats near camp on 5-7 June. Males were seen in groups of 2-3 from 8-23 June displaying in Wet Sedge, Moist Sedge-Shrub, and Riparian habitats. Four nests were located in Wet Sedge tundra between 20 June and 7 July. All nests contained clutches of 4 eggs. Through early July, adults were observed foraging in Wet Sedge, Flooded, and Riparian areas. An adult with 4 young (2-3 days) was first noted on 17 July in Riparian habitat. Single adults and those with broods were seen most frequently foraging on Dryas benches and in wetter areas of polygonized (Mosaic) tundra near camp and along the coast. After July, no adults were seen in the area. Single birds and small groups of juveniles (2-5 birds) were observed in varied habitats between 9 and 16 August. One or two juveniles were seen on Dryas benches and foraged at the water's edge daily through 30 August.

Marsh Creek - Rare Spring and fall visitant. Buff-breasted sandpipers were observed on 3 dates: 6 June, 11 June, and 14 August.

Niguanak - Uncommon breeder. A pair was seen 5 June, and a nest was found in dense Moist Sedge adjacent to Tussock habitat on 18 June. A second nest was discovered on a sedge-covered slope above Flooded tundra; each nest contained 4 eggs. On 15 July, an adult with 3 chicks was seen foraging in a marshy area near camp. The last sighting, of a single bird foraging along the banks of Niguanak Lake, occurred on 19 August.

LONG-BILLED DOWITCHER

Okpilak - Fairly common breeder. Long-billed dowitchers were seen regularly from 2 June to 14 August. Two nests were found on 24 June in Wet Sedge habitat. One nest contained 3 eggs and hatched prior to 15 July. The other nest had 2 eggs when first discovered, had 4 eggs on 2 July, was being incubated on 16 July, and hatched sometime before 23 July. In late June, small flocks were observed.

Katakturuk - Uncommon visitant. Long-billed dowitchers were observed on 22-23 and 28-29 June.

Jago Bitty - Uncommon breeder. Long-billed dowitchers were sighted in Wet Sedge, Moist Sedge, and Moist Sedge-Shrub habitats from 6 June through 12 August. Adults were seen in Wet Sedge habitat on 6 days between 15 June and 25 July. Although no nests were found, at least one pair was believed to nest in Wet Sedge tundra. Adult dowitchers performed distraction displays on 29 June and 11 and 19 July. No adults were seen after 26 July, but several juvenile dowitchers were sighted in Moist Sedge-Shrub and Moist Sedge habitats between 22 July and 12 August.

Aichilik - Uncommon resident: probable uncommon breeder. Long-billed dowitchers were first seen 10 June in Moist Sedge-Shrub habitat, and observations continued through 6 August. Defensive displays directed at observers, including aerial circling and loud calling on 16 and 22 July, suggested the likelihood of young in the area.

Sadlerochit - Uncommon breeder; fairly common summer visitant. Long-billed dowitchers were seen regularly from 1 June to 15 August. Pairs were observed together in Wet Sedge and bluff melt-water ponds from 1-5 June: observations after this date through June were primarily of single adults foraging in Wet Sedge habitat and Wet Sedge inclusions in Mosaic and Moist Sedge-Shrub habitats, and along Moist Sedge vegetation on river bank. One nest was located in Wet Sedge on the date of hatching (4 chicks), 28 June. Through July, the defensive attitude of adults and consistent observations of distraction displays suggested the probability of additional nests or chicks present in Wet Sedge and Mosaic habitats. Small flocks of juveniles and adults were seen flying eastward over camp and foraging in Wet Sedge tundra and melt-water ponds near the coast from 11-15 August. An adult in transition to winter plumage was observed on 25 July.

Jago Delta - Fairly common breeder: common summer resident and fall migrant. Birds were frequently seen in the area from 4 June through 30 August. Single birds, pairs and groups of 3-6 dowitchers were observed foraging and flying about in all habitats through June. One nest, containing 4 eggs, was located in Wet Sedge tundra on 18 June. Flocks of 5 to 14 dowitchers were sighted on 2-3 July in Flooded habitat, vocalizing loudly and flying excitedly. Through July, pairs and groups of 3-6 adults were seen regularly, calling in Flooded, Mosaic, and Moist Sedge-Shrub habitats; no chicks were noted. Juveniles were first sighted on 7 August, and after 13 August were the only age group observed in the area. Eastward juvenile migration and staging areas appeared concentrated at the coast. Peak numbers reached 187 and 266 birds on 23 and 25 August, when birds were observed foraging on mudflats in mixed shorebird groups. Average flock sizes ranged from 5 to 20 juveniles, with maxima of 113 and 167 noted on above dates.

Marsh Creek - Rare visitant. Long-billed dowitchers were observed on 3 dates: 7 June, 8 June, and 22 July. The last sighting was of 5 birds flying east.

Niguanak - Fairly common breeder and fall migrant. Long-billed dowitchers were regularly observed from 2 June through 30 August. During June, dowitchers utilized Flooded and Wet Sedge habitats, as well as small ponds interspersed in Moist Sedge-Shrub. One nest with 4 eggs was found on 12 June on a small sedge-covered hummock in Flooded habitat. The eggs hatched prior to 3 July. Flocks of 4-6 birds (probably females) were frequently observed during late June. Chicks were attended in Wet Sedge communities near pond peripheries and were actively defended by adults. During late August, tight flocks of 10-30 individuals moved through the area and frequently fed in the mucky soils exposed by receding ponds and lakes.

RED-NECKED PHALAROPE

Okpilak - Common breeder. Red-necked phalaropes were fairly abundant when observations were initiated on 2 June. Courtship and territorial displays were frequent in Wet Sedge and Flooded habitats until about 25 June. Birds began congregating in small flocks in Flooded habitat, and by 3 July, females were much more conspicuous than incubating males. Five nests were located, each containing 4 eggs, in Flooded, Wet Sedge, and Mosaic habitats. Peak laying and incubating period was 20 June to 9 July. The latest nest with eggs was noted on 18 July.

Katakturuk - Rare breeder. Birds were sighted infrequently in Moist Sedge-Shrub habitat during June. One nest with 3 eggs was located in Moist Sedge-Shrub on 15 June. On 29 June, the nest contained 3 chicks, and an agitated male was observed in the vicinity on 6 July.

Jago Bitty - Uncommon breeder. Red-necked phalaropes were observed regularly in Moist Sedge-Shrub and Wet Sedge habitat types, and occasionally in Moist Sedge habitat, between 7 June and 18 July. Not more that 8 individuals (on 1 July in Moist Sedge-Shrub habitat) were ever observed during one day. One nest was located in Wet Sedge on 21 June; the clutch of 3 eggs hatched between

5 and 10 July. Assuming an incubation period of 18-20 days (Harrison 1978), the earliest possible date of clutch completion was 16 June. Adult red-necked phalaropes flocked and performed group "distraction" displays in Moist Sedge-Shrub habitat on 1 and 8 July. No adults were seen after 18 July; a single juvenile was sighted in Moist Sedge tundra on 7 August.

Aichilik - Uncommon summer resident and breeder. Phalaropes were seen at the small ponds and lakes scattered in the Aichilik area. A pair was seen copulating on 12 June, and a nest containing 4 eggs was found on 19 June in a Moist Sedge-Shrub margin of a Tussock study plot. A male with 3 chicks was seen in Moist Sedge-Shrub habitat on 1 July. The largest number seen was 6 females on a small lake on 22 June.

Sadlerochit - Uncommon breeder; fairly common summer visitant. When observers arrived on 31 May, phalarope pairs were present in the area, swimming and performing courtship displays on melt-water ponds in Wet Sedge, Mosaic, Moist Sedge-Shrub, and on polygonized margins of upland Tussock habitats. Copulation was observed on 2 June and pairs were frequently observed together through mid-June. Males were much less observable after 19 June, at which time female groups of 2-9 birds were regularly seen flying and swimming together in melt-water ponds below the bluff and along the coast. Female phalaropes had departed from the area by 3 July. One nest was located in Wet Sedge habitat on 21 June. The clutch of 4 eggs was presumably hatched by 16 July, but no young were seen in the vicinity. Males with chicks were infrequently observed foraging in bluff melt-water ponds through mid-July. The presence of additional agitated males near ponds in Mosaic habitat through mid-July, and a male with 2 chicks in Moist Sedge-Shrub on 1 July, suggested the probability of more successful nests in the area. Juvenile phalaropes were first observed on 15 July, flying with juvenile pectoral and semipalmated sandpipers. Juveniles were observed in flocks of 3-10, foraging in ponds of Wet Sedge, Mosaic, and Moist Sedge-Shrub habitats through the end of July. By August many adults had begun to molt into winter plumage, making age distinction difficult. Flocks of up to 32 birds foraged in ponds below the bluff and made increasing use of lagoon mudflats through 15 August.

Jago Delta - Fairly common summer resident; probable breeder. Red-necked phalaropes were sighted regularly from 3 June through 30 August. Pairs were observed together in Riparian, Mosaic, and Flooded habitat from 3-18 June. No nests were located. However, agitated vocalizations of males observed in early July indicated that nests may have been present in Mosaic and Flooded habitats. Through July, observations consisted primarily of single birds and small groups of adults flying through the area and foraging by ponds and lakes and in Flooded habitat. When the coast was first visited on 19 July, small groups were observed feeding on mudflats by Martin Point. Juveniles were first observed in Mosaic habitat on 11 August. Only juveniles were observed from 11-30 August; flocks of up to 29 birds were seen almost daily in either Mosaic, Flooded, or Wet Sedge tundra, by ponds and on mudflats of the coast, and flying in eastward migration.

Marsh Creek - Rare visitant. Red-necked phalaropes were observed in the Marsh Creek area on 2 dates: 15 June and 16 July.

Niguanak - Common breeder. This species was seen daily from 2 June to 28 August. During early June, most observations were associated with small ponds interspersed in Moist Sedge-Shrub habitat. The phalaropes possibly utilized smaller water bodies early in the season due to earlier warming and advanced invertebrate production. As thaw progressed, most phalaropes were seen in Flooded habitat. Copulation was observed on 4, 13, and 19 June. Six of eight identified nests were near water bodies in Flooded habitat, sometimes in close proximity (less than 10 m) to one another. Active nests were observed between 18 June and 3 July. In late June, females formed small flocks of 6-12 in Flooded habitat, and by 10 July, females were no longer present in the Niguanak area. Males attended chicks in Flooded habitat along with several other shorebird species (e.g. pectoral sandpiper, long-billed dowitcher, stilt sandpiper, red phalarope). An adult in winter plumage was noted on 24 July, and by 3 August all birds had apparently changed plumage. During the latter half of August, flocks of males and juveniles were commonly observed, often on Niguanak Lake.

RED PHALAROPE

Okpilak - Fairly common breeder. On 2 June, birds were already fairly abundant in Flooded habitat, and territorial and courtship displays were frequent. Copulation was observed on 19 June. The earliest nest with eggs was 23 June, the latest was 18 July. All nests (n=4) contained 4 eggs and were located in Flooded habitat. Known hatch dates were 10 and 16 July. By 25 June, small flocks appeared in Flooded habitats, probably post-breeding females. On 8 August, a pectoral sandpiper adult was seen caring for a red phalarope chick.

Sadlerochit - Uncommon summer visitant. Solitary female red phalaropes were sighted on 3 occasions: one flew over Wet Sedge tundra on 9 June, one flew over the river near the coast on 14 June, and a third perched by the lagoon on 15 June. A male phalarope was observed on 11 and 15 July, calling excitedly over Mosaic habitat as if young might have been present in area, but no red phalaropes were observed again through the remainder of the season.

Jago Delta - Fairly common summer resident; probable breeder. Red phalaropes were observed regularly from 4 June to 30 August. Pairs and groups of 3-5 adults were seen together from 4 June to 18 July, swimming and foraging in small ponds and low center polygons of Flooded, Mosaic, and Wet Sedge habitats. Loud vocalizations were noted from 8-11 June, and "chasing" displays by small groups of adults were observed on 18 June. Several repeated sightings of pairs and single birds occurred at ponds near camp through June, but no nests were located. An adult with a single chick (less than 1 week), and another with a brood of 4 were seen in Flooded habitat on 10 and 15 July, respectively. Pairs and small groups were seen through 7 August. First juveniles were observed on 23 July foraging by Flooded tundra ponds. After 7 August, observations were exclusively of juvenile phalaropes, with singles and flocks of up to 13 birds seen in Flooded habitat near camp, swimming in Tapkaurak Bay, and flying westward along the coast.

Niguanak - Uncommon breeder. Red phalaropes were frequently observed in Flooded habitat between 12 June and 24 August. Two nests were discovered, both in close proximity to water bodies. One nest had 4 eggs and was empty by 10 July and the second nest contained 4 day-old chicks on 8 July. Males attended chicks in Flooded habitat. An adult in winter plumage was first seen on 7 August.

POMARINE JAEGER

Okpilak - Fairly common summer resident. Pomarine jaegers were observed from 2 June to 14 August. Large numbers moved eastward during the first two weeks of June. Birds were infrequently observed after 18 July, although an unusually large aggregation was observed on 21 July between Three Drum Marsh and the creek south of camp. No nests were found in the Okpilak vicinity.

Katakturuk - Uncommon spring visitant. Pomarine jaegers were observed hunting in area on 7-8 June, and 15-16 June.

Jago Bitty - Common spring migrant and visitant. Many birds migrated through between 5 and 13 June, and hunted over all habitats on the study area. The peak of migration appeared to occur on 10 June, when approximately 50 pomarine jaegers flew over during a 6-hour period. Utilization of the area coincided with the presence of large numbers of calving caribou. Many jaegers fed on dead caribou calves and on caribou afterbirth. After 13 June, only 7 more birds were seen in June, and 1 bird was observed in July.

Aichilik - Fairly common spring migrant; uncommon breeder. The largest numbers were observed during the first 2 weeks in June, particularly hunting over Tussock habitat. Sightings decreased, and between 22 June and 9 August only 3 observations were made during plot censuses. A nest containing 2 recently hatched chicks was found in a wet hummocked area between Wet Sedge and Tussock habitats. Back-dating from hatching provided an estimate for the initiation of incubation of 16-20 June (Harrison 1978).

Sadlerochit - Fairly common spring migrant and visitant. Flocks of 3-5 birds were frequently observed flying eastward and hunting over all habitats during the first week of June. Daily sightings were made of 1-3 single birds hunting throughout the study area through the end of June. A large concentration of 50 pomarines hunted with long-tailed and parasitic jaegers, and glaucous gulls over Riparian habitat from 6-8 July, coinciding with the end of a large storm and a period of insect emergence. Many sandpiper and Lapland longspurs had also just hatched, although none were observed to be depredated. On 6 August, 2 juveniles and an adult hunted over Tussock and Moist Sedge-Shrub habitats, and a single adult flew near camp on 13 August.

Jago Delta - Fairly common breeder; common migrant and summer resident. Twenty to 25 pomarine jaegers were seen daily between 4 and 11 June, hunting or sitting in all habitats. One nest containing 2 eggs was located in Flooded tundra on 12 June and was active through at least 22 June. More nests were suspected in the area due to the continuing presence of adults hunting in Flooded, Wet Sedge, Mosaic, and Riparian habitats, and mobbing of investigators and other jaegers through mid-July. An adult was observed killing and eating a microtine rodent in Moist Sedge-Shrub habitat on 22 July. No juveniles were noted until 13 August, when 11 adults and juveniles were sighted in Flooded habitat near camp and enroute to the coast. Adults were seen accompanying large flight-capable young in Mosaic, Moist Sedge-Shrub, and Flooded habitats from 15-30 August. They were increasingly observed in family groups chasing shorebirds on coastal mudflats during the last few days of August.

Marsh Creek - Fairly common spring migrant. Pairs and groups were seen daily from 2-20 June traveling in a generally eastward direction. Pomarine jaegers were not observed after the spring migration.

Niguanak - Common breeder and spring migrant. Pomarine jaegers were common locally within the Niguanak area. Six pairs nested within 3 km of camp. During early June, several groups of 3-8 birds hunted over the general area, but numbers quickly declined to the 6 nesting pairs. Nest sites were in open areas on raised ground or hummocks surrounded by saturated soils. The first nest was found on 11 June and contained 1 egg. Full clutches averaged 2 eggs. After nests were initiated, adults were frequently observed mobbing ravens, gulls, and raptors or engaging in territorial boundary disputes with other jaegers. Aggressive vocalizations and dive threats were directed at foxes, caribou, and observers near nests or young. Eggs were observed pipping on 9 and 14 July. Within a few days, young chicks moved to Flooded habitat where they were attended on lake banks. At threat of danger the chicks would move onto the water. By the end of August, most young had fledged and over 18 adults and juveniles congregated at Niguanak Lake. As the young birds grew, adults mobbed only the peregrine falcons and gyrfalcons that passed through the area.

PARASITIC JAEGER

Okpilak - Fairly common summer resident. Birds were frequently observed from 2 June to 13 August. Sightings were most common in Flooded habitat. During mid-June, pairs were observed feeding on a fresh northern pintail carcass, attacking a stilt sandpiper, and chasing Lapland longspurs. No nests were found in the Okpilak vicinity.

Katakturuk - Uncommon summer resident; probable breeder. Two parasitic jaegers were observed in the study area on weekends from 7 June through 17 August. A nest was suspected in Riparian habitat, but no chicks or juveniles were observed.

Jago Bitty - Uncommon breeder. Small numbers of parasitic jaegers were observed regularly between 2 June and 15 August. Birds were sighted in similar numbers in all habitats except Tussock tundra which received infrequent use. One nest was found in Wet Sedge habitat on 15 June, and a second nest was found in Moist Sedge on 3 July. Each nest contained 2 eggs; one clutch began to hatch on 3 July, the other on 8 July. Assuming an incubation period of 24 to 28 days (Harrison 1978), eggs were laid between 5 and 14 June. Young parasitic jaegers were very secretive and difficult to locate during first few weeks (i.e. before fledging), but appeared to stay in the nest site area. On 9 August, 2 flight-capable young were observed with 2 adults near the Wet Sedge nest site, and on 7 and 13 August, 2 fledglings were seen with adults near the nest in Moist Sedge. Observations of feeding activity by parasitic jaegers included use of avian and mammilian prey: depredation of rock ptarmigan eggs, moderate feeding on dead caribou calves and caribou afterbirth, and extensive hunting and killing of juvenile ptarmigan.

Aichilik - Uncommon summer resident. Parasitic jaegers were seen from 2 June to 15 August, but only rarely were more than 2 individuals positively identified on any day. They were seen most frequently in Moist Sedge-Shrub and Tussock habitat, but occasionally occurred near camp in Riparian areas.

Sadlerochit - Uncommon breeder; fairly common summer visitant. Parasitic jaegers were observed regularly from 31 May through 16 August. Pairs and single birds hunted over all habitats through June, but most consistently over

Wet Sedge, Mosaic, Moist Sedge-Shrub, and Tussock habitats. Beginning on 3 June, a pair consisting of light and dark phased individuals was noted in Wet Sedge habitat, near where a similar pair had nested in 1984 (Miller et al. 1985), and was suspected of nesting in 1983 (Spindler et al. 1984). Courtship "head-touching" behavior was observed on 3 June, and a nest was discovered on 14 June on a mossy hummock in Wet Sedge habitat. The nest contained 2 eggs. One chick (2-5 days old) was found 3 meters from the nest on 12 July; the other egg, or chick, was not located. A second chick (found partially covered with tar in a coastal tarpit) was fostered next to the resident chick on 14 July. The adults apparently accepted it, and 2 young were seen once on 19 July before fledging. Through July, adults hunted primarily in Wet Sedge and Riparian habitats, coinciding with greatest aggregations of Lapland longspur and shorebird fledglings. From mid-July onward, they hunted always as a team and became increasingly efficient in capturing fledgling longspurs and shorebirds (up to 9 per day). Adults invariably returned with prey to young hidden in Wet Sedge and Moist Sedge vegetation along the riverbank. On 7 August, two fledglings were first noted in the area, and became increasingly observable through mid-August while learning to hunt along the river near camp. On 9 and 15 August, a third fledgling was observed in the vicinity, leading investigators to suspect that both resident young, as well as the fostered chick, had survived.

Jago Delta - Uncommon breeder and summer visitant. Sightings of single or paired parasitic jaegers occurred almost daily between 8 June and 28 August. Birds were observed flying, hunting, and/or being chased by other avian species over all habitats except open water. Three nests were located between 24 June and 6 July, one each in Flooded, Mosaic, and Moist Sedge-Shrub habitats. All nests held clutches of 2 eggs, and were located on drier, slightly elevated microrelief in sedge vegetation. Two adults with a juvenile were observed near a nest area in Moist Sedge-Shrub habitat on 5 August. Birds were sighted on the coast chasing pomarine jaegers on 20 July. Fewer parasitic jaegers were seen near camp from 7-28 August, but a juvenile and a nesting pair were observed hunting regularly in Flooded and Riparian habitats. Single birds were observed chasing and capturing shorebird juveniles along coastal mudflats on several occasions during this period.

Marsh Creek - Uncommon breeder; fairly common summer resident. Parasitic jaegers were seen frequently in the Marsh Creek area. A nest with 2 eggs was found on 12 June on a small, mossy high-center polygon. Flight-capable juveniles were seen in the area beginning on 1 August.

Niguanak - Uncommon summer resident. Frequent sightings were made between 6 June and 16 August, however, several were repeated observations of a local pair that frequently hunted along tussock-covered hillsides above a ravine. The last sighting occurred 7 km south of camp on 29 August.

LONG-TAILED JAEGER

Okpilak - Uncommon breeder; fairly common summer resident. Sightings of long-tailed jaegers occurred almost daily from 2 June to 14 August, but the birds were less conspicuous after 2 July. Moist Sedge-Shrub was the most frequently used habitat type. On 17 June, a nest with 2 eggs was found in Wet Sedge habitat, but it was never relocated.

Katakturuk - Fairly common breeder. Long-tailed jaegers were sighted frequently in the study area from 7 June through 17 August. One nest was discovered in Moist Sedge habitat on 28 June; however, from frequent sightings of adults in the surrounding area, several more nests were probably present in Moist Sedge and Moist Sedge-shrub habitats. The known pair was unsuccessful in hatching their one undersized egg (1 cm shorter than the mean of 5.1 cm). They were still actively defending the presumably infertile egg on 17 August.

Jago Bitty - Fairly common breeder; common summer resident. Moderate numbers of long-tailed jaegers were observed regularly in all habitat types from 2 June through 15 August. Slightly elevated levels of use were noted in Moist Sedge and Wet Sedge types. A pair of long-tailed jaegers was observed copulating on 3 June. Nests were located between 9 June and 2 July in Moist Sedge (n=3), Wet Sedge (n=2), and Riparian (n=1) habitats. All nests contained 2 eggs. At 5 successful nests hatching occurred between 29 June and 6 July; assuming an incubation period of 23 days (Harrison 1978), eggs were laid between 6 and 21 June. Chicks were typically gone from nests within several days after hatching. Hatchlings were secretive and difficult to locate during pre-fledging period. Flight-capable young were observed with adults near 4 of the 5 successful nests between 8 and 15 August. Long-tailed jaegers were seen feeding on dead caribou calves (during June), and on juvenile ptarmigan (during August).

Aichilik - Uncommon breeder; common summer resident. Long-tailed jaegers were seen from 2 June to 15 August. They were very common during the first 10 days of June (10-20 individuals seen daily). By the end of the second week of June, the numbers had stabilized and approximately 4-6 birds were seen daily, primarily in Moist Sedge-Shrub, Tussock, and Moist Sedge habitats. A nest was found on 1 July on a mossy hummock in Wet Sedge. One of the 2 eggs was hatched by 20 July. The nestling appeared to be 2-3 days old; using a 23-day incubation period (Harrison 1978) for back-dating, incubation began on 25 or 26 June. The second egg was gone by 22 July and the parents behaved defensively at the site. This nest was initiated about 2 weeks later in the season than the 2 nests reported at Aichilik in 1984 (Miller et al. 1985).

Sadlerochit - Fairly common breeder; common summer resident. Long-tailed jaegers were observed daily from 31 May to 16 August. Highest numbers of single birds and pairs hunted the river area, while a consistent 1-3 birds hunted over Wet Sedge, Mosaic, Moist Sedge-Shrub, and Tussock habitats through June. Members of a pair were observed lying next to each other on a Mosaic habitat hummock on 7 June. Three nests were located between 9 and 17 June, one each in Moist Sedge-Shrub, Riparian, and Moist Sedge habitats. Two nests contained single eggs, and the third held 2 eggs. Egg laying was known to have been initiated during 8-9 June at the Riparian nest and on approximately 15 June at the Moist Sedge-Shrub nest where 1 chick (2-3 days old) was observed on 8 July. Flightless young were sighted near the nest located in a Moist Sedge area on the river floodplain on 21 July. An insurgence of 30-60 adult long-tailed jaegers hunted along the river with other jaeger species and gulls from 1-10 July, and on 26 July another large flock foraged in Riparian habitat. It was uncertain what prey they were hunting, but the earlier aggregation coincided with a large insect emergence and the hatching of many shorebirds and longspurs. Long-tailed jaegers were consistently observed perched along river banks from mid-July through mid-August, and were noted capturing and swallowing lemmings on at least 3 occasions. In August, few birds remained in the area, most hunting singly by the river, near camp, and over the lagoon. A juvenile was observed hunting in Riparian habitat on 15 August.

Jago Delta - Uncommon breeder. From 1 to 4 birds were seen almost daily from 4 June to 28 August. Long-tailed jaegers were observed hunting over all habitats, but most frequently in Mosaic and Riparian tundra. A pair was first observed on 5 June, and a nest containing 2 eggs was located in Mosaic habitat on 12 June. Chicks were presumed hatched between 6 and 11 July, when the nest was found empty and highly defensive adults were nearby. After observing adults consistently in the area for a month, a juvenile was sighted with them in Mosaic habitat on 14 August. At least one adult was observed with a juvenile in the area through 28 August. Single adults were sighted regularly hunting along the river delta, mudflats, and Riparian habitat from 20 July through 28 August.

Marsh Creek - Fairly common breeder. Birds were observed daily from 2 June to 15 August. A nest with 2 eggs hatched during the first week of July, and a second nest with 2 eggs on a Dryas bench hatched on 16 July. Juveniles were seen in flight beginning 30 July.

Niguanak - Uncommon breeder; fairly common summer resident. Long-tailed jaegers were frequently observed from 3 June to 30 August. Up to 4 individuals were frequently observed hunting in a hovering manner over Tussock habitat. A nest was found on a northwest facing Dryas bench near the head of a large ravine. Two chicks, about 2-3 days old, were seen outside the nest on 16 July accompanied by highly defensive adults.

MEW GULL

Okpilak - Rare visitant. One adult was seen on 27 June feeding on a lake.

Aichilik - Fairly common spring visitant; uncommon summer and fall visitant. One or two birds were seen almost daily during June, then 1 bird was seen weekly through 14 August. Sightings were restricted to river areas.

Sadlerochit - Rare spring migrant. A single adult flew from southeast to northwest along the bluff on both 4 and 18 June.

HERRING/THAYER'S GULL

Okpilak - Rare spring migrant. One adult was seen flying east on 20 June.

Katakturuk - Rare spring migrant. An adult herring gull was observed flying north along the Katakturuk River on 21 June.

Aichilik - Probable rare summer visitant. A large gull, more closely resembling field guide descriptions of herring gull than of any other species, was seen infrequently from 7 June until 4 August. The bird was usually in close association with resident glaucous gulls. In all respects except the black-tipped outer primaries, the bird appeared identical to a glaucous gull.

Sadlerochit - Rare spring migrant. A single adult was seen on 3 occasions: flying south along river on 31 May, hunting over Riparian habitat on 2 June, and flying over coastal Wet Sedge tundra on 5 June.

SLATY-BACKED GULL

Sadlerochit - Casual summer visitant. An adult slaty-backed gull in a large, mixed flock of jaegers and glaucous gulls was observed for one hour on 3 July, apparently hunting insects along the river near camp. A dark plumaged, first-winter bird flew east along the coastline on 19 July.

GLAUCOUS GULL

Okpilak - Fairly common breeder. Birds were observed almost daily from 2 June to 14 August. The large majority of sightings and 2 nests occurred in Flooded habitat. One nest contained a single egg on 11 June, 2 eggs on 19 and 25 June, and was found empty on 3 July with 2 chicks nearby on 11 July. The second nest contained 3 eggs on 3 July and was empty on 9 July. Three chicks were seen in the nest area on 11 July. Both nests were constructed on islands. A flock of over 20 gulls was seen in flight on 17 June, and two flocks of more than 10 flew east on 23 June.

Katakturuk - Uncommon summer visitant. Single glaucous gulls were seen on 7, 8, 15, and 21 June, 26 July, and 16-17 August flying through the study area along the Katakturuk River.

Jago Bitty - Common spring migrant and visitant. From 2-16 June, relatively large numbers of glaucous gulls (up to 11 individuals per group) were observed in the study area. Most birds were sighted near the Jago River in Moist Sedge, Wet Sedge, or Moist Sedge-Shrub habitats. Maximum utilization of the area by gulls coincided with the presence of large numbers of calving caribou. Between 16 June and 15 August, lone birds and occasional pairs were periodically observed along the river.

Aichilik - Fairly common summer resident; probable breeder. Glaucous gulls were seen daily throughout the study period (2 June to 15 August). Singles and pairs frequently traveled along the Aichilik River drainage. On 6 July, a glaucous gull eggshell was found in Riparian habitat, and on 25 July, defensive behavior by a pair indicated that a nest or young were probably nearby. Glaucous gulls were occasionally seen away from the river, apparently feeding on carrion.

Sadlerochit - Uncommon breeder; common summer resident. Glaucous gulls were observed daily from 31 May to 16 August. Many gulls seen singly or in flocks flew over all habitats, perched on beach and river edges, and swam in the lagoon and in the river through 23 June. The area by the bluff was frequently used as a flight path. After 23 June, fewer gulls were noted and were usually observed as singles or groups of 2-5 birds. One nest, which was located on a shallow mud bar in the river delta, contained one chick (approximately 1 week old) on 4 July. Assuming an incubation period of 27-30 days (Harrison 1978), the nest was initiated during the first week of June. Another nest was suspected in Riparian habitat approximately 3 km south of the coast. By the end of July most sightings were of gulls hunting over the lagoon, barrier islands and shoals, and along the river. Three first-year juveniles were seen near the lagoon on 12 August.

Jago Delta - Fairly common breeder at coast; common summer resident. Glaucous gulls were sighted daily from 1 June to 30 August. Gulls were observed frequently throughout the day in flocks of up to 11 birds flying over all habitats, and perching on drier hummocks in Flooded and Wet Sedge tundra through 23 June. After this date the number of total gulls dropped substantially and daily sightings were restricted to single birds flying in various directions over the study area. A colony of 8 nests was located on the coast on 19 July, and 18 adults and 7 young (10-15 days old) were present in the area. A 3-nest colony with 6 adults and 3 chicks was found at Martin Point near some lakes on 23 July. Adults and birds in first-winter plumage were first observed at the coast on 20 July, and fledged juveniles from both colonies were seen on 7 August. Through the end of the season, small flocks were observed near the coast with a maximum of 52 migrants (not from colonies) sighted on 23 August.

Marsh Creek - Fairly common spring visitant; uncommon fall visitant. Singles and pairs were frequently observed until 20 June flying along Marsh Creek. Thereafter, sightings were restricted to 3 dates: 24 July, 6 August, and 14 August.

Niguanak - Fairly common visitant. Glaucous gulls were regularly seen during June in groups of 1-3 birds. During July and August, sightings of single individuals were less frequent. Several were observed feeding on a caribou carcass in early June; however, most sightings were of birds flying through the area.

ROSS' GULL

Okpilak - Rare spring migrant. A single individual was seen flying southwest along the coast on 2 June.

SABINE'S GULL

Okpilak - Rare spring migrant. Two observations were made of birds flying eastward over camp: a single bird on 8 June and a pair on 9 June.

Sadlerochit - Rare visitant. A single adult Sabine's gull was observed flying eastward over camp area on 7 and 8 June. On 20 June, a group of 3 adults flew eastward, and 1 adult was observed flying westerly and hunting briefly over Mosaic habitat on 11 July.

Jago Delta - Rare visitant. One adult was observed resting on the shore of a lake near camp for the afternoon of 8 June, and a single bird flew northeast over upland tundra on 24 June. Three observations were made of adult Sabine's gulls near the coast during late summer: 7 flew along the Jago River and foraged over coastal mudflats on 19 July, 4 flew over Jago lagoon on 5 August, and a flock of 5 flew east over Tapkaurak Bay on 12 August.

ARCTIC TERN

Okpilak - Uncommon visitant. Arctic terns were occasionally seen between 5 June and 12 August. During mid-June, pairs were frequently observed feeding in Flooded habitat or flying near Okpilak River. A flock of over 15 fed in Flooded habitat on 17 June, and a flock of 5 was seen flying east on 20 June.

Jago Bitty - Rare visitant. A single arctic tern was observed along the Jago River approximately 3 km northeast of camp on 21 June, and on 11 July a group of 3 terns was seen along the river 5 km northeast of camp.

Aichilik - Uncommon summer resident. Beginning on 7 June, arctic terns were seen hunting over the Aichilik River in singles or pairs. The sightings occurred 3 or 4 times weekly, but no direct evidence of nesting was found. On 21 July, a parasitic jaeger harassed a tern into dropping its fish prey. Beginning the third week of July, larger groups of terns were seen as they frequently traveled along Dryas benches. The largest flock recorded was 9 birds on 11 August.

Sadlerochit - Rare breeder: fairly common summer visitant and fall migrant. Arctic terns were observed regularly from 3 June to 15 August. Groups of 3-9 birds hunted over the river and lagoon daily from 15-19 June, and 1-4 July. A pair was first observed on 8 June, and their nest containing 2 eggs was discovered on a river gravel bar near camp on 8 July. Through July, the pair hunted over the river and vigorously defended the nest. The nest was unsuccessful, possibly due to frequent flushing of the adults by jaegers and gulls in the vicinity; the single remaining egg was abandoned on 15 August. From 7-13 August, groups of 5-25 terns were again seen moving through the area, hunting along the river, and swimming and foraging in the lagoon. An arctic tern flew well out of normal hunting range (approximately 4-5 km south of coast) to chase a peregrine falcon over upland Moist Sedge-Shrub and Tussock habitats on 17 June.

Jago Delta - Fairly common summer visitant; common fall migrant. Single terns and flocks of up to 8 birds were observed flying in various directions over study area on 9 days between 2 and 21 June, and on 17 and 19 July. A few terns hunted briefly over lakes and ponds in the area. From 20 July through 30 August, small flocks were seen almost daily at the coast feeding in lagoons and resting on delta mudflats. Average numbers ranged from 5-15 birds sighted per day, with maxima of 63 and 90 observed on 25 and 30 August. A large percentage of those observed on 30 August was juvenile.

Niguanak - Uncommon visitant. Arctic terns were observed on 17 days beginning 7 June and ending 14 August. Most sightings consisted of solitary birds hunting the larger water bodies of the Niguanak area. On 11 August, 3 birds fed together over a shallow Arctophila pond near camp.

SNOWY OWL

Okpilak - Fairly common summer resident. Snowy owls were seen regularly from 2 June through 14 August. They were generally observed hunting in Mosaic and Moist Sedge-Shrub habitats and occasionally in Wet Sedge.

Aichilik - Rare migrant. No confirmed sightings were made; however, 1 dead immature owl was found on 5 June in Wet Sedge habitat.

Sadlerochit - Common summer resident. An adult and a heavily streaked immature owl were observed in the study area daily from 31 May to 16 August. The birds were either sighted alone or within 100 m of each other, perched and hunting from polygon ridges, hummocks, and driftwood stumps. Owls were seen in all habitats throughout the season, with the bluff edge appearing to be a highly preferred perch area for reconnaissance. Owls utilized Mosaic habitat, swales of Moist Sedge east of the river delta, and Wet Sedge tundra near the lagoon to a higher extent in June and early July. Three to 5 owls (including 2 immatures) were observed on 9 days in relatively close association with one another between 6 and 26 July. Sightings of individuals hunting from perches in Riparian habitat occurred from mid-July onward, coinciding with the emergence of arctic ground squirrel (Citellus parryi) young from burrows. Owls were twice observed capturing microtine rodents. The parasitic jaeger pair in study area were the only birds that harassed snowy owls: chases occurred frequently during late incubation and early brood periods of jaeger chicks. The presence of immatures with adult owls, and the lack of any observations of adults carrying prey indicate these were probably non-breeding individuals.

Jago Delta - Uncommon breeder; common summer resident. Snowy owls were seen daily from 4 June to 30 August. Three birds were regularly observed through June perched on, or hunting from, mounds in Flooded, Wet Sedge, Mosaic, and Riparian habitats. Beginning in early July, at least 2 more owls were frequently seen in the study area, and owl use was relatively higher in Flooded and Riparian habitats. Two or 3 owls were observed near the coast on several days at the end of July. Numbers of owls at coastal areas increased slightly through August, with a maximum of 14 birds (including 2 juveniles) seen between camp and Tapkaurak Bay on 25 August. No nests were located, but evidence of breeding in the study area was supported by observations of adults feeding 3 large young in Flooded habitat on 7 August. Two young were fledged by 15 August, and the third was beginning to fly awkwardly on 16 August.

Niguanak - Uncommon breeder: fairly common spring visitant. During the first 3 weeks of June, 1-3 individuals were frequently seen perched on hummocks near Niguanak Lake or resting on the lake ice. On 15 June, a nest was found atop a steep knob 12 m above the mouth of a ravine 3 km northeast of camp. One chick had just hatched and 5 eggs remained in the nest. A sixth egg was found 0.5 m away from the nest. Back-dating using a 32-37 day incubation period (Harrison 1978), indicated the first egg was laid between 9 and 14 May. The nest site afforded excellent visibility of the surrounding area and the female skittishly flushed when observers approached within 500 m. As the nest was approached, the female flew onto a snowfield, where she vigorously beat her wings and sporadically vocalized in a distraction display. The male attended the female and was often seen chasing jaegers, ravens, and rough-legged hawks. The last snowy owl observation occurred at the nesting area on 2 July; the fate of the young was undetermined.

SHORT-EARED OWL

Okpilak - Uncommon summer resident; probable breeder. Observations were made on 12 days during the field season, the first on 3 June and the last on 13 August. No nests were found in the Okpilak vicinity, although one was suspected to exist 1.5 km south of camp in Mosaic habitat. On 13 August, 5 owls were seen flying together south of camp which were probably a family group from the suspected nest.

Katakturuk - Uncommon summer resident; probable breeder. Short-eared owls were observed infrequently on 6 of 10 surveys in the study area. No nests were located, but nesting in vicinity of bluffs was suspected. Owls were first observed on 7 June, and on 17 August a group of 5 birds were seen flying in Tussock habitat.

Jago Bitty - Uncommon breeder. Small numbers of birds were observed regularly from 2 June through 15 August. Short-eared owls were seen in all habitats, but most frequently in Riparian areas. The 2 nests located in Riparian habitat were believed to have been initiated by a single pair of owls. The first nest was located on 13 June and contained 6 eggs. On 20 June, the nest was empty and abandoned, and an owl was flushed from a partially constructed nest 350 m from original site. On 28 June, the second nest contained 4 eggs, and, on 24 July, 3 chicks (3-8 days old) were present. The nest was empty on 8 August, and no owls were seen in the vicinity. An owl pair performed distraction and defensive displays over Wet Sedge and Riparian habitats 8 km east of camp on 19 July, suggesting they also had young. A group of 7 owls was observed on Okpirourak Creek on 14 August. Two owls harassed observers for several minutes, then all birds landed on a gravel bar.

Aichilik - Fairly common breeder. Short-eared owls were seen occasionally from 2 June to 15 August, particularly during the evening hours. Three nests were found, all in upland habitats on small hummocks or between tussocks. One nest contained 6 eggs on 11 June and was not disturbed again until 3 July, when it contained 1 egg and 1 nestling. The chick was large and healthy on 16 July, and on 23 July the nest was empty. Laying was backdated to approximately 10 June. Another nest held 2 nestlings about 10 days old on 19 June. A third nest contained 5 eggs on 19 June, 7 eggs on 24 June, and 1 egg, 6 young, and 9 microtines on 17 July. On 8 August the nest was empty. Juveniles were observed roosting in Wet Sedge and Moist Sedge-Shrub habitats during August.

Sadlerochit - Uncommon breeder. Members of 1-2 short-eared owl pairs were observed daily in the study area from 31 May through 16 August. Owls hunted over all habitats through June, especially Wet Sedge tundra near camp, Moist Sedge-Shrub habitat, and floodplain between the river and the bluff. Two birds performed aerial chase displays on 7 June, but it was uncertain whether this was courtship behavior between male and female, or territorial aggression between 2 males. A nest containing 6 eggs was located in dense willow of Wet Shrub-Sedge habitat approximately 5 m from the river bank on 23 June. On 2 July, the nest contained 2 chicks and 3 eggs, and by 17 July, 1 downy young and 1 unhatched egg remained. At this time a cache of 9 voles (Microtus oeconomus) was noted in the nest. Fledgling owls were first seen in Wet Sedge habitat near camp flying with adults on 7 August, and in Tussock habitat on 13 August, indicating the probability of more nests in area. Short-eared owls were observed on several occasions vigorously chasing golden eagles and arctic foxes, often up to 5 km away from nest site.

Jago Delta - Fairly common breeder. Short-eared owls were sighted infrequently (on 13 days) from 5 June to 29 August. One nest containing 4 eggs was located in Moist Sedge-Shrub habitat on 5 June, and was depredated by a pomarine jaeger on 10 June. On 17 June, the female flushed from the same site, but upon inspection on 24 June, the nest was abandoned. A second nest containing 6 young and 1 egg was found in Moist Sedge habitat on 17 July. An adult with 3 juveniles was observed flying in Moist Sedge-Shrub habitat on 21 August, and a flock of 4 individuals hunted near Tapkaurak Bay on 29 August.

Marsh Creek - Fairly common breeder. A pair was observed on 22 May; 1 individual made loud displaying wing beats in flight in front of the second perched bird. During early June, single birds were seen hunting over Riparian habitat and the adjacent hills and benches. A nest containing 6 eggs was found in Moist Sedge-Shrub habitat on 17 June. One chick and 3 eggs were noted on 8 July, and on 15 July, just 3 eggs remained. Short-eared owls were seen daily from 2-15 August. Four individuals were flushed from solifluction mounds in Moist Sedge habitat on 12 August; at least 2 birds were juveniles.

Niguanak - Common breeder. Short-eared owls were seen from 1 June to 30 August. Five nests were found: 3 in Moist Sedge-Shrub and 2 in Wet Sedge habitat. All nests were in areas with considerable habitat heterogeneity and microrelief. Nest sites were on hummocks or polygon ridges providing good visibility. One nest containing 7 eggs on 8 June was found empty on 17 June, but a suspected renest with 2 eggs was found nearby on the same day; however, that nest was never observed again. Another nest, containing 6 eggs on 9 June, was observed with 6 healthy chicks and 1 egg on 12 July. The male engaged intensively in a "broken-wing" distraction display while the female remained on the nest. Nine days later, the single egg was being incubated but the chicks had disappeared. A third female was observed incubating 5 eggs between 20 June and 6 July, but the nest was found empty with only the remains of a single young chick on 15 July. A fourth nest, containing 5 eggs on 8 June and 7 eggs on 17 June, appeared to successfully fledge the 4 chicks observed in the nest on 8 July. During August, adults and juveniles were frequently flushed from roosting areas in deep moist depressions. Adults quickly left the area, but the juveniles curiously circled the human intruders. By late August, at least 9 juveniles had congregated around Niguanak Lake, hunting the abundant lemming and vole populations during crespuscular and nocturnal hours.

HORNED LARK

Katakturuk - Rare fall visitant. Several horned larks were observed on 9 and 10 August on the bluffs 4 km south of camp.

Aichilik - Rare spring migrant. A single horned lark was seen 13 June at Aichilik camp on a Dryas bench near the river.

Marsh Creek - Rare spring visitant; probable breeder. On 20 June, a pair with 1 fledgling was observed feeding on the bluff 3 km south of camp. The pair was seen again in the same area on 23 June.

BANK SWALLOW

Jago Delta - Casual migrant. Three bank swallows were seen flying west over a small coastal lake near the Jago River delta on 7 August.

BARN SWALLOW

Jago Delta - Casual visitant. On 30 June, 2 barn swallows flew into the camp area, landed briefly on radio antennae wires, and then flew west over the Jago River.

COMMON RAVEN

Okpilak - Uncommon summer resident. Ravens were seen on 10 days during the field season, the first on 5 June and the last on 13 August. Birds were usually observed in flight; however, on 11 June and 7 August ravens were seen foraging in Moist Sedge-Shrub habitat. On 10 August, a pair was noted perching on a camp structure.

Katakturuk - Uncommon summer visitant. Ravens were sighted in groups of 3-4 birds on 4 of 10 weekends the study area was surveyed: 7-8 June, 5-6 July, 13-14 July, and 16-17 August.

Jago Bitty - Fairly common visitant. Small numbers of birds (up to 4 in a group) were observed on 5 days between 5 and 28 June, on 11 July, and on 14 August. Ravens were seen in all habitats except Moist Sedge-Shrub.

Aichilik - Uncommon summer resident. Individuals and small flocks of 2-4 birds were seen on a regular basis (once or twice a week) throughout the study period. There was no evidence of local breeding.

Sadlerochit - Uncommon summer visitant. From 1-4 ravens were seen flying over all habitat types, or along the coast, sporadically between 31 May and 15 July. Two or 3 birds were sighted flying and calling together near the coast on 6, 8, and 11 August.

Jago Delta - Uncommon summer visitant. A single raven was observed perched in Wet Sedge habitat on 20 June, after which 1-3 birds were sighted on 6 occasions through 20 July flying in various directions through the study area. On 9 August, a group of 4 ravens was seen flying south along the river.

Marsh Creek - Uncommon visitant. The first sighting occurred on 6 June, the last on 11 August. Other observations were noted on 19 and 20 June and on 15 and 24 July.

Niguanak - Fairly common resident. Beginning 13 June, ravens were observed several times a week throughout the field season. Up to 4 individuals were commonly observed in flight over ridges and Tussock habitat. Ravens were frequently mobbed by pomarine jaegers, and on 18 June, 2 ravens were aggressively chased by a male snowy owl near the owl's nest site.

NORTHERN WHEATEAR

Aichilik - Rare fall migrant. One bird was observed in Riparian habitat on 15 August.

Marsh Creek - Rare fall migrant. One male, molting into winter plumage, was seen in Riparian habitat on 11 August.

Niguanak - Rare fall migrant. A single individual was observed on the south banks of Niguanak Lake on 14 August.

HERMIT THRUSH

Marsh Creek - Accidental visitant. A solitary male was heard and seen in the willows near camp between 3 and 19 July.

AMERICAN ROBIN

Katakturuk - Casual visitant. A single adult robin was observed in Riparian habitat on the surveys of 9-10 and 16-17 August.

VARIED THRUSH

Aichilik - Accidental migrant. One female was seen 5 km downstream from camp along the river bank on 30 June.

YELLOW WAGTAIL

Katakturuk - Fairly common breeder. Wagtails were observed frequently from 7 June through 17 August in Riparian habitat, along the Katakturuk bluffs, and occasionally in Tussock habitat. Two nests were located in willow thickets on 7-9 June: one in Riparian habitat, and the other at the base of the bluffs. Several other wagtail nests were suspected along the bluffs.

Jago Bitty - Fairly common breeder. Relatively small numbers of birds were observed regularly during June and July, and occasionally during August. Only 6 birds were counted during censuses: 2 each in Moist Sedge-Shrub, Tussock, and Riparian habitat types. Male wagtails performed courtship displays between 7 and 16 June; displaying birds were particularly noticeable in willow thickets bordering Okpirourak Creek, 2 km north of camp. Although no nests were found, it was suspected that at least 1 pair nested in the Tussock/Moist Sedge transition zone at the north end of Bitty, and that several pairs nested in Moist Sedge-Shrub habitat along the north bank of the river between 2 and 5 km north of camp. Adults were observed performing distraction displays in these areas between 21 June and 8 July.

Sadlerochit - Uncommon breeder. Single yellow wagtails and occasional pairs were observed every few days from 10 June to 14 August. A pair was first sighted, acting defensively, in Riparian habitat on 10 June. Males were heard singing in flight and while perched on low willows in Riparian habitat from 13-24 June; aerial display flights, possibly distractive, were observed from 20 June to 9 July. An active nest was suspected because of repeated observations of vigorous distraction flights by a pair of wagtails in Riparian habitat near camp in early July. Hatching was assumed to have occurred when adults were noted carrying food (insects) in their bills through this area between 10 and 14 July. No fledglings were observed; adults were sighted through July in Riparian willow habitat, and occasionally also in Moist Sedge-Shrub habitat during August.

Marsh Creek - Fairly common summer resident; uncommon to fairly common breeder. Yellow wagtails were conspicuous residents of Riparian habitat; however, birds flushed from long distances and nests were difficult to locate. One nest containing 6 eggs was found under a prostrate willow in Riparian habitat on 18 June. The nest held 4 2-day-old chicks and 1 apparently infertile egg on 24 June. Birds were observed throughout the field season (ending 14 August).

WATER PIPIT

Katakturuk - Uncommon summer resident; probable breeder. Water pipits were infrequently observed on 6 of 10 surveys. They were first sighted on 15 June and last observed on 10 August, typically in either Riparian or Tussock habitat, and on the bluffs. No nests were located, although the bird was suspected of breeding in the area.

Jago Bitty - Rare summer visitant; possible breeder. Several water pipits were observed in the Riparian zone extending from 5 to 10 km south of camp on 12 and 13 July.

YELLOW WARBLER

Jago Bitty - Rare summer visitant. One bird was heard singing in a willow thicket by the mouth of Okpirourak Creek on 22 June, and a second bird was observed in willows approximately 6 km south of camp on 13 July.

AMERICAN TREE SPARROW

Katakturuk - Uncommon breeder. Tree sparrows were observed in Riparian willow habitat from 7 June through 17 August. Singing males were seen in early June. One nest containing 4 eggs was located under a sedge tussock and willow on 28 June. On 5 July, the nest held 1 newly hatched chick, and on 19 July, the nest was empty. Juvenile tree sparrows were observed in Riparian habitat from late July through mid-August.

Jago Bitty - Rare breeder. Small numbers of birds were observed periodically during June and July in the dense willow thickets near the mouth of Okpirourak Creek and in the study area near camp. A nest containing 4 eggs was located on 13 June in Riparian habitat; on 20 June, the nest was empty and abandoned. Only one sighting occurred after 15 July: a group of 3 birds was observed in Riparian willows on 14 August.

Marsh Creek - Fairly common breeder. Sightings occurred daily in Riparian habitat through mid-July, beginning the first day of field study (3 June). Two nests were found at the bases of willow plants in Riparian habitat. On 26 June, one nest contained 5 newly-hatched young and the other nest held 4 eggs. Tree sparrow observations were less frequent during late July and August.

SAVANNAH SPARROW

Okpilak - Rare spring visitant. Up to 5 individuals were observed singing in Riparian habitat along the Okpilak River on 14-16 June.

Katakturuk - Fairly common breeder. Savannah sparrows were observed frequently from 15 June through 17 August. Observations through early July were primarily made in Tussock habitat, where one nest containing 5 eggs was located on 21 June. On 6 July, the nest held 5 nestlings, and it was empty when checked on 13 July. Savannah sparrows were observed more frequently in Riparian habitat as the fledglings and juveniles dispersed with adults towards the river.

Jago Bitty - Fairly common breeder. Low to moderate numbers of birds were observed frequently through June and July, and occasionally in August. Fifty percent of all savannah sparrows counted during censuses were in Riparian habitat; the remaining sightings were distributed relatively uniformly among Wet Sedge, Moist Sedge, Moist Sedge-Shrub, and Tussock habitat types. One nest containing 5 eggs was located in Moist Sedge on 25 June. Eggs began hatching on 1 July, and 5 young fledged between 9 and 12 July. Assuming an incubation period of 12 days (Harrison 1978), eggs were laid on approximately 18 June.

Aichilik - Fairly common breeder. Savannah sparrows occupied willow thickets near river and ridge tops. Two to 4 individuals were observed regularly in Riparian habitat. Sightings were also frequent in Moist Sedge-Shrub where a nest with 6 eggs was found on 24 June. Nestlings found on 8 July were estimated to be 4 days old; initiation of incubation was estimated to have occurred on 22 June (Harrison 1978). Vocalizing males were conspicuous during June but this behavior tapered off and ended in late July.

Sadlerochit - Fairly common breeder. Savannah sparrows were observed from 2 June to 15 August. Males were heard singing primarily in willow strangs of Wet Sedge habitat and Riparian willow thickets from 2 June through the hatching period, 7 July; fewer were observed in Moist Sedge-Shrub and Tussock habitats. A pair was first seen on 13 June. Two nests were located in willow strangs of Wet Sedge habitat, and 1 was found in closed Riparian shrub (willow) vegetation on a river bank. All nests held clutches of 5 eggs. One nest discovered on 9 June contained 5 nestlings on 23 June. Two nests were located on 21 June: one held an incomplete clutch, and the other was beginning to hatch, suggesting a protracted breeding peroid. Active nests were suspected in Tussock habitat because of recurring sightings of adults through July. Adults and juveniles were infrequently observed after hatching in Wet Sedge and Riparian willow habitats from mid-July to mid-August.

Marsh Creek - Fairly common breeder. Observations were most common in Riparian habitat, although birds were noted in all habitat types. Two nests, containing 4 and 5 young nestlings, were found in Riparian and Moist Sedge-Shrub habitat on 24 June. Riparian habitat was utilized extensively by adults and by juveniles after fledging.

Niguanak - Rare fall visitant. A single bird foraged along the banks of Niguanak Lake on 27 August. Savannah sparrows were observed outside the immediate Niguanak area during visits to Riparian habitats along the Niguanak River (7 July) and Okerokovik River (9 August).

CLAY-COLORED SPARROW

Marsh Creek - Accidental spring visitant. A solitary male was first noted singing from Riparian willows on 23 June. The bird remained in the area for several days and a positive identification was made. This was the first clay-colored sparrow sighting in Northern Alaska.

WHITE-CROWNED SPARROW

Katakturuk - Uncommon summer resident; probable breeder. Birds were infrequently observed from 7 June through 17 August in Riparian habitat. Relatively large numbers were seen on 7-8 June, many of them singing. These may have been primarily migrants, as numbers diminished thereafter to a few observations of territorial males. No nests were located, although several juvenile sparrows were seen late in the season.

Jago Bitty - Rare visitant. On 20 June, a white-crowned sparrow was heard singing in Riparian habitat 2 km northeast of camp, and on 13 July, several birds were seen in willow thickets 3-8 km south of camp.

Marsh Creek - Uncommon breeder. White-crowned sparrows were seen exclusively in Riparian habitat. Observations extended across the field season, but were most common during June and early July. Three nests were found. Clutch size was 4-5 and hatching occurred between 23 June and 2 July. Usually only 1 adult was seen on or near the nest.

Niguanak - Rare spring visitant. One bird was observed in a ravine on 15 June.

LAPLAND LONGSPUR

Okpilak - Abundant breeder. Birds were abundant and observed daily from 2 June to 14 August. The earliest nest was found on 3 June and contained 3 eggs. Peak laying and incubation took place during 5-17 June and hatching occurred through 24 June. The first nestlings were seen on 17 June, earliest of all bird species. Renesting was apparently common, and nestlings were observed until 9 July. The young left their nests in 4-7 days. Average clutch size was 5.06 (n=16) and ranged from 4-6 eggs. All clutches were at least partially successful. Seven nests were found in Moist Sedge-Shrub, 5 in Mosaic, 4 in Wet Sedge, and 1 in Flooded habitat. During early July, fledglings were frequently seen in Mosaic and Moist Sedge-Shrub habitats. On 21 July, over 100 birds flocked near camp. During August, longspurs dispersed across all habitat types.

Katakturuk - Abundant breeder. The first active nest was found on 8 June and the first young were observed on 15 June. Mean clutch size was 4.7 (n=10); six nests were found in Tussock habitat, 2 in Moist Sedge, and 2 in Riparian. By mid-July juvenile young were much more common than fledglings, particularly in Riparian habitat. Densities of longspurs were much higher in Riparian than any other habitat. Longspurs were the predominant species observed by late July.

Jago Bitty - Abundant breeder. Large numbers of longspurs were observed from 2 June through 15 August. Males performed courtship displays from 3-24 June (most vigorously from 3-15 June). Twelve nests were found in Riparian habitat, 9 in Moist Sedge, 7 each in Moist Sedge-Shrub and Tussock, and six in Wet Sedge habitat. The first nest was found on 7 June and first young on 17 June. Mean clutch size was 4.68 (n=41) and the peak of laying appeared to be 3-12 June. Juveniles were apparent in early July. Longspurs were most common in Riparian habitat throughout the summer.

Aichilik - Abundant breeder. Longspurs were abundant throughout the study period and were present in all habitat types. In early to mid-June, highest density was in Moist Sedge-Shrub, while Wet Sedge was the least utilized habitat. In July, fledglings and attendant adults were more abundant in riparian willow stands than could be accounted for by local nest density, indicating a large-scale movement to Riparian areas following fledging. A total of 25 nests were found: 9 in Moist Sedge-Shrub, 6 in Moist Sedge, 5 in Tussock, 3 in Riparian, and 2 in Wet Sedge habitat. Clutch size ranged from 3-7 with a mean of 4.7 (n=15 nests). Nest records indicated that egg laying began in the first week of June and continued into the last week of June and perhaps the first week of July. Fledglings initially appeared in the first week of July and were common a week later. Male territorial displays were largely over by the end of June, with only sporadic and abbreviated flight songs heard in the first week of July. As displays declined in frequency, males were seen aggregating in small flocks in all habitats, but were particularly conspicuous in Riparian habitat. By mid-July flocks of all age and sex groups were conspicuous and remained so throughout the remainder of the field study.

Sadlerochit - Abundant breeder. Lapland longspurs were observed daily from 31 May to 16 August. Pairs were seen on 31 May and courtship displays were observed through 23 June. The first nest was discovered on 5 June and hatching began on 18 June. Nests were found in all habitats: 10 in Tussock, and 7 each in Mosaic, Moist Sedge-Shrub, Wet Sedge and Riparian. Mean clutch size was 4.71 (n=51).

Longspurs were common in all habitats, particularly Riparian. In June and in late July, juveniles were observed flocking along lagoon and pond edges. Parasitic jaegers preyed heavily upon juvenile longspurs, particularly during the jaeger brood-rearing period. During August, longspurs were less evident in upland areas but maintained high densities in Riparian habitat.

Jago Delta - Abundant breeder. Lapland longspurs were observed from 1 June through 30 August. Courtship displays were seen from 1 June through 24 July. First active nests were discovered on 7 June and last seen on 3 July. First chicks were seen on 17 June. Eight nests were found in Moist Sedge-Shrub, 5 in Mosaic, 4 in Wet Sedge, and 2 each in Flooded and Riparian habitats. Mean clutch size was 5.04 (n=23). Longspurs were common in all habitats throughout the summer but were most common in Mosaic and Moist Sedge-Shrub. In August, flocks of juveniles (up to 100 individuals) were seen on coastal mudflats and in Riparian habitat.

Marsh Creek - Abundant breeder. Lapland longspurs were present, displaying, and had nests with eggs upon arrival of the observers on 2 June and were seen daily through mid-August. Four nests were found in Moist Sedge-Shrub and 3 each in Moist Sedge, Tussock, and Riparian habitats. Mean clutch size was 4.75 (n=16), and the first young were seen on 18 June; the last recorded hatching date was after 28 June. Highest densities of longspurs were recorded in Riparian habitat during the reproductive season. Similar numbers were recorded in Riparian and Moist Sedge-Shrub during the post-reproductive season.

Niguanak - Abundant breeder. Longspurs were seen daily between 1 June and 30 August. Males displayed from 1 June to approximately 18 June. Active nests were first observed on 7 June and last seen on 8 July. First chicks were seen on 17 June. Many chicks hatched within the following week and chicks began leaving the nest within 10 days. Mean clutch size was 5.21 (n=32) with a range of 3-7. Sixteen nests were found in Moist Sedge Shrub, 12 in Tussock, 7 in Wet Sedge and 6 in Flooded habitat.

Most longspurs were observed in Moist Sedge-Shrub in July and August. Adults and young congregated in large, loose flocks in Moist Sedge-Shrub during July, and numbers declined through all habitats in August.

SMITH'S LONGSPUR

Okpilak - Rare spring and fall migrant. A single bird was seen foraging in Wet Sedge habitat along the Arey Lagoon shoreline on 2 June. A probable juvenile was observed in Wet Sedge on 13 August.

SNOW BUNTING

Okpilak - Uncommon visitant. In the Okpilak area, snow bunting observations were confined to a line of driftwood along the coast. Singing males were seen on 7-8 June and a pair was noted on 10 June. The last observation was of a single juvenile on 4 August.

Jago Bitty - Rare visitant. Two birds were observed on a snow bank along the north side of the Jago River 4 km northeast of camp on 21 June.

Sadlerochit - Uncommon breeder. Snow buntings were infrequently observed in small numbers from 31 May through 14 August. At least 2 pairs were present, observed from 31 May through 30 June on Anderson Spit: single adults were seen in coastal Wet Sedge habitat and on the lagoon mudflats. No nests were located, but breeding was evident near the coast as juveniles were seen foraging on a grounded barge and in Moist Sedge habitat near the delta on 5 and 21 July. Through July and August, single males were observed occasionally feeding along the river bank and coast.

Jago Delta - Uncommon breeder and fall migrant. Single and paired adults foraging with 3-4 immatures in family groups were observed when the coastal area was first visited on 19, 20, and 22 July, and on 7 August. Flocks of 2-4 juveniles were sighted on 4 occasions between 25 and 29 August in coastal debris (driftwood, oil drums) by Martin Point, and in the camp area. On 30 August, 2 flocks of 10 and 20 birds were observed flying eastward over the study area.

RED-WINGED BLACKBIRD

Jago Bitty - Rare visitant. Two males were observed in a willow thicket at the mouth of Okpirourak Creek on 22 June.

REDPOLL spp.

Okpilak - Uncommon spring visitant. The first sighting occurred on 3 June, the last on 1 July. During mid-June, 1-5 birds were seen along the Okpilak River, and during late June, 2-3 birds were seen in Flooded, Mosaic, and Moist Sedge-Shrub habitats.

Katakturuk - Fairly common breeder. Redpolls were observed from 7 June through 17 August. One nest was found on 8 June and 2 were found on 16 June, all in Riparian willows. The 2 active nests contained 4 eggs each. Adult birds were most commonly seen in Riparian habitat, but were occasionally seen in Tussock and Moist Sedge habitats, and along Katakturuk bluffs.

Jago Bitty - Common breeder. Low to moderate numbers of redpolls were observed from 2 June to 15 August. Males were observed to perform courtship displays on 16 and 19 June. Two nests were located in Riparian habitat, and another was found in Moist Sedge. Mean clutch size was 4.0 (n=3) and the two successful nests hatched on 24 June and 13 July. Assuming an incubation period of 10-13 days (Harrison 1978), eggs were probably laid between 11 June and 2 July. Birds were observed in all habitat types, most frequently in Riparian and least frequently in Wet Sedge.

Aichilik - Common breeder. Redpolls were restricted to willow thickets and surrounding foraging areas. The great majority of sightings and all nests were in Riparian habitat. Seven nests were found in willow communities; clutches averaged 4-5 eggs. Using Harrison's (1978) incubation lengths and fledging periods, egg laying was estimated on 10-12 June for one nest, 4 July for another, and 6 July for a third nest. The later nests in July were probably renesting attempts.

Sadlerochit - Fairly common breeder. Redpolls were seen from 2 June to 24 July; the first of 2 nests was located on 9 July. The second nest was located on 10 July and contained nestlings approximately 3 days old. Both nests were in Riparian habitat and located off the ground on willow limbs. Young were ready to fledge by 16 July. Flocks of redpolls were seen in all habitats in June. Most birds were seen in Riparian habitat during July and no birds were seen in August.

Jago Delta - Rare visitant. Two redpolls were seen foraging in a Riparian area on 3 July.

Marsh Creek - Common breeder. Redpolls were primarily observed in Riparian habitat. Nests were constructed in willows during early June. Clutches averaged 4-5 eggs and egg laying began around 6 June; the eggs of one nest were observed hatching at 10-12 hour intervals. The latest incubation was noted on 9 July. Redpoll sightings declined after hatching, but observations continued through 14 August.

Niguanak - Rare spring and fall visitant. Two females were observed on 22 June feeding on a snowbank along a drainage and 2 others were seen briefly in Wet Sedge habitat on 28 June. One was seen feeding along the lake bank on 27 August, and 2 were seen in a ravine on 30 August. Redpolls were very common in Riparian willow areas south of the aufeis field on the Okerokovik River during early August.

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ANWR Progress Report Number FY86-13

DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF TUNDRA SWANS IN THE COASTAL WETLANDS OF THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1985

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Key words: Tundra Swans, Anatidae, abundance, age composition, reproduction, Arctic-Beaufort.

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Distribution, abundance, and productivity of tundra swans in the coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1985.

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Abstract: Two aerial surveys of tundra swans (*Cygnus columbianus*) on the Arctic National Wildlife Refuge were flown during 27-28 June and 19-20 August 1985. Number of nests (66) in 1985 was down 15% from 1984 to the lowest level in 3 years and numbers of spring nonbreeders in 1985 increased by 25%. The Canning-Tamayariak concentration area accounted for 45% of the decrease in nesting effort. The 1985 estimated breeding population (127 pairs) was down 15% and cygnet production (142) was down 14% from 1984. However, productivity based on the ratio of broods (56) to nests was highest in 1985 at 85%. Average brood size for 1985 was 2.5 ± 1.07 Sd cygnets/brood.

Distribution, abundance, and productivity of tundra swans in the coastal wetlands of the Arctic National Wildlife Refuge, 1985.

Proposed petroleum development on the coastal plain of the Arctic National Wildlife Refuge (ANWR), as well as the proposed federal leasing of nearby offshore tracts and state leasing of nearshore areas will place industrial activity within or close to tundra swan nesting and molting habitats. Coupled with the actual exploration, there will be an increase in air traffic along the coast to support such operations.

Tundra swans are particularly sensitive to such disturbances. Barry and Spencer (1976) stated that molting and breeding swans avoided actual drill sites in the Mackenzie Delta by at least 8km, although swans had previously utilized these areas. Hanson et al. (1956) reported exploitation induced desertion of nesting areas in the Perry River region of Canada. Aircraft disturbance was the probable cause of the desertion of a swan nest at Nuvagapak Point on the ANWR (Andersson (1973). Schmidt (1970) discussed the desertion of a swan nest at Beaufort Lagoon (Arctic NWR) due to helicopter traffic.

Since swans are sensitive to disturbance, highly visible, and have traditionally nested and molted on selected coastal wetlands of ANWR, they were selected for inclusion into the Baseline study program. Tundra swans are a given habitat (King 1973).

The first limited aerial survey of tundra swans on the Arctic National Wildlife Range (ANWR) occurred in 1977 on the Canning River delta. The survey area was expanded to include the Aichilik-Kongakut River delta area in 1978 and additional portions of the coastal plain in 1979. These early surveys delineated high use areas by tundra swans (Jacobson 1979). The surveys were standardized in 1981 and included 5 survey areas on the ANWR coastal plain (Bartels et al. 1983, Bartels and Doyle 1984). A spring nesting survey was initiated in 1983 and has been continued. The objectives of these surveys are: 1) to delineate the distribution of breeding and post-breeding populations; 2) to determine productivity; 3) to estimate abundance; and 4) to determine population trends or fluctuations and their possible causes.

Materials and Methods

Aerial surveys of the outer coastal plain of the ANWR were flown during 27-28 June (Fig. 1) and 19-20 August 1985 (Fig. 2) with methods described by King (1973). Survey routes include concentration areas described by Jacobson (1979). Surveys were flown in a Cessna 185 aircraft with a pilot, an observer, and an observer-data recorder who plotted the survey route and the locations of adult swans, nests, and broods on U.S. Geological Survey topographic maps of 1:63,360 scale. Study areas were systematically searched from an altitude of 150 m at an airspeed of 160 km/h. It was assumed during the spring survey that a single swan at a nest represented a pair and that 2 swans observed together were a mated pair. All statistical procedures follow Sokal and Rohlf (1981). All means intervals reported in the text are displayed as the mean ± 1 standard deviation.

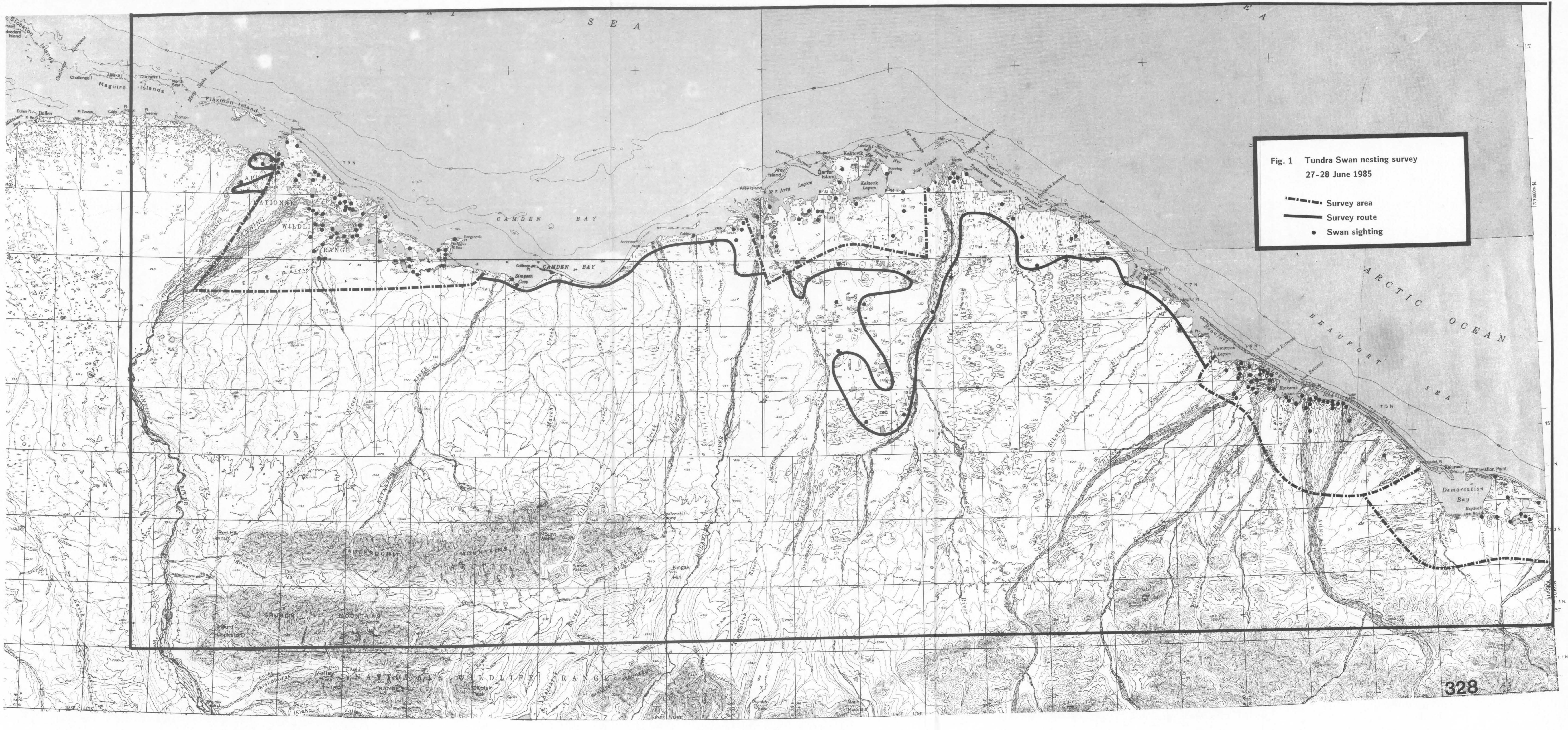

Fig. 1 Tundra Swan nesting survey
27-28 June 1985

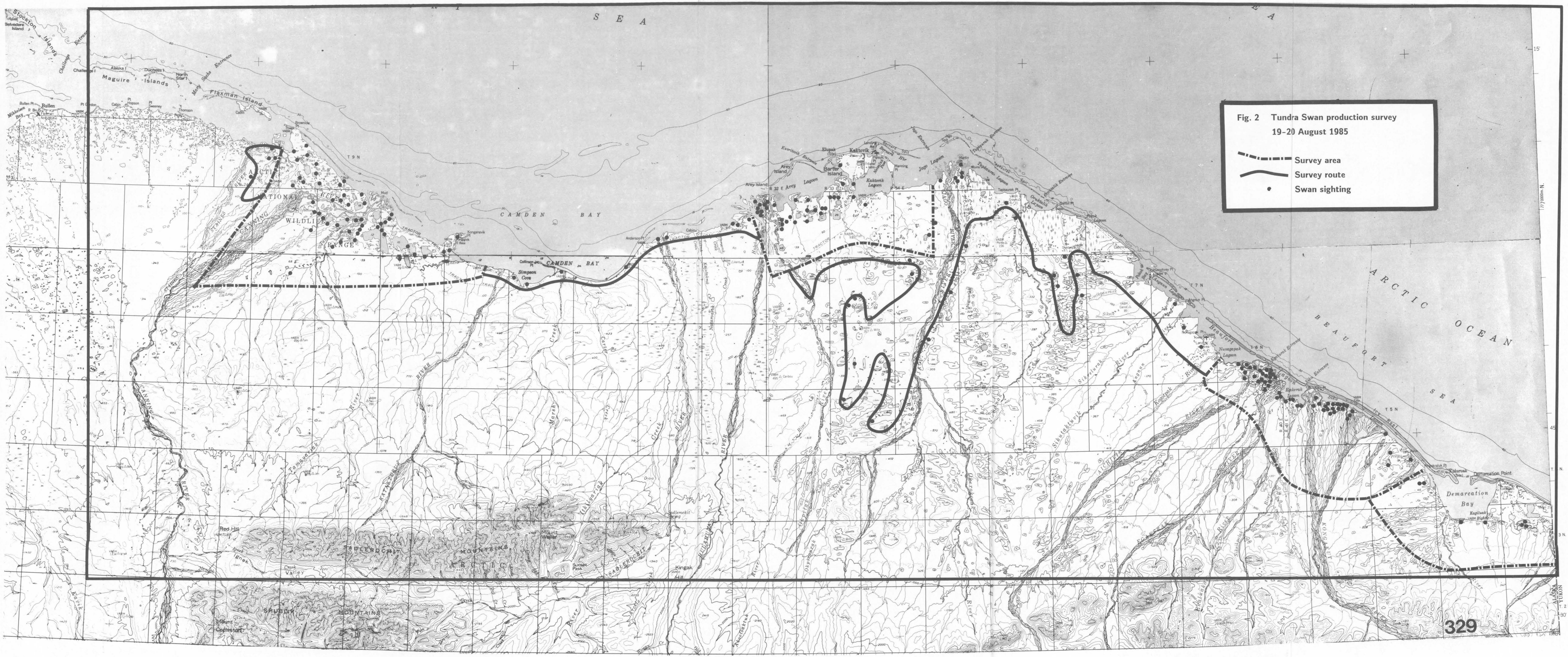

Fig. 2 Tundra Swan production survey 19-20 August 1985

Results and Discussion

The mapped swan locations from 1981 to 1985 showed that the concentration areas originally noted by Jacobson (1979) included large areas not used by tundra swans. Therefore those concentration areas did not accurately represent actual swan habitat. We reduced the size of the areas to make density estimates within high use areas more representative of swan habitat densities (Fig. 1). The original concentration areas (Fig. 3) are now more appropriately considered survey areas. Statistics for the original concentration areas (survey areas) for both June and August surveys are presented in the Appendix Tables 1 and 2. Two new concentration areas have been defined; the Jago River Delta area and the Pingokraluk Point area.

Breeding Population and Nesting Distribution

The numbers of nests and pairs recorded in the June 1985 survey were 15% and 34% lower, respectively, than the 1984 survey (Table 1). Only 66 nests were located in 1985; the lowest number of nests found during the 3 years of nesting surveys and well below the 3 year average of 81.7 nests/year. Although the number of nests was lowest in 1985, the number of pairs (127) was intermediate. In contrast, numbers of nonbreeding adults increased by 25% from 1984 to 1985. The total spring adult count was 403 swans, a net decrease of 14 birds (3%) from 1984, but larger than the 3 year average of 363.7 adults.

The number of nests decreased from 1984 to 1985 in all concentration areas except for the Jago Delta and "Other Areas" (Table 1). The Canning-Tamaryariak delta area (Fig. 4) experienced a 45% decrease in the number of nests from 1984 to 1985. On the Aichilik-Egaksrak-Kongakut delta area (Fig. 5), numbers of nests were 29% and 23% lower than in 1984 and 1983, respectively. Over the 3 years of nesting surveys, the Canning-Tamayariak River delta area and the Aichilik-Egaksrak-Kongakut River delta area were the most important nesting sites on ANWR. These 2 areas contained the highest average numbers of nests, and adults (Table 2). The Hulahula-Okpilak River delta area (Fig. 6) was third and the Jago Delta (Fig. 7) was last in importance in mean number of nests and adults. Average nest density was highest in the Aichilik-Egakshrak-Kongakut delta area, and approximately equal in the Hulahula-Okpilak River delta area and the Canning-Tamayariak River delta area. A newly-defined concentration area, Pingokraluk Point (Fig. 8), with the second highest nest density of all areas, was slightly higher in nest density than the Hulahula-Okpilak and Canning-Tamayariak areas. Other areas such as the coastline between concentration areas and inland wetlands in the Niguanak and Jago River areas accounted for a small number of nests each year.

Post-Nesting Population

During the August 1985 survey (Fig. 3), 485 adult swans were recorded (Table 3); the highest number observed in the fall. This follows a low year in 1984 with 280 adults observed in the fall and amounts to a 73% increase from 1984 to 1985. There was also a spring to fall increase of 20% in total adults from 403 to 485 birds in 1985. The majority of this increase (70

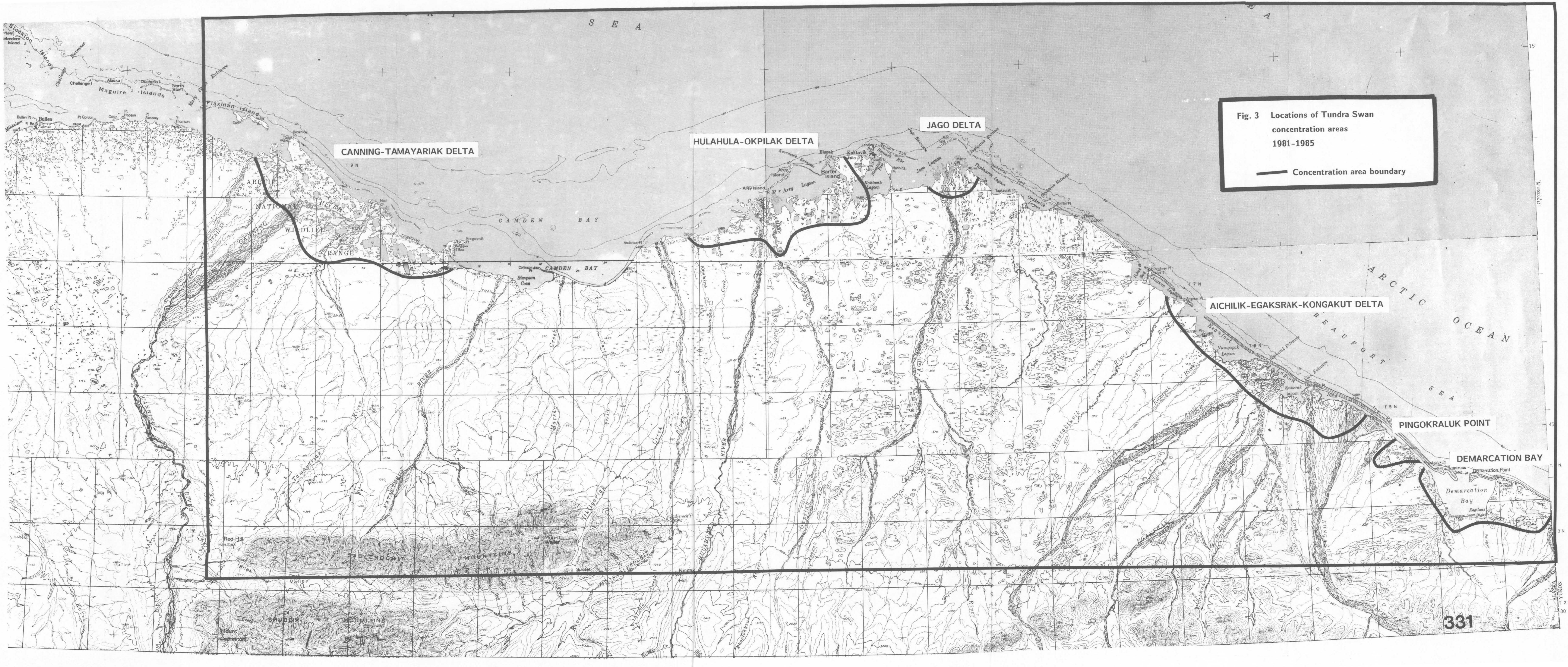

Fig. 3 Locations of Tundra Swan concentration areas 1981-1985

Table 1. Tundra swan population statistics by concentration area for the 1983-1985 June nesting surveys on the Arctic National Wildlife Refuge.

		Number							
Date	Concentration area	Nests	Pairs w/o nests	Total pairs	Unpaired Singles & groups	Total adults	Swans/km^2	Nests/km^2	% Paired
27-28 June 1985	Canning-Tamayariak delta	22	26	48	30	126	0.56	0.10	76.2
26-27 June 1984	(227 km^2)[a]	40	14	54	13	121	0.53	0.18	89.3
2-3 June 1983		26	10	36	28	100	0.44	0.11	72.0
27-28 June 1985	Hulahula-Okpilak delta	9	4	13	13	39	0.46	0.11	66.7
26-27 June 1984	(85 km^2)[a]	14	2	16	8	40	0.47	0.16	80.0
2-3 June 1983		12	3	15	8	38	0.45	0.14	79.0
27-28 June 1985	Jago Delta	2	2	4	2	10	0.53	0.11	80.0
26-27 June 1984	(19 km^2)[a]	0	2	2	0	4	0.21	0.11	100.0
2-3 June 1983		3	0	3	1	7	0.37	0.00	85.7
27-28 June 1985	Aichilik-Egakshrak-	20	11	31	80	142	1.27	0.18	43.7
26-27 June 1984	Kongakut delta	28	15	43	58	144	1.29	0.25	59.7
2-3 June 1983	(112 km^2)[a]	26	7	33	4	70	0.63	0.23	94.3
27-28 June 1985	Pingokraluk Point	0	0	0	1	1	0.08	0.00	0.0
26-27 June 1984	(13 km^2)[a]	3	1	4	1	9	0.69	0.23	88.9
2-3 June 1984		3	0	3	0	6	0.46	0.23	100.0
27-28 June 1985	Demarcation Bay	1	5	6	3	15	0.21	0.01	80.0
26-27 June 1984	(70 km^2)[a]	7	2	9	3	21	0.30	0.10	85.7
2-3 June 1983		2	1	3	10	16	0.23	0.03	37.5
27-28 June 1985	All concentration	54	48	102	129	467	0.89	0.10	43.7
26-27 June 1984	areas	92	36	128	83	339	0.64	0.18	75.5
2-3 June 1983	(526 km^2)[a]	72	21	93	51	237	0.45	0.14	78.5
27-28 June 1985	Other areas surveyed	12	13	25	20	70	0.07	0.01	71.4
26-27 June 1984	(1077 km^2)[a]	8	13	21	36	78	0.07	0.01	53.9
2-3 June 1983		7	6	13	8	34	0.03	0.01	76.5
27-28 June 1985	All areas surveyed	66	61	127	149	403	0.25	0.04	63.0
26-27 June 1984	(1603 km^2)[a]	100	49	149	119	417	0.26	0.06	72.0
2-3 June 1983		79	27	106	59	271	0.17	0.05	78.0

[a] Area within each concentration area.

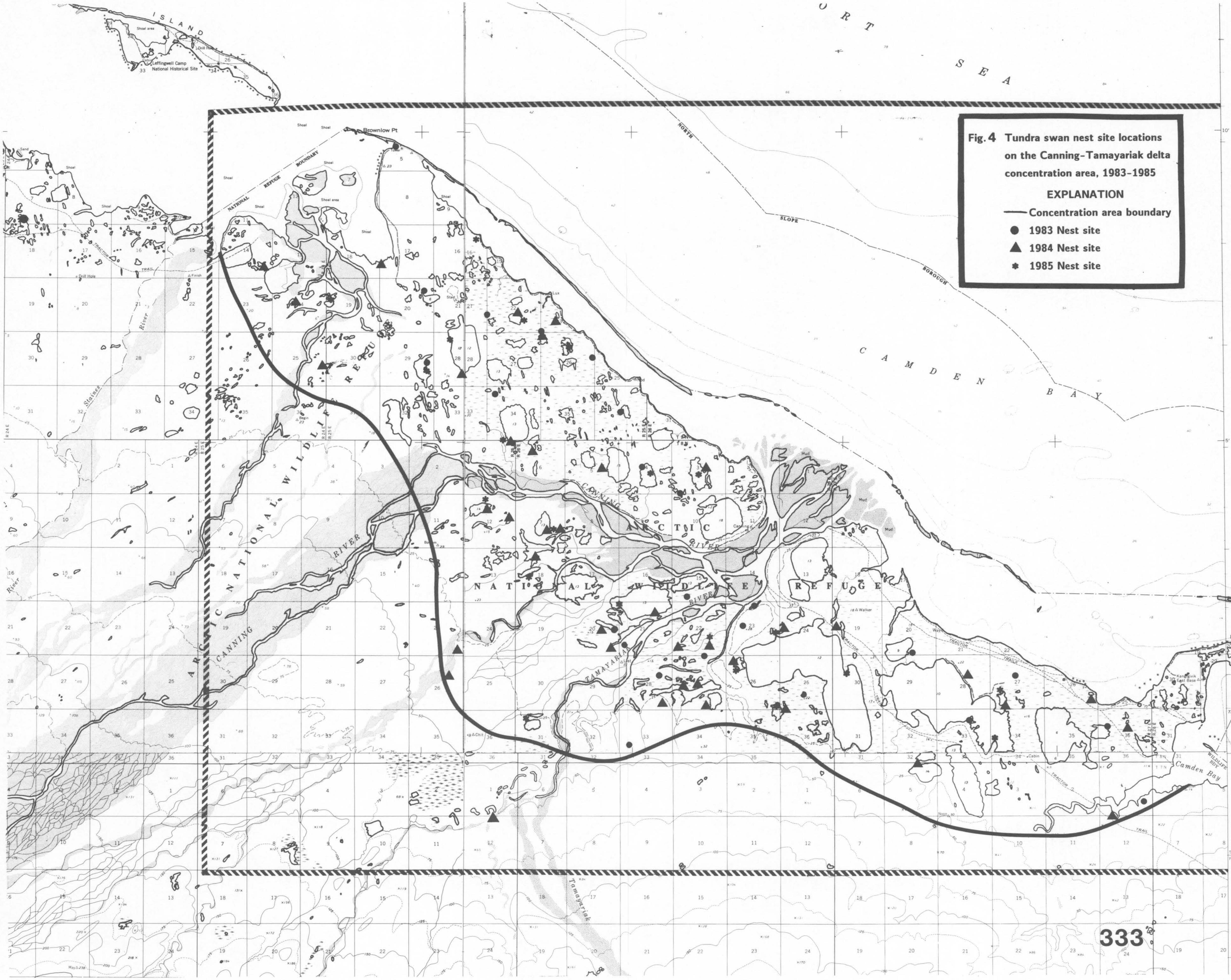

Fig. 4 Tundra swan nest site locations on the Canning-Tamayariak delta concentration area, 1983-1985

EXPLANATION

——	Concentration area boundary
●	1983 Nest site
▲	1984 Nest site
✱	1985 Nest site

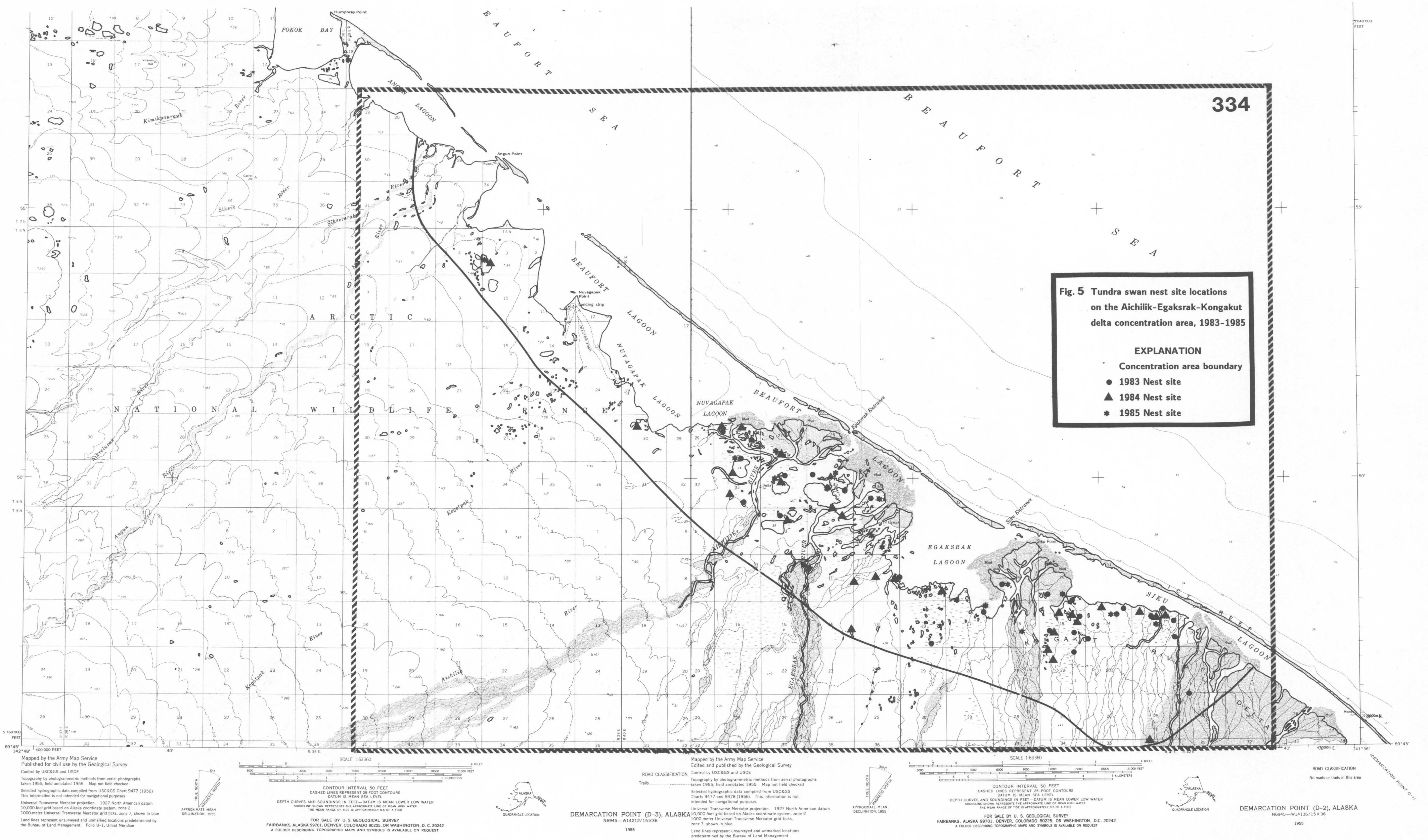

Fig. 5 Tundra swan nest site locations on the Aichilik-Egaksrak-Kongakut delta concentration area, 1983-1985

Table 2. A comparison by concentration area of the mean (±SD) tundra swan population statistics on the Arctic National Wildlife Refuge, June 1983-1985.

Concentration Area (km^2)	No. Nests	Nests/km^2	Adults	Adults/km^2
Canning-Tamayariak Delta (227)	29.3 ± 9.4	0.13 ± 0.04	115.7 ± 13.8	0.51 ± 0.06
Hulahula-Okpilak Delta (85)	11.7 ± 2.5	0.14 ± 0.03	39.0 ± 1.0	0.46 ± 0.01
Jago Delta (19)	1.7 ± 1.5	0.07 ± 0.06	7.0 ± 3.0	0.37 ± 0.16
Aichilik-Egakshrak Kongakut delta (112)	24.7 ± 4.2	0.22 ± 0.04	118.8 ± 42.2	1.06 ± 0.38
Pingokraluk Point (13)	2.0 ± 1.7	0.15 ± 0.13	5.3 ± 4.0	0.41 ± 0.31
Demarcation Bay (70)	3.3 ± 3.2	0.05 ± 0.05	17.3 ± 3.2	0.25 ± 0.05
All concentration areas (526)	72.7 ± 19.0	0.14 ± 0.04	347.7 ± 115.2	0.66 ± 0.05
Other areas surveyed (1077)	9.0 ± 2.7	0.01 ± 0.00	60.7 ± 23.4	0.06 ± 0.02
All areas surveyed (1063)	81.7 ± 17.2	0.05 ± 0.01	363.7 ± 80.6	0.22 ± 0.05

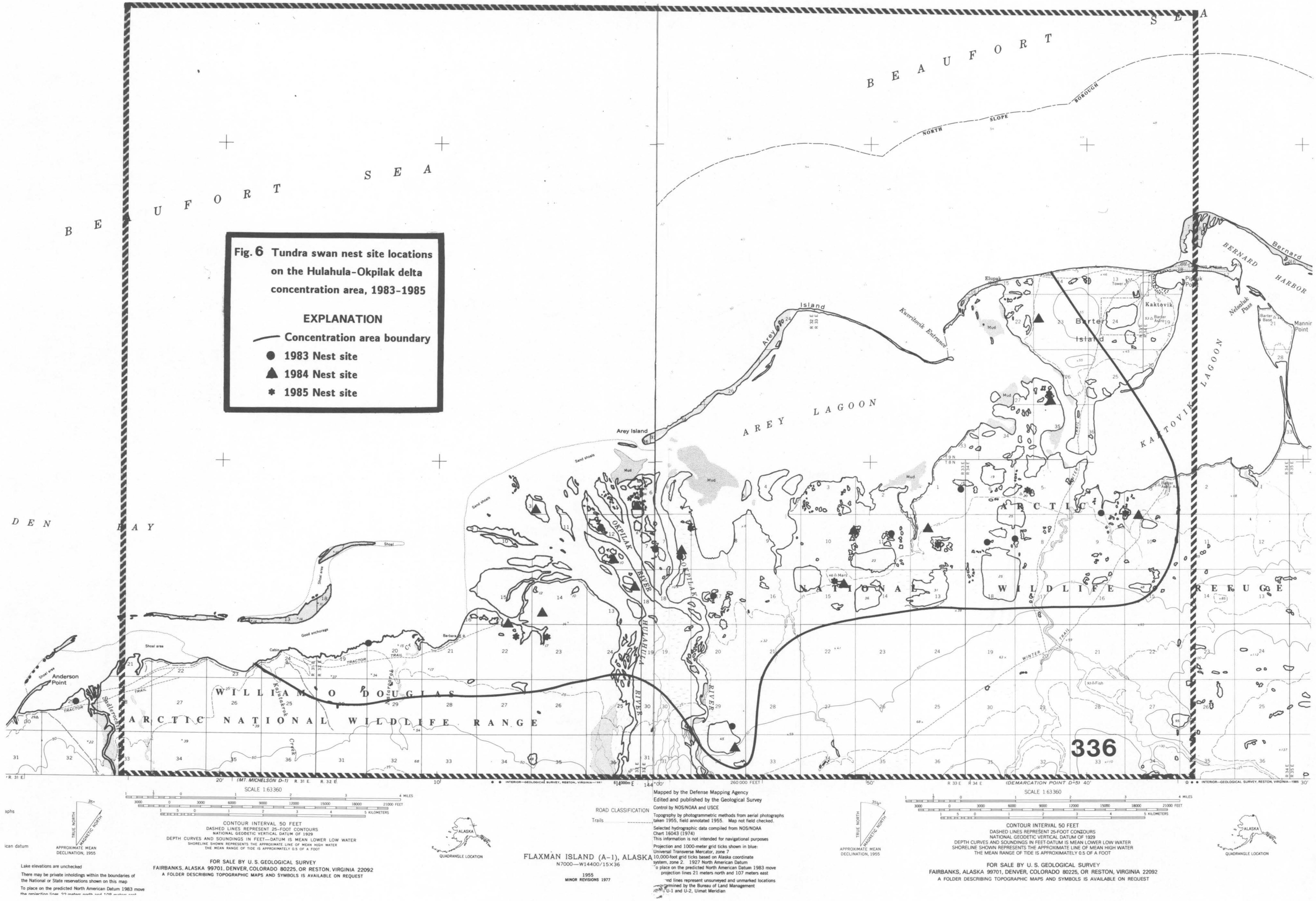

Fig. 6 Tundra swan nest site locations on the Hulahula-Okpilak delta concentration area, 1983-1985

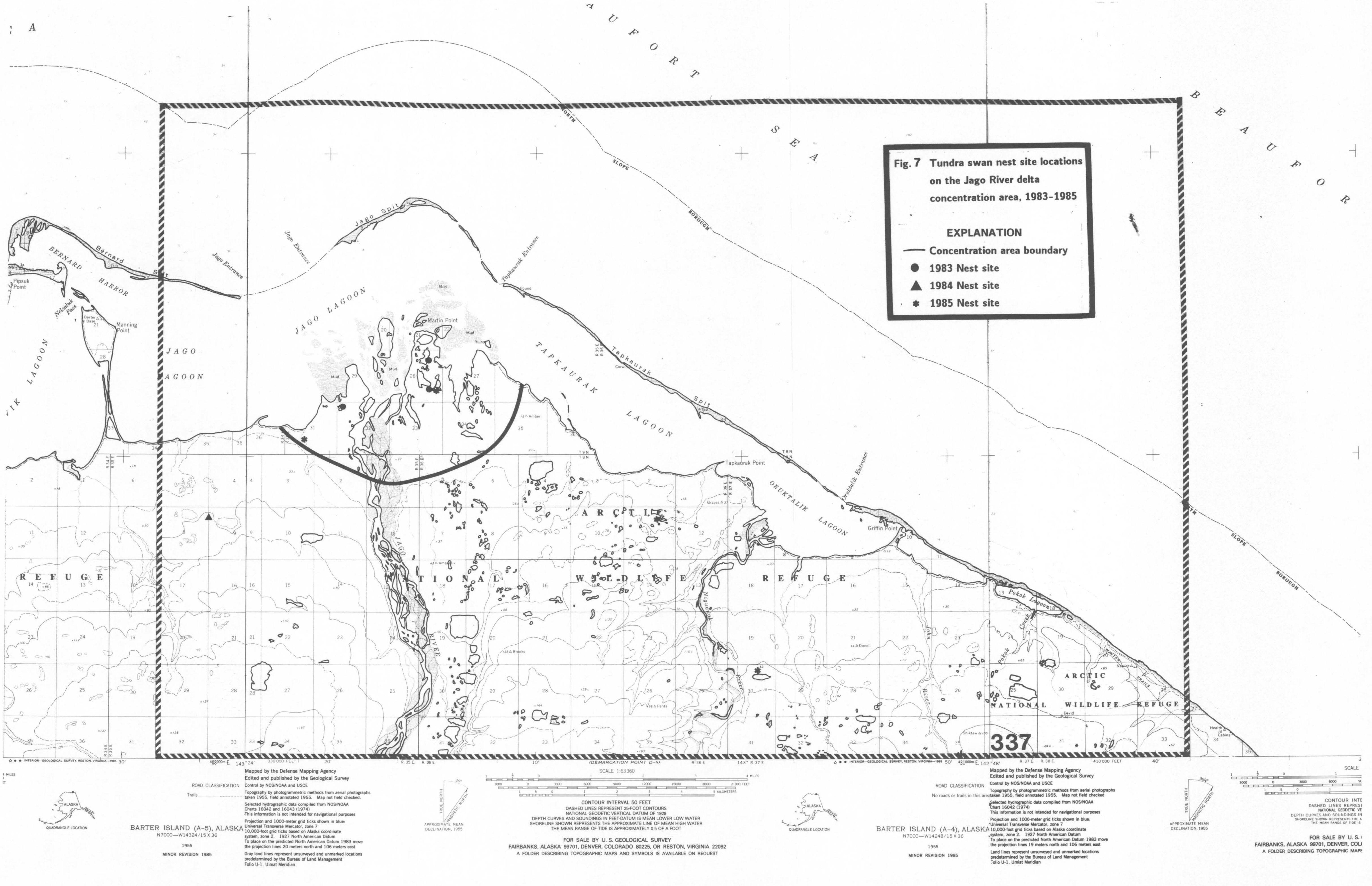

Fig. 7 Tundra swan nest site locations on the Jago River delta concentration area, 1983-1985

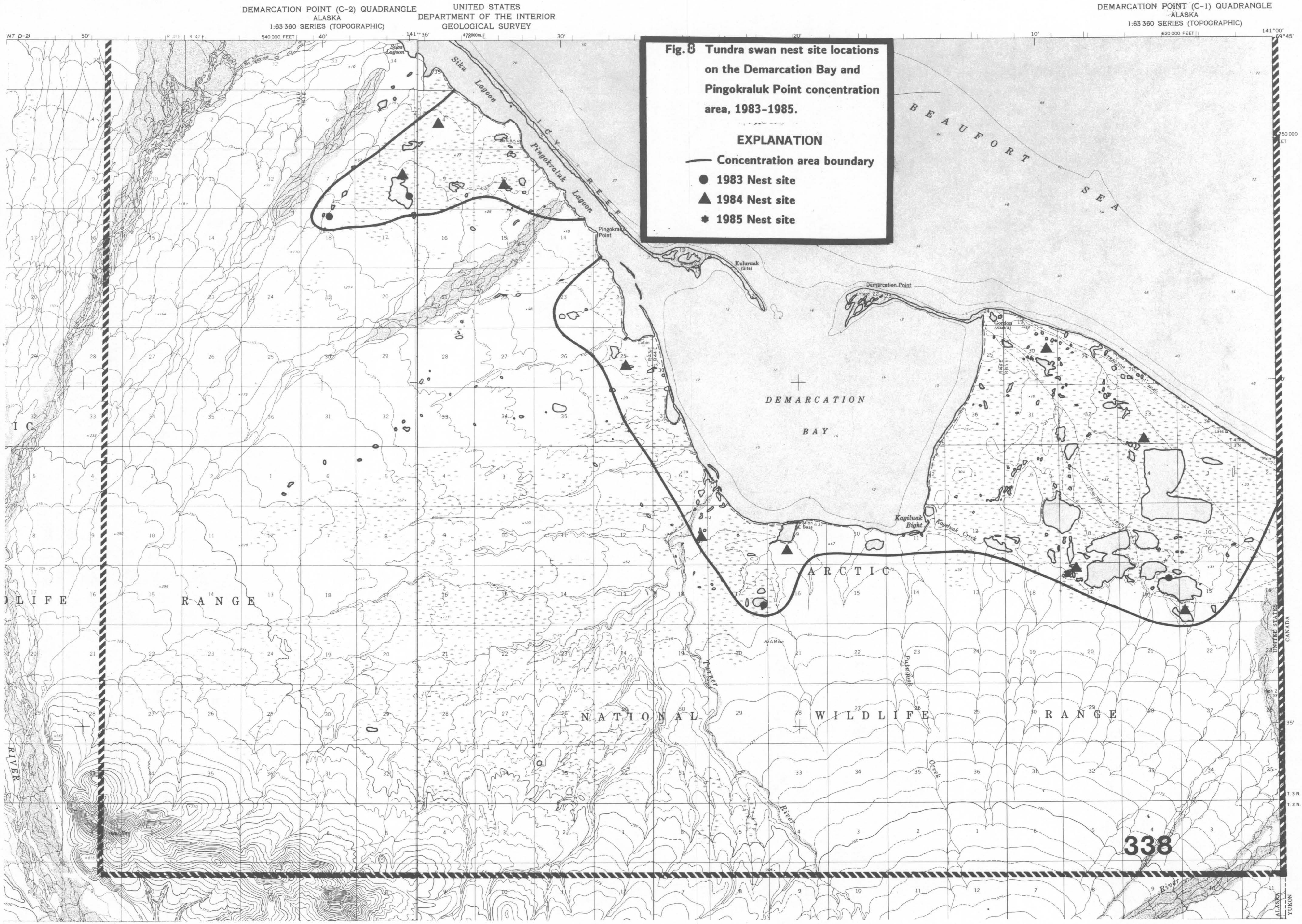

Fig. 8 Tundra swan nest site locations on the Demarcation Bay and Pingokraluk Point concentration area, 1983-1985.

EXPLANATION

- ── Concentration area boundary
- ● 1983 Nest site
- ▲ 1984 Nest site
- ✸ 1985 Nest site

Table 3. Tundra swan population statistics by concentration area for the 1982-1985 August production surveys on the Arctic National Wildlife Refuge.

Date	Concentration Area	Number					Swans/km^2	% Paired	%Pairs w/young	No. Broods
		Total	Adults	Cygnets	Pairs	Unpaired				
19-20 Aug 1985	Canning-Tamayariak delta	182	142	40	40	62	0.80	56.3	40.0	16
23,27-29 Aug 1984		142	96	46	36	34	0.63	75.0	47.2	17
21 Aug 1983		190	126	64	48	30	0.84	76.2	54.2	26
12 Aug 1982		75	63	12	21	21	0.33	66.7	28.6	6
19-20 Aug 1985	Hulahula-Okpilak delta	110	75	35	22	31	1.29	58.7	54.5	12
23,27-29 Aug 1984		73	43	30	16	11	0.86	74.4	62.5	10
21 Aug 1983		93	60	33	19	22	1.09	63.3	52.6	10
12 Aug 1982		48	40	8	10	20	0.57	50.0	30.0	3
19-20 Aug 1985	Jago delta	16	12	4	6	0	0.84	100.0	33.3	2
23,27-29 Aug 1984		0	0	0	0	0	0.00	0.0	0.0	0
21 Aug 1983		12	9	3	2	5	0.63	44.4	50.0	1
12 Aug 1982		0	0	0	0	0	0.00	0.0	0.0	0
19-20 Aug 1985	Aichilik-Egakshrak-Kongakut delta	220	178	42	33	112	1.96	37.1	48.5	16
23,27-29 Aug 1984		137	83	54	30	23	1.22	72.3	73.3	22
21 Aug 1983		171	126	45	36	54	1.53	57.1	18.5	15
12 Aug 1982		162	152	10	27	98	1.45	35.5	18.5	5
19-20 Aug 1985	Pingokraluk Point	9	7	2	2	3	0.69	57.1	50.0	1
23,27-29 Aug 1984		14	6	8	3	0	1.08	100.0	66.7	2
21 Aug 1984		11	7	4	3	1	0.85	85.7	66.7	2
12 Aug 1982		15	10	5	3	4	1.15	60.0	66.7	2
19-20 Aug 1985	Demarcation Bay	15	15	0	7	1	0.21	93.3	0.0	0
23,27-29 Aug 1984		28	17	11	4	9	0.40	47.1	110.0	4
21 Aug 1983		19	13	6	6	1	0.27	92.3	33.3	2
12 Aug 1982		9	4	5	2	0	0.13	100.0	100.0	2
19-20 Aug 1985	All concentration areas	552	429	123	110	209	1.05	51.3	42.7	47
23,27-29 Aug 1984		394	245	149	89	67	0.75	72.7	61.8	55
21 Aug 1983		496	341	155	114	113	0.94	66.9	49.1	56
12 Aug 1982		309	269	40	63	143	0.59	46.8	28.6	18
19-20 Aug 1985	Other areas surveyed	75	56	19	23	10	0.07	82.1	39.1	9
23,27-29 Aug 1984		51	35	16	17	1	0.05	97.1	47.1	8
21 Aug 1983		58	44	14	16	12	0.05	72.7	37.5	6
12 Aug 1982		25	23	2	7	9	0.02	60.9	14.3	1
19-20 Aug 1985	All areas surveyed	627	485	142	133	219	0.39	54.8	42.1	56
23,27-29 Aug 1984		445	280	165	106	68	0.28	75.7	59.4	63
21 Aug 1983		554	385	169	130	125	0.35	67.5	47.7	62
12 Aug 1982		334	292	42	70	152	0.21	47.9	27.1	19

adults) can probably be attributed to an influx of nonbreeders or unsuccessful breeders in singles and flocks entering the area prior to the fall survey. An additional 6 pairs were also observed. A similar situation occurred in 1983 when total numbers of adults increased by 42% from 271 in the spring to 385 in the fall. The seasonal increase in 1983 consisted of 24 pairs and 66 birds in singles or flocks. In 1984, a 33% decline in total adults occurred between the spring and fall surveys (Table 3). This resulted from a reduction of 86 paired (43 pairs) and 51 unpaired birds. In the fall of 1984, 68 adults in singles and flocks were observed compared to 219 in 1985, a 222% increase. The fall population of adult swans over the survey area for all 4 years (361 ± 95, Table 4) was approximately equal to the average spring population (364 ± 81, Table 2).

The Aichilik-Egaksrak-Kongakut concentration area contained the largest number of adults (178, 37% of total) in fall 1985. The Canning-Tamayariak concentration area contained 142 adults (29% of total) followed by the Hulahula-Okpilak area with 75 adults (16%). These areas accounted for 82% of the swans located during the fall survey.

Productivity

Production of cygnets totaled 142 in 1985, a decrease of 14% (23) from 1984 (Table 3). This was the second yearly decrease since the peak number of cygnets observed in 1983. The decline from 1983 to 1984 was only 4 cygnets. In the 1982 fall survey only 42 cygnets from 19 broods were counted, probably due to a June snowfall of 13.7 cm during the normal period of egg laying and incubation (Bartels et al. 1983). Delayed nesting may result in smaller clutch sizes (Bellrose 1976).

Number of broods (56) in 1985 was down 11% from 1984. The overall 4 year average production was 50 ± 21 broods averaging 2.53 ± 0.22 cygnets/brood for a mean of 129.5 ± 59.5 cygnets/year (Table 4). Average brood size was largest (2.97 ± 0.26 cygnets/brood) on the Hulahula-Okpilak delta.

Nest success appeared to be highest in 1985 based upon the ratio of broods to nests. The rate of success was 63% in 1984, and 85% in 1985 (Table 5). Success rate can also be based on the ratio of broods to total spring pairs (Bartels and Doyle 1984), as a minimum possible success rate. Using the two estimates, we calculated the range of nesting success as 44% to 85% in 1985, 42% to 63% for 1984, and 59% to 79% for 1983. The apparent increase in nesting success from 1984 to 1985 may have been due to a late ice melt on lakes and high water levels on the deltas which may have discouraged younger, less successful pairs from nesting.

On the Hulahula-Okpilak area and the Pingokraluk Point area in 1985 more broods were observed in the fall than nests in the spring. This phenomena could be the result of failure to detect some of the nests during the spring survey or immigration of family groups into 1 of the concentration areas before the fall survey.

The density of broods varied considerably between years within concentration areas, but was relatively stable over the coastal plain (0.04 broods/km^2) from year to year (Table 5). Brood densities in all concentration areas

Table 4. A comparison by concentration area of mean Tundra swan population statistics on the Arctic National Wildlife Refuge, August surveys 1982-1985.

	No. Broods	Broods/km^2	No. Cygnets	No. Adults	Adults/km^2
Canning-Tamayariak delta (227)	16.3 ± 8.2	0.07 ± 0.04	40.5 ± 21.6	106.8 ± 34.9	0.47 ± 0.15
Hulahula-Okpilak delta (85)	8.8 ± 4.0	0.10 ± 0.05	26.5 ± 12.5	54.5 ± 16.3	0.64 ± 0.19
Jago delta (19)	0.8 ± 1.0	0.04 ± 0.05	1.8 ± 1.8	5.3 ± 6.2	0.28 ± 0.33
Aichilik-Egakshrak Kongakut delta (112)	14.5 ± 7.1	0.13 ± 0.06	37.8 ± 19.2	134.8 ± 40.5	1.20 ± 0.36
Pingokraluk Point (13)	1.8 ± 0.5	0.13 ± 0.14	4.8 ± 2.5	7.5 ± 1.7	0.58 ± 0.13
Demarcation Bay (70)	2.0 ± 1.6	0.03 ± 0.02	5.5 ± 4.5	12.3 ± 5.7	0.18 ± 0.08
All concentration areas (526)	44.0 ± 17.8	0.08 ± 0.03	116.8 ± 53.0	321.2 ± 82.8	0.61 ± 0.15
Other areas surveyed (1077)	6.0 ± 3.6	0.01 ± 0.00	12.8 ± 7.5	39.5 ± 14.0	0.04 ± 0.01
All areas surveyed (1063)	50.0 ± 17.2	0.03 ± 0.01	129.5 ± 59.5	360.5 ± 95.4	0.22 ± 0.06

Table 5. Tundra Swan reproductive success ratios from the 1982-1985 surveys on the coastal plain of the Arctic National Wildlife Refuge.

Year	Concentration Area	Broods/nest	Broods/pair	Broods/km^2
1985	Canning-Tamayariak Delta	0.73	0.33	0.07
1984		0.43	0.32	0.08
1983		1.00	0.72	0.12
1982		-	-	0.03
1985	Hulahula-Okpilak Delta	1.33	0.92	0.14
1984		0.71	0.63	0.12
1983		0.83	0.67	0.12
1982		-	-	0.04
1985	Jago Delta	1.00	0.50	0.11
1984		0.00	0.00	0.00
1983		0.33	0.33	0.05
1982		-	-	0.00
1985	Aichilik-Egakshrak-Kongakut Delta	0.80	0.52	0.14
1984		0.79	0.51	0.20
1983		0.58	0.46	0.13
1982		-	-	0.05
1985	Pingokraluk Point	0.00	-	0.08
1984		0.67	0.50	0.15
1983		0.67	0.66	0.15
1982		-	-	0.15
1985	Demarcation Bay	0.00	0.00	0.00
1984		0.57	0.44	0.06
1983		1.00	0.66	0.03
1982		-	-	0.03
1985	All Concentration Areas	0.87	0.46	0.09
1984		0.60	0.43	0.09
1983		0.78	0.60	0.11
1982		-	-	0.30
1985	Other Areas Surveyed	0.75	0.36	0.01
1984		1.00	0.38	0.01
1983		0.86	0.46	0.01
1982		-	-	-
1985	All Areas Surveyed	0.85	0.44	0.04
1984		0.63	0.42	0.04
1983		0.70	0.59	0.04
1982		-	-	0.04

combined were highest in 1983 (0.11 broods/km^2) and identical in 1984 and 1985 (0.09 broods/km^2). The Aichilik-Egaksrak-Kongakut delta consistently supported higher brood densities (0.05-0.20 broods/km^2) during each survey year except 1985 when the Hulahula-Okpilak delta and Aichilik-Egaksrak-Kongakut deltas had similar densities (0.14 broods/km^2).

Other North Slope Areas

Sufficient survey data has been accumulated on ANWR and other north slope locations to allow a comparison of the refuge population with densities in other eastern population breeding areas (Table 6). The ANWR swan concentration areas support swan densities and nest densities that are as high as those reported elsewhere on the north slope. Overall, adult densities do not reach the high level of those in the Keewatin area of the Northwest Territories, Canada located in the center of the nesting range of the population. However, mean annual swan and nest densities on the Aichilik-Egaksrak-Kongakut delta exceeded the average densities on the Colville delta and other Alaskan north slope areas.

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Table 6. Densities of nests and Adult Tundra Swans on Arctic National Wildlife Refuge and elsewhere.

Location	Year	Swan density (Adults/km^2)	Nest Density (Nest/km^2)	Author
ANWR concentration areas[a]	1981-1985	0.45-0.64	0.10-0.17	This report, Bartels et al. 1983, Bartels and Doyle 1984.
Aichilik-Egaksrak Kongakut Deltas[a]	1981-1985	0.63-1.29	0.18-0.25	This report, Bartels et al. 1983, Bartels and Doyle 1984.
Colville Delta[b]	1982-1983	0.11-0.22	0.51[c]	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 Long lake[b]	1977-1978	0.2	---	Derksen et al. (1981)
Storkenson Point[b]	1977-1978	0.1 -0.3	---	Derksen et al. (1981)
Keewatin NWT	1975-1976	0.85	---	McLaren and McLaren (1984)

[a] Arctic National Wildlife Refuge

[b] Other north slope locations

[c] 1983 Swan density

APPENDICES

Appendix Table 1. Tundra swan population statistics by survey area for the 1983, 1984, and 1985 June nesting surveys for the Arctic National Wildlife Refuge.

		Number						
Year	Concentration area	# Nests	Pairs w/o nests	Total pairs	Unpaired singles & groups	Total adults	Nests/km^2	Pairs/km^2
1985	Canning-Tamayariak delta (490)[a]	22	25	47	29	123	0.04	0.10
1984		41	14	55	24	134	0.08	0.11
1983		25	11	36	26	98	0.05	0.07
1985	Hulahula delta (168)[a]	8	8	16	6	38	0.05	0.10
1984		14	8	22	32	75	0.08	0.13
1983		11	3	14	8	36	0.07	0.08
1985	Jago delta & wetlands (357)[a]	6	4	10	9	29	0.02	0.03
1984		4	6	10	3	23	0.01	0.03
1983		5	1	6	1	13	0.01	0.02
1985	Aichilik-Egakshrak-Kongakut delta (259)[a]	19	13	32	90	154	0.07	0.12
1984		30	17	47	57	151	0.12	0.18
1983		29	6	35	4	74	0.11	0.14
1985	Demarcation Bay (158)[a]	1	5	6	3	15	0.01	0.04
1984		7	2	9	3	21	0.04	0.06
1983		2	1	3	10	16	0.01	0.02
1985	Other areas (171)[a]	10	6	16	12	44	0.06	0.09
1984		4	2	6	1	13	0.02	0.04
1983		6	5	11	5	27	0.04	0.06
1985	All areas (1603)[a]	66	61	127	149	403	0.04	0.08
1984		100	49	149	120	402	0.06	0.09
1983		78	27	105	54	264	0.05	0.07

[a] Area (km^2) within each study area.

Appendix Table 2. Tundra swan population statistics by survey area for the Arctic National Wildlife Refuge coastal areas, Alaska, during August production surveys, 1981-1985.

Survey	Number						Swans	%			Number	Cygnets/	Swans/
Area	Total	Adults	Cygnets	Pairs	Singles	Flocks	in flocks	Paired	Prs w/Yng	Yng	broods	adults	km^2
Canning/Tamayariak delta: (490)[a]													
4 Aug 1981	186	140	46	30	3	10	77	43	57	25	17	1:3.0	0.38
12 Aug 1982	75	63	12	21	3	4	18	67	29	16	6	1:5.3	0.15
21 Aug 1983	188	125	63	48	7	4	22	77	52	34	25	1:2.0	0.38
23 Aug 1984	149	102	47	39	3	4	21	76	46	32	18	1:2.2	0.30
19-20 Aug 1985	176	136	40	37	8	11	54	54	43	23	16	1:3.4	0.36
Hulahula/Okpilak delta: (168)[a]													
4 Aug 1981	80	67	13	9	0	8	49	27	44	16	4	1:5.2	0.48
12 Aug 1982	39	35	4	10	1	3	14	57	20	10	2	1:8.8	0.23
21 Aug 1983	94	62	32	20	5	3	17	65	45	34	9	1:2.1	0.56
27 Aug 1984	70	38	32	14	10	0	0	74	79	46	11	1:1.2	0.42
19-20 Aug 1985	102	74	28	22	8	4	22	59	45	27	10	1:2.6	0.61
Aichilik/Egkshrak/ Kongakut delta (259)[a]													
4 Aug 1981	171	139	32	17	2	11	101	24	76	19	14	1:4.3	0.66
12 Aug 1982	171	157	14	29	2	7	97	37	21	8	6	1:11.2	0.66
21 Aug 1983	164	112	52	36	6	7	34	64	50	32	18	1:2.2	0.63
29 Aug 1984	130	70	60	32	6	0	0	91	72	46	23	1:1.2	0.50
19-20 Aug 1985	213	175	38	33	8	15	101	38	42	18	14	1:4.6	0.82
Jago delta and Wetlands (357)[a]													
4 Aug 1981	12	8	4	2	1	1	3	50	50	33	1	1:2.0	0.03
12 Aug 1982	4	4	0	2	0	0	0	100	0	0	0	-	0.01
21 Aug 1983	37	29	8	10	1	2	8	69	30	22	3	1:3.6	0.10
27 Aug 1984	46	38	8	10	1	4	17	53	40	17	4	1:4.8	0.13
19-20 Aug 1985	52	34	18	15	0	1	4	88	53	35	8	1:1.9	0.15
Demarcation Bay (158)[a]													
4 Aug 1981	24	18	6	6	0	1	6	67	33	25	2	1:3.0	0.15
12 Aug 1982	16	9	7	1	3	1	4	22	100	44	3	1:1.3	0.10
21 Aug 1983	20	14	6	6	2	0	0	86	33	30	2	1:2.3	0.13
29 Aug 1984	28	17	11	4	1	2	8	47	100	39	4	1:1.5	0.18
19-20 Aug 1985	15	15	0	7	1	0	0	93	0	0	0	-	0.09
Other areas: (171)[a]													
4 Aug 1981	15	13	2	3	2	1	5	46	33	13	2	1:6.5	0.09
12 Aug 1982	25	20	5	3	1	3	15	20	100	20	2	1:5.0	0.15
21 Aug 1983	49	35	14	12	5	2	6	69	50	29	6	1:2.5	0.29
27 Aug 1984	20	15	5	7	1	0	0	93	29	25	2	1:3.0	0.12
19-20 Aug 1985	69	51	18	19	4	2	9	75	42	26	8	1:2.8	0.40
Total coastal area sampled: (1603)[a]													
1981	488	385	103	67	8	32	241	35	57	21	40	1:3.7	0.30
1982	330	288	42	65	10	18	148	45	20	13	19	1:6.9	0.21
1983	552	377	176	132	26	18	87	70	48	32	64	1:2.2	0.34
1984	443	280	165	106	22	10	46	76	58	37	62	1:1.7	0.28
1985	627	405	142	133	29	33	190	55	42	23	56	1:3.4	0.39

ANWR Progress Report Number 86-10

DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF FALL STAGING LESSER SNOW GEESE ON COASTAL HABITATS OF NORTHEAST ALASKA AND NORTHWEST CANADA, 1985

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Key Words: snow geese, Anatidae, waterfowl, staging waterfowl, population, Alaska, north slope, Arctic National Wildlife Refuge, Arctic-Beaufort

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Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1985.

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Abstract: One reconnaissance flight and 2 survey route flights were conducted on 25 and 31 August and 11 September 1985, respectively, to provide visual estimates of staging lesser snow geese populations on the coastal plain of the Arctic National Wildlife Refuge. Black and white photographs were taken of flocks on the 31 August and 11 September flights and on an additional 12 September flight to provide age ratio information and error estimates for visual estimates of flock sizes. Photos of 37 flocks were counted by 3 observers to provide estimates of variation among observers. Two counts of 15 flocks were conducted by each observer to provide estimates of within observer variance. Within and among observer variances were of similar magnitude. The corrected peak staging population estimate for 11 September was 312,572 geese. The main influx of geese onto ANWR occurred between 20 August and 11 September. Major departure occurred between 14 and 17 September. Greater concentrations of geese were observed in the foothills in 1985 than in previous years. Photography was of insufficient quality for determination of population age-ratios.

ANWR Progress Report No. 86-10

Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1985.

The fall staging of lesser snow geese using the coastal plain of the Arctic National Wildlife Refuge (ANWR) and adjacent Yukon and Northwest Territories was monitored for the fourteenth year since surveys were initiated in 1971 by L.G.L., Inc. (Schweinsburg 1974). The surveys represented the eighth year of survey by U.S. Fish and Wildlife Service (USFWS) personnel and the seventh year of photographic age ratio sampling using methods standardized in preceding years (Spindler 1980, 1983a). Objectives of the study were to: (1) determine the chronology of migration and staging; (2) estimate the distribution and numbers of snow geese present during the peak of staging; (3) estimate the percent young present during staging; (4) identify areas used consistently by staging snow geese and (5) obtain estimates of variation for counts of photographs by multiple observers and for multiple counts by individual observers.

Methods and Materials

A predetermined 9.7 km-spaced grid of 2.4 km wide north-south aerial transects (Koski 1977b, Spindler 1983a) from Bathurst, Northwest Territories to Marsh Creek, Alaska was flown using fixed-wing aircraft flying approximately 150 to 500 m above ground level at an airspeed of 200 kph. Flocks of snow geese encountered were assigned sequential numbers and recorded on 1:250,000 U.S.G.S. topographic maps, and estimated flock size and direction of movement were recorded. USFWS Personnel of the Arctic NWR conducted the Marsh Creek to Clarence River portion of the survey and CWS personnel simultaneously (whenever possible) flew the segment from Clarence River to Bathurst Peninsula to avoid double counting of flocks. Established minimum weather and survey standards (Spindler 1980, 1983a) were observed. Direction of movement information minimized double counting of flocks flying towards succeeding transects. A crew of 3 persons (a pilot and 2 observer/photographer/recorders) was used to simultaneously obtain photos and records. All persons helped find flocks. The observer sitting in the right front seat photographed the total flock at a distance for a flock size estimate. At this time the observer/photographers made an estimate of flock size. The pilot then circled closer and age-ratio photographs were taken. To avoid excessive disturbances to the geese, care was taken to minimize circling.

A Mamyia RB-67 60x70 mm large format SLR camera and an Olympus OM-1 35mm SLR camera were used on 31 August and 11 and 12 September for the photography. A 250 mm telephoto lens was used with the large format camera and a 75 to 150 mm zoom lens plus an auto-winder were used with the 35 mm camera. ASA 400 TRI-X Pan film was used in both cameras. Pilot and observer/photographer/recorders used headsets interconnected through an aircraft intercom to facilitate coordination of photography, airplane movements, and record keeping. In addition to the systematic procedures used for the 31 August and 11 and 12 September surveys, a reconnaissance flight was made over the ANWR coastal plain on 25 August and observations made while radio-tracking mammals were also recorded to provide more complete information on the arrival and staging of snow geese. Composition counts of family groups were conducted from ground locations to estimate productivity of successful breeding pairs (Lynch and Singleton 1964, Prevett and MacInnes 1980).

Photographs were enlarged so that each snow goose flock occupied a 20 x 25 cm sheet of photographic paper. Geese were counted independently by 3 counters to obtain estimates of counter variability. In addition, a random sample of 15 photos drawn from 3 different flock size groups was selected to be recounted by the observers without their knowledge to provide estimates of observer precision. For multiple counts of 15 flocks, variance was partitioned into within and among observer components using the variance components technique (Snedecor and Cochran 1967, p. 280). Flocks were then grouped by flock sizes with similar variances. Bounds on the error of estimation (Scheafer et al. 1979) were computed for each of these groups using estimated variances within and among observers to estimate numbers of counts and observers required to provide estimates of flock size within 10% of the mean. The following formula was used:

$$E = \frac{Z_{\alpha/2}\sqrt{n_c\hat{\sigma}_o^2 + \hat{\sigma}_c^2}}{\sqrt{n_o n_c}}$$

where E = bound on the error of estimation
$Z_{\alpha/2}$ = Z score at $\alpha/2 = 0.05$

$\hat{\sigma}_o^2$ = among observer variance
$\hat{\sigma}_c^2$ = within observer variance
n_o = # of observers
n_c = # of counts

The photos of the remaining 22 flocks (for which each observer made 1 count) plus the means within observers of the 15 multiple count flocks were grouped on the basis of the multiple count photo groups and variances among observers were calculated (variance within observers could not be partitioned out). Bounds on the error of estimation were also computed for these groups. Mean results of photo counts were regressed with survey estimates to determine estimation error and a prediction equation. Estimated variances for predicted flock sizes were derived from a curve plotted on the five midpoints of flock size groups for which among-observer variances were computed. The estimated variances were used to calculate total variance for all flocks and subsequently, an estimated confidence interval for the total population estimate. This confidence interval does not account for variation in estimates of flock size among observers during the aerial survey (probably the greatest source of observer variation). Therefore, resulting confidence intervals are probably significantly under-estimated. Calculation of the mean age ratio was not possible due to an insufficient number of usable quality photographs.

Results and Discussion

Observer Precision and Estimation Error

Analyses of data from the 15 multiple count flock photos revealed that both within observer and among observer variances increased with flock size (within observer r=0.9376 P<0.01, among observers r= 0.9350 P<0.01). Three flock size groups were established based on similarities among flock counts of observer variances (Fig. 1). Surprisingly, within observer variances were similar in size to among observer variances within each group and differences were approximately one order of magnitude (Table 1). As $\hat{\sigma}^2_o \approx \hat{\sigma}^2_c$, these variances were averaged. The similarity of $\hat{\sigma}^2_o$ and $\hat{\sigma}^2_c$ facilitates the computation of bounds on the error of estimation for the complete data set of 37 flocks (only $\hat{\sigma}^2_o$ is available for 22 flocks) through a simplification of the equation:

$$E \approx Z_{\alpha/2}\sqrt{\frac{2\hat{\sigma}^2_o}{n_o}}$$

The data from the counts of the 37 flocks were grouped according to the groups defined in the examination of within and among observer variances. Two new groups were added to include flocks in which the numbers of individuals fell between the small and medium flock size groups and between the medium and large flock size groups.

Table 1. Mean estimated within and among observer variances for counts by 3 observers of photographs of 15 flocks of snow geese in 3 flock size groups.

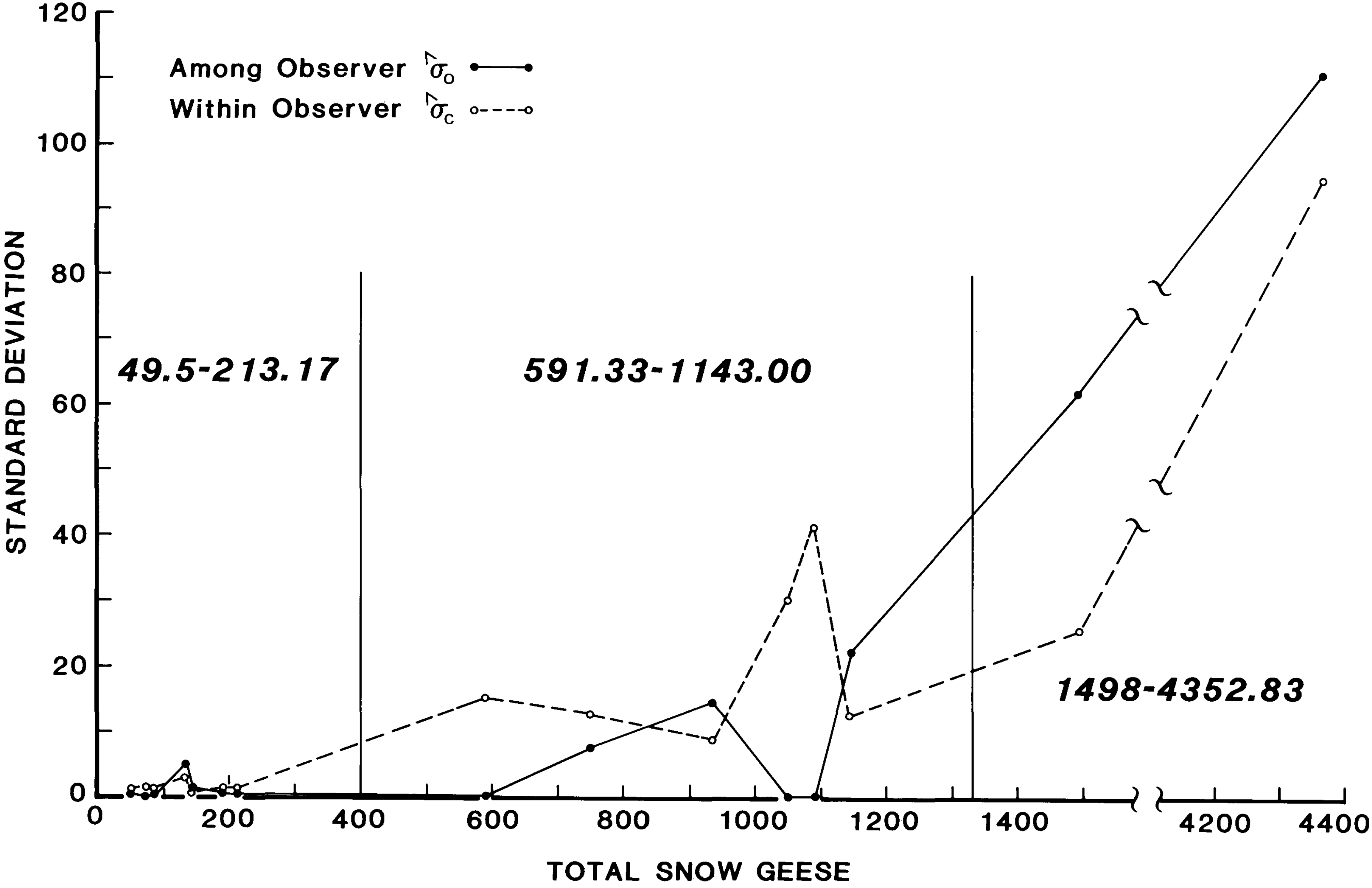
Flock Size Group	n	Within Observer $\hat{\sigma}^2$	Among Observer $\hat{\sigma}^2$
49.50-213.17	7	2.78	5.20
591.33-1143.00	6	546.56	226.25
1498.00-4364.83	2	4806.92	8064.96

Hypothetically, σ^2_o for single counts should be larger than for multiple counts by approximately a factor of two since σ^2_c can not be partitioned out in the former analyses. While the σ^2_o were similar for single and multiple counts for the small and large flock size groups, they were quite different for the medium flock size group (Table 2).

Table 2. Comparisons of variance estimated among observers for counts by 3 observers of photographs of 37 flocks of snow geese in 5 flock size groups and 15 flocks in which within observer variance has been partitioned out.

Flock Size	$\hat{\sigma}^2_o$ Single Counts	(n)	$\hat{\sigma}^2_o$ Multiple Counts	(n)	Ratio Single: Multiple
49.50-213.17	5.07	(9)	5.20	(7)	0.98
311.33-476.00	298.86	(7)	n/a		n/a
591.33-1143.00	487.18	(9)	266.25	(6)	1.83
1223.00-1350.33	6598.17	(2)	n/a		n/a
1498.00-4364.83	6576.92	(10)	8064.96	(2)	0.82

Fig. 1. Within and among observer standard deviations from multiple counts by 3 observers of photographs of 15 flocks of snow geese staging on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985[a].



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[a] Vertical lines delineate breaks between flock size groups.

The numbers of observers and/or counts per observer necessary for a bound within 10% of the mean generally increased with increasing flock size groups (Table 3). This increase was the result of increases of within and among observer variances which occurred with increasing flock size. The necessity for large numbers of observers could be offset somewhat by increasing the numbers of counts per observer.

Table 3. Bounds on the error of estimation for counts of photos of 37 flocks of snow geese in 5 flock size groups[a].

Flock size and Number of counts[b]	Number of Observers 1	2	3
49.50 - 213.17			
1	5.54	3.92	
2	5.03	3.56	
3	4.85		
311.33 - 476.00			
1	47.92	33.88	27.67
2	41.51	29.34	
3	39.13		
100	34.05		
591.33 - 1,143.00			
1	55.88		
2			
3			
1,223.00 - 1,350.33			
1	183.84	129.99	106.14
2	159.23	112.58	
3	150.11		
100	130.64		
1,498.00 - 4,352.83			
1	222.37	157.26	123.39
2	200.57	141.80	
3	192.72		
100	176.54		

[a] Computed bounds within 10% of the mean indicated by underlining

[b] Bounds for multiple counts computed for illustrative purposes using original formula (see text) and substituting $\hat{\sigma}_o^2$ for $\hat{\sigma}_c^2$.

Photo counts were significantly greater than survey estimates of flock size (t=4.97, n=37, P<0.001). Photo counts and survey estimates were also linearly related (Fig. 2). The resulting regression equation was used as a correction factor or calibration formula (Snedecor and Cochran 1967) and corrected estimates of all flocks observed were computed.

Chronology, Distribution, and Numbers

First sightings of snow geese on ANWR were flocks of 15 adults near Jago Delta tundra bird camp and 9 birds of unspecified age at Niguanak bird camp on 14 August. Barry (pers. comm.) reported that snow geese began departing Banks Island on 25 August. He also reported 2,990 birds on the MacKenzie Delta (Tuktoyaktuk to Shingle Point) and 1,150 from Shingle Point to Babbage River on 25 August. The 25 August reconnaissance flight on ANWR revealed 45 flocks totalling 5,720 birds (uncorrected estimate) scattered across the coastal plain from Clarence River to Okpilak River (Fig 3). The early birds were probably non-breeders which left the breeding colony ahead of the breeding geese and young (Barry 1966). Numerous other flocks were sighted on the ANWR coastal plain during mammal radio-tracking flights during the remainder of August and early September (Fig 3).

First major flock sightings were made on 27 August by Barry at Tuktoyaktuk Peninsula (12,144), Bathurst Peninsula (108,640), and Cape Parry (7,732). Barry observed 21,981 geese still on Banks Island on this date. A mass westward migration began on 28 August and Barry (pers. comm.) observed 141,000 geese from Tuktoyaktuk to Shingle Point, 314,235 geese from Shingle Point to Demarcation Bay, and approximately 18,000 geese in a limited survey, from the coast south to the 200 m contour from Demarcation Bay to Barter Island. This was probably the beginning of a major arrival on the ANWR coastal plain. The first intensive survey flight on the ANWR coastal plain was conducted on 31 August. A corrected total of 166,049 ± 1624.43[a] geese were observed in 194 flocks from Clarence River to Itkilyariak Creek (Fig. 4). This count was believed low due to the presence of an impenetrable fog bank along to coast from Demarcation Bay to the Jago Delta. Concentration areas occurred along the Jago River, between the Okerokovik and Aichilik Rivers and the lower Clarence River (Fig. 4).

The second intensive survey flight was conducted on 11 September. Conditions were optimal on ANWR but fog forced a 24 hour delay in the Canadian survey. A corrected total of 312,572 ± 2721.42[a] geese in 300 flocks was observed from the Clarence River to Simpson Cove (Fig. 5). Geese were observed in higher densites in the foothills in 1985 than in previous surveys (Fig. 6) and a major concentration was observed south of the upper Okerokovik and Jago rivers (Fig. 5). Other large concentrations were observed along virtually all of the major drainages in the study area (Fig 5). Barry observed 197,850 geese from Tuktoyuktuk to Shingle Point, and 97,162 geese from Shingle Point to Demarcation Bay on 12 September. There were virtually no snow geese on the Tuktoyuktuk Peninsula, Bathurst Peninsula, Parry Peninsula, and Pearse Point (Barry pers. comm.) on this date. By 13 September, very few geese were present on the Tuktoyuktuk Peninsula, Anderson River, and Kugaluk River (Barry pers. comm.). On 14 September there were approximately 123,000 geese in the MacKenzie Delta to Shingle Point area.

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[a] Confidence interval does <u>not</u> account for variation in estimates of flock sizes among observers during the aerial survey.

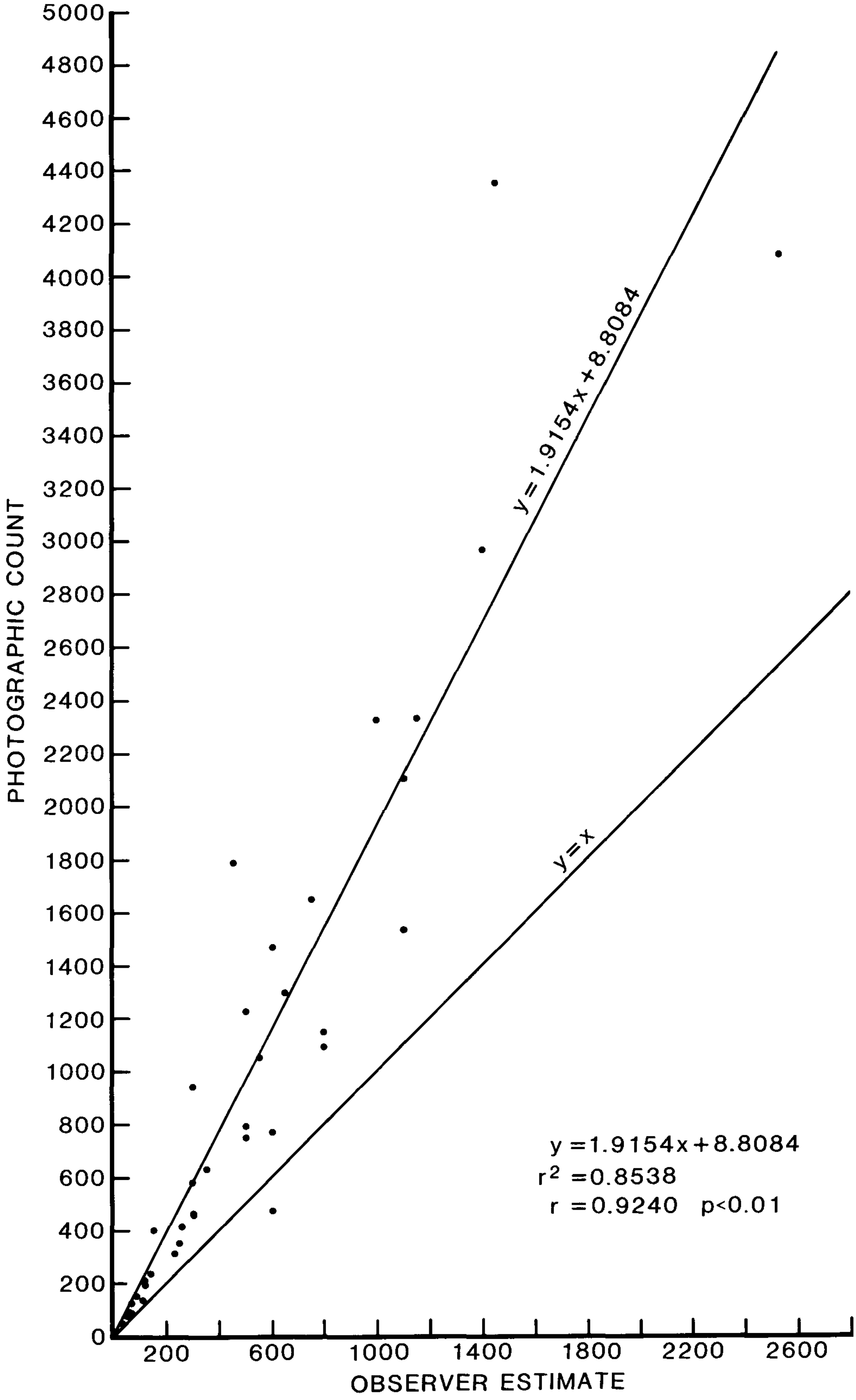


FIG. 2. REGRESSION OF PHOTO COUNTS ON OBSERVER ESTIMATES OBTAINED FROM SNOW GOOSE SURVEYS ON THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1985.

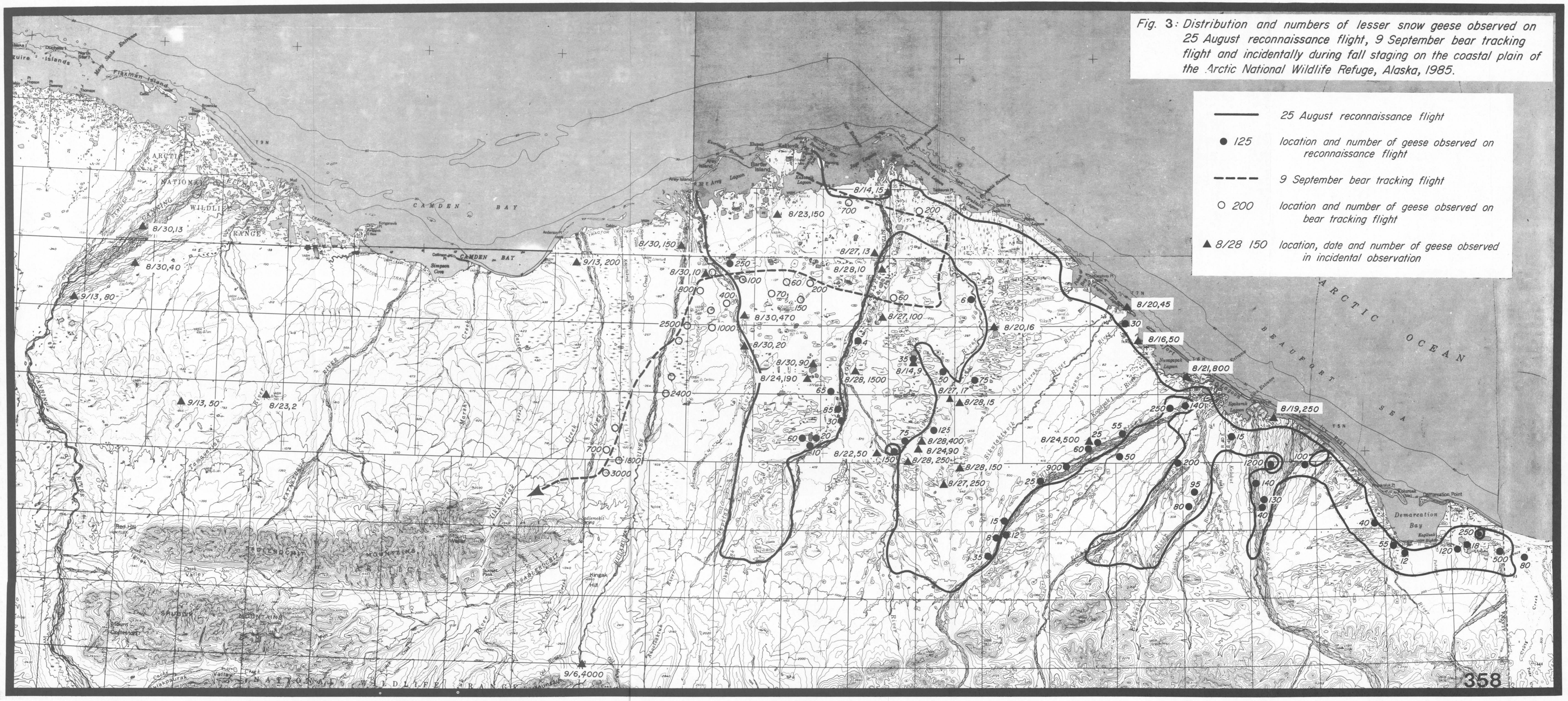
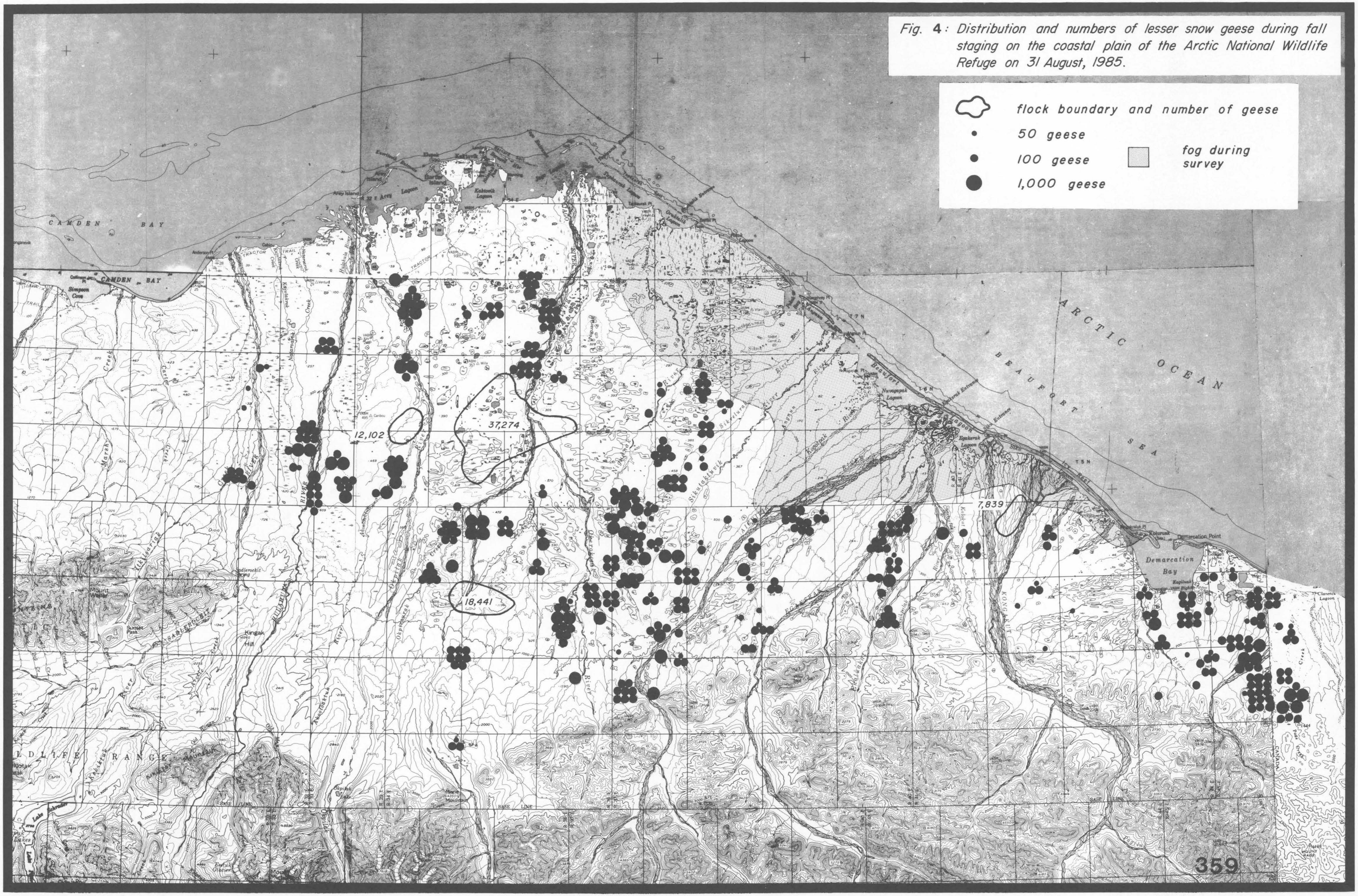


Fig. 3: Distribution and numbers of lesser snow geese observed on 25 August reconnaissance flight, 9 September bear tracking flight and incidentally during fall staging on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1985.

Fig. 4: Distribution and numbers of lesser snow geese during fall staging on the coastal plain of the Arctic National Wildlife Refuge on 31 August, 1985.



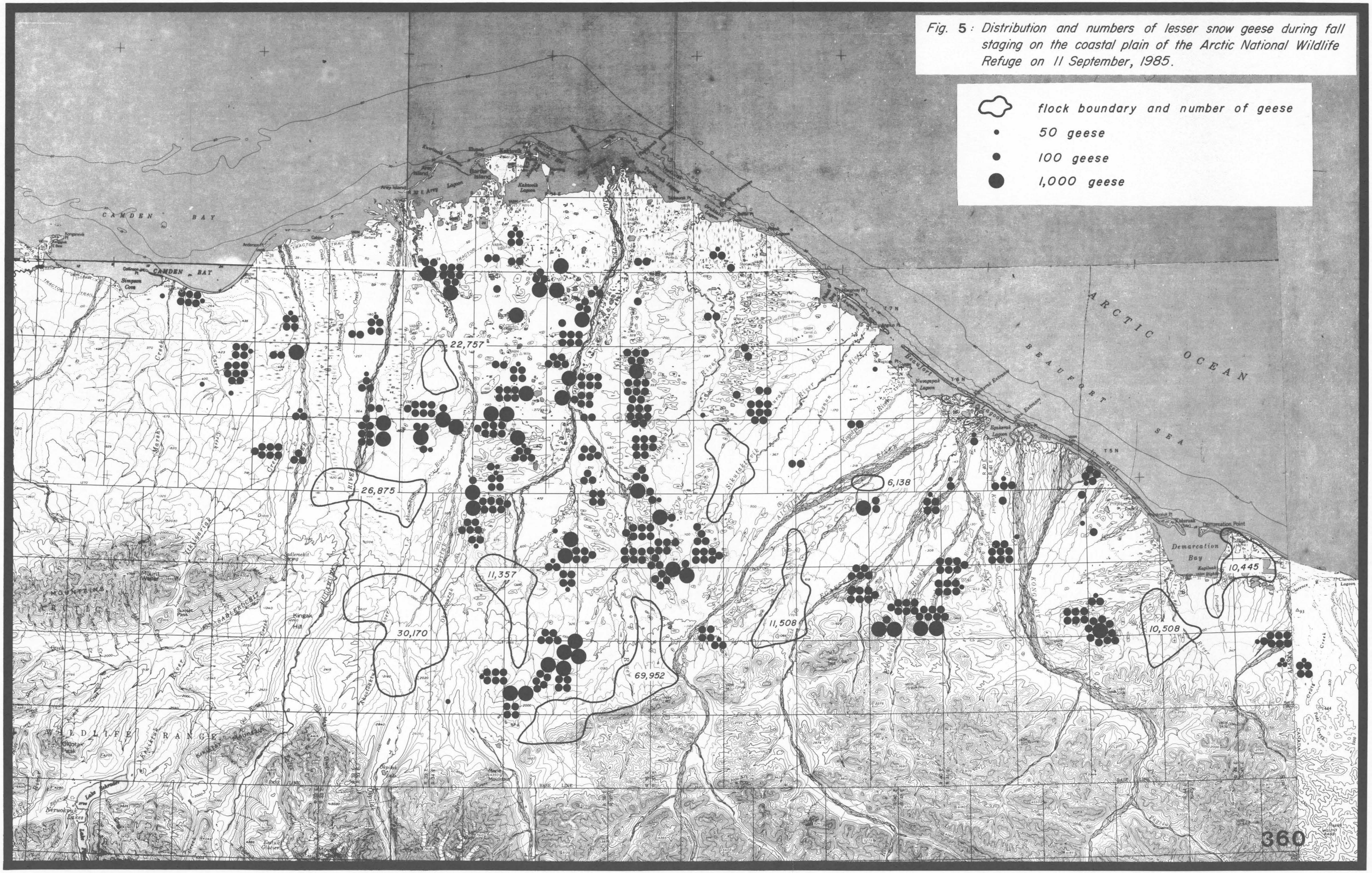
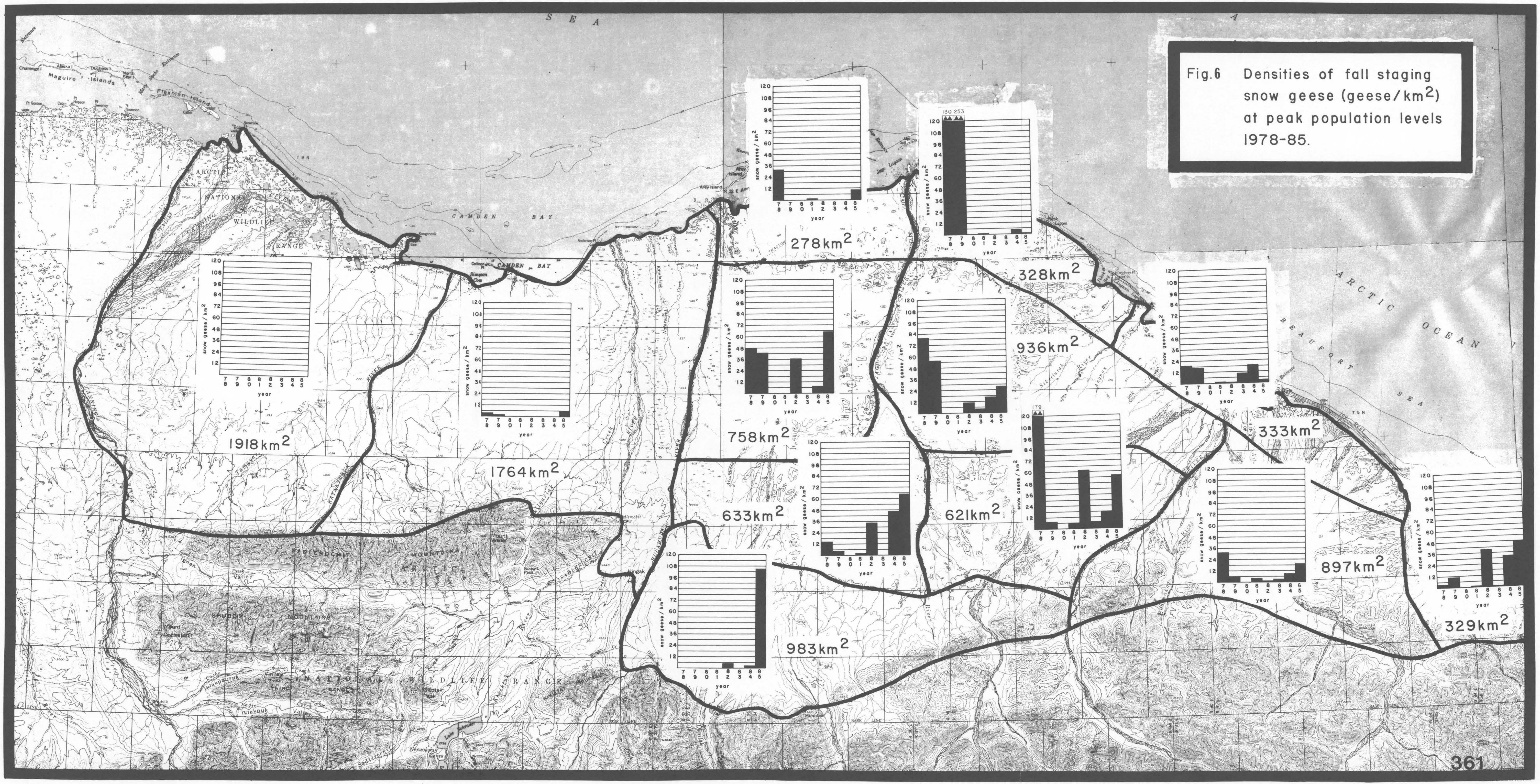


Fig. 5: Distribution and numbers of lesser snow geese during fall staging on the coastal plain of the Arctic National Wildlife Refuge on 11 September, 1985.

Fig. 6 Densities of fall staging snow geese (geese/km²) at peak population levels 1978-85.



Heavy snow began falling on the ANWR coastal plain on 15 September accompanied by high northwest winds (40+ knots) and by 16 September the coastal plain due south of Barter Island had +90% snow cover. A major departure of geese occurred between 14 and 17 September and when aircraft resumed flying on 18 September, no geese were seen on the ANWR coastal plain.

Although the major arrival date was similar to those in previous years, the major departure occurred earlier than most previous years (Fig. 7, Table 4). Peak number of geese observed on ANWR in 1985 (312,572) was 3.31 times the 1984 peak of 94,528 and 2.89 times the mean (107,990) of 10 previous surveys (extending over 10 years, excluding 1980, Table 5).

The proportion of the western arctic breeding population which stage in Alaska was highly variable (Table 3) and was apparently not related to total population size ($r=0.2808$, $p>0.05$). The number of geese staging in Alaska was probably more strongly related to weather conditions (particularly snow cover), but may also be influenced by prevailing winds, maturity of ericaceous berries, and availability of cotton grass (Eriophorum) and horsetail (Equisetum) (T.W. Barry, pers. comm.).

Productivity

Observers were unable to photograph sufficient numbers of geese to obtain reliable age-ratio estimates for ANWR. Composition counts by ground observers of 244 family groups yielded a mean of 2.29 (± 1.08 SD) young per successful breeding pair.

Acknowledgments

Thanks are due pilot R. Kaye who piloted the survey aircraft and provided additional observations. A. Brackney, B. Platte, and J. Morton provided data from ground composition counts. L. McDonald, G. Garner, and D. Thomas contributed invaluable assistance in the analysis of photo count data. T. Barry, CWS, Edmonton; provided advice and data from Canadian surveys. Additional sightings were provided by J. Herriges, M. Masteller, S. Gehman, D. Douglas, and J. Rider. S. Oates assisted in computations and preliminary graphics.

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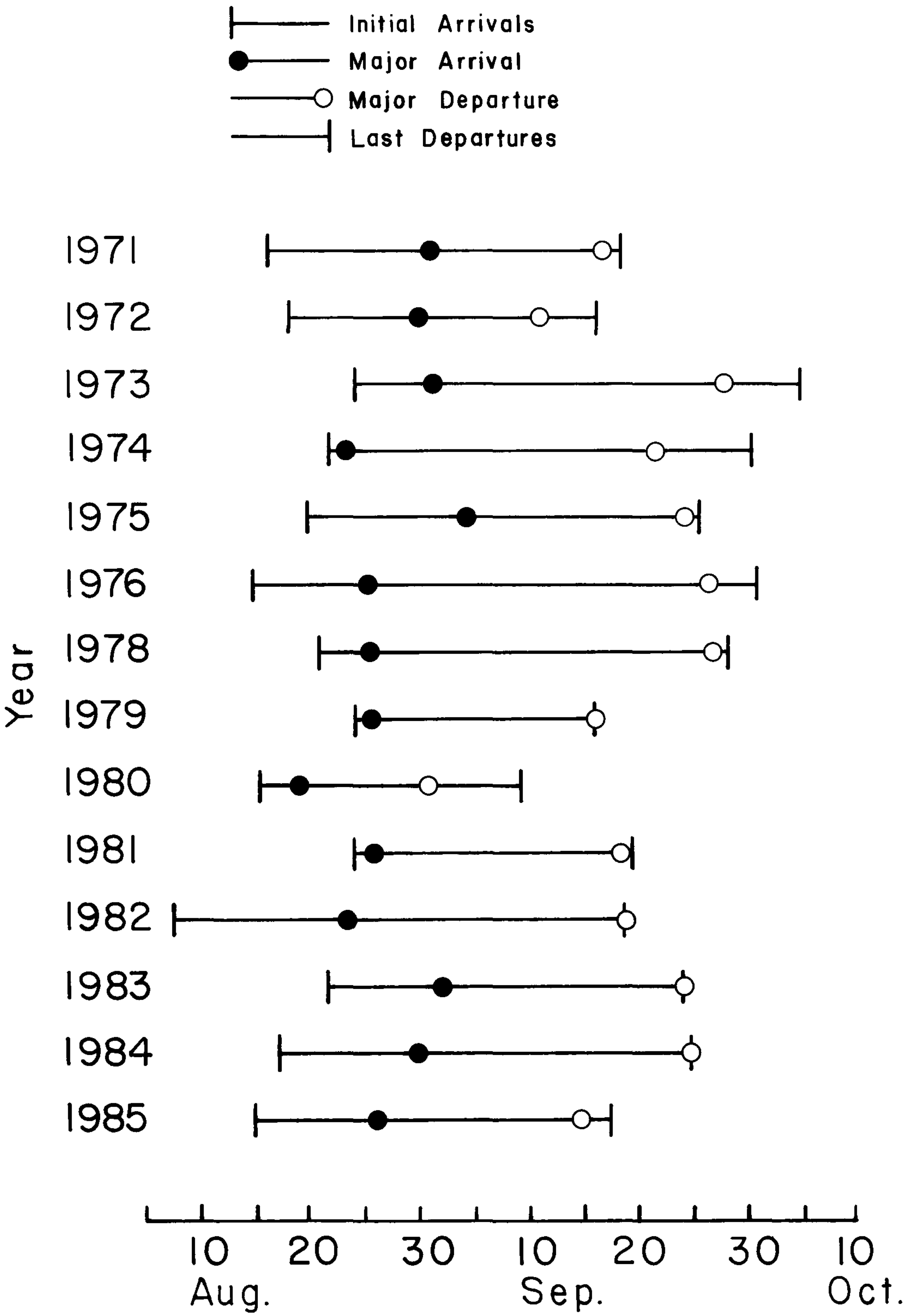

Fig. 7. Chronology of arrival, staging, and departure of the western arctic population of snow geese using the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1971-1985.

Table 4. Dates of arrival and departure of snow geese on the Mackenzie River delta, Yukon north slope, and eastern Alaskan north slope, August and September 1971-1976 and 1978-1984. The 1978-1982 and 1984 data are from Arctic National Wildlife Refuge only, other years include intensive sampling over entire staging area.

Year	Date first flock sighted	Dates of major arrival	Major departure	Date last flock sighted	Survey Period[a]
1971[b]	15 Aug.	31 Aug.-2 Sept.	12-16 Sept.	17 Sept.	4 June-19 Sept.
1972[c]	17 Aug.	27-29 Aug.	7-10 Sept.	15 Sept.	10 July-17 Sept.
1973[d]	23 Aug.	1-12 Sept.	22-25 Sept.	4 Oct.	25 Aug.-29 Sept.
1974[e]	21 Aug.	22-24 Aug.	17-21 Sept.	30 Sept.	24 Aug.-30 Sept.
1975[f]	18 Aug.	3-5 or 6 Sept.	19-24 Sept.	25 Sept.	20 Aug.-25 Sept.
1976[g]	13 Aug.	25-28 Aug.	16-26 Sept.	30 Sept.	15 Aug.-2 Oct.
1978[h]	20 Aug.	25 Aug.-1 Sept.	16-27 Sept.	27 Sept.	10 June-5 Oct.
1979[i]	24 Aug.	26-28 Aug.	15 Sept.	N/D	10 June-12 Sept.
1980[j]	15 Aug.	19-21 Aug.	1-2 Sept.	9 Sept.	5 June-12 Sept.
1981[k]	24 Aug.	26-30 Aug.	16-18 Sept.	18 Sept.	11 July-20 Sept.
1982[l]	7 Aug.	24-26 Aug.	16-18 Sept.	19 Sept.	6 June-25 Sept.
1983[m]	20 Aug.	25 Aug.-2 Sept.	21 Sept.	21 Sept.	1 June-26 Sept.
1984[n]	17 Aug.	30 Aug.-7 Sept.	17-25 Sept.	24 Sept.	28 Aug.-26 Sept.
1985	14 Aug.	28 Aug.-11 Sept.	15-18 Sept.	14 Sept.	28 Aug.-18 Sept.

[a] Dates inclusive of aerial and ground observation period. Locations of ground observation and aerial survey coverage varied: 1971-1976 data emphasized MacKenzie and Yukon locations, while 1978-1981 data emphasized Alaskan locations. The 1982 and 1983 data moe equally covered both Canadian and Alaskan locations; survey periods include dates between which extensive aerial surveys were conducted in which snow geese could have been observed. For details see reprective sources:

[b] Schweinsburg (1974)

[c] Gollop and Davis (1974)

[d] Koski and Gallop (1974)

[e] Koski (1975)

[f] Koski (1977a)

[g] Koski (1977b)

[h] Spindler (1978)

[i] Spindler, M., Wildlife Biologist. [Memo to Refuge Manager, Arctic National Wildlife Refuge, U.S. Fish & Wildlife Service.] 1979,] pp.

[j] Spindler (1980)

[k] Spindler (1983a)

[l] Spindler (1983b)

[m] Spindler (1984)

[n] Oates et al. (1985)

[o] Barry (pers. comm.)

Table 5. Peak numbers of western arctic snow geese counted during August-September staging surveys, Arctic National Wildlife Refuge coastal plain and Canadian areas to the east, 1973-1983.

Year	Alaska	Yukon north slope	Mackenzie River delta and east	Total	Percent Staging in Alaska	Survey dates
1973[a]	104,9752	62,345	39,600	406,920	25.80	Sept. 2,3,5,6,11,12,18,22,23,25
1974[a]	104,715	45,110	13,373	163,198	64.16	Aug. 24,31, Sept.5,11,16,25
1975[a]	0	20,972	354,028	375,000	0.00	Aug. 25-28, Sept.8,10,11,13,17-18, 20,23
1976[a]	228,793	224,401	18,363	471,557	48.52	Aug. 16-20, 29-31, Sept.4-6 ,10-13,18-21
1978[b]	325,760	N/D	N/D	N/D	N/D	Sept. 13-14
1979[c]	195,000	41,000	N/D	N/D	N/D	Sept. 6-7
1980[d]	8,996[e]	7,500[f]	N/D	N/D	N/D	Sept. 9
1981[g]	20,000[h]	80,000[h]	330,000[i]	430,000[f]	4.65	Sept.14,16,20
1982[i]	107,072	117,892	6,155	231,000	46.35	Aug.24,26,29,31;Sept.1,3,5,9,10,14,15,21,22
1983[k]	12,828	300,651	54,523	393,002	3.26	Aug.22,26;Sept.1,8,9,12,21,26
1984[l]	94,528	128,725[m]	195,879	369,232	25.6	Sept. 12,13
1985[l]	312,473 +2,721.42[n]	97,162	197,850	607,485	51.44	Sept. 11,12

Sources:

a	Koski (1977b), extrapolation from transects at several points in time, not all areas covered on each date.
b	Spindler (1978), extrapolation from transects at 1 point in time.
c	Spindler, M., Wildlife Biologist. [Memo to Refuge Manager, Arctic National Wildlife Refuge, U.S. Fish and Wildlife Service.] 1979, 1pp.
d	Spindler (1980)
e	Ground counts by J. Levison, estimates of all flocks seen in continuous count during daylight hours.
f	Estimated total; Actual photograph count was less; Demarcation Bay to Phillips Bay.
g	Spindler (1983a)
h	Visual estimates of flock size, Yukon sample includes only area from U.S.-Canada border to Phillips Bay.
i	Barry 1982. Does not include 250,000 geese estimated to have staged south and west of Paulatuk, which is east of the MacKenzie delta.
j	Spindler (1983b)
k	Numbers given are actual count estimates for area surveyed 12 September; numbers in parentheses are total estimated geese present on 2 September based on adjustments for estimates error and area covered. Estimate given for total of all 3 sub-areas includes 25,000 geese estimated migrating south out of the region on 12 September.
l	Numbers given are total estimated geese present on 13 September based on correction equation for estimation error (Oates et al. 1985)
m	Includes an estimated 30,000 geese between Stokes Point and Komakuk (Barry pers com)
n	confidence interval does not account for variation in estimates of flock sizes among observers during the aerail survey.

APPENDIX
ANWR Progress Report Number 86-10

Appendix Table 1. Counts of numbers of snow geese in flock photographs used to compute within and among observer variances, 1985, Arctic National Wildlife Refuge, Alaska.

Date	Flock	Observer 1		Observer 2		Observer 3	
	Number	Count 1	Count 2	Count 1	Count 2	Count 1	Count 2
31 August	7	1118	1077	1049	1083	1149	1062
	14	992	1065	1064	1058	1061	1051
	19	4355	4265	4236	4308	4412	4613
11 September	44	147	146	145	143	145	145
	71	192	191	193	192	193	196
	109	86	88	86	86	88	86
	176	1138	1144	1118	1121	1183	1154
	181	609	576	591	576	569	576
12 September	1	759	735	729	742	767	752
	3	80	79	79	79	76	80
	6	140	137	126	133	139	141
	10	1478	1475	1434	1459	1542	1600
	13	957	938	923	914	940	947
	14	214	213	211	213	215	213
	15	50	50	49	49	99	50

Appendix Table 2. Photographic count results used to assess accuracy and develop a correction equation for visual flock size estimates of snow geese, 31 August and September, 1985. Arctic National Wildlife Refuge, Alaska.

Date	Flock Number	Visual estimate (X)	Photo count[a] (Y)
August 31	5	300	451.33
	7	800	1089.67
	11	1100	1535.33
	14	550	1048.50
	15	1400	2957.33
	16	1150	2332.00
	19	1450	4352.83
	23	150	402.00
	27	600	774.00
	28	650	1350.33
	71	250	347.00
	72	600	476.00
11 September	13	60	87.00
	14	1000	2319.33
	44	85	145.17
	70	260	410.67
	71	120	193.33
	109	70	87.00
	119	450	1786.67
	133	350	631.33
	176	800	1143.00
	181	300	591.33
	187	500	838.00
	195	500	1223.00
12 September	1	500	747.33
	2	230	311.33
	3	50	78.83
	4	1100	2100.33
	5	70	124.33
	6	110	136.00
	7	300	457.00
	9	750	1643.67
	10	600	1498.00
	12	2525	4090.33
	13	300	936.50
	14	110	213.17
	15	35	49.50

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[a] Values represent means of counts by 3 observers.

Progress Report Number FY86-11

ECOLOGY OF LESSER SNOW GEESE STAGING ON THE COASTAL PLAIN OF THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, FALL 1985

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Robert M. Platte
John M. Morton
David Whiting

Key words: Snow goose, Anser caerulescens, Anseridae, energetics, food habits, body weight, time budgets, behavior, Arctic National Wildlife Refuge, body composition.

Arctic National Wildlife Refuge
U.S. Fish and Wildlife Service
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Ecology of lesser snow geese staging on the coastal plain of the Arctic National Wildlife Refuge, Alaska, fall 1985.

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Abstract: Feeding ecology, time budgets, and body composition of fall staging lesser snow geese (*Anser caerulescens caerulescens*) on the coastal plain of the Arctic National Wildlife Refuge (ANWR) were examined in 1984-1985. A total of 112 snow geese were collected for food habits and body composition analysis. Arriving geese consumed horsetails (*Equisetum variegatum*) (44.7% aggr. dry wt., n=35) and common cottongrass (*Eriophorum angustifolium*) (24.1% aggr. dry wt.). Departing geese fed heavily on common cottongrass (58.8% aggr dry wt., n=30). Hand picked cottongrass stem bases contained maintenance levels of crude protein (12%), high levels of total nonstructural carbohydrates (TNC, 16.3%) and low levels of crude fat (1.2%). Fiber (cellulose + lignin) made up 26.8% of the content. Estimates of true metabolizable energy for cottongrass was 7.49 kj/g. No significant differences were found in fat free dry weight (FFDW) or body measurements (wing, tarsus, bill) between geese collected during the arrival and departure phases of the staging period, indicating that little growth occurred in juveniles and little body protein was added by adults. Geese showed significant increases in body fat in both years. Adult males gained 21.5± 3.3 g fat/day (regression slope b± SE, n=24) and females gained 22.5± 2.7 g fat/day (n=24) in 1985. In juveniles, 10.6± 2.8 (n=17) and 11.7± 3.3 (n=11) g fat/day were added by males and females, respectively, in 1985. Adults accumulated fat at a significantly lower rate in 1984 due to a possible reduction in food intake at the end of the longer staging period. Arriving juveniles lacked sufficient fat reserves in both years to fuel a flight to central Alberta, the migration staging area. Time budget studies showed that adults fed less in the afternoon (46.8%) than in the early morning (58.8%) or evening (59.5%) and juveniles fed less in the afternoon (67.2%) than during the remainder of the day (75.1%-75.9%). Juveniles spent significantly more time feeding (11.7± 0.8 hrs/day, $P < 0.001$) than adults (8.1± 0.4 hrs/day).

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From late August through mid September of each year, snow geese from the Western Canadian Arctic Population (WCAP) stage on the Mackenzie river delta, the Yukon coastal plain, and the coastal plain of the Arctic National Wildlife Refuge (ANWR) in Alaska (Barry 1967, Koski and Gollop 1974, Koski 1975, Koski 1977a and b, Spindler 1983, Spindler 1984, Oates et al. 1985, Oates et al. 1987). In some years >300,000 geese, over half of the WCAP, use the coastal plain of ANWR for fall staging (Spindler 1983, Oates et al. 1987). During this period, the geese feed intensively and accumulate the fat reserves needed for migration (Patterson 1974, Wypkema and Ankney 1979). Body fat is the primary fuel for long distance flight in birds (Farrar 1966, West and Meng 1968, Child 1969, Berger and Hart 1974, Blem 1980), and the size of fat reserves are the major determinant of the potential distance an avian migrant can fly without stopping (Odum and Perkinson 1951, Odum et al. 1961, Nisbet et al. 1963, West and Meng 1968, Blem 1980). Breeding females nearly deplete their fat reserves during incubation (Ankney and MacInnes 1978), and increase their reserves only slightly during brood rearing due to the constraints of molt and parental alertness (Harwood 1977, Wypkema and Ankney 1979). Prior to the staging period, juvenile snow geese (goslings) commit most of their energy to growth and, during the brood rearing period, accumulate little body fat (Patterson 1974, Wypkema and Ankney 1979).

Snow geese which leave the autumn staging grounds with low body weights and low fat reserves stop more often during migration and may suffer higher mortality than those in better condition (Cooch 1958, Cooch et al. 1960, Barry 1967). Cooke et. al (1984) documented higher recruitment rates into the breeding population by early-hatching goslings despite higher fledging success by goslings hatched in the middle period (Cooke and Findlay 1982). Early hatching goslings had higher July weights and longer flight feathers than those hatching in the middle or late stages of the hatch period (Cooke et. al 1984). This higher recruitment rate for early-hatching goslings suggests that better physical condition during migration enhances survival during the critical first migration by juveniles. Lynch (1970) found higher indices of productivity (family group counts and percentages of juveniles) on the gulf coast (eastern arctic population) during late October and early November than in mid January, and lower productivity during late October and November has been found in the northern States and at James Bay (Prevett and MacInnes 1980). Family groups which migrated straight through to the gulf coast may have been in better physical condition and less likely to have interrupted migration for long periods to replenish body reserves (Ankney and MacInnes 1978). Such interruptions subject juveniles to higher mortality on the northern refuges where they are more easily separated from the adults in large flocks (Prevett and MacInnes 1980).

Proposed petroleum development on the coastal plain of ANWR may place human activity in direct conflict with the requirements of staging snow geese and affect the ability of the geese to obtain adequate fat reserves. The present lack of information on behavior and resource needs of the population make the prediction of impacts from such development only speculative. Basic life history information during the fall staging period is necessary to evaluate the effects of disturbance, habitat loss, or displacement of the geese from staging areas. This study was begun in 1984 to provide some of the information needed to predict the effects of these impacts. The objectives of the study were:

1) Quantify the normal daily activity patterns of staging snow geese.

2) Determine the types of foods consumed.

3) Quantify the changes in body weight, and lipid levels during the staging period on ANWR.

4) Determine the nutritional quality of foods ingested.

Methods

Data on nutrition, diet and body composition were obtained through the collection, by shotgun, of 112 snow geese during the arrival and departure phases of the staging period. Collection dates of geese arriving on the refuge were similar in 1984 (30-31 August) and 1985 (26-28 August). Five geese were also collected during the interim period. During the longer 1984 staging period, the collection of geese just prior to departure from the refuge took place on 21-23 September. Because poor weather shortened the 1985 staging period, departing geese were collected on 11-13 September. Collection sites included both coastal and inland locations (Fig. 1).

Immediately after the geese were shot, specimens were aged by plumage characteristics (Bellrose 1980) and sexed by cloacal examination (Hanson 1967). Esophageal and proventricular contents were removed and stored in separate whirlpacks in 1984. Because no differences were detected in food contents between these organs in 1984, samples were combined in 1985. The fresh weight of the geese were taken in the field to the nearest 25 g with a spring scale and all specimens and samples were stored in a cool place, generally for less than 1 day, until they could be transported to Barter Island and frozen.

Body Composition

All geese were shipped to Fairbanks where specimens were partially thawed. Food contents were removed from the gizzard, small intestine, and large intestine, weighed separately and combined by organ within sex/age classes and collection period. Feathers were removed prior to composition analysis. Whole body composition analysis was performed on the carcasses by Hazelton Laboratories, Madison, Wisc. in 1984 and A & L Midwest Agricultural Lab, Omaha, Neb. in 1985. Whole carcasses were partially thawed, chopped into small pieces and finely ground. Duplicate samples of finely mixed homogenate from each carcass were assayed for percent water, lipid, protein, and ash (Horwitz 1975). Lipids were extracted in a soxhlet petroleum ether extractor on samples dried overnight with a mixture of 3-4x their weight in anhydrous sodium sulfate. Percent nitrogen was determined with the Kjeldahl method (Horwitz 1975) and multiplied by 6.25 to obtain crude protein estimates. Caloric content of duplicate samples were measured by bomb-calorimetry. We weighed the geese in the laboratory to the nearest 0.1 g before and after intestinal contents removal, feather shearing, and before whole body analysis to track weight changes.

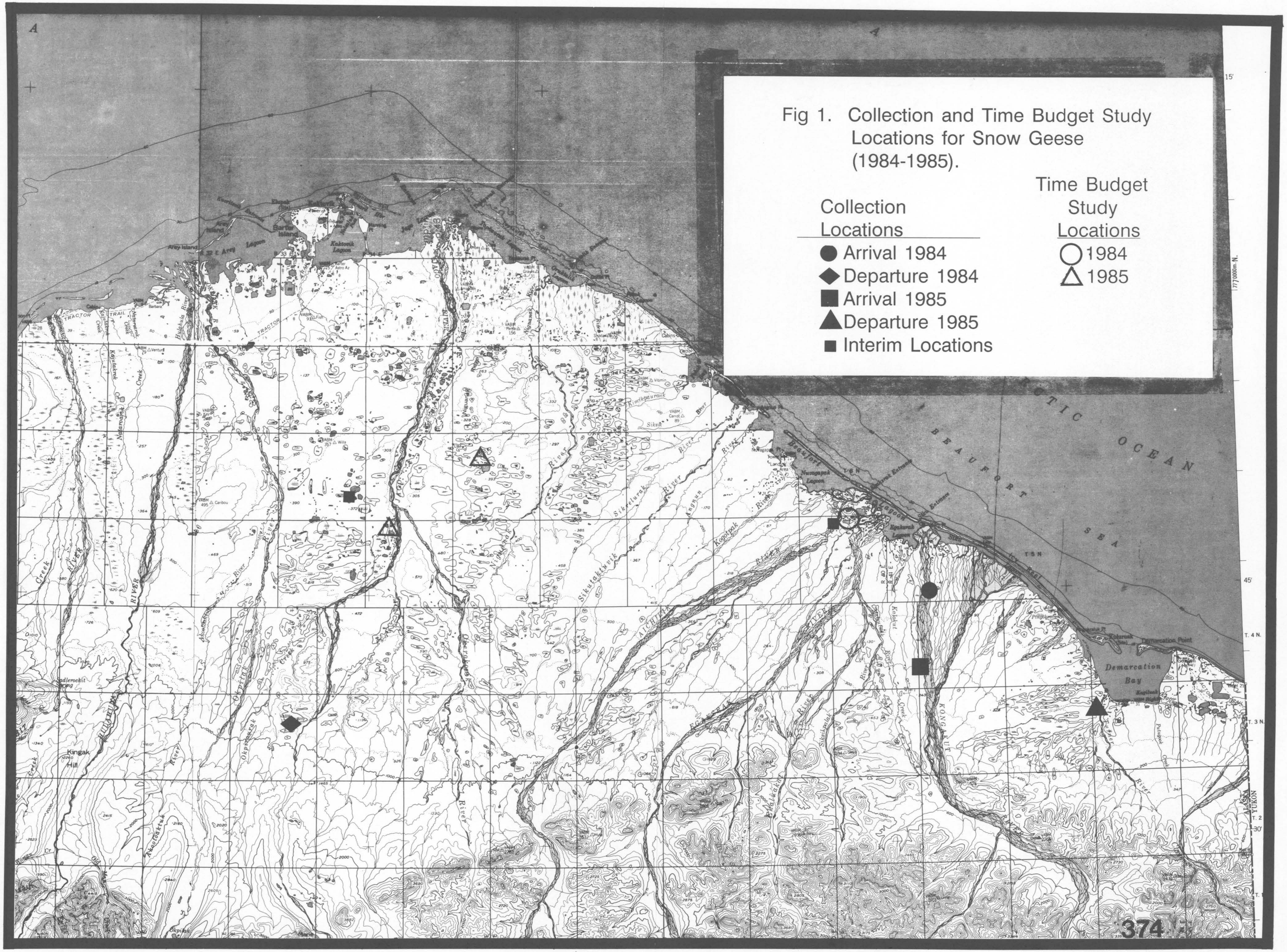

Fig 1. Collection and Time Budget Study Locations for Snow Geese (1984-1985).

Diet and Nutrition

Identifiable food items in the esophagus and proventriculus of each goose were sorted by species and plant part (leaves, shoots, or stem base) counted and weighed wet. Average dry weight for each species was applied to the sample and the % aggregate dry weight (% dry weight of each plant species per goose averaged over the sample) and % of geese containing a specific plant species (Swanson et al. 1974, Prevett et al. 1979) were calculated. Geese with < 0.05 g of dry matter were deleted from the sample. Identification of plant parts were made with the aid of Hulten (1968) and a reference collection. The material was then combined, as in the intestinal contents. The Alaska Agricultural Extension Laboratory, Palmer, performed nutritional analysis on triplicate intestinal samples for percent moisture, acid detergent fiber (ADF), lignin, cellulose, and ash (Van Soest 1963). Caloric density was measured for the esophageal and proventricular contents and large intestine contents with a bomb-calorimeter. Also, 4 samples of the major food items and 12 samples of droppings were collected for additional analysis of moisture, lignin, cellulose, crude protein, crude fat, total nonstructural carbohydrates, ash, and caloric density (Horwitz 1975, Van Soest 1963).

Apparent metabolizable energy (AME) value of snow goose foods were estimated from gross energy (GE) values of the hand-picked food samples, esophageal contents, and droppings. Cellulose was used as an indigestible marker (Almquist and Halloran 1971) to determine energy digestibility. AME values were calculated from the formula of Sibbald et al. (1960):

$$AME_{g\ food} = GE_{g\ food} - [(\%\ marker_{food}/\%\ marker_{excreta})\ GE_{exreta}]$$

Time Budgets

Time budgets of staging geese were quantified during the staging period (1-20 September 1984-85) at 1 coastal and 2 inland sites (Fig. 1.). Observations of individual geese in flocks were made during daylight hours. An observer randomly selected an individual bird and recorded its behavior at 15 sec intervals, timed by a metronome (Wiens et al. 1970). Behavior was classified into 1 of 3 primary activities (sitting, standing, or walking, Frederick and Klaas 1982); and one of 10 secondary behaviors (feeding, drinking, loafing, preening, calling, comfort movements, social interaction, alert, walking, and resting). For purposes of data analysis, feeding behavior while standing (head down posture) was termed "grubbing" as the geese were in the act of removing and ingesting roots and the lower stems of vegetation (Bolen and Rylander 1978). Since little ingestion occurred when the geese were walking in the head-down posture, this behavior was designated "searching". Comfort movement behavior (McKinney 1965) was combined with preening behavior for analysis, and drinking, which occurred less than 0.001% of the time, was combined with feeding. Resting was defined as any sitting or standing posture with the bill tucked under the wing, and loafing was regarded as any sitting or standing posture not involving resting, alert, feeding, preening, or social interaction (calling, aggression, or social displays).The percentage of time spent flying was estimated with the instantaneous scan method (Altmann 1974). At a minimum of 3 minute intervals, the number of geese in a flock were estimated, the flock was quickly scanned and the number of flying individuals were counted.

The temperature, ground cover, fog, wind direction, wind speed, and time of day was recorded for each time budget record. Temperature was measured with a hand-held mercury thermometer at ground level, and wind speed was measured with a Sims anemometer at a height of 1.5 m above ground.

Statistical Analysis

Statistical tests of mean differences were confined to 2-sample t-tests (Snedecor and Cochran 1967). Linear regression was used for the comparison of the rate of fat gain by geese between years, collection periods and age/sex classes. For proportional data, weighted means and standard deviations are reported in all instances. All intervals reported in the text are given as the mean ± 1 standard deviation.

Results

Diet

A total of 65 of 112 geese (58%) collected during the study contained sufficient material in the esophagus and/or proventriculus for analysis(Table 1).

Table 1. Foods consumed by fall staging snow geese, Arctic National Wildlife Refuge, 1984-1985.

	Arrival Period (35)[a][b]		Departure Period (30)[a]	
Plant species	Aggr. % dry wt	% Geese	Aggr. % dry wt	% Geese
Water sedge (*Carex aquatilis*)	2.1	2.9	0	0
Sedge spp. (Cyperaceae)	1.5	11.4	4.9	10.0
Horsetails	44.7	57.1	10.2	16.7
Common cottongrass	24.1	40.0	58.8	66.7
Cottongrass spp. (*Eriophorum* spp.)	0	0	7.9	13.3
Grass (Gramineae)	2.9	2.9	0.4	3.3
Misc. Vegetation	24.8	40.0	19.2	30.3

[a] Sample size in parenthesis

[b] Also includes 2 geese collected on 3 September 1985.

Arriving geese shot in late August had primarily consumed the green shoots of horsetail and smaller quantities of the stem base and lower stems of common cottongrass. Common cottongrass has a large bulb-like storage structure (stem base) immediately below ground level at the lower end of the shoot (Chapin et al.1980) which was the preferred portion of the plant. Departing geese had eaten large quantities common cottongrass stem bases, although some geese (16.7%) had taken horsetail shoots in smaller quantities. Water sedge comprised only 2.1% and 0% aggr. dry wt of the sample of arriving and departing geese, respectively. Food selections were consistent across inland and coastal sites.

Nutrition

Cottongrass, taken from hand collected samples, contained a maintenance level of crude protein (12.0%), high levels of total nonstructural carbohydrate (TNC) (16.3%) and low levels of fat (1.2%) (Table 2). Total dry matter digestibility of the forage (the sum of crude protein, fat, and TNC) was 29.5% . Digestibility may have actually been lower due to high levels of cellulose (16.7%) and lignin (10.1%) in the samples. Horsetails contained similar fiber but much higher ash levels (17.2%) than cottongrass (3.8-4.2%), and lower moisture levels (69.8%) than cottongrass (82.7%). Water sedge contained lower crude protein (10.3%) and TNC (10.7%) than cottongrass.

Table 2. Nutrient content of foods consumed by fall staging snow geese, Arctic National Wildlife Refuge, Alaska, 1985

		% Dry Matter						
Food	N	Crude Protein	TNC	Crude Fat	Cellulose	Lignin	Ash	% Water
Hand-picked samples								
Common cottongrass	6	12.0	16.3	1.2	16.7	10.1	3.8	82.7[a]
Water Sedge	2	10.3	10.7	1.1	23.3	5.2	2.7	75.9
Esophageal samples[b]								
Common cottongrass	8	--	--	--	15.4	8.6	4.2	81.2
Horsetail	6	--	--	--	17.6	5.6	17.2	69.8

[a] 4 samples.
[b] Included minor portions of other plant species.

Metabolizable Energy

Gross energy values (Table 3) were similar between droppings and large intestine contents. Hand collected food samples were slightly lower in gross energy than those taken from the esophagi of the geese. Although lignin, which is relatively indigestible (Crawford 1981), was also assayed, cellulose proved to be a more dependable marker, most likely because several lignin estimates were below the minimum accurate concentration (6.0%) for a marker (Van Soest 1982). Cellulose is not subject to cecal digestion in Anser anser (Mattocks 1971) and has been used as an indigestible marker in several species of geese (Cargill and Jefferies 1984, Ebbinge et al. 1975, Marriott and Forbes 1970). However, Buschbaum et al. (1986) measured non-cecal cellulose and hemicellulose digestion amounting to 28% and 25%, respectively, in Canada geese and brant. In this study, the cellulose to lignin ratios in the organic matter were similar between esophageal (2.50:1), hand-picked cottongrass samples (2.50:1), droppings (2.33:1), and large intestine contents (2:50:1). Ratios in geese which had consumed horsetails were also similar in cellulose:lignin ratios in esophageal (3.13:1) and large intestine (3.59:1) samples. These ratios suggest that the geese did not digestion cellulose.

Estimated AME values were 6.39 ± 0.12 (mean ± SD) for handpicked cottongrass and 7.34 ± 0.06 for esophageal samples used as the feed and droppings used as the excreta. Large intestine contents did not provide reliable estimates because of the presence of endogenous matter in the material stripped from the gut. The energy digestibility coefficient was 43.7%. Since metabolic fecal energy and endogenous urinary energy approach 3% of True metabolizable energy (TME) at high intake rates (Miller and Reinecke 1984), the AME value (7.34 Kj/g) was multiplied by 1.03 to derive a TME estimate of 7.49 Kj/g. This produced a mean energy digestibility coefficient of 44.7%.

Table 3. Gross energy (kj/g) of food and excreta samples used to estimate apparent metabolizable energy values.

	Year			
	1984		1985	
Source	Arrival	Departure	Arrival	Departure
Food				
Hand-picked	--	--	--	16.68[a]
Esophagus	9.67[b]	15.74[a]	13.30[c]	16.80[a]
Excreta				
Large intestine	15.44	16.23	15.80	16.06
Droppings	-	-	-	15.51[d]

[a] Primarily common cottongrass
[b] Mixed horsetail and common cottongrass
[c] Primarily horsetail
[d] Common cottongrass samples and droppings collected in the interim period between arrival and departure

These AME and TME estimates are within the range of values found for other natural waterfowl foods. Burton et al. (1979) estimated an AME value of 5.98 Kj/g for bulrush (Scirpus americanus) rhizomes in snow geese. AME of natural plant foods assayed by Sugden (1973) in blue-winged teal (Anas discors) ranged from 6.94 Kj/g to 11.25 Kj/g, and TME of 5 plant foods (seeds) assayed in mallards by Hoffman and Bookhout (1985) varied from 4.1 to 12.8 Kj/g.

Body Composition

Both adult and juvenile snow geese showed significant weight gains between arrival and departure collection periods in each year of the study (Table 4). The weights of arriving geese were higher in 1984 then 1985, possibly due to water in the plumage of a number of birds as well as higher but non-significant differences in other body components. Plumage weights of geese taken in 1984 were erratic and higher than in 1985.

Growth of juvenile snow geese during the fall staging period has been suggested by for the WCAP (Patterson 1974) and for the Eastern Canadian Arctic Population at James Bay (Wypkema and Ankney 1979). Those studies relied on body measurements. Since real growth would involve an increase in bone and muscle or other protein rich organs, fat free dry weight (FFDW, Odum et al. 1964) were examined as an indicator of growth (Table 5), where FFDW = PBW - Fat - body water, and PBW was the body weight of the geese with feathers and intestinal contents removed.

Table 4. Weights (g) of snow geese collected during fall staging on the Arctic National Wildlife Refuge, Alaska, Aug. - Sept. 1984 & 1985.

		Staging Period			
Age/sex	Year	Arrival	N	Departure	N
Adult male	1984	2507 ± 123[a]	7	3004 ± 226*[b]	4
	1985	2428 ± 154	10	2705 ± 205*	14
Adult female	1984	2282 ± 91	3	2762 ± 340*	4
	1985	2141 ± 165	14	2437 ± 203*	10
Juvenile male	1984	2104 ± 101	4	2484 ± 149*	8
	1985	1915 ± 201	10	2187 ± 252*	7
Juvenile female	1984	---	0	2324 ± 105	6
	1985	1793 ± 128	7	1976 ± 167*	4

[a] Mean ± Sd (g), weights are of thawed geese with emptied intestinal tracts

[b] * Significantly different from preceding value ($P < 0.05$)

No significant differences ($P > 0.05$) were detect in FFDW between the arrival and departure periods in any age/sex class for 1984 or 1985. Juvenile males in 1985 had significantly higher body protein content ($P < 0.01$) in the departure period, with means of 370.58± 33.2 g protein (n=10) and 423.8± 33.7 g protein (n = 7) in the arrival and departure periods, respectively. Despite the difference, FFDW in juvenile males was not significantly different ($P > 0.1$) between collection periods.

Table 5. Fat free dry weights (g) of snow geese collected during fall staging on the Arctic National Wildlife Refuge, Alaska, Aug.-Sept. 1984-1985.

		Staging Period			
Age/sex	Year	Arrival	N	Departure	N
Adult male	1984	532.8 ± 34.3[a]	7	572.0 ± 39.5	3
	1985	589.4 ± 69.8	10	574.5 ± 62.0	14
Adult female	1984	478.7 ± 22.4	3	559.7 ± 68.9	3
	1985	491.0 ± 42.7	14	489.1 ± 46.4	10
Juvenile male	1984	461.9 ± 37.2	4	457.6 ± 27.9	8
	1985	457.0 ± 41.9	10	490.1 ± 36.8	7
Juvenile female	1984	---	0	417.4 ± 27.5	6
	1985	434.4 ± 38.5	7	453.5 ± 51.9	4

[a] Mean ± Sd (g)

As an additional test for growth, the bill, tarsus, and flattened wing (Pettingill 1970) were measured in the 1985 geese (Table 6). Only bill length in juvenile males was significantly different between collection periods. Therefore, no evidence of growth in juveniles nor an increase in body protein content in breeding females were found.

Table 6. Body measurements of fall staging snow geese collected on the Arctic National Wildlife Refuge, Aug.-Sept. 1985.

Age/sex	Collection Period	N	Length Bill (mm)	 Tarsus (mm)	 Wing (mm)
Adult males	Arrival	10	57 ± 1[a]	89 ± 5	422 ± 10
	Departure	4	56 ± 3	86 ± 2	432 ± 13
Adult females	Arrival	14	54 ± 2	85 ± 5	409 ± 14
	Departure	10	55 ± 2	83 ± 3	407 ± 8
Juvenile males	Arrival	10	52 ± 3[b]	87 ± 5	394 ± 14
	Departure	7	55 ± 3	87 ± 5	403 ± 8
Juvenile females	Arrival	6	49 ± 2	84 ± 4	383 ± 16
	Departure	4	52 ± 1	81 ± 3	387 ± 7

[a] Mean ± Sd

[b] Significantly different ($P < 0.05$) from next lower value.

Fat reserves: A substantial portion of the weight gain by the fall staging snow geese came from fat storage. All age and sex classes increased their total body fat content significantly (Table 7). In 1985, mean body fat in departing adults was 217% and 252% of those in arriving females and males, respectively. Juvenile males and females increased body fat by 270% and 240%, respectively, in 1985. In the longer 1984 staging period, departing adults contained 243% and 252% more fat than arriving adult males and females, respectively. Mean fat weight of departing juvenile males was 450% of that in arriving males, although arriving juvenile males in 1984 contained only 70% of the fat weight of those in 1985. Body fat weights were highly variable in arriving geese (CV range = 30.2% - 73.6%) but less variable in departing geese (CV range = 6.4% - 38.1%). Thus, geese with low fat reserves probably accumulated more fat during the staging period than those in better condition.

Table 7. Mean weights (g) of body fat in snow geese collected during fall staging on the Arctic National Wildlife Refuge, Alaska, Aug.-Sept. 1984-1985.

Age/sex	Year	Staging Period Arrival	 N	 Departure	 N
Adult male	1984	258.7 ± 104.8[a]	7	652.8 ± 41.9*[b]	3
	1985	239.4 ± 101.8	10	594.1 ± 93.1**	14
Adult female	1984	242.8 ± 178.8	3	587.0 ± 21.3*	3
	1985	250.7 ± 124.6	14	558.9 ± 119.4**	10
Juvenile male	1984	98.5 ± 46.3	4	443.8 ± 47.8**	8
	1985	141.0 ± 56.3	10	320.1 ± 126.7**	7
Juvenile female	1984	---	0	411.8 ± 70.8	6
	1985	131.4 ± 39.7	7	316.0 ± 120.5*	4

[a] mean ± SD (g)

[b] Significantly different than the preceding value, *($P < 0.05$), **($P < 0.01$)

Lipid indices (fat wt/FFDW x100)6 (Blem 1980, Johnson et al. 1985) allowed an examination of changes in body fat reserves independent of differences in body size between individuals and age/sex classes (Table 8). Indices in arriving adults were less than half those of departing adults and relatively constant between years and sexes. Arriving juveniles had much lower lipid indices than arriving adult and lower indices during the departure period in 1985 than in the longer staging year of 1984. Adult indices were similar between years in both collection periods.

Table 8. Lipid indices[a] of snow geese collected during fall staging on the Arctic National Wildlife Refuge, Alaska, Aug.-Sept. 1984-85.

		Staging Period			
Age/sex	Year	Arrival	N	Departure	N
Adult male	1984	49.6 ± 7.5	7	114.1 ± 5.8	3
	1985	40.6 ± 5.2	10	103.4 ± 5.3	14
Adult female	1984	50.7 ± 18.4	3	105.0 ± 5.2	3
	1985	51.1 ± 6.4	14	114.3 ± 7.5	10
Juvenile male	1984	21.3 ± 39.7	4	97.0 ± 3.5	8
	1985	30.9 ± 5.7	10	65.3 ± 8.8	7
Juvenile female	1984	-----		98.7 ± 5.3	6
	1985	30.2 ± 2.7	7	69.8 ± 9.5	4

[a] (Fat wt/FFDW)x100

A daily rate of fat storage was estimated by linear regression for each age/sex class by year (Table 9). The regression slopes were significantly higher in 1985 than 1984 (P < 0.01) in adults but not in juveniles. Adults had either added fat at a higher rate in 1985 or reduced their food intake at the end of the longer 1984 staging period. In 1985, adults deposited fat at a significantly higher rate (P < 0.01) than juveniles. The slopes were similar in 1984 when arriving juvenile males were substantially lighter than those taken in 1985. The lower rate of daily fat gain by juveniles may have been due to their lower feeding efficiency and added energy expenditures (this study).

Table 9. Snow goose body fat weight (g) at the start of fall staging, and rate of daily fat accumulation (g/day) estimated by linear regression, Arctic National Wildlife Refuge, Alaska, 1984-1985.

	Year							
	1984				1985			
Age/sex	Starting Weight	Rate	R^2	N	Starting Weight	Rate	R^2	N
Adult males	234.5	16.6	0.821	11	185.6	22.5[a]	0.883	24
Adult females	192.0	15.1	0.728	7	191.9	21.5[a]	0.662	24
Juvenile males	71.6	14.6	0.948	12	118.0	10.6	0.486	17
Juvenile females	---	---	---		107.4	11.7	0.577	11

[a] Regression slope significantly higher than 1985 value (P < 0.01)

Theoretical Flight Range

The utility of the fat content of arriving and departing geese were compared through the calculation of theoretical flight ranges for each collection period each year (Table 10). Body weights (Table 4) for 1985 were used in the estimation of BMR (Aschoff and Pohl 1970) and a value of 11.0(BMR) was used as an estimate of flight cost. BMR was calculated for each hour of flight from body weights readjusted for the loss of dry fat weight based on an 80% conversion efficiency of fat. Minimum possible fat content was estimated as 2% of FFDW and flight speed was set at 70 km/hr (Wege and Raveling 1984).

Table 10. Maximum theoretical flight range (km) of fall staging snow geese by staging period based on mean dry weights of body fat.

		Staging Period	
Age/sex	Year	Arrival	Departure
Adult male	1984	3241[a]	7699
	1985	3038	7559
Adult female	1984	3269	7335
	1985	3554	7726
Juvenile male	1984	1297	5899
	1985	2075	4560
Juvenile female	1984	---	5746
	1985	2073	4904

[a]Maximum flight range (km)

Estimated flight ranges of arriving juvenile snow geese were not sufficient to allow a sustained flight to migratory staging areas in central Alberta, a distance of 2100-2400 Km. Flight ranges of arriving juveniles were sufficient to allow nonstop flight to the Hays river, Northwest Territories, a minor migration stopping area (Bellrose 1980). Because 2% body fat, an extreme depletion of fat reserves, represents depletion down to structural levels (Odum et al. 1964), geese are likely to stop in migration before they reach that level.

Time budgets

Behavioral observations were taken on 429 individual snow geese for a total of 11,006 instantaneous scans (45.9 hrs of observation time). Because the observation times averaged only 25.7 scans/goose (6.4 min), scans were pooled by age class within 4 time blocks on each day of observation. The time blocks were 0500-0859 hrs (early morning), 0900-1259 hrs (late morning), 1300-1659 hrs (afternoon), and 1700-2059 hrs (evening).

The time budget estimates in this study are based on the assumption, that geese did not feed at night. Continuous cloud cover prevented the use of a night scope. Nocturnal feeding has been documented in other species of geese (Howard 1940, Boyd 1955, Owen 1972) and in lesser snow geese on the Frazier River delta, British Columbia (Burton and Hudson 1978), when food availability was controlled by tidal movements. Snow geese at DeSoto Bend in the fall of 1976-1977 spent the night hours roosting on a lake (Frederick and Klaas 1982). On the ANWR, we observed snow geese coming into lakes after dark and leaving the vicinity of nearby lakes in the early morning. Feeding activity at night should have been evident in the amount of material in the digestive tracts of geese collected in the early morning. However, X^2 tests showed that the number of snow geese collected in 1985 with empty intestinal tracts was significantly higher than expected in the early morning (Table 11) and significantly lower in the afternoon. Likewise, significantly fewer than expected had full intestinal tracts in the morning and a greater proportion than expected had full tracts in the evening (0500-0700 hrs). If the geese had fed continuously through the night, there should have been food in the intestinal tract of the 13 geese collected in the early morning. Ten of these geese (77%) had empty intestinal tracts and had not fed for at least 2 hours prior to being shot. Had the geese fed in a manner similar to their daytime feeding pattern, a higher proportion would have had partially filled tracts.

Table 11. Observed and expected number of collected snow geese possessing full, empty, or partially filled intestinal tracts, Arctic National Wildlife Refuge, Alaska, August-September 1985.

	Time of Day								
	0500-0700h			0701-1000h			1200-2100h		
Gut Fill[a]	Obs	Exp	(X^2)	Obs	Exp	(X^2)	Obs	Exp	(X^2)
Empty	10	2.9	(17.3)[bc]	6	6.7	(0.1)	1	6.7	(4.9)[c]
Partially Filled	3	5.0	(0.8)	18	11.8	(3.2)	8	12.2	(1.4)
Full	0	5.1	(5.1)[c]	7	11.8	(2.0)	23	12.6	(8.5)[c]

[a] Empty tracts defined < 20 g wet weight;
Full > 100 g, and partially filled 20-100 g in the small intestine

[b] Chi-square value in parenthesis, total Chi-square = 43.3, df = 8, $P < 0.005$

[c] Significantly different ($P < 0.05$, df = 1)

Both age classes showed a diurnal pattern of significantly more ($P < 0.01$) feeding (grubbing + searching behavior) during the early morning and evening, and significantly less feeding and increased resting and preening behavior in the afternoon (Table 12 and 13). The diurnal pattern of juveniles varied less than adults. In juveniles, significantly less time was spent grubbing in late morning and less time was spent searching in the afternoon than other time periods. Loafing, resting, and preening also occupied significantly more time in the afternoon. Juvenile geese fed 75.7%± 3.4 of the early morning, 75.1%± 4.7 of the late morning, 67.2%± 4.2 of the afternoon and 75.9%± 7.8 of the evening hours.

In adults, resting occupied significantly more time in the afternoon than other periods and more time in the late morning than during early morning or evening (Table 13). Searching activity was higher in the early morning and loafing was more prevalent in the late morning. Adult geese preened less in the early morning and evening than in the midday hours. Total feeding time averaged 58.8%± 7.3, 48.3%± 3.4, 46.8%± 3.5 and 59.5%± 5.0 from early morning to evening time blocks.

As a flock behavior, flying time was not separated between age classes. Snow geese flew an average of 0.94 h per day (Table 13) with significantly more flying time in the early morning (10.3%) when geese were flying out of roosts to feeding sites, than in the late morning (3.6%), the afternoon (5.5%) or the evening (6.2%).

Table 12. Percentage of time (mean ± Sd) juvenile snow geese spent in various activities, by 4-hour time block, Arctic National Wildlife Refuge, Alaska, fall 1984-1985

	Time of Day (N)			
Behavior	0500-0859(5)	0900-1259(10)	1300-1659(9)	1700-2059(6)
Resting	2.6 ± 2.2	4.7 ± 1.9	8.0 ± 2.5[ab]	0.1 ± 0.4[c]
Preening	2.3 ± 0.7	4.4 ± 2.2	7.5 ± 1.5	5.7 ± 1.5[ac]
Alert	0.9 ± 0.5	1.6 ± 0.6[a]	3.0 ± 0.7	2.0 ± 0.1
Grubbing	47.2 ± 2.3	44.0 ± 2.6[a]	53.1 ± 2.6[b]	50.6 ± 5.1[b]
Searching	28.5 ± 2.5	31.2 ± 3.9	14.1 ± 3.3	25.3 ± 5.9[c]
Loafing	1.4 ± 0.6	1.5 ± 0.3	2.5 ± 0.4[b]	1.3 ± 0.4[c]
Social	0	0.4 ± 0.2	0.1 ± 0.0	0
Walking	6.4 ± 1.7	7.7 ± 2.3	6.2 ± 1.2	8.8 ± 2.6
Flying	10.3 ± 2.0	3.6 ± 0.7[a]	5.5 ± 1.3[a]	6.2 ± 4.4[b]

[a] Significantly different (P < 0.01) than value in first column
[b] Significantly different (P < 0.01) than value in second column
[c] Significantly different (P < 0.01) than value in third column

Table 13. Percentage of time (mean ± SD) adult snow geese spent in various activities, by 4-hour time block, Arctic National Wildlife Refuge, Alaska, fall 1984-1985.

	Time of Day (N)			
Behavior	0500-0859(6)	0900-1259(12)	1300-1659(9)	1700-2059(8)
Resting	7.5 ± 3.9	12.9 ± 2.7[a]	16.4 ± 3.5[ab]	6.3 ± 2.8[bc]
Preening	2.8 ± 2.5	9.7 ± 1.5[a]	10.2 ± 2.8[a]	5.4 ± 1.2[bc]
Alert	13.7 ± 6.1	16.5 ± 2.2	13.7 ± 2.1	12.8 ± 3.6
Grubbing	40.9 ± 6.3	38.1 ± 2.5	38.0 ± 3.2	48.9 ± 4.6[abc]
Searching	17.9 ± 3.6	10.1 ± 2.3[a]	8.9 ± 1.4[a]	10.6 ± 2.0[a]
Loafing	2.0 ± 0.7	3.4 ± 0.4[a]	2.5 ± 0.7	2.1 ± 0.7[b]
Social	0.6 ± 0.2	0.7 ± 0.3	0.2 ± 0.1[ab]	0.9 ± 0.3[c]
Walking	4.2 ± 0.6	5.3 ± 1.0	4.6 ± 1.0	6.7 ± 0.7[abc]
Flying	10.3 ± 2.0	3.6 ± 0.7[a]	5.5 ± 1.3[a]	6.2 ± 4.4[b]

[a] Significantly different (P < 0.01) than value in first column
[b] Significantly different (P < 0.01) than value in second column
[c] Significantly different (P < 0.01) than value in third column

In order to compare juvenile and adult time budgets over the entire day, weighted percentages were converted to hours (Table 14). Juveniles spent significantly more time grubbing for food, searching for food, and walking than adults. Juveniles also spent significantly less time resting, preening, loafing, alert, and in social interactions than adults. Total feeding time in juveniles (11.7± 0.8 hrs/day) was

3.6 hours more than adults (8.1± 0.4 hrs/day). Juveniles spent 1.6 hours more per day extracting food (grubbing) and 2.1 hours more per day searching for food than adults. Searching occupied 33.2% of total feeding time in juveniles compared to only 22.6% in adults.

Table 14. Estimated number of hours per day spent by fall staging snow geese in various activities, Arctic National Wildlife Refuge, Alaska, 1984-1985.

	Age Class			
	Adults		Juveniles	
Behavior	mean	Sd	mean	Sd
Resting (daytime)[a]	1.85*[b]	0.28	0.73	0.19
Preening	1.23*	0.19	0.81	0.15
Alert	2.31*	0.27	0.35	0.06
Grubbing (feeding)	6.51*	0.33	7.83	0.27
Searching (feeding)	1.83*	0.21	3.89	0.37
Loafing	0.42*	0.05	0.28	0.04
Social Interaction	0.09*	0.02	0.02	0.01
Walking	0.82*	0.08	1.13	0.16
Flying	0.94	0.20	0.94	0.20
Nighttime Roosting[c]	8.00	--	8.00	--

[a] Number of observation periods: Adults = 35, Juveniles = 30

[b] * Significantly different than adjacent mean ($P < 0.01$)

[c] Assumed activity during hours of darkness

Discussion

The diet of snow geese on the refuge coastal plain was highly monotypic and not closely related to availability. In 67 vegetative cover plots sampled on the ANWR staging area by others (Walker et al. 1983, Burgess 1984, Felix et al. 1987), common cottongrass was similar to Carex sp. (species other than water sedge) in abundance (percent cover) but only 9-67% of the cover value of water sedge in most habitats. The highly selective preference of snow geese for common cottongrass may have been due to energy or nutrient gain in relation to handling time (Krebs and Cowie 1976), or to unpalatability of other foods from tannins, alkaloids, phenolics, terpenoids or high silicon content (Swain 1977, Westoby 1978, Rosenthal and Janzen 1979, Buschbaum et al. 1984).

The reliance of fall staging snow geese on cottongrass may have a far reaching influence on their distribution during the staging period. Aerial surveys over the last 12 years have shown high annual variability in the numbers of geese using the refuge coastal plain, and irregular patterns of use within any one area (Oates et al. 1987). Because geese feeding on common cottongrass remove the entire plant, food stocks may be depleted in heavily used areas and may not be renewable on an annual basis; a hypothesis that may explain the lack of consistent use of specific locations by geese. Cottongrass shoots may live 5-7 years (Chapin et al. 1980), but the period required for replacement of removed plants is unknown. Thomas and Prevett (1980) hypothesized that because geese have excellent visual discrimination in the green portion of the spectrum (Kear 1964), they may detect zones of underground bulbs from the air by the green shade of the surface leaves. Geese traversing the north slope to the west may be capable of detecting food abundance and competition for that food from the air and may overfly less desirable foraging areas. Therefore, the number of geese which reach the outer edge of the staging grounds (ANWR) may be a reflection of both population size and food abundance to the east.

Time budgets showed that the geese spend the majority of the daylight hours feeding, and that juveniles may have maximized the amount of time they fed. Juveniles foraged longer, but gained less weight, and were apparently less efficient at locating and extracting cottongrass stem bases than adults. Most cottongrass plants without flower heads superficially resemble Carex sp.. Thus, cottongrass may have been difficult to recognize for the inexperienced juveniles. Also, the smaller juveniles may have been less able to exert the strong pulling action required to remove the underground stem bases. Despite inefficient foraging, juvenile snow geese increased their fat reserves by 3 to 4 fold during the staging period. A shorter staging period in 1985 resulted in lower but adequate fat reserves in juveniles, an indication that factors which decrease the total feeding time available to juveniles, such as early winter storms or aircraft disturbance, may reduce fat accumulation below adequate levels. Other factors such as frozen ground, and early or late breeding seasons may also affect final premigratory fat reserves.

Snow geese arriving on the coastal plain used highly nutritious food sources that allowed a high level of feeding efficiency and fat gain. The assessment, prevention or mitigation of impacts on snow geese staging on the ANWR coastal plain will require a thorough knowledge of their habitat needs and other factors which affect the distribution of geese during staging. Information on food preferences through the comparison of food selection and availability are needed as a first step in understanding habitat use by geese on the coastal plain. In conjunction with food preference, variability, both spatially and temporally, in nutrient quality of available forage needs investigating if habitat use and annual distribution are to be understood. Other factors which affect the distribution of geese during staging such as weather or the number of juveniles in the population need investigating.

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DISTRIBUTION AND RELATIVE ABUNDANCE OF GOLDEN EAGLES IN RELATION TO THE PORCUPINE CARIBOU HERD DURING CALVING AND POST-CALVING PERIODS, 1985.

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Key words: golden eagles, distribution, abundance, predation, caribou, Alaska, north slope, Arctic-Beaufort

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Distribution and relative abundance of golden eagles in relation to the Porcupine caribou herd during calving and post-calving periods, 1985.

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Abstract: Distribution and abundance of golden eagles (*Aquila chrysaetos*) in relation to calving and post-calving activities of the Porcupine caribou (*Rangifer tarandus*) herd were documented by compiling records of incidental observations made by various field personnel. The status of golden eagle production at nest sites adjacent to caribou calving and post-calving areas was determined by aerial and ground surveys. A total of 336 observations (400 eagles) were recorded between 7 April and 26 September 1985. The ratio of sub-adults to adults was 3.4:1 for those observations when age was determined (n=240). Sixty-eight percent of recorded observations were made in areas of current or recent caribou occupation. Golden eagles were observed either feeding or perched at caribou calf carcasses on 15 (4.5%) occasions and were at adult caribou carcasses on 8 (2.4%) occasions. Necropsy investigations confirmed that predation by golden eagles was most probable cause of death in 9 of 25 calf carcasses examined. Concentrations of golden eagles in caribou areas occurred during the late calving (13-19 June) and post-calving (20-30 June) periods when 8.1 and 12.4 eagles sightings/24 h occurred. Only 1 out of 10 eagle nest sites adjacent to caribou calving and post-calving areas produced young in 1985.

Distribution and relative abundance of golden eagles in relation to the Porcupine caribou herd during calving and post-calving periods, 1985.

Predation of caribou (Rangifer tarandus) calves by golden eagles (Aquila chrysaetos) has been documented in several caribou herds located in Alaska and Canada (Murie 1944, Skoog 1956, Kelsall 1968). An apparent concentration of primarily immature golden eagles in association with calving and post-calving segments of the Porcupine caribou herd has been reported (Calef and Lortie 1973; Roseneau 1974; Schweinsburg 1974; Roseneau and Curatolo 1976; Mauer et al. 1983; Whitten et al. 1984, 1985 and 1986; Mauer 1985). Cases of golden eagle predation on Porcupine herd calves have also been recorded on a regular basis (Roseneau and Curatolo 1976, Mauer et al. 1983; Whitten et al. 1984, 1985 and 1986). During recent investigations of Porcupine herd calf mortality, golden eagles were found to be involved as a predator or scavenger in 50% of the mortality occurring among radio-collared calves in 1982 (Mauer et al. 1983). In a three year study of neonatal calf mortality in the Porcupine caribou herd (1983, 1984, and 1985), predation by golden eagles accounted for 60%, 25%, and 33% of natural mortality among radio-collared calves, respectively, during the period 2 June to 15 July (Whitten et al. 1984, 1985, 1986). However the effect of golden eagle predation on calf survival rates of the Porcupine herd cannot be adequately assessed until more information is obtained regarding eagle abundance and distribution. Further information regarding golden eagle predation and scavenging behavior is also needed.

In 1984, field studies were initiated to obtain improved information on the ecology of golden eagles on the Porcupine caribou herd's calving grounds. The initial objectives were:

1) Determine relative abundance and distribution of golden eagles associated with calving and post-calving caribou.

2) Determine temporal aspects of golden eagle occurrence on the northern portion of the Arctic National Wildlife Refuge.

3) Measure productivity of golden eagle nest sites adjacent to caribou calving and post-calving areas.

The results of 1984 investigations were reported by Mauer (1985). Golden eagle investigations were carried out a second year during April-September 1985 as a part of a comprehensive set of baseline studies of the fish, wildlife, and habitats of the coastal plain of Arctic National Wildlife Refuge.

Methods and Materials

The study area consisted of the arctic coastal plain, foothills, and northern mountains of the Brooks Range in the Arctic National Wildlife Refuge from the Canning River on the west to the US-Canada international boundary and in to Canada to the Babbage River (Fig. 1). The physical environment, climate, geology, vegetation, and other biological resources of this area were described in Wilken et al. (1981) and U.S. Fish and Wildlife

Service (1982). Distributions of caribou within the study area were based on information obtained during concurrent caribou investigations (Whitten et al. 1986).

Observation Records. Observations of golden eagles were collected from observers associated with biological field studies underway in the study area during April-September 1985. Ground crews, engaged in terrestrial bird inventories, recorded golden eagle observations around base camps located near the Sadlerochit River delta, the Jago River delta, Jago River foothills, near the foothills of the Aichilik river, on the coastal plain near the Niguanak, Okpilak,and Katakturuk rivers and Marsh Creek (Fig. 1). Observations of golden eagles were also recorded by biologists conducting aerial radio-tracking surveys, and other aerial operations associated with caribou studies (Whitten et al. 1986). During the period of 29 May to 1 July 1985, aerial surveys flown over caribou were conducted on a daily basis and averaged about 3 h/day over areas associated with caribou. Crews engaged with brown bear and wolf capture operations and radio-telemetry surveys also recorded observations of golden eagles. A few additional observations were recorded by fisheries study crews and a raptor/endangered species inventory (Amaral 1986).

All reported sightings of golden eagles in the study area were compiled in a systematic manner recording: date, location, number of eagles sighted, age classification (adult/immature), activity (flying, perched, feeding), and the presences or absence of caribou. Locations were plotted on 1:63,360 and 1:250,000 scale topographic maps. The presence of white coloration on the under-wings and the base of the primary feathers of the tail was the criteria used to distinguish immature birds.

Nest Surveys. Previously identified golden eagle nest sites (Roseneau 1973, 1974, Gill and Amaral 1984, Amaral and Benfield 1985, Mauer 1985) occurring in or adjacent to calving and post-calving areas of the Porcupine herd were surveyed during 23 May - 11 July 1985, from fixed-wing aircraft (Boeker 1970), helicopter (White and Sherrod 1973), or from ground access. New nest sites recorded during the 1985 season were also surveyed. Productivity was determined according to the following definitions proposed by Postupalsky (1974):
Breeding Area: an area containing one or more nests within the range of one mated pair of birds.
Occupied nest: one at which a mated pair of eagles was present at the nest, had repaired the nest, and/or had laid eggs, as determined by an adult in the incubation or brooding posture, observed eggs, or young.
Active nest: an occupied nest in which eggs were laid, as determined by an adult in incubation or brooding posture, or observings eggs or young.
Successful nest: those nests in which at least one young was raised to the age of fledging.
Brood size: the number of young at the age of fledging per successful nest.
Productivity: the number of these young per occupied or active nests, as indicated.
Alternate nest: an occupied nest within the breeding area of one pair of eagles.

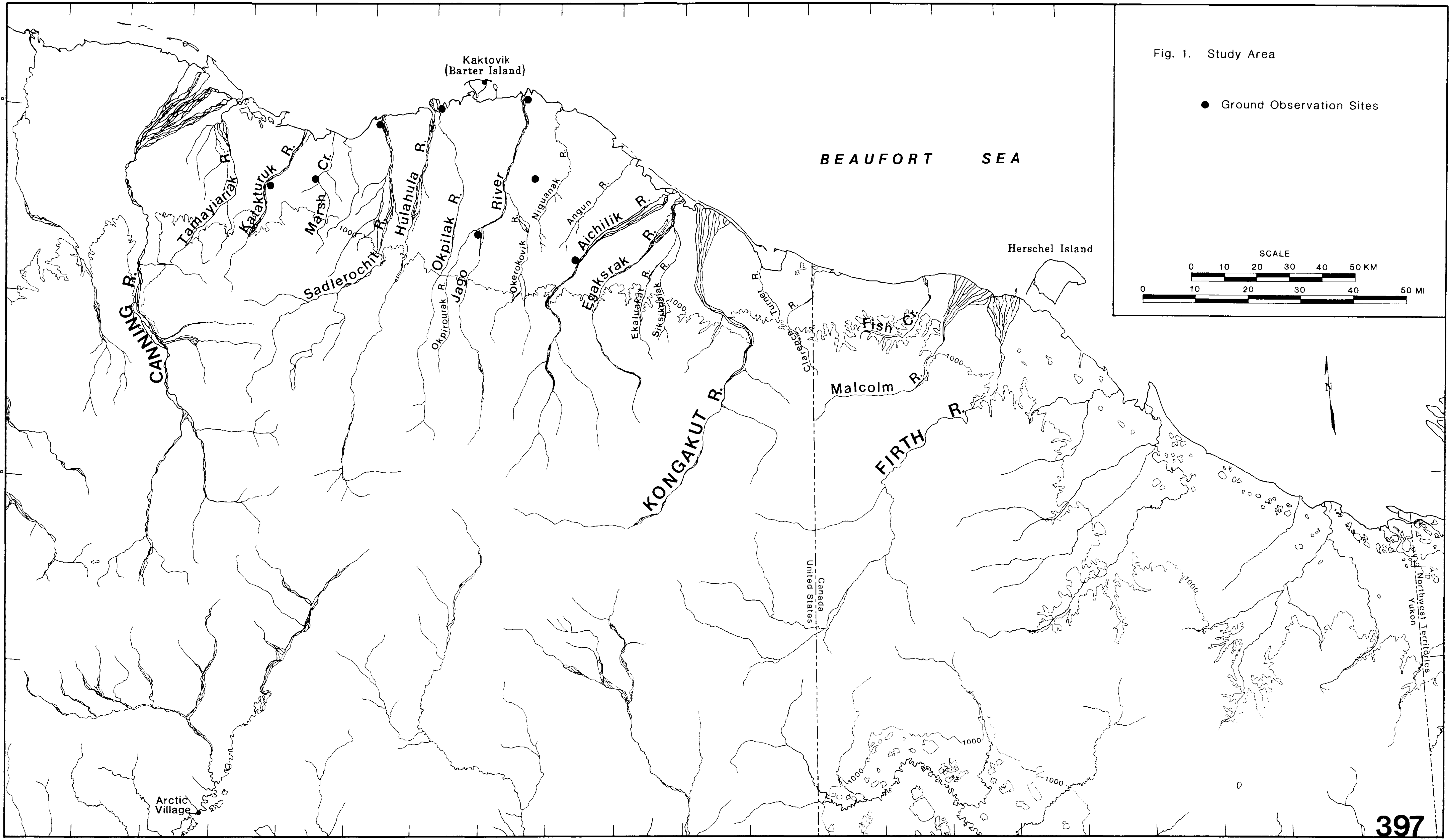

Fig. 1. Study Area

Results and Discussion

Observation Records. A total of 400 golden eagles were sighted during 336 observations (1.2 eagles/observation) made from 7 April to 26 September 1985 on the Porcupine caribou herd calving grounds, post-calving areas, and adjacent areas. Due to the high level of observer effort involved, it is likely that an unknown number of eagles were observed repeatedly during the study period. Of the observed eagles which could be classified according to age (n=240), 78% (186) were sub-adult and 22% (54) were adult birds. There were 160 unidentifiable eagles recorded. Similar proportions, 86% and 89% of sub-adult golden eagles were reported in observations made during 1975 and 1984 on the calving and post-calving areas of the Porcupine caribou herd (Roseneau and Curatolo 1976, Mauer 1985).

Most observations of golden eagles (68%) were recorded in areas currently or recently occupied by caribou (Figs. 2-5). In areas unoccupied by large numbers of caribou, the frequency of reported golden eagle sightings was low and there was no indication of eagle concentrations in these areas (Figs. 2-5). Observer effort was greatest in caribou areas and may have biased the results somewhat. The frequency of golden eagle observations recorded in 1985 followed a pattern similar to that of 1984 (Mauer 1985). Observations steadily increased after the peak of caribou calving and reached the highest level during the post-calving period (20-30 June, Fig. 6). The aggregation of caribou during this time frame coincided with increased frequency of eagle observations. The increased frequency of eagle observations during this time period coincided with the greatest abundance of caribou and when caribou were aggregated into large groups.

Golden eagles were observed either feeding or perched at caribou calf carcasses on 15 occasions and were at adult carcasses on 8 occasions (Fig. 7). The highest level of eagle observations at adult caribou carcasses occurred during the calving period (27 May - 12 June). It is likely that mortality factors associated with parturition may result in a relative abundance of adult caribou carcasses at that time. The number of eagle sightings at calf carcasses reached its highest level during the post-calving period (20-30 June). Observations of more than 1 eagle/sighting were also most prevalent during the 20-30 June period due to the increase in carcass feeding. Many of the sightings of eagles at caribou carcasses were made from fixed-wing aircraft in locations lacking access on the ground. Consequently most carcasses could not be investigated. Predation by golden eagles was the most probable cause of death in 9 of 25, (36%) caribou calf carcasses that were examined. These results are biased towards golden eagles because the presence of golden eagles at carcass sites enhances detection. Three of 9 mortalities (33%) among 60 radio-collared calves were the result of golden eagle predation (Whitten et al. 1986). Golden eagle predation on a caribou calf was documented as late as 30 June.

Golden eagles were observed with other predator/scavenger species on 5 occasions (Appendix 1). Wolves (Canis lupus) were involved in 3 cases and brown bears (Ursus arctos) in 2 cases. One observation was made of a golden eagle feeding on a willow ptarmigan (Lagopus lagopus). Observations of adult bald eagles (Haliaeetus leucocephalus) were recorded for the second consecutive year on the Kongakut River. An abundant population of arctic char in this river may provide a food source for bald eagles.

Nest Surveys

A total of 21 nest sites were investigated in 1985 by this study and that of Amaral (1986). Ten nest sites occurred within or adjacent (25 km) to areas used by calving and post-calving caribou of the Porcupine herd, and 11 sites were located 25-80 km beyond caribou use areas (Fig. 8). Nine sites were unoccupied and 12 were occupied (Table 1). Of the occupied nest sites, 6 were active (incubation and/or eggs present). Young were present at 2 sites, no young were produced in 2 other active sites and the ultimate status of the remaining 2 sites was not determined. The actual number of young fledged was not determined due to logistical limitations during August.

Table 1. Productivity status of golden eagle nests investigated in 1985 relative to distribution of the Porcupine caribou herd during the calving/post-calving period.

	Sites Associated with Caribou	Sites not Associated with Caribou	Total
Unoccupied	4	5	9
Occupied	6	6	12
Active	3	3	6
Successful[1]	1	1	2
Occupied sites/total sites	0.60	0.56	0.57
Active sites/total sites	0.30	0.27	0.29
Successful sites/active sites[2]	0.50	0.50	0.50
Successful sites/occupied sites	0.17	0.17	0.17
Young/active site	0.66	0.33	0.50
Young/occupied site	0.33	0.17	0.25
Young/successful site[2]	2.0	1.0	1.5

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[1] Assumes that young observed on 16-20 June (Amaral 1986) and 11 July (this study) survived to fledge.

[2] Includes only sites where productivity were confirmed (n=4).

In general, the productivity of golden eagles in 1985 was similar to that of 1984 (Mauer 1985), and lower than that reported by Roseneau (1974) for 1973. Because of the low number of nests with young present, any possible association between productivity and caribou as a food item is not clear. A nest site discovered directly adjacent to calving and post-calving habitats may yield additional information in future years. Direct observation of food delivery at such sites, as well as collection/analysis of pellets and prey remains will yield information on the caribou-eagle food chain.

The data presented in this report represents a compilation of observations collected primarily in Alaska during 1985. Additional nest sites exist in adjoining areas in Canada and in the mountainous region of the eastern Brooks Range in Alaska. In the future, a more comprehensive, regional survey of golden eagle nests should be conducted to provide a better over-all understanding of productivity and ultimately, population status.

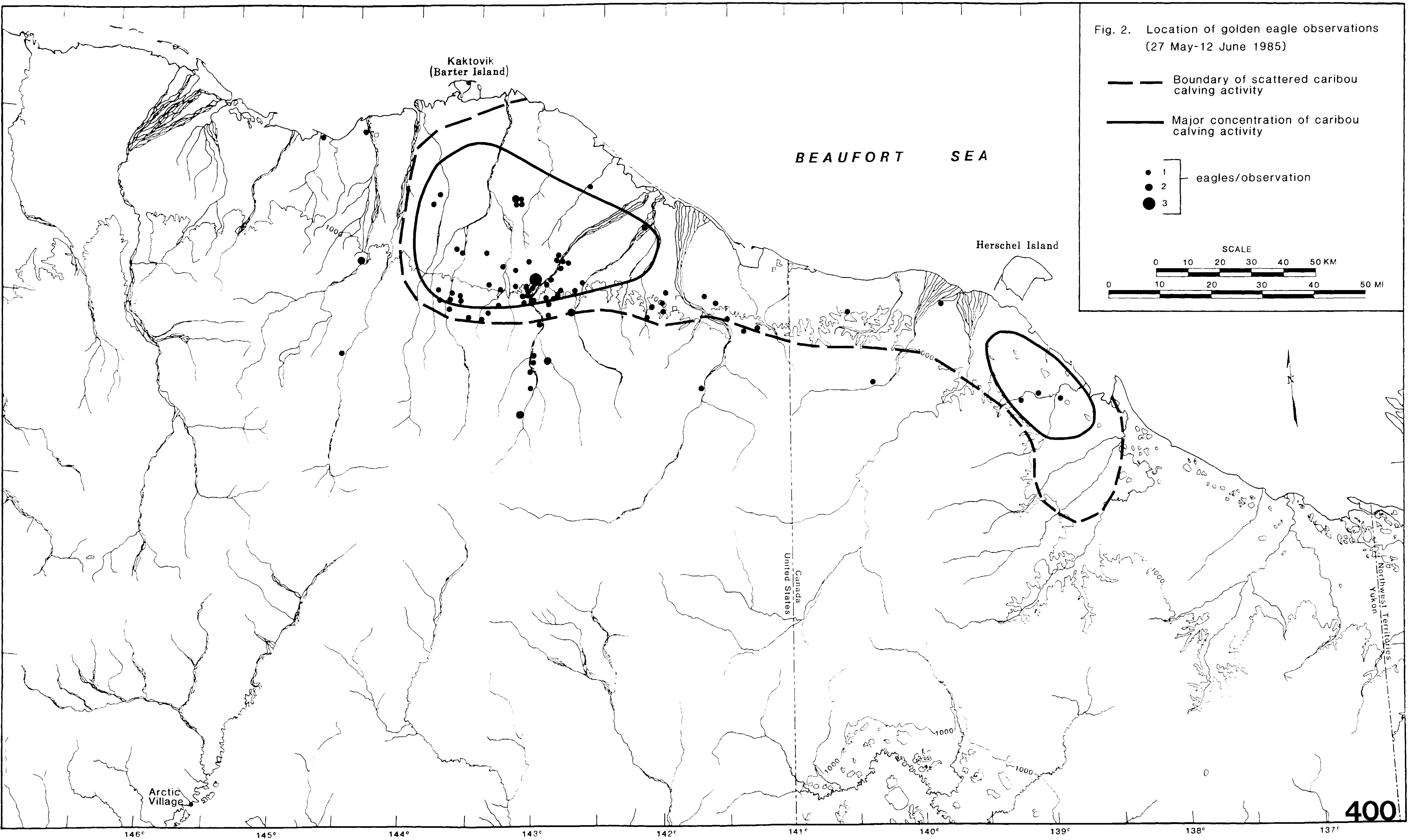

Fig. 2. Location of golden eagle observations (27 May-12 June 1985)

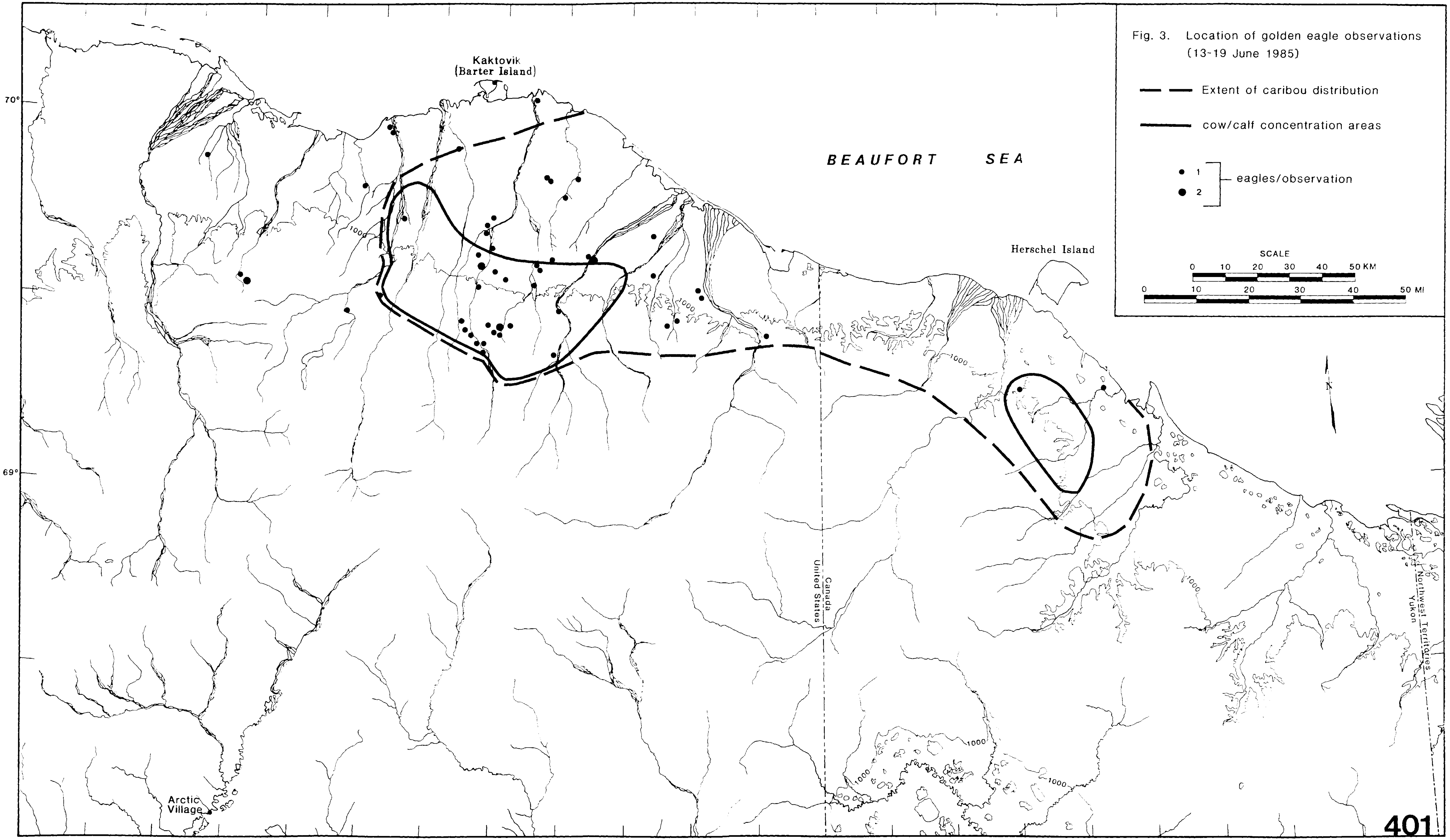

Fig. 3. Location of golden eagle observations (13-19 June 1985)

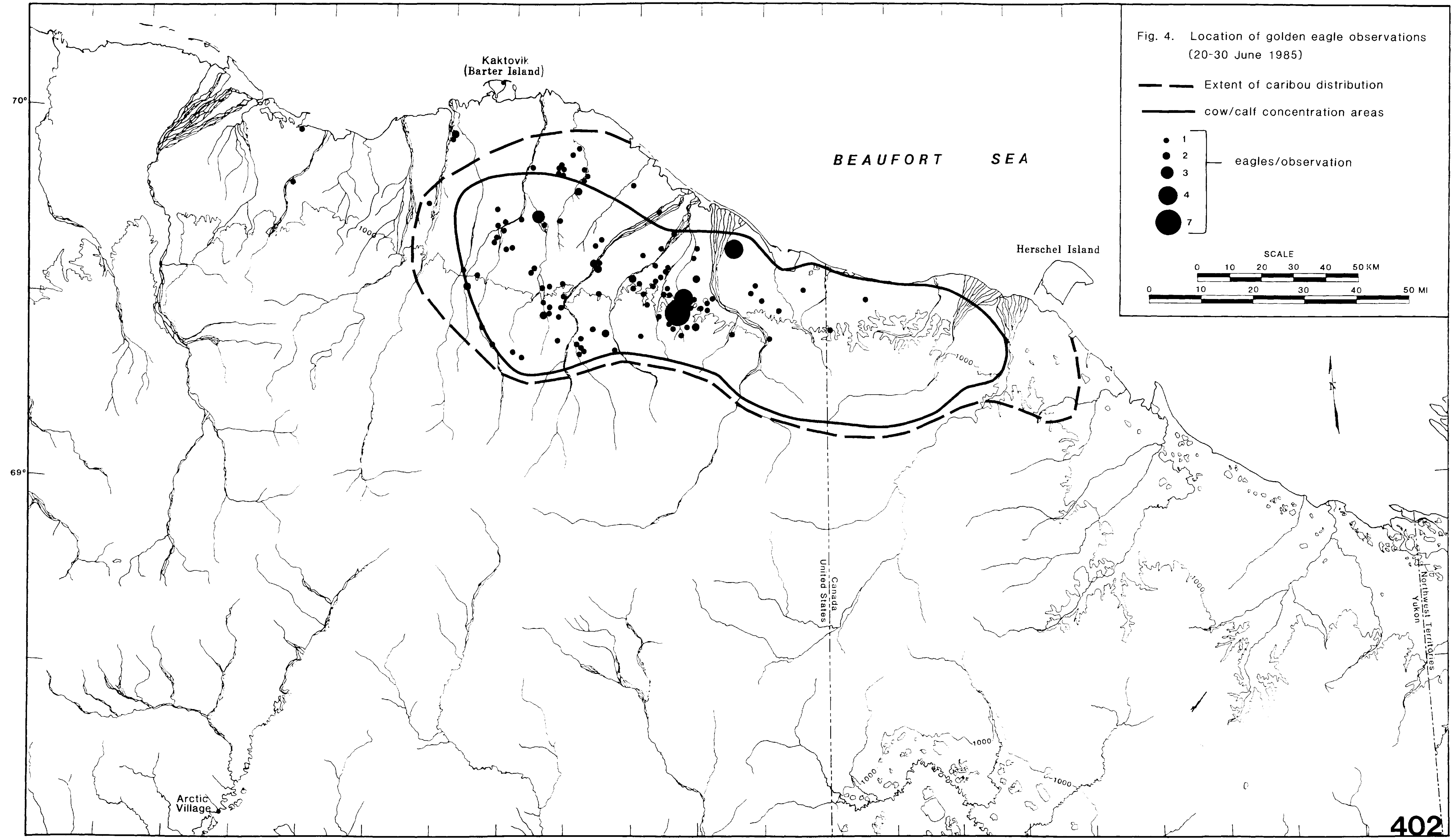

Fig. 4. Location of golden eagle observations (20-30 June 1985)

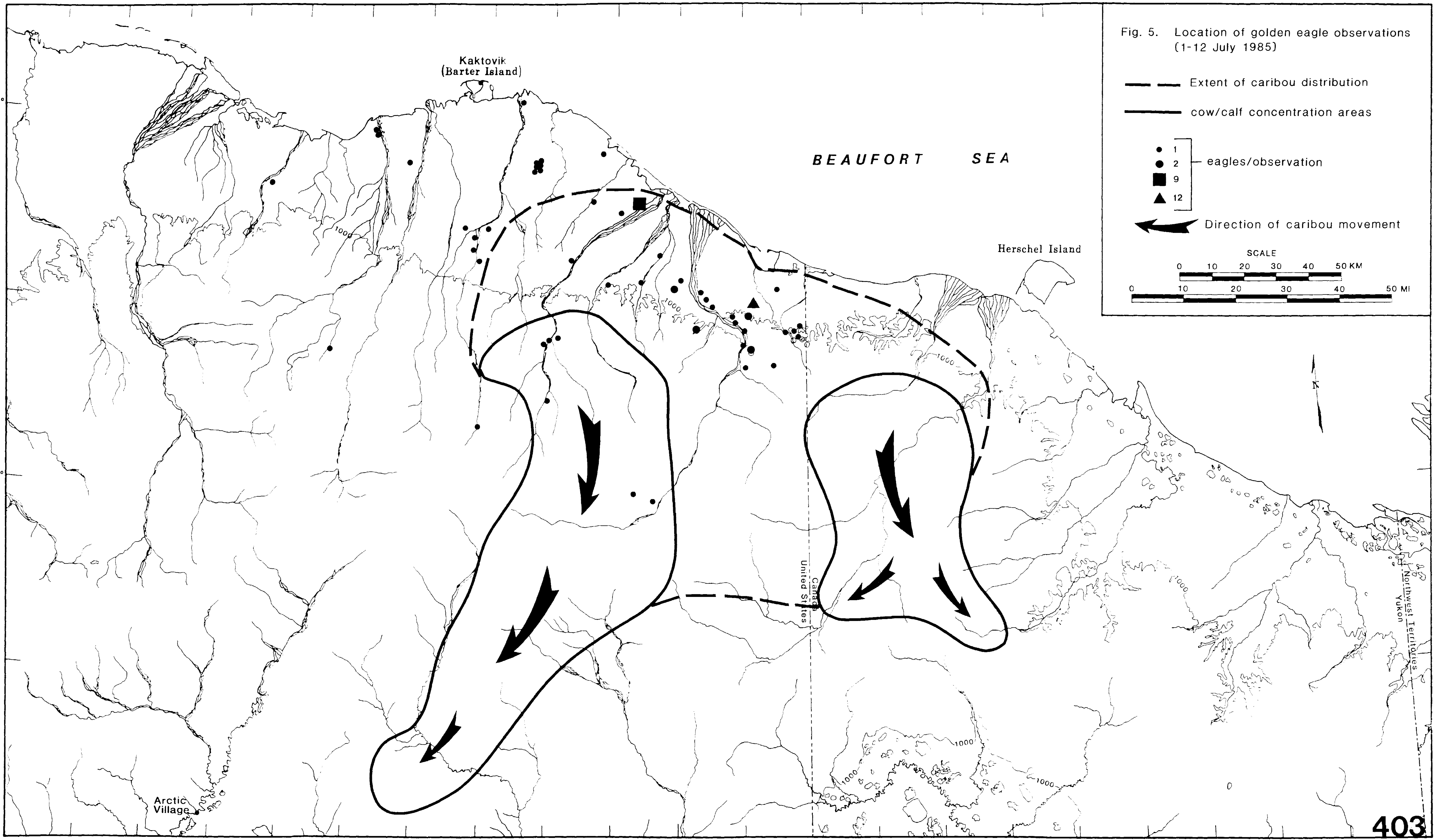
Fig. 5. Location of golden eagle observations (1-12 July 1985)

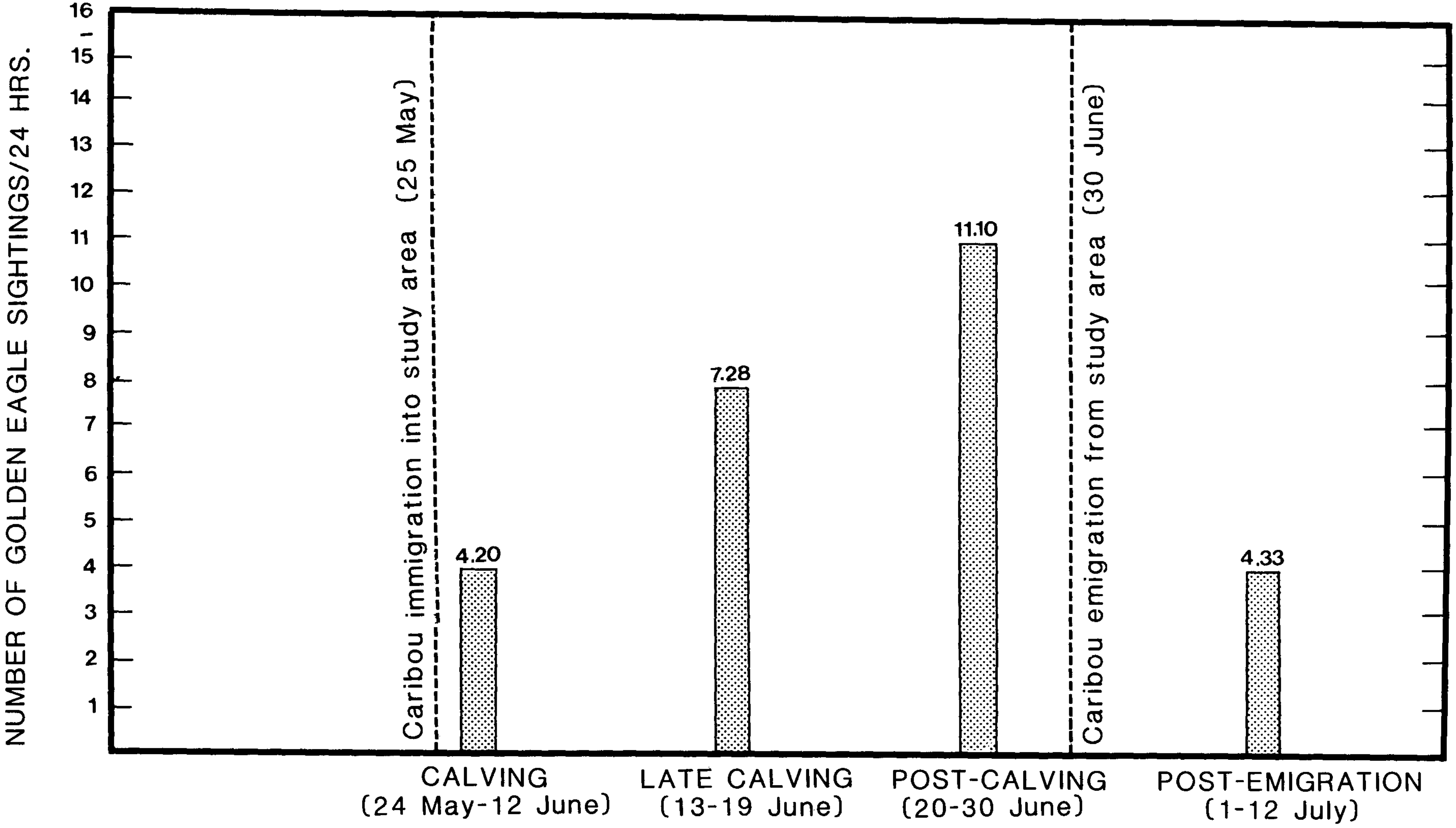

Fig. 6. Frequency of observations of golden eagles during calving and post-calving periods, Porcupine caribou herd, 1985.

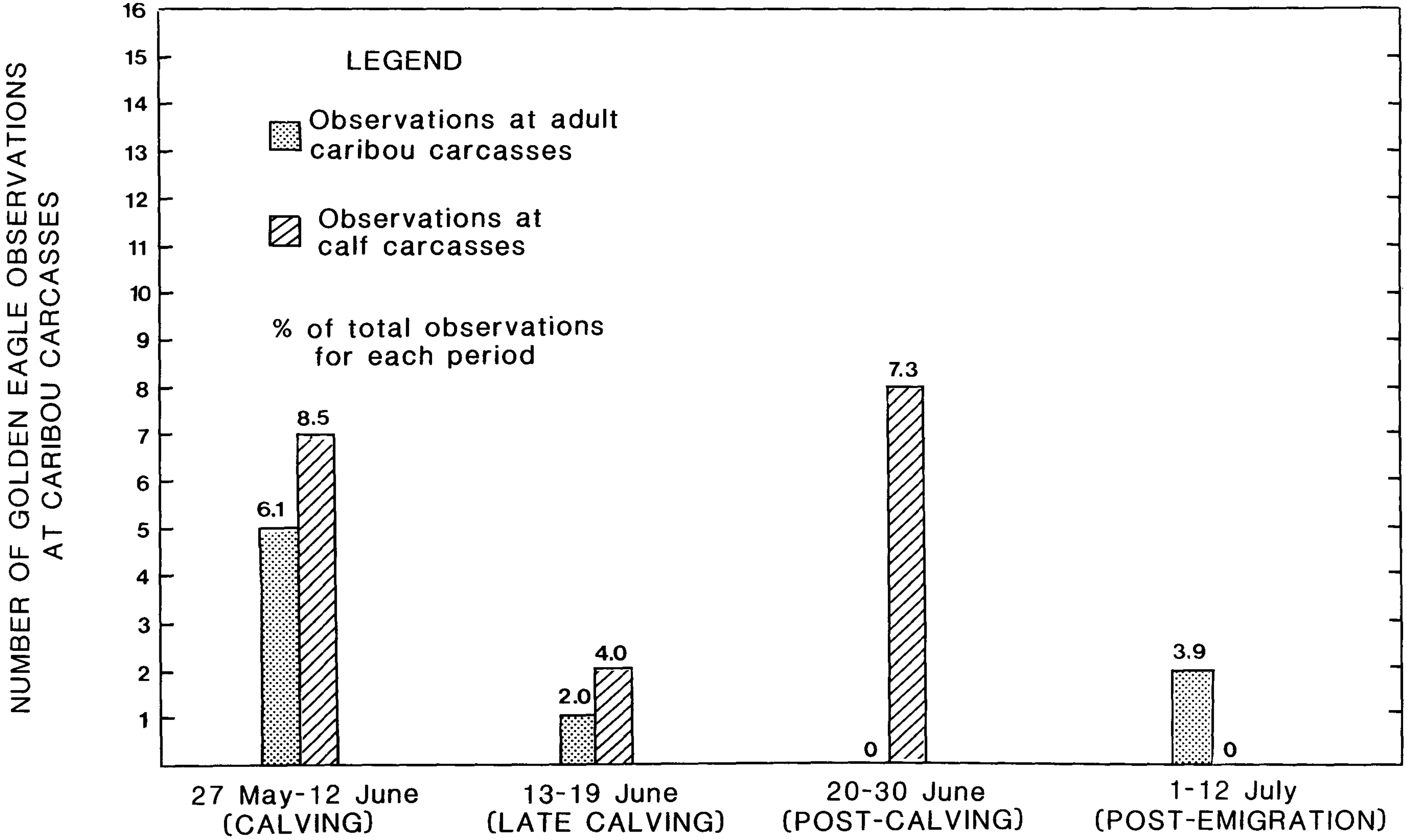

Fig. 7. Frequency of observations of golden eagles at caribou carcasses during calving and post-calving periods, Porcupine caribou herd, 1985.

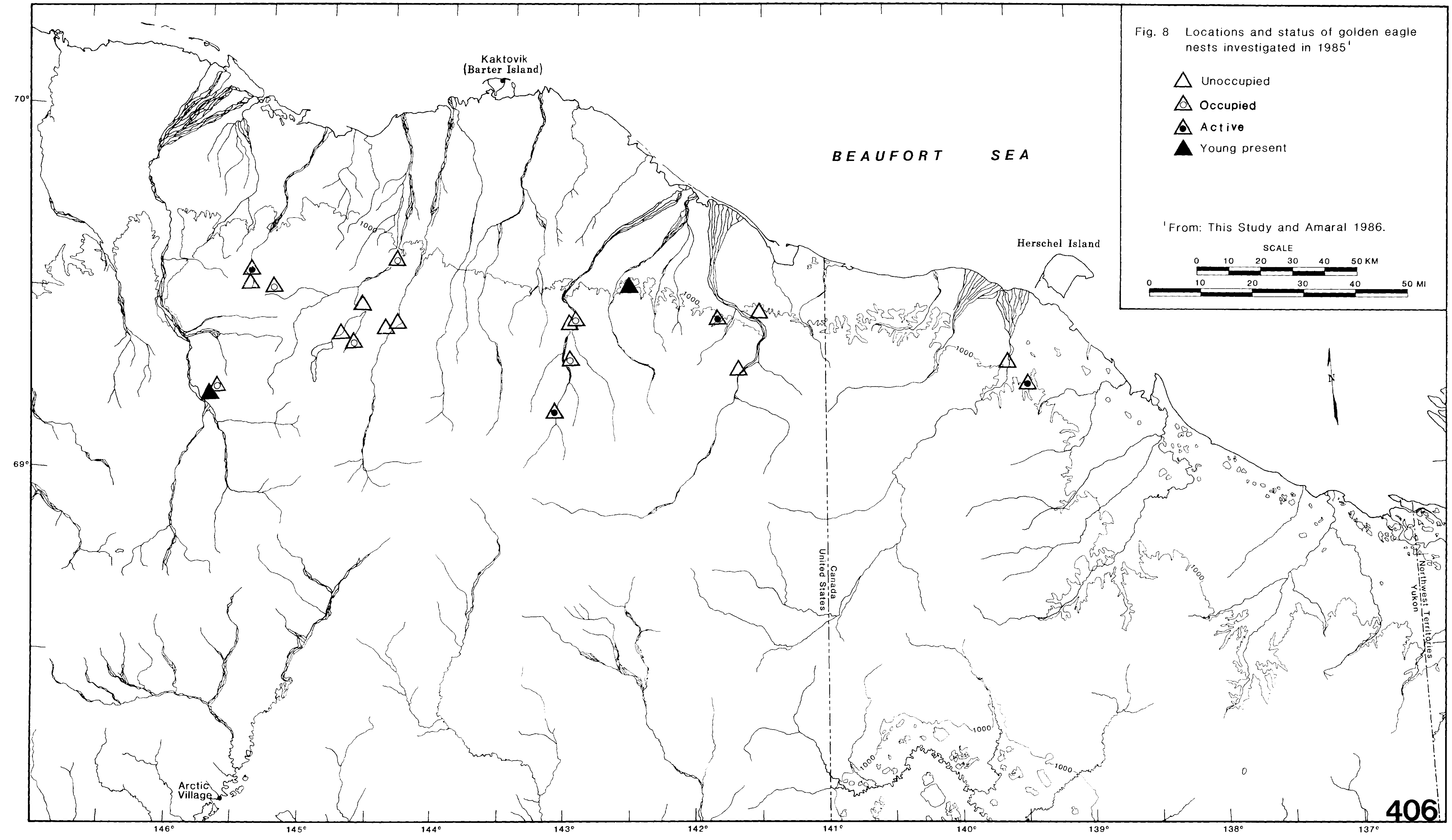

Fig. 8 Locations and status of golden eagle nests investigated in 1985[1]

More work needs to be done to determine the numbers of eagles associated with caribou calving areas and to assess the effects of eagle predation on herd dynamics. Further information should also be collected on eagle killing rates/behavior on the calving ground, effects of alternative food resources, and golden eagle movements and migration routes from wintering areas to the caribou calving grounds.

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APPENDIX
ANWR Progress Report FY86-4

Appendix Table 1. Observations of golden eagles on the northern portion of the Arctic National Wildlife Refuge, Alaska and northwestern Canada, spring and summer 1985.

Observation #	Date	Location^{a}	Adult	Sub-adult	U^{b}	Activity^{c}	Caribou^{d}	Type^{e}	Remarks
1	7 Apr	Marsh Fk Canning (M)			1			1	
2	7 Apr	Canning R (M)			2	P		1	Ungulate carcasss
3	7 Apr	Mt. Copleston (M)		1				1	
4	8 Apr	Aichilik (M)			2			1	
5	24 May	Okerokovik (F)		1		P	+	1	
6	26 May	Egaksrak (F)			2	F	+	1	
7	27 May	Aichilik (F)		1		P	+	1	Adult & calf carcass
8	29 May	Kongakut (F)		1		F	+	1	
9	30 May	Okerokovik (F)			1		+	1	
10	30 May	Aichilik (F)			1		-	1	
11	31 May	Malcolm (M)			1	F	+	1	
12	31 May	Bitty (CP)			1		+	1	
13	1 Jun	Angun (CP)		1		P	-	1	
14	1 Jun	Aichilik (F)		1		P	+	1	Same as # 7
15	1 Jun	Spring R (CP)		1		P	+	1	
16	1 Jun	Roland Cr. (CP)		1		P	+	1	
17	1 Jun	Malcolm Delta (CP)		1		P	+	1	
18	1 Jun	Jago (F)			1	F	+	2	
19	2 Jun	Sadlerochit Delta (CP)	1			F	-	3	
20	3 Jun	Kongakut (F)	1			F	+	1	
21	3 Jun	Niguanak (CP)		1		F	+	3	
22	4 Jun	Siksikpalak (F)			1	-	+	1	
23	4 Jun	Kongakut (F)			1	-	+	1	
24	5 Jun	Jago (F)		1		F	+	1	
25	5 Jun	Hulahula (M)		1		F	-	1	Near Dall sheep
26	6 Jun	Aichilik (F)		1		P	+	1	Calf carcass
27	6 Jun	Aichilik (F)			1	P	+	1	Near adult caribou carcass
28	6 Jun	Jago (CP)		1		P	+	1	Near adult caribou carcass
29	6 Jun	Aichilik (F)		1		P	+	1	2 caribou calf carcasses
30	6 Jun	Aichilik (F)		1		F	+	1	
31	7 Jun	Aichilik (CP)		1		P	+	1	

Observation #	Date	Location[a]	Adult	Sub-adult	U[b]	Activity[c]	Caribou[d]	Type[e]	Remarks
32	7 Jun	Aichilik (F)		1		P	+	1	
33	7 Jun	Jago (CP)			1	-	+	1	
34	7 Jun	Jago (F)		1		-	+	2	
35	7 Jun	Aichilik (CP)		1		F	+	1	
36	8 Jun	Aichilik (F)			1	-	+	1	
37	8 Jun	Turner (F)			1	P	+	1	Bear on caribou carcass
38	8 Jun	Okerokovik (F)			1	P	+	1	Adult caribou carcass
39	8 Jun	Aichilik (CP)			1	F	+	1	
40	8 Jun	Aichilik (CP)			1	F	+	1	
41	8 Jun	Aichilik (M)	2			P	-	4	(1) bird incubating
42	8 Jun	Aichilik (CP)	1			F	+	3	
43	9 Jun	Egaksrak (CP)	1			F	+	2	
44	9 Jun	Jago (CP)		1		F	+	1	
45	9 Jun	Kongukut (F)	1			F	+	2	
46	9 Jun	Aichilik (F)			1	P	+	1	
47	9 Jun	Aichilik (F)			1	P	+	1	Caribou calf carcass
48	9 Jun	Aichilik (F)			1	P	+	1	Caribou calf carcass
49	9 Jun	Aichilik (F)			1	F	+	1	
50	9 Jun	Aichilik (M)		1		F	-	4	
51	9 Jun	Aichilik (M)	1			F	-	4	
52	9 Jun	Aichilik (M)	1	1		F	-	4	
53	9 Jun	Aichilik (M)		1		F	-	4	
54	9 Jun	Aichilik (M)	1	1		F	-	4	
55	9 Jun	Marsh Cr. (CP)		1		F	-	3	
56	9 Jun	Niguanak (CP)			2	F	+	3	
57	10 Jun	Okerokovik (F)	1			F	+	1	
58	10 Jun	Aichilik (M)	2			F	-	4	
59	10 Jun	Aichilik (F)		1		F	+	4	
60	10 Jun	Siksikpalak (F)		1		F	+	2	
61	10 Jun	Kongakut (M)	1			F	+	2	
62	10 Jun	Egaksrak (F)		1		P	+	2	
63	10 Jun	Niguanak (CP)			1	P	+	3	
64	11 Jun	Okerokovik (CP)			1	P	+	1	
65	11 Jun	Aichilik (F)			1	P	+	1	
66	11 Jun	Kongakut (F)		1		P	+	1	

Observation #	Date	Location^a	Adult	Sub-adult	U^b	Activity^c	Caribou^d	Type^e	Remarks
67	11 Jun	Akootoaktuk (CP)		1		P	+	1	
68	11 Jun	Egaksrak (F)			1	P	+	1	
69	11 Jun	Jago (F)		1		P	+	1	
70	11 Jun	Okpilak (CP)			1	P	+	2	
71	11 Jun	Jago (F)		1		F	+	2	
72	11 Jun	Jago (F)		1		F	+	2	
73	11 Jun	Niguanak (CP)		1		F	+	3	
74	12 Jun	Okerokovik (F)	2	1	2	F	+	2	
75	12 Jun	Gwen (F)			1	F	+	1	
76	12 Jun	Okerokovik (F)			2	P/F	+	1	
77	12 Jun	Clarence (F)			1	F	+	1	
78	12 Jun	Okerokovik (F)		1		F	+	1	
79	12 Jun	Okerokovik (F)			1	P	+	1	
80	12 Jun	Okerokovik (F)			1	F	+	1	
81	12 Jun	Aichilik (F)			1	F	+	1	
82	12 Jun	Aichilik (F)			1	P	+	1	
83	12 Jun	Aichilik (F)			1	P	+	1	
84	12 Jun	Aichilik (F)			1	P	+	1	
85	12 Jun	Backhouse (F)			1	F	+	1	
86	12 Jun	Roland Cr.(CP)			1	F	+	1	
87	12 Jun	Malcolm (M)			1	F	+	1	
88	12 Jun	Sadlerochit (M)	1	1		F	-	4	
89	13 Jun	Jago (F)			1	F	+	2	
90	13 Jun	Egaksrak (CP)		1		P	+	2	Feeding on Ptarmigan
91	13 Jun	Okerokovik (F)		1		P	+	2	
92	13 Jun	Jago (F)		1		P	+	2	
93	13 Jun	Kongakut (F)			1	P	+	1	
94	13 Jun	Kongakut (F)			1	P	+	1	
95	13 Jun	Jago (CP)		1		F	+	3	
96	13 Jun	Sadlerochit Delta (CP)		1		F	-	3	
97	14 Jun	Jago Delta (CP)		1		F	+	3	
98	15 Jun	Kekiktuk (F)		1		F	+	4	
99	15 Jun	Katakturuk (F)	1		1	F	-	4	
100	15 Jun	Katakturuk (F)	1			P	-	4	Incubating
101	15 Jun	Sadlerochit (CP)		1		F	+	4	

Observation #	Date	Location[a]	Adult	Sub-adult	U[b]	Activity[c]	Caribou[d]	Type[e]	Remarks
102	15 Jun	Okpirourak (F)	1			P	+	1	Near wolf
103	15 Jun	Okerokovik (CP)			1	F	+	1	
104	15 Jun	Ekaluakat (F)			1	F	+	2	
105	15 Jun	Aichilik (F)			1	F	+	2	
106	15 Jun	Jago (CP)		1		F	+	2	
107	15 Jun	Okerokovik (F)	1			F	+	2	
108	15 Jun	Okerokovik (F)			1	F	+	2	
109	15 Jun	Okpirourak (F)		1		P	+	2	
110	16 Jun	Firth R	1			P	+	1	Incubating
111	16 Jun	Stokes (CP)			1	F	+	1	
112	16 Jun	Jago (CP)		1		F	+	3	
113	16 Jun	Sadlerochit Delta (CP)			1	F	-	3	
114	16 Jun	Niguanak (CP)		1		F	+	3	
115	17 Jun	Jago (CP)	1			P	+	1	Near wolf
116	17 Jun	Tamayariak (CP)	1			F	+	2	
117	17 Jun	Arctic Cr (F)	1			F	+	2	
118	17 Jun	Carter Cr (CP)		1		F	-	5	
119	17 Jun	Aichilik (CP)	1			F	+	3	
120	18 Jun	Jago (F)			1	F	+	1	
121	18 Jun	Jago (CP)			1	F	+	1	
122	18 Jun	Okpilak (CP)			1	F	+	1	
123	18 Jun	Jago (F)	1			F	+	2	
124	18 Jun	Jago (F)		1		F	+	2	
125	18 Jun	Jago (F)		1		P	+	2	Caribou calf carcass
126	18 Jun	Jago (F)	1			F	+	2	
127	18 Jun	Jago (F)	1			P	+	2	
128	18 Jun	Aichilik (M)		1		-	+	5	
129	18 Jun	Siksikpalak			1	P	+	5	Adult caribou carcass
130	18 Jun	Aichilik (CP)			1	F	+	3	
131	19 Jun	Niguanak (CP)		1		F	+	1	
132	19 Jun	Niguanak (CP)			1	F	+	1	
133	19 Jun	Kongakut (F)			1	F	+	1	
134	19 Jun	Okerokovik (F)		1		F	+	1	
135	19 Jun	Okerokovik (F)		2		F	+	1	Caribou calf carcass
136	19 Jun	Okerokovik (F)		1		F	+	1	Near wolf

Observation #	Date	Location^{a}	Adult	Sub-adult	U^{b}	Activity^{c}	Caribou^{d}	Type^{e}	Remarks
137	19 Jun	Okerokovik (F)			1	P	+	1	
138	19 Jun	Ekaluakat (M)		1		-	+	2	
139	19 Jun	Achilik (CP)	1	1		F	+	3	
140	20 Jun	Okerokovik (F)			2	F	+	1	
141	20 Jun	Okerokovik (F)		1		F	+	1	
142	20 Jun	Jago (CP)		1		F	+	2	
143	20 Jun	Jago (F)			1	F	+	2	
144	20 Jun	Okpilak (F)		2		F	+	2	
145	20 Jun	Aichilik (CP)		1		P	+	2	
146	20 Jun	Okerokovik (F)			1	F	+	2	
147	20 Jun	Okerokovik (F)		1		F	+	2	
148	20 Jun	Jago (F)			1	F	+	2	
149	20 Jun	Okerokovik (F)		1		F	+	2	
150	20 Jun	Jago (F)			1	F	+	1	
151	21 Jun	Okerokovik (F)		1		F	+	2	
152	21 Jun	Jago (CP)		1		F	+	2	
153	21 Jun	Jago		1		F	+	2	
154	21 Jun	Okpilak (F)		1		F	+	1	
155	21 Jun	Jago (F)		1		F	+	1	
156	21 Jun	Egaksrak (F)			1	P	+	1	
157	21 Jun	Jago (CP)			1	F	+	3	
158	21 Jun	Katakturuk (CP)			1	F	-	3	
159	22 Jun	Aichilik (CP)			2	F	+	3	
160	22 Jun	Okerokovik (CP)			3	F	+	3	
161	22 Jun	Niguanak (CP)		1		F	+	3	
162	22 Jun	Niguanak (CP)	1			F	+	3	
163	22 Jun	Kongakut (M)			1	-	-	6	
164	23 Jun	Hulahula (CP)		1		P	+	1	Caribou calf carcass
165	23 Jun	Kongakut (CP)			1	P	+	1	
166	23 Jun	Niguanak (CP)	1			F	+	2	
167	23 Jun	Niguanak (CP)	1			F	+	2	
168	23 Jun	Okerokovik (M)			1	F	+	2	
169	23 Jun	Jago (CP)	1			F	+	3	
170	24 Jun	Okerokovik (CP)		1		F	+	2	
171	24 Jun	Hulahula (CP)		2		P	-	1	Caribou calf carcass

Observation #	Date	Location^{a}	Adult	Sub-adult	U^{b}	Activity^{c}	Caribou^{d}	Type^{e}	Remarks
172	24 Jun	Egaksrak (M)		2		P	+	1	Caribou calf carcass
173	24 Jun	Hulahula (CP)			1	F	+	1	
174	24 Jun	Aichilik (CP)			1	F	+	3	
175	24 Jun	Jago (CP)		1		P	-	3	
176	24 Jun	Niguanak (CP)	1			F	+	3	
177	25 Jun	Egaksrak (F)		1		F	+	2	
178	25 Jun	Okerokovik (CP)	1			P	+	2	
179	25 Jun	Okerokovik (CP)		1		P	+	2	
180	25 Jun	Aichilik (F)			1	F	+	2	
181	25 Jun	Aichilik (F)		1		F	+	2	
182	25 Jun	Egakarak (F)			1	F	+	1	
183	25 Jun	Siksikpalak (F)		7		P	+	1	Caribou calf carcass
184	25 Jun	Turner (F)			1	F	+	1	
185	25 Jun	Turner (F)			1	F	+	1	
186	25 Jun	Ekaluakat (F)			1	F	+	1	
187	25 Jun	Egaksrak (F)		1		F	+	2	
188	25 Jun	Jago (CP)			1	F	-	3	
189	25 Jun	Niguanak (CP)			1	F	-	3	
190	26 Jun	Kongakut (F)			1	F	+	3	
191	26 Jun	Backhouse (CP)			1	F	+	3	
192	26 Jun	Kongakut (CP)		4		P	+	3	Caribou calf carcass
193	26 Jun	Siksikpalak (F)			1	F	+	3	
194	26 Jun	Siksikpalak (F)			1	P	+	3	
195	26 Jun	Kongakut (F)		1		F	+	3	
196	26 Jun	Siksikpalak (F)		1		P	+	3	Near ill caribou-female
197	26 Jun	Ekaluakat (F)	1			F	+	3	
198	26 Jun	Ekaluakat (F)			1	F	+	3	
199	26 Jun	Ekaluakat (F)			1	F	+	3	
200	26 Jun	Aichilik (F)			1	F	+	2	
201	26 Jun	Egakarak (F)			1	F	+	2	
202	26 Jun	Ekaluakat (F)			1	F	+	2	
203	27 Jun	Angun (CP)			1	P	+	1	
204	27 Jun	Craig Cr (F)			1	P	+	1	
205	27 Jun	Siksikpalak (F)			1	P	+	1	
206	27 Jun	Egaksrak (CP)			1	P	+	1	
207	27 Jun	Niguanak (CP)		2		F	-	2	

Observation #	Date	Location^{a}	Adult	Sub-adult	U^{b}	Activity^{c}	Caribou^{d}	Type^{e}	Remarks
208	27 Jun	Ekaluakat (F)		1		F	+	2	
209	27 Jun	Turner (F)		1		F	+	2	
210	27 Jun	Turner (F)		1		F	+	2	
211	28 Jun	Canning (CP)		1		F	+	7	
212	28 Jun	Jago (CP)			1	F	-	3	
213	29 Jun	Egaksrak (CP)		1		P	+	1	
214	29 Jun	Egaksrak (CP)			2	F	+	1	
215	29 Jun	Siksikpalak (F)		4		P	+	1	Caribou calf carcass
216	29 Jun	Ekaluakat (F)		1		P	+	1	Caribou calf carcass
217	29 Jun	Niguanak (CP)			1	P	+	1	
218	29 Jun	Niguanak (CP)		1		F	-	2	
219	29 Jun	Niguanak (CP)	1			P	-	2	
220	29 Jun	Niguanak (CP)	1			P	-	2	
221	29 Jun	Angun (CP)			1	P	-	2	
222	29 Jun	Angun (CP)			1	P	-	2	
223	29 Jun	Aichilik (CP)			1	P	-	2	
224	29 Jun	Egaksrak (CP)	1			P	+	2	
225	29 Jun	Siksikpalak (CP)	1			P	+	2	
226	29 Jun	Siksikpalak (CP)			1	P	+	2	
227	29 Jun	Siksikpalak (CP)	1			P	+	2	
228	29 Jun	Kongakut (CP)				-	+	2	
229	29 Jun	Aichilik (CP)	1		1	F	+	3	
230	30 Jun	Ekaluakat (F)			1	F	+	1	
231	30 Jun	Siksikpalak (F)	1			P	+	1	
232	30 Jun	Aichilik (F)			1	P	+	1	Caribou calf carcass
233	30 Jun	Kongakut (F)			1	F	+	1	
234	30 Jun	Kongakut (F)			1	F	+	1	
235	30 Jun	Aichilik (F)			1	F	-	1	
236	30 Jun	Aichilik (F)			1	P	-	1	
237	30 Jun	Aichilik (F)			1	F	-	1	
238	30 Jun	Jago (CP)		1		P	-	2	
239	30 Jun	Acihilik (F)		1		P	-	2	
240	30 Jun	Clarence (CP)		1		P	+	2	
241	30 Jun	Kongakut (M)	1			F	+	2	
242	30 Jun	Kongakut (M)			2	F	+	2	

Observation #	Date	Location[a]	Adult	Sub-adult	U[b]	Activity[c]	Caribou[d]	Type[e]	Remarks
243	30 Jun	Siksikpalak (M)	1			P	+	2	
244	30 Jun	Egaksrak (M)	1			F	+	2	
245	30 Jun	Egaksrak (M)			1	P	+	2	
246	30 Jun	Aichilik (M)	1			P	+	2	
247	30 Jun	Aichilik (M)		1		P	+	2	
248	30 Jun	Okerokovik (F)			1	F	-	2	
249	30 Jun	Jago (CP)		1		F	-	3	
250	30 Jun	Niguanak (CP)			1	F	-	3	
251	1 Jul	Kongakut (CP)			1	F	+	2	
252	1 Jul	Aichilik (F)		1		P	+	2	
253	1 Jul	Aichilik (F)		1		P	+	2	
254	1 Jul	Aichilik (F)		1		F	+	2	
255	1 Jul	Niguanak (CP)			1	F	-	3	
256	2 Jul	Niguanak (CP)			1	F	-	3	
257	3 Jul	Aichilik (F)			1	F	+	8	
258	3 Jul	Kongakut (M)			1	F	+	8	
259	3 Jul	Kongakut (M)			2	F	-	1	
260	4 Jul	Clarence (F)			1	-	+	2	
261	4 Jul	Clarence (F)			1	F	+	2	
262	5 Jul	Kongakut (M)			1	F	+	1	
263	5 Jul	Katakturuk			1	-	-	3	
264	5 Jul	Niguanak (CP)		1		F	-	3	
265	6 Jul	Pokok (CP)			1	F	-	2	
266	6 Jul	Niguanak (CP)		1		F	-	3	
267	7 Jul	Saderochit (CP)			1	F	-	2	
268	7 Jul	Kongakut (CP)		2		P	+	2	
269	7 Jul	Kongakut (F)		1		P	+	2	
270	7 Jul	Kongakut (F)	1			F	+	2	
271	7 Jul	Kongakut (F)		1		F	+	2	
272	7 Jul	Turner (F)		12		P	+	2	Adult caribou carcass
273	7 Jul	Turner (F)			2	F	+	2	
274	7 Jul	Clarence (F)		1		F	+	2	
275	7 Jul	Kongakut (F)	1			F	+	2	
276	7 Jul	Kongakut (F)	1			F	+	2	
277	7 Jul	Kongakut (M)			1	F	+	2	

Observation #	Date	Location[a]	Adult	Sub-adult	U[b]	Activity[c]	Caribou[d]	Type[e]	Remarks
278	7 Jul	Jago (M)			1	F	+	2	
279	7 Jul	Jago (CP)		1		F	-	3	
280	7 Jul	Sadlerochit Delta (CP)		1		F	-	3	
281	8 Jul	Jago (CP)		1		F	-	3	
282	8 Jul	Jago Delta (CP)		1		F	-	3	
283	9 Jul	Jago (CP)		1		F	-	3	
284	9 Jul	Sadlerochit Delta (CP)		1		F	-	3	
285	9 Jul	Niguanak (CP)			1	F	-	3	
286	10 Jul	Clarence (F)		1		F	-	4	
287	10 Jul	Kongakut (F)		1		F	-	4	
288	10 Jul	Ekaluakat (CP)		1		F	-	4	
289	10 Jul	Aichilik (CP)		1		F	-	3	
290	10 Jul	Kongakut (F)		1		F	-	4	
291	10 Jul	Kongakut (F)		1		F	-	4	
292	11 Jul	Clarence CP)		1		F	-	2	
293	11 Jul	Ekaluakat (F)		1		F	-	2	
294	11 Jul	Egaksrak (F)		1		F	-	2	
295	11 Jul	Aichilik (CP)		9		P	+	2	Adult carcass & B. bear
296	11 Jul	Aichilik (CP)		1		F	+	2	
297	11 Jul	Angun (CP)		1		F	-	2	
298	11 Jul	Karen Cr (F)	1			P	-	4	Near vacant nest
299	11 Jul	Kongakuk (F)	2			F	-	4	
300	11 Jul	Jago (CP)		1		F	-	3	
301	12 Jul	Jago (CP)		1		F	-	3	
302	12 Jul	Niguanak (CP)			1	F	-	3	
303	15 Jul	Karen Cr (F)		1		F	-	6	
304	15 Jul	Niguanak (CP)		1		F	-	3	
305	16 Jul	Aichilik (F)		1		F	-	3	
306	20 Jul	Jago (CP)		1		F	-	3	
307	22 Jul	Niguanak (CP)		1		F	-	3	
308	23 Jul	Jago (CP)		1		F	-	3	
309	23 Jul	Niguanak (CP)			1	F	-	3	
310	24 Jul	Sadlerochit Delta (CP)		1		F	-	3	
311	24 Jul	Niguanak (CP)			1	F	-	3	
312	26 Jul	Marsh Cr (CP)		1		-	-	3	

Observation #	Date	Location[a]	Adult	Sub-adult	U[b]	Activity[c]	Caribou[d]	Type[e]	Remarks
313	30 Jul	Schrader (M)			1	F	+	2	
314	30 Jul	Fire Cr (F)		1		F	-	2	
315	30 Jul	Ignek Cr (F)			2	F	-	8	
316	2 Aug	Canning (F)		1		F	-	3	
317	6 Aug	Karen Cr (F)		1		P	+	5	
318	6 Aug	Niguanak (CP)		1		F	-	3	
319	7 Aug	Aichilik (CP)		1		F	-	3	
320	9 Aug	Okerokovik			1	F	-	3	
321	10 Aug	Niguanak (CP)			1	-	-	3	
322	10 Aug	Niguanak (CP)			1	-	-	3	
323	13 Aug	Canning (F)		1		F	-	5	
324	14 Aug	Jago (CP)		1		F	-	5	
325	14 Aug	Kongakut (F)		1		F	-	2	
326	15 Aug	Niguanak (CP)			1	F	-	3	
327	16 Aug	Kekiktuk (F)		1		F	-	5	
328	16 Aug	Niguanak (CP)		1		P	-	3	
329	16 Aug	Jago Delta		1		F	-	3	
330	20 Aug	Sadlerochit (F)			1	F	-	2	
331	21 Aug	Kongakut (M)			1	F	-	2	
332	25 Aug	Okerokovik (CP)		1		P	-	2	
333	29 Aug	Sadlerochit (M)			2	P	-	2	
334	6 Sep	Jago (CP)			1	F	-	7	
335	13 Sep	Kongakut (F)			1	F	-	2	
336	26 Sep	Kongakut (F)			1	F			

[a] (M) = mountains
(F) =foothills
(CP) =coastal plain
[b] U =unidentified
[c] F =flying
P =perched
[d] + =caribou present or recently present
\- =caribou not present

[e] (1) = caribou survey (aerial)
(2) = bear survey (aerial)
(3) = terrestrail bird investigations (ground)
(4) = raptor survey (ground and aerial)
(5) = musk ox survey (aerial)
(6) = fisheries investigations (ground)
(7) = tundra swan survey (aerial)
(9) = miscellaneous (ground)

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MIGRATORY BIRD USE OF THE COASTAL LAGOON SYSTEM OF THE BEAUFORT SEA COASTLINE WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1985

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Key words: Migratory birds, oldsquaw, abundance, distribution, Arctic-Beaufort

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Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska 1985.

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Abstract: Two aerial surveys were flown in 1985 on 14 lagoons and a 400 m wide strip adjacent to the shoreline and barrier beaches along the coast of the Arctic National Wildlife Refuge. A total of 21,478 and 19,605 birds of 17 species were counted on 26 July and 15 August, respectively. Oldsquaw (*Clangula hyemalis*) comprised 92.3% and 92.6% of the total number of birds present on 26 July and 15 August, respectively. The mean number of species present during 5 years of surveys was 16.6 ± 2.6 SD. A comparison of lagoon physical characteristics (area, water depth, barrier island length, mudflat length, shoreline length, and lagoon type) with abundance parameters showed that water depth and area was the major positive determinant of the proportion of the oldsquaw in the system which may use a particular lagoon. The number of species in a lagoon during a survey was influenced only by shoreline length. Weekly means of oldsquaw numbers estimated during 5 years of surveys (1981-1985) peaked during the first week in August and declined steadily into early September. Other species were variable in numbers and seasonal distribution.

Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic Wildlife Refuge, Alaska 1985.

Substantial concentrations of breeding and post-breeding migratory birds use the Beaufort Sea coastal lagoons during the short open-water season. Previous studies of Beaufort Sea coastal lagoons have found that oldsquaw undergoing post-breeding wing molt and premigratory staging is the predominant species present (Schmidt 1970, Bartels 1973, Gollop and Richardson 1974, Ward and Sharp 1974, Harrison 1977, Divoky and Good 1979, Spindler 1979, Johnson and Richardson 1981, Bartels and Zellhoefer 1983, Johnson 1983, Bartels and Doyle 1984, Brackney et al. 1985).

Proposed petroleum exploration of the coastal plain of the Arctic National Wildlife Refuge, as well as leasing of nearby offshore tracts and nearshore areas will place industrial activity in close proximity to the lagoon system. Air and boat traffic along the coast will increase to support these exploration programs. A thorough knowledge of population levels and temporal and spatial distribution patterns of migratory birds using the lagoon system is essential to predict the potential effects of disturbance and pollution.

Aerial surveys of migratory birds using the lagoon system of the ANWR were initiated in 1970 and continued sporadically until they were standardized in 1981 (Schmidt 1970, Frickie and Schmidt 1974, Spindler 1978 and 1979, Bartels and Zellhoefer 1983, Bartels and Doyle 1984, Brackney et al. 1985). The objectives of the 1985 season were:

1. Obtain an index of relative numbers of migratory birds using coastal lagoons, and oldsquaw molting in selected lagoons.

2. Continue investigating the validity of the 400 m strip aerial census by comparing data for 400 m strips with aerial census of the entire lagoon surface.

3. Examine the distribution of oldsquaw within the 16 km offshore area of the Beaufort Sea.

Methods and Materials

Three aerial surveys were conducted on the coastal lagoons of ANWR from the Canning River to the U.S.-Canada border. Data from the second survey was omitted from the analysis. The survey was completed under marginal weather conditions that had reduced visibility on several lagoons. A fourth survey was attempted but could not be completed due to adverse weather conditions. Flights along 16 km offshore transects perpendicular to the shoreline were not possible in 1985, as ice conditions offshore did not permit safe flight with available aircraft.

Ten selected lagoons (Demarcation Bay, Egaksrak Lagoon, Nuvagapak Lagoon, Oruktalik Lagoon, Tapkaurak Lagoon, Jago Lagoon, Arey Lagoon, Simpson Cove, Tamayariak Lagoon, and Brownlow Lagoon) have been surveyed annually since 1981 when survey techniques were standardized. The 1985 surveys included 4 additional lagoons (Sadlerochit Lagoon, Kaktovik Lagoon, Siku Lagoon, and

Angun Lagoon/Pokok Bay) which were first surveyed in 1984. Aerial survey methods followed those described by Bartels and Zellhoefer (1983). Transects were flown with a Cessna 206 floatplane at an altitude of 30 m and an indicated air speed of 160 kph along predetermined routes parallel to the barrier islands and shorelines. Successive transects were flown across the lagoon until the entire lagoon was surveyed. Two observers, one on each side of the aircraft, identified and counted or estimated numbers of all birds seen within a 200 m strip on their respective sides. Data were recorded with portable cassette recorders and later transcribed by the observers. A 400 m strip offshore of the barrier islands and shoreline of the entire coast was also surveyed.

An examination of the effectiveness of partial lagoon surveys as estimators for whole lagoon densities was initiated in 1983. This comparison of survey techniques was postponed until 1985 when all data for the 10 selected lagoons from 1981 to 1985 were analyzed. Oldsquaw densities of certain transects were compared with the density of entire lagoons using paired t tests and regression analysis.

Statistical procedures reported here follow the guidelines of Snedecor and Cochran (1967). All statistical analysis were run in the SCSS statistical package (Nie et al. 1980) on a microcomputer.

Results and Discussion

All bird species 1985

Peak bird use probably occurred between the 2 valid surverys conducted on 26 July and 15 August 1985.surveys. On 26 July a high of 21,478 birds was observed in the 10 lagoons and the 400 m offshore transect (Table 1). On 15 August an estimated 19,605 birds were present.

Table 1. Number of migratory birds observed in 10 coastal lagoons and 400 m offshore strip along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, 1985.

	Date of Survey			
	26 July		15 August	
Lagoon	No. Birds	No. Taxa	No. Birds	No. Taxa
Demarcation	3899	12	3957	8
Egaksrak	164	10	586	11
Nuvagapak	1732	9	3886	11
Oriektuluk	1145	7	1770	7
Tapkaurak	1485	7	1653	7
Jago	4364	8	2840	7
Arey	703	9	360	7
Simpson Cove	1829	6	546	5
Tamayariak	878	6	642	5
Brownlow	80	3	50	5
400m offshore	5199	1	3315	1
Total	21478	17	19605	17

The 1985 season appeared to be normal in bird use and distribution within the lagoon system. Seventeen species were observed in each survey in 1985, which was close to the 5 year mean of 16.6 species per survey (Table 2).

Table 2. Numbers of bird species observed in the coastal lagoons during 5 years of lagoon surveys in the Arctic National Wildlife Refuge coastline 1981-85.

	Year					
Time Period	1981	1982	1983	1984	1985	Mean
20-31 July	20	12		13	17	15.5
1- 7 August	16		17	15		16.0
8-15 August		17	18		17	17.3
16-23 August	13	17	22	17		16.0
7 September			18			
Overall Mean (±SD)						16.6 ± 2.6

Oldsquaw 1985

Estimated numbers of oldsquaw in the 10 select lagoons and 400 m offshore area were 19,885 on 26 July and 18,103 on 15 August (Table 3). Oldsquaw made up 92.3% to 92.6% of the total birds present in those lagoons. In all 14 lagoons surveyed, oldsquaw totaled 24,204 and 20,630 on 22 July and 15 August. Four additional lagoons contained 17.8% and 12.3% of the oldsquaw seen on 22 July and 15 August respectively (Table 4).

Table 3. Number of oldsquaw estimated in 10 select lagoons and 400m offshore strip on the Arctic National Wildlife refuge Alaska, 1985.

	Survey Date	
Lagoon	26 July	15 August
Demarcation	3621	3690
Egaksrak	121	152
Nuvagapak	1615	3730
Oruktulik	1121	1710
Tapkaurak	1450	1574
Jago	4137	2753
Arey	593	328
Simpson Cove	1797	537
Tamayariak	836	491
Brownlow	70	35
400m offshore	4524	3103
Total	19885	18103

Table 4. Oldsquaw observed in 4 additional lagoons surveyed in 1984-1985.

	1984			1985	
Lagoon	22 July	5 August	13 August	26 July	15 August
Siku	41	58	22	08	03
Angun/Pokok	319	1464	1909	1583	1618
Kaktovik	1405	1441	822	2161	731
Sadlerochit	903	752	1352	567	175
Totals	2668	3715	4105	4319	2527

Oldsquaw densities in the 10 select lagoons were consistent with past years and in the middle range of past surveys. Overall densities were 54.7 oldsquaw/km^2 on 26 July and 49.8 oldsquaw/km^2 on 15 August (Table 5). Oruktalik lagoon, as in past years, contained the highest densities at 127.4 and 194.3 oldsquaw/km^2 on 26 July and 15 August, respectively. Brownlow and Arey lagoon had low usage by oldsquaw in 1985. The 2.7 oldsquaw/km^2 seen at Brownlow on 15 August was the lowest recorded during the 5 years of surveys, and the 5.3 oldsquaw/km^2 seen on 26 July, was the 3rd lowest. Arey lagoon experienced a density of only 8.1 oldsquaw/km^2 on 15 August. Densities on Arey lagoon have varied from 4.3 to 40.6 oldsquaw/km^2 in 15 surveys over the 5 years.

Table 5. Density (birds/km^2) of oldsquaw counted in 10 select lagoons and a 400m offshore strip in 1985 on the Arctic National Wildlife Refuge, Alaska.

		Survey Date	
Lagoon	Area km^2	26 July	15 August
Demarcation	38.7	93.6	95.3
Egaksrak	14.0	8.6	10.9
Nuvagapak	31.2	51.8	119.6
Oruktulik	8.8	127.4	194.3
Tapkaurak	20.5	70.7	76.8
Jago	47.3	87.5	58.2
Arey	40.6	14.6	8.1
Simpson Cove	44.4	40.5	12.1
Tamayariak	15.9	52.6	30.9
Brownlow	13.1	5.3	2.7
400m offshore	88.8	50.9	34.9
Total	363.3	54.7	49.8

The 400 m offshore transect accounted for 18.7% and 15.0% of the oldsquaw along the coastline on 26 July and 15 August. The number and proportions of oldsquaw in the offshore transect did not increase during the season as in past years, possibly due to mid-August departures of large numbers of oldsquaw.

5 Year Summary

Weekly mean numbers of oldsquaw and all bird species were plotted for the 10 lagoons and the offshore transect to summarize the results of the 5 years of surveys and evaluate trends (raw values are tabulated in the Appendix). Total bird numbers increased early in the season with a peak in early to mid-August (Fig. 1a) (Bartels and Zellhoefer 1983, Bartels and Dolye 1984, Brackney et al. 1985). The majority of birds observed in the lagoons and offshore were oldsquaw (Fig. 1a). Mean oldsquaw numbers peaked during early-August and then declined sharply from mid-August to September (Fig 1b). The large September increase for all species was due to an estimated 16,000 phalaropes tallied during a September 1983 survey in the offshore transect (Fig. 1c). Eiders and scoters showed large fluctuations in mean numbers from late July to September, with a general trend downward (Fig. 2c,2d). 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. 2f). Mean loon numbers appeared to decrease from mid-August to September (Fig. 2a) 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. 2e). 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 at other Beaufort Sea coastal areas. Their data and the data from this baseline study highlight the importance of these coastal areas to migratory birds.

Lagoon Characteristics and Bird Densities

To compare the relative value of the 10 selected lagoons, an index was calculated from the density ratio (lagoon density/grand density), the proportion of birds per lagoon, and the mean number of species present (Table 6). 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 relatively higher value for all birds on Demarcation Bay, Jago, and Nuvagapak Lagoons (Table 6). Medium value lagoons were Oruktalik, Tamayariak, and Simpson Cove. Tapkaurak, Arey, Brownlow, and Egaksrak rated low despite the high species richness in Egaksrak 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 values for Arey, Brownlow and Egaksrak Lagoons. The high density ratios at Oruktalik raised the value on that lagoon for oldsquaw in relation to the total species value.

The relative value measures were compared (Table 6) with the physical characteristics of the lagoons (Table 7) by multiple regression to examine the

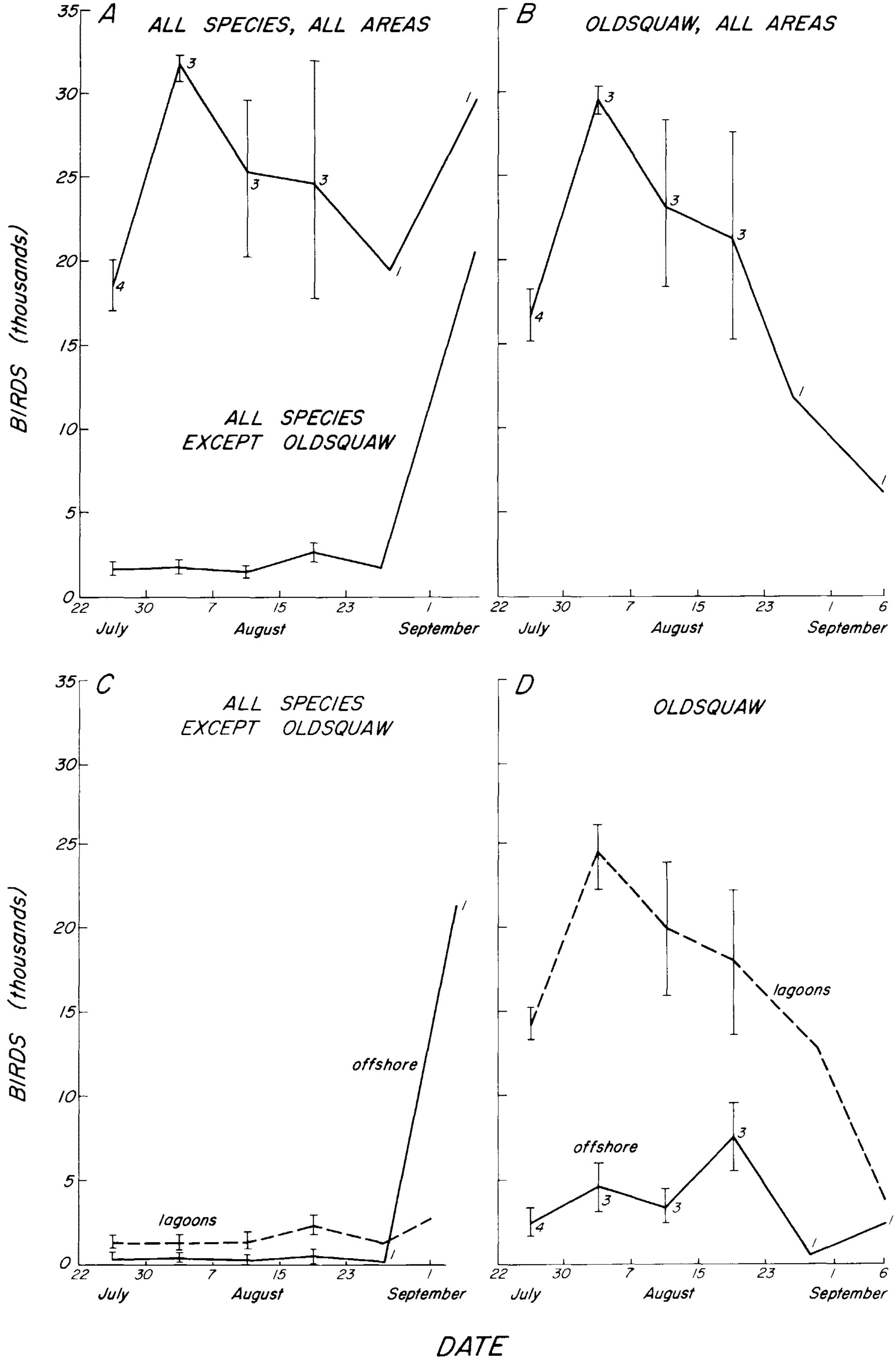

FIG. **1**. SEASONAL DISTRIBUTION OF MEAN NUMBERS OF OLDSQUAW AND ALL SPECIES IN LAGOON AND OFFSHORE HABITATS, ARCTIC NATIONAL WILDLIFE REFUGE 1981-1985. VERTICAL BARS INDICATE S.E. AND NUMBERS INDICATE SAMPLE SIZE.

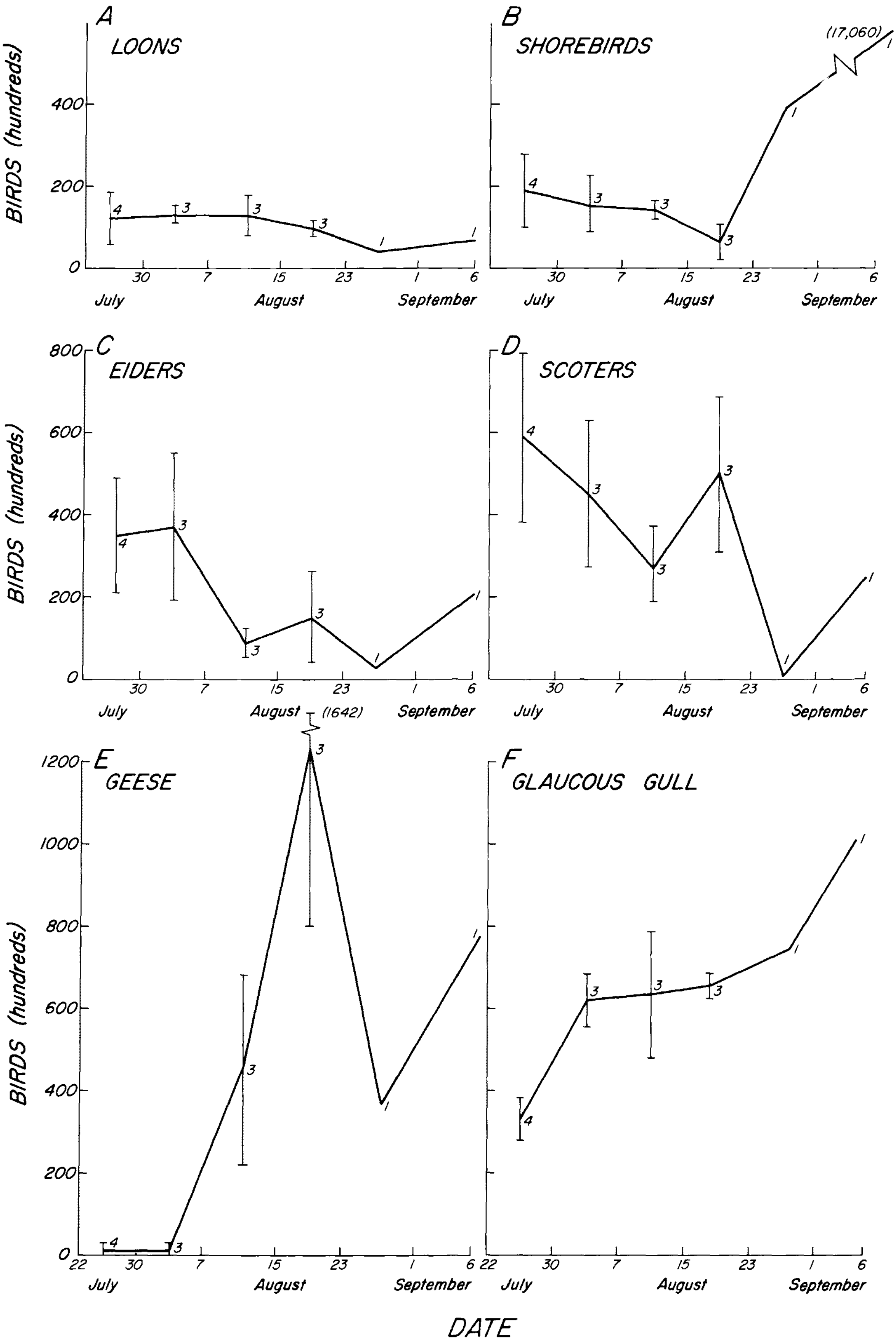

FIG. **2**. SEASONAL DISTRIBUTION OF MEAN NUMBERS OF VARIOUS WATERBIRD GROUPS IN LAGOON AND OFFSHORE HABITATS, ARCTIC NATIONAL WILDLIFE REFUGE 1981-1985. VERTICAL BARS INDICATE S.E. AND NUMBERS INDICATE SAMPLE SIZE.

Table 6. Measures of the relative value of 10 selected lagoons for oldsquaw and all species.

	All Species				Oldsquaw		
Lagoon	Proportion[a] of total	Mean[b] density ratio	Mean[c] No. species	Relative 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 7. Physical characteristics of 10 lagoons on the ANWR Coastline.

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	0.0	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	0.0	Pulsing
Nuvagapak	31.2	2.0	10.9	27.8	0.0	Pulsing
Tamayariak	15.9	1.8	4.6	12.6	4.5	Open
Tapkaurak	20.5	1.4	9.6	9.0	0.0	Pulsing
Arey	40.6	0.6	13.8	30.9	0.0	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).

influence of other physical variables on bird use. Back-stepping multiple regression procedure (Zar 1973) revealed a positive association between proportion of birds in the system present in a particular lagoon with water depth and lagoon area ($P < 0.001$, $R^2 = 0.92$). The proportion of oldsquaw in a lagoon was also positively associated with water depth and area ($P < 0.001$, $R^2 = 0.92$). The number of species in a lagoon was positively dependent on shoreline length ($P < 0.03$, $R^2 = 0.68$). All other physical characteristics had little effect on species richness. Long shoreline length may provide a higher probability that nontypical and semi-aquatic birds species may enter the lagoon. Species which breed along shorelines may have also had a higher probability of being included in the survey in lagoons with long shorelines. 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.

Offshore Habitats

The species with the highest estimated numbers in the offshore transect (generally 0-400 m offshore of the barrier islands) was oldsquaw (Figs. 1c and d). Second in abundance was the glaucous gull. This trend was valid for all surveys except the 7 September 1983 survey when phalaropes dominated the estimates (Fig. 1b). Total numbers of oldsquaw estimated on the 88.8 km^2 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.1b and d). This increase coincided with the completion of the molt in oldsquaw. We have observed oldsquaw leaving the offshore area and flying into the lagoons to roost in the evening during the period following molt (Brackney unpubl. data). 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 suggests that this area supports considerable bird use. As in the lagoons, this use varies widely within a particular season and from year to year.

Density Estimators

Whole lagoon surveys (i.e. the entire lagoon is covered by aerial transects) are expensive and time-consuming. A complete survey of 14 lagoons on the ANWR coastline involved 8 hours of air time at a minimum. Weather conditions often changed between the begining and end of the surveys which made some estimates between lagoons less comparable due to changes in visibility. We investigated several combinations of the transects along the barrier island, mid-lagoon, and shoreline in order to find a suitable estimator as an alternative to whole lagoon surveys. Areas within transects (Table 8) and corresponding numbers of oldsquaw observed were used to determine densities for each alternative and regression estimators of the whole-lagoon density were calculated. Only lagoons with more than 3 transects were used in the regression analysis.

None of the transect combinations proved to be adequate estimators of oldsquaw density (Table 9). The method of Johnson and Richardson (1981) was the most tenable (R^2 = 0.78). In this method the mid-lagoon and shoreline transects were used to estimate the number of oldsquaw in the lagoon outside of the barrier island area, than this total was added to the number along the barrier island transect. The method worked best on lagoon surveys with less than 4300 birds per lagoon (R^2 = 0.806). However the regression failed to account for nearly 20% of the variance in the data.

Table 8. Area (km^2) within the barrier islands, mid lagoon, and shoreline aerial transects of 8 lagoons along the coastline of the Arctic National Wildlife Refuge.

	Transect Area (km^2)		
Lagoon	Barrier Island	Mid-Lagoon	Shoreline
Simpson Cove	6.7	5.5	5.2
Arey	5.4	4.9	3.4
Jago	5.4	2.5	2.8
Tapkaurak	4.3	3.2	0.6
Oruktalik	2.2	2.1	0.8
Nuvagapak	5.9	4.6	1.6
Egaksrak	2.7	1.3	0.9
Demarcation Bay	2.0	3.1	2.0

Table 9. Regression equations of estimated densities (y) on whole lagoon densities (x) from 15 survey of 8 select lagoons, Arctic National Wildlife Refuge, 1981-1985.

Density Estimator	N	Regression Equation	R^2
BI + Mid + Shore[a]	71	y= -8.40 + 2.05X	0.719*[b]
BI + Mid	71	y=-20.41 + 2.43X	0.620*
BI + Shore	71	y=-38.07 + 2.90X	0.588*
Mid + Shore	71	y=-91.90 + 4.57X	0.432*
[Mid + Shore] + BI[c]	71	y= 16.49 + 1.26X	0.780*
[Mid + Shore] + BI[cd]	65	y= 17.25 + 1.19X	0.806*

[a] BI = barrier island transect, Mid = mid-lagoon transect, Shore = shoreline transect

[b] * Significant ($P < 0.001$)

[c] [[((Mid + Shore no.)/(Mid Area + Shore Area)) * (Total Area - BI Area)]+BI no.]/ Total Area, after Johnson and Richardson (1981).

[d] Sample limited to lagoon estimates less than 4300 oldsquaw.

One problem with these estimates was the failure of the mid-lagoon and shoreline transects to adequately represent the density in the lagoon outside of the barrier island area. A regression of the mid-lagoon plus shoreline transect densities on the non-barrier island area density accounted for only 67.1% of the variance. Thus, the combination of these transects with the higher densities in the barrier island transects could not adequately estimate densities in the entire lagoon. Therefore, past efforts which used incomplete surveys (Spindler 1978 and 1979, Johnson and Richardson 1981, Johnson 1983) must be viewed as rough estimates of oldsquaw densities in Beaufort Sea lagoons. In these baseline studies also, although we maintained strict controls in regard to minimum acceptable weather conditions, the accuracy of estimates of oldsquaw numbers varied due to differences in visibility between surveys (and between lagoons within surveys), annual changes in observers, and possible observer errors in estimation of bird numbers (see Oates et al. 1985 and Oates et al. 1986). No effort was made during the studies to verify or correct for observer errors or bias. Most oldsquaw flocks, however, were less than 100 birds and seldom more than 300 at any one location, which tended to facilitate precise estimation.

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APPENDIX
ANWR Progress Report Number FY85-15

Appendix Table 1. Number of migratory birds estimated in 10 coastal lagoons and offshore Arctic National Wildlife Refuge, Alaska, 1981-1985.

	Survey Dates															
Lagoon	22-23 July 1981	25-26 Aug 1981	25-26 July 1982	3-4 Aug 1982	7&13 Aug 1982	22 Aug 1982	4 Aug 1983	10 Aug 1983	20 Aug 1983	6-8 Sept 1983	22 July 1984	5 Aug 1984	18 Aug 1984	26 July 1985	15 Aug 1985	Mean No. Species (mean + SD)
Demarcation Bay																
No. birds	2865	1667	849	1611	538	1061	8299	11586	1500	876	2380	3281	2504	3899	3957	
No. taxa	13	6	9	9	9	6	8	8	9	9	5	12	10	12	8	8.97 ± 2.36
Egakshrak Lagoon																
No. birds	547	1146	111	441	967	580	435	418	1552	220	144	536	986	164	586	
No. taxa	15	10	5	9	5	5	7	7	6	6	4	7	6	10	11	7.5 ± 3.0
Nuvagapak Lagoon																
No. birds	1477	1060	146	2486	2845	2286	5746	4654	1755	535	812	3153	3983	1732	3886	
No. taxa	13	5	5	10	13	8	10	6	8	9	7	11	10	9	11	9.0 ± 2.5
Oruktalik Lagoon																
No. birds	2032	41	1704	1714	1958	545	1533	3226	367	249	1604	1733	1956	1145	1770	
No. taxa	10	3	3	4	3	4	4	5	4	7	7	6	7	7	7	5.4 ± 2.1
Tapkaurak Lagoon																
No. birds	2720	2159	1304	2897	703	85	891	2125	669	690	1736	1550	2105	1485	1653	
No. taxa	6	3	4	6	6	5	3	3	4	5	6	5	6	7	7	5.1 ± 1.4
Jago Lagoon																
No. birds	4131	5986	4189	5895	806	1053	6192	2681	676	854	2150	4803	3033	4364	2840	
No. taxa	12	5	9	8	9	8	7	6	5	6	7	6	7	8	7	7.3 ± 1.8
Arey Lagoon																
No. birds	376	209	306	1319	603	456	2541	1233	1859	2629	1105	1208	1702	703	360	
No. taxa	12	4	4	10	9	8	6	11	10	11	7	12	7	9	7	8.5 ± 2.6
Simpson Cove																
No. birds	920	317	3015	9296	4376	711	817	2881	9781	1217	4498	4235	1411	1829	546	
No. taxa	9	7	6	10	7	8	6	9	7	8	8	9	5	6	5	7.3 ± 1.5
Tamayariak Lagoon																
No. birds	174	202	916	2846	5222	337	582	313	3172	446	2359	1571	2072	878	642	
No. taxa	5	6	7	10	7	6	5	7	7	5	7	6	9	6	5	6.4 ± 1.7
Brownlow Lagoon																
No. birds	52	111	446	744	748	238	58	93	823	164	537	376	595	80	50	
No. taxa	2	6	4	5	5	6	5	4	8	3	7	7	6	3	5	4.9 ± 1.8
Total lagoon	15294	12898	12986	29249	18766	7352	27094	29210	22154	7880	17325	22446	20349	16279	16290	
400 m offshore	1947	1086	1927	3257	2046	4274	4667	5881	8935	21384	3305	7923	11433	5199	3315	
All areas	17241	13984	14913	32506	20812	11626	31761	35091	31089	29264	20630	30369	31782	21478	19605	

Appendix Table 2. Number of oldsquaw estimated in 10 coastal lagoons and offshore, Arctic National Wildlife Refuge, Alaska, 1981-1985.

	1981[a]			1982[a]			1983[b]				1984[c]			1985	
Lagoon	22-23 July	3-4 Aug	22-26 Aug	25-26 July	7-13 Aug	22 Aug	4 Aug	10 Aug	20 Aug	6-8 Sept	22 July	5 Aug	18 Aug	26 July	15 Aug
Demarcation	26786	1557	1611	617	299	191	8116	11319	1301	293	2218	2884	1916	3621	3690
Egaksrak	107	355	97	82	234	61	324	314	205	6	98	445	520	121	152
Nuvagapak	1427	2448	1004	126	2669	1422	5689	4572	1076	222	732	2996	3631	1615	3730
Oruktalik	1997	1698	38	1657	1906	508	1524	3206	335	84	1531	2669	1932	1121	1710
Tapkauruk	2688	2867	2150	1273	642	71	884	2102	647	78	1620	1491	2070	1450	1574
Jago	3988	5184	5674	3845	650	727	5757	2342	551	761	1892	4544	2730	4137	2753
Arey	293	1076	174	274	347	352	2410	1055	1548	1886	942	979	1634	593	328
Simpson Cove	850	9187	205	2906	4326	665	750	2792	9678	1119	4113	4069	1396	1797	537
Tamayariak	162	2606	150	625	5202	321	565	276	3116	334	2165	1503	1945	836	491
Brownlow	50	693	95	415	711	204	45	70	750	150	453	310	560	70	35
Total lagoons	14240	27671	11198	11820	16986	5250	26064	28048	19207	4943	15764	20890	18334	15361	15000
400 m offshore strip	1696	2868	8258	1339	1911	3867	3849	5379	8225	2533	2796	7378	10995	4524	3103
All areas	15936	30539	12022	13159	18897	9117	29913	33427	27432	7476	18560	28268	29329	19885	18103

[a] Data from Bartels and Zellhoefer (1983).
[b] Data from Bartels and Doyle (1984).
[c] Data from Brackney et al. (1985).

Appendix Table 3. Density (birds/km^2) of oldsquaw counted in 10 selected lagoons and offshore, Arctic National Wildlife Refuge, Alaska, 1981-1985.

Lagoon	Area km^2	1981[a] 22-23 July	1981[a] 3-4 Aug	1981[a] 22-26 Aug	1982[a] 25-26 July	1982[a] 7-13 Aug	1982[a] 22 Aug	1983[b] 4 Aug	1983[b] 10 Aug	1983[b] 20 Aug	1983[b] 6-8 Sept	1984[c] 22 July	1984[c] 5 Aug	1984[c] 18 Aug	1985 26 July	1985 15 Aug
Demarcation	38.7	69.2	40.2	41.6	15.9	7.7	23.7	210	292	34	8	57.3	74.5	49.5	93.6	95.3
Egaksrak	14.0	7.6	25.4	6.9	5.9	16.7	4.4	23	22	15	0.4	7.0	31.8	37.1	8.6	10.9
Nuvagapak	31.2	45.7	78.5	32.2	4.0	85.5	45.6	182	147	34	7	23.5	96.0	116.4	51.8	119.6
Oruktalik	8.8	226.9	193.0	4.3	188.0	216.6	57.7	173	364	38	10	174.0	189.6	219.5	127.4	194.3
Tapkauruk	20.5	131.1	139.8	105.5	62.1	31.3	3.5	43	103	32	4	79.0	72.7	101.0	70.7	76.8
Jago	47.3	84.3	122.9	120.0	81.2	13.7	15.4	122	50	12	16	40.0	96.1	57.7	87.5	58.2
Arey	40.6	7.2	26.5	4.3	6.7	8.5	8.7	59	26	38	46	23.2	24.1	40.3	14.6	8.1
Simpson Cove	44.4	19.1	206.7	4.1	65.4	97.4	15.0	17	63	218	25	92.6	91.6	31.4	40.5	12.1
Tamayariak	15.9	10.2	163.9	9.4	39.3	327.2	20.2	35	17	196	22	136.2	94.5	122.3	52.6	30.9
Brownlow	13.1	3.8	52.9	7.3	31.6	54.3	32.9	3	5	57	11	34.6	23.7	42.8	5.3	2.7
Total lagoon	274.5	51.9	100.8	40.8	43.1	61.9	19.1	95	102	70	18.0	57.4	76.1	66.8	56.0	54.6
400m offshore strip	88.8	19.1	32.3	9.3	15.1	21.5	43.6	43.3	60.6	92.6	28.5	31.5	83.1	123.8	50.9	34.9
All areas	363.3	43.9	84.1	33.1	36.2	52.0	25.1	82.3	92.0	75.5	20.6	51.1	77.8	80.7	54.7	49.8

[a] Data from Bartels and Zellhoefer (1983).
[b] Data from Bartels and Doyle (1984).
[c] Data from Brackney et al. (1985).

Appendix Table 4. Numbers of oldsquaw and all species in 10 coastal lagoons and a 400m offshore transect grouped by weekly periods, Arctic National Wildlife Refuge, 1981-1985.

	20-31 July	1-7 Aug	8-15 Aug	16-22 Aug	23-30 Aug	7 Sept
All spp., all areas						
mean	18565	31545	25169	24832	13984	29264
SD	3046	1085	8614	11442	-	-
All spp., 10 lagoons only						
mean	15471	26263	21422	1661	12898	7880
SD	11853	3477	6857	8075	-	-
All spp., offshore only						
mean	3094	5282	3747	8214	1086	21384
SD	1544	2393	1954	3634	-	-
All spp. except oldsquaw, all areas						
mean	1680	1972	1694	2873	1962	21788
SD	319	126	208	680	-	-
All spp. except oldsquaw, in lagoons only						
mean	1175	1388	1411	2355	1700	2937
SD	277	310	326	515	-	-
All spp. except oldsquaw, offshore only						
mean	506	584	283	518	262	18851
SD	183	217	194	167	-	-
No. oldsquaw, lagoons only						
mean	14296	24875	20011	14263	11198	4943
SD	1772	3542	7030	7818	-	-
No. oldsquaw, offshore only						
mean	2589	4698	3464	7696	824	2533
SD	1431	2372	1762	3593	-	-

[a] SD = standard deviation

Appendix Table 5. Mean numbers of major bird species grouped by weekly period in 10 coastal lagoons and a 400 m offshore transect, Arctic National Wildlife Refuge 1981-1985.

Weekly Period		Eiders	Scoters	Glaucous Gulls	Loons	Shorebirds	Geese	Oldsquaw
July 20-31	mean (n = 4)	318.8	594.0	295.0	101.3	165.3	12.5	16885.0
	SD	248.2	412.0	54.8	89.7	165.3	18.8	2977.1
Aug 1-7	mean (n = 3)	372.7	454.0	419.0	125.7	155.0	12.7	29573.3
	SD	370.7	298.5	111.6	22.5	135.2	17.0	1173.0
Aug 8-15	mean (n = 3)	89.7	257.0	414.7	119.0	135.3	431.7	23475.7
	SD	60.9	160.1	273.4	76.3	49.3	359.7	8627.3
Aug 16-22	mean (n = 3)	155.3	502.0	447.7	97.0	64.7	1225.7	21959.0
	SD	190.1	325.5	40.2	27.9	68.6	725.1	11162.1
Aug 23-30	mean (n = 1)	23	6	544	41	388	369	12022
Sept 7	mean (n = 1)	206	250	1005	64	17060	770	7476

Appendix Table 6. Migratory bird species and numbers observed during aerial surveys of Brownlow and Tamayariak Lagoons along the Beaufort Sea coastline, in the Arctic National Wildlife Refuge, Alaska, 1985.

	Brown Low Lagoon		Tamayariak Lagoon	
Species	26 July	15 Aug	26 July	15 Aug
Common Loon				
Yellow-billed Loon				
Arctic Loon	4			1
Red-throated Loon		1		1
Loon spp.	5		2	2
Red-necked Grebe				
Tundra Swan				
Brant				142
Snowgoose				
Goose spp.				
Northern Pintail		8	15	
Scaup spp.				
Oldsquaw	70	35	836	491
Common Eider				
King Eider				
Spectacled Eider				
Eider spp.				
White-winged Scoter				
Surf Scoter			3	
Black Scoter				
Scoter spp.			2	
Red-breasted Merganser			3	
Duck spp.				
Sandhill Crane				
Plover spp.				
Phalarope spp.				
Shorebird spp.				
Jaeger spp.				
Glaucous Gull		1	17	5
Herring-Thayer's Gull				
Black-legged Kittiwake				
Sabines Gull				
Arctic Tern		5		
Black Guillemot				
Passerine spp.	1			
Raven				
Snowy Owl				
Mew Gull				
Gull spp.				
Gyrfalcon				
Unidentified spp.				

Appendix Table 7. Migratory bird species and numbers observed during aerial surveys of Simpson cove and Sadlerochit lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1985.

	Simpson Cove		Sadlerochit lagoon	
Species	26 July	15 Aug	26 July	15 Aug
Common Loon			1	
Yellow-billed Loon			2	
Arctic Loon	2		2	
Red-throated Loon	3		1	
Loon spp.				
Red-necked Grebe				
Tundra Swan	2			
Brant				
Snowgoose				
Goose spp.				
Northern Pintail				26
Scaup spp.				
Oldsquaw	1797	537	567	175
Common Eider	3			
King Eider				
Spectacled Eider				
Eider spp.	4			
White-winged Scoter				22
Surf Scoter				
Black Scoter				
Scoter spp.		1		
Red-breasted Merganser				
Duck spp.				
Sandhill Crane				
Plover spp.				
Phalarope spp.				
Shorebird spp.		4	13	1
Jaeger spp.			1	
Glaucous Gull	18	3	26	9
Herring-Thayer's Gull				
Black-legged Kittiwake				
Sabines Gull				
Arctic Tern		1		19
Black Guillemot				
Passerine spp.				
Raven				
Snowy Owl				
Mew Gull				
Gull Species				
Gyrfalcon				
Ross Gull			10	
Unidentified ssp.				
Seal				

Appendix Table 8. Migratory bird species and numbers observed during aerial surveys of Arey and Kaktovik lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1985.

	Arey Lagoon		Kaktovik Lagoon	
	26 July	15 Aug	26 July	15 Aug
Common Loon				
Yellow-billed Loon	7		14	
Arctic Loon	13		7	4
Red-throated Loon	5		2	
Loon spp.	15	2	12	
Red-necked Grebe				
Tundra Swan				
Brant				
Snowgoose				
Goose spp.				
Northern Pintail		1		
Scaup spp.				
Oldsquaw	593	328	2161	731
Common Eider	4			
King Eider		2		
Spectacled Eider				
Eider spp.	4			
White-winged Scoter				
Surf Scoter		15		
Black Scoter				
Scoter spp.				
Red-breasted Merganser				
Duck spp.				
Sandhill Crane				
Plover spp.				
Phalarope spp.				
Shorebird spp.	5			
Jaeger spp.				
Glaucous Gull	55	11	54	6
Herring-Thayer's Gull				
Black-legged Kittiwake				
Sabines Gull				
Arctic Tern		1	2	
Black Guillemot				
Passerine spp.				
Raven	5			
Snowy Owl	1			
Mew Gull				
Gull Species				
Gyrfalcon				
Unidentified spp.				
Seal				

Appendix Table 9. Migratory bird species and numbers observed during aerial surveys of Jago and Tapkuarak lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1985.

	Jago Lagoon		Tapkuarak Lagoon	
	26 July	15 Aug	26 July	15 Aug
Common Loon				
Yellow-billed Loon	12	4	7	2
Arctic Loon	21	7	4	
Red-throated Loon	5	1	1	1
Loon spp.	10	11	1	2
Red-necked Grebe				
Tundra Swan				
Brant				
Snowgoose				
Goose spp.				
Northern Pintail				
Scaup spp.				
Oldsquaw	4137	2753	1450	1574
Common Eider				
King Eider				
Spectacled Eider				
Eider spp.			4	
White-winged Scoter				
Surf Scoter	50	45		10
Black Scoter				
Scoter spp.		1		33
Red-breasted Merganser	15			
Duck spp.				
Sandhill Crane				
Plover spp.				
Phalarope spp.				
Shorebird spp.			16	20
Jaeger spp.				
Glaucous Gull	109	15	2	11
Herring-Thayer's Gull				
Black-legged Kittiwake				
Sabines Gull				
Arctic Tern	5	3		
Black Guillemot				
Passerine spp.				
Raven				
Snowy Owl				
Mew Gull				
Gull Species				
Gyrfalcon				
Unidentified spp.				

Appendix Table 10. Migratory bird species and numbers observed during aerial surveys of Oruktalik and Angnun lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1985.

	Oruktalik Lagoon		Angnun Lagoon	
	26 July	15 Aug	26 July	15 Aug
Common Loon				
Yellow-billed Loon	8	4	5	2
Arctic Loon	2	1	2	1
Red-throated Loon		1		1
Loon spp.	1	7		
Red-necked Grebe				
Tundra Swan	2			
Brant		45		
Snowgoose				
Goose spp.	1			
Northern Pintail				
Scaup spp.				
Oldsquaw	1121	1710	832	897
Common Eider				
King Eider				
Spectacled Eider				
Eider spp.				
White-winged Scoter				
Surf Scoter				
Black Scoter				
Scoter spp.				1
Red-breasted Merganser	3			
Duck spp.				
Sandhill Crane				
Plover spp.				
Phalarope spp.				
Shorebird spp.				
Jaeger spp.				
Glaucous Gull	7	1	8	1
Herring-Thayer's Gull				
Black-legged Kittiwake				
Sabines Gull				
Arctic Tern				
Black Guillemot				
Passerine spp.				
Raven				
Snowy Owl		1		
Mew Gull				
Gull spp.				
Gyrfalcon				
Unidentified spp.				

Appendix Table 11. Migratory bird species and numbers observed during aerial surveys of Pokok Bay and Nuvagapak lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1985.

	Pokok Bay		Nuvagapak Lagoon	
	26 July	15 Aug	26 July	15 Aug
Common Loon				
Yellow-billed Loon	6		12	
Arctic Loon	1		9	3
Red-throated Loon	1		3	4
Loon spp.	5	2	5	5
Red-necked Grebe				
Tundra Swan	2			1
Brant				15
Snowgoose				
Goose spp.				
Northern Pintail				
Scaup spp.				10
Oldsquaw	747	706	1615	3730
Common Eider				
King Eider			4	
Spectacled Eider				
Eider spp.				
White-winged Scoter				
Surf Scoter		22		35
Black Scoter				
Scoter spp.	2	5		6
Red-breasted Merganser		5	2	40
Duck spp.				1
Sandhill Crane				
Plover spp.				
Phalarope spp.			54	25
Shorebird spp.		10		
Jaeger spp.				
Glaucous Gull	3	2	25	10
Herring-Thayer's Gull				
Black-legged Kittiwake				
Sabines Gull				
Arctic Tern			3	
Black Guillemot				
Passerine spp.				
Raven				
Snowy Owl		1		
Mew Gull				
Gull ssp.				
Gyrfalcon				1
Unidentified spp.				

Appendix Table 12. Migratory bird species and numbers observed during aerial surveys of Egaksrak and Siku lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1985.

	Egaksrak Lagoon		Siku Lagoon	
	26 July	15 Aug	26 July	15 Aug
Common Loon				
Yellow-billed Loon	2		10	
Arctic Loon	4	10	3	5
Red-throated Loon	1	13		1
Loon spp.	2	2	1	4
Red-necked Grebe				
Tundra Swan	5	1	5	
Brant		305		66
Snowgoose				
Goose spp.				5
Northern Pintail		6		
Scaup spp.				
Oldsquaw	121	152	8	3
Common Eider	5			
King Eider				
Spectacled Eider				
Eider spp.		12		
White-winged Scoter				
Surf Scoter	4			
Black Scoter				
Scoter spp.				
Red-breasted Merganser		30	2	
Duck spp.		22		
Sandhill Crane				
Plover spp.				
Phalarope spp.	4	18		
Shorebird spp.			99	
Jaeger spp.				
Glaucous Gull	14	9	40	8
Herring-Thayer's Gull				
Black-legged Kittiwake				
Sabines Gull				
Arctic Tern	2	6	12	1
Black Guillemot				
Passerine spp.				
Raven				
Snowy Owl				
Mew Gull				
Gull ssp.				
Gyrfalcon		1		
Unidentified spp.				

Appendix Table 13. Migratory bird species and numbers observed during aerial surveys of Demarcation Bay and 400 m offshore Transect along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1985.

	Demarcation Bay		Offshore Transect	
	26 July	15 Aug	26 July	15 Aug
Common Loon				
Yellow-billed Loon	3		3	2
Arctic Loon	13	1	13	5
Red-throated Loon	4	5	4	3
Loon spp.	13	4	16	14
Red-necked Grebe		14		
Tundra Swan	2			
Brant				55
Snowgoose				
Goose spp.				
Northern Pintail			25	
Scaup spp.	2		2	
Oldsquaw	3621	3690	4524	3103
Common Eider	9		396	
King Eider				
Spectacled Eider				
Eider spp.	9		127	7
White-winged Scoter	2			
Surf Scoter	169	161		2
Black Scoter				
Scoter spp.		38	13	5
Red-breasted Merganser	10	16		
Duck spp.				1
Sandhill Crane				
Plover spp.				
Phalarope spp.				
Shorebird spp.		6	44	29
Jaeger spp.				
Glaucous Gull	23	22	30	15
Herring-Thayer's Gull				
Black-legged Kittiwake				
Sabines Gull				
Arctic Tern	1		4	66
Black Guillemot				4
Passerine spp.				
Raven				4
Snowy Owl				
Mew Gull				
Gull ssp.				
Gyrfalcon				
Unidentified spp.				
Seal			1	

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HABITAT USE AND BEHAVIOR OF MOLTING OLDSQUAW ON THE COAST OF THE ARCTIC NATIONAL WILDLIFE REFUGE, 1985.

Alan W. Brackney
Robert M. Platte

Keywords: Oldsquaw, Clangula hyemalis, habitat, behavior, condition indices, body composition, protein reserves, fat reserves, weight, feeding, food habits, diet, Beaufort Sea, Arctic National Wildlife Refuge.

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Habitat use and behavior of molting oldsquaw on the coast of the Arctic National Wildlife Refuge, 1985.

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Abstract: Diet, behavior within specific habitats, and body condition indices of oldsquaw (Clangula hyemalis) in molt were examined at Beaufort Lagoon and adjoining lagoons on the Arctic National Wildlife Refuge (ANWR) coastline in 1985. Oldsquaw (N=18) primarily consumed amphipods (30.3% aggregate volume), gastropods (16.5%), and mysids (12.8%). The high percentage of amphipods in the diet differed from other studies at Beaufort Lagoon and elsewhere on the Beaufort Sea Coast in previous years, where mysids formed a major portion of the diet. A significantly higher number of oldsquaw in flocks ($P < 0.05$) were feeding while in lagoon open water (20.9%), ocean open water (27.1%), passes between barrier islands (53.0%), and ocean shoreline (34.3%), compared with numbers along barrier islands (4.5%), lagoon shorelines (7.6%), or internal lagoon spits (3.1%). Other variables (wave height, time of day, water depth) had no significant influence ($P > 0.05$) on oldsquaw behavior. Males molted earlier than females and most males (75%) were finished with molt when the majority of females (50%) were beginning molt (11-15 August). Males lost a significant amount of plucked body weight (wet weight), carcass weight, and breast muscle weight from premolt to early molt. A portion of that weight loss was recovered by the late molt stage. Abdominal fat deposits were utilized and not restored. Subcutaneous fat was maintained through the molt. Leg muscle weight increased through mid-molt then declined by late molt. Oldsquaw apparently catabolized small amounts of body fat and protein reserves in early molt to meet their nutritional needs in that period. The immobility of molting oldsquaw and their dependence on the lagoon food web to meet these high nutritional demands may make them highly susceptible to impacts on food sources.

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Habitat use and behavior of molting oldsquaw on the coast of the Arctic National Wildlife Refuge, 1985.

Large concentrations of oldsquaw gather in the Beaufort Sea coastal lagoons during the short open water season of summer (Johnson and Richardson 1981) when numbers along the Arctic National Wildlife Refuge coastline reach 30-35,000, by early August of each year (Bartels and Zellhoefer 1983, Bartels et al. 1984, Brackney et al. 1985a, Brackney et al. 1987,). Most oldsquaw in the coastal lagoons and bays at this time are males and non-breeding females undergoing the simultaneous primary feather (remige) molt (Johnson and Richardson 1981, Johnson 1983, Bartels and Doyle 1984, Brackney et al. 1985b.) common to all waterfowl. These molt migrations by postbreeding males to congregation areas distantly removed from the breeding grounds are a universal behavior in migratory ducks (Bergman 1973, Salomonsen 1968). Molt migrations are considered adaptive because they reduce competition for food between males, breeding females, and broods (Salomonsen 1968).

The remige molt has been described as the period of greatest stress in waterfowl because most species weigh the least at a time when nutritional demands of feather growth are high (Hanson 1962, Hanson and Jones 1976, Weller 1957.). The avian molt is a period of intense modification of physiological processes and adjustment of energy and nutrient budgets (King 1980). However, studies on waterfowl (Ankney 1979, Owen and Ogilvie 1979, Petersen 1981, Young and Boag 1982, Ankney 1984, Bailey 1984) have concluded that remige molt was not stressful because body protein and fat reserves were comparable at the beginning and end of molt. A bird may respond to the nutritional demands of wing molt through an increase in nutrient intake, a compensatory reduction in other energy and nutrient demands, or the catabolism of body reserves if exogenous sources are inadequate (Ankney 1979, King 1980.). The strategy oldsquaw employ during molt will determine their ability to adapt to potential disturbances or habitat modification resulting from petroleum development. In earlier investigations of molting oldsquaw (Brackney et al. 1985b), an apparent trend toward lower body weights was detected in molting as opposed to premolt males captured for radio-telemetry studies. A portion of this study was initiated to further investigate that trend.

Knowledge of oldsquaw physiological adaptations to molt and their dependence on specific habitats for food and shelter are needed to assess future impacts on the population. In order to provide that information, this study was initiated in 1985 with the following objectives.

1. Determine the changes in oldsquaw body condition during molt.
2. Determine time budget changes in relation to weather and habitat
3. Quantify the diet of molting oldsquaw and compare that information with other studies.

Study Area

Postbreeding oldsquaw were studied at Beaufort Lagoon (Nuvagapak, Egaksrak), Angun Lagoon and Pokok Bay on the Beaufort Sea coastline of the Arctic National Wildlife Refuge, 64 km east of Barter Island and 56 km west of the U.S. - Canada border at Demarcation Point, Alaska. The lagoons and bay are elongated, brackish estuaries, 0-4 meters in depth, lacking vegetation and generally separated from the Beaufort Sea by low barrier islands. Openings to the ocean are narrow, and all lagoons in the study area are of the pulsing type (Hachmeister and Vinelle 1983) with water exchange primarily limited to tidal movement and storm surges. The lagoons remain ice-covered until early July each year, although open water and over ice sheet flow may occur around the major deltas from spring snow melt. These open water areas are used extensively by early-arriving oldsquaw (Spindler 1981). Oldsquaw numbers in the lagoons gradually increase through July and peak during the first week of August in a normal year (Brackney et al. 1987). A steady decline in numbers occurs through mid to late August as most oldsquaw complete molt and depart the refuge to the west.

Methods

Food habits and the effects of primary feather molt on body composition were analyzed for 100 oldsquaw collected by shotgun between mid-July and mid-August. Collected oldsquaw were immediately dosed with a small quantity of isopropyl alcohol to preserve food items in the esophagus. The birds were then stored in a cool location until body, muscle and organ measurements were taken, usually 4-8 hrs..

Sex was determined by plumage and cloacal examination, and subadults were identified by the presence of a bursa of fabricus and plumage characteristics. Premolt birds were identified by feather wear of the primaries and lack of sheath remnants on the feathers. The length of the 1st, 5th and 10th primary feathers was measured as an index of molt progression. Since the 10th primary was the least variable in length of the 3 primary feathers or any combination of the 3 in premolt birds, molt stage was categorized from the 10th primary length into 4 time-molt classes: premolt, all old primary feathers present; early molt, 10th primary $\leq$ 40 mm; mid-molt, 10th primary > 40 mm and $\leq$ 80 mm; and late molt, 10th primary < 80 mm.

Diet

For diet analysis, only esophageal material was used to avoid bias associated with differential digestion of hard items in the gizzard (Swanson and Bartonak 1970). Food items removed from the esophagus were fixed in 10% formalin and later rinsed and preserved in 70% ethanol. The esophageal contents were sorted by major taxonomic groups and counted. Volumetric measurements were taken by water displacement and the material was then dried for 24 hrs at 60°C and weighted to the nearest 0.001g on an electronic scale.

Condition Indices

The following measurements were used as an index of body condition: whole fresh body weight; plucked weight (all feathers removed except small pin feathers and down); carcass weight (body weight minus the head, the wing distal to the humerus, the intestinal tract and reproductive organs); and fresh wet weights of the gizzard, liver, heart, abdominal fat, whole plucked skin, and the breast and leg muscles from the right side. Breast muscles consisted of the pectoralis major, pectoralis minor, the supercoracoideus and minor corcobranchialis. The leg muscles consisted of all those which originated or inserted on the tibiotarsus. The protein reserve index (PRI) was used as an index of body protein levels (Ankney and MacInnes 1978, Bailey 1984) and for this study consisted of the combined weight of the gizzard, heart, breast, and leg muscles. Changes in body fat were inferred from differences in abdominal fat weight and whole plucked skin weight with subcutaneous fat deposits. All weights were taken on a balance scale to the nearest 0.1g.

Statistical tests for differences in weights were made with one-way analysis of variance (Sokal and Rohlf, 1984) in the GLM procedure of the statistical analysis system (SAS) (SAS Institute 1985) with unequal sample sizes. Means comparisons were tested with the least significant difference tests (LSD, Snedecor and Cochran 1967).

Time budgets

Differences in the quantity of feeding and other behaviors between habitats were estimated with standard time-budget methods. The behavior of all individuals located in similar habitat within sight of the observer were recorded with the instantaneous scan method (Altmann 1974). At 30 min. intervals, the observer scanned the flock and entered the behavior of each individual on a counter at the moment it was observed. Recorded behaviors included feeding; maintenance (preening and comfort movements); resting, inactivity with the bill tucked under the wing; swimming, locomotion without other associated behaviors; flying; and other behaviors which included aggression and predator avoidance. Observers watched the flocks for up to a minute after recording the behavior of birds on the water's surface to account for oldsquaw under the surface during a scan. Oldsquaw on the surface between dives were counted as feeding individuals.

In conjunction with behavior, the habitat type, water depth from navigational charts, wave height within 15 cm increments, time of the day, and general weather conditions were recorded. Habitats were distinguished hierarchically into primary, secondary, and tertiary categories. Primary habitats were ocean and lagoon. Secondary habitats included barrier islands, sand spits inside lagoons, mainland shorelines, passes (breaks between barrier islands), open water, and delta mudflats. Oldsquaw in the water within 200 m of a barrier island, spit or shoreline were included in that habitat type. Water and land comprised the tertiary habitats.

For statistical analysis, each 30 min. scan of a flock was considered a case replicate. Only flocks with a minimum of 25 birds were included in the data analysis. The proportions of each behavior displayed by a flock within each scan were arc-sine square root transformed to stabilize the variances (Sokal and Rohlf 1981). ANOVA were performed on feeding behavior as the primary dependent variable with the GLM procedure of SAS, and LSD test for mean comparisons. Means and standard deviations reported in the text are presented as untransformed percentages to put them in more meaningful terms.

Results

Diet

Only 18 of the 100 oldsquaw collected during the study contained identifiable food items in the esophagus. Foods in oldsquaw esophagus were composed primarily of crustaceans and mollusks (Table 1). The plant materials in the sample were probably ingested incidental to the consumption of invertebrates.

Table 1. Esophageal contents of 18 oldsquaw collected on the Beaufort Sea coast of the Arctic National Wildlife Refuge, July - August 1985.

	Percentage of Aggregate Total[a]		
Taxa	Dry weight	Volume	% occurrence (N=18)
Crustacea	36.4	56.9	88.9
Amphipods	17.8	30.3	88.3
Mysids	7.7	12.8	50.0
Isopods	5.0	7.3	33.3
Cumaceans	5.8	7.3	22.2
Ostracods	tr[b]	0.9	11.1
Copepods	tr	0.3	5.6
Molluska	45.8	23.9	44.4
Gastropods	31.7	16.5	33.3
Pelecypods	14.2	7.3	16.7
Unidentified Animal	16.9	17.4	100.0
Plant	0.9	1.8	33.3

[a] Total material (Dry wt. or volume) in that species/Total material in sample

[b] tr = < 0.1

Gastropods (snails) and pelecypods (bivalves) of the molluska made up a slightly higher percentage of the dry weight (45.8%) than crustaceans (36.4%), but were considerably less important than crustaceans if percent volume was used as the criteria. Mollusks made up 23.9% of the aggregate volume and occurred in 44.4% of the oldsquaw compared to 56.9% of the aggregate volume and 88.9% occurrence of crustacea. Since a large proportion of the mollusk weight was shell, aggregate dry weight probably overestimated the contribution of that group to the overall diet.

Specific taxa of importance in the diet by aggregate volume were amphipods (30.3%), gastropods (16.5%) and mysids (12.8%). Isopods, cumaceans and pelecypods each accounted for 7.3% of the aggregate volume. Oldsquaw collected at Beaufort Lagoon in 1985 consumed substantially more amphipods (30.3% dry weight) than those sampled at Beaufort Lagoon in 1982 (13.1% wet weight, Johnson 1983), at Simpson Lagoon near Prudhoe Bay in 1977-1978 (14.2% aggregate volume, Johnson 1984) and offshore in the Beaufort Sea (23% dry weight, Divoky 1984). Fish, which comprised a large part of the sample taken by Johnson (1983) at Beaufort Lagoon in 1982, were absent from the esophagi of the oldsquaw collected in this study. As in other studies (Johnson 1983, Johnson 1984), infaunal benthos (bivalves, cumaceans) made up a small percentage of the diet.

Time budgets

Since resource use within the lagoons is closely tied to food sources, the analysis focused on feeding as the primary behavior of concern. A 4-factor ANOVA with wave action, water depth, habitat and time as independent variables was performed on the Arc-sine transformed proportions of oldsquaw feeding in each flock scan. The time of day was categorized for each observation into classes: (0-0559, 0600 - 1159, 1200 - 1759, 1800 - 2400 hr), and water depth was categorized into 1 m increments. Only flocks observed on the water were included in the analysis.

Of the 4 independent variables, only habitat had a significant influence ($P < 0.05$) on feeding behavior. Significantly higher proportions of oldsquaw in flocks were observed feeding while in passes (53.0%) than in other aquatic habitats (Table 2). Likewise, significantly more oldsquaw ($P < 0.05$) were feeding while in the open water of lagoons (20.9%), in the ocean (27.1%), and along ocean mainland shorelines (34.3%), then along barrier islands on the lagoon side (4.5%) or the ocean side (4.5%), along lagoon spits (3.1%), or along lagoon mainland shorelines (7.6%).

Table 2. Mean percentages of flock behavior shown by oldsquaw in various habitats.

		Behavior				
Habitats	N[a]	Feeding[b]	Preening	Swimming	Flying	Resting
Lagoon						
Barrier Island	14	4.5^{dg}	18.4	22.1	0.1	54.1
Spit	13	3.1^{dg}	19.0	4.1	0.1	72.0
Open Water	68	20.9^{efg}	16.2	5.1	1.5	55.7
Shoreline	39	7.6^{dfg}	14.4	9.9	tr[c]	67.8
Ocean						
Barrier Island	7	4.5^{dg}	11.4	19.0	29.8	35.4
Open Water	35	27.1^{efg}	15.0	12.3	3.3	42.2
Shoreline	7	34.3^{efg}	5.9	31.8	2.5	25.4
Pass	13	53.0^{g}	10.5	9.2	tr	27.1
Land	21	0.1	38.9	0.0	0.0	60.9

[a] Sample size (No. of flock scans).
[b] Same letter = significant difference ($P < 0.05$) Duncan's multiple range test
[c] Tr= < 0.1%

Resting, the most frequent behavior, was seen most often on land, along barrier islands shorelines and open water of lagoons (54.1-67.8%). Preening behavior was fairly consistent (5.9-19%) between habitats. High winds and heavy waves did not appear to affect resting or preening behavior.

Timing of Molt

The primary period of molt for oldsquaw during the study was from early to mid August. Of the oldsquaw collected during the period 4-16 August, a significantly higher proportion of the males ($X^2 = 100.3$, $P < 0.001$) and females ($X^2 = 12.6$, $P < 0.005$) were in molt than those taken 16-31 July (Table 3). Although there was no significant difference ($X^2 = 0.96$, $P \geq 0.05$) between sexes in the proportions of molting and premolt oldsquaw during 16-31 July, a significantly higher proportion of the males ($X^2 = 43.7$, $P < 0.001$) than females were molting during the 4-16 August period. Nearly 50% of the females collected in 4-10 August and 37.5% collected 11-16 August had not yet started to molt while only 6.4% and 3.6% of the males were in the premolt stage on 4-10 August and 11-16 August, respectively. By 11-16 August, 75% of the males were in the late stages of molt while only 12.6% (2 of 16) of the females had progressed past the early molt stage. No differences in the chronology of molt were detected between age classes.

Table 3. Percentages of oldsquaw collected at Beaufort lagoon in various stages of molt progression, July-August 1985, Arctic National Wildlife Refuge, Alaska.

		Molt Stage			
Period	N	Premolt	Early Molt[a]	Mid Molt[b]	Late Molt[c]
Males					
16-31 July	18	72.2	27.8	0	0
4-10 Aug	16	6.3	18.8	50.0	25.0
11-16 Aug	28	3.6	3.6	17.9	75.0
Females					
16-31 July	9	88.9	11.1	0	0
4-10 Aug	12	50.0	50.0	0	0
11-16 Aug	16	37.5	50.0	6.3	6.3

[a] 10th Primary $\leq$ 40 mm
[b] 10th Primary > 40 mm and $\leq$ 80 mm
[c] 10th Primary > 80 mm

Condition Indices

The best indicators of an adequate diet and the degree of stress placed on the oldsquaw by primary feather molt are the changes in fat and protein content of the body. Condition indices provide good indicators of protein and lipid levels in the body, particularly for trends and comparative purposes. Bailey (1979) examined 9 condition indices for fat in redhead ducks in relation to ether-extractable body fat and derived correlation coefficients (R) of 0.83 for abdominal fat weight, and 0.90 for plucked skin weight and skin fat weight. Wet weights of various muscle masses have also been used as indicators of body protein levels in waterfowl (Ankney and MacInnes 1978, Bailey 1984).

Age classes were combined for analysis of condition indices because T-tests performed on body weights, organ weights and feather measurements showed no significant differences between adult and subadult age classes ($P \geq 0.05$).

Body Weights: Body weights were variable and not significantly different between molt stages ($P \geq 0.05$) despite a decrease of 62.2g from premolt to early molt in males (Table 4), and a 9.5g decrease in females (Table 5). Males suffered significant ($P < 0.05$) losses of 65.9g and 71.2g in plucked body and carcass weights, respectively. Male body weights increased from early to late molt but the differences were not significant ($P \geq 0.05$).

Table 4. Condition indices of male oldsquaw taken during progressive stages of primary feather molt, Beaufort lagoon, Arctic National Wildlife Refuge, 1985.

	Molt Stage				
Condition Index	Premolt	Early molt	Mid molt	Late molt	F Value
	(15)[a]	(9)	(13)	(24)	
Whole body	850.3 ± 71.8[b]	795.1 ± 82.5	824.9 ± 58.3	813.2 ± 50.3	2.04
Plucked body	814.6 ± 71.0*[c]	748.7 ± 78.4	759.6 ± 51.7	758.5 ± 48.3	3.10*
Carcass	613.4 ± 61.4*	542.2 ± 60.7	555.5 ± 44.0	562.8 ± 38.9	5.33*
Plucked skin	140.7 ± 28.6	147.5 ± 36.1	159.0 ± 19.1	142.4 ± 21.1	1.50
Abdominal fat	11.1 ± 16.0*	3.1 ± 3.5	1.8 ± 1.6	1.0 ± 0.6	4.05*
Gizzard	16.1 ± 3.1	15.7 ± 4.7	15.5 ± 2.8	16.1 ± 3.2	0.18
Heart	10.6 ± 2.1	9.7 ± 0.8	10.7 ± 1.1	10.0 ± 1.0	1.20
Liver	36.3 ± 9.0	33.2 ± 6.2	34.7 ± 5.2	36.1 ± 5.6	1.19
1/2 breast muscle	72.9 ± 6.6*	49.7 ± 4.5	49.4 ± 3.3*	58.1 ± 5.4	47.50*
1/2 leg muscle	12.9 ± 2.0*	15.3 ± 1.3	16.5 ± 1.5*	15.3 ± 1.3	11.50*
PRI	111.7 ± 7.6*	90.4 ± 9.2	92.1 ± 6.3*	99.5 ± 7.5	20.51*
FRI	116.6 ± 30.1	115.5 ± 39.0	125.8 ± 19.6	108.3 ± 21.4	1.26

[a] Sample size (N)
[b] Mean±Sd (g) wet weight
[c] * Significantly different ($P < 0.05$) from the next adjacent mean.

Fat Reserves: A fat reserve index (FRI) (Ankney and MacInnis 1978) was calculated from the sum of abdominal fat and skin fat weights. Skin fat weights were obtained by subtraction from skin weight of 35g, the skin weight of starved redheads (Bailey 1984) of comparable size. FRI did not change significantly ($P \geq 0.05$) in either males or females with progressive growth of the 10th primary feather. Sample sizes of females in mid and late molt were not adequate for statistical analysis. The non-significant decrease in FRI in males (8.3g) resulted primarily from a 91% decrease in abdominal fat weight from a mean of 11.1g in premolt to 1.0g in late molt. Skin weights showed no significant trends. Therefore, during the 2-3 week molt period male oldsquaw apparently catabolized only 8-10g of body lipids (316-395 kj) which is 22-28kj of energy a day over a two week period. If oldsquaw basal metabolic rate (BMR) is predictable by the Beta equation of Aschoff and Pohl (1970), energy from catabolized fat was less than 10% of the 260 kj/day expended on basal metabolism in an 800 g male, but only 3-5% of daily energy expenditure at 2-3 x BMR.

Protein Reserves: Wet weights of the gizzard, heart, and liver were not significantly altered between molt stages and showed marked uniformity in weight. Initially, both male and female oldsquaw had significant ($P < 0.05$) decreases in PRI from premolt to early molt followed by a significant ($P < 0.05$) gain in protein reserves in males, from the mid to late molt stages. These changes were driven by a significant ($P < 0.05$) 42% drop in breast muscle weight from premolt to early molt and a gain (nonsignificant) in mean breast muscle weight from mid

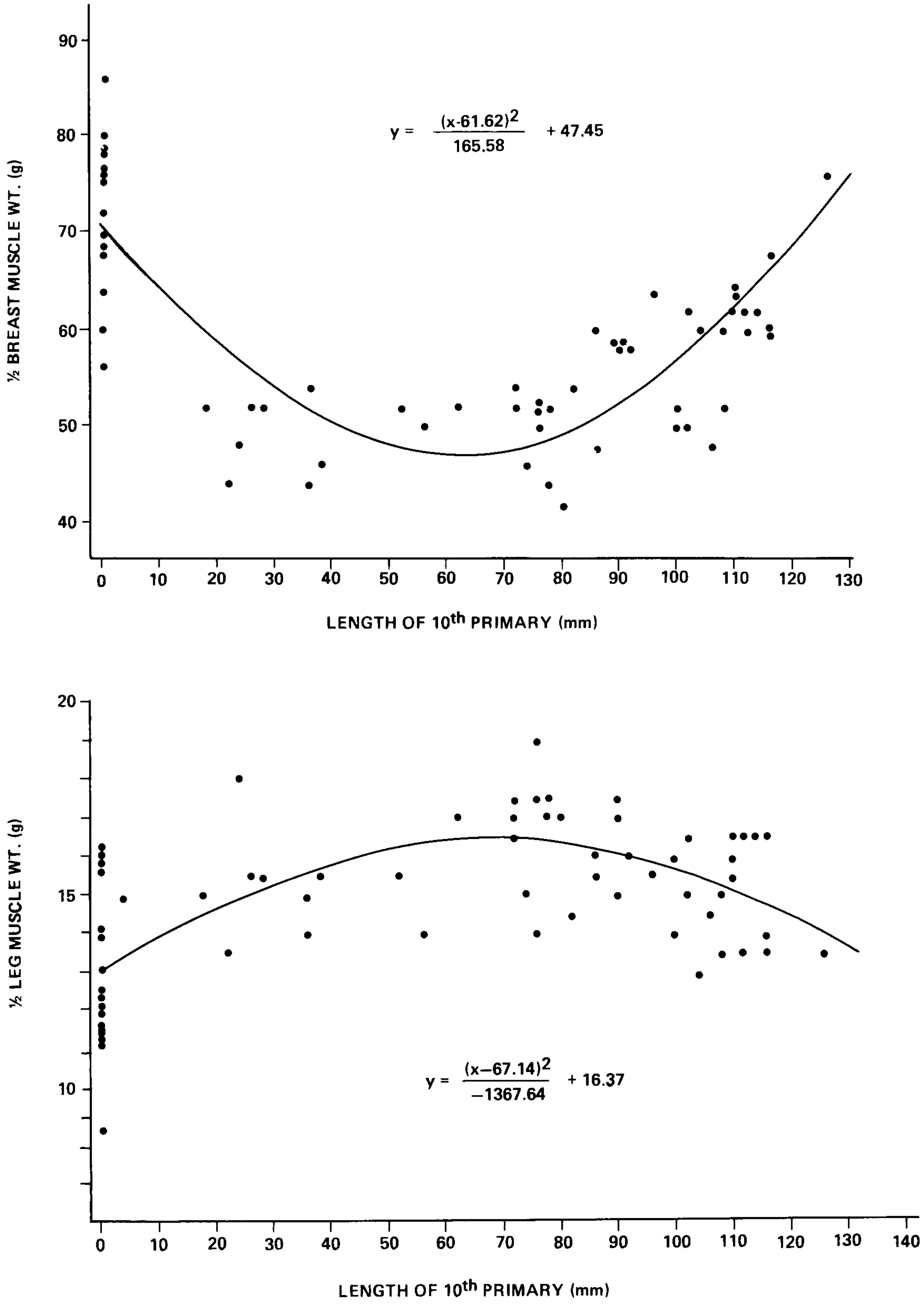

Fig 1. Curvilinear regressions of oldsquaw breast muscle and leg muscle weight against the length of the 10th primary feather during molt.

to late molt. Leg muscle weights varied in the opposite direction with significant ($P < 0.05$) gains from premolt to mid molt and a significant ($P < 0.05$) decrease in weight from mid to late molt. Curvilinear regressions of these changes (breast and leg muscle weight on the 10th primary length) in males (Fig. 1) shows a close relationship of this phenomena with flight capability. As the primaries became sufficiently long to allow exercise of the pectoral muscles, such as wing flapping, the muscle mass increased. Leg muscle mass began to drop shortly after breast muscle started to gain weight.

Table 5. Condition indices of female oldsquaw taken during progressive stages of primary feather molt, Beaufort lagoon, Arctic National Wildlife Refuge, 1985.

	Molt Stage				
Condition Index	Premolt	Early molt	Mid-molt	Late molt	F Value
	(20)[a]	(15)	(1)	(1)	
Whole body	731.3 ± 61.2[b]	721.8 ± 47.4	696.2	703.3	0.23
Plucked body	693.9 ± 58.5	678.6 ± 52.8	643.1	651.9	0.53
Carcass	538.2 ± 83.4	507.0 ± 48.7	495.8	489.7	0.69
Plucked skin	126.9 ± 34.9	144.4 ± 30.6	132.4	129.9	0.80
Abdominal fat	5.4 ± 3.9	2.6 ± 2.4	1.0	1.4	2.45
Gizzard	12.1 ± 1.9	10.6 ± 1.4	11.0	9.1	2.64
Heart	10.0 ± 2.2	8.8 ± 1.2	10.5	8.9	1.20
Liver	34.2 ± 5.6	31.8 ± 3.5	25.5	29.0	1.68
1/2 breast muscles	63.1 ± 5.9*[c]	48.1 ± 6.6	40.0	47.2	19.78*
1/2 leg muscles	12.6 ± 1.5*	15.2 ± 1.7	15.5	13.5	8.33*
PRI	97.7 ± 7.1*	82.8 ± 7.7	77.0	78.7	14.04*
FRI	97.3 ± 38.4	112.0 ± 32.5	98.4	96.3	

[a] (N)

[b] Mean ± S.D. (g) wet weight

[c] * Significantly different ($P < 0.05$) from the next adjacent mean

The large weight fluctuations in males were largely a function of the PRI changes with molt. The muscle weight changes for both sides of the body (2x breast + 2x leg weight change) plus the abdominal fat lost from premolt to early molt was 49.6g in males and 27.6g in females. These tissues accounted for only 69% and 88% of the carcass weight loss in males and females, respectively. The additional weight loss came from other fat sources, other skeletal muscles or from moisture loss in proteinaceous tissue. However, body water tends to rise in proteinaceous tissues during molt (Dolnik and Gavrilou 1979, Ankney 1984), which would place protein catabolism at an even higher level than shown by the indices.

Discussion

The varied diet of oldsquaw highlights the opportunistic nature of their food selection (Sanger and Jones 1984), in which they tend to take epibenthic prey in proportion to the availability (Peterson and Ellarson 1979, Johnson 1984). Oldsquaw diets may be affected by the differences in availability of certain taxa seasonally and annually within a lagoon or between lagoons (Griffiths and Dillinger 1981, Jewett et al. 1983). Fluctuations in epibenthic invertebrate biomass and numbers within lagoons may result from changes in predator (fish) density, disruption in invertebrate migration into or out of lagoons, or shifts caused by winds or currents (Griffiths and Dillinger 1981). Such changes in invertebrate abundance may underscore the seasonal and annual variability in lagoon use by oldsquaw and may explain the marked differences in diet between locations and between years in the same location.

The high incidence of feeding by oldsquaw in passes indicated that a high availability of invertebrates existed in those areas, at least on an intermittent basis. Mysids, which migrate in and out of lagoons (Griffiths and Dillinger 1981), may have created a temporarily high biomass of food in passes at certain times, perhaps in relation to the pulsing action of tidal movements. Oldsquaw were commonly observed loafing onshore along the points of barrier islands at passes. This have may have allowed them better access to temporally abundant food sources and may have also allowed access to open water inside or outside of the lagoons. Although differences in behavior in relation to wave height were not detected, oldsquaw may choose habitats which provide protection from wind and wave action (Johnson and Richardson 1981) as opposed to altering their time budgets in response to weather. Radio-fitted oldsquaw located by Bartels et. al. (1984) and Brackney et al. (1985b) occurred along barrier islands and passes at a higher frequency than expected from available habitat area (Brackney et al. 1985b). Thus passes may provide the most flexibility for the birds to meet their needs of both food and shelter. The increased feeding behavior by oldsquaw in open water habitats in this study coincides with Griffith and Dillinger's (1981) finding that a higher biomass of epibenthic invertebrates occurred in the mid-lagoon area of Simpson Lagoon in 1977-78.

The decrease in protein reserves and body weight by male oldsquaw demonstrated an immediate demand at the onset of primary feather growth for protein and energy which the birds did not acquire from exogenous sources. However, oldsquaw were not able to replace all of the catabolized protein from food sources before feather growth was complete. Catabolized abdominal fat reserves were not recovered by male oldsquaw before completion of molt, although oldsquaw appeared to maintain energy intake at maintenance levels through mid and late molt. Because oldsquaw spent a majority of their time resting and preening while catabolizing body protein and fat reserves, feeding behavior may have been attenuated for physiological or environmental reasons during early molt. Inadequate food resources and/or increased thermoregulatory costs from reduced feather insulation may have made feeding too costly compared to the benefits during periods of reduced water temperatures, high wave action, excessive turbidity or large shifts in epibenthic invertebrates caused by wind driven currents. Although weather had little effect on feeding behavior within habitats in this study, qualitative observations have shown increased use of open water habitats (where food resources are greater) by oldsquaw during periods of calm weather (Brackney et al. 1985b). New pin feathers are engorged with blood and extremely delicate. Since oldsquaw use a wing flapping type of underwater propulsion (Snell 1985), feeding may have been avoided during the early molt period to prevent mechanical damage to the new growing primaries.

A decrease in breast muscle weight and an increase in leg muscle weight, similar to this study, has been demonstrated in interior Canada geese (Hanson 1962), mallards (Young and Boag 1982), snow geese (Ankney 1979), and redheads (Bailey 1984). Redheads (Bailey 1984) did not lose body protein but shifted protein from the breast into other proteinaceous tissues including the legs. Hanson (1962) suggested that protein from the pectoral muscles was catabolized to provide essential amino acids for hypertrophy of the leg muscle and feather growth. However, Ankney (1979) contended that the decrease in mass of the breast muscles by snow geese was from disuse atrophy and that leg muscles increased in mass from additional use. Ankney (1984) conceded that the rapid decrease in breast muscle of brant was partly due to protein catabolism to supply protein to the leg muscles as well as to disuse. Why females oldsquaw showed proportionally smaller losses in breast muscle and body weight is unexplained by the available data. Bailey (1984) found that male redheads maintained protein reserves in non-breeding years, but not in breeding years when energy and protein demands were higher; an indication that waterfowl maintain reserves through molt when possible. An alternative to Ankney's hypothesis is that the male oldsquaw, which molted earlier than females, had less available food during early molt and were not able to sustain the protein demands of early molt. Griffiths and Dillinger (1981) found large differences in the timing of peak invertebrate abundance at Simpson Lagoon between 1977 and 1978. In 1977, mysid and amphipod biomass did not peak until after 15 August; the period in 1985 when most females were entering molt.

Oldsquaw in all stages of primary feather molt are highly dependent on several lagoon habitats for food and shelter. Barrier islands and internal lagoon spits serve as shelter from prevailing NE winds and for basking/loafing sites. Loafing on islands and spits probably reduces thermoregulatory costs and such locations are less accessible to predators. Presumably passes between barrier islands allow temporally high food resources and access to the open ocean and lagoon habitats. Open water, under suitable conditions, provides the necessary food resources to meet the high energy and protein costs of molt. Since these costs are such that oldsquaw must both catabolize body energy and protein reserves and feed during molt, they are dependent on available food resources. Therefore, in their state of reduced mobility, molting oldsquaw may be highly susceptible to habitat alteration and perturbations of the food web.

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A PRELIMINARY STUDY OF EPIBENTHIC INVERTEBRATES AND WATER QUALITY IN COASTAL LAGOONS OF THE ARCTIC NATIONAL WILDLIFE REFUGE

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A preliminary study of epibenthic invertebrates and water quality in coastal lagoons of the Arctic National Wildlife Refuge.

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Abstract: A preliminary study of factors which affect the distribution and abundance of epibenthic invertebrates in coastal lagoons of the Arctic National Wildlife Refuge was conducted during July - early August 1981. Invertebrate abundance was hypothesized as a factor affecting waterfowl abundance and distribution. Samples from 5 net grabs at stations in each of 4 habitat types (mainland shoreline, mid-lagoon, barrier island, pass) in 8 lagoons showed no significant differences in numbers of mysids, amphipods, large amphipods (*Onismus* sp + *Gammarus* sp.) or total invertebrates between lagoons or between habitat types. Two additional stations were placed in 3 habitat types (mainland, mid-lagoon, barrier island) at Tamayariak Lagoon and one additional station was placed in mainland and barrier island habitats at Brownlow Lagoon. Significant differences in total invertebrate numbers were found between stations in the same habitat types at Brownlow lagoon. At Tamayariak, large differences existed between barrier island stations in total numbers of invertebrates, amphipods, and total amphipods. Mid-lagoon stations were significantly different in total invertebrate and mysid numbers. Temporal variability in invertebrate abundance also occurred at stations in 3 lagoons that were sampled a second time in late August or early September. Measurements of surface temperature, bottom temperature, surface salinity, bottom salinity, depth, and visibility were not significantly correlated with invertebrate abundance. Invertebrate abundance was not significantly different between bottom types (sand, mud, peat, mixed). The very high spatial and temporal variability in invertebrate numbers will necessitate a more complex and intensive sampling plan in future studies to delineate trends in invertebrate distribution and abundance within and between lagoons.

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A preliminary study of epibenthic invertebrates and water quality in coastal lagoons of the Arctic National Wildlife Refuge.

Lagoons and other nearshore areas along the Beaufort Sea coast are important staging and feeding areas for migratory waterfowl (Johnson and Richardson 1981, Divoky 1983). Spring migrating waterfowl, primarily eiders and oldsquaw, use river overflow areas near deltas as rest stops and frequently concentrate in the limited open water they offer prior to breakup of tundra nesting areas. Use increases throughout the open water season with peak densities occurring in late July to early August when male oldsquaws congregate in the lagoons to molt prior to fall migration (Schmidt 1970, Spindler 1978, 1979, 1981, Johnson 1982, U.S. Fish and Wildlife Service 1982, Bartels and Zellhoefer 1983). Maximum recorded densities of oldsquaw in nearshore lagoon waters of the Arctic National Wildlife Refuge (ANWR) ranged from 20.6-92.0 birds/km^2 for surveys conducted from July 1981 to August 1985 (Spindler 1981, Bartels and Zellhoeffer 1983, Bartels and Doyle 1984, Brackney et al. 1985, Brackney et. al. 1987). Invertebrates are the primary food source of oldsquaw (Johnson 1984), scoters (Sanger and Jones 1984), and eiders (Bellrose 1980). An understanding of factors affecting invertebrate abundance and distribution in lagoons habitat types may shed some light on the annual and seasonal variability of waterfowl use in the coastal lagoons of ANWR, and allow assessment of potential impacts from proposed petroleum development in or adjacent to the lagoons.

Methods and Materials

Modified 'Clutter Nets', a central pursing drop-net developed for the Simpson Lagoon studies (Johnson and Richardson 1981) were used to sample epibenthic invertebrates in ANWR Lagoons. The net screening was 1.0mm nitex, and the purse collar was nylon ballistics cloth with 0.65 cm^2 atlas netting around the margin. The net was operated by folding the purse collar back over the metal frame so that the metal rings on the collar encircled the bottom edge of the frame. With both the top and the bottom of the net open, it was dropped to the bottom. Both purse lines were immediately pulled to enclose the sample in the net. The sample was then washed down the sleeve into a collecting bucket and the net was inspected to insure that all organisms had been removed. Samples were preserved with 10% Formalin and placed in sealed Whirl-Paks immediately after capture. Concurrently with invertebrate sampling, salinity and water temperature were measured at the surface and on the bottom at each station with a portable meter. Visibililty was taken with that Secchi disc and bottom type was infered from material brought up with the cluster net.

Nine lagoons were sampled out of 19 lagoons on the refuge. Those lagoons selected include an assortment of oldsquaw use levels: high (Brownlow L., Kaktovik L., Oruktalik L.) medium (Tamayariak L., Simpson L. Tapkaurak L.) and low, (Arey L., Jago L., Pokok L.) based on survey data (Spindler 1981). Lagoons were divided into 4 habitat types with a sampling station in each habitat; at the entrance to the lagoon (pass), near the mainland shore (mainland), in the middle (mid lagoon) and near the inner shore of the barrier islands (barrier island). Five drop net samples were taken at each station. In Brownlow Lagoon the sample station in the middle of the lagoon was deleted due to the limited width of the lagoon. In 2 lagoons, Brownlow and Tamayariak, 2 or 3 stations were sampled per habitat. All 9 lagoons were sampled between 28 July and 7 August 1981. Three lagoons were sampled a second time at the same stations between 13 August and 9 September. Ideally all stations within a lagoon were sampled in a single day, however, some lagoons were sampled over 2 or more days because of the time required for each station or poor weather conditions.

For lagoon, habitat, and water quality comparisons of invertebrate abundance, the 5 samples at each station were combined to avoid pseudoreplication (Hurlbert 1984). Because sample sizes were small, nonparametric Freidmans rank 2-way analysis of variance tests (Hollander and Wolfe 1973) were used for between-lagoon comparisons with habitat (strata) used as the block. Within lagoon comparisons were examined with Wilcoxson and Kruskal-Wallis rank sum tests (Hollander and Wolfe 1973). Each of the 5 samples per station were treated as a replicate for comparisons within habitats within a lagoon. Standard correlation analysis (Snedecor and Cochran 1967) were used to investigate relationships between invertebrate abundance and water quality parameters.

Results

Invertebrates

Species Present. A total of 43 invertebrate taxa were identified from the drop-net samples gathered in each of 9 lagoons on ANWR (Table 1). Of these, 29 were identified to species and the remaining 14 to genus or family. Tamayariak Lagoon had the greatest species richness with 29 species present. More typically, lagoons of intermediate richness (Brownlow, Simpson, Arey, Jago, Tapkaurak and Oruktalik) contained 15-19 taxa. Pokok and Kaktovik Lagoons showed the lowest richness with 11 and 15 taxa, respectively.

Variability Between Lagoons. The Freidmans rank test failed to detect any significant differences ($P > 0.05$) in total numbers of invertebrates (Table 2), total numbers of amphipods (Table 3), or numbers of large amphipods (Onisimus sp. + Gammarus sp.) (Table 4) between lagoons. The tests for differences in total numbers of mysids (Table 5) were significant ($P < 0.02$) but no significant comparisons ($P > 0.05$) were found between individual lagoons. Thus, all lagoons were either similar or the sampling scheme was not sufficient, given the level of variability in invertebrate abundance, to detect difference between lagoons when within lagoon (strata) differences were accounted for by the Friedmans test.

Variability Between Habitats. Differences between habitats were examined using the Freidmans test by considering habitats as treatments, and lagoons as blocks. Significant differences were found between habitats in total amphipod numbers and total mysid numbers ($P < 0.05$). No differences were detected between habitats for total invertebrate numbers ($P = 0.15$). For amphipods,

Table 1. List of epibenthic invertebrates and incidentally-caught fauna identified in drop-net samples from coastal lagoons of the Arctic National Wildlife Refuge, July-August 1981.

INVERTEBRATES[a]

- *Aceroides latipes*
- *Alcyonidium disciforme*

Amphipods[b]

- *Acanthostepheia incarinata*
- *Acanthostepheia behringiensis*
- *Apherusa glacialis*
- *Apherusa megalops*
- *Atylus carinatus*
- *Boechosimus affinis*
- *Gammaricanthus loricatus*
- *Gammarus setosus*
- *Gammarus sp.*
- *Monoculodes crassirostris*
- *Monoculodes schneideri*
- *Monoculopsis affinis*
- *Monoculopsis longicornis*
- *Oedicerotidae*
- *Onisimus littorals*
- *Onisimus gracialis*
- *Parathermisto abyssarum*
- *Paroediceros lybnceus*
- *Pontoporeia affinis*
- *Pontoporeia efemerata*
- *Weyprichtia heiglini*
- *Weyprichtia sp.*

Bivalves

- *Portlandia arctica*

Bryozoans

Copepods

- *Acartia clausia*
- *Calanus glacialis*
- *Calanus hyperboreus*
- *Jashnovia tolli*
- *Limnocalanus grimaldi*
- *Pseudocalanus* sp.
- Harpactucoid copepod

Cumacean

- *Diastylis subcata*

Diptera

- *Hiperia* sp.

Hydroid

- *Corymorpha flammea*
- *Coryne princeps*
- *Perigoniums yoldia-arctica*
- *Tubularidae-hydroid polyp*

Isopoda

- *Saduria entomon*

Lysianassidae

Mysids

- *Mysis litoralis*
- *Mysis relicta*
- *Mysis sp.*

Polychaetes

- *Sphaerodoropsis minnta*
- *Rozinante fragilis*
- *Stenothoidae*

VERTEBRATES

Pisces - Fish

- Cottidae - sculpin
- *Myrocephalus* sp. (4-horned sculpin,

- Gadidae - cod
- *Liparus* sp.

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a. Phylum
b. class or family

Table 2. Numbers of invertebrates collected, by stations, in 8 coastal lagoons on the Arctic National Wildlife Refuge July-August 1981.

	Station Location (habitat)			
Lagoon	Mainland	Mid Lagoon	Barrier Island	Pass
Tamayariak[a]	89	131	67	11
Simpson	61	55	17	24
Arey	54	46	15	20
Kaktovik	7	15	15	57
Jago	14	21	32	5
Tapkaurak	24	32	21	25
Oruktalik	38	85	194	12
Pokok	10	59	12	8

[a] Mean of 3 stations per habitat

Table 3. Numbers of amphipods collected, by stations, in 8 coastal lagoons on the Arctic National Wildlife Refuge July-August 1981.

	Station Location (habitat)			
Lagoon	Mainland (rank)	Mid Lagoon (rank)	Barrier Island (rank)	Pass (rank)
Tamayariak	11[a](6)[b]	27[a](8)	35[a](8)	10 (6)
Simpson	24 (9)	3 (2)	6 (2)	13 (8)
Arey	18 (8)	4 (3)	5 (1)	5 (4)
Kaktovik	5 (1)	0 (1)	7 (5)	7 (5)
Jago	12 (4.5)	9 (4)	22 (6)	2 (1)
Tapkaurak	8 (2.5)	11 (5)	8 (3)	20 (9)
Oruktalik	12 (4.5)	20 (6)	74 (9)	6 (2.5)
Pokok	8 (2.5)	23 (7)	10 (4)	6 (2.5)
Brownlow	16[c](7)	--	28[c](7)	11 (7)

[a] Mean of 3 stations per habitat

[b] rank in parenthesis

[c] Mean of 2 stations

Table 4. Numbers of large amphipods (Onisimus sp + Gammarus sp) collected, by station, in 8 coastal lagoons on the Arctic National Wildlife Refuge July-August 1981.

	Station Location (habitat)							
Lagoon	Mainland	(rank)	Mid Lagoon	(rank)	Barrier Island	(rank)	Pass	(rank)
Tamayariak	2[a]	(8.5)	1[a]	(5)	5[a]	(7)	1	(6.5)
Simpson	1	(6)	0	(2)	2	(2.5)	1	(6.5)
Arey	1	(6)	1	(5)	1	(1)	0	(3)
Kaktovik	0	(2.5)	0	(2)	3	(5)	0	(3)
Jago	0	(2.5)	4	(7)	3	(5)	0	(3)
Tapkaurak	0	(2.5)	1	(5)	3	(5)	0	(3)
Oruktalik	0	(2.5)	8	(8)	1	(9)	0	(3)
Pokok	2	(8.5)	0	(2)	2	(2.5)	0	(3)
Brownlow	1	(6)	--		10	(8)	3	(8.5)

[a] Mean of 3 stations per habitat

[b] rank in parenthesis

[c] Mean of 2 stations

Table 5. Numbers of mysids collected by station in 8 coastal lagoons on the Arctic National Wildlife Refuge July-August 1981.

	Station Location (habitat)							
Lagoon	Mainland	(rank)	Mid Lagoon	(rank)	Barrier Island	(rank)	Pass	(rank)
Tamayariak	42[a]	(8)	49[a]	(7)	29[a]	(7)	1	(2)
Simpson	36	(7)	19	(4)	8	(4)	8	(7)
Arey	33	(6)	42	(6)	10	(5.5)	12	(8.5)
Kaktovik	3	(3)	5	(2)	1	(1)	2	(3)
Jago	2	(2)	3	(1)	3	(3)	3	(4)
Tapkaurak	14	(4)	17	(3)	10	(5.5)	4	(5)
Oruktalik	25	(4)	64	(8)	95	(9)	6	(6)
Pokok	1	(1)	28	(5)	2	(2)	0	(1)
Brownlow	43[b]	(9)	--		65[b]	(8)	12	(8.5)

[a] Mean of 3 stations per habitat

[b] Rank in parenthesis

[c] Mean of 2 stations

barrier island stations had significant more ($P < 0.01$) individuals than passes, but all other comparisons were not significant ($P > 0.05$). Likewise, mid-lagoon stations contained significantly ($P = 0.03$) more mysids than passes. Despite these two significant comparisons, the analysis revealed no clear trends in invertebrate abundance within lagoons.

Variability within Lagoons. A within-lagoon comparison was possible in the examination of the variability between stations in the same habitats at Tamayariak and Brownlow Lagoon. Two stations per habitat were sampled at Brownlow lagoon and 3 stations per habitat were sampled at Tamayariak Lagoon. At Brownlow, significant differences were detected between mainland shoreline stations and also between barrier island stations in total numbers of mysids ($P < 0.05$), total number of amphipods ($P < 0.05$), and total invertebrate numbers ($P < 0.05$). At Tamayariak Lagoon, Kruskal-Wallis tests on 3 stations in each of the mainland shoreline, mid-lagoon, and barrier island habitats showed significant differences in total amphipod numbers between barrier island stations ($P < 0.02$); total mysid numbers between mid-lagoon stations ($P < 0.05$), and between barrier island stations ($P < 0.01$), and total invertebrate numbers between mid-lagoon stations and between barrier island stations. No significant differences were found between mainland stations in total mysid numbers ($P = 0.21$), and total amphipod numbers ($P = 0.29$). Amphipod numbers were also significantly different between mid-lagoon stations ($P = 0.32$). Apparently stations within the same habitat and lagoon may be similar in the abundance of one invertebrate group but not in others, or may be highly dissimilar in all groups and in total numbers of invertebrates. Alternatively, variability in some invertebrate groups may be too high for differences to be detected by this sampling intensity.

For final examination of within-lagoon variability, drop net samples at each station were combined and a Kruskal-Wallis test for differences between habitats were run on Tamayariak lagoon samples. No significant differences were found in total invertebrate numbers ($P = 0.511$) and total mysids ($P = 0.92$). Undoubtedly variability between stations within habitats was nearly as high as variability between habitats.

The high lagoon spatial variability of invertebrate abundance levels in both Brownlow and Tamayariak lagoons may have been due to the location of the stations in relation to other physiographic features. The Tamayariak River empties into the west end of the Tamayariak Lagoon and barrier islands extend along only that portion of the lagoon. A set of sampling stations was located near the river delta in an area bound by barrier islands. The other stations in this lagoon were located at the opposite end, beyond the direct influence of the delta and more exposed to the sea. Brownlow Lagoon also borders a river delta but is largely an enclosed lagoon. The stations were located at opposite ends of the lagoon; the east end was influenced by the river delta and the west end by a pass between the barrier islands. Riverine flow into portions of both these lagoons may have affected suitability of water for invertebrates or the immigration of those invertebrates into the lagoons since the majority of stations adjacent to the deltas had lower invertebrate abundance values (an exception being the mid-lagoon stations in Tamayariak Lagoon).

Temporal changes. Three lagoons, Arey, Kaktovik, and Jago were sampled for temporal changes in relative species abundances during a second time period between 13 and 9 September. The most numerous species in the first sample (28 July - 7 August) were *Mysid relicta*, *Mysid littoralis*, *Monoculopsis longicornis*, *Monoculodes crassirostris* and *Apherusa megalops*. These species were also the most numerous in the second, later sampling period (Table 6). In Arey Lagoon *Apherusa megalops* became the most abundant species in the late sample, while the formerly most abundant *Mysid relicta* became second in abundance. In Kaktovik Lagoon, *Monoculodes crassirostris* was most abundant late, while *Apherusa megalops* was most abundant early. At Jago Lagoon *Mysid littoralis* became most abundant late and the formerly most-abundant, *Monoculopsis longicornis*, became second in abundance.

The spatial distribution of temporal change was not uniform. In Arey Lagoon mean total invertebrate abundance dropped from early to late season at mainland and mid-lagoon stations, as well as overall. The barrier island station at Arey Lagoon showed an increase in abundance late in the season (Table 6). In Kaktovik and Jago Lagoons the pattern was somewhat clearer with all stations in Jago Lagoon increasing in abundance and all stations except the pass station in Kaktovik Lagoon increasing in abundance late in the season.

Environmental Variables

Variability Between Lagoons. Freidmans tests were used to examine environmental differences between lagoons. Brownlow and Tapkaurak lagoons had missing values and were deleted from this analysis. Significant differences occurred between lagoons in surface salinity (P 0.005, Table 7) and bottom salinity(P 0.03). However, no significant comparisons were found in bottom salinity values. Surface salinity was significantly higher at Tamayariak lagoon than at Pokok Lagoon. All other comparisons of surface salinity were not significant (P 0.05).

No significant differences between lagoons were found in surface temperatures (Table 7). Bottom temperatures were significantly different ($P < 0.04$), however, the only significant comparison ($P < 0.05$) occurred between temperatures at Jago Lagoon and the higher bottom temperatures at Pokok Lagoon.

Kruskall Wallis tests revealed that sandy bottoms had higher surface salinity than peat bottoms, and peat bottoms had the highest surface and bottom temperature. Mud bottom sites had the greatest water depth ($P = 0.03$ Table 8). Conversely, peat bottoms had the lowest salinity, and least depth. Peat bottoms were observed to retain benthic ice later into the season.

Correlation with Invertebrate Abundance. Correlation coefficients for 4 indicies of invertebrate abundance against 6 environmental variables were calculated. None of the coefficients were significant ($P < 0.05$, Table 9). Therefore, little effect on invertebrate abundance by temperature, salinity, depth or visibility of the water was detectable in these samples.

Table 6. Temporal/spatial changes in numbers of abundant invertebrae species in 3 coastal lagoons on the Arctic National Wildlife Refuge, 1981.

Species	Arey		Jago		Kaktovik	
	31 July	9 Sept.	28 July	28 Aug.	31 July	9 Sept.
Barrier Island						
Mysid relicta	0	3	3	3	1	0
Mysid Littoralis	10	5	0	24	0	3
Monoculopsis longicornis	1	0	17	0	0	1
Monoculopsis crassirostris	0	3	1	7	1	7
Apherusmegalops	2	0	0	3	4	2
Mid Lagoon						
Mysid relicta	6	0	2	1	0	1
Mysid littoralis	36	2	0	23	0	12
Monoculopsis longicornis	2	1	4	8	5	0
Monoculopsis crassirostris	0	0	0	14	0	0
Apherus megalops	1	0	0	6	0	3
Shoreline						
Mysid relicta	28	0	2	0	0	1
Mysid litoralis	5	3	0	7	0	4
Monoculopsis longicornis	1	3	2	0	4	0
Monoculopsis crassirostris	14	2	0	4	0	22
Apherus megalops	1	0	0	1	0	0
Pass						
Mysid relicta	5	1	1	1	2	0
Mysid Littoralis	7	7	2	2	0	2
Monoculopsis longicornis	1	0	1	14	0	0
Monoculopsis crassirostris	1	0	0	1	0	0
Apherusa megalops	0	1	1	1	35	7

Table 7. Water quality and bottom substrate characteristics of 8 coastal lagoons by station on the Arctic National Wildlife Refuge 31 July - 7 August 1981.

Environmental Variable	Station	Lagoon							
		Tamayariak	Simpson	Arey	Kaktovik	Jago	Tapkaurak	Oruktalik	Pokok
Surface Temperature (^0C)	Mainland	8	9	12	10	10	7	9	10
	Mid-lagoon	5	7	7	10	9	-	7	9
	Barrier Island	7	8	7	9	7	7	8	11
	Pass	7	7	8	6	9	4	4	7
Bottom Temperature (^0c)	Mainland	8	9	11	10	8	7	7	10
	Mid-lagoon	7	4	6	9	0	-	4	8
	Barrier Island	7	8	7	0	5	6	5	12
	Pass	7	6	4	0	1	4	3	7
Surface Salinity (OHM)	Mainland	22.0	23.0	16.1	16.0	15.0	16.5	10.2	12.0
	Mid-lagoon	23.0	25.0	16.2	15.5	15.5	-	15.5	12.2
	Barrier Island	22.0	20.5	16.1	16.5	18.5	16.3	15.5	12.0
	Pass	17.0	20.0	22.2	20.0	16.0	17.5	16.0	16.5
Bottom Salinity(m)	Mainland	22.0	23.0	20.0	16.0	18.0	15.0	16.0	12.9
	Mid-lagoon	22.0	27.0	17.1	17.0	27.5	-	17.0	14.5
	Barrier Island	22.0	20.5	16.0	17.0	20.0	17.0	17.2	12.6
	Pass	17.0	20.0	25.6	27.0	26.0	17.2	16.0	16.9
Depth(m)	Mainland	1.7	1.2	0.7	2.2	2.0	1.6	1.1	1.3
	Mid-lagoon	4.3	4.0	2.0	3.5	2.8	-	2.4	1.8
	Barrier Island	0.7	1.1	2.0	1.2	2.0	2.1	2.1	1.5
	Pass	1.1	2.7	3.8	2.8	2.5	1.9	1.5	1.0
Visibility(m)	Mainland	1.7	1.2	0.7	2.2	1.2	1.6	1.1	0.9
	Mid-lagoon	3.0	3.3	1.9	2.0	1.2	-	1.5	0.8
	Barrier Island	1.3	1.1	1.8	1.2	1.2	1.8	1.4	0.9
	Pass	1.1	1.5	1.5	1.5	1.2	1.9	1.5	1.0
Bottom Type	Mainland	mix	mud	peat	mix	mud	mud	mud	mix
	Mid-lagoon	sand	mud	mud	mud	mud	-	mud	mud
	Barrier Island	sand	sand	sand	sand	sand	mud	mud	peat
	Pass	sand	sand	sand	mix	mix	sand	sand	sand

Table 8. Mean values of environmental variables (± 1 standard deviations) by bottom type from 8 lagoons on the coast of the Arctic National Wildlife Refuge July-August 1981.

Physical Measurement Types	Bottom Type				
	Sand	Mud	Peat	Mixed	All
N[a]	12	12	2	5	31
Surface Temperature	6.6 ± 1.6[b]	8.3 ± 1.2	11.5 ± 0.7*	8.6 ± 1.7	7.9 ± 1.9
Bottom Temperature	6.2 ± 1.8	6.1 ± 2.6	11.5 ± 0.7*	5.8 ± 4.9	6.4 ± 3.0
Surface Salinity	18.8 ± 2.6c*	16.4 ± 4.0	14.1 ± 2.9*	17.2 ± 3.9	17.3 ± 3.6
Bottom Salinity	19.2 ± 3.0	18.9 ± 4.4	16.3 ± 5.2	20.7 ± 6.2	19.1 ± 4.2
Depth	1.9 ± 1.4	2.2 ± 0.8	1.1 ± 0.6	2.1 ± 0.6	2.0 ± 0.9

[a] Sample size (number of stations)
[b] Mean ± 1 standard deviation
[c] Kruskal - Wallis test, * significantly different (P 0.05)

Table 9. Correlation coefficients (R) of physical measurements against numbers of invertebrates in 8 coastal lagoons, Arctic National Wildlife Refuge 3 July - 7 August 1981.

Physical Measurement	Total Mysids	Large Amphipods	Total Amphipods	Total Invertebrates
Surface Temperature	-0.067[a]	-0.265	-0.061	-0.167
Bottom Temperature	0.10	-0.297	0.026	-0.86
Surface Salinity	0.128	-0.077	0.004	0.263
Bottom Salinity	0.007	-0.0077	-0.092	0.155
Depth	0.074	-0.092	-0.138	0.199
Visibility	0.160	-0.093	-0.126	0.246

[a] Sample size (N) = 31

Conclusions

Trends in invertebrate abundance between lagoons, between habitats within lagoons, between bottom types, or between areas with differing water quality were not detected in this study due to the high variability in invertebrate numbers between lagoons and between stations within the same habitat. A high variability was also evident between grabs at any one station and between sample periods at the same stations. A much higher level of sampling may be needed to detect trends, if they exist, in invertebrate numbers with lagoon characteristics and locations.

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