ARCTIC NATIONAL WILDLIFE REFUGE COASTAL PLAIN
RESOURCE ASSESSMENT

1983 UPDATE REPORT BASELINE STUDY OF THE FISH, WILDLIFE, AND THEIR HABITATS

Section 1002C
Alaska National Interest Lands Conservation Act

U.S. Department of the Interior
U.S. Fish and Wildlife Service
Region 7
Anchorage, Alaska
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Edited by
Gerald W. Garner and Patricia E. Reynolds

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Conversion Table

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

Multiply Metric (Sl) Units	By	To obtain American Units
Centimeters (cm)	0.3937	Inches (in)
Meter (m)	1.0936	Yards (yd)
Kilometers (km)	0.6215	Miles (mi)
Grams (g)	0.0352	Ounces (oz)
Kilograms (kg)	2.2046	Pounds (lb)
Liters (L)	0.2642	Gallons (gal)
Square kilometers (km^2)	0.3861	Square miles (mi^2)
Square kilometers (km^2)	247.1050	Acres
Hectares (ha)	2.4711	Acres
Kilograms per hectare (kg/ha)	0.8262	Pounds per acre (1 lb/acre)
Cubic meters per second (m^3/s)	35.7143	Cubic feet per second (ft^3/s)
Degrees Celsius (°C)	(°Cx1.8+32)	Degrees Fahrenheit (°F)

Chapter 1

INTRODUCTION

The Alaska National Interest Lands Conservation Act (ANILCA), 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) as well as an analysis of the impacts of oil and gas exploration, development, and production. This report is the second in a series of annual updates of new information which supplement the initial baseline report prepared in 1981 (USFWS 1982). It summarizes work completed or on-going in 1983 with emphasis on studies being conducted by U.S. Fish and Wildlife Service (USFWS) personnel which were designed to obtain new information about ANWR coastal plain resources. 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 briefly summarized in this update report. Publications or unpublished reports of other studies may be available from the investigating agencies or individuals at some time in the future. The report follows the format of the initial baseline report (USFWS 1982) and the 1982 update report (Garner and Reynolds 1983). Tables and figures cited in the chapter summaries can be found in the progress reports contained in the appendices.

Table 1 lists studies summarized in this report by chapter, as well as principle investigators and report status. No new information was available for several chapters because new work had not been done or reports were not completed or available in time for inclusion in this interim report. Many of the results reported are part of on-going studies whose findings should be viewed as preliminary.

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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 Service, Anchorage, Alaska. 507 pp.

Garner, Gerald W. and Patricia E. Reynolds. (eds). 1983. 1982 update report. Baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, Alaska. 379 pp.

Table 1. Arctic National Wildlife Refuge coastal plain resource assessment: status of on-going studies.

Initial Baseline Report Ch. No. Title	Work conducted in 1983	Principal investigators		Project/report status
2. DESCRIPTION OF THE STUDY AREA	No new information obtained	--		---
3. SOILS AND VEGETATION	Completion of final report: "1:63,360-scale geobotanical mapping studies in the Arctic National Wildlife Refuge	D. Walker P. Webber K. Everett	Univ. Colorado Univ. Colorado Ohio State Univ.	Final report on file, USFWS-ANWR Fairbanks
	Cooperative land cover/terrain mapping of the ANWR	C. Marcon S. Talbot M. Shasby L. Strong L. Pank	USFWS, Anchorage USFWS, Anchorage USGS, Anchorage USGS, Anchorage USFWS, Research, Fairbanks	Data analysis in progress
	Soil studies	F. Ugolini	Univ. Washington	Status unknown
	Studies on balsam poplar	M. Edwards P. Dunwiddie	Univ. Washington Univ. Washington	Status unknown
4. BIRDS	Terrestrial bird populations and habitat use on coastal plain tundra	M. Spindler P. Miller C. Moitoret	USFWS-ANWR,Fairbanks USFWS-ANWR,Fairbanks USFWS-ANWR,Fairbanks	Fieldwork continuing ANWR Progress Report No. FY84-9(See Appendix)
	Species accounts of migratory birds observed at study sites	M. Spindler P. Miller C. Moitoret	USFWS-ANWR,Fairbanks USFWS-ANWR,Fairbanks USFWS-ANWR,Fairbanks	Field work continuing ANWR Progress Report No. FY84-13 (See Appendix)
	Migratory bird use of coastal lagoons	R. Bartels T. Doyle	USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks	Field work continuing, ANWR Progress Report No. FY84-7 (See Appendix)
	Movements of molting oldsquaw	R. Bartels T. Doyle T. Wilmers	USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks	Field work continuing, ANWR Progress Report No. FY84-6 (See Appendix)
	Snow goose surveys	M. Spindler	USFWS-ANWR, Fairbanks	Field work continuing, ANWR Progress Report No. FY84-2 (See Appendix)

Table 1. (Continued).

Initial Baseline Report Ch. No. Title	Work conducted in 1983	Principal investigators	Project/report status
	Tundra swan survey	R. Bartels USFWS-ANWR, Fairbanks T. Doyle USFWS-ANWR, Fairbanks	Field work continuing, ANWR Progress Report No. FY-84-8 (See Appendix)
	Bird use of arctic tundra habitats on the Canning River delta	P. Martin Univ. Ak., Fairbanks	M.S. thesis completed
	Bird use at coastal shorelines on the Canning River delta	K. Moitoret Univ. Ak., Fairbanks	M.S. thesis completed
5. MAMMALS	Size, composition, and distribution of the Porcupine caribou herd	K. Whitten ADF&G, Fairbanks R. Cameron ADF&G, Fairbanks	Field work continuing preliminary and interium reports (See Appendix)
	Calving distribution, initial productivity, and neonatal mortality of the Porcupine caribou herd	K. Whitten ADF&G, Fairbanks G. Garner USFWS-ANWR, Fairbanks F. Mauer USFWS-ANWR, Fairbanks	Field work continuing, ANWR Progress Report No. FY84-12(See Appendix)
	Distribution of biting and parasitic insects on the coastal plain and adjoining foothills	L. Pank E. Friedman C. Curby A. Jones USFWS, Research, Fairbanks	Denver Wildlife Research Center Prog. Rept. (See Appendix)
	Yearling mortality study of the Porcupine caribou herd	Yukon Dept. of Renewable Resources Whitehorse, Y. T.	Field work and data analysis continuing
	Spring migration and staging of male caribou in the Porcupine caribou herd	Canadian Wildlife Service Whitehorse, Y.T.	Field work and data analysis continuing
	Behavioral, foraging and movement patterns of cow caribou during spring migration of the Porcupine caribou herd	L. Duquette Univ. Ak., Fairbanks	M.S. thesis being finalized

Table 1. (Continued).

Initial Baseline Report Ch. No. Title	Work conducted in 1983	Principal investigators		Project/report status
	Development and alteration of movement patterns in the Central Arctic caribou herd	R. Cameron K. Whitten W. Smith	ADF&G, Fairbanks ADF&G, Fairbanks ADF&G, Fairbanks	Interim report available ADF&G, Juneau
	Surveys of the Central Arctic caribou herd	Renewable Resources Consulting Services, Ltd., Anchorage		Status unknown
	Surveys of the Central Arctic caribou herd	Alaska Biological Research, Fairbanks		Status unknown
	Muskox ecology	P. Reynolds L. Martin T. Wilmers T. Doyle	USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks	Field work continuing, ANWR Progress Report No. FY84-10(See Appendix)
	Muskox habitat use	C. O'Brian	Univ.Alaska, Fairbanks	M.S. thesis in preparation
	Moose surveys	L. Martin G. Garner	USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks	Field work continuing, ANWR Progress Report No. FY84-4(See Appendix)
	Polar bear population movements and denning	S. Amstrup	USFWS, Research, Anchorage	Field work continuing
	Bowhead tissue sample studies	T. Albert	North Slope Borough, Environment Protection Office, Barrow	Study continuing
	Brown bear ecology	G. Garner H. Reynolds L. Martin T. Wilmers T. Doyle	USFWS-ANWR, Fairbanks ADF&G, Fairbanks USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks USFWS-ANWR, Fairbanks	Field work continuing, ANWR Progress Report No.FY84-11(See Appendix)

Table 1. (Continued).

Initial Baseline Report Ch. No. Title	Work conducted in 1983	Principal investigators	Project/report status
	Habitat use and behavior of brown bears	M. Philips Univ. Ak., Fairbanks	M.S. thesis in prep, ANWR Progress Report No. 84-1 (See Appendix)
	Preliminary wolf denning survey	H. Haugen Univ. Ak., Fairbanks	Field work continuing, ANWR Progress Report No. FY84-5 (See Appendix)
	Distribution and densities of microtine rodents and arctic ground squirrels	C. Babcock Univ. Ak., Fairbanks	Field work continuing, ANWR Progress Report No. FY84-3(See Appendix)
	Ecology of arctic foxes at Demarcation Bay	B. Burgess Univ. Ak., Fairbanks	M.S.thesis completed
6. FISH	Fisheries studies on the north slope	D. Daum, P. Rost, M. Smith USFWS, Fishery Resource Station, Fairbanks	Field work continuing, Fishery Res. Progress Report No. FY84-1 (See Appendix)
	Aquatic macroinvertebrate populations	R. Glesne, S. Deschermeier USFWS Fishery Resource Station Fairbanks	Field work continuing, Fishery Res. Progress Report No. FY84-2 (See Appendix)
	Aquatic survey of the Kaktovik dredging operation, 1983	P. Craig L.G.S. Consulting Services Ltd., Anchorage	Final report to North Slope Borough (on file, USFWS-ANWR, Fairbanks)
7. HUMAN CULTURE AND LIFESTYLE	Literature review	USFWS-ANWR, Fairbanks Staff	work on-going
8. POTENTIAL IMPACTS OF GEOPHYSICAL EXPLORATION	Literature review	N. Felix USFWS-ANWR, Fairbanks D. LaPlant USFWS-ANWR, Fairbanks	work on-going
9. IMPACTS OF FURTHER EXPLORATION DEVELOPMENT AND PRODUCTION OF OIL AND GAS RESOURCES	Literature review	USFWS-ANWR, Fairbanks staff	work on-going

Chapter 2

DESCRIPTION OF THE STUDY AREA

No new information was obtained to update this chapter.

Chapter 3

SOILS AND VEGETATION

Land Cover Mapping of the Arctic Coastal Plain

In 1983, a final report describing the system used to make 1:63,360 (1 inch = 1 mile) scale geobotanical maps of sample areas within the Arctic National Wildlife Refuge (ANWR) was completed by D.A. Walker and P.J. Webber of the Institute of Arctic and Alpine Research at the University of Colorado, Boulder, Colorado, and K.R. Everett of the Institute of Polar Studies of Ohio State University, Columbus, Ohio (Walker et al. 1983). The 6 areas which were mapped totaled about 1600 km^2 and included the Mt. Michaelson (D-3) quadrangle as well as 5 areas corresponding to 1:60,000 scale color infrared (CIR) photographs. These areas were representative of terrain types encountered in the ANWR coastal plain study area (Walker et al. 1982a), and were also used for an accuracy assessment of the 1982 Landsat - derived land cover map prepared by Acevedo et al. (1982). This assessment is discussed in a preliminary report by Strong et al. (1983).

Legends for the maps used a system in which information about vegetation and vegetation diversity, landforms, surface forms, and percentage water or soils were coded. Vegetation nomenclature was based primarily on plant growth forms and vegetation physiognomy. The 1:63,360 scale vegetation mapping units derived from photo-interpretation were presented as part of a hierarchical classification scheme which described tundra vegetation at 4 levels: 1)very small scale units 2)Landsat land cover units 3)photo-interpreted units and 4)plant community descriptions (Walker 1983). Equivalent units for the Alaska state vegetation classification system (Viereck et al. 1982), which is being used for the North Slope Borough (NSB) Area Inventory were also presented.

In addition to vegetation type, the map legend also contained vegetation diversity codes which were based on the number of color tones or textures identifiable from aerial photographs. This scheme permitted most areas of high vegetation diversity to be identified.

Landform/terrain units used in the map legend were primarily based on the system of Kreig and Reger (unpublished) utilized by the NSB Area Inventory and described by Environmental Systems Research Institute (ESRI) and Arctic Slope Technical Services (1982). This system was modified to include common features such as hill slopes, pingos and bluffs.

Surface form units in the map legend were primarily pattern ground and permafrost features that could be recognized on 1:60,000 scale aerial photographs. Surface form units also included river allevium, incised stream drainages, icings, dunes and beach features (Everett 1980, Walker et al. 1982b). These units were related to equivalent units in the NSB/ESRI system.

Percentage water was interpreted for the 5 mapped areas, excluding the Mt. Michaelson D-3 quadrangle. The codes, developed as an indicator of wetland terrain, were based on visual estimates of the percentage of open water in each map unit.

Soils were interpreted by K.R. Everett on the Mt. Michaelson (D-3) quadrangle only. Soil names follow the U.S. soil taxonomy (Soil Survey Staff 1975) and were coded as complexes that indicate dominanat and subdominant soils in each map unit.

The report included the original handlettered 1:60,000-scale geobotanical maps of the 5 representative areas; the original handlettered 1:63,360 - scale geobotanical map of the Mt. Michaelson (D-3) quadrangle and computer - drawn maps showing primary and secondary vegetation, vegetation diversity, soils and surface forms on the Mt. Michaelson (D-3) quadrangle. A similar series of computer - drawn maps showing primary vegetation, soils and surface forms in the northeast corner of the Mt. Michaelson (D-3) quadrangle were also part of this report.

Vegetation was sampled at 68 sites (35 in August 1981 and 33 in August 1982) which appeared to be representative of common vegetation types. In this report, plot descriptions, which included percentage of cover based on visual estimates, landforms (major and meso-scale features, pattern ground descriptions slope and aspect) and site factors (moisture, snow, wind stability, cryoturbation and water depth) were presented as well as species lists and percent cover of each species at each site.

According to the authors, the geobotanical maps produced by this study are useful primarily for regional studies, planning purposes, and providing a broad perspective for inventory of wildlife habitat. They do not provide sufficient information for detailed site specific studies.

The legend system presented in this report was a first attempt at developing a scheme for mapping vegetation at this scale. The authors state that experience with the system is needed before it can be thoroughly evaluated. The report discusses the fact that information integrated into a computer data base must be accurate in order to avoid costly revisions and disillusionment with the system. It suggests that relatively small studies in limited areas which result in accurate classification systems for vegetation and surface forms should be done before committing large sums of money to extensive mapping programs.

Other Soils and Vegetation Studies

In August 1983, a cooperative land cover/terrain mapping effort of the entire Arctic National Wildlife Refuge was carried out by C. Marcon and S. Talbot (USFWS planning staff), M. Shasby and L. Strong (USGS Anchorage field office) and L. Pank (USFWS research division). Photo interpretation of high elevation infrared color transparencies and ground truthing were completed on 24 forty nine mile square blocks, 10 of which were north of the Brooks Range mountains and 1 which was within the ANWR study area. Classification of the multi-spectral scanner data was also initiated. Although most of this mapping effort was outside the ANWR study area, much of it covered the range of the Porcupine caribou herd (L. Pank, wildlife biologist, USFWS Research Division, pers. comm.).

F.C. Ugolini (University of Washington), conducted studies of soil-forming processes near the Okpilak River in the summers of 1980, 1981 and 1982 in conjunction with similar studies at a boreal forest site. In 1980, tension lysimeters were implanted and soil solutions were collected in 1980 and 1981 as were measurements of soil temperature, pH and soil moisture tension. In 1980, litter bags were implanted to assess decomposition rates and approximately half the emplaced litter was retrieved in 1981. Biomass samples were collected from 1 m^2 lichen/heath plots in 1980 and 1981, and herbivore exclosures were erected in 1980. In 1981 plant and soil distribution patterns were analyzed along transects and grids. No information was available about 1982 or 1983 field work (report on file, USFWS, ANWR, Fairbanks).

In July 1983 M. Edwards and P. Dunwiddie (University of Washington), collected information about the size, age and extent of a balsam poplar (Populus balsamifera) stand in the Cache Creek area approximately 30 km south of the ANWR study area. The purpose of the study was to assess reproductive status and population structure of one of the largest poplar stands reported on the North Slope. Trees were cored, diameters were measured and isolated clonal groups were studied in detail. Moss polsters were collected inside and outside of the stand for airfall pollen counts. Density of trees and distribution of sexes were measured along a 30 m transect. Soil studies were carried out, ripening fruit were collected and species lists of vascular plants within the stand were made. Pending the outcome of laboratory results, future studies may be initiated (report on file, USFWS, ANWR, Fairbanks).

Dr. J.E. Hobbie (Ecosystems Center, Marine Biological Laboratory, Woods Hole, Massachusettes) is completing a manuscript entitled "The ecology of tundra ponds of the Arctic coastal plain: a community profile" for the National Coastal Ecosystems Team, USFWS, Slidell, Louisiana. This synthesis provides an overview of tundra pond ecology throughout the Arctic coastal plain and much of the information maybe applicable to the ANWR coastal plain.

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Chapter 4

BIRDS

New information obtained on birds in 1983 included continuing studies of bird populations and habitat use on coastal plain tundra, and migratory bird use of the coastal lagoon systems as well as annual update surveys for staging snow geese and tundra swans on the ANWR coastal plain conducted by USFWS biologists. Other studies included master thesis projects completed by graduate students.

In addition to the reports described below, USFWS biologists prepared and presented 2 papers on birds at the 34th Alaska Science conference held in Whitehorse, Yukon, 28 September to 1 October 1983. One paper described the results of 1981 and 1982 studies of migratory bird use of the coastal lagoon system (Bartels and Zellhoefer 1983). A second paper discussed the distribution, abundance, and productivity of lesser snow geese staging in late August and early September in the arctic coastal regions between Parry Peninsula, Northwest Territories and the Canning River, Alaska, from 1971 until 1983 (Spindler and Barry 1983).

Bird Use of Tundra Habitats

USFWS-ANWR biologists M.A. Spindler, P.A. Miller and C.S. Moitoret continued their studies of bird populations and habitat use on coastal plain tundra in 1983. Methods and results are reported in ANWR Progress Report No. FY84-9 (See Appendix). The objectives of this study were: 1) determine and compare nesting and staging habitat occupancy levels of birds, 2) determine nesting and staging population density estimates of quality sufficient to make total population extrapolations for the ANWR coastal plain, and 3) determine baseline levels of annual and seasonal variations for the most abundant and conspicuous species.

A total of 41 ten-ha bird plots were established in one of 7 habitat types and censused at 1 coastal and 2 inland study sites between June and August 1983. Habitat types were classified as: Flooded Tundra, Riparian, Moist/Wet Sedge (Mosaic), Moist Sedge-Shrub, Wet Sedge, Tussock Dwarf Shrub, and Moist Sedge. Habitat type controlled mean total density, and numbers of species as well as numbers of passerines and shorebirds, and numbers of Lapland longspurs, red-necked phalarope, pectoral and semipalmated sandpiper.

Flooded Tundra was the most important habitat with respect to mean total density, followed by Riparian and Moist/Wet Sedge (Mosaic). These 3 habitat types had significantly higher densities than Moist Sedge-Shrub, Wet Sedge, Tussock Dwarf Shrub and Moist Sedge (Appendix, ANWR Prog. Rep. FY84-9, Table 9). By contrast, Riparian habitat had significantly higher breeding bird densities than all other habitat types (Appendix, ANWR Prog. Rep. FY84-9, Table 10).

Variability in habitat use by birds was also related to season and the date of the census. Wet Sedge, Moist/Wet Sedge, and Moist Sedge-Shrub habitat sites showed more constant total population densities than did Flooded Tussock Dwarf Shrub and Riparian habitat sites, which showed distinct peaks and troughs in density (Appendix, ANWR Prog. Rep. FY84-9, Fig. 12). Population densities were initially high in June at some inland habitats (ie: Wet Sedge) but dropped drastically later in the season at a time when other coastal habitats, such as Flooded, Riparian and Wet Sedge showed distinct and possibly related peaks in population. At the coastal study site in 1978, 1982 and 1983, annual variability in habitat use by breeding birds, which was compared by ranking habitat types on the basis of breeding densities, was significant (Appendix, ANWR Prog. Rep. FY84-9, Table 18&19). Large changes in breeding densities of a few species, such as red-necked and red phalaropes in Flooded Tundra and semi-palmated sandpipers in Moist/Wet Sedge Tundra, caused most of this annual variability in breeding bird densities. Habitat use, when ranked by mean total population densities, was not significantly different in the 3 years. Flooded Tundra consistently supported the highest total bird densities, followed by Moist/Wet Sedge (Mosaic), Moist Sedge-Shrub, and Wet Sedge Tundra.

Total bird use was not significantly different in each of the 3 study sites except for shorebirds and waterfowl which were dependent on habitats more prevalent at the coastal site and where riparian habitat types varied due to shrub height differences.

Species accounts of migratory birds observed during this study are compiled in ANWR Progress Report No. FY84-13 (See Appendix).

Bird Use of Lagoons and Offshore Habitats

Two studies on bird use of lagoons were conducted by USFWS-ANWR biologists in 1983. R.F. Bartels and T.J. Doyle flew aerial surveys of 10 coastal lagoons with the following objectives: 1) obtain an index of relative numbers of birds using coastal lagoons and define the peak population of oldsquaw, 2) compare data from 400 m strip census with census of the entire lagoon, 3) evaluate the relationship between census of shoreline, mid-lagoon and barrier island strips and census of the entire lagoon surface, and 4) determine oldsquaw distribution within the 16 km offshore area. Methods and results are presented in ANWR Progress Report No. FY84-7 (See Appendix). Oldsquaw, which comprised over 80% of the total bird population in 1983, were the major species using the lagoons (Appendix, ANWR Prog. Rep. No. FY84-7, Table 1). In 1983 the total number of oldsquaw observed was approximately the same as numbers observed in 1981, but exceeded numbers observed in 1982 (Appendix, ANWR Prog. Rep. No. FY84-7, Fig. 1). Location of the birds varied from year to year, but the temporal distribution of oldsquaw was similar in all 3 years. As the season progressed, oldsquaw use of the lagoons apparently shifted to the west and offshore. (Appendix, ANWR Prog. Rep. No. FY84-7, Fig. 2 & 3). A comparison between old squaw numbers and densities observed in one 400 m strip transect within a lagoon with numbers and densities in the entire lagoon showed birds were not randomly distributed (Appendix, ANWR Prog. Rep, No. FY84-7, Table 7). Similar results were obtained with 3 strip surveys (Appendix, ANWR Prog. Rep. No. FY84-7, Table 8) indicating that total lagoon surveys remain the best method for estimating oldsquaw numbers.

R.F. Bartels, T.J. Doyle and T.J. Wilmers (USFWS-ANWR) initiated a study to monitor movements of molting oldsquaws within ANWR coastal lagoons with the use of radio-tagged birds. Methods and results are reported in ANWR Progress Report No. FY84-6 (See Appendix). In August 1983, 21 molting oldsquaws were captured in Tapkaurak lagoon and 16 of these birds were fitted with backpack radio-transmitters. They were relocated each day that weather conditions permitted radio-tracking flights to be made until the birds left the refuge in October. Seven of the 16 radio tagged birds died by mid-October. Over 75% of oldsquaw radio relocation points were within lagoons or within 400 m of barier islands in the ocean (Appendix, ANWR Prog. Rep. No. FY84-6, Table 2). The radio-tagged oldsquaw were relatively sedentary; 47% of all relocations were in the lagoon system from which they had been captured (Appendix, ANWR Prog. Rep. No. FY84-6, Table 2). Nearly 90% of the relocation points were found in water less than 5m deep (Appendix, ANWR Prog. Rep. No. FY84-6, Table 3). Average daily movement ranged from 1.77 to 12.20 km/day for 9 oldsquaw alive at the onset of migration (Appendix, ANWR Prog. Rep. No. FY84-6, Table 4). Males moved farther than females, but differences were not significant. Migration coincided with the beginning of lagoon freeze up. Relocation data suggests that oldsquaw move from lagoons to offshore and ocean areas as migration commences. Similar results were seen in oldsquaw distribution during the 1983 lagoon surveys (Appendix ANWR Prog. Rep. No. FY84-7).

Snow Goose Surveys

Surveys of lesser snow geese staging on the ANWR coastal plain were conducted by USFWS-ANWR biologist M. Spindler in 1983. Annual surveys have been conducted since 1971. Methods and results are reported in ANWR Progress Report No. FY84-2 (See Appendix). The objectives of the survey in 1983 were to: 1) determine distribution, abundance and productivity of snow geese, 2) document changes in temporal and spatial distribution within the staging area, 3) record behavior activities and responses to aircraft over flights. Surveys of staging snow geese were conducted in cooperation with the Canadian Wildlife Service. In 1983, fall staging was later than staging observed during the 11 previous years. Major arrivals occurred within the Canadian sections on 1 September and in the ANWR coastal plain on 8 September, 13 days later than staging in 1982 and 2 days later than the long-term average. Peak numbers were seen on 12 September.

An estimated total of 393,000 snow geese were seen: 12,828 on the ANWR coastal plain, 300,651 on the Yukon north slope, 54,523 on the MacKenzie delta and 25,000 south of the delta (Appendix, ANWR Prog. Rep. FY84-2, Table 2). In 1983 total numbers of geese in the ANWR and Mackenzie delta were much lower than long term averages (99,107 and 172,826 respectively). By comparison, numbers of birds observed in the Yukon were much higher than long term averages (106,312).

Aerial photography used for determining age ratios was obtained over the entire staging area. A weighted age ratio of 26.8% $\pm$ 11.0 (SD) young was obtained from the analysis of 94 aerial photographs of flocks representing 8500 geese. The highest per cent young (45%) was observed on the Mackenzie River delta and the lowest (14%) was observed on the Yukon north slope (Appendix, ANWR Prog. Rep. FY84-2, Table 4). In 1983 productivity levels were higher than 5 of the 9 previous years.

Major departure from the staging areas occurred from 21-26 September, 5 days later than in 1982, and 1 week later than the 11 year average. After 5 days of strong west wind and freezing temperatures, no geese were seen. Total duration of staging was 4 days less in 1983 than in 1982 and 2 days less than the long term average.

Snow geese staging on the ANWR coastal plain used the area between the Hulahula River and Egaksrak River in 1983. This distribution was generally the same seen in previous years although the "core concentration" area had shifted from the Okerokovik River to the lower Aichilik, Egaksrak and Kongukut River deltas. Snow cover in 1983 may have influenced this slight change in distribution.

Behavioral observations of snow geese were made on the Aichilik River on 11 September 1983. The majority of the geese observed were feeding on sedge rootstocks in Wet Sedge Tundra and grass blades in Riparian habitat.

Responses of geese to aircraft over flights were recorded. Birds flushed when aircraft were an average of 3 km away and up to 3000 m above ground level. One evening overflight caused all geese within a 4 km radius to take flight. Seventy percent of the birds left the area, but by the next morning total numbers were comparable to goose numbers seen before the overflight. Low altitude aircraft (less than 30 m) produced less response than did aircraft at higher altitudes.

Tundra Swan Surveys

Two tundra swan surveys were conducted by USFWS-ANWR biologists R.F. Bartels and T.J. Doyle in 1983. Methods and results are reported in ANWR Progress Report No. FY84-8 (see Appendix). The objective of these annual aerial swan surveys, which have been carried out since 1981 (USFWS 1982), was to describe the distribution, abundance and productivity of tundra swans utilizing ANWR coastal plain wetlands. A breeding pair/nesting survey, conducted for the first time in 1983, was flown in mid-June. The second survey to document production was flown in mid-August. Survey methods were those described by Bartels et al. (1983).

In 1983, the nesting population was estimated to be a minimum of 105 pairs and 264 total adults (Appendix, ANWR Prog. Rep. No. FY83-8, Table 1). Compared with 1981 and 1982, total swan numbers in 1983 increased 13% and 67%, respectively (Appendix, ANWR Prog. Rep. No. FY83-8, Table 2). Number of adults counted in 1983 were 2% less than the number of adults counted in 1981 and 31% more than those counted in 1982. Cygnet production in 1983 was 70% higher than in 1981 and 316% higher than in 1982 (Appendix, ANWR Prog. Rep. No. FY83-8, Table 2). Numbers of swans in one area of concentration were similar during all 3 years. A second area concentration area showed similar numbers in 1981 and 1983, but had fewer swans in 1982. In a third area of concentration, numbers of swans seen in 1983 were higher than numbers observed in the 2 previous years. Numbers of swans in a fourth concentration area were higher than numbers observed in 1982, but were lower than numbers seen in 1981. Air traffic and human disturbance were similar in 1982 and 1983. Milder weather conditions in 1983 probably contributed to greater production.

Other Bird Studies

In 1983, 2 graduate students from the University of Alaska-Fairbanks (UAF) completed masters degree theses related to bird use of ANWR coastal plain habitats. A study of bird use of arctic tundra habitats at the Canning River delta on the northwest edge of the ANWR coastal plain was completed by Martin (1983). Objectives of this study were: 1) estimate avian populations in the major coastal tundra habitat types by species and community, during 2 successive breeding seasons including spring and fall migration periods, 2) determine the extent of bird utilization of coastal lagoons and estuaries of the Canning River delta, 3) determine the preferred breeding habitats of birds nesting in arctic coastal tundra of the Canning River delta, 4) evaluate the relationship of productivity of major habitats to use by breeding birds on the arctic coastal plain, and 5) identify habitats that are of critical importance to birds using the Canning River delta. Four 255-27 ha plots with different habitat characteristics were studies in 1980: upland, mesic, and low land tundra and coastal saline flats. Upland and lowland plots were also censused in 1979. Emergence of crane flies from terrestrial microhabitats were monitored on the 3 tundra plots in 1980. In 1979 and 1980, 84 species of birds were observed, and 31 of these were confirmed breeders. Seven species were common breeders and other species nested in low densities and/or in uncommon habitats.

The mesic plot had the greatest species richness and highest overall nesting density of all 4 plots studied. Shorebirds characteristically nesting on one of the other habitat plots, also occurred on the mesic plot in equal or greater numbers. The lowland plot received intensive use by late summer transients including use by shorebirds and Lapland longspurs. Use of the saline habitat was consistently high. In both years the upland site had greater diversity of breeding species but lower breeding density than the lowland site. The upland plot attracted more birds only in early June when other areas were snow-covered or flooded. Use by both breeding and transient birds was greatest on the lowland plot. Upland breeders shifted to wetter habitats during and after brood rearing and transients.

Density and diversity of shorebirds in the coastal salt flats plots was consistently high over the entire season. Breeding bird density apparently was positively correlated with microhabitat diversity and wetness. Intense use by late summer migrants appeared to be correlated with habitat containing shallow ponds and very wet tundra.

Total food supply, based on emergence of adult insects, was greatest in the lowland plot, less in the mesic plot and least in the upland plot. Total bird use of plots followed the same order, but breeding densities were highest in the mesic plot. Cold weather in mid-July 1980 may have depressed crane fly emergence. Food supplies may be higher in mesic areas during a warmer summer.

This study suggested that reproductive success may be limited by food supply. The energetic value of emerged insects in each plot compared to the energetic needs of shorebird chicks indicated that available food supply was insufficient to support 50% of the fledgelings produced in 2 of the 3 plots studies.

In 1983 a thesis project of bird use of coastal shorelines on the Canning River delta was also completed by Moitoret (1983). The objectives of this study were: 1) identify and describe coastal shoreline habitats and their use by birds, 2) note how bird use of coastal shoreline areas was affected by season, weather, tide, ice and snow cover, geography, and other factors, and 3) identify the most important shoreline habitats and seasons of use. Bird censuses were conducted along 27.5 km of shoreline transects at 4 day intervals from mid-June to early September 1980. Oldsquaw was the most abundant species of the 51 species of local or migratory birds which used shoreline habitats for feeding, nesting, molting or staging. Eight species, including oldsquaw, were fairly abundant and 14 other species were fairly common in the study area.

Bird use was most intensive from late July until early September when birds from inland sites moved to coastal areas to feed and stage prior to migration. Bird use of shorelines during spring migration was limited due to land fast ice covering most of the shores. Bird numbers were low in late June and early July when most birds were nesting on the tundra. Only 10 species of birds nested on shorelines. Flock size increased for most species as the summer progressed and peaked during fall migration. Ice and snow cover concentrated birds at river mouths and on exposed dunes or bluffs during spring. Six shoreline habitats were identified in this study on the basis of species and intensity of use. Areas where impacts would most affect birds were found to be barrier islands (especially the tips and gaps in between them), saline meadows and littoral flats and river mouths. Shorelines were important to feeding and migratory shorebird and waterfowl.

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Chapter 5

MAMMALS

In 1983 USFWS ANWR biologists continued studies of caribou (Rangifer tarandus), productivity, calving distribution, and neonatal mortality, and muskoxen (Ovibos moschatus) and brown bear (Ursus arctos) ecology. On-going caribou research by Alaska Department of Fish and Game, (ADF&G), USFWS, and Canadian biologists continued as did work on polar bears (Ursus maritimus). New studies on wolves, (Canis lupus) and rodents were begun in cooperation with University of Alaska - Fairbanks (UAF) graduate students. Other graduate students completed field work or theses on caribou energetics, muskox habitat, brown bear habitat use and blood parameters, and arctic fox ecology.

In addition to the reports described below, USFWS-ANWR biologists prepared and presented 5 papers on mammal studies at professional meetings in 1983. Three papers were presented at the 34th Alaska Science Conference held in Whitehorse, Yukon, 28 September to 1 October 1983. Mauer and Garner (1983) presented a paper on evaluating mortality-sensing radio-transmitters for assessing neonatal caribou-calf mortality in the Porcupine caribou herd. Reynolds and Garner (1983) discussed techniques of immobilizing and marking muskoxen. Garner (1983) presented a paper on ecology of brown bears inhabiting the ANWR coastal plain and adjacent foothills. Two papers were presented at the First International Muskox Symposium held in Fairbanks, Alaska, 22-25 May 1983. Reynolds and Ross (1984) presented information on the population status of ANWR muskox herds, based on data collected from 1978 to 1983. A poster paper on muskox distribution, movements and herd dynamics was also presented (Reynolds 1984).

Ungulates

Caribou (Rangifer tarandus granti)

Porcupine Caribou Herd

1982 Calving Distribution, Productivity, Population Size and Composition: Results of studies conducted by ADF&G biologists K. Whitten and R. Cameron in cooperation with USFWS-ANWR and Yukon Department of Renewable Resources (YDRR) staff are summarized in interim reports included in the Appendix.

Fixed wing reconnaissance surveys of calving distribution beginning 1 June 1982 found a calving concentration between Firth River and Spring River in northwestern Canada. Few caribou calved in the ANWR coastal plain study area, possibly because of the unusually late snow melt in 1982. But scattered cows with calves were seen on the coastal plain between the Clarance and Kongakut Rivers. Calving began about 1 June and peaked 4-6 June in the Canadian concentration area. By 8 June, radio-collared cows in Canada had calved (Appendix, ADF&G Inter. Rep. (distribution and productivity), Table 1) and over 80% of all cows seen along transect surveys had calves. In lower density calving areas to the south and west, calving appeared to be delayed by 4-5 days.

In the Canadian concentration area, more cows calved near the foothills than near the coast (Appendix, ADF&G Inter. Rep. (distribution and productivity),

Table 2, Fig. 2). A total of 23,400 cows may have calved in Canada. Along transect surveys of the Canadian calving area, 81 calves/100 cows were seen. By contrast, 58 calves/100 cows were found in the low density calving area to the west. Overall productivity in 1982 was apparently good in spite of unusually extensive snow cover, delayed migration and displacement of calving.

The Porcupine caribou herd was censused in July 1982 using the aerial photo-direct count extrapolation technique described by Davis et al. (1979). In 1982, the caribou aggregated in 2 separate areas. About 30% of the animals were found on ridges, mountain tops and snow patches in the northern Brooks Range southeast of the ANWR study area. A total of 46,107 caribou were counted on photographs of aggregations in the mountains. The remainder of the herd was on the coastal plain. Counts from photographs taken of coastal aggregations totaled 81,473 caribou. No caribou were seen in 14 random count areas peripheral to aggregation areas.

Composition counts of caribou herds seen in the mountains were thought to be reasonably accurate as samples were classified from most groups, and 20% of the caribou were classified. (Appendix, ADF&G Inter. Rep.(size and composition), Table 1). Composition counts of coastal groups were apparently not representative of the aggregation.

The Porcupine herd population was estimated to be 137,264 caribou in July 1982 (Appendix, ADF&G Inter. Rep. (size and composition), Table 2). The minimum population, counted from photographs was 125,174 caribou. The growth rate was estimated at 5.8-7.7% per year between 1979 and 1982 (Appendix, ADF&G, Inter. Rep. (size and composition), Table 3).

<u>1982-83 Fall, Winter, Spring Distribution; 1983 Population Size:</u> Preliminary analysis of data collected on the Porcupine herd in 1983 was summarized in a preliminary report prepared by ADF&G biologist K. Whitten (See Appendix). Distribution and movements were determined by monitoring radio-collared caribou including 16 animals collared near Arctic Village in March 1983. Mid-summer movements occurred east along the ANWR coastal plain to the Babbage/Blow River valleys and the British Mountains in the Yukon Territory, northwestern Canada. Other aggregations moved south across the Brooks Range through the Okpilak, Hulahula and Jago valleys and later joined the rest of the herd near the Blow and Babbage Rivers. A second major movement from the Yukon Territory back into Alaska apparently occurred in mid-winter.

During spring migration, animals moved northward across the Sheenjek and Coleen valleys eventually into the Firth River valley and from there they moved westward across the northern foothills and coastal plain of ANWR. The herd was censused in July 1983 using an aerial photo direct count technique (Davis et al. 1979). Aggregations which were partly located by following 140 active radio-collared caribou, were observed and photographed in 2 major areas: the Egaksrak valley of the Brooks Range and between the Aichilik and Niguanak Rivers.

A total of 135,284 caribou were counted on aerial photographs. Compared to unadjusted counts from previous years, the annual increase to the population may have been 6 to 8% between 1979 and 1982.

In the coastal plain aggregations, 93,645 caribou were counted, including one group of 80,651 caribou. In the mountains, 41,639 caribou were counted, inlcuding 12,396 in a single group.

1983 Calving Distribution, Productivity, and Neonatal Calf Mortality: A 3 year study of calving distribution, initial productivity, and neonatal calf mortality in the Porcupine caribou herd was initiated by K. Whitten (ADF&G), G. Garner and F. Mauer (USFWS-ANWR) in 1983. Methods and results are presented in ANWR Progress Report No. FY84-12 (See Appendix). Primary objectives of this study were: 1) delineate calving distribution, 2) determine initial calf production and the extent, causes, and chronology of neonatal (4-6 weeks postpartum) calf mortality, and 3) measure variation in calf mortality and calf mortality factors between core and peripheral areas and/or between different habitat types or localities.

Calving distribution was determined by relocating 23 radio-collared adult female caribou and by flying reconnaisance surveys and transects during late spring migration and throughout the calving season. In 1983, calving occurred in the coastal plain and foothills from the Sadlerochit River in Alaska to the Firth River in Canada. A major concentration occurred in the lower foothills and adjacent coastal plain along the Jago River, similar to that observed during 8 of 11 years in which calving distribution has been documented. Another concentration of calving occurred on the coastal plain and foothills between the Kongakut River and Komakuk Beach. Calving distribution in 1983 was similar to that observed in 1976, 1978, and 1979.

The peak of calving occurred on 4 June throughout the calving area. Initial productivity was 74 calves/100 cows, based on aerial composition transects over calving concentrations. Eighteen of 25 (78%) of radio-collared cows produced calves.

Mortality of neonatal calves was studied in 1983 by outfitting 69 calves with mortality sensing radio-transmitters. Calves were captured on 4-8 June, monitored at least twice daily, and checked visually every 48 h from 4 June to 2 July. Radio-collared cows with calves, which served as uncaptured controls, were monitored at 1 to 3 day intervals from 29 May - 2 July. Monitoring of radio-collared calves was less intensive through the remainder of July and occurred monthly during the rest of 1983.

Seventeen study calves died from 4 June to 3 August. Excluding 6 calves which died due to study-induced abandonment, the mortality rate of radio-collared calves was 17.5%. Causes of study calf mortality were identified as: 1) predataor kills (45.5%), 2) probable natural abandonment (27.3%), 3) undetermined - excluding predation/scavenging (9.1%), and 4) undetermined - involving predataor/scavenger (18.2%). (Appendix, ANWR Prog. Rep. No. FY84-12, Table 3). Five (27.8%) of the control calves died between 29 May to 2 July. Differences in geographic distribution of study and control groups may have contributed to the higher mortality of control calves. Golden eagles (Aquila chrysactos) killed 3 study calves and were observed feeding on unmarked calves on several occasions. Brown bears killed 2 study calves and were seen killing and/or feeding on unmarked calves on 11 occasions.

Natural mortality was higher in study calves captured in coastal plain areas (21.9%) compared with calves captured in foothill areas (12.9%). Most study calves captured on the coastal plain moved into the foothills, where the majority (60%) of mortalities occurred. Four study calves died from unknown causes between 1 August and 10 December 1983.

Between 4 June and 2 July, 1983, mortality of study calves was low. Herd compostion data collected during the peak of calving and in early July also indicated initial high survival of calves in 1983. By comparison, between 7-30 June 1982, 45% of 23 radio-collared calves died from natural causes on the coastal plain south of Herschel Island. Factors associated with spring migration and geographic distribution of calving may have influenced calf mortality in 1983 and 1982.

Distribution of Biting and Parasitic Insects: Insects are central to the ecology of caribou on the summer range. Caribou behavior, condition and habitat are all modified by insect harrassment and infestation. In 1983, L. Pank, E. Friedman, C. Curby, and A. Jones initiated a study assessing the feasibility of delineating the spatial and temporal distribution of biting and parasitic insects on the coastal plain and adjoining foothills of the ANWR. Methods and preliminary results are reported in a Denver Wildlife Research Center Progress Report (See Appendix). The principal objective of the study was to assess the feasibility of: 1) delineating general spatial and temporal distributions and relative activity of mosquitoes (Culicidae), gad flies (Tabananidae), black flies (Simuliidae), biting midges (Caratopogonidae), and parasitic diptera (Oestridae) with sticky traps, Manitoba traps and subjective measures of harrassment, 2) detecting differences in insect activity and possibly relative abundance in perceived insect and insect relief habitat, and 3) correlating trap results with land cover classes, topography, subjective human and caribou harassment levels, weather variables and existing harassment models. A second objective was to define limitations, logistics, variances and assumptions associated with the protocols employed.

Preliminary analysis of results indicate the Manitoba traps were ineffective for delineating the distributions of biting and parasitic dipterans. Cylindrical sticky traps were simple, transportable and effective for estimating the spatial and temporal distribution of mosquitoes, warble flies and gad flies, but unsatisfactory for biting midges and black flies.

Mosquitoes first appeared in the coastal plain and foothills traps on 1-9 July, 17-25 June and 26-30 June respectively. The catch peaked 10-23 July and dropped to minimum levels by 20 August at all trap locations. Adult warbles were first caught at the coast and plain sites between 1-10 July and did not appear in the foothill traps until mid-August. The gadfly season was the most restricted. Captures occurred between 1-23 July at the plain sites and 1 July - 7 August at the foothill sites.

Mosquito distributions varied significantly between locations. The central plain traps caught the largest numbers; the foothill traps averaged the lowest numbers and the coastal sites were intermediate. The warble catch was restrictly almost exclusively to the coastal and plain sites. Gad flies were caught exclusively at the foothill and plain sites (Appendix DWRC Prog. Rpt. Tables 1-5).

Mosquito distributions based on subjective levels of harassment to human differed from the catch distributions. Harassment levels were lowest at the coastal sites and highest at the foothill sites (Appendix, DWRC Prog. Rpt. Table 13). Harassment levels were higher in insect habitat (ie wet sedge) than non insect habitat (ie gravel bar) however, differences in trap catch were not significant.

Other Porcupine Caribou Herd Studies: A cooperative study of yearling mortality was initiated by the Yukon Department of Renewable Resources and USFWS-ANWR biologists in 1982. Efforts were made to capture and place radio-transmitter collars on yearling caribou at river crossing sites on the Porcupine River during fall 1982. Migration of the herd was late, however, and freeze-up of the river prevented capture of caribou by boat. In late March 1983, YDRR biologists captured and radio-collared 43 yearling caribou wintering in the Whitefish Lake region of the Yukon Territory. Monitoring of radio-collared yearlings has been on a cooperative basis between the two agencies. Field data are presently being analyzed and collection of new data is ongoing.

A study of spring migration and staging activities of male caribou was initiated by the Canadian Wildlife Service (CWS) in 1981. Radio-collared bull caribou were marked in the Richardson Mountains and relocated during spring migration. The study was expanded in 1982 and included ground observations of caribou activity, collection of pellet samples and study of vegetation phenology. Continued field study occurred in 1983. Results of this project are currently being analyzed and prepared.

In 1983, a thesis project on the behavioral, foraging and movement patterns of cow caribou in the Porcupine Herd during spring migration was being finalized (Duquette 1984). Objective of this were to: 1) document the activity patterns of migrating cow caribou, 2) characterize cow caribou range relationships during migration, and 3) characterize movement patterns throughout migration. In 1982 and 1983 the overall rate of travel per day was similar despite differences in the onset of migration which was more than 3 weeks later in 1983 than 1982. The walking speed of caribou was also the same during the 2 years. Time spent walking increased only when the time spent lying was decreased. The amount of time spend grazing remained relatively constant throughout migration. Information on forage utilization and intake during migration and a discussion of managements consideration area also included in this study.

Central Arctic Caribou Herd

Investigations of the development and alteration of movement patterns in the Central Arctic caribou herd were carried out by ADF&G from January 1982 through June 1983. Results were presented by Cameron et al. (1983a). During calving in 1982 and 1983, radio-collared cows were found within 50 km of the coast in 4 distinct areas, one of which bordered the western boundary of the ANWR coastal plain study area. Yearly variations in calving distribution were apparently related to spring snow cover, the progress of snow melt, and/or the extent of flooding within the coastal zone (Cameron et al 1983b). Calf production was high: 86% and 80% of radio-collared cows were accompanied by calves in June 1982 and 1983, respectively. Excellent summer survival and moderate overwinter survival of calves occurred in 1982-1983, indicating that recruitment to the Central Arctic Herd continued to be good.

Renewable Resources Consulting Services, Ltd. and Alaska Biological Research also conducted surveys of the Central Arctic Herd in 1983. Status of their field work is unknown.

Muskox (Ovibos moschatus)

USFWS Studies: P.E. Reynolds, L.D. Martin, T.J. Wilmers and T.J. Doyle continued a study of muskox ecology on the ANWR coastal plain in 1983. Methods and preliminary results are described in ANWR Progress Report No. FY 84-10 (See Appendix). The objectives of this study were: 1) determine population size, composition, and herd dynamics 2) document seasonal distribution patterns, movements and habitat use, and 3) locate and define calving areas.

The 1983 pre-calving population in and adjacent to ANWR was estimated to be 257 muskoxen. In early April 1983, 235 muskoxen were counted. Fourteen additional bulls were seen east of the Kongakut in June 1983 and 8 muskoxen including 3 adult bulls, 3 adult cows and 2 subadults were seen on the Kavik river in November. In early November an estimated 311 muskoxen were counted in or adjacent to the ANWR. Of these, 288 animals were in the major study area between the Canning river and Aichilik River. The population, which increased at a rate of 15% between 1982 and 1983, has more than doubled since 1979 (Appendix, ANWR Prog. Rep. No. FY84-10, Table 5, Fig.2).

Composition counts made in April, June and August suggested that seasonal changes in herd composition may occur (Appendix, ANWR Prog. Rep. No. FY84-10, Table 6). Most adult bulls were found in bull groups in April and June, but were seen in mixed sex herds during the rut in August. Numbers of 3 year old males in mixed sex herds declined between June and August suggesting displacement by adult males during the rut. Cows 3 years of age and older comprised 33% of the samples classified in June and August 1983.

An estimated 64 calves were born between late April and late June 1983. In August 1983, 66 calves per 100 cows (3 years of age and older) were observed and calves comprised 22% of the population. Yearling recruitment was high in both 1982 and 1983 and mortality appeared to be low. Nine adult mortalities, including 4 adult bulls killed by hunters and 2 adult bulls killed or scavenged by a grizzly bear, were recorded between April 1982 and November 1983. One adult bull also died from wounds sustained during fighting, 1 adult cow died from malnutrition in October 1982, and 1 3 year old cow died from unknown causes 1 month after being captured (Appendix, ANWR Prog. Rep. No. FY84-10, Table 10).

Herd dynamics were similar in 1982 and 1983 (Appendix, ANWR Prog. Rep. FY84-10, Figs 4-7). Herds were stable from January until mid-March 1983. During calving from late April through mid-May, herds congregated in calving areas and intermixed. Most herds were relatively stable as they dispersed from calving areas in early June but intermixed again in July when they moved back to major river drainages after emergence of willows. In August muskoxen were generally associated with small harem groups. By late September large herds had aggregated along major rivers. Mean herd size varied seasonally. Largest herds were generally seen in mid-April, late October and early November and the smallest herds were usually seen in August during the rut (Appendix, ANWR Prog. Rep. FY84-10, Fig.8).

In 1982 and 1983 muskoxen in the Okerokovik area east of the Jago River calved along the Niguanak River, the Sikrelurak River and the Angun River. In 1983, most muskoxen from the Sadlerochit area calved in the hills between Marsh Creek and the Katakturuk river, about 12 km west of the Carter Creek hills area which had been used by muskoxen since at least 1978. Animals from the Tamayariak area which calved with Sadlerochit animals in the Carter Creek hills in 1982, calved on bluffs near the main fork of the Tamayariak

River in 1983. Five of 9 radio-collared cows did not use the same area (within 13 km) during calving in 1982 and 1983 (Appendix, ANWR Prog. Rep. No. FY84-10, Table 12).

Habitat use changed seasonally in 1983 and 1983 and may be related to seasonal movements of muskoxen in some areas. Snow-covered areas along drainages or ridges were used in late winter 1983 (January through mid-March). Ridges and bluffs partially blown free of snow were used from late March until mid-or late May. In early June animals used low vegetation or bare areas along drainages or ridges. In late June and early July muskoxen began using large willow stands as they moved into major river drainages. In August 1982, muskoxen were associated with tussock communities along rivers or in flat areas. In August 1983, wet sedges or Equisetum along small drainages were used. In September and October animals were seen in willow stands or low vegetation along major rivers (Appendix, ANWR Prog. Rep. No. FY84-10, Tables 13 and 14).

High productivity and low mortality in the transplanted ANWR muskox herds have resulted in a rapidly expanding population which may be beginning to exploit new geographic areas. Some long range movements by radio-collared cows by be related to dispersal. Dispersal of at least 1 young-aged herd from the Tamayariak area into a new area on the Katakturuk River was documented in 1982 and 1983.

Other Muskox Studies: UAF graduate student C. O'Brien completed fieldwork on a masters thesis project studying habitat by muskoxen in the ANWR coastal plain study area. The objectives of the study were: 1) to compare the vegetation of drainages used and not used by muskoxen in the Arctic National Wildlife Refuge and on the Seward Peninsula near Brevig Mission and 2) to use these comparisons to define muskox habitat preferences and to estimate the potential for expansion or displacement of existing muskox populations on the Alaskan mainland.

The study which began in 1982 as an extension of Robus's (1980) work, expanded this muskox habitat description to other drainages in the ANWR and the Seward Peninsula. From June to August 1982, areas of consistent muskox sightings were studied intensively along the Tamayariak, Okerokovik, and Niguanak Rivers. True color aerial photographs (scale 1:18000) were ground-truthed, and the vegetation was quantitatively described with a point intercept method and with occular estimates of percent cover. Fecal pellets were collected opportunistically, and have been analyzed at the Composition Analysis Laboratory, Ft. Collins, Colorado.

From the data collected in 1982, the vegetation of 8 drainages in the ANWR was described using the 1:18,000 true color aerial photographs and a random dot method (Marcum and Loftsgaarden 1980). Over 1100 dots have been classified into 15 major vegetation types. Drainages used and not used by muskoxen are being compared on these random dots. Several additional areas frequently used by muskoxen were visited in July 1983 and the vegetation described. Random points selected from aerial photographs were ground-truthed to test the accuracy of the photo-interpretation techniques used in the present study. The test was limited to 45 points due to logistical complications; however, the results have aided in choosing an accurate level of vegetation description.

Muskox distribution data selected from the information gathered during 2 years of radio-relocation flights by USFWS (Appendix, ANWR Prog. Rep. No. FY 84-10, Fig. 9) are being used to examine the assumption that muskoxen tend to localize along drainages in the ANWR. This data has been coded and filed on computer, enabling the testing of several related hypotheses on muskox distributions and drainage proximity. A final report (masters thesis) of this study will be available in 1984 (C. O'Brien, UAF, pers. comm.).

Moose (Alces alces)

In 1983 moose surveys were made by L.D. Martin (USFWS-ANWR) along the Canning River and the Kongakut River drainages in areas adjacent to the ANWR coastal plain study area. Methods and results described in ANWR Progress Report No. FY84-4 (See Appendix). The objectives of this study were: 1) determine population size, composition and distribution of moose within the Canning and Kongakut River drainages, 2) determine productivity of these 2 moose herds and, 3) determine overwinter calf survival, and to compare these data with similar information collected in previous years.

The Canning River drainage was surveyed in mid-September and late October to determine seasonal shifts in moose distribution. Numbers of moose observed increased from 78 in September to 149 in October (Appendix, ANWR Prog. Rep. No. 4, Table 1 and 2). Fall movements into the drainage apparently had not occurred by mid-September 1983. Snow depth was still shallow and snow cover was incomplete at this time. The 149 moose observed in late October 1983 were very similar to the 148 moose seen in a 1980 spring survey of the same area suggesting that the Canning River population may be relatively stable.

Along the Kongakut River drainage, 158 moose were counted in late September 1983, 28% more moose than were seen along the same survey route in the spring of 1980. This apparent increase to the population may be due to immigration from surrounding river valleys and/or high reproductive rates.

Marine Mammals

Polar Bear (Thalarctos maritimus)

Polar bear studies being conducted by USFWS Research Division continued in 1982 and 1983. Objectives of this project are: 1) determine the size and trends of polar bear populations in Alaska, 2) determine movement and distribution patterns of Alaskan polar bears, and 3) determine the distribution, timing and importance of polar bear maternity denning in Alaska (Amstrup et al. 1983a, 1983b).

A mark and recapture program in the eastern Beaufort Sea was conducted between 1 April and 10 May 1983. Polar bear distribution was different than in previous years and bears were difficult to find. Only 21 bears including 8 adult females, 3 adult males, 5 subadults and 5 litter members were captured as a result of aerial searches. Compared with previous years, family groups comprised a far smaller proportion of the sample caught. Six of the 21 bears had been previously marked, a proportion similar to the long term average of 20% recaptures which has occurred in the Beaufort sea study since 1972. Nine bears were captured with the aid of radio-telemetry: some of these animals were recollared individuals and some were previously unmarked bears accompanying a radio-collared animal.

From 1 October until 15 November 1983, another mark and recapture program was conducted in the eastern Beaufort Sea. Forty seven of 50 bears observed were captured including 8 adult males, 11 adult females, 6 subadult males, 12 subadults females, 6 yearling and 4 cubs of the year. Litter size averaged 1.5 young per litter in 3 litters of yearlings and 3 litters of cubs. Four of the 47 bears captured and one other bear seen but not captured, had been previously tagged.

Captured bears were weighed, measured, ear tagged and tattooed. A vestigial pre-molar was pulled for age determination. In the spring of 1983, 10 adult females (including recollared animals) were radio-collared. In the fall of 1983, 6 adult females, 1 subadult female, 1 adult male was radio collared and one other was fitted with an experimental ear-tag transmitter. Radio-collared animals were relocated during the fall of 1982 and 1983. Movements of some individuals have now been monitored for over 24 months.

Bowhead Whale (<u>Balaena mysticetus</u>)

In 1983 T.F. Albert (North Slope Borough (NSB) - Environmental Protection Office) continued tissue and structural studies of the bowhead whale. Animals harvested in the annual subsistence hunt by Eskimo whalers have been examined by N.S.B. biologists, in five arctic villages including Kaktovik. These studies were initiated by the National Marine Fisheries Service and later carried out by the North Slope Borough, beginning in 1981. The purpose of such studies is to further the understanding of the anatomy, physiology and life history of the bowhead whale to ensure good management practices and help determine the probable effects of offshore industrial development on bowheads. Specifically, studies are directed at describing the reproductive, integumentary and digestive systems, documenting the presence of toxic substances, characterizing normal bacterial and viral flora, and determining food habits of the bowhead. Kaktovik is the only village where the whales consistently have food in their stomachs. The collected specimens are preserved and sent out to several universities for detailed analysis. Several publications have resulted from the program (J.C. George, NSB Environmental Protection Office, pers. comm.).

Predators

Brown Bear (<u>Ursus arctos</u>)

<u>USFWS Studies</u>: In 1983 G.W. Garner, L.D. Martin, T.J. Wilmers and T.J. Doyle (USFWS-ANWR) in cooperation with H.V. Reynolds (ADF&G) continued studies of brown bear ecology in and adjacent to the ANWR coastal plain. Methods and preliminary results are reported in ANWR Progress Report No. FY84-11 (See Appendix). Objectives of the study were: 1) determine the location of denning and ecology of denning for brown bears using the ANWR coastal plain, 2) determine seasonal habitat use patterns of brown bears using the ANWR coastal plain, 3) determine seasonal interrelationships between brown bears and other wildlife species, especially caribou, and 4) determine the structure, size, status and reproductive biology of brown bear populations on the northern slope of the eastern Brooks Range.

A total of 80 brown bears were captured and marked in 1982 and 1983 (Appendix, ANWR Prog. Rep. FY84-11, Table 1). Radio-collars put on 60 of these animals were monitored until the bears denned in October or November.

Captured bears included more males in age classes 5.5 years or less and more females in age classes 6.5 or more (Appendix, ANWR Prog. Rep. FY84-11, Fig. 2). The sex ratio for captured bears was equal.

In 1983, 10 of 17 young bears (cubs and yearlings) apparently died. By comparison, no natural mortalities of cubs and yearlings were observed in 1982. Reason for this high mortality rate (58.9%) is unknown.

No interactions between brown bears and muskoxen were seen in 1982, but in 1983, brown bears were observed feeding on muskox carcasses on 2 occasions and were seen stalking or chasing muskoxen on 2 other occasions.

Preliminary analysis of radio-location data indicate that bears appear to shift habitat use locations to coastal areas in June when these locations are occupied by calving and post-calving caribou. Brown bears were observed feeding on caribou carcasses 6 times in 1982 and 15 times in 1983. Bears chasing caribou were observed once in 1982, and on 15 occasions in 1983. Three of these 1983 chases were successful caribou calf kills. Caribou did not react to the nearby presence of bears during 66% of 98 occasions when the 2 species were in close proximity.

Thirty-eight bear dens, located during the fall of 1982, were monitored in spring 1983 to document approximate dates of emergence. Ten bears had already emerged by 24 April and 8 bears emerged by 1 May. Thirteen of these bears were single males or non-paturient females. The remaining bears, predominantly females with young, emerged throughout May.

Physical characteristics of 39 dens were measured in late May 1983. In late July vegetation and soil characteristics of these dens and 6 other dens were also measured. Elevation of den sites ranged from 48.8-1341.1 m with a mean of 816.2 ± 61.4 M (SE). Soil textures at 29 den sites were predominately silty and sandy loams. Only 1 of 26 dens observed had not collapsed by late July. Dens were predominately located on southeast facing slopes with a mean aspect of 145° ± 20° SE (Appendix, ANWR Prog. Rep. FY84-11, Table 6).

Fifty eight dens of radio-collared and unmarked bears were located in late September, October and early November 1983. Fifty two bears denned during the last half of October. Bears again moved south into the foothills and mountains to den. Only 2 dens were located in the coastal plain of the ANWR study area in 1983.

Preliminary estimates of population size and productivity of bears in and adjacent to the ANWR study area are tentative. Three or more years of intensive study are needed before accurate estimates can be made. A minimum of 87 bears were in the study area in 1983. Assuming 80% of the bears were captured, 108 bears comprised the population and bears occurred at a density of 1 bear/80km^2 in the 8300 km^2 study area. These figures are preliminary and subject to several biases.

Information on a reproductive biology was obtained from 11 females. Results presented are preliminary. No females were observed with young or showed evidence of having young at or before 5.5 years of age, and no 3.5 year old females were observed breeding. The earliest age at which females first produced cubs ranged from 6.5 years (2 sows) to 8.5 years (1 sow) with a mean of 7.4 years (N = 11). The potential length of reproductive life for females in ANWR is at least 16 years: one 23.5 year old female was observed breeding during 1983. A mean litter size of 1.9 was calculated for 6 litters of cubs and 9 litters of yearlings. Litter size ranged from 1 to 3 cubs. The average minimum reproductive interval was calculated to be 3.6 years (N = 7), a figure that is likely low. Theoretically, a female could produce a total of 8.4 young during her reproductive life or an average of 0.5 young/year. This relatively high reproductive rate, if accurate, may be related to the accessibility of ANWR bears to the Porcupine caribou herd as a food source.

Other Brown Bear Studies: Field work for a masters degree project (UAF) on the habitat use and behavior of brown bears in the ANWR was completed by M. Philips in 1983. Methods and results are described in ANWR progress report No. FY84-1 (See Appendix). Bears were observed near the Caribou Pass area along the Kongakut River, east of the ANWR coastal plain study area from 27 June - 11 August 1982, and 24 May - 29 August 1983. Bear densities in this area were low (1 bear/130-260 km^2). Bears were observed for a total of 387 bear-unit hours. Behavior was described as one of 6 catagories (21 sub-categories). Bears were most often observed feeding (114 bear unit hours), foraging (113 bear unit hours) and resting (88 bear unit hours) (Appendix, ANWR Progress Report No. FY84-1, Fig 2).

Food items most commonly used included *Hedeysarum alpinum* roots, flowers and leaves from *Equisetum arvense* and *Boykinia richardsoni*, crow berries (*Empetrum nigrum*), cranberries (*Vaccinium vitis-idaea*), bear berries (*Arctostaphylos rubra*), caribou (*Rangifer tarandus*), ground squirrel (*Spermophilus parryi*) and microtine rodents. From late May to late June, caribou, particularly calves, were an important food item for grizzlies. Bears shifted their ranges to include areas frequented by caribou, primarily at or near the caribou calving grounds. Information on habitat use was collected during 398 bear-unit hours of observation. Habitat types were classified by dominanent topographic and vegetative features. Bears were observed in 6 different topographic features but were most commonly seen in valley flats (107 bear-unit hours), mountain slope/hillsides (90 bear unit hours) and cutbank/gulley/creek (89 bear-unit hours). In 1983 bears were seen in 20 vegetation types, but most frequently used sedge tussock mixed-shrub tundra, sedge-willow tundra, and mixed-shrub tundra.

Another masters degree thesis on blood profiles of brown bear central and northern Alaska was completed in 1983 (Brannon 1983). The objectives of this study were: 1) to establish baseline data for blood and physiological variables by sex, age, weight, and reproductive status, 2) to determine to what extent these characteristics are influenced by the stress of the capture effort and by the immobilizing drug, and 3) to assess the usefulness of these variables as indicators of physical condition. Blood from 151 brown bears captured between 1973 and 1982 in the Brooks Range and the Alaska Range was examined for 7 hematological, 24 serum chemistry, and 6 protein electrophoretic determinations. Differences in these characteristics between samples collected one hour apart indicate a response to stress during capture. Location differences in leukocyte count, erythrocyte count, hemoglobin, hematocrit, and cortisol suggest that Alaska Range bears were more stressed by capturing than Brooks Range bears. Sodium, creatinine, and urea nitrogen were negatively correlated with capture date, suggesting varied diet reinstatement and regained renal function as time from den emergence increased. Calcium, phosphorus, and alkaline phosphatase were negatively correlated with age, reflecting increased osteoblast activity and bone formation in young bears. Males had higher values than females for erythrocyte count, hematocrit, glucose, creatinine, calcium, phosphorous, and alkaline phosphatase, while glutamic-oxalacetic and glutamic-pyruvic transaminases were higher in females.

Wolf (Canis lupus)

A preliminary study to examine prey utilization by wolves and to assess wolf and prey densities on three drainages adjacent to the ANWR coastal plain study area was initiated in 1983 by UAF graduate student H.S. Haugen. Methods and results are presented in ANWR Progress Report FY84-5 (See Appendix). The objectives of this preliminary study were 1) determine the relative utilization of the available prey species, 2) verify reported wolf homesites, 3) determine the relative availability of major prey species, 4) determine which wolf pack(s) would be best suited for further study. A 10 day reconnaissance survey in each of 3 river drainages (Kongakut River, Hulahula River and Canning River) was conducted in July 1983. Visual observations of wolves and prey species, as well as remains and signs were made. Wolf scats were collected in all 3 drainages.

In the Kongakut drainage, where 3-7 wolves were seen, moose, caribou and Dall sheep (Ovis dalli) were all available as wolf prey items. Sheep were abundant in the Hulahula drainage, where tracks of 1 wolf were observed. In the Canning drainage, where 2 wolf pups were seen, moose occurred in relatively high densities and caribou were also present. Scat analysis which included theoretical calculations of numbers of individuals consumed per wolf per year, indicated that wolves in all 3 drainages preyed on caribou (Appendix, ANWR Prog. Rep. FY84-5, Table 2-4, Fig. 4). Wolves in the Kongakut drainage utilized the 3 available ungulate species in proportion to the relative availability of each species. Wolves in the Hulahula drainage depended more heavily on Dall sheep. Scats from the Canning River contained no moose. All 3 packs have different prey bases and may be of interest for further study.

Arctic Fox (Alopex lagopus)

A masters project thesis on the ecology of arctic foxes at Demarcation Bay east of ANWR coastal plain study area was completed in 1983 (Burgess 1983). This study will be summarized in the 1984 update report.

Small Mammals

In 1983 C.A. Babcock, a UAF graduate student initiated a master's degree study on microtine rodents and ground squirrels of the coastal plain and foothills of ANWR. Methods and results are described in ANWR Progress Report No. FY 84-3 (See Appendix). Objectives of this study were: 1) estimate the distribution and densities of all microtine rodent species in the ANWR study area, 2) determine habitat use and population dynamics of each microtine species, 3) estimate distribution and densities of arctic ground squirrels (Spermophilus parryii) in the ANWR study area, 4) determine habitat use and population dynamics of arctic ground squirrels, and 5) note use of microtine and ground squirrels by predators.

Three study sites were sampled to provide a latitude/altitude transect across the coastal plain and to reflect coastal and mountain differences. Each location was trapped 3 times during the summer of 1983, at monthly intervals.

Microtine Rodents: Four species of microtines were trapped during the study. The singing vole (*Microtus miurus*) was found only at the mountain site (Kongakut River) at higher elevations and on slopes of ridges in herbaceous tundra. The tundra vole (*Microtus oeconomus*) was found in all 3 sites, but was least common at the northern coastal site (Okpilak delta). The collared lemming (*Dicrostonyx torquatus*) was seen at all 3 sites, but was mostly found at the northern coastal site as was the brown lemming (*Lemmus sibericus*). The coastal microtines appeared to be at a low point in their cyclic fluxuations. No red backed voles (*Clethrionomys rutilus*) were caught during this study, although this species has been reported in the northern foothills of the Brooks Range. Microtines are utilized by avian predators, such as snowy owls, jaegers, glaucous gulls, rough-legged hawks and ravens, and mammalian predators such as weasels, foxes, wolverine, wolves and grizzly bears.

Arctic Ground Squirrels: Squirrels were trapped at the inland site (Katakturuk River) and the mountain site (Kongakut River) and some evidence of squirrel use of bluffs and sand dunes near the coastal site (Okpilik delta) was observed. Density distribution of arctic ground squirrel depended on suitable burrowing conditions and forage quality. Principle predators of ground squirrel include wolves, foxes, wolverines, and grizzly bears as well as golden eagles and rough legged hawk.

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Chapter 6

FISH

U.S. Fish and Wildlife Service Studies

Fish Distribution and Habitat

During 1983, the Fairbanks Fishery Resource Station (FFRS) of the U.S. Fish and Wildlife Service (USFWS) continued studies on the ANWR coastal plain which were initiated in 1982. D. Daum, P. Rost and M.W. Smith conducted fisheries studies in several coastal plain rivers. Methods and results are reported in Fairbanks Fishery Resources Progress Report No. FY84-1 (see Appendix). Objectives of this study were to: 1) assess general distribution and life histories of major fish species on the Okpilak, Jago, and Hulahula Rivers and smaller drainages between the Katakturuk River and the Aichilik River, 2) identify and describe char overwintering movements and habitat requirements on the Canning and Hulahula Rivers, 3) monitor anadromous char migration patterns on the Hulahula River and 4) identify and describe char spawning grounds and habitat requirements for the Hulahula River. Physical characteristics of the drainages, including discharge, channel width, depth, and configuraion, velocity, % pool area and % riffle area, predominant substrate were examined and related to potential overwintering habitat (Appendix, FFRS Prog. Rep. No. FY 84-1, Tables 2, 10, 14,23). Chemical characteristics of the drainages including alkalinity, total hardness, conductivity, water and air temperature and pH were described in this report (Appendix, FFRS Prog. Rep. FY84-1,Tables 1,9,15,22,).

Distribution and abundance of fish species, and the size, age, sex ratios, weigh and condition of fish caught were described for the study drainages. Spawning and overwintering habitat in each drainage was discussed (Appendix, Fishery Resources Progress Report No. FY84-1,Tables 3-8,11-13,16-20). The following rivers lacked fish populations: Katakturuk River, Marsh Creek, Carter Creek, Jago River, Angun River, Sikrelurak River, and Kogotpak River.

One major emphasis of the study was to determine fall and winter movements and spawning areas of arctic char in the Hulahula River. Char movement into the Hulahula river occurred from the beginning of August through the beginning of September with the peak movement apparently occurring in the last week of August.

Fall concentrations of char on the Hulahula River, determined by aerial survey in mid-September, were located in 3 fish hole sites which have been historically used for subsistence fishing (Jacobsen and Wentworth 1982). Major spawning areas were located at the upper 2 fish holes. Overwintering pools appear to be limited. Twenty-nine fish radio-tagged during September 1983 in the Hulahula River showed little movement during late fall and early winter. A few tagged fish remained at the original site and the remaining fish had moved no further than 5 km downstream into a large aufeis field.

Fifteen fish implanted with radio-transmitters in 1982 were used to monitor fall and winter movements of fish in the Canning River. The fish were caught at Shublik Springs and overwintered within the aufeis area below the spring. By mid-November, 1 fish had moved 23.5 km downstream and 5 had moved 18 km or more. All fish had moved at least 3 km away from the original tagging site. Four of 5 overwintering areas identified in

1981-1982 were used in 1982-1983 (Appendix, FFRS Prog. Rep. No. FY84-1, Fig. 25). Considerable movement of radio-tagged fish was recorded throughout the winter (Appendix, FFRS Prog. Rep. No. FY84-1, Table 25). Overwintering locations within the aufeis field may not be as isolated as was previously thought.

Aquatic Invertebrates

Another study conducted in 1982 and 1983 by R.S. Glesne and S.J. Deschermeier (USFWS-FFRS) surveyed aquatic macroinvertebrate populations from 46 sites along 13 different drainages on the ANWR coastal plain. Methods and results are reported in FFRS Prog. Rep. Number FY84-2 (see Appendix). The report provides baseline data on invertebrate populations which are important in the food chain of most fish species and, because aquatic macroinvertebrates are more sensitive to environmental change than fish, may be a potential measurement of perturbation associated with resource development.

Physical characteristics including stream type, % pool, riffle and shallows, substrate particles, discharge, depth and velocity, and chemical characteristics, including pH, total hardness, total alkalinity, dissolved oxygen and conductivity were described at each sampling site (Appendix, FFRS Prog. Rep. No. FY84-2,Table 1, Table 2,). Benthic samples were collected between June and September 1982 and between July and September 1983. Density, biomass, number of taxa, diversity (H') and evenness (J') vales were determined for macroinvertebrate communities at all stations. Mean values were compared for tundra, spring and mountain stream types. Density of invertebrates ranged from 11 organisms/m^2 to 15,555 organisms/m^2 and may be close to seasonal minimum densities due to the midsummer sampling scheme. Mean density varied between stream types, increasing by nearly an order of magnitude between mountain and tundra streams and between tundra and spring streams. Mountain streams had greater fluctuations in discharge, turbidity, and greater instability of substrate compared with the intermediate stability of tundra streams. Spring streams were very stable. Organic matter input decreased from spring streams to tundra streams to mountain streams. Spring streams had much higher values for conductivity and alkalinity which were similar in mountain and tundra steams. Density and biomass of aquatic invertebrates showed strong correlation with alkalinity and conductivity values (Appendix, FFRS Prog. Rep. No FY84-2, Table 7).

Species composition of all 3 stream types was dominated by the taxa Simuliidae, Orthoeladinae, Diamesinae, Baetidae, and Oligochaeta. These gatherer and scraper functional groups generally feed on fine particulate organic matter. The low diversity of functional groups was reflected in the low values found for species diversity (H') throughout the study area. Mean diversity and evenness (J') values for mountain streams were very low due to the instability of this stream type. H' and J' values were also very low for spring streams where chronomids accounted for 85% of the species composition. Tundra streams exhibited the highest diversity and evenness values, which may be partially explained by the wide range of temperatures found in these waters (Appendix, FFRS Prog, Rep. No. FY84-2, Table 6).

Other Fish Studies

One other study conducted in 1983 contained information about fisheries resources adjacent to the ANWR coastal plain study area. P. Craig (L.G.S. Alaska Research Associates, Inc.) conducted an aquatic survey of the 1983 Kaktovik gravel dredging operation for the Material Source Division, North Slope Borough, Barrow, Alaska (Craig 1983). The objectives of this study were to document: 1) fish present in the dredging area, 2) fish mortalities in slurry outlet and gravel stockpile, and 3) pattern of increased turbidity and suspended sediment in receiving waters due to dredging activities. The results of this survey suggested that the dredging operation at Kaktovik did not adversely affect local fish populations.

Fourhorn sculpin comprised 70% of the 203 fish caught in gill net and seine surveys in the dredge embayment and adjacent waters of Kaktovik lagoon. Arctic char and arctic cisco comprised 18% and 10%, respectively. One arctic flounder and one saffron cod were also caught. The catch per unit effort (using gill nets) was highest in the stockpile outflow (71 fish/24 h); 52 fish/24h were caught in the dredge embayment and 33 fish/24h were caught in Kaktovik lagoon. The arctic char caught in the outflow area tended to be smaller than those caught elsewhere in the embayment or Kaktovik lagoon. Juvenile fourhorn sculpin comprised 48 of 50 fish caught in seines along shorelines. These small sculpins were most abundant in the turbid outflow area.

No mortalities were observed in the gravel stockpile or outflow areas.

Turbidity and suspended sediments in surface water were very high at the stockpile outflow but lower throughout the rest of the dredge embayment. A gravel spit separating the dredge embayment and Kaktovik lagoon was generally effective in retaining the silt-laden waters of the stockpile outflow, except when strong winds from the west caused some waves to spill over the gravel spit. The amount of sediment entering the lagoon was small.

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Chapter 7

HUMAN CULTURE AND LIFESTYLE

Early History and Archaeology

No new information was obtained on early history and archaeology of the Arctic National Wildlife Refuge (ANWR) in 1983 (B. Gal, Supervisory Archaeologist, BLM, pers. comm.).

Subsistence

Kaktovik

Two technical papers containing information about subsistence use in the ANWR have been prepared by the Alaska Department of Fish and Game (ADF&G) Division of Subsistence during the past 2 years. In 1982, the first in a series of regional subsistence bibliographic publications which included a wide range of topics dealing with the subsistence activities, economies, and culture of Alaska's north slope was completed (Anderson 1982). This bibliography cites 665 works including 45 references related to the village of Kaktovik. Each citation includes a brief abstract and is indexed by key words. In 1981 a paper which provides an overview of ADF&G Subsistence Division concerns and research efforts on subsistence use of the Porcupine caribou herd was completed (Caulfield and Pederson 1981). On-going research projects aimed at documenting land and resource use in Kaktovik and Arctic Village are briefly summarized in this report.

A paper which described caribou hunting by the people of Kaktovik was presented at the 34th Alaska Science Conference at Whitehorse, Yukon, 28 September to 1 October 1983 (Pedersen 1983). Data presented included geographic descriptions of both general and high yield hunting areas through time and by season, which were obtained from intensive land use mapping efforts. Information on the annual harvest of caribou including time, location, and numbers harvested, was also presented. Land and resource management implications were discussed in the context of the major land use changes facing the area.

S. Pedersen (ADF&G Subsistence Division) is also currently working on a project entitled "Subsistence land and resource use dimensions in the eastern and central arctic: Kaktovik, Nuiqsuit, Anaktuvik Pass". The final report will describe and summarize subsistence resource use and outline competing or conflicting land and resource management practices in the area (ADF&G 1982). Two reports addressing subsistence use of resources in Kaktovik are in preparation and are tentatively scheduled for completion early in 1984 (Haynes 1983). Information about populations, sociocultural systems and subsistence patterns of north slope villages, including the village of Kaktovik, was summarized in the draft environmental impact statement prepared for the Diaper field lease offering (Mineral Management Service 1983).

Other Villages

In 1983, 2 technical papers prepared by the ADF&G Subsistence Division included information on subsistence use of the Porcupine caribou herd in villages south of the Brooks Range. One was a report on subsistence land use in upper Yukon-Porcupine communties which included chapters on Arctic Village and Venetie, the principal communities involved with hunting the Porcupine caribou herd (Caufield 1983). The second report was a bibliography which covered a wide range of topics dealing with subsistence activities, economies and culture of interior Alaska. References related to Arctic Village, Venetie, and the Porcupine caribou herd are included in this bibliography (Andersen 1983).

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Chapter 8

Potential Impacts of Geophysical Exploration

Impacts on Vegetation and Surface Stability

A review of recent vegetation impact studies not discussd in the initial baseline report (USFWS 1982) included studies conducted to look at the soil and vegetation characteristics leading to increased production associated with disturbed areas.

Gersper and Challinor (1975) measured soil properties in old vehicle tracks. In the vehicle tracks, bulk density and temperature were higher, thaw depth was greater and moisture percentage was lower than in undisturbed areas. Challinor and Gersper (1975) reported that the concentration of soil nutrients was higher in vehicle tracks. These more favorable soil conditions produced larger plants with higher nutrient content.

Chapin and Shaver (1981) looked at a broad range of environmental factors that could cause changes in productivity in disturbed areas. In vehicle tracks, they found a significant increase in soil temperture, thaw depth and soil phosphate. Species richness or number of species per area was lower in the tracks than in nearby undisturbed areas. Total biomass was higher in tracks in wet areas, but lower in dryer habitats. Nitrogen and phosphate concentrations in graminoids were higher in the disturbed areas. This study concludes that the increase in soil temperature and thaw depth are insufficient to explain the total increase in plant productivity.

Stuart and Miller (1982) studied changes in soil aeration by measuring oxygen and carbon dioxide concentrations in soils of disturbed and undisturbed areas. Severely disturbed tracks, which were .5 meters deep, had the lowest soil oxygen concentration. These tracks were poorly drained and filled with water during the wet season. Decreased aeration in severe vehicle tracks can cause lower rates of growth, nutrient uptake, and mineralization of nitrogen and phosphate by micro organisms.

Fetcher and Shaver (1983) studied the growth patterns of tillers of cotton grass tussocks in disturbed and undisturbed areas. Tiller survival was lower in disturbed areas with a generation time one-half that of undisturbed tussock tillers. However, in disturbed areas, daughter tillers were produced earlier. Tussocks in disturbed areas were smaller, but contained the same number of tillers as larger undisturbed tussocks.

Gartner, Chapin and Shaver (1983) studied natural revegetation of disturbed areas. Presence or absence of a viable seed pool was the main factor in natural recovery. The area studied was a tussock tundra with Eriphorum vaginatum and Carex bigelowii as dominant species. Seeds of these species were abundant in the top layer of organic soil. This study concludes that stockpiling the top layer of organic soil and returning it to the site after disturbance would be a most effective revegetation method. The organic material provides a natural source of fertilizer and protection from frost heaving as well as a seed source.

Impacts to Wildlife and Fish

Birds

Additional information related to impacts to birds not previously cited, include recommendations from Derksen et. al. (1979) for the protection of molting areas used by brant, Canada geese and white fronted geese, based upon their observations at the Teshekpuk Lake area which were included in the Initial Baseline Report Study (USFWS 1982). In view of their results of flock responses to human disturbances, Derksen suggested that:

1. Molting areas be more clearly delineated as a management unit to protect geese during the molting period and to preserve the habitat that makes the areas unique.

2. Small aircraft should not be allowed to fly over the area at altitudes less than 1525 m during the month of July, or to spend extended periods over the area.

3. On the ground disturbances should be minimized during July.

4. Modification of water levels should be avoided because of possible implications on wet meadows that produce foods for geese, and on the ice action that may modify shorelines.

5. Oil exploration and development activities should be minimized during July.

Simpson et. al. (1983) stated that the most frequently recorded disturbances to brant at East Long Lake near Cape Halkett, Alaska was from aircraft used in support of petroleum exploration. They reported that "Birds reacted to aircraft by exhibiting alert postures, running, or entering the lake where they would swim for variable periods of time depending upon the strength of the stimulus. Interruptions of feeding bouts may have deleterious effects on the birds ability to replenish depleted body reserves." The aircraft disturbances that they recorded, prevented molting brant from feeding 2.4% of the time. They suggested that the combined effects of the lost feeding time, energy requirements during periods of lowered ambient temperatures and extra energy costs for escape behavior may retard growth of flight feathers and delay the move to new feeding areas prior to fall migration. Simpson also reported that there was no difference between reactions to fixed-wing aircraft and reactions to helicopters by brant during molt.

Similar aircraft disturbances during geophysical exploration activities conducted in summer on the Arctic National Wildlife Refuge (ANWR) coastal plain have the potential to negatively impact the activities of various bird species during the relatively short growing season. Aircraft disturbances at this rate also have the potential of disturbing traditional snow goose staging activities on the refuge, prior to their migration when energy requirements are critical.

Nearshore or lagoon seismic exploration could result in fuel spills occurring on the ice during early spring. Richardson and Johnson (1981) reported that because marine birds depend on open water for access to food, and such areas are scarce in much of the Beaufort Sea in spring, migrating waterbirds can be expected to land on any available open water in nearshore areas. Therefore, some waterbirds likely would be contaminated if oil or another contaminants were present. Some birds appear to be attracted to pools of oil on top of ice, presumably mistaking the oil for open water. He also reported that this situation would be serious in years when there is little or no open water shore in the Beaufort Sea. Waterbirds may be stressed in such years and would be expected to be attracted even more than usual to any available areas of open water or to a pool of oil. A similar situation would exist in the event of a fuel spill by seismic exploration activity on lagoon ice.

Caribou

Two additional sources of information related to caribou disturbances that may result from geophysical exploration are discussed here.

Horejsi (1981) in his studies of behavioral responses of caribou to moving vehicle along the Dempster Highway, Yukon Territory, Canada, concluded that caribou react to a vehicle based on the rate of approach rather than on the movement itself. He found that vehicles moving at speeds of 56-81 km/hr were disturbing to caribou. This observation is similar to that cited in the initial baseline report (USFWS 1982), where a greater intensity reaction of caribou was observed in rolling terrain due to the "surprise" of a moving object suddenly appearing over a rise. In general, Horejsi found that caribou exhibited signs of anxiety and fear when encountering a fast-moving vehicle and they exerted themselves strenuously for short periods of time when withdrawing from the vehicle. If flight is in response to a pursuing object, such as a snow machine or slow moving aircraft, escape reactions can be expected to be more prolonged since the threatening object stays within a certain distance of the animal. Situations of this sort have potential to exist and create negative impacts during winter seismic activities being supported by helicopters or snow vehicles. The surprise of a fast moving, low flying helicopter for example, followed by a period of both caribou and aircraft moving in a common direction, could result in disturbance to caribou.

As a result of an investigation of helicopter harassment of caribou by Miller and Gunn (1981) it was found that calves are often the first to respond to this type of stimuli. They suggested that this was because of the calves lack of experience with their environment. They found that this higher level of excitement in the calves led to a general readiness to be active, but because of the absence of social signals from adults, the readiness of the calves to be active was often released in play. They concluded that although play by calves during and after stressful situations could suggest to observers a state of well-being, such play may be a release of tension, and may actually indicate that the calves have been stressed. They suggest play should not be used as an indication of well-being.

Muskox

In addition to potential impacts discussed in the initial baseline report (USFWS 1982), Jingfors & Kline (1982) in their study of seasonal activity budgets and movements of muskox characterized their grazing behavior as having a conservative activity budget and limited seasonal movements. They stated that muskox have longer resting periods in winter which may be due to lower quality (less digestable) forage which requires longer rumination time. A large portion of time spent resting, leaving less for activity, also provides a means of conserving energy, and reducing forage requirements during a season of low nutrient availability. Therefore, disturbances resulting from winter seismic exploration operations have the potential of upsetting this winter routine.

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Chapter 9

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

No new information was obtained to update this chapter.

Appendices

List of Appendices

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ANWR Progress Report Number FY84-1

HABITAT USE AND BEHAVIOR OF GRIZZLY BEARS IN THE ARCTIC NATIONAL WILDLIFE REFUGE

Michael K. Phillips

Key words: grizzly bear, behavior, habitat use, caribou predation, Arctic National Wildlife Refuge, Arctic - Beaufort, north slope

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Habitat use and behavior of grizzly bears in the Arctic National Wildlife Refuge.

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Abstract: Habitat use and behavior of grizzly bears (Ursus arctos) were studied from 27 June-11 August 1982 and 24 May-29 August 1983, in the Caribou Pass/Kongakut River area of the Arctic National Wildlife Refuge. Data are presented as bear-unit hours. A bear-unit was defined as one bear, a family unit, or a male bear with consort(s). Bear densities are low on the study area (1 bear/130-260 km^2). Intensive searching for bears resulted in the collection of 387 bear-unit hours of behavioral information. Six categories (21 sub-categories) were used to describe behavior. Bears were most often observed feeding, foraging, or resting (114,113, and 88 bear-unit hours, respectively). The most common food items were Hedysarum alpinum (roots), Equisetum arvense, Boykinia richardsonii (flowers and leaves), berries (Empetrum nigrum, Vaccinium vitis-idaea, and Arctostaphylos rubra), caribou (Rangifer tarandus), ground squirrels (Spermophilus parryi) and microtines. Most use of caribou by bears occurs on the coastal plain at or near the caribou calving grounds. Grizzlies shift their ranges to include areas frequented by caribou. For about 1 month (24 May-21 June) caribou (especially calves) are an important food item for grizzlies. Habitat types were described by the dominant topographic and vegetative feature. A total of 398 bear-unit hours was collected concerning habitat use. Bears were observed in 6 topographic types. Valley flats mountain slope/hillside, and cutbank/gulley/creek were the most common topographic types used (107, 90, and 89 bear-unit hours, respectively). A different vegetation classification system was used in 1982 than 1983. Results from 1982 are being converted to the 1983 system. In 1983 bears were observed in 20 vegetation types. Sedge tussock mixed-shrub tundra, sedge-willow tundra, and mixed-shrub tundra were the most common vegetation types used.

Habitat use and behavior of grizzly bears in the Arctic National Wildlife Refuge.

The Alaska National Interest Land Conservation Act (ANILCA) became law on 2 December 1980 and mandated geophysical exploration for oil and gas reserves in the northern portion of the Arctic National Wildlife Refuge (ANWR). The potential for adverse impact of development on grizzly bears in Alaska is probably greatest from the Brooks Range north to the Arctic Ocean (Reynolds 1980). Here the period of food availability during the summer season is short, the stunted vegetation of the region provides little cover, individual bears require large home ranges, and reproductive potential is low (Reynolds 1980). Possible impacts of development on grizzly populations include disruption of habitat, increased harassment throughout the year, and increased human habitation (Brooks et al. 1971). However, before the potential impact of development can be accurately assessed it is necessary to gain a clear understanding of grizzly ecology in the area. This belief influenced the decision to initiate an "on the ground" study of grizzly bears in the Caribou Pass/Kongakut River area of ANWR.

Grizzlies use the area, but the nature of this use was poorly understood. The role that predation and scavenging of caribou plays in bear ecology in this area was unknown. Additionally, information concerning sex and age structure, habitat use, behavior, movement patterns, and denning characteristics was needed before an accurate evaluation of possible impacts on the grizzly population could be made. Habitat use and behavior of grizzlies were studied from 27 June-11 August 1982 and 24 May-29 August 1983.

Methods

In 1982 the field camp was located on a bluff just above the river. However, in 1983 the camp was situated on a rock outcrop approximately 1200 m from the Kongakut; this site afforded better visibility of the approximately $104 km^2$ area than did the bluff in 1982. Also, in 1983, 2 "spike camps" were manned at the coastal plain/foothills interface from 12-22 June and 29 June-2 July (Fig. 1).

Seasonal designations were spring from 24 May - 6 June, summer from 7 June - 8 August, and fall from 9 August - 29 August. These divisions are based on my arrival and departure from Caribou Pass and on the following parameters of the study area: climatic changes, phenological development of certain plants, and behavior of bears. Spring is characterized by warming temperatures, continuous daylight, and the post-emergence activities of bears from the winter den. This period also corresponds to the pre-growing season. Summer is the growing season and is characterized by consistently warm temperatures, grizzlies breeding, bears' utilization of new vegetative growth, and decrease in daylight in late July. Fall is associated with the senescence of herbaceous vegetation, increasing loss of daylight, falling temperatures, and increasing snowcover. These divisions are similar to those used by Stelmock (1981) and Gebhard (1982).

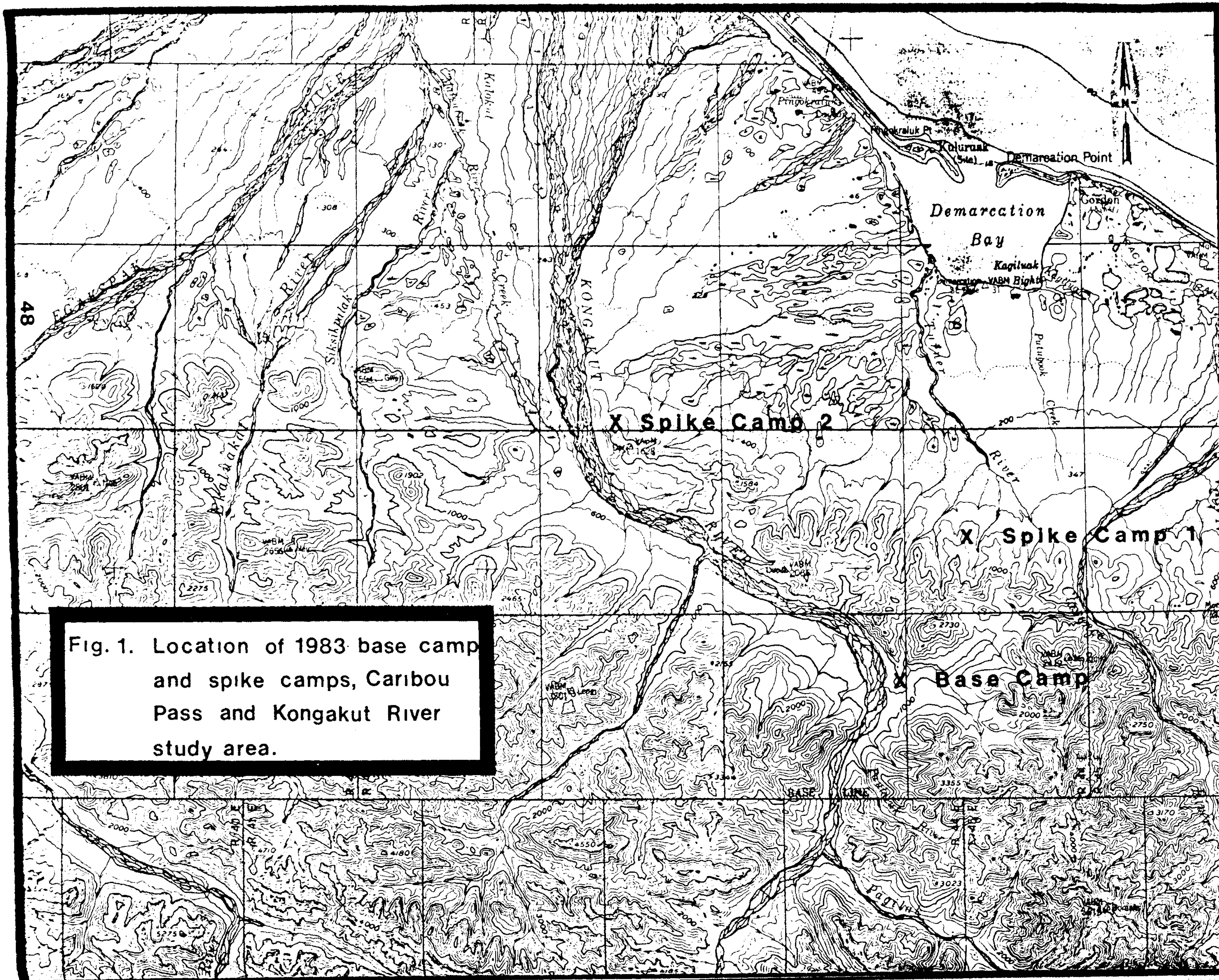

Fig. 1. Location of 1983 base camp and spike camps, Caribou Pass and Kongakut River study area.

Data on activities and habitat use were collected by direct observation from vantage points located throughout the study area. Bears were located using binoculars (10x50mm). A variable power spotting scope (15-60x) was used to observe bears once they had been detected. Observation distances ranged from 35-5400m. Sex of unmarked bears could occasionally be determined by observing the bears urinating. Behavior and relative size were used to infer the sex of individuals of breeding units. Bears exhibiting breeding behavior were assumed to be mature (>4.5 years old). Two exceptionally large bears were assumed to be mature males.

A standard method for locating bears was adopted that involved a 15-20 min visual scan of the area. Usually no more than one scan was done per hour. At the onset of each scan, the date, time, light and wind conditions, overall visibility, location of bear (if applicable) and presence of other large mammals were recorded. Areas were scanned even after 1 bear-unit (b-u) had been located. A b-u was defined as 1 bear, a family unit, or a male bear with consort(s) (Stelmock 1981). Generally, more than 1 b-u could be watched simultaneously on the study area. One b-u hour was defined as observing 1 b-u for 1 hour.

Ground tracking of all radio-collared bears believed to use the Caribou Pass/Kongakut River area was done after most scans. These bears were 1186, 1188, 1189, 1190, 1193, 1194, 1195, 1196, 1226, 1227, 1229, 1230, 1234 and 1235 (Appendix-Table 1). While tracking, the date, time, location of tracker, signal (if applicable), description of signal (i.e. strength, direction from tracker), and location of bear (if applicable) were recorded.

Looking for bears while hiking was used in combination with scanning and ground tracking. While hiking the date, time, location, total kilometers hiked (straight line distance), and any bears seen were recorded.

Times and changes in habitat use and behavior of bears were recorded. All times were Alaskan Daylight Savings Time (ADST). Behavior was determined by direct observation. The following behavioral categories were used: feeding, foraging, travel, rest, intraspecific interactions and interspecific interactions. Feeding and foraging were subsequently divided by food item (e.g. Equisetum or squirrel). These sub-categories were determined by direct observation and inspection of feeding sites. In many cases, the foods selected could not be determined because of the distance at which the bears were observed and the concealment afforded the animals by shrubs or terrain. Traveling was divided into walking or running. Resting was divided into sitting or laying. These categories follow Stelmock's (1981).

Feeding. Bears were spending 50% or more (usually greater than 90%) of their time collecting and ingesting food rather than searching for food or traveling. In cases where the distinction between feeding and foraging was not clear, the cumulative time spent feeding for a 2-3 min interval was used to determine the appropriate category:

1) on vegetation - this sub-category was divided by plant type when possible.

2) on arctic ground squirrels - this sub-category consisted of consuming squirrels.

3) on caribou - this sub-category consisted of consuming caribou.

Foraging. The head was lowered to the ground and there were frequent stops to investigate and/or ingest food items, but less than 50% (usually less than 25%) of the time was spent ingesting food:

1) for animals and/or vegetation

2) for squirrels - this sub-category included travel while investigating and digging ground squirrel burrows.

3) for microtines - this sub-category included travel while investigating and digging microtines burrows.

4) for caribou - this sub-category included travel while pursuing caribou.

Travel. The head was usually held high and there were infrequent stops to investigate and/or ingest food:

1) running.

2) walking.

Rest.

1) lie.

2) sit.

Intraspecific Interactions.

1) other - this sub-category consisted of moving towards or away from other bear-units.

2) play - play among a mother and her young and play between siblings were included in this sub-category. Play between members of a breeding unit was excluded.

3) nurse - the mother, being the focal animal of the family, was providing milk for the young.

4) breeding behavior - this sub-category consisted of interactions between members of a breeding unit.

a) mate-directed 1 - exploratory actions that included wrestling, pushing, sniffing, herding, and visual inspection.

b) mate-directed 2 - involved standing closely with heads lowered and rocking back and forth, movements were slow and often in a circular path.

4) copulation - this sub-category included attempted mountings.

Interspecific Interactions. These activities occurred when in close proximity to other wildlife species and humans. Such interactions were seen between bears and other animals including: golden eagles (Aquila chrysaetos), ravens (Corvus corax), and moose (Alces alces). These interactions were not predatory attempts by the bear.

Habitat types were defined by the dominant topographic and vegetative feature. Occasionally bears would disappear into a uniform habitat type, only to reappear in the same area shortly afterwards. In such cases continual data on habitat use were recorded. Topographic categories were coastal plain, mountain slope/hillside, cutbank/gulley/creek, valley flats, rolling hills, and gravel bar/river. In 1983, vegetation categories were assigned according to the five level hierarchical classification system developed by Viereck and Dyrness (1980). Mapping of the Caribou Pass/Kongakut River area was done to level IV from elevated points located opposite the area being mapped and by "on foot" inspection of much of the area. A different vegetation classification system was used in 1982. This system is being converted to the Viereck and Dyrness (1980) system.

Results

A minimum of 25 bears was observed. Of the 25, 7 were mature females, 2 were immature females, 3 were females of unknown age, 7 were mature males, 1 was a yearling of unknown sex, 2 were cubs of-the-year, and 4 were of unknown age and sex. The following marked animals were observed: 1186, 1188, 1189, 1227, 1234, 1235 and 1252 (Appendix Table A-1).

A total of 387 b-u of behavioral information was collected (Fig. 2). The average observation lasted 2.5 b-u hours. Six categories (21 sub-categories) were used to describe behavior (Appendix Table A-2). Bears were most often observed feeding, foraging, or resting (114, 113, and 88 b-u hours, respectively). Food items included unidentified plants, (Hedysarum alpinum (roots), Equisetum arvense, Boykinia richardsonii (flowers and leaves), berries (Empetrum migrum, Vaccinium vitis-idaea and Arctostaphylos rubra), caribou, ground squirrels, and microtines.

A total of 398 b-u hours of data were collected concerning habitat use (Figs. 3 and 4 and Appendix Table A-3). Valley flats, mountain slope/hillside, and cutbank/gulley/creek were the most common topographic types used. In 1983 bears were observed in 20 vegetation types. Sedge tussock mixed-shrub tundra, sedge-willow tundra and mixed-shrub tundra were the most common vegetation types used. Data are being analyzed to determine if grizzlies select habitat types.

Bear #1188 (a 4.5 year old male) was observed for a total of 70.6 b-u hours: on 25 July 1982 and on 7-8 , 10-13, 16-20, 26-27 and 29 August 1983. These data will be discussed in detail in the final report.

Three families were observed. A sow and yearling were watched from the first "spike camp" (see bear/caribou interaction section). The other families were observed in the Caribou Pass/Kongakut River area. Bear #1227 and her two 2 year old female young (bear #1234 and 1235) were observed on 11, 14 and 20 July 1982 for a total of 9.5 b-u hours. In 1983 this family split up. The sow was observed in the company of a male during June (G. Garner pers. comm.) and she was observed alone on 8, 10, 18 and 22 July and

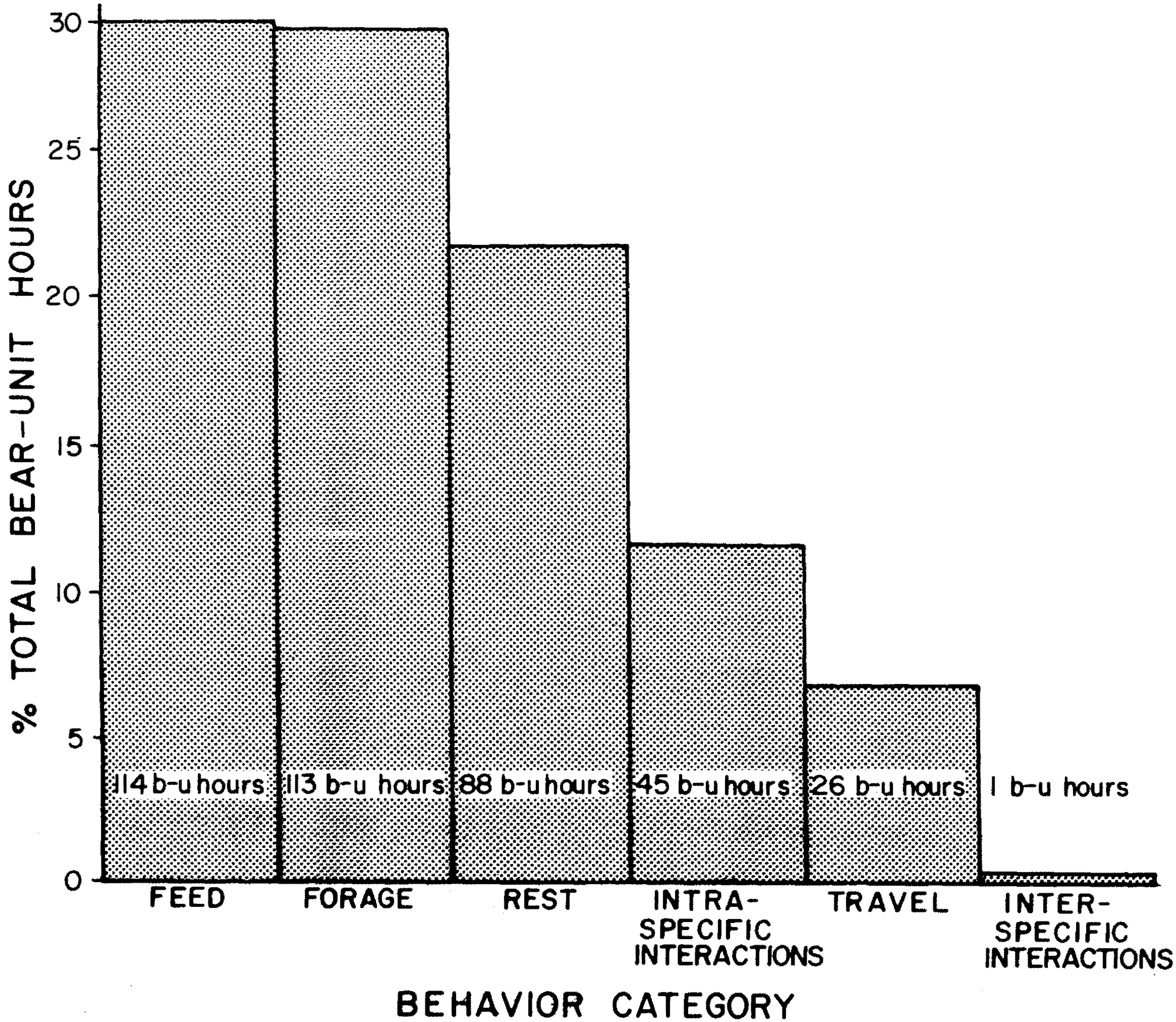

Fig. 2. Proportion of observed bear-unit hours occurring within each behavior category, summer 1982 and 1983.

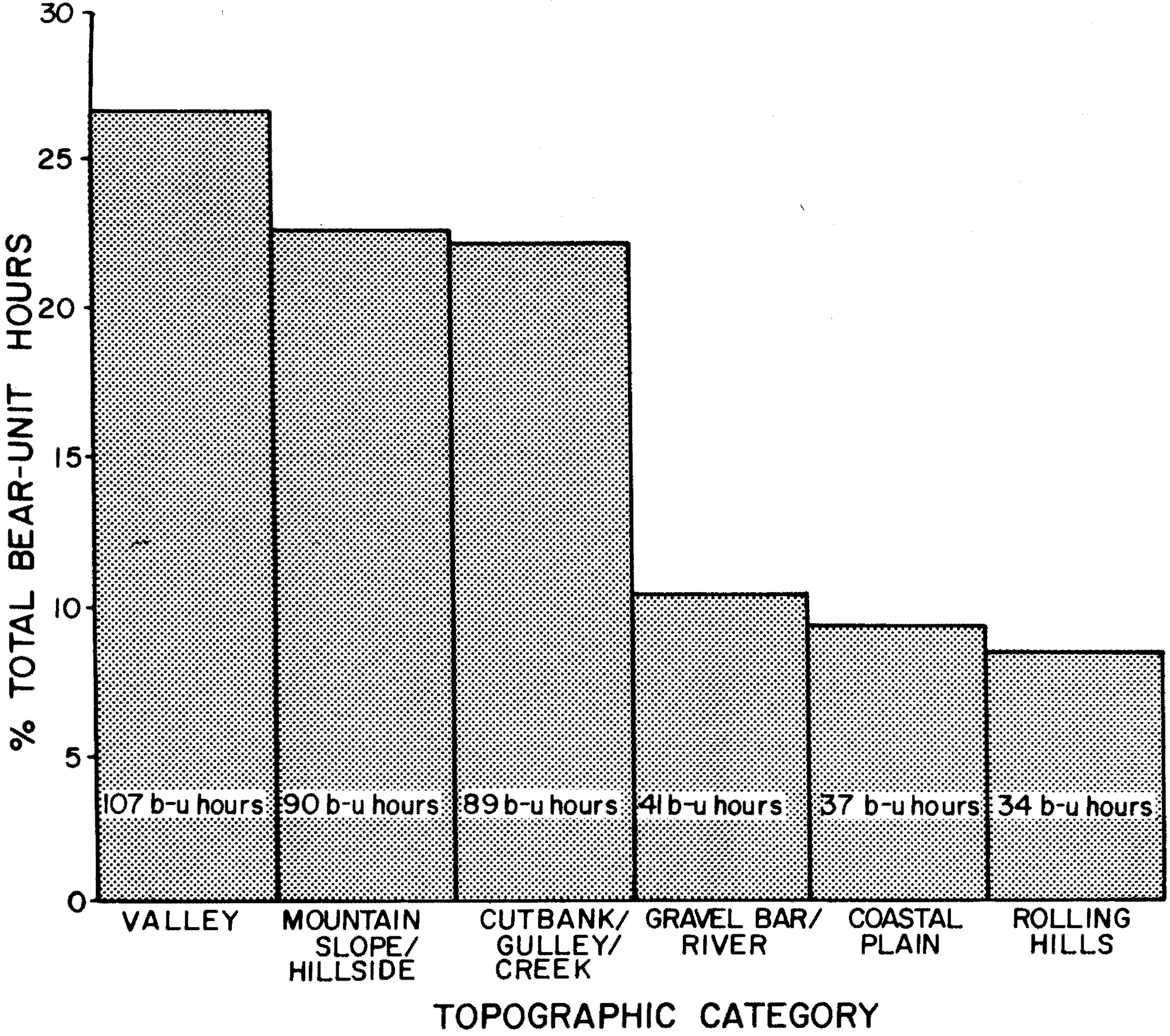

Fig. 3. Proportion of observed bear-unit hours occurring within each topographic category, summer 1982 and 1983.

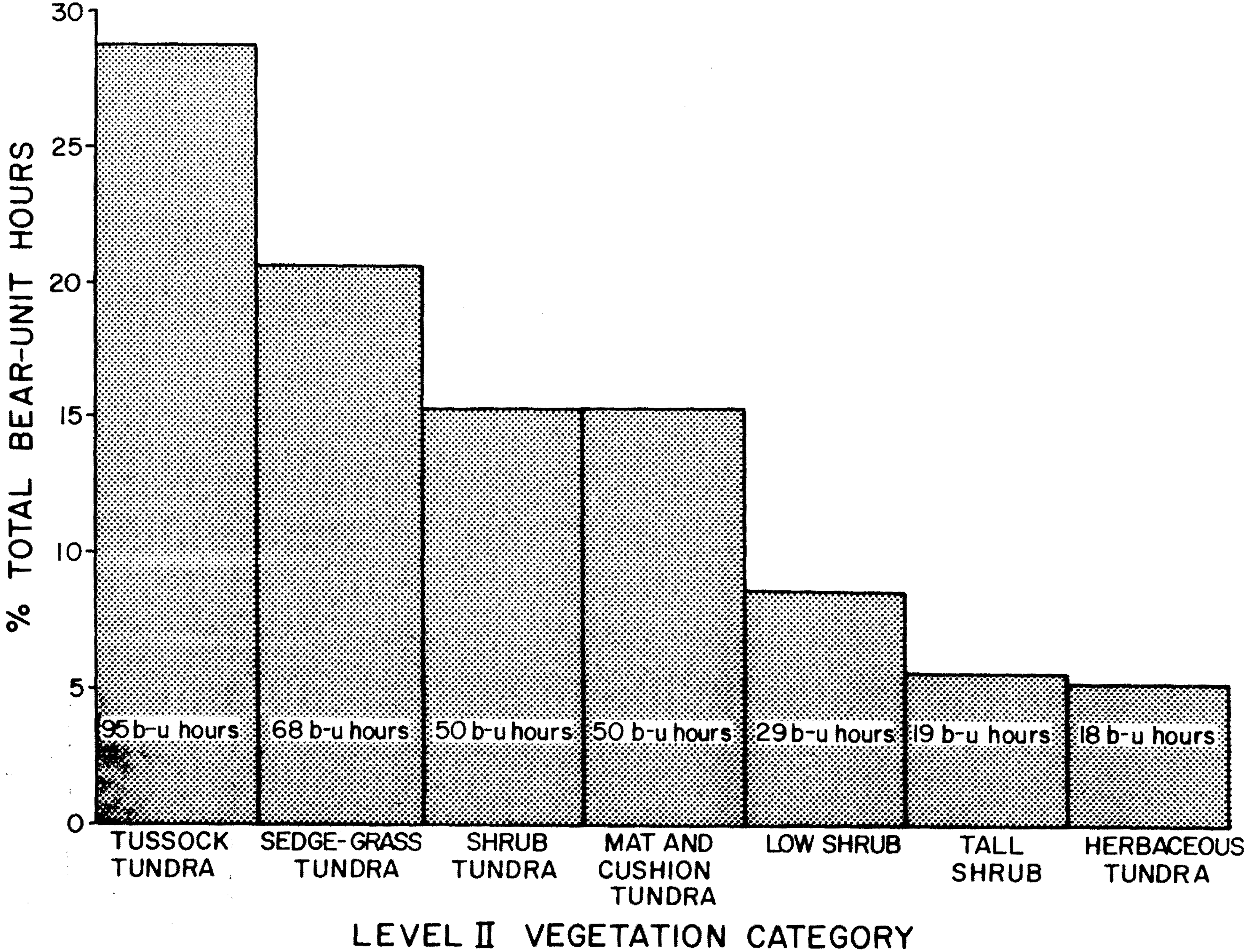

Fig. 4. Proportion of observed bear-unit hours occurring within each Level II vegetation category.

7 and 27 August for a total of 8.0 b-u hours. The siblings were watched together on 5, 8, 10, 19, and 23 July and 2 August for a total of 18.4 b-u hours. One of them (#1234) was observed along on 16 and 18 August for 6.8 b-u hours. The siblings denned separately (G. Garner pers. comm.). This family will be discussed in greater detail in the final report. On 7 occassions in 1983, a sow with 2 cubs of-the-year was observed a total of 14.8 b-u hours.

Discussion

The method for used for studying bears in the Caribou Pass/Kongakut River area and the coastal plain/foothills interface included scanning and radio-tracking from camp, then following the bear on foot if necessary. This method has been used elsewhere with success (Linderman 1974, J. Hechtel pers. comm.).

Bears were usually observed feeding or foraging in patches of lush, green vegetation. Other authors have reported that behavior and habitat use of bears are largely determined by nutritional requirements (Curatolo and Moore 1975, Murie 1981, Stelmock 1981).

During spring, we observed bears feeding on *Hedysarum alpinum* (roots) and caribou, and foraging for squirrel and microtines. During summer, bears fed primarily on *Equisetum arvense* and unknown grasses and sedges. During fall, bears fed on berries (*Empetrum nigrum*, *Vaccinium vitis-idaea* and *Arctostaphylos rubra*, *Hedysarum alpinum* (roots) and ground squirrels and microtines. The idea that the food habits of grizzlies are related to the phenological development of certain plants is not new (Mealy 1975, Murie 1981, Stelmock 1981, F.C. Dean pers. comm.).

Bear #1188 was observed after a snowstorm on 19 August 1983, and 6 bears (2 mature females - 1 was bear #1227; bear #1188; 2 spring cubs; 1 bear of unknown age and sex) were observed after a snowstorm on 27 August 1983. These observations resulted in the collection of 18.4 b-u hours of behavioral information; 90% of this time bears were feeding/foraging for roots and/or squirrels and microtines. This is typical fall behavior (Stelmock 1981, F.C. Dean pers. comm., J Hechtel pers. comm.).

Intraspecific interactions excluding breeding behavior (i.e. play, nurse, and other) accounted for little of the observed behavior (0.85% of the total observation time). Researchers have suggested that play occurs most frequently between littermates (Murie 1981, Stelmock 1981, Gebhard 1982). This study supports the idea as 80% of the observed play was between littermates. That nursing behavior was infrequently observed is understandable since families were rare in the Caribou Pass/Kongakut River area. Rarity of families could be due to topography; the area consists of rolling hills and valley flats whereas more mountainous country lies to the south. Researchers have suggested that families, especially sows with cubs of-the-year, tend to use higher elevations (Pearson 1975, Russell et al. 1979, Murie 1981, Stelmock 1981, J. Hechtel pers. comm., F.C. Dean pers. comm.), perhaps as a means of reducing contact with other bears (Murie 1981, J. Hechtel pers. comm., F.C. Dean pers. comm.).

Other intraspecific interactions resulted from the accidental encounter between bear-units. These interactions consisted of detection and mutual avoidance. This type of behavior is a common response to chance encounters between conspecifics during the nonbreeding season (Murie 1981, Stelmock 1981, J. Hechtel pers. comm.). One exception was a mature male who followed bear #1188 (4.5 year old male) for 62 min.

Interspecific interactions with wildlife species (excluding caribou) were rare. On 4 occasions bears interacted with ravens. Usually the bear was at a carcass or foraging/feeding on squirrels and microtines. Bear #1188 was accompanied by a golden eagle for 5 hours while foraging for squirrels and microtines. One bear (unknown age and sex) surprised at close distance (within 400m) a 3-4 year old bull moose; they ran in opposite directions after detecting one another.

Bears detected human observers 11 times. Six times they ran in the opposite direction and 5 times they left the area reluctantly. Most bears were intolerant of aircraft and would leave the are immediately after detecting a plane or helicopter. Bear #1188 was the exception and only ran from the helicopter after being harassed.

Bear/Caribou Interactions

Previous work done on the ANWR has shown that grizzly bears use caribou for food but the nature of this use was not well defined (USF&WS 1982, Garner et al. 1983). The present study included data that clarified somewhat the relationship between grizzlies and caribou. The chronology of specific bear/caribou interactions observed during the 1983 field season are as follows:

24 May- Bears and caribou were seen in close proximity in the Caribou Pass/Kongakut River area.

26 May- A grizzly was observed hunting caribou in the Caribou Pass/Kongakut River area.

5 June- The peak of bear interest in caribou occurred during this period (see discussion for this period).

18 June- Bears first began to exhibit an indifferent attitude toward caribou.

20 June- This was the last data a grizzly was observed feeding on caribou.

A discussion of the interactions is presented below. Distances and caribou numbers reported are visual estimates. The relationship between bears and caribou is different in the Caribou Pass/Kongukut River areas than in the coastal plain/foothills area, therefore each will be discussed separately.

Caribou Pass/Kongakut River Area

24 May-12 June. A total of 8.9 bear-unit (b-u) hours of behavioral information from a minimum of 6 bears (1 mature female; 1 mature male--based on size; and 4 of unknown age and sex) were recorded during this time period (Fig. 5). Despite the relatively large number of different bears seen, the area was used little by grizzlies. Average observation length was 1 b-u hour, with 44% of the activity during the observation time being traveling.

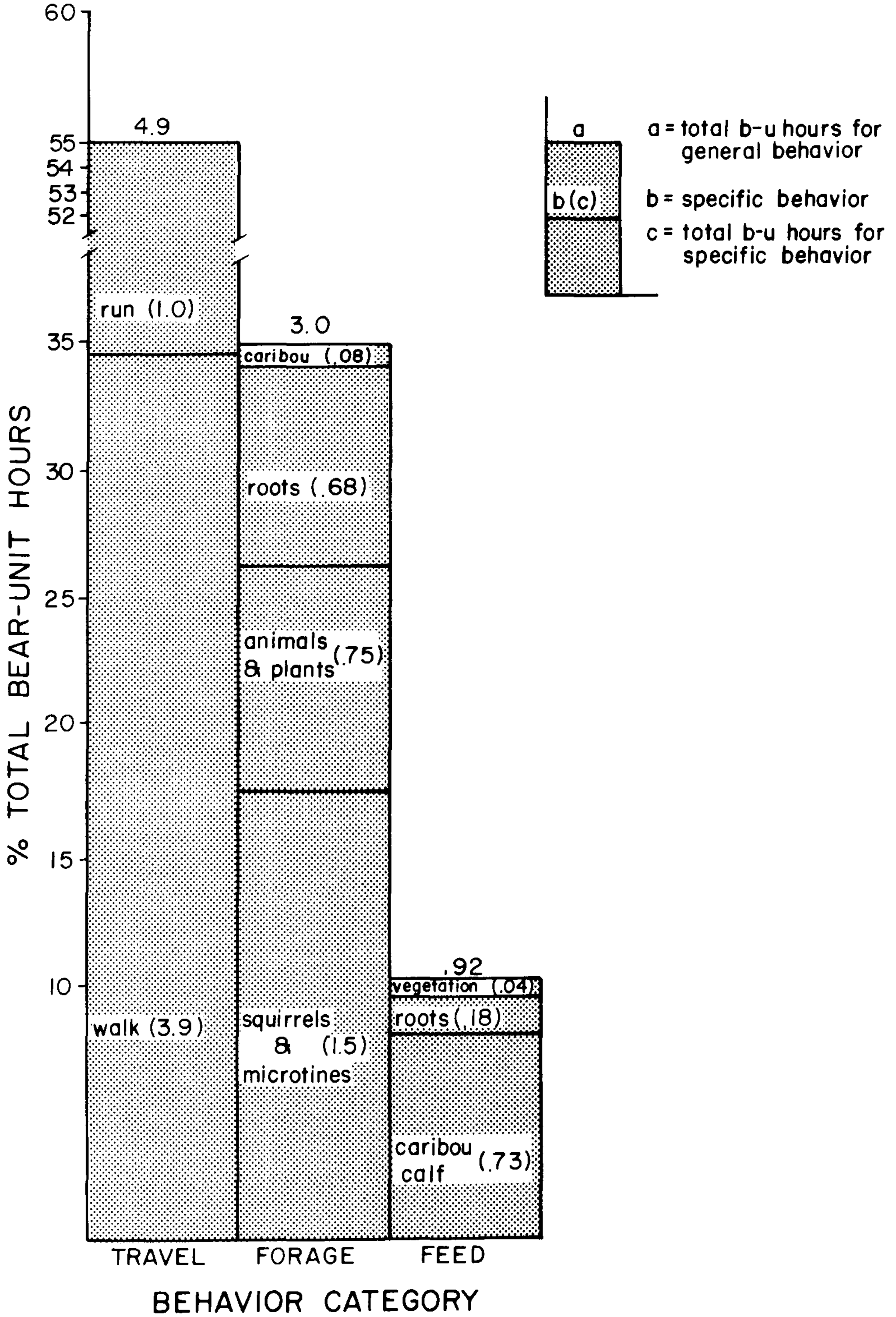

Fig. 5. Behavior of grizzly bears at Caribou Pass from 24 May - 12 June 1983.

Spring is a time when grizzlies wander widely in search of food (Murie 1981, Stelmock 1981, J. Hechtel pers. comm.).

Approximately 7500 caribou, mostly adult females moving to the northwest were observed during this period. Over 90% of these animals were observed before 29 May. No calves were seen. Bears and caribou were seen in close proximity to one another 3 times. On 24 May, 8-10 cow caribou were within 1200-1600m of a grizzly; the bear showed no interest. During the afternoon of 26 May, a grizzly followed a group of 400 caribou (mostly cows) for 5 min before becoming disinterested. On 5 June a female grizzly was seen feeding on a caribou calf; 10 cow caribou were within 400 m. The caribou left the area soon after detecting the bear. The grizzly fed on the carcass for 44 min before leaving.

On 29 May, a cow caribou was located that had recently been killed by wolves (Canis lupus). Although the area was given special attention during subsequent scans, only ravens frequented the carcass. On 31 May, a wolverine (Gulo gulo) traveled within 400 m of the carcass but did not stop to investigate. On 15 July the carcass could not be located during a ground reconnaissance of the area. No grizzly sign was found in the area.

22-29 June. Small groups (avg. 10-15 ind.) of adult male and female caribou were usually visible, but grizzlies were rare, with a total of 4.2 b-u hours of behavioral information being collected from 3 bears of unknown age and sex (Fig. 6). Bears and caribou were not observed in the same area despite the almost constant presence of caribou.

3 July-29 August. Caribou were relatively rare, while grizzlies were common. Mixed-groups of 5,000 and 2,000 caribou were observed on 4 and 11 July, respectively; both groups moved through the area in a matter of hours unattended by bears.

The carcass of a caribou calf was located on 18 July. Bones that were present were articulated and furred; there were no signs of large predators having visited the site. A golden eagle feather was found at the carcass. A grizzly was within 400-550 m of the carcass but it did not investigate. On 1 August, a grizzly was observed feeding on vegetation within a few m of the carcass.

On 20 and 24 July, individual caribou carcasses were sighted. Wolves, golden eagles, and ravens were seen feeding on these 2 carcasses. On 24 July, 3 different grizzlies were within 550 m of one of the carcasses, but none of the 3 investigated.

On 27 August, a bull and cow caribou traveled within 400 m of a grizzly that was feeding (probably on a squirrel). The caribou left the area immediately after detecting the bear; the grizzly acknowledged their presence and continued feeding.

Caribou were not an important food item for grizzlies in the Caribou Pass/Kongakut River area in 1982 or 1983. In 1982 grizzlies were not observed feeding on caribou, although 8,000-10,000 caribou were seen in the area from 27 June-18 July. On 3 occasions bears and caribou were within 400-800 m of one another. Bears responded to this close proximity with indifference; caribou usually moved quickly in the opposite direction. A

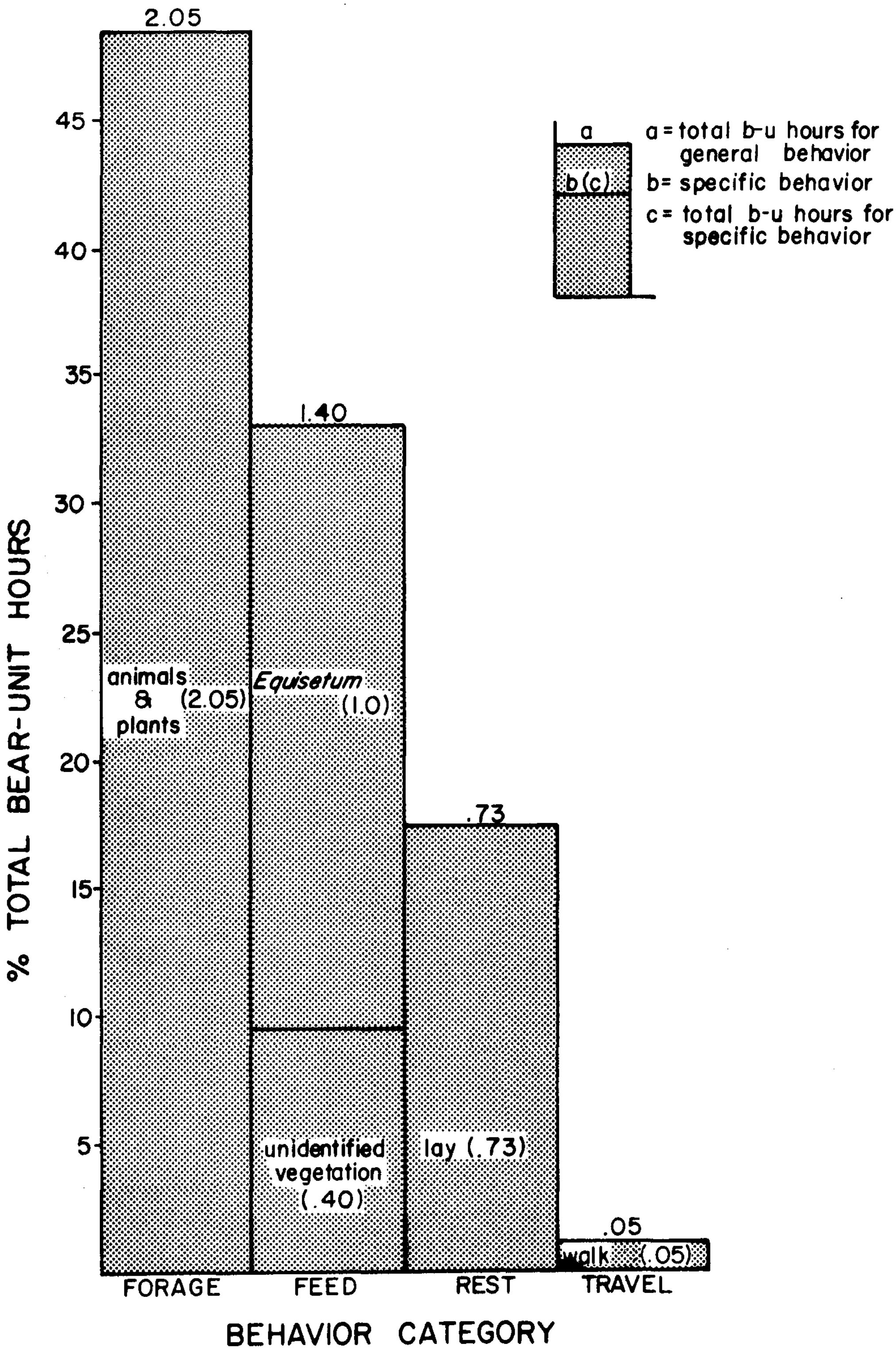

Fig. 6. Behavior of grizzly bears at Caribou Pass from 22-29 June 1983.

bull caribou carcass was observed continuously for 43.5 hours (12 July 1220h - 14 July 0800h 1982) and during each scan through 11 August. The carcass had not been present for more than 4 days prior to detection. On 12 July a sow grizzly was observed traveling upwind within 10 m of the carcass; she did not stop to investigate. An estimated 10% of the carcass had been consumed at this time. Wolves, immature golden eagles, gulls (Larus hyperboreus, L. argentatus), long-tailed jaegers (Stercorarius longicaudus) and ravens were seen feeding at the carcass. Despite frequent scans no scavengers were seen at the carcass after 0800h on 14 July.

Bear/caribou interactions in the Caribou Pass/Kongakut River area for 1982-1983 are summarized as follows:

1. A total of 25,000 caribou were seen; all but a small fraction were seen on or before 11 July. Prior to 4 July, grizzlies were relatively rare. Bears that were spotted were traveling out of the area.

2. Six large (250 ind.) groups of caribou moved through the area unattended by bears.

3. Six caribou carcasses were present (2 bulls, 1 cow, 2 calves of unknown sex, 1 of unknown age and sex) in the area. One of the calves was fed on for 44 min by a sow grizzly.

4. Caribou were not an important food item for grizzlies.

Coastal Plain/Foothills

12-16 June. This camp was located 12 km NE of base-camp (Fig. 1) and was established with a sow and her yearling in sight. In the next 14 hours, 4 grizzlies (2 mature males--1 based on size and the other based on breeding behavior; 1 mature female--based on breeding behavior; and 1 of unknown age and sex) were sighted. A total of 44.9 b-u hours of behavioral information was recorded in spite of inclement weather precluding observations for 31% of the time (Fig. 7). By 22 June, bears were relatively rare.

A total of 15,000 caribou was seen during this period. Most cows and calves in groups of 200-300. Calf/cow ratio of 60/100 was estimated for these groups. Although the peak of calving occurred on 5 June, one calf was born on 13 June. Caribou were almost always present until 16 June; by this time caribou had moved further to the west.

Caribou were an important food for grizzlies. Bears were seen feeding only on caribou calves and 35% of the time spent foraging was devoted to hunting caribou. Many of the bears that were handled by ADF&G and USF&WS biologists had blood on their faces, which was assumed to be from feeding on caribou (H. Reynolds pers. comm.). When observations of the sow and yearling first began, they were within 400 m f 40 caribou (30 cows and 10 calves). Within minutes the sow was chasing the caribou. Her attempt was unsuccessful, but after a long period of rest she again foraged for caribou. At 0003h on 13 June she ran over a hummock and out of sight. Two min later she was again in sight and was feeding on a caribou calf. Apparently she had gotten relatively close (within 200 m) to a group of 18 caribou (cows and calves) and was able to catch a calf after a chase of 400 m.

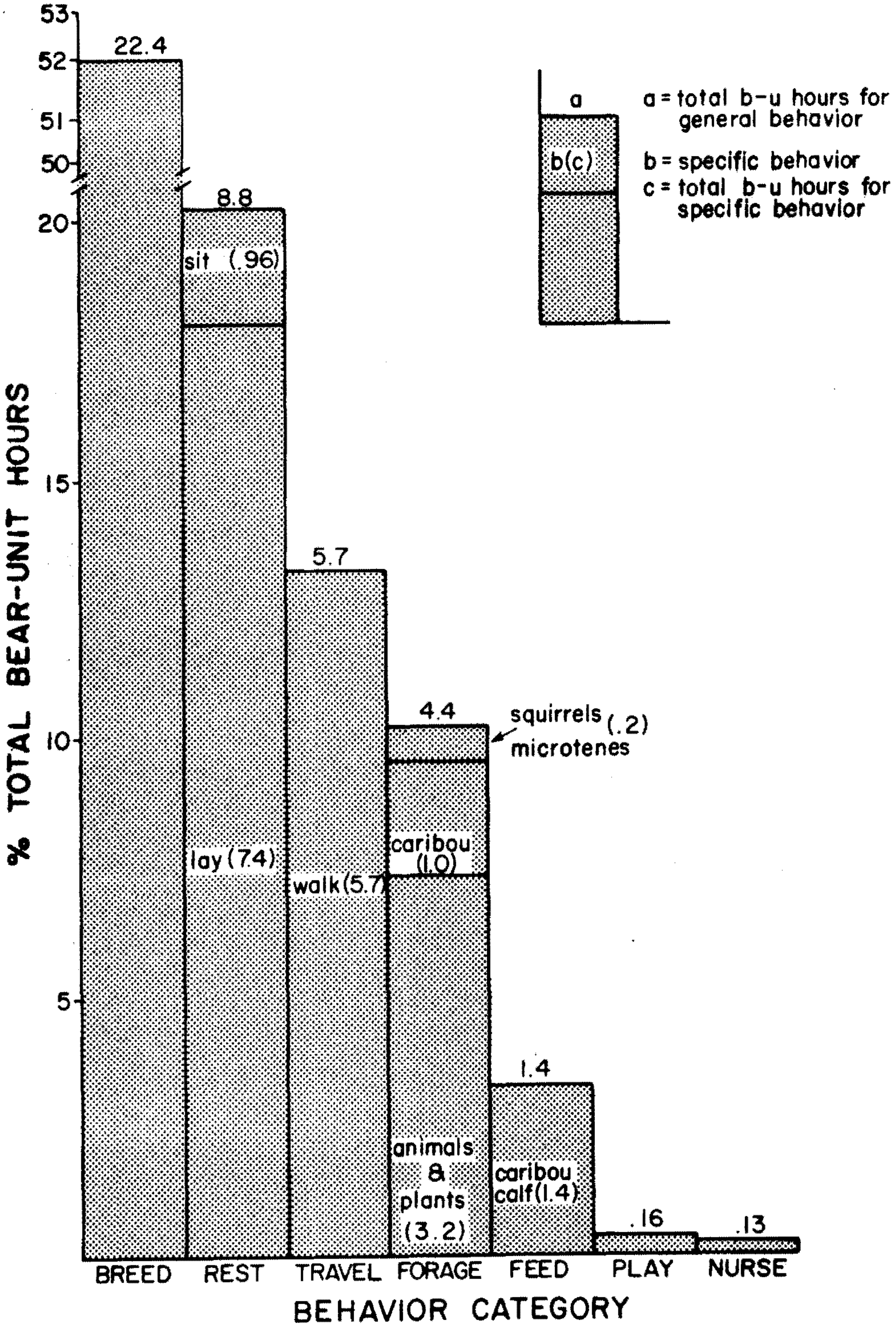

Fig. 7. Behavior of grizzly bears at the coastal plain/foothills area from 12-16 June 1983.

She fed on the calf for 5 min and then began traveling toward a group of 200 caribou (cow and calves) located 1.6 km to the south. The caribou flushed while the bear was over 800 m away. After 100 m the sow gave up the chase but continued to the area the caribou had been and began investigating the caribou's resting sites. The yearling who stayed behind to feed on the calf, now caught up with the sow.

At 0013h the sow continued to the south moving toward 50 caribou (cows and calves) that were feeding and resting in a gulley. The bear could not see the caribou and vice-versa. At 0024h the grizzly ran down into the NE end of the gulley; the caribou came running out the other end. One calf was not fast enouth and was killed when the grizzly caught up and pinned it to the tundra. The chase covered 400 m. The sow fed on the calf for 20 min and the yearling fed for 31 min. Although the cow offered no defense for her calf, she did stay near the kill site until the grizzly began traveling.

At 0124h the sow again began foraging for caribou. She encountered 2 groups of caribou, but both flushed while she was over 800 m away. At 0201h both the sow and yearling were out of sight. At 1500h on 14 July they were again sighted. By 1537h the sow was chasing a group of 8 calves and 3 calves. This unsuccessful chase covered 100 m. At 1705h the family was out of sight and never seen again.

This sow and yearling were watched for 9.3 b-u hours and 30.3% of their active time was devoted to hunting caribou. She tested 7 caribou groups and was successful twice (28.5% predation efficiency). The successful chases covered 400 m and resulted from surprising the caribou at close range (within 150-300 m). The unsuccessful chases were less than 100 m and the caribou flushed while the bear was over 800 m away.

During the early morning of 13 June, 2 mature male grizzlies were sighted, each feeding on a caribou calf. At 0442h one of the males was joined by a female. This breeding pair was observed for 23.0 b-u hours. For 22 min they hunted caribou but were unsuccessful. All the caribou tested flushed while the grizzlies were over 500 m away. At 1645h on 14 June, the pair was within 800 m of caribou and at 1740h they were within 550 m of 7 adult caribou. Both times the bears showed no interest in the caribou. The pair was not observed feeding or foraging after their unsuccessful pursuit of caribou on 13 June. At times, the pair was attended by 1-4 ravens. Other studies have shown that breeding pairs spend little time feeding or foraging (A. Murie 1981, J. Hechtel pers. comm.).

On 16 June, only the female was observed and she spent most of the afternoon foraging. At 1512h she chased 3 adult caribou (1 bull, 2 cows) for 400 m but was unsuccessful. At 1530h she disappeared from sight.

At 1449h on 14 June a grizzly was observed chasing 100 caribou. The chase covered a minimum of 50 m and was unsuccessful. Because of the distance at which the observation was made it was not possible to determine if calves were present.

Two caribou carcasses (one a calf) were found that had probably been fed on by grizzlies. Only bone chips and the hair mat were present at the calf carcass site. One grizzly scat containing calf hair and a calf hoof was found at the site. The second carcass was a yearling of unknown sex.

Because of blood on the vegetation, the presence of broken bones, the 2 grizzly scats at the site and the lack of sign of other predators, this caribou was probably killed by a bear. Visual inspection of the femur marrow indicated that over 50% of the fat reserves had been depleted. There was a strong odor associated with the site and there was meat left on many of the bones.

The peak of bear/caribou interaction occurred during 12-16 June. This period is summarized as follows:

1. A minimum of 6 grizzlies was observed. Two were mature females, 2 were mature males, 1 was a yearling of unknown sex and 1 bear was of unknown age and sex. A total of 44.9 b-u hours of behavioral information was collected.

2. A total of 15,000 caribou were seen in groups averaging 200-300 with a calf/cow ratio of 60/100.

3. Ten attempts by bears to kill caribou were witnessed; 2 were successful. Success depended on the bear's ability to get close (within 200-300 m to the caribou before being detected.

4. Caribou (mostly calves) were an important food for grizzlies. Many of the bears that were handled by ADF&G and USF&WS biologists had caribou blood on their faces, 35% of the grizzlie's foraging time was devoted to hunting caribou and bears were observed feeding only on calves. If more non-breeding bear units had been observed we probably would have witnessed greater use of caribou by bears.

5. Two carcasses (1 calf and 1 yearling) were found. Both carcasses were probably fed on by grizzlies, and there was no evidence that other predators visited either site. The yearling was probably killed by a bear.

16-22 June. This camp was located about 20 km NW of base-camp (Fig. 1). A minimum of 8 bears (3 mature males; 2 females--a 6 year old (1189) and 1 of unknown age; 3 bears of unknown age and sex) were sighted and 47.6 b-u hours of behavioral information were collected (Fig. 8). Bears were still common when observations were terminated from this site. A total of 8,000 caribou were seen from this camp. Most of these animals were in mixed-groups of variable size (10-300 ind./group); the smaller groups were predominantly cows with calves. The caribou were moving west and still common when this site was abandoned.

Bears were not seen hunting caribou, but 84.5% of the bears' feeding time was spent at some type of carcass. Five different bears were seen feeding on 4 different carcasses. Average time spent at these carcass sites was 3.4 b-u hours. Because of the distance at which the bears were observed (often 4.8+ km), the positive identification of carcasses as caribou is not certain. However, based on the almost constant presence of caribou, the lack of other ungulates in the area (2 bull musk-oxen, *Ovibus moschatus* were the only other ungulates seen) and the average time spent at a carcass site, caribou are considered the most likely candidate.

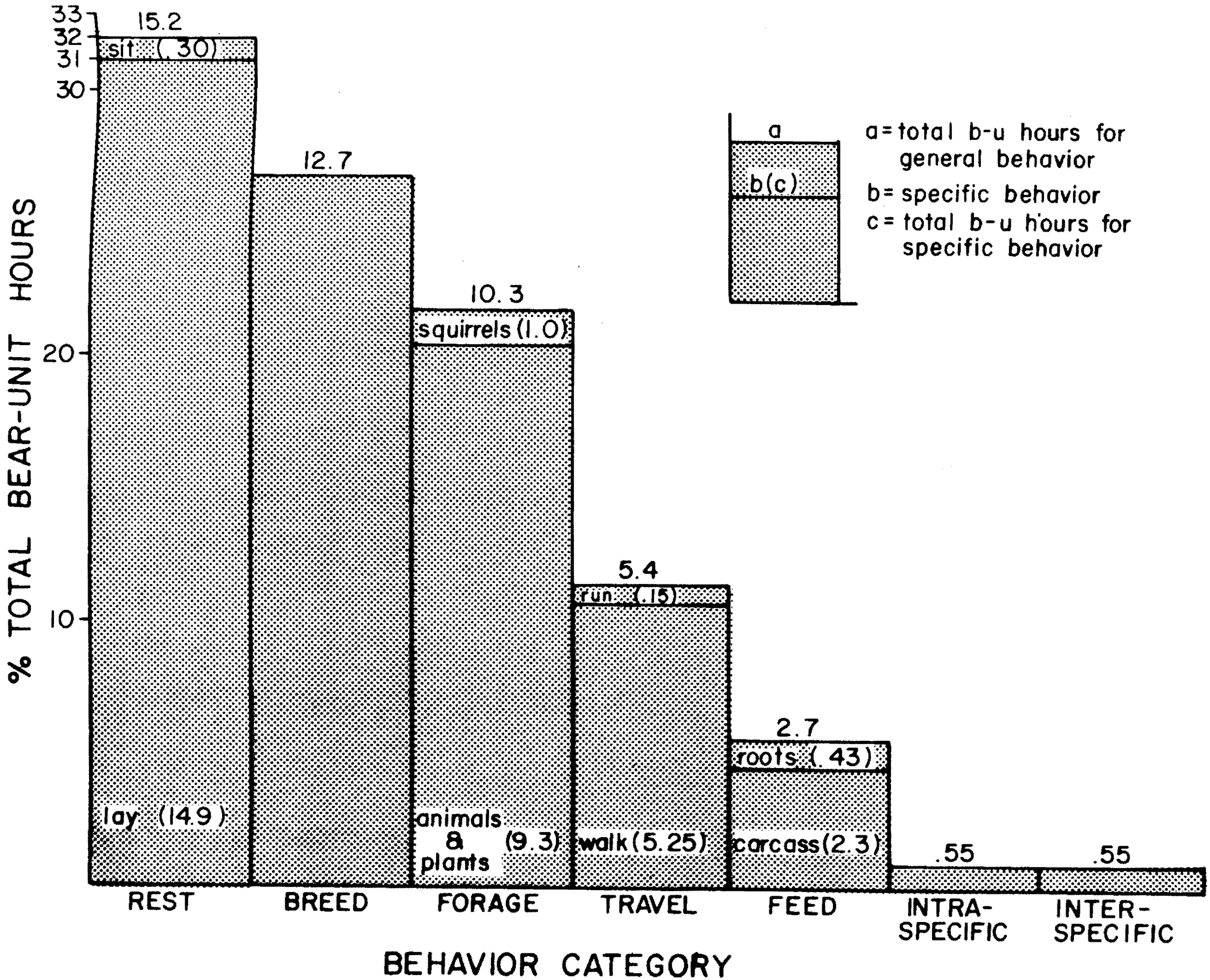

Fig. 8. Behavior of grizzly bears at the coastal plain/foothills area from 16-22 June 1983.

By 18 June, bears began to exhibit an indifferent attitude towards caribou. Calves were over 2 weeks old by this time and able to keep up with the adults. The adults had sufficient time to build up the energy reserves that had been depleted as a result of migration and calving. Also, Equisetum arvense, grasses and sedges, and Boykinia richardsonii (flowers and leaves) were becoming available to grizzlies.

29 June - 2 July. Bears were rare in the area. A breeding pair was sighted on 2 July and 6 b-u hours of behavioral information were collected (all breeding behavior). A total of 40,000 caribou was sighted during this period, with most of these animals in large (5,000 ind.) mixed groups. All groups were heading south/southwest. Bears and caribou were not seen simultaneously in the same area.

Summary of Bear/Caribou relations in the ANWR

Most use of caribou by bears occurs on the coastal plain at or near the caribou calving grounds. Grizzlies shift their ranges to include areas frequented by caribou (G. Garner pers. comm., this study). For about 1 month (24 May - 21 June) caribou (especially calves) are an important item for grizzlies. Calves are most vulnerable to predation during the first month of life (peak of calving occurs from 3-5 June) because of limited ability to escape predators.

During 144 days in the field, a minimum of 10 bears (3 mature females, 4 mature males, 1 yearling of unknown sex and 2 bears of unknown age and sex) were observed feeding on 11 caribou carcasses (6 calves and 1 yearling all of unknown sex, and 4 of unknown age and sex). An additional 5 carcasses (1 cow, 2 bulls, 1 calf of unknown sex, and 1 of unknown age and sex) were not fed on by grizzlies. A minimum of 11 attempts by bears to prey on caribou were observed; two of these were successful. Success depends on the ability of bears to get relatively close (within 200-300 m) to the caribou before being detected. Cow caribou did not defend their calves.

Grizzly Bear Breeding Behavior

In 1983, 5 breeding units were observed between 13 June-8 July (Fig. 9). Seven females (8 year old bear #1252, 6 year old bear #1189, and 5 of unknown age) and 4 males (all of unknown age) were involved. Two breeding units consisted of 2 females and 1 male was involved in 2 breeding units.

The first breeding pair was sighted at 0440h on 13 June. The male was feeding on a caribou calf and the female (bear #1252) was approaching the male from 800 m to the southwest. There was no aggression exhibited by the male toward the female over the carcass. The male did however, run off with a piece of the carcass when the female arrived. For the next 15.8 hours of observation time the pair rested, traveled and exhibited mate-directed 1 behavior. At 2020h on 14 June (39 hours since the pair was first sighted) mate-directed 2 behavior was observed.

Almost 60 hours after the pair was first observed, they were joined by a second female. Female 1 ran from female 2 while the male went to investigate. After a short wrestling match with 2, the male chased female 1; the newcomer followed about 20 m behind. For the next 4.2 hours of

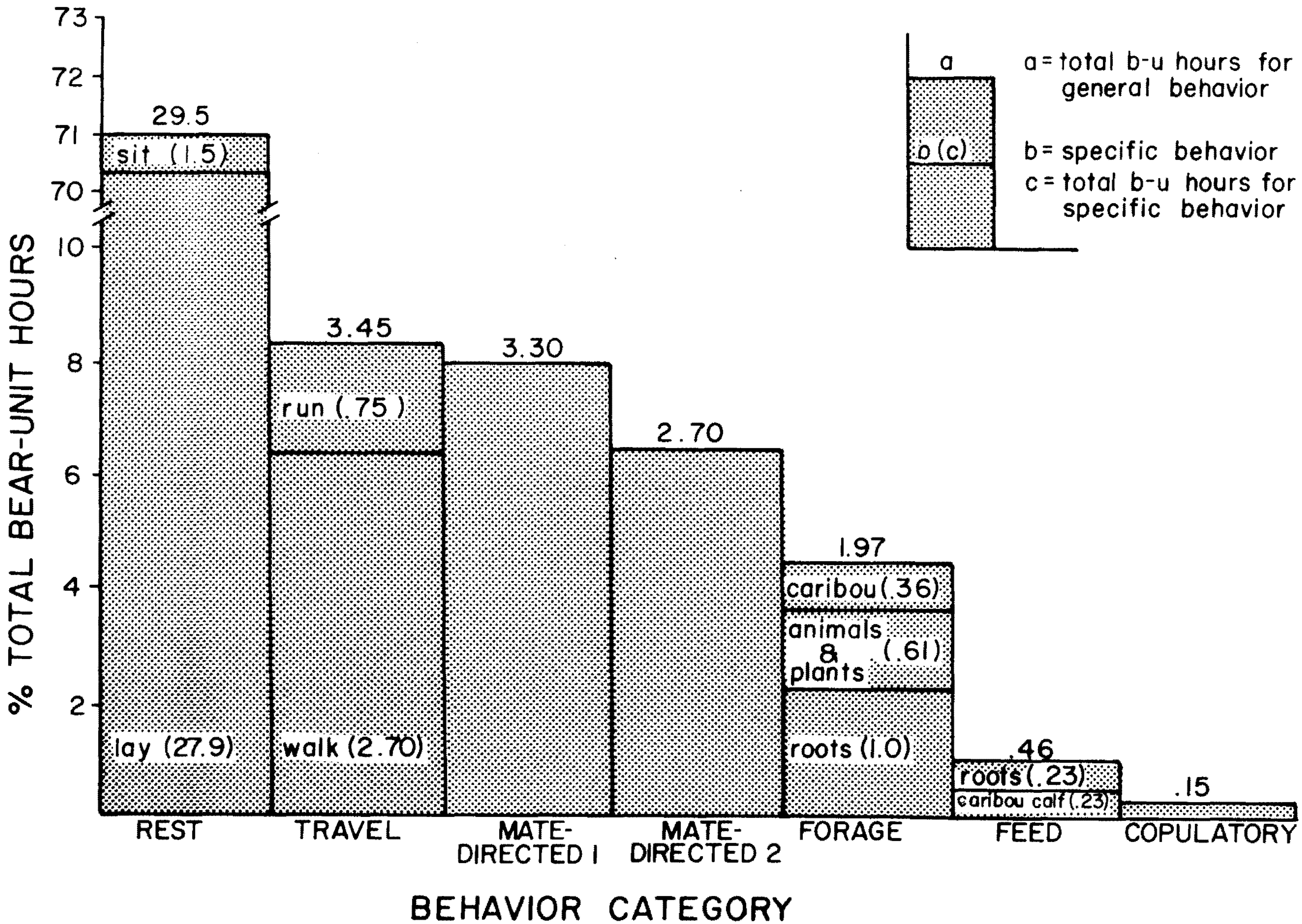

Fig. 9. Behavior of breeding units observed in 1983.

observation time the pair rested, traveled and exhibited mate-directed 2 behavior. Female 2 rested near (often within 10-15 m) the pair. On 2 occasions the male herded female 1 away from female 2; both times female 2 was within 10 m of the pair. At 2044h on 15 June, the bears disappeared from sight. The next day only female 1 was located.

The pair had been together for a mimimum of 64 hours. They were in sight for 36% of this time (23.0 b-u hours). Copulatory behavior was not observed. The pair was attended by a second female for 6.7% of the minimum time together. Although the male and female were apart when we first sighted them, I do not believe we witnessed the initial formation of the pair. In northern regions, breeding pairs usually stay together for more than 64 hours (J. Hechtel pers. comm.). Also, if the pair had just formed there would probably have been more aggression exhibited by the male toward the female at the carcass site. That this pair was joined by a second female is not unusual (H. Reynolds pers. comm., J. Hechtel pers. comm.)

The second breeding pair was spotted at 1430h on 20 June. They were in sight for the next 6.5 hours; 58% of this time the pair rested. Nine min of copulatory behavior was observed. The first attempt to mount by the male was unsuccessful. Twnety-nine min later the male again tried to mount the female from behind. After 7 min the female cooperated and the pair copulated for 1 minute. Intromission probably occurred as male made 3 quivering thrusts. Copulatory behavior was followed by mate-directed 1 behavior. At 2100h fog prevented further observations of the pair.

The following day, the pair was sighted at 1143h. They were observed for 5.3 hours; 92% of this time they were resting. At 1650h the female began foraging and within minutes she was out of sight. The male was still resting when the observation period ended at 1800h. The female was not resighted.

The third breeding pair was observed on 21 June, for 1 hour; 73% of this time the female (bear #1189) was walking or running from the male. The pair traveled within 500 m of 200 caribou but showed no interest. Occasionally the male would stop and investigate the trail of the female. On June 18 this male was observed following in a similar fashion, a 4 year old male (bear #1186) for 62 min.

The male from the third pair was also involved in the fourth breeding pair. They were observed from 1415-2015h on 2 July, with 83% of this time being spent resting. The sow's behavior was similar to that exhibited by the female of the third pair (i.e. her active time was spent avoiding the male). The pair was resting within 1 m of each other when the observation ended.

The final breeding unit was seen on 8 July. It consisted of a male and 2 females. The females were observed feeding on vegetation within 800 m of one another at 0305h. At 0320h female 1 detected and avoided female 2. At 0340h the male was observed following female. This sow began walking and running toward female 2; female 2 ran away. When the male detected female 2 he began chasing her, and female 1 followed. This female drove female 2 out of the immediate area. After this, the male resumed his pursuit of female 1. She again chased after female 2. When the bears went out of sight at 0411h female 2 was being chased by female 1, who was being chased by the male.

Breeding season extends from May through mid-July, with the peak of breeding occurring in mid-June (A. Murie 1981, J. Stelmock 1981, J. Hechtel pers. comm., this study). Breeding pairs were not observed in 1982 but Garner et al. (1983) reported they were common between 23 June-11 July. Most of these observations were made in the foothills area (G. Garner pers. comm.). In 1983 most observations of breeding bear-units were made near the coastal plains/foothills interface. This area was used probably because of the presence of large numbers of caribou.

If exploitation of oil and gas reserves in ANWR occurs, management of grizzlies will be a necessity. A thorough understanding of all aspects of grizzly ecology is needed before an ecologically sound and cost-efficient management program can be developed. This study provided baseline information on previously unknown or little understood areas of grizzly ecology in ANWR. For example, areas were identified that are important to grizzlies and the temporal use patterns for each area were determined. These data will permit management to make decisions that would restrict oil and gas activity during critical periods in occupied grizzly bear habitat.

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APPENDIX

ANWR Progress Report Number FY84-1

Table A-1. Marked bears that used the Caribou Pass/Kongakut River area during 1982 and 1983.

Bear number	Frequency	Ear tags[a] left/right	Age	Sex
1186	151.996	W/BK	7.5	M
1188	151.591	G/G	4.5	M
1189	151.950	G/R	6.5	F
1190	151.501	R/R	7.5	F
1193	151.582	R/W	8.5	F
1194	151.490	G/BK	11.5	M
1195	151.990	DB/DB	4.5	M
1196	151.935	LB/LG	7.5	M
1226	151.550	R/BK	10.5	M
1227	151.910	DB/W	5.5	M
1230	151.884	BK/W	3.5	F
1235	151.121	BK/R	3.5	F

a- W= white
Bk= black
G= green
R= red
B= blue
L= light (i.e. LB= light blue)
D= dark

Table A-2. Behavior categories of grizzly bears and bear-unit hours observed, 1982-1983.

Behavior Category sub-category	Total Bear-Unit hours
Feed	114.3
Undetermined vegetation	54.0
Equisetum arvense	22.1
Boykinia richardsonii	0.3
Hedysarum alpinum	14.3
berries	18.0
squirrels	2.2
caribou calf	2.4
caribou (undetermined sex and age)	1.0
Forage	113.3
animals and/or plants	80.2
Hedysarum alpinum (roots)	2.4
squirrels/microtines	29.6
caribou	1.1
Travel	25.9
run	23.3
walk	2.6
Rest	87.8
lay	85.8
sit	2.0
Intraspecific Interactions	45.0
other	2.3
play	0.8
nurse	0.2
breeding behavior	41.7
Interspecific Interactions	1.2

Table A-3. Vegetation types used by grizzly bears in 1983

Classification Levels (I-IV)[a]				
I	II	III	IV	Bear-Unit hours
Tundra				
	Sedge-Grass			
		wet sedge-grass	wet sedge meadow	0.7
			wet sedge-grass meadow	0.6
			wet sedge-herb meadow	0.1
		mesic sedge-grass	mesic sedge-grass meadow	0.1
			mesic sedge-herb meadow	0.2
		sedge-shrub	sedge-willow	46.4
		sedge-mat and cushion	sedge-dryas	20.0
			Total	68.1
	Herbaceous	low elevation herbs	seral herbs	17.6
		alpine herbs	herbs-sedge	0.4
			Total	95.02
Shrub Tundra		willow	willow-sedge	7.0
		birch and ericaceous shrubs	birch and eric. shrub-sedge	0.8
		mixed shrub	undifferentiated understory	42.0
			Total	49.8
	Mat & Cushion	open mat and cushion	ericaceous shrubs	24.6
		closed mat and cushion	mat and cushion grass	6.4
			dryas/herb	19.2
			Total	50.2
SHRUBLAND				
	Tall Shrub	closed tall shrub	willow	13.7
		open tall shrub	willow	5.0
			Total	18.7
	Low Shrub	closed low shrub	willow	4.6
		open low shrub	willow	25.0
			Total	29.6

a- Vierick, L.A., and C.T. Dyrness. 1980. A preliminary classification system for for vegetation of Alaska. U.S. Forest Serv., Pacific Northwest Forest and Range Experiment Station, General Technical Report. PNW-106. 38 pp.

ANWR Progress Report Number FY84-2

DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF FALL STAGING LESSER SNOW GEESE ON COASTAL HABITATS OF NORTHEAST ALASKA AND NORTHWEST CANADA, 1983

Michael A. Spindler

Key Words: snow geese, Anatidae, waterfowl, staging waterfowl, population, age ratio, Alaska, North Slope, Arctic National Wildlife Refuge

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16 December 1983

Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1983.

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Abstract: The 1983 distribution, abundance, and productivity surveys of lesser snow geese staging in August and September in northeast Alaska and northwest Canada were conducted by the U.S. Fish and Wildlife Service, in cooperation with the Canadian Wildlife Service. The 1983 surveys emphasized changes in temporal and spatial distributions within the staging season through increased survey frequency and examined habitat use, feeding, and behavioral response to aircraft overflights through ground observations. Fall staging was later than the previous 11 years with major arrival occurring within the Canadian sections on 1 September and on ANWR sections on 8 September, a full 13 days later than 1982 and 2 days later than the long-term average. Peak numbers were detected on 12 September. A total of 393,000 snow geese were estimated to have been present: 12,828 on ANWR; 300,651 on the Yukon north slope; 54,523 on the Mackenzie River delta; and 25,000 south of the delta. In 1983, total numbers of geese estimated in ANWR and Mackenzie delta were much lower than the respective long-term averages (99,107 for ANWR and 172,826 for Mackenzie delta), but were much higher than the Yukon long-term average (106,312). Also on this date, age ratio aerial photography was obtained over the entire staging ground. Analysis of 94 usable aerial photographs of flocks representing 8500 geese indicated a weighted age ratio of 26.8% $\pm$ 11.0 (SD) young. Age ratios varied spatially with the highest percent young (45%) observed on the Mackenzie River delta and the lowest (14%) observed on the Yukon north slope. Productivity levels in 1983 were higher than 5 of the 9 previous years, and were higher than any recent year since quantitative photo counts were initiated. Major departures occurred from 21-26 September: by the latter date no geese were seen following 5 days of strong west wind and freezing temperatures. The departure was 5 days later than 1982 and a week later than the 11 year average. Total duration of staging was 4 days less in 1983 than in 1982 and 2 days less than the long-term average. On ANWR, snow goose distribution in 1983 occupied generally the same area between the Hulahula and Egaksrak Rivers as in previous years, except in 1983 the most frequently used "core" concentration area centered more coastally and eastward in the Aichilik, Egaksrak, and Kongakut River deltas. The Okerokovik River area, used more extensively in previous years, was not used as greatly in 1983. Snow cover in 1983 may have been a factor in this slightly-changed distribution. A majority of geese seen in ground behavior scans on the lower Aichilik River on 11 September 1983 were feeding. Observation of feeding geese and areas where geese had recently fed indicated extensive use of sedge rootstocks in wet sedge tundra and grass leaf blades in riparian areas. Snow geese on the ANWR coastal plain were as sensitive to aircraft overflights as geese from other studies in Yukon, with flushing distances averaging 3 km and altitudes up to 3000 m causing flushing in both areas. An evening aircraft overflight on the lower Aichilik River caused all geese within a 4 km radius to take flight, 70% of which left the area; however, total numbers the next morning were comparable to goose numbers the previous morning. Low altitude (less than 30 m) aircraft overflights produced less disturbance than higher altitudes, perhaps due to lessened lateral dispersion of sound.

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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 twelfth year since surveys were initiated in 1971 by L.G.L., Inc. (Schweinsburg 1974). The 1983 surveys represented the sixth year of survey by refuge staff, and the fifth year of photographic age ratio sampling using methods standardized in preceeding 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 habitat types and areas used consistently by staging snow geese; and (5) document the normal daily activity regime of staging snow geese and determine if it changes in response to aircraft overflights. The 1983 program emphasized coordination with Canadian biologists to conduct 4 concurrent region-wide surveys during the staging season (late August, early September, mid-September, and late September). This survey design provided data that would describe population changes as well as changes in temporal and spatial distribution. A preliminary test of ground study methods for documenting feeding ecology, habitat use, and behavior, especially following disturbance by aircraft, was conducted in 1983.

Methods and Materials

Sampling procedures employed a predetermined 9.7 km-spaced grid of 2.4 km wide north-south aerial transects (Koski 1977b, Spindler 1983a). Transect surveys were flown with a Helio-courier H-295 aircraft flying approximately 150 m above ground level (AGL) at an airspeed of 200 kph. Flocks of birds encountered were assigned sequential numbers and recorded on a 1:250,000 U.S.G.S. topographic map, along with estimated flock size and direction of movement. Other information such as behavior, circling type of flight vs. migrational, and photograph frame numbers (if any) were coded to the flock number in a separate notebook. Direction of movement information was important in avoiding double counting of flocks moving towards succeeding transects. A crew of 2 persons (1 pilot/observer and 1 observer/photographer/recorder) was used to simultaneously obtain adequate photos and records. Both 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/photographer and pilot made independent estimates of flock size, and came to an agreement as to which estimate would be recorded (usually estimates agreed to within 10%). The pilot then circled closer and age ratio photographs were taken. To avoid excessive disturbances to the geese, care was taken to not circle a flock more than once.

A Mamyia RB-67 60x70 mm large format SLR camera was primarily used for the photography, in combination with a 250 mm telephoto lens and ASA 400 TRI-X PAN film. Secondarily, a 35 mm Pentax SLR with 135 mm telephoto lens and

ASA 50 H&W VTE PAN (Ferguson and Gilmer 1980) was used. Pilot and observer/ photographer/recorder used headsets interconnected through an aircraft intercom to facilitate coordination of photography, airplane movements, and record keeping. Photographs were enlarged so that each snow goose flock occupied a 20 x 25 cm sheet of photographic paper. Geese were counted with the aid of a light table. Calculation of the mean age ratio weighted according to flock size was allowable because no correlation was found between percent young and total flock size (R^2 = -0.239). Calculation of weighted mean and its variance weighted by flock size was according to the formulae recommended by S.J. Harbo (pers. comm.):

$$\bar{x}w = \frac{\sum_{i=1}^{n} (xi-wi)}{\sum_{i=1}^{n} wi},$$

where $\bar{X}_w$=weighted mean
X_i=percent young in flock
W_i=size of flock
n = number of flocks

$$V(\bar{x}w) = \frac{\sum_{i=1}^{n} (xi-xw)^2 \cdot wi / \sum_{i=1}^{n} wi}{n}$$

Age ratio in various groups was compared with F-test and t-test (Steel and Torrie 1960). Estimation of flock size and acutal photo count comparisons were done using paired-t and linear regression (Steel and Torrie 1960).

In addition to the systematic procedures used for the 9-12 September survey, several reconnaissance flights were made over the ANWR coastal plain to provide more complete information on the arrival, staging, and emigration of snow geese. Both fixed-wing and rotary aircraft were used in these reconnaissance flights, which followed varying survey routes. Dependent on other survey schedules, weather conditions, and available daylight.

Behavioral and feeding data were gathered on the ground by 3 persons positioned in the center of a large snow goose aggregation area. A Questar 60X and 120X spotting scope was set up in a blind tent pitched on a promontory offering good visibility within a 4 km radius of surrounding terrain. Observations of flocks were made at hourly intervals using the instantaneous-scan method (Altman 1974). Counts were made of the number of birds in each flock engaged in each of 5 main activities (feeding, sleeping, preening, flying, and other), similar to methods employed by Frederick and Klaas (1982). Environmental, habitat, and responses to aircraft disturbance were also noted. A preliminary aircraft disturbance experiment was conducted (after behavioral and feeding data were recorded) using a Helio-courier H-295 aircraft flying at an altitude of 150 m.

Results and Discussion

Population and Estimation Error

In order to accurately estimate peak population using the staging ground, several sources of error must be addressed: (1) completeness and extent of area surveyed, (2) timing of survey segments -- concurrent or nearly so, or otherwise, (3) weather conditions under which surveys were conducted and,

(4) estimation error for flock size. These sources of error are minimized by standardizing the survey protocol: (1) the area of coverage is flown using a systematic survey pattern; (2) the USFWS and CWS portions of the survey are conducted concurrently, and (3) a set of minimum weather and survey conditions must be met (Spindler 1980, 1983a). Estimation error was first addressed in the 1982 survey data when a correction factor of 1.2 was determined and used to correct visual estimates based upon actual photo counts of flocks (Spindler 1983b).

Actual numbers of snow geese counted on 15 photographs of total flocks were compared to instantaneous visual estimates of corresponding flocks made during the aerial surveys of 9 and 12 September 1983 (Appendix Table A-2). Actual photo counts were significantly greater than corresponding visual estimates ($t=2.149$, $n=15$, $p < 0.05$) and a linear relationship existed between the 2 values ($R^2=0.967$, $p < 0.005$). The survey crew consistently underestimated total flock size on ANWR by a factor of 1.15 so that all estimates made on these days were adjusted using this correction factor (Table 1). Adjustments were made on the CWS data by T.W. Barry using similar methods, but also taking into account extent of survey coverage.

Chronology and Numbers

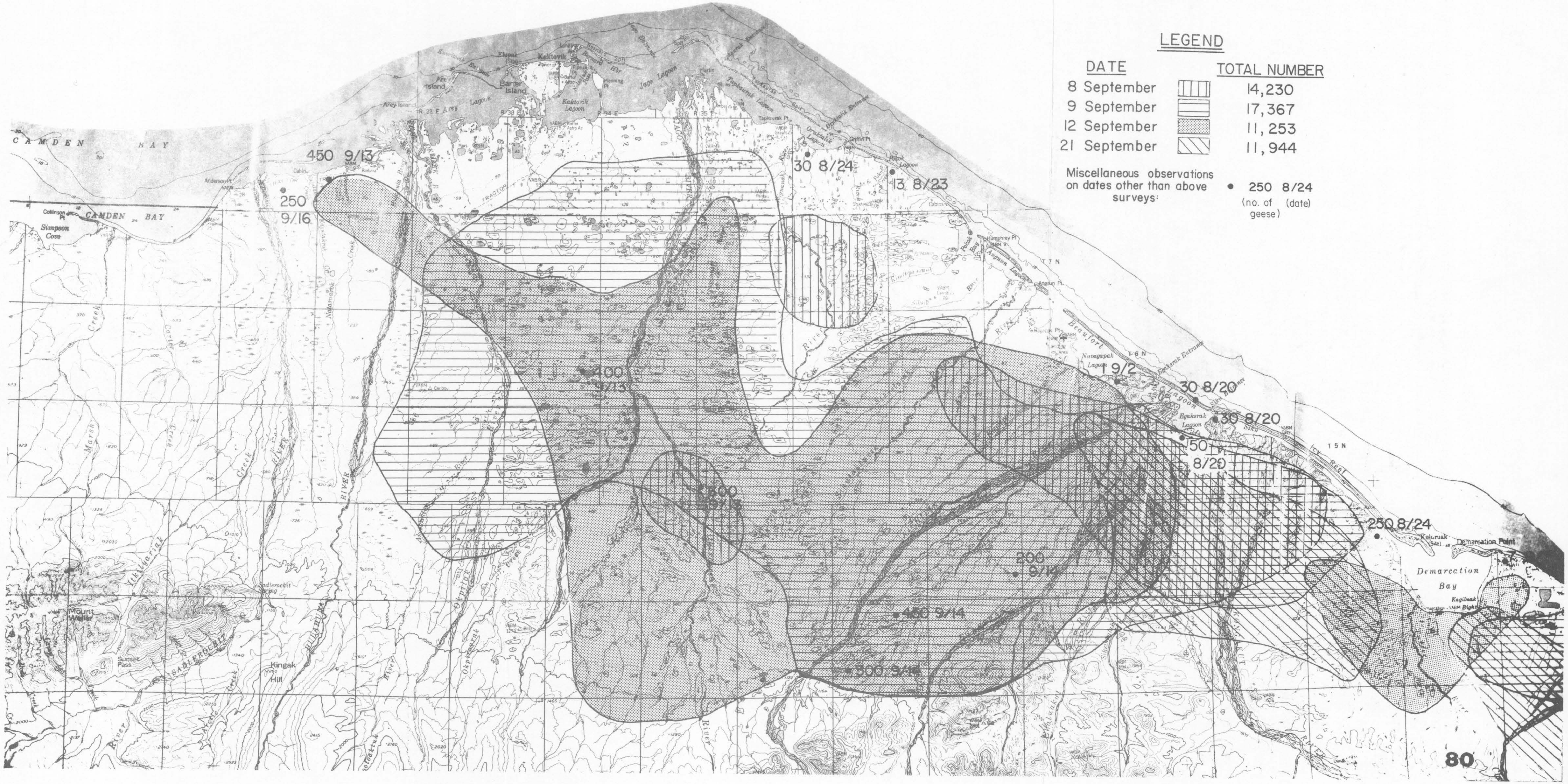
As in previous years, during June 1983 small flocks of snow geese were observed on the coastal plain (a group of 4 and 1 birds flying west on 3 and 4 June, respectively, at VABM Bitty on the Jago River; 26 birds grazing on 13 June and 6 birds flying west on 19 June at Okpilak delta). The first birds observed on ANWR during the staging season were 2 separate flocks each of 30 and a flock of 50 seen at the Egaksrak and Kongakut River deltas on 20 August (Fig. 1, Table 1). Most breeding and molting adults and flightless young in the Banks Island nesting colony (Kerbes 1983) depart and travel overland a distance of about 50 km to the southwest coast of Banks Island in mid-August (Fig. 2). Such overland walks by molting adults and flightless young have also been reported in southern Keewatin as post-nesting dispersal between about 15 and 25 August 1976 (McLaren and McLaren 1982). On 26 August 1983, T.W. Barry (unpubl. data) sighted 6128 geese in the Sachs River area on the southwest coast of the Banks Island, while 5133 were seen on the Canadian mainland, mostly in the Bathurst Peninsula area. By 1 September, however, most of the breeding birds departed the island with their fledged young making their first flight across the Amundsen Gulf. Initial landfalls were made on the Bathurst and Tuktoyaktuk Peninsulas, and the McKinley and Liverpool Bay shorelines (Fig. 2). Also, 3992 birds were seen on the Yukon north slope between the Blow and Malcolm Rivers. The majority of these birds came south from Banks Island on a strong north wind the night of 1 September (T.W. Barry, unpubl. data).

The first major westward movement towards the Yukon and Alaska north slopes was noted on 5 September 1983. Numbers of snow geese on the ANWR coastal plain remained low through 7 September, when only one flock of 7 birds was observed. By 8 September an influx was apparent with over 14,000 snow geese being counted on a reconaissance flight (Table 1). The peak number of geese staging on the ANWR coastal plain is estimated at 19,800 (Table 1). It is likely that the staging populations on ANWR stabilized at about 11,000-12,000 birds for the week of 12-21 September (Table 1). The 12 September survey extended from the Hulahula River on the west to Cape Bathurst on the east, and included all major staging areas on ANWR, the

Table 1. Results of aerial snow goose surveys and incidental observations taken during other aerial surveys, coastal plain of the Arctic National Wildlife Refuge, Alaska, Yukon north slope, and Mackenzie River delta, August - September 1983. Numbers given are actual counts or visual estimates; numbers in brackets are total geese estimated to have been present, based on adjustments for estimation error and area covered.

Date	Time when geese were observed (Alaska Daylight Time)	Flight time (h)	Survey type and area	Estimated numbers	Observer(s)
20 August	1330	8.0	Coastal lagoons/oldsquaw, ANWR	110	ANWR: R. Bartels, T. Doyle
20 August	1400	1.5	Bear telemetry Barter Is. to Firth R.	100	ANWR: L. Martin
22 August	1530-1545	4.1	Snow goose recon. Barter Island to Mackenzie River	172 (122 ad, 50 young)	ANWR: M. Spindler, D. Ross
23 August	1400-1630	2.5	Coastal lagoons/oldsquaw, ANWR	13 (12 ad, 1 young)	ANWR: T. Doyle, T. Wilmers, W. Post
24 August	1700-1930	2.5	Coastal lagoons/oldsquaw, ANWR	310	ANWR: T. Doyle, T. Wilmers, L. Martin
25 August	0600-1500	9.0	Snow goose census Demarcation B. to Tuktoyaktuk	11,111	CWS: T.W. Barry
28 August	0700-1930	11.5	Snow goose census Tuktoyaktuk to Banks Island		CWS: T.W. Barry
1 September	1120-1910	8.5	Snow goose census Tuktoyaktuk to Parry Peninsula	57,587	CWS: T.W. Barry
2 September	1700-1900	2.0	Coastal lagoons/oldsquaw, ANWR	26	ANWR: T. Doyle, R. Bartels, W. Audi
7 September	1200-1430	2.5	Coastal lagoons/oldsquaw, ANWR	7 (4 ad, 3 young)	ANWR: T. Doyle
8 September	1300-1530	2.5	Snow goose reconnaissance	14,230	ANWR: L. Martin, M. Smith
9 September	1405-1908	5.0	Snow goose census Barter Is. to U.S./Canada border	17,357[19,787]	ANWR: M. Spindler, D. Ross
10 September	0630-1500	8.5	Snow goose census Tent Island to Nicholson		CWS: T.W. Barry
12 September	1500-1650 1835-1953	3.4	Snow goose census Barter Is. to U.S./Canada border	11,253[12,828]	ANWR: M. Spindler, D. Ross
12 September	0750-1250 1400-1830	9.5	Snow goose census Demarcation Bay to Cape Bathurst	127,462 [380,174]	CWS: T.W. Barry
21 September	1000-1400	4.0	Snow goose census Barter Is. to U.S./Canada border	11,944	ANWR: T. Doyle, L. Martin, W. Audi
25 September	1130-1900	7.5	Snow goose census Tuktoyaktuk to Komakuk Beach	0	CWS: T.W. Barry
26 September	1100-1700	6.0	Snow goose recon. Barter Island to U.S. Canada border, oldsquaw/bear telemetry	0	ANWR: T. Doyle, L. Martin, T. Wilmers

FIG. 1
1983 SPATIAL AND TEMPORAL DISTRIBUTION OF LESSER SNOW GEESE DURING FALL STAGING ON THE COASTAL PLAIN OF THE ARCTIC NATIONAL WILDLIFE REFUGE ALASKA



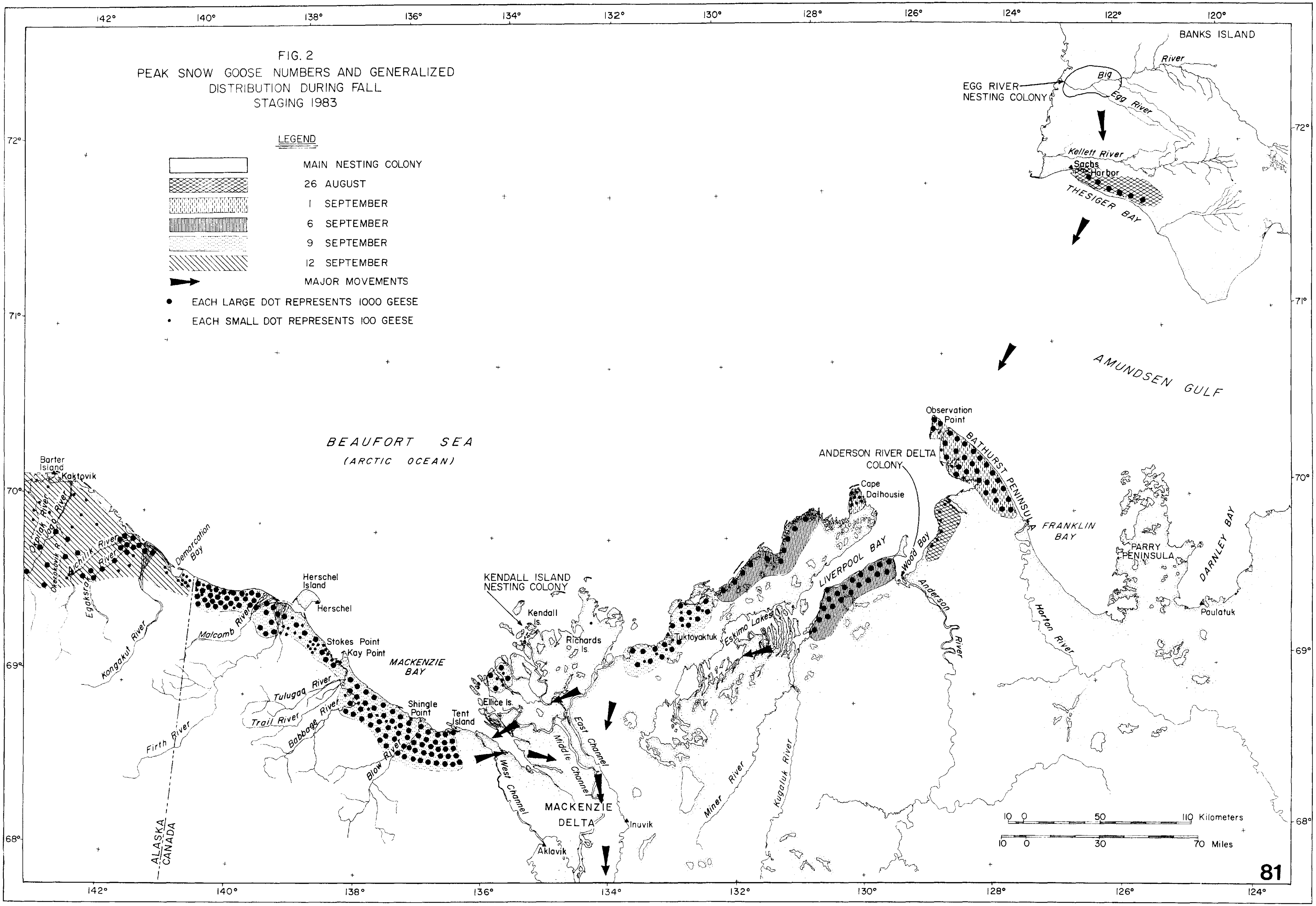


FIG. 2
PEAK SNOW GOOSE NUMBERS AND GENERALIZED DISTRIBUTION DURING FALL STAGING 1983

Yukon north slope, the Mackenzie River delta, the Tuktoyaktuk Peninsula, and the Anderson River delta (Fig. 2, Tables 1 and 2, Appendix Table A-4). The total estimated population of western arctic snow geese staging in ANWR and northern Canada was approximately 393,000 birds (Table 2, Appendix Table A-4). The majority of geese staging in Canada occurred in the Tent Island-Blow River area, the Blow River-Babbage River area, and the Malcolm River-Komakuk Beach areas (Appendix Table A-4).

The main emigration of geese from the staging areas probably occurred between 21 and 26 September: about half of the geese seen on the 21 September survey of the ANWR coastal plain were migrating east; and on 26 September, after 5 days of west winds with snow and freezing temperatures, no geese were seen on ANWR (Table 1). On 25 September no geese were seen on the Mackenzie River delta and Tuktoyaktuk portions of the Canadian staging grounds and all but 5% of the wetlands were frozen and under complete snow cover (T.W. Barry, unpubl. data).

Staging activities were later in 1983 than in 1982, and later than the average of the previous 11 years. Arrival was 13 days later in 1983 than in 1982, and 2 days later than the average arrival date the previous 11 years (Table 3, Fig. 3). Staging also started later: 7 days later than 1982 and 3 days later than the average initiation of staging the last 11 years (Table 3, Fig. 3). Duration of staging in 1983 was 4 days less than 1982 and 2 days less than the long-term average. Major departure started 5 days later than 1982 and a week later than the average for the last 11 years.

Total numbers of snow geese staging in Alaska were only 12.0% of the previous year and 11% of the average of the last 9 years (Table 2). Numbers of geese counted on the Yukon north slope were 14.0% less than in 1982 but 23.6% more than the 8 year average for that area. The Mackenzie River delta showed 424.2% more birds than in 1982, but 1983 still had only 13.6% of the 6-year average (Table 2). Including adjusted 1983 data, long-term averages of 99,107, 106,312, and 172,826 snow geese staged in the Alaska, Yukon, and Mackenzie areas respectively. The Alaska and Yukon north slopes appeared to be similar in mean numbers while the Mackenzie Delta averaged approximately 1 1/2 times as many birds.

Fewer snow geese staged on ANWR in 1983 than in 1982 possibly because of differing wind regimes during the 15 August - 10 September period when geese would have been migrating west into the refuge. At Barter Island, generally westerly to northwesterly winds (headwinds) predominated during this period in 1983 (67% of the days), whereas northeasterly to easterly winds (tailwinds) predominated in 1982 (70% of the days). Large flocks staging on ANWR in 1982 departed the refuge to the east on 16 and 17 September, 2 days after the first steady and strong west winds of the season at Barter Island (N.O.A.A. Climatological Records for Barter Island, Alaska, 1982 and 1983). In 1983 departure occurred, again with prevailing west winds, on 21-25 September. The direction of these winds was not unique for that season, however, their velocity was, averaging 35 kph from 21-25 September as compared to a mean of 23 kph the previous 2 weeks.

Wind appears to be a major factor in fall departure from ANWR staging grounds, however, other factors not specifically studied may play an important role (e.g. temperature, chronology of freeze-up on wet tundra and wetland habitats). A favorable strong following wind was reported to be the

Table 2. Total 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	Survey dates
1973[a]	44,037	126,960	86,520	257,517	Sept. 2,3,5,6,11,12,18,22,23,25
1974[a]	48,591	37,435	28,913	114,939	Aug. 24,31, Sept.5,11,16,25
1975[a]	0	20,972	685,305	706,277	Aug. 25-28, Sept.8,10,11,13,17-18,20,23
1976[a]	228,793	224,401	18,363	471,557	Aug.16-20,29-31, Sept.4-6,10-13,18-21
1978[b]	325,760	N/D	N/D	N/D	Sept. 13-14
1979[c]	195,000	41,000	N/D	N/D	Sept. 6-7
1980[d]	8,996[e]	7,500[f]	N/D	N/D	Sept. 9
1981[g]	20,000[h]	80,000[h]	330,000[i]	430,000[i]	Sept. 14,16,20
1982[j]	107,072	117,892	6,155	231,000	Aug.24,26,29,31; Sept.1,3,5,9,10,14,15,21,22
1983[k]	11,253	101,350	26,112	144,819	Aug.22,26;Sept.1,8,9,12,21,26
	(12,828)	(300,651)	(54,523)	(393,002)	

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. Includes 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 12 September based on adjustments for estimation 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.

Table 3. 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 1978-1983. The 1978-1982 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	Duration of staging (days)	Major departure	Date last flock sighted	Survey period[a]
1971[b]	15 Aug.	31 Aug.-2 Sept.	9	12-16 Sept.	17 Sept.	4 June-19 Sept.
1972[c]	17 Aug.	27-29 Aug.	10	7-10 Sept.	15 Sept.	10 July-17 Sept.
1973[d]	23 Aug.	1-12 Sept.	9	22-25 Sept.	4 Oct.	25 Aug.-29 Sept.
1974[e]	21 Aug.	22-25 Aug.	22	17-21 Sept.	30 Sept.	24 Aug.-30 Sept.
1975[f]	18 Aug.	3-5 or 6 Sept.	12	19-24 Sept.	25 Sept.	20 Aug.-25 Sept.
1976[g]	13 Aug.	25-28 Aug.	18	16-26 Sept	30 Sept.	15 Aug.-2 Oct.
1978[h]	20 Aug.	25 Aug.-1 Sept.	14	16-27 Sept.	27 Sept.	10 June-5 Oct.
1979[i]	24 Aug.	26-28 Aug.	17	15 Sept.	N/D	10 June-12 Sept.
1980[j]	15 Aug.	19-21 Aug.	10	1-2 Sept.	9 Sept.	5 June-12 Sept.
1981[k]	24 Aug.	26-30 Aug.	16	16-18 Sept.	18 Sept.	11 July-20 Sept.
1982[l]	7 Aug.	24-26 Aug.	20	16-18 Sept.	19 Sept.	6 June-25 Oct.
1983	20 Aug.	25 Aug.-2 Sept.	16	21-26 Sept.	21 Sept.	1 June-26 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 more 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 respective sources:
[b] Schweinburg (1974)
[c] Gollop and Davis (1974)
[d] Koski and Gollop (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, 1 pp.
[j] Spindler (1980)
[k] Spindler (1983a)
[l] Spindler (1983b)

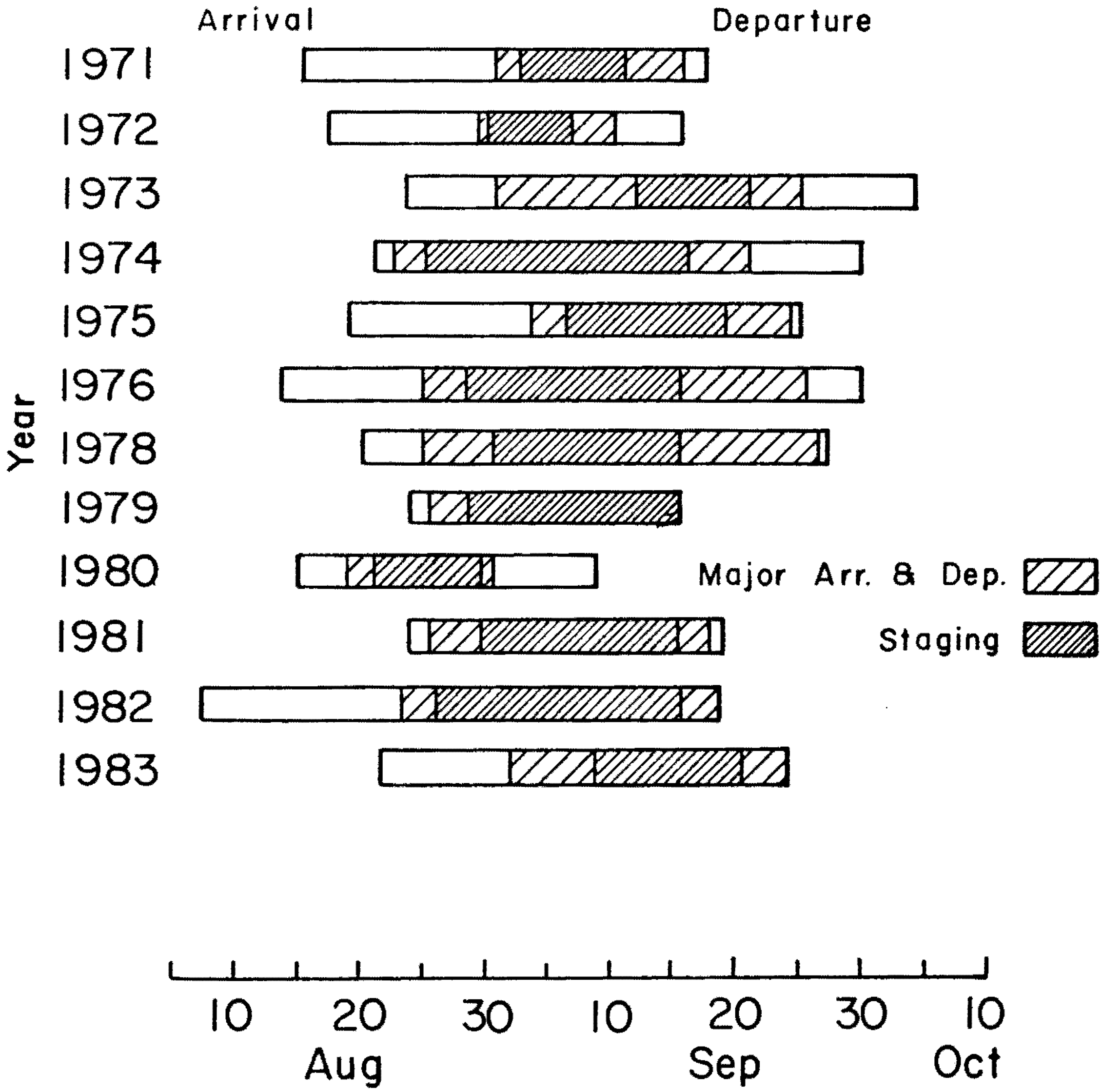


Fig. 3. Chronology of arrival, staging, and departure of the western arctic population of lesser snow geese using the coastal plain of the Arctic National Wildlife Refuge, Alaska, north slope of the Yukon Territory, and the Mackenzie River delta, N.W.T.

most important factor triggering northward migration of waterfowl in the Mississippi Flyway (USDI 1970) and of Canada geese in Minnesota and Manitoba (Wege and Raveling 1983). Other studies, however, have indicated that initiation of northward movements of snow geese were not strongly influenced by surface wind direction (Blokpoel 1974), but that maximum daily air temperature did have a strong influence (Flickinger 1981).

Spatial Distribution

The initial arrival areas in August 1983 were the Kongakut and Egaksrak River deltas (Fig. 1). The major arrival on 7-8 September was to these deltas and the area to 16 km inland between the Sikutaktuvik River and Pingokraluk Point (Fig. 1). On 9 September birds spread across the coastal plain west to the Hulahula River and inland up to 40 km (Fig. 1). By 12 September, distribution had reached its maximum extent, with a further westward expansion to the Sadlerochit River delta, a southward expansion to the area between VABM Bitty and the upper Okerokovik River, and another concentration around the south side of Demarcation Bay. The final area to be occupied by snow geese before major departure was similar to that occupied during major arrival -- Aichilik, Egaksrak, and Kongakut River deltas and inland up to 16 km, as well as south and east of Demarcation Bay to the U.S.-Canada border (Fig. 1).

Distribution in 1983 occupied generally the same area between the Hulahula River and Egaksrak Rivers as in 1982, except in 1983 the most frequently used "core" concentration area centered more coastally and eastward in the Aichilik, Egaksrak, and Kongakut River deltas. In 1982, the "core" area was the upper Niguanak and the Sikutaktuvik Rivers and the central Okerokovik River (Spindler 1983b). The reason for differential use of areas between years is undetermined. However, snow cover may have been a factor. Snow geese initially occupied the generally snow-free areas on the coastal plain on 8 September 1983 (Fig. 1; L.D. Martin, pers. comm.). On 9 September 1983, 15-25% snow cover occurred above the 330 m contour line, but by 12 September all the snow below 660 m had melted (Fig. 1). In most previous years, snow cover was not a factor in the initial distribution of snow geese because the first major snowfall occurred later (in mid-September), which coincided with the departure of the geese and not their arrival (USFWS 1982, Spindler 1983a and 1983b).

The "core" staging areas from 1973 to 1982 included the upper Sikutaktuvik and Niguanak River areas, the middle Okerokovik River and the entire coastal plain portion of the Aichilik River (USFWS 1982, Spindler 1983a). In 1983, the "core" differed only slightly from the previous 8-year pattern in that less of the Okerokovik area was used and more of the Aichilik/Egaksrak/Kongakut River areas were used. Also, the Demarcation Bay area was used more extensively in 1983 than in most previous years (Fig. 1; USFWS 1982; Spindler 1983a, 1983b).

Productivity

Age ratio sampling coverage in 1983 was comparable to coverage in 1982, with the majority of the staging area from the Bathurst Peninsula to Barter Island being surveyed on 12 September 1983 (Tables 1 and 4). On ANWR, a total photo sample of 4619 geese representing estimated flocks including 7438 geese was obtained from 24 usable photographs (Appendix Table A-1).

Table 4. Productivity of western arctic snow geese during staging, Bathurst Peninsula, N.W.T. to Barter Island, Alaska, as determined from coordinated surveys and aerial photography. (All segments were surveyed 12 September 1983, except Bathurst Peninsula which was 1 September).

Survey segment	Adults	Young	Total	% Young	No.of photos
Bathurst Peninsula[a]	2335	2644	4979	53.1	31
Tuktoyaktuk Peninsula	1281	393	2174	41.1	38
Ellice Island to Tent Island	406	504	910	55.4	22
Blow River to Babbage River	288	68	356	19.1	6
Babbage River to Stokes Point	1591	63	1654	3.8	9
Stokes Point to Komakuk Beach	461	259	720	36.0	7
ANWR - Demarcation Bay to Hulahula River	2154	492	2686	18.3	12
Total	8516	4923	13,479	36.5±14.0(SD)	125
Total less Bathurst Peninsula[a]	6181	2279	8500	26.8±11.0(SD)	94
Northwest Territories Segment	1687	1397	3084	45	
Yukon Territory Segment	2340	390	2730	14	
Alaska Segment	2154	492	2686	19	

[a]Bathurst Peninsula survey (1 September) deleted for calculation of regionwide estimate of productivity to avoid movements and double-counting between 1 September and 12 September surveys.

For ANWR, the weighted mean percentage of young birds on 9 September, was 30.0 ± 8.6 (SD) and on 12 September was 19.0 ± 5.5 (SD), a significant difference apparently due to daily changes in flock composition. Because of the significant differences in percent young in only 3 days time between 9 and 12 September 1983 on ANWR, further analyses of ANWR and Canadian age ratios were limited to only those data taken on 12 September.

A total of 10,793 geese were counted on 113 photos of the Canadian staging grounds by T.W. Barry on 1 and 12 September. To avoid the problems of movements and double-counting, only those ANWR and Canadian segments of the survey photographed on 12 September were used to calculate the productivity estimate. This restriction on the photography yielded a sample of 8500 geese from 94 photographs. Therefore, the weighted estimate of western arctic snow goose productivity was 27% ± 11 (SD). These data (Table 4) indicate considerable variation between sample segments, with the greatest concentration of non-breeders occurring in the Babbage River to Stokes Point segment. Conversely, the greatest abundance of family groups was in the Ellice Island to Tent Island segment on 12 September (and the Bathurst Peninsula segment on 1 September). The spatial and temporal differences in age ratios for 1983 (Table 4) were similar in magnitude as observed in previous years (Spindler 1983a, 1983b), underscoring the necessity to conduct the age ratio surveys over the most extensive area within the shortest time frame possible.

The greatest percent young was observed in the Northwest Territories areas, followed by Alaska and Yukon (Table 4). In 1982 a similar pattern existed between Alaska and Yukon, with lowest percent young observed in the Yukon (Spindler 1983b). In 1981 the Northwest Territories areas also had the highest proportion of young in the surveys (Spindler 1983a).

Productivity levels in 1983 were higher than 5 of the 9 previous years and were higher than any recent year since quantitative photo counts were initiated in 1979 (Table 5). Recent age ratio data have not approached the high proportions of young observed in 1973 and 1975 (Table 5). Some of the extreme variation between years is probably attributable to annual variations in sampling coverage and high spatial variation of age ratios within years, particularly 1979, 1980, and 1981 (Spindler 1982a). The 4 earliest years of data (1973-1976) and the 2 most recent years do represent the most extensive real-time coverage attainable given the survey conditions, and these years still exhibit extreme variations in productivity. However, the earlier 4 years (1973-1976) are based upon composition counts, while the 1982 estimates are based on photo estimates (Table 5), and the comparability of productivity estimates derived from these two techniques is not known. Such annual variation may reflect actual changes in productivity, which appears realistic in light of the variation reported from long term colony productivity studies in the eastern Canadian arctic (Davies and Cooke 1983).

Behavior and Feeding

On 10 September a field camp and observation blind were established near the mouth of the Aichilik River, 6 km inland from the coast on a bluff on the east side of the river (69°47'30"N, 142°12'00" W). The blind was located atop the bluff, affording an unobstructed view for a 4 km radius surrounding the site. The camp was located 0.5 km to the west of the blind and was at a lower elevation and out of sight from geese visible from the blind.

Table 5. Age ratios for western arctic snow geese staging on the Alaska and Yukon north slope, and Mackenzie River delta 1973-1976 (Koski 1977b) and 1979-1983 (Barry 1982, USFWS 1982, Spindler 1983a,b,) .

Year	Adults	Young	% Young	Area of survey[a]	Technique
1973	4533	5399	119.1	MD, YNS, AK	Composition count
1974	28,647	29	1.0	MD, YNS, AK	Composition count
1975	12,223	13,638	111.6	MD, YNS, AK	Composition count
1976	7375	5541	75.1	MD, YNS, AK	Composition count
1979	4275	133	3.1	YNS, AK	Photo
1980	1046	37	3.3±1.2SD	YNS, AK	Photo
1981	39,693	5082	11.3±4.1SD	MD, YNS, AK	Photo
1981	175,000	75,000	30.0	Paulatuk and southwest	(estimate)[b]
1982	14,904	889	4.6±0.7SD	MD, YNS, AK	Photo
1983[c]	6181	2279	27.0±11.0SD	MD, YNS, AK	Photo

[a] MD - Mackenzie River delta; YNS - Yukon north slope; AK - ANWR, Alaska.
[b] Paulatuk is a rarely used staging area, no quantitative survey was conducted. Data are estimates made by T.W. Barry.
[c] Estimate based only on those observations made 12 September 1983

Behavior scan data indicated that the majority of geese surrounding the blind area were feeding, and that the most intense time of feeding activity was early morning (Table 6). Staging flocks of snow geese were typically in constant motion as they clipped and uprooted sedges, each time moving a step or two forward to the next clump of sedges. Geese were tallied as walking only if they were not also engaged in feeding. It was not unusual for a flock to move, without flying, 0.5 km during the course of a few hours of feeding if not disturbed.

Table 6. Results of behavior scans of snow goose staging flocks, lower Aichilik River, Arctic National Wildlife Refuge, Alaska, 11 and 12 September 1983 (Figures are average % of all birds seen engaged in each behavior class followed by total numbers of geese observed in behavior classes for all scans in parentheses).

Behavior	Early morning	Afternoon
Sit	0 (0)	1 (10)
Stand	5 (9)	9 (91)
Feed/walk	93 (163)	80 (809)
Walk only	2 (3)	8 (81)
Fly	0 (0)	1 (6)
Bathe	0 (0)	1 (10)

Observations of undisturbed snow geese staging on the north slope of the Yukon Territory by Davis and Wiseley (1973) also reported that the major activity was feeding (57%). However, Fredrick and Klaas (1982) noted that feeding activity (21.6% ± 0.9 SD) in migrating snow geese in Iowa was not the major activity, but was secondary to sleeping (25.3% ± 1.0 SD) and other activities (47.5%± 1.0 SD).

Plant species eaten by snow geese grazing in wet sedge tundra along the lower Aichilik River area on 11 September included (*Carex membranacea*, *C. aquatilis* ssp. *stans*, *C. aquatilis* ssp. *aquatilis*, and *Eriophorum angustifolium* ssp. *subarcticum*. Tubers of these species were uprooted and eaten in patches up to 3 m in diameter over several ha. Considerable grazing also occurred in riparian floodplains adjacent to the Aichilik River where clumps *Poa alpina* and *Arctagrostis latifolia* were heavily utilized. Leaf tips of these grass species were grazed extensively in some areas, and mud surrounding the grass clumps was heavily trampled.

Reaction to Aircraft Overflight

Sensitivity of snow geese to aircraft overflights has been documented on the Yukon north slope adjacent to ANWR (Davis and Wiseley 1974), on the Mackenzie River Delta (Barry and Spencer 1976), and near Prudhoe Bay (Welling et al. 1981). Miscellaneous observations pertaining to the reaction of snow geese to aircraft on ANWR have been made during previous years surveys, but specific studies have not been attempted until 1983.

On 10 September at the lower Aichilik ground observation area a total of 163 snow geese were visible from the blind between 1530 and 1830h, however, visibility was poor, ranging from 13.0 to 0.8 km in light to heavy snow. More geese were heard in the distance beyond the limits of visibility, and after dark, geese were heard flying overhead most of the night. On 11 September, 4 area counts were conducted to determine the numbers of geese visible from the blind and indicated 1444 to 2441 geese present (Table 7). Numbers of geese in the area apparently increased from morning to afternoon except for 1 count taken under conditions of bad heat waves.

Table 7. Numbers of snow geese visible from lower Aichilik River ground observation point, coastal plain, Arctic National Wildlife Refuge, 11-12 September 1983.

Date	Census	Time	No. of snow geese	Conditions (wind/temp/clouds)
11 September	1	0630h	1444	NE 5/25°F/ 150 m overcast
	2	0945h	1761	NE 8/32°F/ high overcast
	3	1300h	1575	NE 8/42°F/ clear, heat waves
	4	1505h	2441	NE 5/35°F/ high overcast
Post Aircraft overflight		1630h	679	NE 5/35°F/ high overcast
12 September	5	0625h	1571	SW 8/40°F/ high overcast

Following completion of the 1505 h count on 11 September, an aircraft overflight was made around the 4 km radius area under observation. The flight was made with a Helio-courier H-295 aircraft at an altitude of 150 m and lasted 10 minutes, takeoff to landing. The count immediately following the disturbance indicated 679 snow geese in the area a 72.2% reduction in numbers (Table 7). Short-term effects of the disturbance were that all flocks within a 4 km radius took flight. Three flocks circled and landed within the observation area, the remainder departed to the south. Flocks took flight from distances as far way as 4 km. One flock of 500 birds 1 km away from and out of sight of the aircraft took flight apparently in response to the sound of the engine run-up since the birds became airborne just as the engine was run-up and before the airplane began to taxi. Numbers of birds in the area under observation started to increase gradually about 1 h after the disturbance as small flocks (numbering 10 to 20) began to move in. The next morning, snow goose numbers were 108.8% of the numbers observed the preceding morning, however, numbers were 64.4% of those observed prior to disturbance the preceding afternoon (Table 7).

Based upon the above observations and additional observations made during the same period and in previous years, (Appendix Table A-3) snow goose reactions to aircraft overflights appear to have had the following characteristics:

(1) Snow geese reacted to aircraft overflights of up to 3000 m AGL. On the Yukon north slope Davis and Wisely (1974) noted similar reactions.

(2) On ANWR snow geese reacted to aircraft at distances up to 10 km. In the Yukon, snow geese reacted to aircraft up to 22 km distant, but average distance for reactions was 3 km (Davis and Wisely 1974).

(3) Low altitude fixed-wing overflights (30 m AGL) apparently did not disperse the noise laterally from the flight line as far as higher altitudes, therefore low altitude overflights did not cause the widespread disturbance associated with overflights occurring at higher altitudes.

(4) Following aircraft disturbances, snow geese returned to the area gradually, reaching numbers comparable to those present the preceding morning within 14 hours and 2/3 the numbers present prior to disturbance.

Documented reactions of snow geese to aircraft vary considerably -- ranging from taking flight and leaving the area in response to overflights at 3000 m AGL (this study and Davis and Wisely 1974) to nearly complete habituation on the approach and departure routes for the majority of aircraft traffic at Tuktoyaktuk, N.W.T. (T.W. Barry, pers. comm.). Reported variations in sensitivity may be attributed to desirability of food sources, migratory restlessness, and distance from core staging areas. The most intensive disturbance study performed to date on snow geese yielded the following general conclusions (Davis and Wisely 1974):

(1) Flocks of geese reacted significantly more strongly to small fixed-wing (Cessna 185) overflights at 2 h intervals than at 1/2 h intervals, indicating potential habituation.

(2) Flocks flushed at greater distances with 1/2 h intervals than at 2 h intervals of Cessna-185 overflights but flew further in response to the 2 h overflights.

(3) The duration of flock reaction was greater the closer the overflight occurred to the flock.

(4) Flocks took flight at greater distances in reaction to small helicopters than small, medium, and large fixed-wing aircraft.

(5) Snow geese gradually habituated to frequent (1/2 h interval) helicopter flights by flushing closer to the aircraft and flying less distance once flushed, and, conversely, habituated to frequent (1/2 h interval) fixed wing flights by flushing further from the aircraft but not flying as far.

(6) Estimated loss in energy storage caused by reduced feeding time due to disturbance from Cessna-185 overflights at 2 h intervals was 20.0%, and from Bell 206 helicopters was 9.5%.

It was hypothesized that snow geese feeding rates were maximum during staging in order to store sufficient body reserves for migration. Snow geese tend to remain in staging areas as long as possible before freeze up and extensive snow cover, therefore, they can ill-afford to forego feeding opportunities (Davis and Wisely 1974, Patterson 1974)

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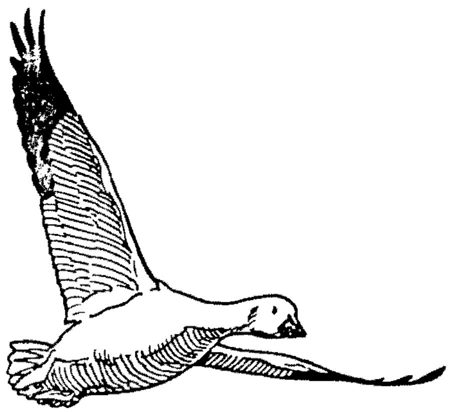

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APPENDIX

ANWR Progress Report Number FY84-2

Table A-1. Age ratios of western arctic snow geese as determined from photographic counts on 9 and 12 September 1983, Arctic National Wildlife Refuge, Alaska.

Photo I.D. (roll & frame)	Flock number	Flock size	Sample total	Total adults	Total young	% young
9 September						
VTE 1-5	15	52	52	29	23	44.2
VTE 1-7	16	143	49	24	25	51.0
VTE 1-11	17	147	147	88	59	40.1
VTE 1-14	19	182	182	97	85	46.7
VTE 1-19	21	100	117	62	55	47.0
VTE 1-21	22	262	262	181	81	30.9
VTE 1-25	23	336	336	223	113	33.6
VTE 1-28	25	150	48	40	8	16.7
VTE 1-31	27	200	185	154	31	16.8
VTE 2-9	38	52	52	37	15	28.8
TXP 1-5	41	500	251	217	44	17.5
TXP 1-10	46	350	282	201	81	28.7
TOTAL		2474	1963	1353	620	30.0±8.6SD[a]
12 September						
VTE 2-11	101	157	157	152	5	3.2
VTE 2-17	102	300	101	67	34	33.7
VTE 2-21	110	600	81	59	22	27.2
VTE 2-28	112	500	369	253	116	31.4
VTE 2-35	120A	1000	486	456	30	6.2
TXP 2-3	120B	1000	569	515	44	7.7
TXP 2-6	121	223	223	203	20	9.0
TXP 2-7	124	300	145	89	56	38.6
TXP 2-8	126	172	172	88	84	48.8
TXP 2-16	130A	300	156	117	39	25.0
TXP 2-11	130B	300	85	68	17	20.0
TXP 2-18	131	112	112	87	25	22.3
TOTAL		4964	2656	2154	492	19.0±5.5SD[a]
Overall		7438	4619	3507	1112	22.7±4.6SD[a]

[a] Means and standard deviations are weighted according to flock size.

Table A-2. Photographic count results used to assess accuracy of visual flock size estimates for snow geese, 9 and 12 September, 1983, Arctic National Wildlife Refuge, Alaska.

Photo I.D. (roll & frame)	Flock number	Total geese estimated visually (X)	Actual photo count (Y)
VTE 1-5	15	49	52
VTE 1-9	16	120	143
VTE 1-11	17	100	147
VTE 1-14	19	100	182
VTE 1-19	21	100	117
VTE 1-21	22	150	262
VTE 1-25	23	250	336
VTE 1-31	27	200	185
VTE 2-9	38	50	52
VTE 2-11	101	150	157
TXP 2-19	119	100	144
VTE 2-31	120	1000	919
TXP 2-6	121	200	223
TXP 2-8	126	150	172
TXP 2-18	131	100	112

Mean	187.9	213.5
Standard deviation	231.4	208.4

Ratio For each estimated goose there were 1.146 counted on photos.

Linear regression $R^2 = 0.967$

Equation $y = 0.886x + 47.1$

ANOR $F = 375.5, p < 0.005$

Paired-t All observations $n = 15$ $t = 2.149, p < 0.05$

Table A-3. Reactions of snow geese to aircraft and human disturbance, Arctic National Wildlife Refuge, Alaska, and adjacent areas, 1978 - 1983

Date	Time	Reaction
13 Sept.1978	-	Turbine Beaver overflight at 150 m AGL caused geese 4-8 km away to take flight; most groups circled (Clear & sunny).
7 Sept.1979	-	Turbine Beaver overflights up to of 3000 m AGL caused geese to take flight; the higher altitudes caused geese to take flight from farther distances away from aircraft flight path. (High overcast.)
15 Sept.1982	-	Cessna 185 overflights at 300 to 600 m AGL caused snow geese 4-10 km away to take flight. (Clear and sunny).
9 Sept.1983	-	Helio H-295 overflights at 150 m AGL caused geese to take flight from distances of 4-6 km. (High overcast).
10 Sept.1983	1530h	Helio H-295 take-off with intentional departure away from geese and maintaining 30 m AGL until 15 km away caused variable reaction depending on distance from airstrip. One flock of 15 birds 1 km away from airstrip took flight and landed 2 km distant (Birds could not see aircraft from its take-off point). Flocks of 30, 50 and 20 birds 3 km away from airstrip did not take flight.
10 Sept.1983	1715h	Helio H-295 landing with low approach caused 100 geese nearest air-strip (0.2 km away) to take flight and land 0.5 km away.
11 Sept.1983	1120h	Photographer on ground intentionally stalked to within 150 m lateral distance of flock of 45 birds, causing it to take flight and land 2 km away.
11 Sept.1983	1600h	Helio H-295 airplane intentionally flown over snow goose aggregations at 150 m AGL for 10 minutes, lower Aichilik River, caused reduction in snow goose numbers from 2441 to 679 in immediate 4 km radius of study site. The first flock to be disturbed numbered about 500 birds and departed to the southwest upon hearing the aircraft engine run-up, then landed 0.5 km away. As the aircraft took off this flock and 6 others, numbering 150, 200, 400, 200, 300, and 300 birds, took flight and departed to the south; all except 1 flock disappeared beyond the horizon. The 1 remaining flock, numbering 400, landed 5 km to the south of the observation blind. One flock 12 km to the south (visible only through 120x Questar scope) did not take flight during the disturbance, therefore in this instance, reaction distance appeared to be between 4 and 10 km. Weather conditions were high (2000 m AGL) broken clouds, clear 45 km to the east, temperature 40°F, winds northeast at 7 km/h. The Helio did not sound as loud as a Cessna 207 which passed later in the day in level cruise flight at similar altitude.
11 Sept.1983	1700h	Helio H-295 aircraft took off, departing to northwest at 30 m AGL, caused 1 flock of 371 birds 5 km to the east

Table A-3. Continued.

Date	Time	Reaction
		to take flight, circle for 1 minute and land. Another flock 6 km to the north did not take flight but became alert, with heads erect (High overcast).
11 Sept.1983	1855h	Landing Helio H-295 approached from north, flew 30 m AGL over Aichilik River to minimize disturbance and caused 2 flocks (numbering 180 and 370 birds) to take flight for 30 seconds and land 0-5 km from where they were disturbed. Reaction distance was about 3 km (High overcast).
12 Sept.1983	0850h	Helio H-295 taxiing to turn around on a gravel bar caused flocks of 300 and 400 (out of sight of airplane) to take flight. As aircraft takes off 500 other snow geese take flight. 700 geese fly 4 km in about 5 minutes, disappearing beyond the horizon. Flocks of 200 and 300 land 3 km from airstrip (High overcast).
12 Sept.1983	1020	Landing Helio H-295 approached from north, flew 30 m AGL over Aichilik River causing flock of 400 geese 0.6 km to east to take off and fly 3 km to north in 2 minutes, and land. Also a flock of 50 geese 3 km east took off and flew south 0.5 km in 30 seconds and landed (High overcast).
25 Aug. - 12 Sept.1983	-	With Cessna 185 airplane and Bell 206B helicopter, T.W. Barry noted flushing distances of 1-5 km from survey altitudes of 150-500 m Bathurst Peninsula to Demarcation Bay. Also noted was habituation of snow geese to 20-50 helicopter flights/day near Tuktoyaktuk.

Table A-4. Population estimates of staging snow geese using various survey segments, Bathurst Peninsula, Northwest Territories to Hulahula River, Alaska, 12 September 1983.

Segment	Estimated number
Nicholson - Wood Bay	540
McKinley Bay	7,860
Tuktoyaktuk - Toker Pt.	28,275
Richards Is., Langley Is.	320
Ellice Is., Tent Is.	17,528
Tent Is., - Blow R.	93,000
Migrated south of Mackenzie	25,000
Blow R. - Babbage R.	120,953
Babbage R. - Stokes Pt.	11,310
Stokes Pt. - Roland Bay	5,248
Roland B. - Firth R.	15,240
Firth R. - Malcolm R.	12,000
Malcolm R. - Komakuk	35,490
Komakuk - Clarence Lagoon	6,210
Clarence Lagoon - Demarcation B.	1,200
Demarcation B. - Hulahula R.	12,828
Total	393,002

ANWR Progress Report Number FY84-3

MICROTINE RODENTS AND GROUND SQUIRRELS OF THE COASTAL PLAIN AND FOOTHILLS OF THE ARCTIC NATIONAL WILDLIFE REFUGE: DISTRIBUTION, DENSITIES, AND GENERAL ECOLOGY.

Christopher A. Babcock

Key words: Microtine rodents, *Microtus miurus*, *Microtus oeconemus*, *Dicrostonyx torquatus*, *Lemmus sibericus*, ground squirrels, *Spermophilus parryii*, distribution, population, density, demography,habitat use, predation, Arctic National Wildlife Refuge, Arctic-Beaufort, north slope

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Microtine rodents and ground squirrels of the coastal plain and foothills of the Arctic National Wildlife Refuge: distribution, densities, and general ecology.

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Abstract: A microtine rodent trapping survey was done at 3 locations across an altitude/coastal influence gradient in the Arctic National Wildlife Refuge from 2 June - 18 August 1982. Each location was trapped 3 times, at monthly intervals. Microtus oeconomus decreased in density and Dicrostonyx torquatus and Lemmus sibericus increased towards the coast. Microtus miurus occured only at the most inland site. The coastal microtines appeared to be at a low point in their cyclic fluctuation. Arctic ground squirrels (Spermophilus parryii) were also surveyed at the same locations. Density distributions of S. parryii depends primarily on suitable burrowing conditions and forage quality. Herbivory by, and predator use of microtines and ground squirrels suggests their integral importance in the Arctic ecosystem.

Microtine rodents and ground squirrels of the coastal plain and foothills of the Arctic National Wildlife Refuge: distribution, densities, and general ecology.

Microtine rodents and ground squirrels are a vital part of the food web in the Arctic. On the coastal plain, microtines may rival ungulates in terms of production of biomass per unit area. (Batzli et al. 1981) The brown lemming (Lemmus sibericus), collared lemming (Dicrostonyx torquatus), tundra vole (Microtus oeconomus), singing vole (M. miurus), and red backed vole (Clethrionomys rutilus) all are known to occur in the study area of the Arctic National Wildlife Refuge (ANWR). Ground squirrels also occur throughout ANWR and their distribution corresponds closely to that of substrate suitable for burrowing. The material presented in this report represents a portion of the data gathered during the first season (1982) of a 2 year study program. The objectives of this study are as follows:

1. Estimate the distributions and densities of all microtine rodent species occuring in the study area of ANWR.

2. Determine habitat use and population dynamics of each microtine species.

3. Estimate distribution and densities of ground squirrels in the study area of ANWR.

4. Determine habitat use and population dynamics of the ground squirrels.

5. Note predatory use of microtines and ground squirrels.

Methods and Materials

Study Areas

The study was carried out from 2 June through 18 August, 1983, and concentrated on 3 study sites. The sites were chosen to give a latitude/altitude transect across the coastal plain and to reflect differrences between coastal and mountain influences. Logistics considerations also helped to determine site location (each site also supported other projects being done by USFWS). The sites are located on the Kongakut and Katakturuk rivers and also near the Okpilak river delta, southwest of Barter Island (Fig. 1). Study site descriptions are as follows:

1) Kongakut (69° 25'N, 142° 30'W): This study site is on the Kongakut River at its intersection with Caribou Pass in the high foothills of the eastern Brooks Range. There is relatively high relief and associated vegetation community heterogeneity in this area. The microtine live trapping grid was installed on a gently sloping bench, approximately 25m above the level of the river. This trapping grid was placed in a strongly dissected polygon field, characterized by broad wet troughs and high centers. The sandy bluffs along the river and the overgrown talus slopes at higher

elevations are excellent areas for observation and capture of ground squirrels. The summer climate of the area is generally warmer than that of the other 2 study sites, and also appeared to receive more total precipitation. The vegetation communities (after the classification of Walker et al. 1982) most common in the area were:

Moist Sedge Tussock, Dwarf Shrub Tundra - on hillsides.
Herbaceous Tundra - on north facing slopes and moist swales.
Willow/Dwarf Birch Shrub Tundra - along drainages.
Dryas/Fell Field - on exposed eroded ridges.

2) Katakturuk (69° 51'N, 145° 18'W): This study site is on the Katakturuk river, approximately 20km upstream from the mouth. The river valley is broad and flanked by rolling hills to the southeast and a rather barren and eroded bluff to the northwest. The microtine live trapping grid was installed on a low wet sedge terrace about 3m above the level of the river. The grid area was lightly polygonized and fairly well drained. The bluffs associated with the river were used by a few ground squirrels and some trapping was done. The climate at this area is warm and generally drier than the other 2 sites, seeming to escape both coastal fog and mountain storms. Vegetation communities dominating the area are:

Moist Sedge Tussock, Dwarf Shrub Tundra - on hilltops.
Wet Sedge Tundra - on poorly drained river terraces.
Willow/Dwarf Birch Shrub Tundra - along drainages.
Dryas River Terrace Tundra - on low terrances with good drainage.

3) Okpilak (70° 03'N, 143° 52'W): This study site is located about 13km southwest of Barter Island and 5km east of the Okpilak River, near VABM "Mars". Low relief, ponds, and regular polygonization characterize the area. The microtine live trapping grid was located on a heavily polygonized area with numerous small ponds and mounds (classified as mosaic: containing elements of dwarf shrub and wet sedge tundra). Signs of ground squirrel activity were noted on the bluffs adjacent to the river, but no trapping was done. Climatically this site is the coolest of the 3 and is often fog shrouded in the summer. The area is dominated by the following vegetation types:

Dwarf Shrub Tundra - on low ridges, polygon rims and 'uplands'.
Wet Sedge Tundra - on low, poorly drained areas.
Mosaic - a combination of the above classification.
Willow/Birch Shrub Tundra - on the major drainages and associated with alluvium.

Each study site was visited 3 times over the field season, for about 9 days per visit. Transportation between sites was by light aircraft or helicopter.

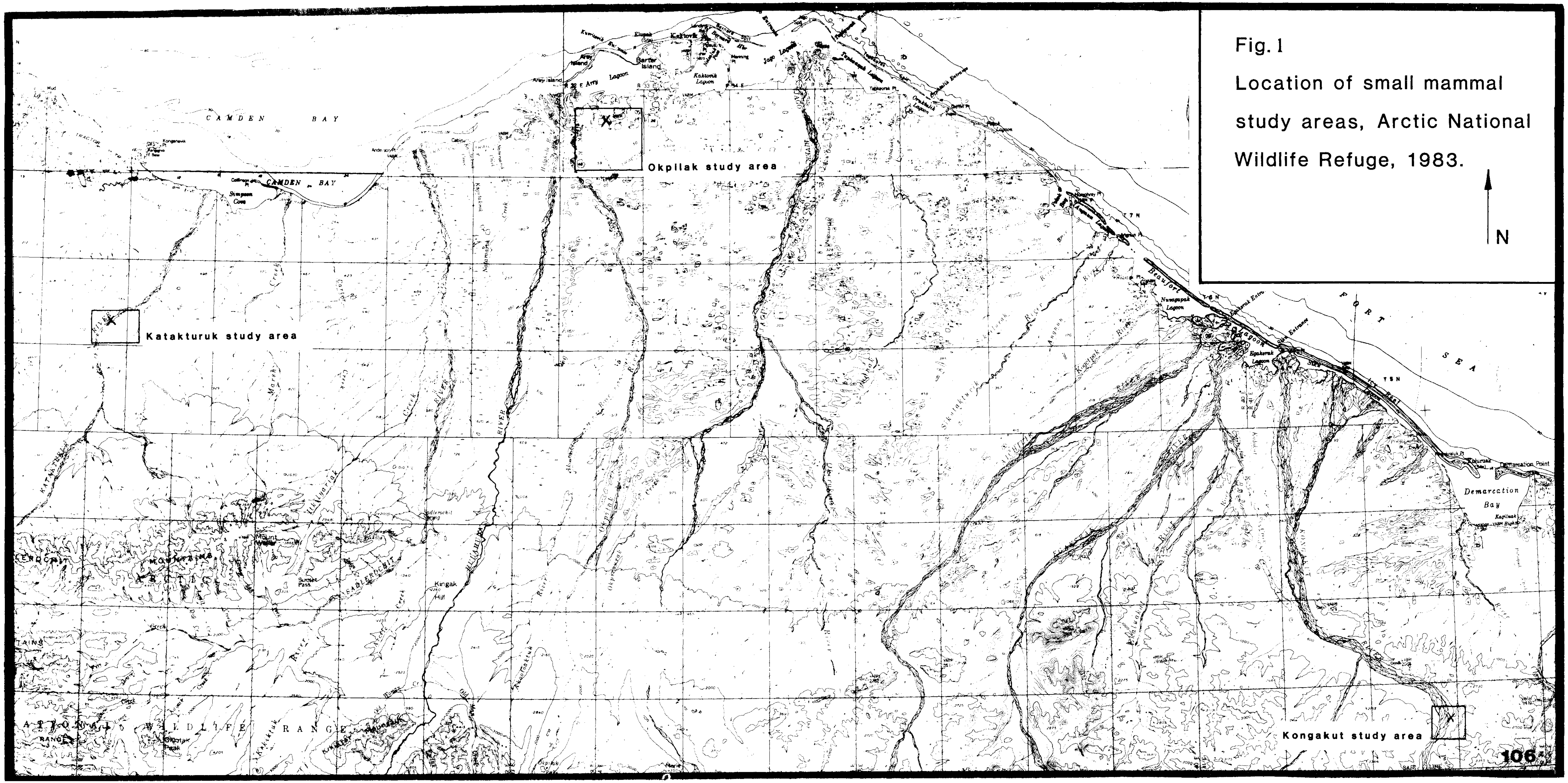

Fig. 1
Location of small mammal study areas, Arctic National Wildlife Refuge, 1983.

Microtine Trapping

At each study site a live trapping grid was surveyed and staked using a compass and chain. Trap points were located at 10m intervals on the 140 X 140m grid, giving a total of 196 trap locations, and a total grid area of approximately 2ha. A large size (7.6 X 7.6 X 22.9cm) folding Sherman live trap was placed at each grid point and was stuffed with indigenous vegetation as insulation. Traps were not baited. The grid was checked at 4-6 hour intervals (dependent on ambient temperature and precipitation) for 5 days. All captured animals were identified to species, sexed, weighed, noted for reproductive state, and marked using the toe clip method of Melchior and Iwen (1965). Each grid was run for the 5 day trapping period at monthly intervals, for a total of 3 periods at each site.

Opportunistic snap trapping (using Museum Specials baited with peanut butter) was done at each area also, to collect skins and skulls for comparison with remains found in raptor pellets. In addition, stomachs were collected from snap trapped animals and preserved in formalin for possible dietary analysis. A semi-quantitative snap trap transect was done across a colony of Microtus miurus at the Kongakut area, to estimate density and demography of the species.

Raptor and jaeger pellets were collected from the Katakturuk and Okpilak study areas. The pellets will be analyzed to aid estimates of proportions of the microtine species at these areas.

Vegetation Sampling

Vegetation was systematically sampled on each live trapping grid. A $0.25m^2$ quadrant was dropped within 1m of each grid point, and within the quadrant species occurence and ground cover percentage classes were recorded. These data were used to refine the broad land cover classification that applied to the area of the grid. This refined classification was accomplished using a reciprocal averaging technique (Cornell Ecology Program Series 1979). These refined cover microhabitat classes were compared for indication of differential trapping success. Notes were taken on the phenology of greening and flowering, and observations were made of microtine and ground squirrels' use of plant material.

Ground squirrel trapping

Ground squirrels were live trapped at the Kongakut and Katakturuk areas but due to the distance to any trappable population at Okpilak, no trapping was done there. Squirrels were captured in "Have-A-Heart" style traps, baited with rotten potatoes. The traps were placed near any obvious burrow or sign of activity and were checked every 4-6 hours. Captured animals were sexed, noted for reproductive condition, weighed, and marked by toe clipping and pattern fur clipping (after the methods of Melchior and Iwen 1965). Fur clipping was done to permit identification of individual squirrels from a distance. The ground squirrel trapping areas were located on bluffs near the river; feeding behavior was observed and home range was estimated. Transects 2m wide and of various distance were run across the ground squirrel colonies and adjacent bluff top to estimate burrow densities. The transect information will be used for correlation with known squirrel densities and to facilitate estimates of ground squirrel densities in other areas, based on transect burrow incidence alone.

Results and Discussion

Microtine Rodents

Microtine rodents of the north slope have been studied extensively at Barrow (Pitelka 1973, Batzli et al 1981), Atquasuk (Batzli and Jung 1980), and Prudhoe Bay (Feist 1975). There are few references in the literature regarding microtines at other places on the north slope in general and virtually no data from the eastern north slope area.

Four species of microtines were captured over the season and approximate densities and habitat use relationships were estimated. The species differed widely in abundance with Microtus oeconomus decreasing towards the coast, and Dicrostonyx torquatus and Lemmus sibericus decreasing away from the coast. Microtus miurus occurred only at the Kongakut study area (Fig. 2). Capture success on the live trapping grids varied greatly between sites and also over the season (Table 1). The Kongakut grid showed the greatest absolute density of microtine rodents and the lowest species diversity, the Okpilak area was lowest in microtine density and showed comparable diversity to the Katakturuk site (Fig. 3).

Microtus miurus (singing vole or Alaska vole): This species was captured only at the Kongakut study area, where it occurred rather commonly in restricted habitats. M. miurus inhabits the higher elevations and slopes of ridges where vegetation may be classed as herbaceous tundra. These particular areas are also such that snow beds persist on them well into spring breakup (usually due to a northerly aspect of the slope). The favored habitat is moist yet well drained and covered with thin but apparently productive soil. These microtines were not seen in herbaceous tundra at lower elevations or lower degrees of slope, nor did they appear to venture into adjacent areas of tussock tundra. There were no M. miurus captured on the live trapping grid at the Kongakut, which was located about 300 m downslope from a breeding population of M. miurus. This species was seen to begin harvesting and storing roots and other vegetation in early to mid-August.

A semi-quantitative snap trapping survey of a M. miurus population was done from 31 July - 3 August. A total of 31 individuals were collected in 264 trap nights (88 traps X 3 nights) and this effort apparently was sufficient to collect a majority of the animals in an area of approximately 0.5 ha. The capture rate was 1.17 per 10 trap nights. The sex ratio was not significantly unbalanced, breeding animals made up 13% of the trapped animals, 71% were nonbreeding adults (probably the first cohort of the spring) and 16% were juveniles (of the second cohort).

Microtus oeconomus (tundra vole): This species was captured on each of the live trapping grids, as well as by snap trapping in areas removed from the grids. M. oeconomus tends to use a broad variety of habitats, and commonly coexists in the same general habitat with Lemmus and Dicrostonyx. Batzli and Jung (1980) have described M. oeconomus as a generalist herbivore where it is found with the 2 lemming species. This species does however tend to select wetter microhabitats and has been found to select forage from both woody dicotyledonous plant and graminoid groups (Batzli and Jung 1980).

The density of trappable animals (post-weanlings) increased from 9 per ha to

TABLE 1. SCHEDULE OF LIVE-TRAPPING EFFORT AND NUMBER OF CAPTURES FOR ALL SPECIES, SUMMER 1983 (# OF INDIVIDUALS IN PARENTEHSIS).

Study Area	Trapping Period and Dates		
	1	2	3
Kongakut	6/5 - 6/10	7/2 - 7/7	7/28 - 8/2
	28 (19)	43(20)	54(31)
Katakturuk	6/15 - 6/20	7/11-7/16	8/5-8/10
	24 (12)	17(12)	36(19)
Okpilak	6/23 - 6/28	7/19 - 7/24	8/12 - 8/17
	8(3)	16(11)	4(3)

INCIDENCE OF MICROTINES

Study Area	*Microtus miurus*	*M. oeconomus*	*Dicrostonyx*	*Lemmus*
Kongakut	abundant	abundant	uncommon	
Katakturuk		common	uncommon	uncommon
Okpilak		common	common	common

FIG. 2. INCIDENCE OF MICROTINE RODENTS ON 3 STUDY AREAS, ARCTIC NATIONAL WILDLIFE REFUGE, 1983.

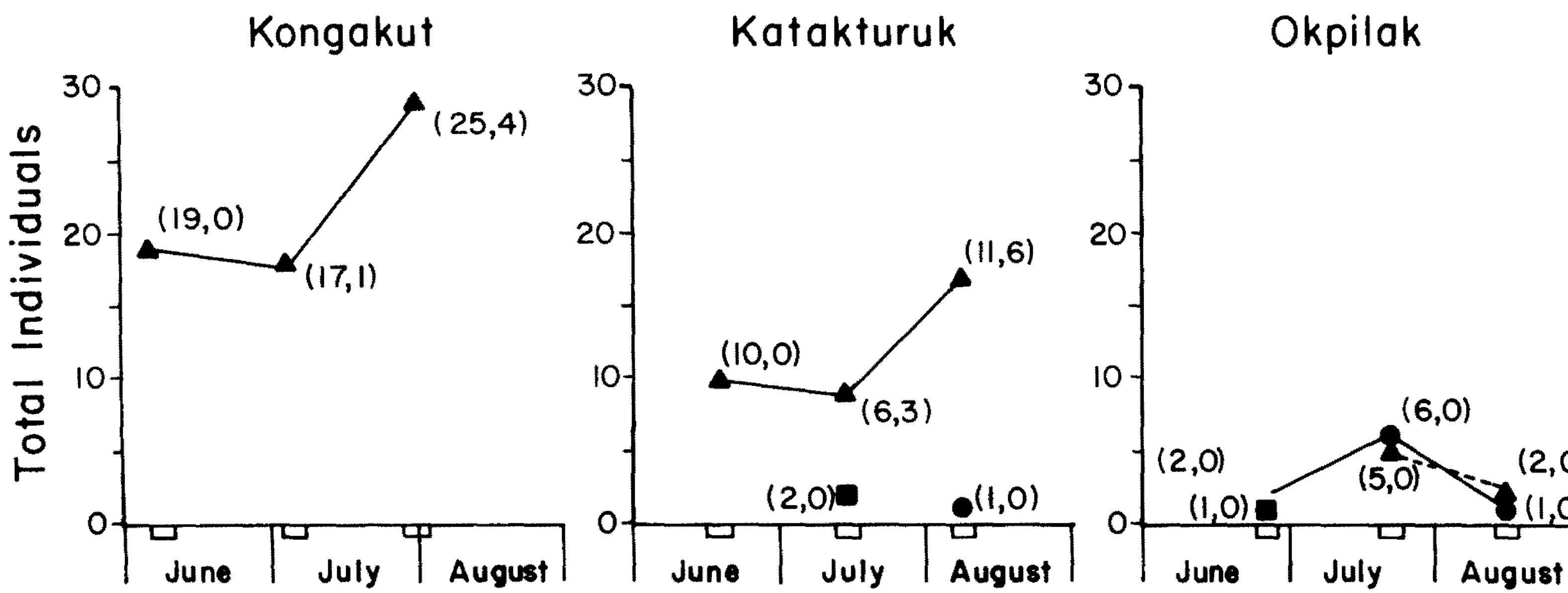

Fig. 3. Number of individuals newly captured, plus number of individuals recaptured at each trapping grid and trapping period (▲= *M. oeconomus*, ■= *Lemmus*, ● = *Dicrostonyx*).

approximately 15 per ha by the third trapping period at the Kongakut. At the Katakturuk grid, the density increased from about 5 per ha to 9 per ha over the season. In the willow shrub tundra along the Katakturuk, densities appeared to be cons..derably higher than on the grid, although no quantitative trapping was done in that vegetation class. At the Okpilak grid, M. oeconomus was not the most commonly caught species and densities never reached higher than approximately 2 per ha. It appeared that the individuals of this species that were caught on the coastal grid were dispersers (primarily medium weight males) from some adjacent breeding population. Sex ratios of the trapped populations at the Kongakut and Katakturuk did not deviate significantly from even, indicating that the trapped populations wre probably actively breeding and relatively stable.

Age classes were estimated from capture data (sex, reproductive state, and weight) for the Kongakut and Katakturuk population of M. oeconomus. (Figs. 4 and 5) The weight classes are defined somewhat subjectively, using what appear to be natural gaps in the weight distribution. Breeding males had higher mean weights throughout the season than breeding females. It appears that at least two cohorts of non-breeding animals were recruited into the trappable population over the season. Those animals captured in the first trapping period at both areas probably represent individuals that had overwintered.

Dicrostonyx torquatus (collared lemming): Collared lemmings were observed at all 3 study sites, although only 1 was captured on the Katakturuk live trapping grid, and none on the Kongakut grid. It is impossible to make good density estimates for these 2 areas: in their most suitable habitats they probably remain well below 0.5 per ha. On the Okpilak grid, collared lemmings were the most abundant species, but showed July (peak) densities of only about 3 trappable animals per ha. One obvious cohort of recently weaned juveniles was found on the grid during the July trapping period and, based on their weights at that time, appeared to have been born in late May. Another cohort was at the 2-3 week old suckling stage on 18 August, when a nest was uncovered.

The collared lemming has been reported to have a specialized dietary adaptation for (deciduous) woody dicotyledons, especially Salix pulchra (Batzli and Jung 1980). In the coastal region this type of vegetation grows predominantly on polygon rims and within other relatively well drained microhabitats. A comparison between capture success for all species and vegetation microhabitats over others (0.005 P 0.001) and visual inspection of the data seems to indicate selection for higher polygon rim and 'mounds'.

Lemmus sibericus (brown lemming): This species occured only at the Okpilak and Katakturuk study areas. A single animal was caught on the live trap grid at Okpilak (during the first trapping period), and 2 were captured during the second period at Katakturuk. None were caught later into the season at either area on the live trap grids or in opportunistic trapping of seemingly favorable habitats identified from June snap trapping. Earlier in the season Lemmus was snap trapped at Okpilak in small quantities only at the sedge dominated margins of larger ponds and lakes.

The brown lemming has been studied extensively with special reference to cyclic changes in population density. At Barrow, peak densities have been recorded of up to 225 per ha, dropping to lows of 0.02 per ha with 3 to 6

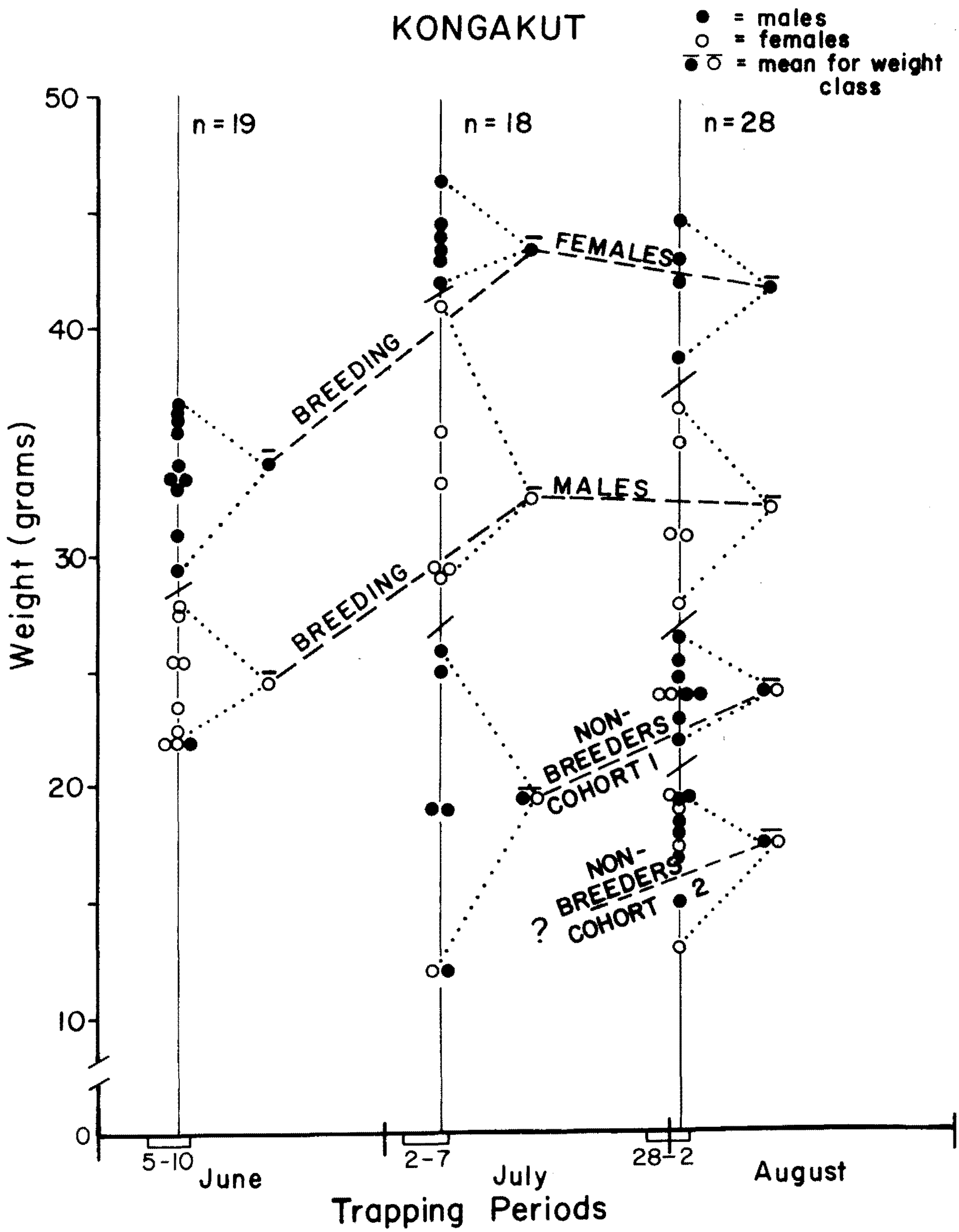

Fig. 4. Sex and weight class distribution of *M. oeconomus* at the Kongakut study area, 1983 (separation between weight classes denoted by slash).

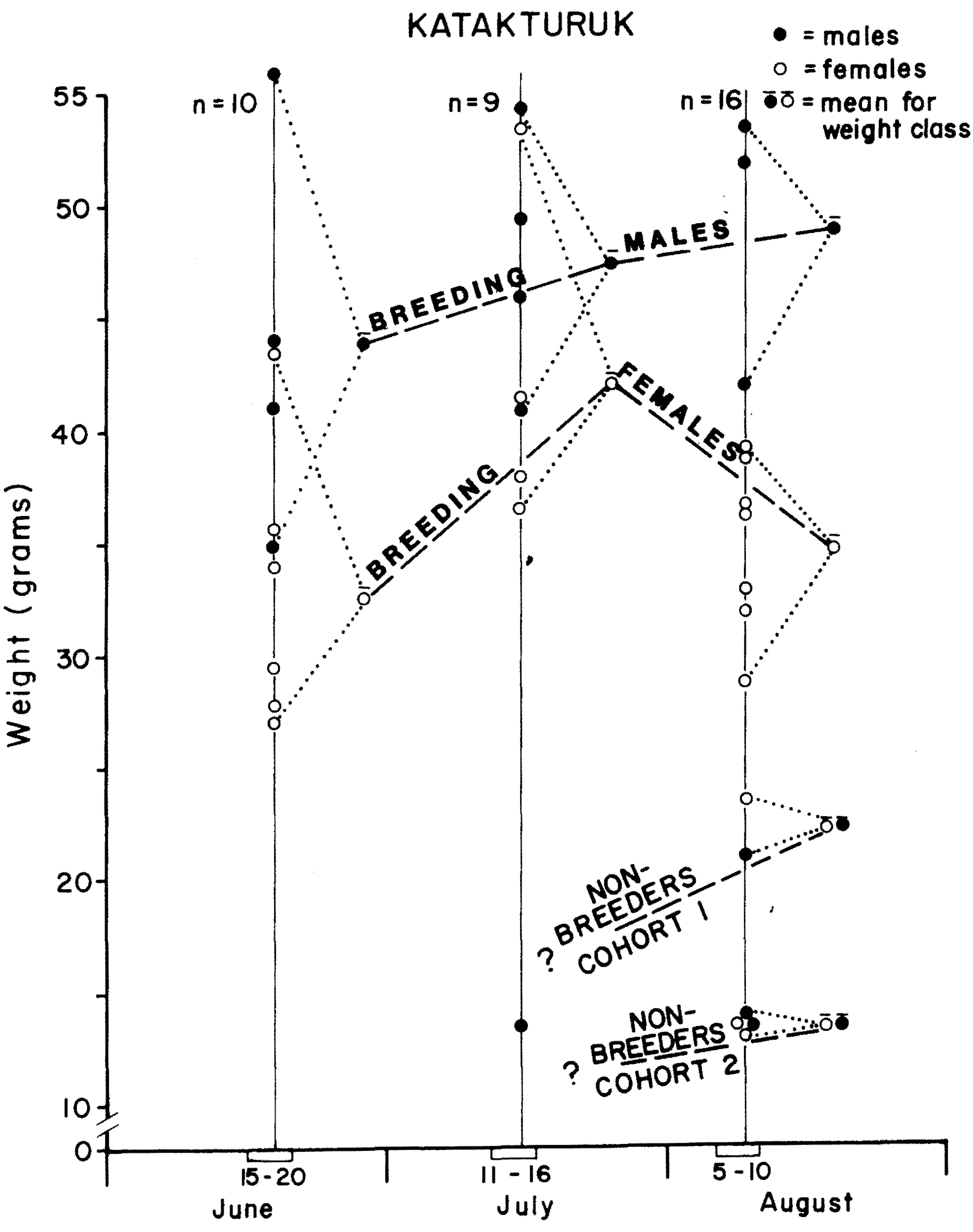

Fig. 5. Sex and weight class distribution of *M. oeconomus* at the Katakturuk study area, 1983.

years between peaks (Batzli et al. 1981). Causes for the cycle have been ascribed to climatic, nutritional (Schultz 1964, Pitelka 1973), predatory (MacLean et al. 1974), and even endocrine, genetic, and social factors (Chitty 1967, Krebs et al 1973). It seems rather clear that no single factor contributes exclusively to the phenomenon. Cycling in Lemmus may be best explained by the nutritional quality of available forage and predation effects (especially in winter). In the Okpilak area in 1982, brown lemmings were reportedly common (Pam Miller pers. comm.). This information tends to support the hypothesis that this species was in a population density low point in its cycle during the 1983 summer season.

Clethrionomys rutilus (red backed vole): This species has been recorded occurring in the northern foothills of the Brooks Range and specifically from the Peters and Schrader Lakes area of the ANWR (Steve MacLean pers. comm.). Of all study sites, the Kongakut was considered to provide the best possibility for finding this species, but none were captured or seen at any of the sites.

Details of morphological differences and dentitions of these microtine species are summarized by Bee and Hall (1956).

Predator Use of Microtines

The microtines of the foothills and coastal plain are a very important food source for a large variety of predators. Microtines are the primary prey of short tailed weasel (Mustela erminea) and the least weasel (Mustela nivalis), whose densities have been reported to track the lemming cycle at Barrow though with an apparent lag time (MacLean et al. 1974). Other obligate mammalian predators include arctic fox (Alopex lagopus), red fox (Vulpes fulva), wolverine (Gulo gulo), wolf, (Canis lupus), and grizzly bear (Ursus arctos). Microtines are probably most important in the diets of the foxes and mustelids during the months of snow cover when the availability of alternative bird prey is lowest. The avian predators on microtines include raptors, jaegers, glaucous gulls, and ravens. At Barrow, breeding densities and fledging success of snowy owls (Nyctea scandiaca) and pomarine jaegers (Stercorarius pomarinus) have been reported to increase with increases in the lemming population (Maher 1970, Pitelka 1974). Clutch size of other raptors (most notably the rough legged hawk) appears to be dependent on the available densities of microtines (Harrison 1978). One unidentified species of weasel was trapped on the Okpilak grid in the first trapping period (late June). At least one grizzly bear was seen to dig for microtines while traversing a mountain slope near the Kongakut. Only one snowy owl was seen in the Okpilak area during the season, although they were a common visitant and were seen hunting in 1982 (Spindler and Miller 1983). Jaegers bred at both the Okpilak and Katakturuk areas and were commonly seen hunting. A nesting pair of rough legged hawks laid a clutch of 3 eggs (2 chicks were surviving as of 10 August) at the Katakturuk. Marsh hawks, short eared owls, rough legged hawks, and golden eagles were all seen hunting within the Kongakut area.

Raptor and jaeger pellets were collected from the Katakturuk and Okpilak areas. These have yet to be analyzed, but it is hoped they will help in estimates of proportions of microtine species in both areas and relative use of microtines by these avian predators.

Ground Squirrel Results

Ground squirrels (Spermophilus parryii) were live trapped at the Kongakut and Katakturuk, where a bluff face $4300m^2$ in area was surveyed for density, and sex and age class distribution. In the sample of 12 animals marked from that site, the sex ratio was even, and all males were in the range of 600-700g weight and all females 400-575g. All recaptured individuals from early trapping periods had weight gains of about 50g over a month interval. All but 1 of the females were lactating or had recently weaned young. Juveniles were occasionally caught on the microtine grid at the Kongakut during the second trapping period (2-7 July) and weighed in the 275-325g range. These weanlings were apparently dispersing up slope from the bluff colonies (Carl 1971). The vegetation of the bluff slope was not quantitatively sampled, but it appeared to have denser willow growth and greater diversity and abundance of forb species than the bluff top. Ground squirrels were common on the rocky outcrops of ridges in the Kongakut area.

At the Katakturuk bluff area, no attempt was made at quantification of ground squirrel numbers. Trapping during the first visit to the Katakturuk produced only 2 captures - both mature males. These squirrels appeared to be in poor physiological condition; they were missing large patches of fur and behaved quite differently than the captured squirrels from the Kongakut. Due to difficulty in crossing the Katakturuk River during unpredictable flood stages, trapping was suspended in the second and third visits to the area. Juvenile ground squirrels began to disperse down onto the river margin in late July. There was evidence of squirrel burrowing on the opposite side of the river from the bluffs, but no individuals were seen across the river until 11 August. The bluff vegetation at the Katakturuk was generally sparse and appeared to be of marginal food value (Batzli and Soboski 1980). This may be attributable to the apparently high salt content of the geological formation from which the bluff has eroded.

No trapping was done at the Okpilak; the distance to the river made humane trapping procedures unfeasible. There was however, good evidence of squirrel use of the bluffs and sand dunes at the river margin.

Predator use of ground squirrels

Wolves, foxes, wolverines, and grizzly bears are all known predators of ground squirrels. At all areas where squirrel colonies were found at the Kongakut study area, there was evidence of digging by grizzly bears (See report of M.K. Phillips, this volume). Carl (1971) attributes most predator-related mortality in ground squirrels of the Cape Thompson region to red fox and grizzly bears. All large raptors are known to take ground squirrels, although the dietary proportions may vary considerably. Golden eagles were commonly seen hunting squirrels during July and August in the Kongakut area and rough legged hawks were seen to hunt the Katakturuk bluff area periodically throughout the season.

Acknowledgements

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ANWR Progress Report Number FY84-4

POPULATION SIZE, COMPOSITION, AND DISTRIBUTION OF MOOSE ALONG THE CANNING AND KONGAKUT RIVERS WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, FALL 1983

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Key words: Moose, population, composition, distribution, Arctic-Beaufort, north slope

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25 January 1984

Population size, composition and distribution of moose along the Canning and Kongakut Rivers, in the Arctic National Wildlife Refuge, Alaska, fall 1983.

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Abstract: Aerial surveys to determine the population size, composition, and distribution of moose (*Alces alces*) along the Canning and Kongakut River drainages were conducted on the Arctic National Wildlife Refuge. The Canning River drainage was surveyed in mid-September and late October to determine seasonal shifts in moose distribution. Numbers of moose observed increased from 78 in September to 149 in October. Moose had evidently not yet moved into the drainage in September. Shallow snow depth and incomplete snow cover are believed to be the major factors for differences in moose numbers between the 2 surveys. Number of moose along the Canning River (149) was approximately the same as the 1980 spring survey (148). This population is evidently relatively stable. The Kongakut River survey detected 158 moose, which is 28% more than the 1980 spring survey. The increased population may be due to immigration from surrounding river valleys, which has been a factor in previous years. The population may also be increasing on its own.

Population size, composition, and distribution of moose along the Canning and Kongakut Rivers within the Arctic National Wildlife Refuge, Alaska, fall 1983

Aerial moose surveys were first conducted along the Canning and Kongakut Rivers in 1972 (Roseneau and Stern 1974). Surveys were conducted again in 1973 - 1974 (Lenarz et al. 1974); however, the Kongakut River was not surveyed in 1974. Arctic National Wildlife Refuge (ANWR) staff conducted surveys from 1976 - 1978. The Kongakut River was not surveyed in 1976. Surveys were conducted in both drainages during the spring of 1980 by refuge staff.[1] Timing of these earlier aerial surveys (March-April or September-October), and survey coverage and intensity have varied between years; therefore direct comparisons of the resultant data sets are difficult. The 1983 survey routes were conducted in identical areas as covered in the 1980 spring survey routes for the 2 drainages (Figs. 1 and 2). This effort was the first time survey coverages have been comparable and used standardized survey routes. Two surveys were conducted within the Canning River drainage during the fall of 1983. These surveys were conducted a month and a half apart and were conducted to assess differences in seasonal moose distributions within the drainage. Only 1 survey was conducted within the Kongakut River drainage.

Objectives of aerial moose surveys within the ANWR are as follows:
1) determine the population size, composition and distribution of moose within the Canning and Kongakut River drainages;
2) determine productivity of these 2 moose herds;
3) determine overwinter calf survival.

Materials and Methods

In 1980, survey routes were standardized for the Canning and Kongakut River drainages (see Appendix Fig. 1 and 2). These standardized survey routes and areas were used in 1983 and will continue to be used in future surveys of the 2 drainages. Survey routes were flown with a Super Cub at 100 - 200 m above ground level (AGL) at an indicated airspeed between 112 - 144 kph. An average of 5.6 hrs. were spent on the 2 surveys conducted along the Canning River. The 2 day survey on the Kongakut River required a total of 8 hours to complete. Two days were used because of the insufficient daylight in late October. The Canning River has approximately 500 km of survey route and the Kongakut River has approximately 790 km of survey route.

Moose were easily seen in most areas where snow cover was adequate. Where willows were dense or >2m tall, sequential transects oriented along the drainage were flown to avoid missing bedded animals. Transects were approximately 100 m wide in these areas. Larger groups were circled until accurate age and sex identifications were made.

Results and Discussion

For the purpose of this report, only the 1980 and 1983 surveys will be used for direct comparisons. Surveys in previous years did not cover comparable areas, therefore direct comparisons of the earlier data with recent data are

[1]Spindler, M.S., Wildlife Biologist, Arctic National Wildlife Refuge. [Memo to the refuge manager, Arctic National Wildlife Refuge]. 28 May 1980.

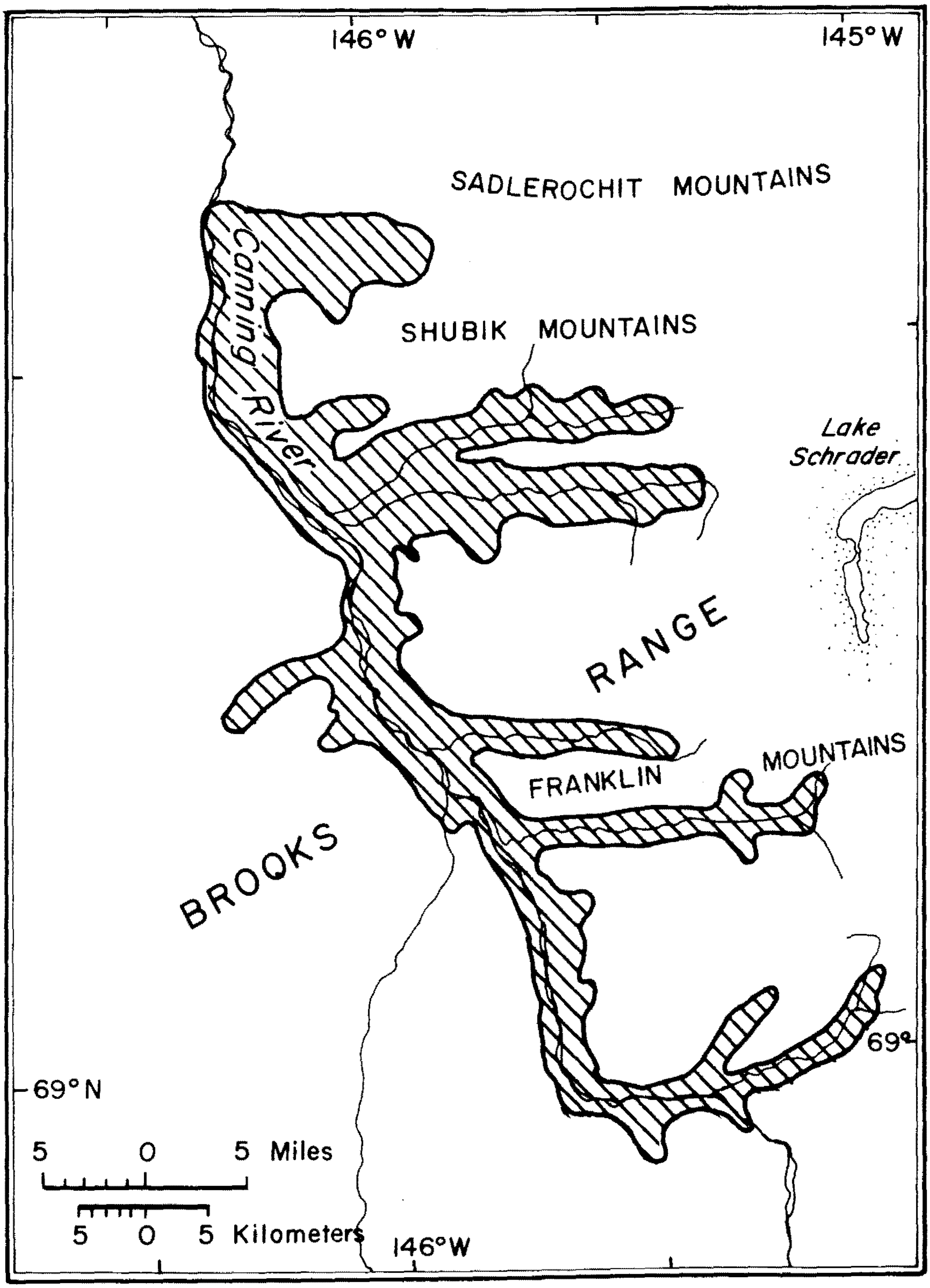

Fig. 1. Canning River moose survey area, fall 1983.

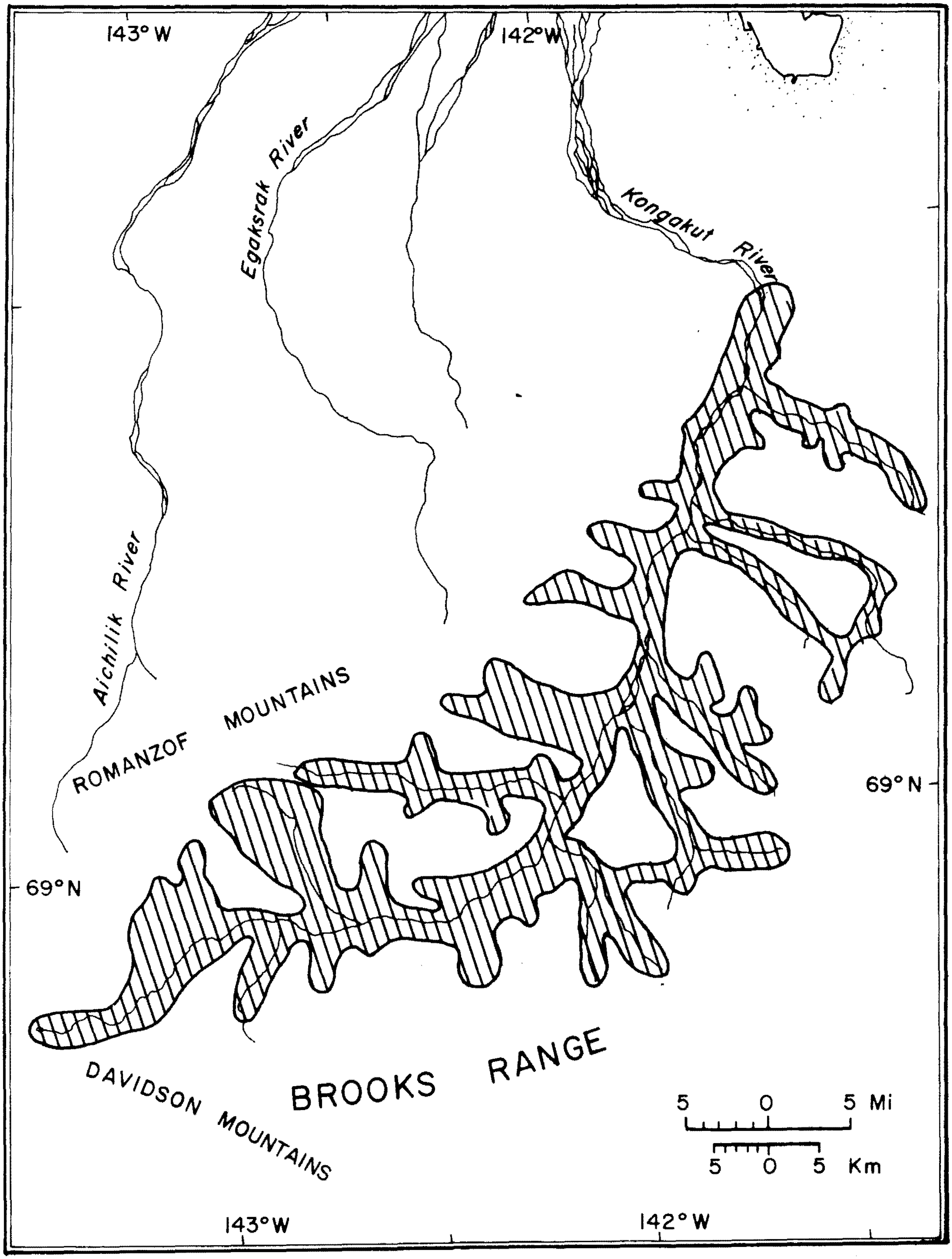

Fig. 2. Kongakut River moose survey area, fall 1983.

not possible. Two comparisons will be discussed: 1)the 2 Canning River surveys will be compared to assess changes in seasonal moose distributions and 2) the 1980 and 1983 surveys will be compared for both survey areas.

Canning River Drainage

During the 14 September 1983 survey, a total of 79 moose were tallied (Table 1). Of these moose, 42 (53.2%) were located within the Cache/Eagle Creek area of the drainage (Table 2). Visibility was good for the first half of the survey. Bedded moose were difficult to detect late in the survey. Snow cover was poor on the river bed, but was approximately 90% on hillsides and slopes. Sightability was estimated to be 80 to 85%.

Table 1. Composition (N/%) of moose observed along the Canning and Kongakut Rivers, Arctic National Wildlife Refuge, Alaska, fall 1983.

		Number of moose observed				
Drainage	Survey date	Adult bulls	Yearling bulls	Cows	Calves	Total number
Canning	14 Sept.	27/34.6	5/6.4	39/50.0	7/9.0	78
Canning	30 Oct.	44/29.5	7/4.7	73/49.0	25/16.8	149
Kongakut	27,29 Oct.	59/37.3	16/10.1	62/39.2	21/13.3	158

During the 30 October 1983 survey, a total of 149 moose were tallied (Table 1). Of the total, 130 (87.3%) were located within the Cache/Eagle Creek portion of the drainage (Table 2). Visibility was good throughout the survey, with a snow cover of approximately 95%, with only small areas along the river bed being snowfree. Moose were easily seen during the survey. Sightability was estimated at approximately 95%. Moose that might have been in small side drainages and therefore missed during the survey are believed to be few in number.

Differences in numbers of moose sighted between the mid-September survey and the late October survey may be associated with several factors: 1) sightability may have been reduced by poor light and lack of snow cover during the September survey; 2) lack of snow cover may have allowed moose to use habitats outside the survey area. The latter factor is believed to be the main reason for differences in the 2 surveys. Moose had apparently not yet concentrated in the Canning River drainage in mid-September, but had in late October. Lenarz et al. (1974) noted that a majority of the Canning River herd was present in the Cache/Eagle Creek area by mid-October 1973. The late October survey indicated that the majority of the herd had moved into the Cache/Eagle Creek area, which is similar to other years when data were reported for the Cache/Eagle Creek segment of the Canning River herd (Table 2). During the September survey moose were apparently still dispersed throughout the Canning River drainage and other non-surveyed

Table 2. Numbers of moose observed during aerial surveys of the Canning and Kongakut Rivers on the Arctic National Wildlife Refuge, 1972-1983.

Month - year	Drainage		
	Canning River (including Cache/Eagle Creeks)	Cache/Eagle Creeks	Kongakut River
March-April 1972[a]	48	16	21
September-October 1972[a]	7	2	8
March-April 1973[b]	64	--	--
May 1973[b]	45	--	--
October 1973[b]	69	64	68
March 1974[b]	42	--	--
September 1976[c]	--	42	--
April 1977[c]	48	--	54
April 1978[c]	43	--	58
April 1980[c]	147	111	123
September 1983	79	42	--
October 1983	149	130	158

[a]Roseneau and Stern 1974
[b]Lenarz et al. 1974
[c]Arctic National Wildlife Refuge files

areas. The late ingress into the drainage contained a disproportionate number of cows with calves, as reflected by % calves (Table 1). Based on these data, it appears that a mid-to-late October survey is most efficient in determining numbers and composition of moose within the Canning River drainage during the fall.

Numbers of moose recorded during the 1983 fall surveys are comparable to the numbers of moose detected during the 1980 spring surveys in the Canning River drainage (Table 2). Calves comprised 16.8% of the population in fall 1983, whereas, calves comprised 9.5% of the population in the spring of 1980. Because of discontinuity in the timing of these surveys between years, no inferences on the significance of this difference can be made. The survey planned for spring 1984 should provide data on overwinter survival of calves and also provide data for comparisions with the spring 1980 surveys.

Kongakut River Drainage

A total of 158 moose were recorded during the fall 1983 survey on the Kongakut River, whereas 123 moose were tallied during the 1980 survey (Table 2). The 1983 total is a 28.5% increase over the 1980 total and is the highest number of moose recorded during any previous survey of the Kongakut River (Table 2). The proportion of calves in this population declined from 20.3% in spring 1980 (25 calves among 123 moose) to 13.3% in fall 1983 (Table 1). Reasons for the increase in moose along the Kongakut River are unclear; however, the Kongakut moose population is highly variable and is subject to periodic emigration and/or immigration of moose either into or from the Sheenjek River to the south and the Firth River/Mancha Creek drainages to the east (Roseneau and Stern 1974). The spring survey planned for the Kongakut Rivers in 1984 will provide data on overwinter mortality/emigration and may clarify interrelationships between moose using the 3 drainage systems.

Canning River and Kongakut River Moose Composition

Bulls (yearlings and adults) were more prevalent along the Kongakut River (47.5%) than along the Canning River (34.2%). Conversely, the Canning River population was predominated by cows (49.0%) compared to 39.2% cows along the Kongakut River (Table 1). To further evaluate the relative composition of moose in the 2 drainages, Gasaway et al.'s (1983) adjustment for indistinguishable yearling cows was applied to the 1983 survey data. This adjustment estimates the number of cows >30 months of age in the October survey by substracting the number of yearling males observed from the total cows observed. Yearling males are assumed to equal yearling females in number. Following this adjustment, an estimated 66 adult cows were present along the Canning River and an estimated 46 cows were present along the Kongakut River. Adjusted adult sex ratios indicate 67 bulls/100 cows were present along the Canning River, while this ratio is almost double along the Kongakut River (128 bulls/100 cows). Reasons for this difference in the 2 populations are unknown, but mortality rates due to predation and/or hunting mortality in the Canning River drainage may be possible factors involved in this difference.

Productivity of the 2 populations is similar with the Kongakut River population having a higher rate. Using the adjusted cow data, productivity of Kongakut River moose was 45.7 calves/100 cows, while productivity of the Canning River population was 37.9 calves/100 cows. Reasons for this difference are unknown. Surveys planned for Spring 1984 will provide data on overwinter survival of calves and may aid in further analysis of these apparent differences between the 2 populations. These data indicates that the 2 moose populations are viable and were above minimum recruitment levels necessary to sustain the population (Franzmann 1978), however overwinter mortality may reduce these recruitment levels.

Miscellaneous Moose Sightings.

During the 1983 summer field season, incidental moose sightings were recorded on the coastal plain and along river valleys between the Canning and Kongakut Rivers (Table 3). A majority of these sightings were in or near various types of willow habitat. These observations indicate that moose occurred on the coastal plain as early as late May, however, moose were more common during July and early August. The origins of these moose are unknown, as is their overwintering areas.

Table 3. Miscellaneous moose sightings on the Arctic National Wildlife Refuge coastal plain and mountains between the Canning and Kongakut Rivers, summer 1983.

		Number of Moose		
Date	Location	Bulls	Cows	Calves
2 August	Egaksrak R., N of foothills	1		
14 October	Upper Egaksrak R., in mountains		1	
12 September	Middle fork Aichilik R., in mtns.	1		
14 October	West fork Aichilik R., in mtns.		3	
13 June	Okpirourak Creek, NW of VABM Bitty		1	1
7 July	Jago R., N of VABM Bitty	2		
2 August	Jago R., N of VABM Bitty	1		
14 July	1-2 km S of coast, NW of VABM Mars, Okpilak River		2	
31 July	Hulahula R., middle portion of river		3	
5 September	Hulahula R., S of Kikiktat mtn.	1	1	2
1 August	Sadlerochit Springs	1	2	
28 May	Carter Creek 4 km S of coast		1	
17 July	Carter Creek 5 km S of coast	2		
6-8 July	Katakturuk R., 15-17 km S of coast	1		
10 July	Katakturuk R., 15-17 km S of coast		1	2
24 July	Katakturuk R., 15-17 km S of coast	2		
25 July	Katakturuk R., 8 km N Sadlerochit mtns.			1
22 July	Katakturuk R., S. of Sadlerochit mtns.	1		
	Totals	13	16	5

Lenarz at al. (1974) believed the summer dispersal of moose along the Canning River drainage was limited to side drainages in the mountains, however subsequent observations of moose, along the Sadlerochit River on the coastal plain (Magoun and Robus 1977, this study), on the Okpilak delta (Spindler 1979, this study), and along Carter Creek and the Katakturuk River (this study), indicate that summer dispersal from the Canning River drainage may be relatively wide spread. Moose observed along the Hulahula River and other drainages to the east during 1983 (Table 3) may represent summer dispersals from either the Kongakut River or the Canning River. Few moose are believed to overwinter along rivers between the Canning River in the west and the Kongakut River in the east, however, Hutson (1977) did record 10 moose along the Aichilik River and 8 moose along the Egaksrak and Ekaluakut Rivers in April 1977.

Future fall surveys will be conducted in late October to detect maximum moose numbers and spring surveys will be conducted in April along both rivers to assess overwinter mortality and/or emigration. These surveys will be repeated annually to assess population trends of moose occurring in the north slope of ANWR.

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APPENDIX

ANWR Progress Report Number FY84-4

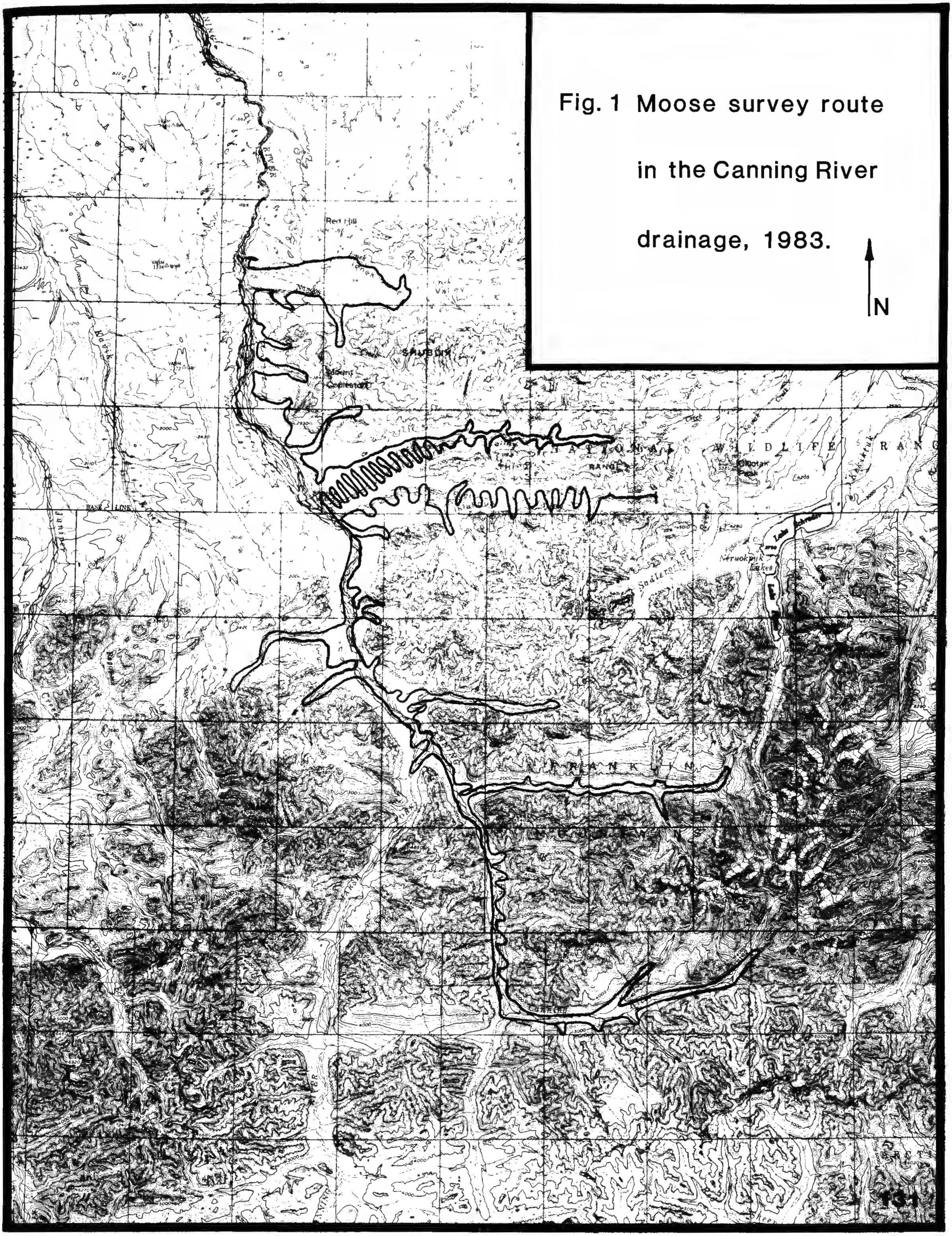
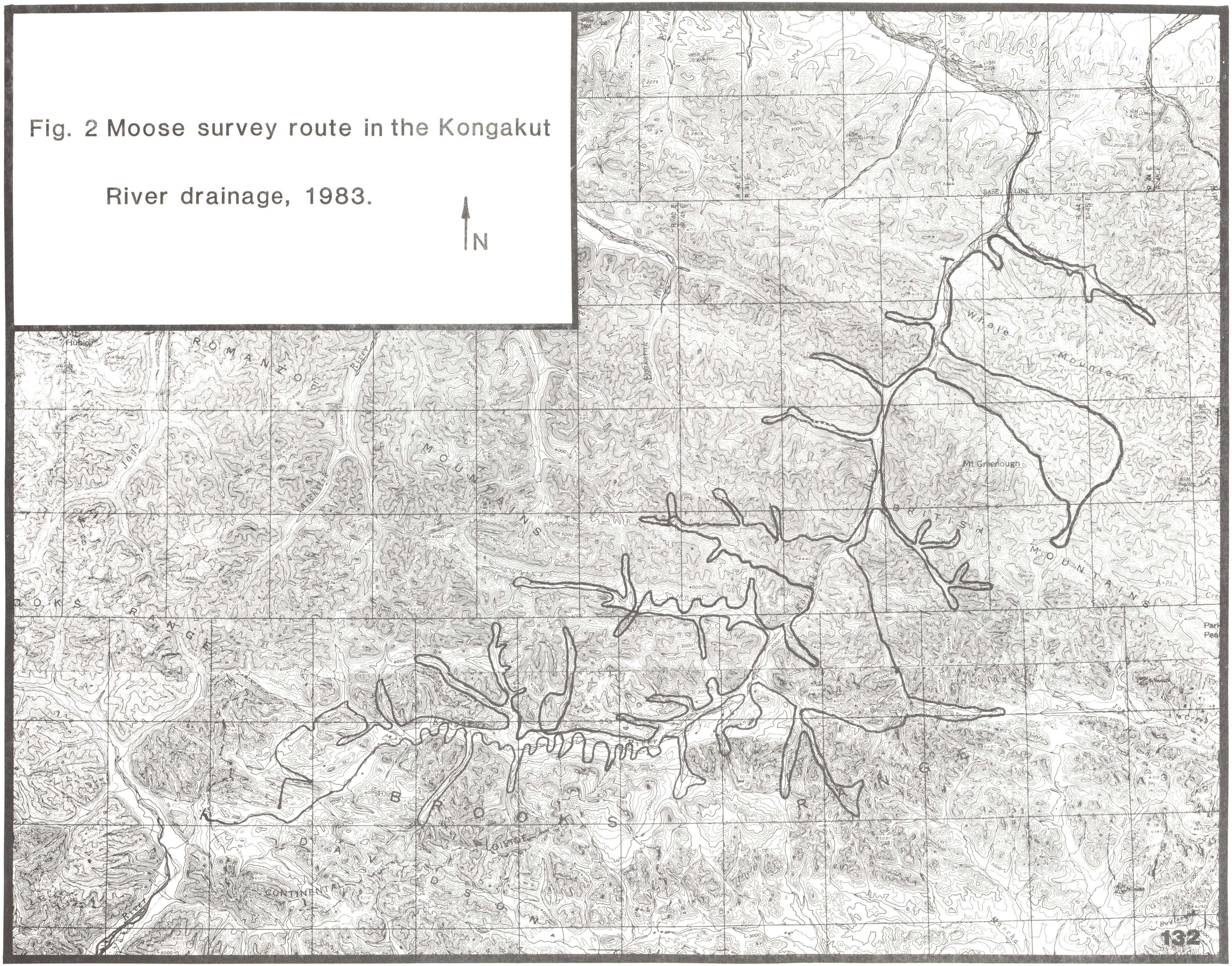


Fig. 1 Moose survey route in the Canning River drainage, 1983.

Fig. 2 Moose survey route in the Kongakut River drainage, 1983.



PREY UTILIZATION BY WOLVES AND A PRELIMINARY ASSESSMENT OF WOLF AND PREY DENSITIES IN THREE DRAINAGES WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

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Key words: Wolf, food habits, prey populations, predation, Arctic National Wildlife Refuge, Arctic-Beaufort, north slope

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Prey utilization by wolves and a preliminary assessment of wolf and prey densities in three drainages within the Arctic National Wildlife Refuge, Alaska.

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Abstract: The relative utilization and availability of prey types used by wolves (*Canis lupus*) in the Kongakut, Hulahula and Canning River drainages was assessed by visual observation and by analysis of wolf scats. Wolves were observed in each of the 3 drainages. Visual assessment indicated that moose (*Alces alces*), caribou (*Rangifer tarandus*), and Dall sheep (*Ovis dalli*) were available to the wolves in the Kongakut drainage. In the Hulahula drainage, sheep seemed to be the prey species most available, while in the Canning moose were present in relatively high densities and caribou at a lower but stable density. Scat analysis indicated that the Kongakut wolves preyed on the 3 available ungulates, but focused on caribou; the Hulahula wolves also utilized all 3 species, but ate relatively more sheep; while no moose remains were found in the scats from the Canning.

Prey utilization by wolves and a preliminary assessment of wolf and prey densities in three drainages within the Arctic National Wildlife Refuge, Alaska.

Wolves inhabit much of the remote regions of the Northern Hemisphere (Mech 1970). In North America, wolves once occupied nearly the entire continent, while today they can be found in most of Alaska and Canada, certain parts of Minnesota, Michigan and Wisconsin, the northern Rockies, and regions of Mexico (Mech 1982). In the past, 32 subspecies of wolves were recognized, but this has been reduced over the past century. Pedersen (1982) suggests that the 4 subspecies once recognized in Alaska should be reduced to 2. Wolves inhabiting the coastal plains of the Arctic National Wildlife Refuge (ANWR) have earlier been identified as C.l.tundarum (Hall 1981), but may be classified as C.l.pambasileus, the Alaskan Interior/Southcentral wolf (Pedersen 1982).

The wolf is the largest wild member of the dog family (Canidae). Adult males average 43-45 kg, while adult females average 36-39 kg (Mech 1970). Color ranges from white through gray and brown, to black.

Due to their social behavior, which is primarily manifested in the social unit or pack, wolves have evolved to become one of the most widely distributed species of mammals. Wolf packs are usually descendants from 1 breeding pair (Mech 1970, Peterson 1977, Woolpy 1979), within which a hierarchy system usually limits breeding activity to only the dominant female and the alpha or beta male (1 of the 2 most dominant males) of the pack (Rabb et al. 1967, Zimen 1981). Breeding occurs in Alaska from late February through March (Rausch 1967). Dens are prepared or visited by the pregnant female as early as 4-5 weeks prior to parturition (Chapman 1977). Pups are born in mid-May to early June in arctic areas (Chapman 1977), and the average litter size is 4-6, but may vary somewhat (Mech 1970). Within 11 to 15 days the pups eyes open, and in about 3 weeks the pups can be seen outside the den opening (Chapman 1977). Whelping dens are usually abandoned after 4-14 weeks, but in the arctic dens are usually abandoned in July (Chapman 1977). Rendezvous sites are used during the summer when the pups are left behind while the adults are hunting. Both parents, and usually other members of the pack, hunt and care for the young (Murie 1944, Harrington et al. 1983).

In 1962 it was recognized that wolf numbers on the north slope were reduced from previously relative high numbers, and an annual bag limit of 2 wolves was imposed (Stephenson and Johnson 1972). In 1970 aerial hunting of wolves on the north slope was banned. Wolf populations on the north have remained low, however, due in part to continued aerial hunting and harvest by hunters using snowmobiles (Stephenson per. comm.). Population densities for wolves in northern Alaska range from 1/130 km^2 to 1/594 km^2. The density increases from the coastal plain south into the foothills and mountains, and it is higher in the fall than in the spring. The determination of carrying capacity of wolf habitats is a complex problem, but apparently the density of wolves on a given range is influenced by factors such as prey biomass, social dynamics of packs, disease, human disturbance and harvest levels, and other ecological relationships.

Mortality and population numbers are influenced by several naturally occurring processes. Pre-parturition mortality (in utero) has been reported by Rausch (1967). The causes of such mortality remain undetermined. Other forms of mortality have been documented in the literature and include canine distemper, rabies, parasites, porcupine quill infections, malnutrition, predators (golden eagles, brown bears), cannibalism, and accidents (Murie 1944, Kuyt 1972, Stephenson and Johnson 1972, Chapman 1977, 1978). In analyzing reported data from 22 wolf litters in a variety of locations in North America, Chapman (1977) found an average summer survival rate of 85% for wolf pups. High mortality rates in wolf litters has been reported in cases where food supply is limited or declines (Kuyt 1972, Mech 1977). It is believed that certain social mechanisms such as stress, competition, and subordination may also function to control wolf populations (Mech 1970, Zimen 1976).

It appears that wolves roam throughout the ANWR coastal plain and probably utilize most habitats of the area, but information is insufficient to determine if certain habitat types or portions of the ANWR coastal plain are preferred by wolves. Wolf den sites in arctic Alaska are usually found on moderately steep southern exposures where the soil is well drained and unfrozen (Stephenson 1975). Land forms such as cut banks, escarpments, dunes, kames, and moraines are often associated with wolf dens (Stephenson 1974, Lawhead 1983). Although wolves are known to den on the coastal plain to the west of the refuge (Stephenson 1975), no wolf dens have been found within the ANWR coastal plain even though the basic habitat requirement for denning appear to be present.

During the past 10 years, active wolf dens have been found in mountainous terrain of the Kongakut, Hulahula, and the Canning River drainages. It is generally believed that wolves range primarily in the arctic foothills and mountains of the Brooks Range and are more abundant there because prey species such as Dall sheep and moose are also more abundant in these areas on a year-round basis (Stephenson pers. comm.). During May and June, when caribou are abundant on the ANWR coastal plain, most wolves are occupied with denning activities in the mountains to the south. The hunting range of denning wolves is usually limited to approximately a 32 km radius from the den site (Stephenson pers. comm.), thus, wolf predation on caribou in the ANWR coastal plain during calving and post-calving is probably low. Current numbers, movement patterns, and requirements of wolves which occasionally use the ANWR coastal plain are not known.

Scat analyses show that summer food items of wolves in the north-central Brooks Range are predominantly large ungulates (caribou, Dall sheep, and moose) (Stephenson 1975). Significant quantities of microtine rodents, ground squirrels (Spermophilus parryii), birds, and eggs and insects are often utilized during summer by wolves in arctic Alaska (Stephenson and Johnson 1972). During the rest of the year, large ungulates are often utilized more exclusively. In some locations such as the Northwest Territories in Canada (Kuyt 1972) and northwestern Alaska (Stephenson and Johnson 1973, Stephenson 1979, Stephenson and James 1982), wolves tend to move their ranges in concurrence with the seasonal caribou migrations. Similar shifts may not be as prevalent in the northcentral and northeastern Brooks Range due to a greater abundance of less migratory prey (Dall sheep and moose).

A reconnaissance survey of 3 river drainages (Kongakut River, Hulahula River, and Canning River) was conducted during July 1983 to collect preliminary data on use of each drainage by wolves and the prey species utilized by wolves in each drainage. The objectives of this preliminary field study were as follows:

1) Determine the relative utilization of the available prey species.

2) Verify reported wolf homesites.

3) Determine the relative availability of major prey species.

4) Determine which wolf pack(s) would be best suited for further study.

Methods and Materials

Visual observations were made of prey species as well as signs of and remains from these animals during extensive ground surveys in the 3 drainages. Binoculars and spotting scopes were used to scan available terrain identifying animals in the vicinity. These watches were primarily intended for spotting wolves in areas already identified as probable wolf areas through information received from R.O. Stephenson (pers. comm.) and from scats and other wolf signs. Wolf scats were collected in each drainage and analyzed in the laboratory with the aid of reference collections and manuals.

Prey items in scats were recorded as frequency of occurrence and volumetric portion (ocular estimate). The sum of the volumetric portions of all scats for each prey type was identified as the volumetric total. These volumetric totals were converted to weight of prey consumed (Kg eaten) by use of the equation: $Y = 0.38 + 0.02X$, where X is the average live weight of an individual of the prey type, and Y is the weight represented per volumetric total in scats (Floyd et a.l 1978). Average live weights and weight eaten per scat containing each prey item are listed in Table 1. Kg eaten was determined by multiplying volumetric totals for each prey item by the corresponding volumetric occurrence value for that prey item. The sum of adult caribou, unknown age caribou, and unknown age ungulates was established as the common base for comparing the prey utilized within the 3 drainages. Ratio kg eaten was calculated by dividing the kg eaten for each prey item by the sum of kg eaten for adult caribou, unknown age caribou, and unknown age ungulate. Number of individuals eaten was calculated by dividing the kg eaten for a prey item by the correpsonding assumed live weights for that prey item. The ratio of the number of individuals eaten was determined in the same manner as for ratio kg eaten.

To estimate the minimum number of individuals of prey items that a wolf would have consumed each year to duplicate the food habits depicted by scat analyses, it was assumed that 1.7 kg per day of total food material was the minimum daily maintenance requirement for each wolf (Mech 1970). By multiplying this value by the number of days in a year, a total of 620.5 kg are required by each wolf for maintenance purposes. The minimum annual maintenance requirement was divided by the total kg eaten as represented in the scat analysis data for each drainage, and this correction factor was multiplied by number of individuals eaten to determine the number of each prey item eaten by each wolf throughout the year.

Table 1. Assumed live weights and calculated weight consumed per volumetric occurrence of each prey item in wolf scats collected along 3 drainages in the Arctic National Wildlife Refuge, summer 1983.

Prey item	Assumed live weight (kg)	Calculated weight eaten per volumetric occurrence (kg)
Caribou:		
adult or unknown age	68.2	1.74
young	5.0	0.48
Moose:		
adult or unknown age	409.0	8.56
young	30.4	0.99
Dall sheep:		
adult or unknown age	54.5	1.47
young	4.0	0.46
Unknown ungulate:		
young	5.0	0.48
unknown age	68.2	1.74
Rodents:		
ground squirrel	0.8	0.40
Microtine	0.1	0.38
other	0.1	0.39
Miscellaneous:		
porcupine	8.6	0.55
wolverine	21.5	0.81
other mustelids	7.8	0.54
brown bear	264.0	5.66
unknown bird	0.1	0.38
vegetation	-	-

Results and Discussions

Each of the 3 drainages was surveyed for approximately 10 days. A total of 210 km of ground survey was conducted and a variety of weather conditons was experienced, including +30°C and 5 cm of snow. Two active homesites were located, and between 4 and 8 adult wolves and 2 pups were observed.

Kongakut River Drainage

A total of 79.5 hours were spent watching for wolves, 78 scats were collected, and 75 km of ground surveys were performed in this drainage. Ten days (29 June - 9 July) were spent along the Kongakut River. The survey began near Mt. Greenough (Fig. 1, Camp 1) at an altitude of 470 m, and proceeded north to a field camp in Caribou Pass at 330 m. The survey crew returned to Whale Mountain via helicopter (Fig. 1, Camp 4) on the west side of the river.

During the 10 days along the Kongakut, 3-7 wolves were observed. These wolves were along the west side of the river in the Whale Mountain area. Conversations with rafters and M.K. Phillips indicated that there were probably 4 adult wolves in the area: 3 gray and 1 black. No pups were seen in this area, but some smaller tracks (6.5 x 4.5 cm) were seen at the homesite, which might have been from young wolves. Case histories of wolves observed in the Kongakut River drainage are contained in the Appendix.

The wolf homesite was located on the gravel and cutbanks where a smaller creek (hereafter called Den Creek) flows into the Kongakut west of Whale Mountain. Several old and recent bone remains (red meat attached) from ungulates and rodents were found here. The bones seemed to primarily be from caribou and ground squirrels. Twenty-seven scats were collected at the homesite, and 48 along the trail leading north along the river. This trail seemed well used, as the ground was flat and smooth, and some of the scats were found in aggregations and may have represented scent posts.

Caribou, moose, and Dall sheep were often observed at different locations in the area. Several times sheep were observed coming down onto the floodplain, at times crossing water channels, below the salt licks north of Camp 4 (Fig. 1). Both ewes and rams came down to the river, but 1 or 2 rams were often observed on the cliffs next to the lick rather than moving down to the river.

Several individual holes, as well as entire colonies of ground squirrels were excavated in and around the homesite area, but it is not known if wolves were responsible. The frequency of destroyed holes seemed to increase the closer they were situated to Den Creek, and the holes in and around the trail seemed to be more often excavated.

Hulahula River Drainage

A total of 40.3 hours were spent watching for wolves, 79 km were covered by ground survey, and 32 scats were collected. Ten days (9-19 July) were spent along the Hulahula River, and Camp 5 (Fig. 2) was located approximately 5 km north of Chapman's den (Chapman 1977). Two ground surveys were made to the south of this den, and 1 ground survey north to East Patuk Creek, up this creek, and then straight across the mountains (1810 m in elevation) back to

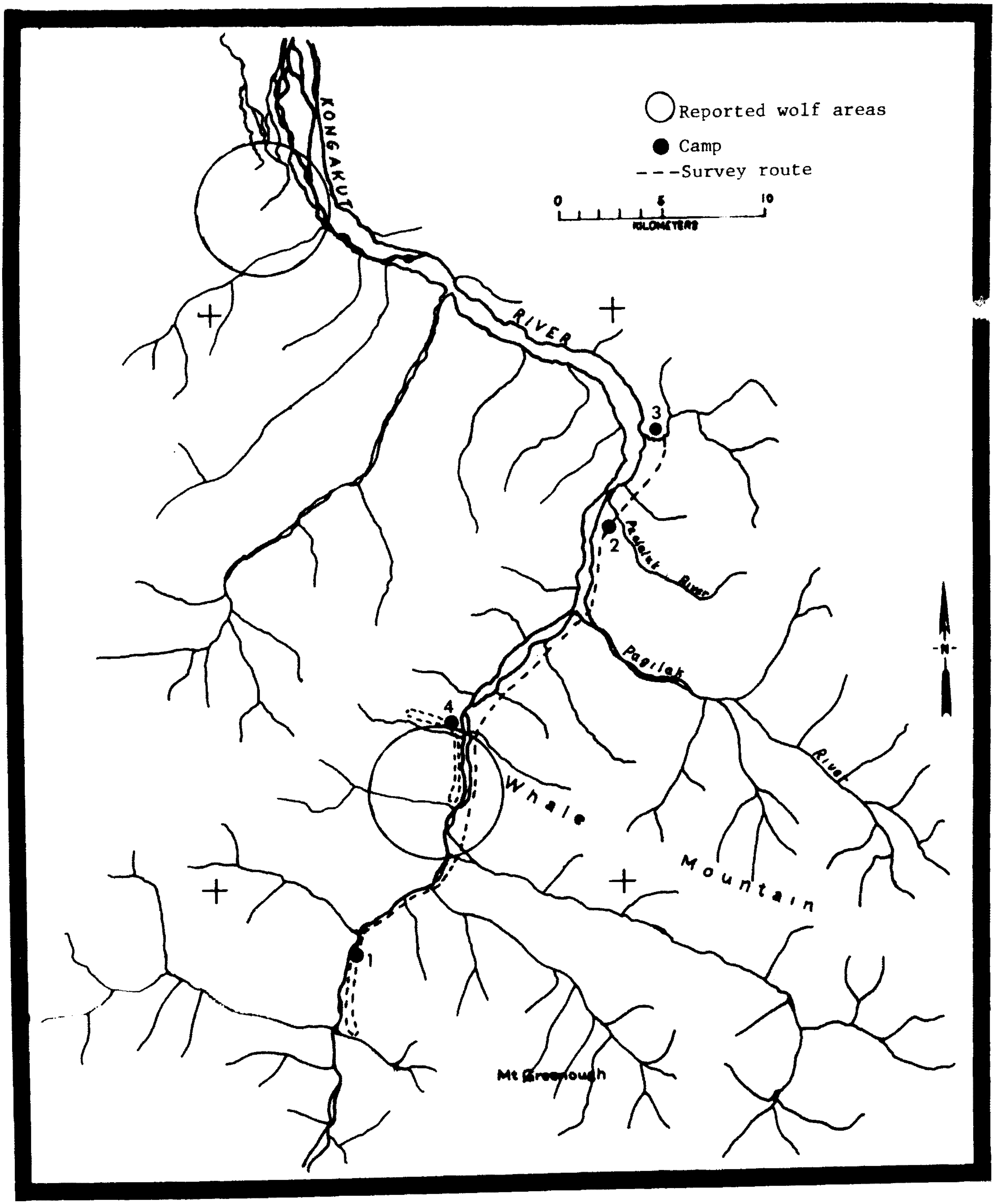

Fig. 1. Kongakut River wolf survey area, 29 June - 9 July 1983.

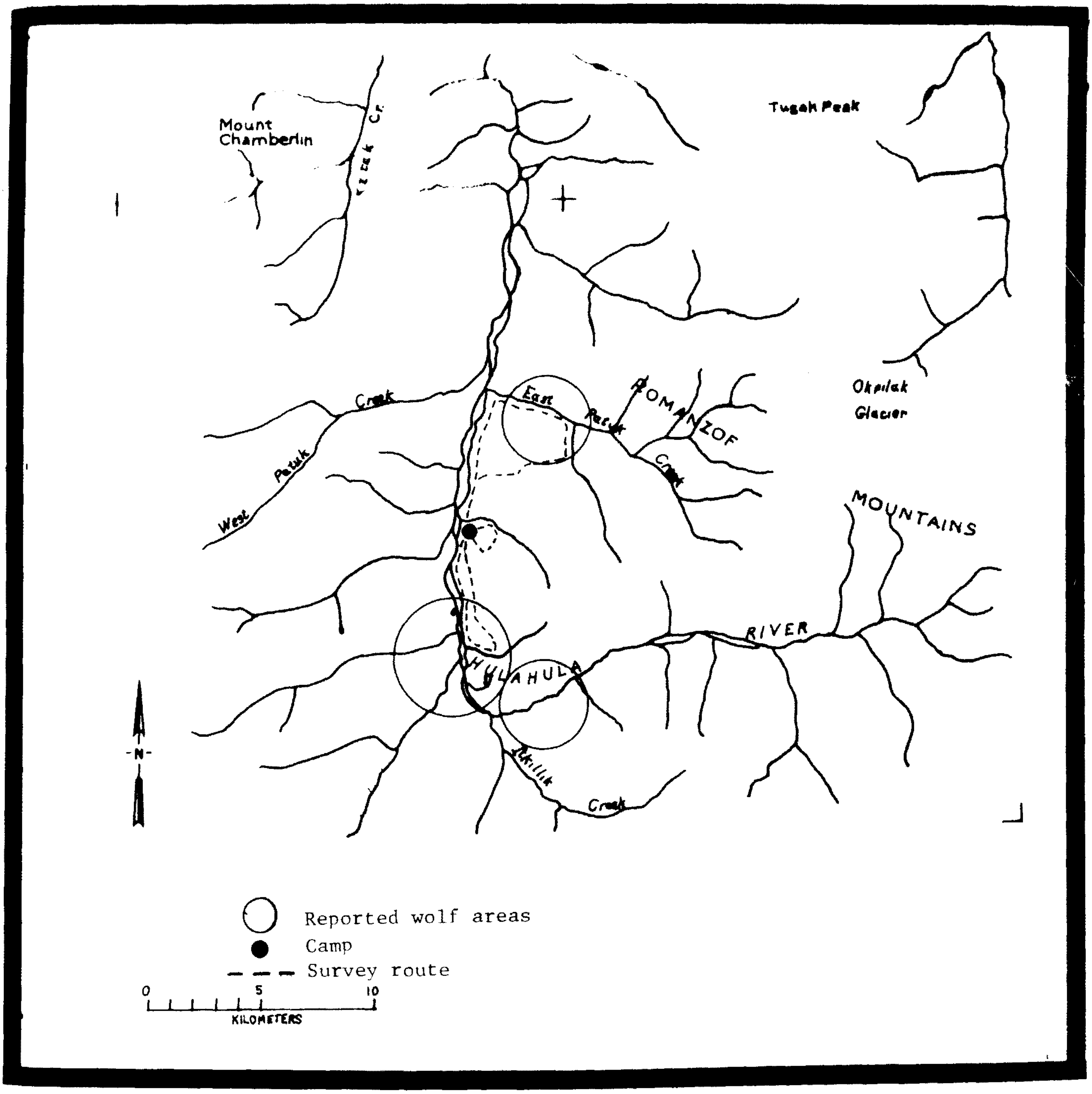

Fig. 2. Hulahula River wolf survey area, 9-19 July 1983.

Camp 5. A porcupine was observed traveling along a small mountain stream at 1200 m. There was little woody vegetation along the creek, only some small willow bushes (Salix spp.) there were about 200 m above and 1.5 km distant from the reported wolf den area at East Patuk Creek (R.O. Stephenson pers. comm.).

Two reported den areas and 1 rendezvous site were inspected, but no recent activity was observed. No wolves were seen during the gound surveys, but 34 scats were collected. This area supports a large Dall sheep population, and several remains of sheep (bones and horns) were found in concentrations and scattered on higher knoll-like plateaus. Only 2 old caribou antlers were found. Some wolf tracks were seen, singly and along well used trails, but these did not indicate that there was more than the 1 wolf observed in the area. Case history of this wolf observation is contained in the Appendix.

Seasonal lone caribou were seen traveling along the river, and 1 moose was observed foraging in a willow thicket. Ground squirrels were plentiful, and it appeared that brown bears (Ursus arctos) were the principal excavators of ground squirrel borrows.

Canning River Drainage

A total of 16.6 hours were spent watching for wolves, 54 km were covered by ground surveys, and 21 scats were collected. Nine days (19-28 July) were spent along the Canning River. Three ground surveys were made in the vicinity of a reported den area (R. Stephenson pers. comm.), 1 km north of the confluence of the Marsh Fork of the Canning and the Canning River (Fig. 3). One overnight ground survey was conducted further south along the main fork of the river. During the return to Camp 6, 2 pups were seen on an island. No adult wolves were observed in the area. Several tracks of wolves were seen, and in certain areas the dried out creek bottoms were covered by moose droppings. A few caribou were seen during the survey. Case histories of the wolf observations in the Canning River Drainage are contained in the Appendix.

Prey Utilization Results

Of the 131 collected scats, 117 were positively identified as wolf scats (by size and texture) in the lab. The content of 3 scats could not be identified, and the remaining 114 were analyzed. Most of the remains were identified to species and age, but some items could not be aged. In 3 scats the remains could not be identified as any specific ungulate. It is assumed that these unknown food remains are from adult prey, and the 3 Kongakut River scats with unknown ungulate were classified as adult caribou. This classification decreases the overall accuracy of the estimates, however, caribou appear to be the most important food item for the wolves in the Kongakut drainage. Therefore, this lumping of "unknown" with adult caribou will minimize inaccuracies. Results of the scat analyses are presented for the 3 drainages in Tables 2,3, and 4.

Another potential source of error is in the assumption of 1.7 km minimum daily maintenance requirement for wolves (Mech 1970). This value may be low, as values from 1.2 to 6.5 kg/wolf/day can be found in the literature (Mech 1966, Mech and Frenzel 1971, Kolenosky 1972, Kuyt 1972, Mech 1977), therefore, data presented in this report should be regarded as a conservative estimates of wolf diets in the 3 drainages (Tables 2, 3, and 4).

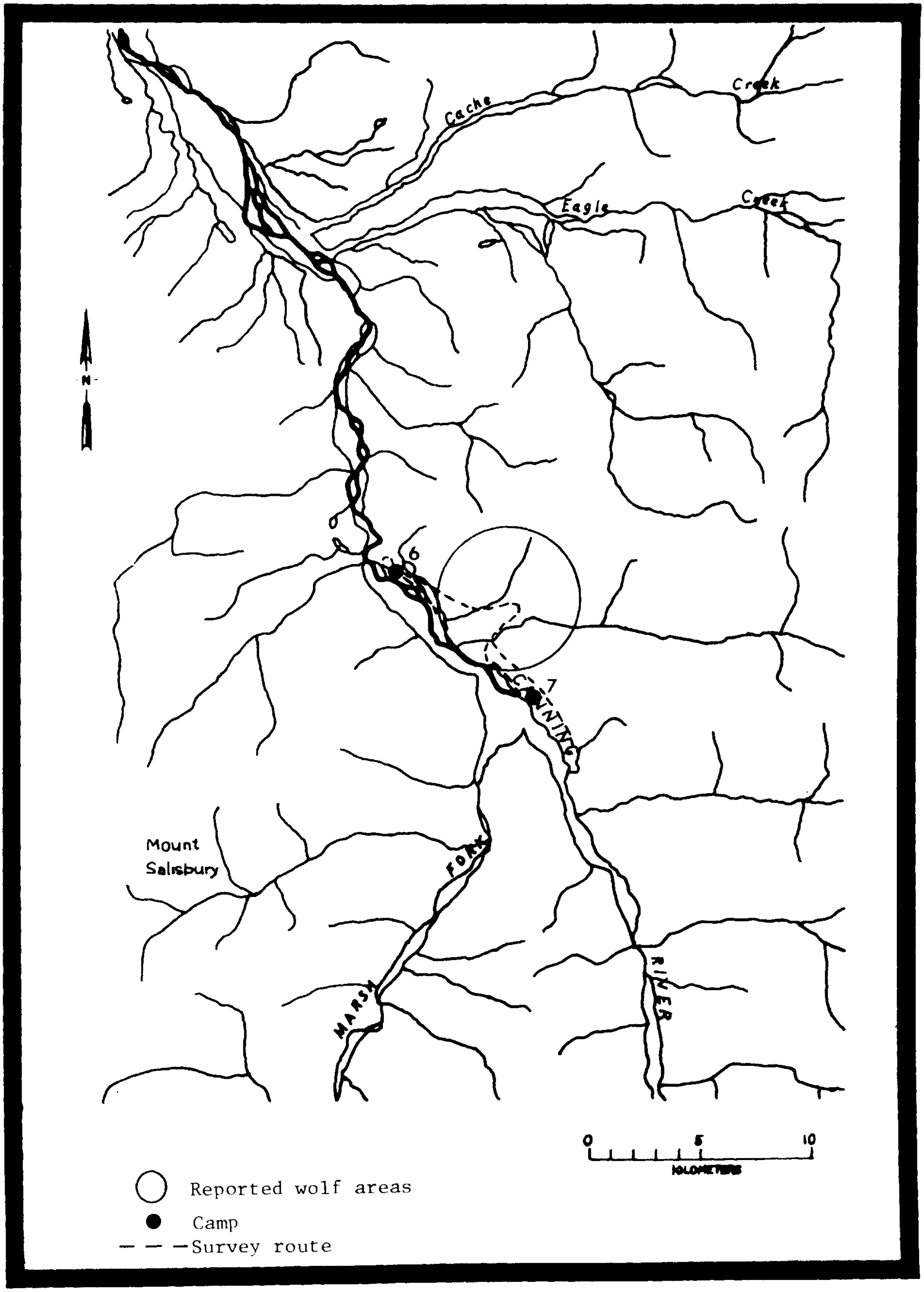

Fig. 3. Canning River wolf survey area, 19-28 July 1983.

Table 2. Prey utilization by wolves in the Kongakut River drainage based upon analysis of 73 scats[a] collected during summer 1983.

Prey item	Frequency	Volumetric total	Kg eaten	Ratio of kg eaten	#individuals eaten	Ratio # individuals eaten	Individuals/ wolf/ year
Caribou:							
adult	5	5.0	8.70	0.23	0.13	0.23	0.73
young	33	32.9	15.79	0.41	3.16	5.54	17.82
unknown age	16	15.9	27.67	0.73	0.41	0.72	2.31
Moose:							
adult	1	1.0	8.56	0.22	0.02	0.04	0.11
young	4	4.0	3.96	0.10	0.13	0.23	0.73
unknown age	4	4.0	34.24	0.90	0.08	0.14	0.45
Dall sheep:							
adult	2	2.0	2.94	0.08	0.05	0.09	0.28
young	1	1.0	0.46	0.01	0.12	0.21	0.68
unknown age	3	3.0	4.41	0.12	0.08	0.14	0.45
Unknown ungulate:							
young	2	2.0	0.96	0.03	0.19	0.33	1.07
unknown age	1	1.0	1.74	0.05	0.03	0.05	0.17
Rodents:							
ground squirrel							
microtines	1	0.1	0.04	0.001	0.40	0.70	2.26
others	2	0.2	0.08	0.002	0.80	1.40	5.51
Miscellaneous:							
porcupine							
wolverine							
other mustelids	1	0.9	0.49	0.01	0.06	0.11	0.34
brown bear							
unknown bird							
vegetation							
Totals	76	73.0	110.04				

[a]4.1% of scats contained more than 1 prey item.

Table 3. Prey utilization by wolves in the Hulahula River drainage based upon analysis of 24 scats[a] collected during summer 1983.

Prey item	Frequency	Volumetric total	Kg eaten	Ratio of kg eaten	#individuals eaten	Ratio # individuals eaten	Individuals/ wolf/ year
Caribou:							
adult							
young	6	5.1	2.45	1.41	0.49	16.33	20.36
unknown age	1	1.0	1.74	1.00	0.03	1.00	1.25
Moose:							
adult							
young	2	2.0	1.98	1.14	0.07	2.33	2.91
unknown age							
Dall sheep:							
adult	1	1.0	1.47	0.84	0.03	1.00	1.25
young	4	4.0	1.84	1.06	0.46	15.33	19.12
unknown age	2	1.3	1.91	1.10	0.04	1.33	1.66
Unknown ungulate:							
young							
unknown age							
Rodents:							
ground squirrel	3	2.9	1.16	0.67	1.45	48.33	60.26
microtines	2	1.1	0.42	0.24	4.20	140.00	174.55
others							
Miscellaneous:							
porcupine	1	0.9	0.34	0.19	0.04	1.33	1.66
wolverine	2	2.0	1.62	0.93	0.08	2.67	3.32
other mustelists							
brown bear							
unknown bird							
vegetation	3	2.7	-	-	-	-	-
Totals	27	24.0	14.93				

[a]12.5% of scats contained more than 1 prey item.

Table 4. Prey utilization by wolves in the Canning River drainage based upon analysis of 17 scats[a] collected during summer 1983.

Prey item	Frequency	Volumetric total	Kg eaten	Ratio of kg eaten	#Individuals eaten	Ratio # individuals eaten	Individuals/ wolf/ year
Caribou:							
adult							
young	3	3.0	1.44	0.08	0.29	1.04	6.32
unknown age	11	11.0	19.14	1.00	0.28	1.00	6.10
Moose:							
adult							
young							
unknown age							
Dall sheep:							
adult							
young							
unknown age	1	1.0	1.47	0.08	0.03	0.11	0.65
Unknown ungulate:							
young							
unknown age							
Rodents:							
ground squirrel	1	1.0	0.40	0.02	0.50	1.79	10.90
microtines							
others							
Miscellaneous:							
porcupine							
wolverine							
other mustelids							
brown bear	1	1.0	5.66	0.30	0.02	0.07	0.44
unknown bird	1	0.01	0.38	0.02	3.80	13.57	82.76
vegetation							
Totals	18.0	17.0	28.49				

[a] 5.9% of scats contained more than 1 prey item.

Overall impressions from the visual observations of prey availability in the 3 drainages this summer are summarized in Table 5. Each prey species was assigned a prey importance in an attempt to assess the availability of the prey species for wolves within each drainage. All minor food items are combined under other species.

The relative rank of the major prey species is depicted in Table 6. This relative rank was determined through comparisons of the energy gained (ratio kg eaten) and energy spent (ratio of the number of individuals eaten) which formed the analytical basis for the ranking scheme. It appears that other species are an important food source for Hulahula River and Canning River wolves, but small sample sizes and seasonal availability are believed to influence this apparent disproportionate dependence upon minor prey species.

Discussion of Prey Utilization

Comparing the results of the scat analysis, it seems that the wolves in all 3 drainages focused on the abundant caribou (Fig. 4, Table 2). The Kongakut River wolves utilized the 3 available ungulate species in proportion to the relative availability of each species. Caribou are relatively easy to catch, while moose protect and defend themselves relatively well. Dall sheep are probably difficult to capture because of the terrain they occupy. The Kongakut River wolves diet is supplemented with smaller mammals.

The Hulahula wolves apparently depend more heavily upon Dall sheep (Fig. 4, Table 3). There are few moose in the area, and wolves concentrate their activity on Dall sheep. The few caribou that enter this drainage may be from either the Central Arctic or the Porcupine caribou herds. A diet based on Dall sheep might cause competition with other predators, therefore, it is not surprising that 2 scats contained remains from an adult wolverine(s).

It was unexpected not to find remains from moose in the scats collected along the Canning river, but the scats were collected in a period when caribou were present on the floodplains (Fig. 4, Table 4).

The 3 packs apparently have different prey bases and would all be of interest for further work. The Hulahula River wolves apparently feed heavily on Dall sheep, and the Kongakut River wolves, with their apparent dependence on caribou, would both be candidates for further study of wolves with contrasting prey bases. For purposes of observing wolf denning behavior, the visibility of the homesites of the Hulahula and the Kongakut River wolves is relatively good, thus, these 2 packs seem to be better suited for further study of denning ecology. If only 1 wolf is present in the Hulahula drainage, the Canning River wolves should be considered for further study also.

Acknowledgements

First I would like to thank Dr. G.W. Garner for letting me do this job, which I could not have done without the briefing by R.O. Stephenson (ADF&G) prior to my entering the field. Dr. E.H. Follmann and Dr. P.S. Gipson of the University of Alaska-Fairbanks campus provided valuable advice. D. DeVoe was a field assistant during the surveys and gave me a lot to think about. But what could I have done without a supporting wife at home?

Table 5. Visual assessment of the relative seasonal availability of the various prey species by drainage, Arctic National Wildlife Refuge, summer 1983.

River drainage/ wolf status prey importance[a]	Caribou	Moose	Dall sheep	Other species
Kongakut River:				
wolf migratory	spring/summer	summer	summer	summer
wolf nonmigratory	spring	yearlong	summer	summer
prey importance	1	1	1	4
Hulahula River:				
wolf migratory	NA[b]	NA	NA	NA
wolf nonmigratory	spring	winter	yearlong	summer
prey importance	2	2	1	4
Canning River:				
wolf migratory	NA	NA	NA	NA
wolf nonmigratory	spring	yearlong	-	summer
prey importance	2	1	4	4

[a]prey importance scalar from 1 = most important to 4 = least important.
[b]NA not applicable, assuming Hulahula and Canning River drainages are not major caribou migratory areas, therefore wolves would not be migratory.

Table 6. Relative rank of importance for the major prey categories within each of 3 drainages on the north slope of the Arctic National Wildlife Refuge, summer 1983.

River/prey item	Frequency	Ratio of kg eaten	Ratio # individuals eaten	Importance rank[a]
Kongakut River:				
caribou	57	1.45	6.87	1
moose	9	1.22	0.41	2
dall sheep	6	0.21	0.44	3
other species	4	0.013	2.21	4
Hulahula River:				
caribou	7	2.41	17.33	1
moose	2	1.14	2.33	4
dall sheep	7	3.00	17.66	2
other species	11	2.03	192.33	3
Canning River:				
caribou	14	1.08	2.04	1
moose	-	-	-	4
dall sheep	1	0.08	0.11	3
other species	3	0.34	15.43	2

[a]Importance rank determined by assessing the magnitude of energy gained (ratio of kg eaten) and energy spent (Ratio of #individuals eaten).

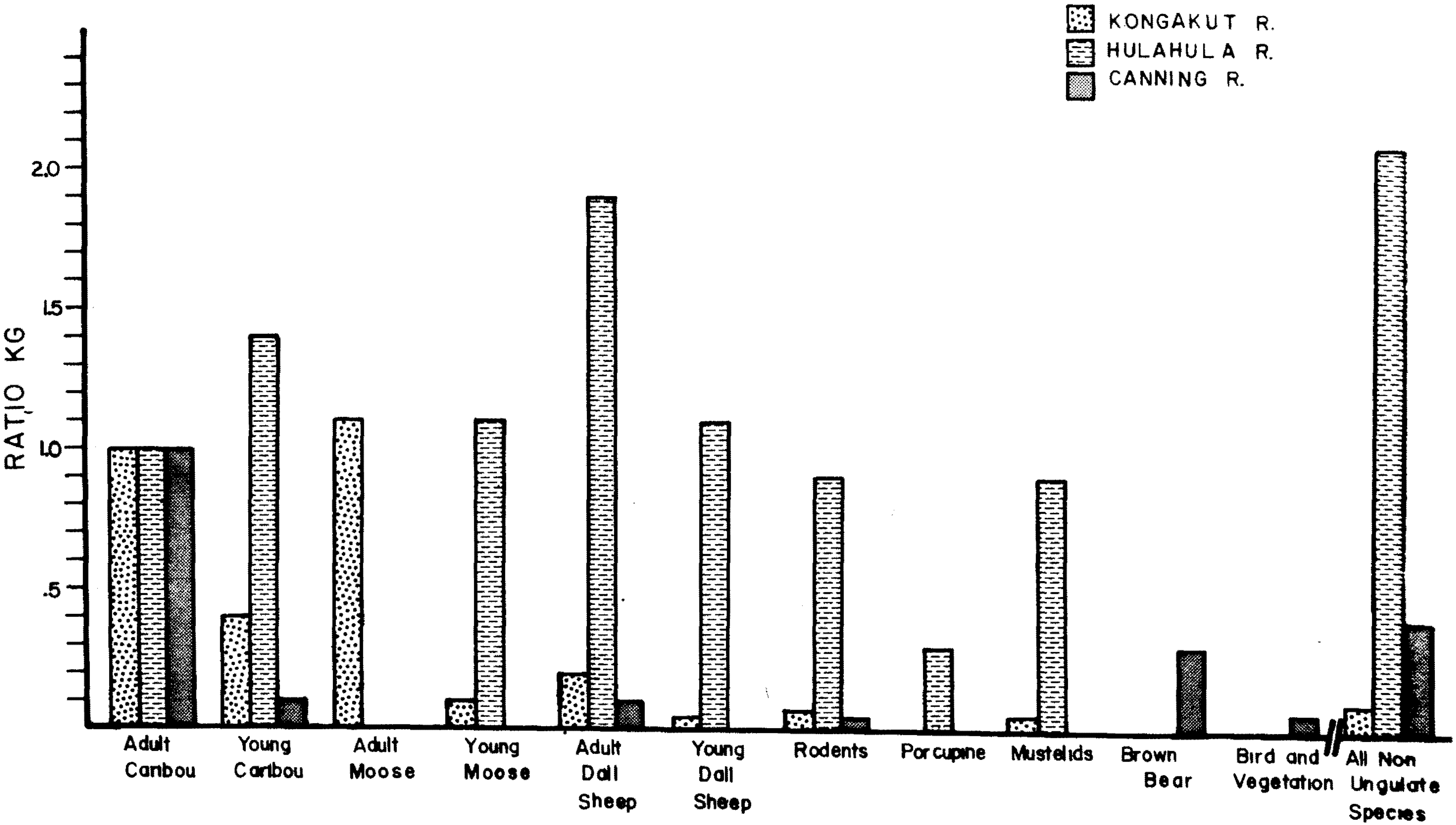

Fig. 4. Relative utilization of prey species in 3 drainages on the Arctic National Wildlife Refuge, summer 1983.

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APPENDIX

ANWR Progress Report Number FY84-5

Case histories of wolves observed in ANWR during field work the summer of 1983.

Case history 1

June 30, Whale Mountain at Kongakut River, time: 2252 h. Two wolves, a dark (black) and a light (grey), were seen trotting along a trail on the west side of the river leading south from the homesite (Den Creek), and around the bend by Mt. 4880. The black wolf was seen first as it howled, and the gray was seen following behind. They both urinated at several locations, the black with raised hind leg while the gray squatted. I howled at them and they stopped to look in our direction. The gray wolf gave a short reply after having walked up to and above the black one. The black's tail was often lifted high up as they walked. They disappeared out of sight at 2323 h.

Case history 2

July 1, Whale Mountain at Kongakut River, time: 0100 h. One dark wolf was seen 1.5 km north of Den Creek where the trail leads down onto the riverbar.

Case history 3

July 1, Whale Mountain at Kongakut River, time: 0345 h. Two sightings of a dark wolf (wolves) seen in the same area as where the dark wolf was discovered howling on June 30.

Case history 4

July 1, Den Creek at Kongakut River, time: 1425 h. Two gray wolves were seen resting and wandering around among the willows along the gravel bar at the homesite where Den Creek enters the Kongakut. One gray laid down next to the willow thickets after the other gray had faced the spot (as if smelling), and this second wolf took off approximately 100 m upstream and laid down on the mudflats.

Case history 4b

July 1, Den Creek at Kongakut. This is the area where the rafters, at approximately the same time as case history 4a, saw 4 wolves. They also told us that they had seen 1 light wolf following us as we hiked along the hillside on the east side of the river. This wolf followed us for quite some distance, approximately 100 m behind us. Unfortunately we did not turn around to check behind us.

Case history 4c

Kongakut. Two other rafters told us that they had seen a gray wolf cross (swim) the southernmost creek we checked, on the west side of the Kongakut, west of Mt. Greenough.

Case history 5

July 17, Camp 3, north of Chapman's Den at Hulahula River. One white wolf was seen checking the ground approximately 100 m south of camp at 1035 h.

Its fur was very long (perhaps molting), nearly hanging to the ground. The wolf was in view for approximately 5 minutes, during which it interrupted its travel a couple of times facing the ground and raising its head.

Case history 6

July 25, by Moose Creek at Canning River, time: 1210 h. One brown wolf pup was seen searching in the grass along the edge of an island. Detecting us it ran and hid, so we sat down on top of a nearby knoll to investigate. After 1 hour without seeing anything, I howled. A pup answered from the center of the island. It came out of the brush, approaching our sound, but stopped when the pup we first observed replied and met this second pup. They greeted and ran around for a while before entering the bushes again. Losing sight of them, we investigated the island but found only 2 pup scats, mainly pup tracks spread over the entire island, some adult tracks and a short section of a well used trail. Adult howling had been heard the night before from this area, and the following night howling was heard again.

ANWR Progress Report Number FY84-6

MOVEMENT OF MOLTING OLDSQUAW WITHIN THE BEAUFORT SEA COASTAL LAGOONS OF ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1983

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Key Words: Oldsquaw, Anatidae, movement, distribution, Arctic-Beaufort

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16 December 1983

Movement of molting oldsquaw within the Beaufort Sea coastal lagoons of the Arctic National Wildlife Refuge, Alaska, 1983.

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Abstract: During August, 1983, 16 molting oldsquaw were captured in Tapkaurak Lagoon and fitted with a backpack radio transmitter. Birds were relocated each day that weather permitted until they departed the refuge. Over 75% of the oldsquaw relocation points were within lagoons or within 400 m of barrier islands in the ocean. Radioed oldsquaw were relatively sedentary with 47% of relocations in Tapkaurak - Oruktalik lagoon system where captured. Nearly 90% of the relocation points were found in water less than 5 m deep. The average movement rate for the 9 oldsquaw alive at the onset of migration ranged from 1.77 to 12.20 km/day. The average daily movement rate for males exceeded that for females, but the difference was not significant. The average date of migration initiation was 22 September, and coincided with the beginning of lagoon freeze up. The relocation data suggests oldsquaw move from lagoons to offshore and ocean areas as molt is completed and migration begins. The radio relocation data is in agreement with the distribution data obtained during the 1983 aerial surveys.

Movement of molting oldsquaw within the Beaufort Sea coastal lagoons of the Arctic National Wildlife Refuge, Alaska, 1983.

The Congressionally mandated seismic exploration program on the coastal plain of Arctic National Wildlife Refuge, as well as the proposed Federal leasing of offshore tracts and state leasing of nearshore areas will place industrial activity in or close to coastal lagoon systems. Coupled with these exploration programs, there will be an increase in air and boat traffic along the coast to support the exploration operations. During the short open water season, substantial concentrations of migratory birds are found within and immediately adjacent to coastal lagoons. Previous studies of Beaufort Sea coastal lagoons substantiate that oldsquaw undergoing postnuptial wing molt and premigratory staging are the predominate species present (Schmidt 1970, Bartels 1973, Frickie and Schmidt 1974, Gallop and Richardson 1974, Ward and Sharp 1974, Harrison 1977, Spindler 1978, Divoky and Good 1979, Spindler 1979, Johnson and Richardson 1981, Bartels and Zellhoefer 1983, Johnson 1983). Oldsquaw are presumed to move from both Alaskan and Canadian areas to utilize Alaskan coastal lagoons (Salter et al. 1980). Knowledge of the movements of birds within the lagoons as well as residence time is important to predict potential effects of pollution and disturbance upon oldsquaw using the coastal lagoon system.

Methods and Materials

A field camp was established on the barrier island of Tapkaurak Lagoon approximately 24 km east of Barter Island. This site was selected for the following reasons: easy accessibility by boat from Barter Island, a large population of molting oldsquaw, several spits and irregular shoreline areas suitable for drive trapping. The majority of the field camp equipment and capture materials was flown to Tapkaurak Lagoon on 31 July 1983. Personnel in boats traveled to the barrier island site on 6 August 1983 and set up camp.

Two capture sites were utilized within Tapkaurak lagoon. "North cove" was a sheltered water area formed by a gravel spit extending into Tapkaurak Lagoon from the barrier island. "South cove" site was a spit extending into the lagoon from the mainland, across Tapkaurak Lagoon from "North cove".

The trapping method devised to capture flightless oldsquaw was through use of mist nets set in the lagoon waters. A similar method was described by Alison (1975). The design of the trap consisted of 4 sections of 10 cm mesh mist nets, each being 3 m wide by 18 m long. The ends of each net were attached to 3.6 m aluminum conduit poles. The poles holding 3 sections of mist net were pushed into the sandy bottom at the selected capture site in a straight line. Thus, a 54 m wing of mist net extended from the shore out into the lagoon. The fourth segment of mist net was stretched at right angles to the long wing, forming an L shaped drive trap. The mist net drive trap extended from the lagoon bottom to approximately 30 cm above the water surface. Once the trap was in place, 2 or 3 boats were used to drive oldsquaw into it. Rafts of oldsquaw, often up to 3.2 km from the trap, could be herded from mid-lagoon towards the shore. By pursuing the birds very slowly with boats, rafts of oldsquaw could be pushed towards the shore or barrier island, and then along the shoreline toward the trap. Through trial-and-error it became apparent that flocks of oldsquaw had to be driven slowly and persistantly enough to keep them swimming in the desired direction. If oldsquaw were driven too fast, they begain diving and often swam back under the boats into the open lagoon.

When a flock of oldsquaw swam into the L-shaped trap area, they were rushed with the boats. Some of the ducks would panic and swim into the mist nets and become entangled. There was sufficient slack in the pockets of the nets that birds entangled even at the bottom of the net would float to the surface. Only 1 mortality occurred when the entangled duck floated to the surface and dove back through the net. This duck then became entangled about 15 cm under the water surface, and drowned before the net could be pulled to free the bird.

Upon capture, oldsquaw were fitted with a U.S. Fish and Wildlife Service metal leg band, and a back-pack radio transmitter was attached to selected birds (Telonics, Inc. Mesa, Arizona). The radio unit was a sealed cylinder 1.7 cm in diameter by 5.6 cm long and weighed 28 g. The radio was attached to the oldsquaw with 0.64 cm wide x 7.6 cm long material that was sewn into a circle. The radio sat on the birds back between the wings and an elastic band passed around each wing. The radio had a flexible 38.1 cm rubber coated antenna. The sex of each bird was recorded and the lengths of the first, fifth, and tenth primary flight feathers were measured.

Relocation flights were begun when the first group of oldsquaw were fitted with radios. Radio tracking flights were conducted daily when the weather conditions were favorable for flying. A total of 40 relocation flights were conducted, totaling approximately 100 hours of flight time.

Results and Discussion

A total of 21 oldsquaw were captured and banded between 7 and 18 August 1983 (Table 1). One oldsquaw drowned as a result of the capture efforts. Of the 21 captured oldsquaw, 16 were equipped with radio transmitters (Table 1). Distribution of oldsquaw captures include 5 (2 males, 3 females) in the barrier island cove of Tapkaurak Lagoon ("south cove") and 16 (9 males, 7 females) at the Tapkaurak Point cove ("north cove"). Sex ratio of captured birds was 1 female to 1.1 males.

There were 7 documented mortalities during the study. Two radioed birds died shortly after release. The signal from Oldsquaw #5 disappeared 19 August and reappeared on 1 October. On-ground investigation of the site revealed that the signal was coming from beneath the ice surface near the capture site. Oldsquaw #15 was found dead, apparently due to exposure, 5 km from the capture site, 7 days after release. A signal coming from that same area shortly after capture indicated the bird may have been dead as soon as 1 day after capture. Other mortalities during the study include Oldsquaw #13 that was shot by local hunters, and Oldsquaws #1 and #10 which both appeared to be killed by avian predators. Oldsquaws #2 and #12 died in mid-October apparently from exposure. Of the remaining 9 birds, 2 were documented as being west of the refuge and 7 disappeared during the course of the study. However, prior to their disappearance, these 7 oldsquaw had begun a westward movement. Therefore, it is assumed that they continued their westward movement off the refuge coastline.

Table 1. Physical characteristics of oldsquaw captured in 1983 on the Arctic National Wildlife Refuge, 1983.

Bird number	Capture date	Capture location	Sex	Primary length (cm) 1	5	10	Other
1	7 Aug	N. Cove	M	near complete			Dead-1 Oct.
2	7 Aug	"	F	2.5	2.5	2.5	Dead-15 Oct.
3	8 Aug	"	F	1.4	1.6	1.4	Off refuge-29 Sept.
4	8 Aug	"	M	7.7	10.2	10.0	Off refuge-29 Sept.
5	8 Aug	S. Cove	F	2.5	2.5	2.5	Dead-19 Aug.
6	8 Aug	"	M	near complete			Lost cont.-9 Oct.
7	8 Aug	"	M	near complete			Lost cont.-9 Oct.
8	8 Aug	"	F	2.5	2.5	2.5	Lost cont.-12 Oct.
9	16 Aug	N. Cove	F	4.5	3.2	5.0	Lost cont.-22 Sept.
10	16 Aug	S. Cove	F	4.0	4.8	4.1	Dead-15 Sept.
11	16 Aug	"	F	5.5	6.7	5.6	Lost cont.-15 Oct.
12	17 Aug	"	F[a]	12.4	11.6	8.1	Dead-10 Oct.
13	17 Aug	"	M	6.1	6.9	5.7	Dead-7 Sept.
14	18 Aug	"	M	8.8	10.5	9.6	Lost cont.-28 Sept.
15	18 Aug	"	F	5.1	5.8	5.5	Dead-23 Aug.
16	18 Aug	"	M	6.8	10.2	10.4	Lost cont.-21 Sept.
17	18 Aug	"	M	8.5	11.0	10.4	no radio
18	18 Aug	"	M	8.4	10.4	10.1	no radio
19	18 Aug	"	M	8.4	10.3	9.8	no radio
20	18 Aug	"	M	8.9	11.0	12.2	no radio
21	18 Aug	"	F	6.2	7.8	6.8	no radio

[a]with brood of 5 at capture.

Molting patterns of oldsquaw were similar to those reported elsewhere (Johnson and Richardson 1981). Post-breeding and non-breeding males completed molt before non-breeding and unsuccessful females. Both of these groups completed molt before females with broods (Table 1). After the first week of August 1983, feather development in male oldsquaws was nearly complete, while flight feathers of non-breeding and unsuccessful females were just beginning to develop. During this time period (7-8 August), very few oldsquaw were capable of flight when they were driven into the positioned mist nets. By mid-August (16-18 August) flight feather development of non-breeding and unsuccessful females was approximately 50% complete. Oldsquaw #13, captured in mid-August, had completed approximately 50% of the flight feather molt. Oldsquaw #12, a female with a brood of 5 captured in mid-August, had not yet molted. In addition a large proportion of the males were capable of flight in mid-August when they were driven into the capture nets.

Distribution of radioed oldsquaw indicate a high degree of association with the coastal lagoon system (Table 2). Over 75% of the oldsquaw relocations were in lagoons or within 400m of land while in the ocean. Of the remaining relocations, 16% were greater than 400 m into the ocean and 6.6% were in lakes and ponds isolated from the lagoon system. Oldsquaw #12, a female rearing a brood of 5 ducklings, accounted for the majority of the pond and lake observations. The female was captured in the lagoon, but moved the brood to the lake and remained until the study ended. The fate of the brood is not known. Of the 295 oldsquaw locations in lagoons or within 400 m of land while in the ocean, 59.7% were utilizing the lagoons themselves while 40.3% were in the ocean.

Radioed Oldsquaw were relatively sedentary during this study (Table 2). Almost half (47.0%) of the observations were in the Tapkaurak-Oruktalik Lagoon system. Several oldsquaw drifted east during the study accounting for 35.7% of the observations. In contrast only 17.3% of the observations occurred west of the capture sites, although this percentage is affected by the smaller number of birds alive during the westward migratory movements.

In agreement with oldsquaw's affinity to the lagoon system, radioed oldsquaws also showed a preference for shallow water (Table 3). Of all relocations, 77% were of oldsquaw in water less than 2 m deep with nearly 90% of the observations in water less than 5 m deep. Six % of the locations were in water greater than 10 m deep with 1 Oldsquaw located in water 30 m deep.

Daily movement rates for radioed oldsquaw ranged from 0 to 208 km/day. Average movement rates for individual birds alive through migration ranged from 1.77 to 12.20 km/day (Table 4). Although the average movement rate for males (5.48 km/day) as higher than for females (4.40 km/day), there was no significant difference between sexes (= 0.05, t= 0.7753, df= 10). For the 12 birds alive through migration, maximum movement rates ranged from 12.5 to 208 km/day. Two of these individuals had larger maximum movement rates east than west. However, they eventually moved westward prior to being "lost".

The average date of migration initiation (indicated by consistently high movement rates in a westerly direction) was 22 September and coincided with the date of lagoon freeze up (Table 4). The earliest migration date was 9 September with the latest being 30 September. Male oldsquaws had earlier

Table 2. Locations of radioed oldsquaw in various lagoons of the Arctic National Wildlife Refuge, 1983.

Lagoon System	Water Body Lagoon	Ocean 400m	400m	Pond/ lake	Total
Siku Lagoon (Pingokraluk-Siku Pt.)		2	2		4
Egaksrak Lagoon (Siku Pt.-Egaksrak Ent.)	9	1	3		13
Beaufort Lagoon (Egaksrak Ent.- Angun Pt.)	3	17	8		28
Angun Lagoon (Angun-Humphrey Pt.)	12	9	5	1	27
Pokok Bay (Humphrey Pt.-W. end Pokok Bay)	9	12	8		29
Pokok Bay - Pokok Lagoon	N/A	13	6		19
Pokok Lagoon (E. end Pokok Lag. Griffin Pt.)	4	7	4	1	16
Oruktalik Lagoon (Griffin - Tapkaurak Pt.)	61	18	4	23	106
Tapkaurak Lagoon (Tapkaurak - Martin Pt.)	61	8	4		73
Jago Lagoon (Martin Pt. - Barter Island)	4	17	6		27
Arey Lagoon (Barter Island - E. end Hulahula)	1	3	3		7
E. end Hulahula delta - Anderson Point			3		3
Anderson Point - Camden DEW	N/A	6			6
Simpson Cove (Camden DEW - Konganevik Pt.)	5		2		7
Tamayariak Lagoon(Kongonevik Pt-Tamayariak delta)	7	2	1		10
Brownlow Lagoon (Tamayariak delta - Brownlow Pt.)	3			3	
West of refuge		1	2		3
Total	176	119	61	25	381
Proportion of Total (%)	46.2	31.2	16.0	06.6	100.0

Table 3. Frequency of water depths of 381 relocations of 14 radioed oldsquaw on the Arctic National Wildlife Refuge, 1983.

Water depth(m)	Oldsquaw Number														Total
	1	2	3	4	6	7	8	9	10	11	12	13	14	16	
0	2	3	1			1				1			1	3	12
1	18	24	10	11	7	21	17	4	7	30	28	12	15	13	217
2	6	7	7	2	6	7	14	3	3	3			3	4	65
3	1		6	3		2	4	1	3	2			2	1	25
4		1		5			1	2			3		1		14
5								1	1		2				4
6			1		1	1		2	3		1				9
7	1	2		2	1					1					7
8	1			1	3										5
9					1										1
10	1		2					1	1						5
11															
12				1				1							2
13		1						3					1		5
14				1											1
15							1	2							3
16															
17								2					1		3
18															
19															
20					1										1
21															
22															
23															
24															
25				1											1
26															
27															
28															
29															
30								1							1
														Total	381

Table 4. Summary of movement data for radioed oldsquaw on the Arctic National Wildlife Refuge, 1983.

Oldsquaw	Sex	Movement rate (km/day) Average	Movement rate (km/day) Maximum	Migration Initiation date	Movement rate (km/day) on day of migration initiation
1	M	4.21	26.7	19-20 Sept.	26.7
2	F	4.23	38.6	30 Sept.	38.6
3	F	5.19	36.5	17 Sept.	14.9
4	M	12.20	208.0	9-10 Sept.	12.0
5	F				Dead before migration
6	M	3.08	10.0[a]	9-30 Sept.	3.0
7	M	3.95	30.7	28-30 Sept.	30.7
8	F	5.35	32.2	30 Sept.	32.2
9	F	5.54	19.9[a]	12 Sept.	12.5
10	F	2.76	9.2[a]		Dead before migration
11	F	4.33	27.5[a]	30 Sept.	19.8
12	F	1.77	17.9	28 Sept.	6.8
13	M	1.26	5.1		Dead before migration
14	M	5.86	50.0	19-20 Sept.	50.0
15	F				Dead before migration
16	M	3.61	12.5	18 Sept.	10.1

[a]Movement east

migration initiation dates (19 September) than did females (24 September), but the difference was not significant (α = 0.05, t= 1.192, df = 9). Females showed more variability in their time of migration than did males. In 6 of 12 cases the maximum daily movement rate coincided with the migration initiation date.

The distribution of radioed oldsquaw in the various water areas during the pre-migration and the post-migration period indicate that lagoon locations drop from 51% during pre-migration to 22% during the post-migration period (Table 5). The post-migration period is defined as beginning when a bird begins a consistently high westerly movement. Conversely, the 400m offshore zone and the open ocean zone sightings increased from 28% and 13% respectively during pre-migration to 48% and 31% respectively during post-migration. These, data suggest that oldsquaw undergo a movement from lagoons to offshore and ocean areas as molt is completed and the westward migration commences. Johnson and Richardson (1981) in the Simpson Lagoon study area to the west of the Refuge, suggest that male oldsquaw move offshore as the molt is completed.

Table 5. Number of locations in various water bodies for 12 radioed oldsquaws pre- and post-migration initiation, Arctic National Wildlife Refuge, 1983.

		Pre-migration				Post-migration		
Bird No.	Migration Date	Lagoon	Offshore	Ocean	Pond	Lagoon	Offshore	Ocean
1	9/19	12	7	3	1	5	2	
2	9/30	24	2	1		1	5	4
3	9/17	9	5	7		2	3	1
4	9/9	4	3	6	1	7	3	3
5	-							
6	9/9-9/30	5	3	6			5	1
7	9/28	15	10	1		1	4	1
8	9/30	10	18				5	4
9	9/12	1	5	9	1		1	6
10	-	1	15	2				
11	9/30	24	3				10	1
12	9/28	4			22		2	6
13	-	12						
14	9/19	13	5	2		2		
15	-							
16	9/18	14	6			1		

The last 2 aerial surveys of lagoons in 1983 were conducted on 20 August, and 6 and 8 September, respectively (Bartels and Doyle 1984). During these 2 surveys, an average of 68% of observed oldsquaw were in the lagoons, and 32% were in the 400m offshore area corresponding to the respective lagoon. The radio relocation data for marked oldsquaw 16 August through 10 September period (Table 6) are comparable to the aerial lagoon survey data. The proportion of oldsquaw fixes in the 400 m offshore zone is 34%, while the proportion of locations found in lagoons is 66%. Although the number of oldsquaw fitted with radios is small, these data suggest that their distribution during the later portion of the molt period is representative of the molting population.

Table 6. Frequency of radioed oldsquaw in various water bodies, before and after 10 September 1983, Arctic National Wildlife Refuge.

	16 August - 10 September		11 September - 13 October	
Water body	No. Observations	%	No. Observations	%
Lagoon	104	50.0	72	41.4
Offshore	53	25.5	65	37.3
Ocean	34	16.3	29	16.7
Pond/Lake	17	08.2	8	4.6
Totals	208	100.0	174	100.0

Sixteen percent of all radio relocation fixes were in the vast area extending from 400 m offshore of the barrier islands to 16 km into the ocean. Thus, aerial surveys conducted during the later portion of the molt period could be missing a large number of oldsquaw present. This vast offshore area would be extremely difficult to adequately sample with available resources (Bartels and Doyle 1984). However, if data from succeeding seasons of field radio telemetry work substantiate this distributional relationship, then it may be possible to calculate a correction factor for oldsquaw missed in the ocean during normal lagoon aerial surveys.

Oldsquaw

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MIGRATORY BIRD USE OF THE COASTAL LAGOON SYSTEM OF THE BEAUFORT SEA COASTLINE WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1983

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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, 1983

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Abstract: Aerial surveys were conducted on 10 selected coastal lagoons of Arctic National Wildlife Refuge during 1983 to obtain an index of relative numbers of migratory birds using the lagoon and to determine the relationship between three different survey techniques. Oldsquaw were identified as the major species using the lagoon (over 80% of the total population). The total number of oldsquaw observed in lagoons in 1983 approximated 1981 totals and exceeded 1982 numbers. Although the temporal distribution of oldsquaw observed was similar in all three years, the spatial relationships varied. As the season progressed, there appeared to be a westerly shift in oldsquaw use of lagoons. A shift from lagoon to offshore was, also, noted. Comparison of oldsquaw numbers and density observed in a 400m strip transect within the lagoon to the whole lagoon areas showed that the birds were not randomly distributed and the strip transect cannot be used as an index of oldsquaw number or density in the entire lagoon. A three strip survey was compared to the total lagoon survey, and revealed that the total lagoon survey remains the best estimate of oldsquaw numbers.

Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1983.

The Congressionally mandated seismic exploration program on the coastal plain of 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 in or close to the lagoon system. Coupled with these exploration programs, there will be an increase in air and boat traffic along the coast to support the exploration operations.

During the short open water season, substantial concentrations of migratory birds are found within and immediately adjacent to coastal lagoons. Previous studies of Beaufort Sea coastal lagoons substantiate that oldsquaw undergoing postnuptial wing molt and premigratory staging is the predominant species present (Schmidt 1970, Bartels 1973, Gallop 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). Oldsquaw are presumed to move from both Alaskan and Canadian areas to utilize Alaskan coastal lagoons (Salter et al. 1980).

Knowledge of peak populations of molting oldsquaw is essential to predict the potential effects of disturbances and pollution. Molting oldsquaw would be particularly vulnerable to oiling. Increased stress due to disturbance may also, lead to increased mortality (Jacobson 1974).

Aerial surveys of migrating birds of the lagoon system on the Arctic National Wildlife Refuge were initiated in 1970 and have continued sporadically to the present (Schmidt 1970, Frickie and Schmidt 1974, Spindler 1978 and 1979, Bartels and Zellhoefer 1983).

Aerial survey techniques were modified in 1981 and they were continued in 1982 and 1983. The objectives of the 1983 season were as follows:

1. Obtain an index of relative numbers of migratory birds using coastal lagoons, especially oldsquaw molting in selected lagoons. Emphasis in 1983 was placed on defining the peak population of oldsquaw.

2. Continue investigating the validity of the 400 m strip aerial census by comparing data from 400 m strip with aerial census of entire lagoon surface.

3. Evaluate the relationship between aerial strip census of shoreline, mid-lagoon, and barrier island strips and aerial census of entire lagoon surface.

4. Examine the distribution of oldsquaw within the 16 km offshore area of the Beaufort Sea.

Materials and Methods

The study area includes the Beaufort Sea coastal portions of ANWR, extending from the Canning River delta on the west to the U.S. Canadian border on the east. Ten lagoons were repeatedly surveyed: Demarcation Bay, Egaksrak

Lagoon, Nuvagapak Lagoon, Oruktalik Lagoon, Tapkaurak Lagoon, Jago Lagoon, Arey Lagoon, Simpson Cove, Tamayariak Lagoon, and Brownlow Lagoon.

Survey methods for lagoon aerial surveys were described in detail by Bartels and Zellhoefer 1983. Bascially, 2 observers count all birds seen in a 200 m wide strip on their respective sides of the aircraft. Therefore, a 400 m strip is surveyed with each successive pass of the aircraft.

Successive 400 m wide strips were flown parallel to the barrier islands until the entire lagoon surface was censused. Data collected from the 400 m strip adjacent to the barrier islands, the 400 m strip in the middle of each lagoon, and the 400 m strip adjacent to the mainland was recorded separately for comparative purposes. Comparison of the 3 strip survey to the total lagoon survey was done to determine if less flying time could be used to adequately describe oldsquaw populations.

The single 400 m offshore strip parallel to the barrier islands was continued. In addition, the distribution of oldsquaw within the 16 km offshore area was investigated. Four transects 400 m wide were flown from the barrier islands to 16 km offshore. Using elapsed time and known airspeed, the 16 km transect was divided into 10 segments. Two offshore transects were flown from Arey Lagoon and 2 from Jago Lagoon.

Results and Discussion

The total number of bird taxa observed in 1981, 1982, and 1983 were 32, 30, and 25 respectively. The species and numbers for each survey are listed by each lagoon as well as the offshore transects in the Appendix Tables A-1 through A-11. Differences in the number of species observed may be real; however, these differences may partially be a result of using different observers throughout the 3 year study. The majority of birds observed during these surveys were oldsquaw (Table 1). The total number of oldsquaw observed in the 10 lagooons during the 3 years of aerial surveys show a similar seasonal distribution between years (Fig. 1). Peak numbers of oldsquaw in 1981 (28,301 oldsquaw) and 1983 (28,048) were approximately identical, while both were greater than the 1982 peak (16,986). These data are generally reflected by data from individual lagons. However, certain lagoons exhibit much variation between years: Tamayariak and Brownlow had higher totals in all 3 surveys in 1982 than 1981; Demarcation Bay and Nuvagapak Lagoon showed considerably higher peaks in 1983 than other years (Table 2).

Overall, the aerial survey data suggest that the 1983 peak appears later than peak populations in 1981 and 1982 (Fig. 1). However, during 1981, the extremely long period between the 2nd and 3rd surveys (almost 3 weeks) could likely have resulted in missing the peak. Johnson (1983) stated that in 1982 at Nuvagapak Lagoon, 50% of the oldsquaw collected (n=22) during 1-8 August period had not yet begun molt of flight feathers. In 1983, 8 oldsquaw were captured on 7-8 August (Bartels et al. 1984). Four of the 8 ducks were in the late stages of completing wing molt, while 4 others were flightless with new flight feathers just beginning growth. From this small sample, it appears that the 1983 molt period was 1 week to 10 days earlier than peak molt in 1982. Because of the long period between the 2nd and 3rd surveys (15 days) in 1982, it is very likely that the peak molting population was missed by the surveys. Therefore, the peak population

Table 1. Number of migratory birdo bserved using 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Lagoon	Survey dates									
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	4 Aug. 1983	7 & 13 Aug. 1982	10 Aug. 1983	24-26 Aug. 1981	20 Aug. 1983	22 Aug. 1982	6-8 Sept. 1983
Demarcation Bay (38.7km^2)										
All Species	2865	849	1611	8299	538	11586	1667	1500	1061	876
Oldsquaw	2678	617	1557	8116	299	11319	1611	1301	919	293
No. Taxa	13	9	9	8	9	8	6	9	6	9
Egaksrak Lagoon (14.0km^2)										
All Species	547	111	441	435	967	418	1146	1552	580	220
Oldsquaw	107	82	355	324	234	314	97	205	61	6
No. Naxa	15	5	9	7	5	7	10	6	5	6
Nuvagapak Lagoon (31.2km^2)										
All Species	1477	146	2486	5746	2845	4654	1060	1755	2286	535
Oldsquaw	1427	126	2448	5689	2669	4572	1004	1076	1422	222
No. Taxa	13	5	10	10	13		5		8	9
Oruktalik Lagoon (8.8km^2)										
All Species	2032	1704	1714	1533	1958	3226	41	367	545	249
Oldsquaw	1997	1657	1698	1524	1906	3206	38	335	508	84
No. Taxa	10	3	4	4	3	5	3	4	4	7
Tapkaurak Lagoon (20.5km^2)										
All Species	2720	1304	2897	891	703	2125	2159	669	85	690
Oldsquaw	2688	1273	2867	884	642	2102	2150	647	71	78
No. Taxa	6	4	6	3	6	3	3	4	5	5
Jago Lagoon (47.3km^2)										
All Species	4131	4189	5895	6192	806	2681	5986	676	1053	854
Oldsquaw	3988	3845	5814	5757	650	2342	5674	551	727	761
No. Taxa	12	9	8	7	9	6	5	5	8	6
Arey Lagoon (40.6km^2)										
All Species	376	306	1319	2541	603	1233	209	1859	456	2629
Oldsquaw	293	274	1016	2410	347	1055	174	1548	352	1886
No. Taxa	12	4	10	6	9	11	4	10	8	11
Simpson Cove (44.4km^2)										
All Species	920	3015	9296	817	4376	2881	317	9781	711	1217
Oldsquaw	850	2906	9187	750	4326	2792	205	9678	665	1119
No. Taxa	9	6	10	6	7	9	7	7	8	8
Tamayariak Lagoon (15.9km^2)										
All Species	174	916	2846	582	5222	313	202	3172	337	446
Oldsquaw	162	625	2606	565	5202	276	150	3116	321	344
No. Taxa	5	7	10		7		6	7	6	5
Brownlow Lagoon (13.1km^2)										
All Species	52	446	744	58	748	93	111	823	238	164
Oldsquaw	50	415	693	45	711	70	95	750	204	37
No. Taxa	2	4	5	5	5	4	6	8	6	3

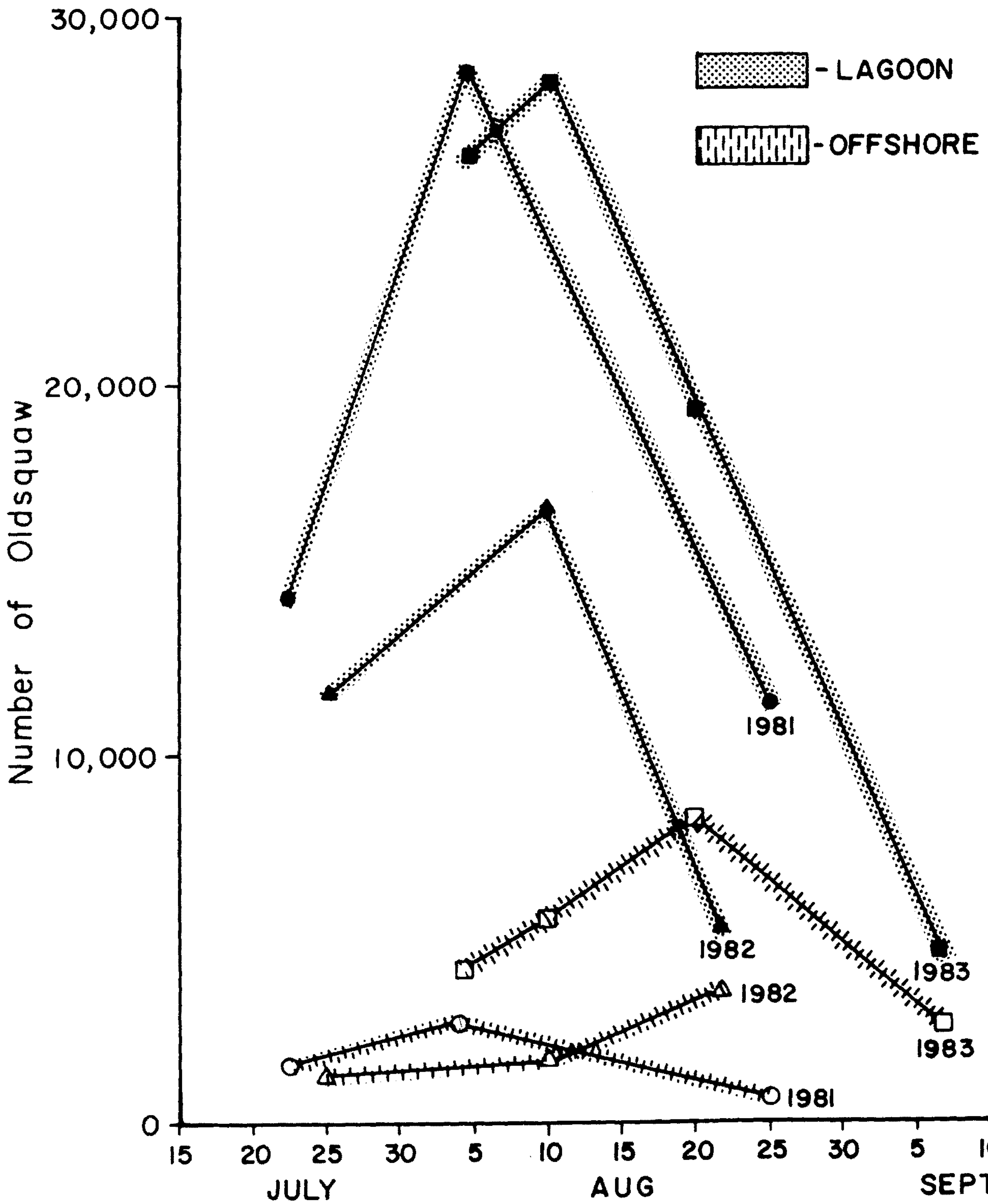

Fig. 1. Number of oldsquaw observed in coastal lagoons and offshore waters of the Beaufort Sea coastline in the Arctic National Wildlife Refuge, 1981, 1982, and 1983.

Table 2. Number of oldsquaw observed in 400 m strip and total area of coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge Alaska, 1981, 1982, and 1983.

Lagoon	Survey dates									
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	4 Aug. 1983	7 & 13 Aug. 1982	10 Aug. 1983	24-26 Aug. 1981	20 Aug. 1983	22 Aug. 1982	6 & 8 Sept. 1983
Demarcation Bay										
Total Lagoon	2678	617	1557	8116	299	11319	1611	1301	919	293
400 m strip	1272	232	726	3651	67	7410	864	284	447	196
Egaksrak Lagoon										
Total Lagoon	107	82	355	324	234	314	97	205	61	6
400 m strip	101	62	299	183	34	269	56	175	35	0
Nuvagapak Lagoon										
Total Lagoon	1427	126	2448	5689	2669	4572	1004	1076	1422	222
400 m strip	494	6	435	1233	941	1265	586	441	498	18
Oruktalik Lagoon										
Total Lagoon	1997	1657	1698	1524	1906	3206	38	335	508	84
400 m Strip	1828	840	517	503	1090	2656	9	162	88	41
Tapkaurak Lagoon										
Total Lagoon	2688	1273	2867	884	642	2102	2150	647	71	78
400 m Strip	2149	521	1082	153	572	1227	97	35	25	39
Jago Lagoon										
Total Lagoon	3988	3845	5184	5757	650	2342	5674	551	727	761
400 m Strip	615	661	585	932	189	75	484	109	73	82
Arey Lagoon										
Total Lagoon	293	274	1076	2410	347	1055	174	1548	352	1886
400 m Strip	267	180	461	58	26	356	97	1117	223	1214
Simpson Cove										
Total Lagoon	850	2906	9187	750	4326	2792	205	9678	665	1119
400 m Strip	180	725	1164	91	1952	1182	47	4328	310	443
Tamayariak Lagoon										
Total Lagoon	162	625	2606	565	5202	276	150	3116	321	344
400 m Strip	78	210	860	281	4647	132	31	1850	120	4
Brownlow Lagoon										
Total Lagoon	50	415	693	45	711	70	95	750	204	150
400 m Strip	50	415	690	42	705	70	94	750	204	96
Total										
Total Lagoon	14240	11820	28301	26064	16986	28048	11198	19207	5250	4830
400 m Strip	7034	3852	6819	7127	10223	14642	2365	9251	2023	2133

depicted in Fig. 1 for 1982 is probably lower than the actual peak oldsquaw population.

In 1983, the lagoons east of Barter Island accounted for the majority of oldsquaw encountered during the two earlier surveys. During the third and fourth surveys, there was a shift in this relationship (Fig. 2). The 4 lagoons west of Barter Island held a greater number of oldsquaw than did the 6 lagoons east of Barter Island. These data indicate a general westward shift in oldsquaw use of coastal lagoons during late August and early September.

The data for the 400m offshore survey exhibit the same trend for a westerly shift in lagoon use by oldsquaw. However, the shift to the offshore areas west of Barter Island was noted during the second survey in mid-August (Fig. 3).

Overall, these data indicate a westerly shift from early August to early September in oldsquaw utilizing the surveyed lagoons in 1983. Radio telemetry data (Bartels et al. 1984) indicate a general westerly movement along the coast by oldsquaw after molt was complete, and migration began.

The proportion of oldsquaw in the 400m offshore area of a particular lagoon in relation to the total oldsquaw in lagoons and the offshore, increased with time (Table 3). The 2 earliest surveys of 1983 showed 8.9% and 9.4% of oldsquaws sighted respectively for the proportion of oldsquaw occurring in the offshore areas. By the third and fourth survey, the proportion of oldsquaw found offshore increased to over 30% (Table 3). This shift offshore is noted in Fig. 1 for the 1982 and 1983 data. The decline in the offshore noted during the third survey of 1981 may be due to the long period between the second and third surveys (21 days). Also, there could have been a peak in oldsquaw using the lagoons and a subsequent decline as migration began during the period between these 2 surveys in 1981. Johnson and Richardson (1981), also noted a movement of post-molting oldsquaw to offshore areas.

The ocean transects designed to sample ocean areas between barrier islands to 16 km offshore were not conclusive in 1983 (Table 4). The first set of ocean transects had to be terminated at 5 km from the barrier islands due to unsafe flying conditions. However, oldsquaw that were observed were less than 3 km from the shoreline. The second survey produced no observations of oldsquaw. The third set of surveys indicated that oldsquaw were present to 14.5 km offshore. A larger sample of offshore transects would be necessary before sufficient data could be collected to elucidate the relationships between oldsquaw use of lagoon and nearshore habitats and offshore habitats. These surveys should not be conducted in the future with a single engine aircraft, due to the hazard of flying far out to sea over broken ice and water.

During 1983, the density of migratory birds using the lagoons ranged from a low of 3 birds/km^2 in Brownlow lagoon to a high of 364 birds/km^2 in Oruktaluk Lagoon (Table 5). In most instances, oldsquaw comprised over 80% of the birds using the lagoons (Table 1).

The relative proportions of numbers of oldsquaw observed in the 400 m transect and the total lagoon surface were compared to the respective

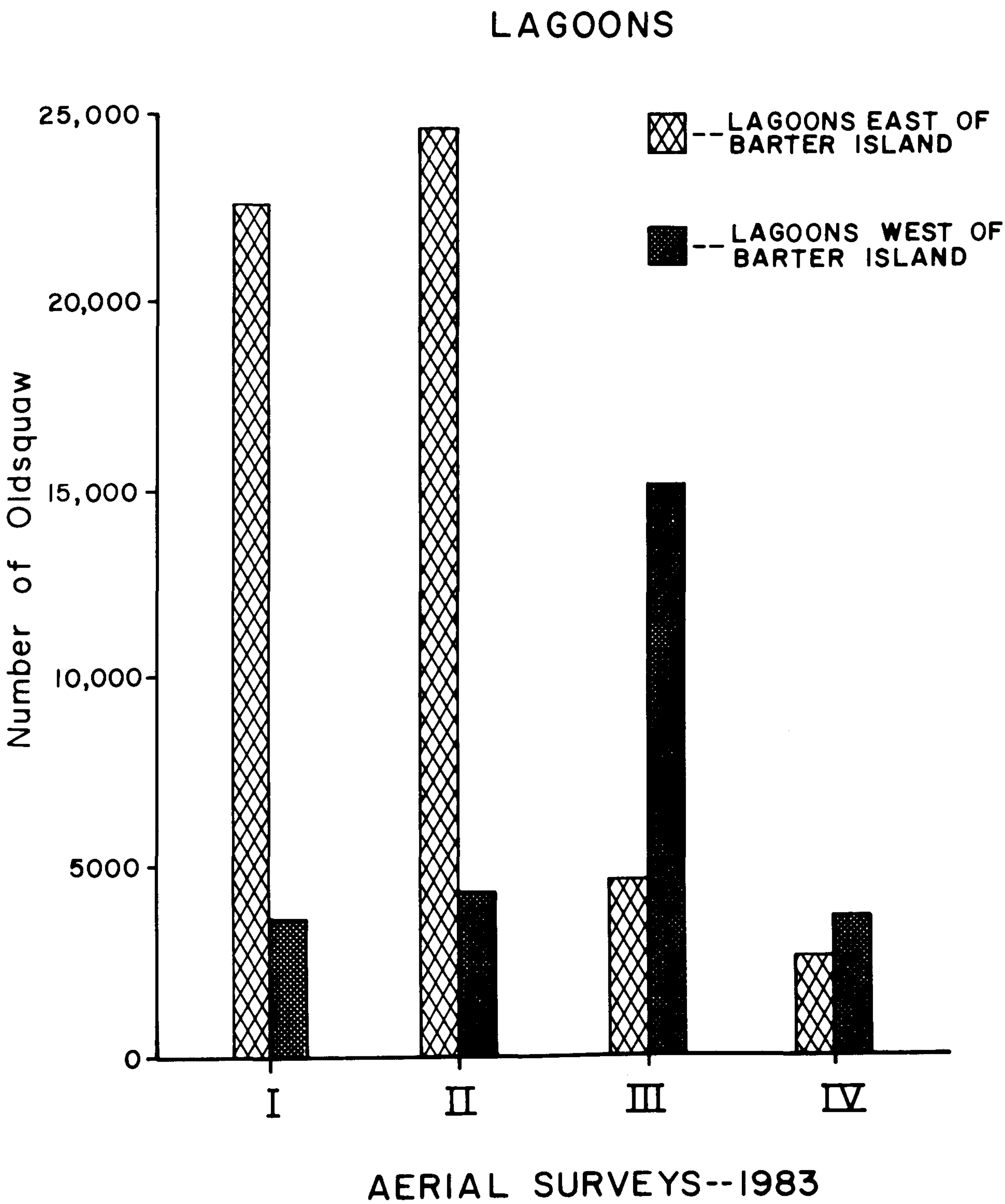

Fig. 2. Number of oldsquaw in coastal lagoons of the Arctic National Wildlife Refuge, 1983.

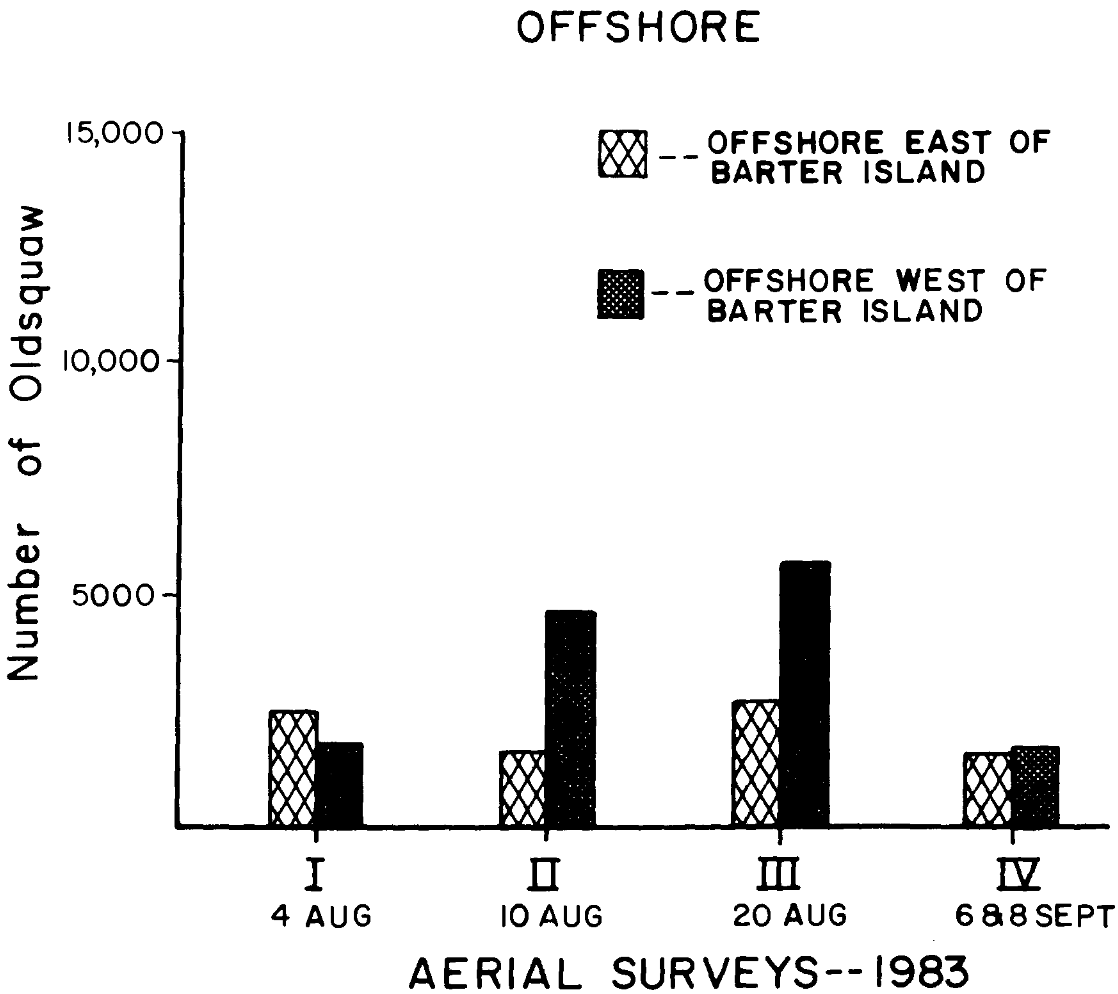

Fig. 3. Number of oldsquaw in 400 m offshore area of Arctic National Wildlife Refuge, 1983.

Table 3. Number of oldsquaw in selected lagoons and corresponding 400 m offshore zone along the Beaufort Sea coastline of Arctic National Wildlife Refuge, Alaska, 1983.

Survey date	Lagoon										Proportion
	Demarcation	Egaksrak	Beaufort	Oruktalik	Tapkaurak	Jago	Arey	Tamayariak	Brownlow	Total	offshore
4 Aug.:											
Offshore	740	283	264	115	267	147	450	30	142	2,438	8.8%
Lagoon	8,116	324	5,689	1,524	884	5,757	2,410	565	45	25,314	
10 Aug.:											
Offshore	10	76	5	246	395	303	227	1,076	283	2,621	9.4%
Lagoon	11,319	314	4,572	3,206	2,102	2,342	1,055	276	70	25,256	
20 Aug.:											
Offshore	149	7	70	775	407	501	946	75	1,190	4,120	30.2%
Lagoon	1,301	205	1,076	335	647	551	1,548	3,116	750	9,529	
6 & 8 Sept.:											
Offshore	129	14	16	157	91	488	616	9	680	2,200	37.2%
Lagoon	293	6	222	84	78	761	1,886	344	37	3,711	

Table 4. Number of oldsquaw observed during ocean transects on Beaufort Sea coastline of Arctic National Wildlife Refuge, Alaska, 1983

Offshore transect		Km from barrier island									
		1.6	3.2	4.8	6.4	8.0	9.6	11.2	12.9	14.5	16.1
4 Aug.	Arey I										
	Arey II	96									
	Jago I										
	Jago II	63	2								
20 Aug.	Arey I										
	Arey II										
	Jago I										
	Jago II										
8 Sept.	Arey I									20	
	Arey II			35							
	Jago I		35						2		
	Jago II			6	3	1					

Table 5. Density (birds/km^2) of oldsquaw observed in 400 m strip and total area of coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982 and 1983.

Survey area	Survey dates: 22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	4 Aug 1983	7&13 Aug. 1982	10 Aug. 1983	24-26 Aug. 1981	20 Aug. 1983	22 Aug. 1982	6 & 8 Sept. 1983
Demarcation Bay										
Total Lagoon	38.6	15.9	73.1	210	7.7	292	41.6	34	23.7	8
400 m Strip	636.0	116.0	363.0	1825	33.5	3705	432.0	142	223.7	98
Egaksrak Lagoon										
Total Lagoon	7.6	5.9	25.4	23	16.7	22	6.9	15	4.4	0.4
400 m Strip	37.4	22.9	110.7	68	12.7	97	20.7	65	13.0	0
Nuvagapak Lagoon										
Total Lagoon	45.7	4.0	78.5	182	85.5	147	32.2	34	45.6	7
400 m Strip	83.7	1.0	73.7	209	159.4	214	99.3	75	84.4	3
Oruktalik Lagoon										
Total Lagoon	226.9	188.0	193.0	173	216.6	364	4.3	38	57.7	10
400 m Strip	823.4	381.0	235.0	229	495.4	1207	4.0	74	40.0	19
Tapkaurak Lagoon										
Total Lagoon	131.1	62.1	139.8	43	31.3	103	105.0	32	3.5	4
400 m Strip	499.8	121.1	251.6	36	133.0	285	22.5	8	5.8	9
Jago Lagoon										
Total Lagoon	84.3	81.2	122.9	122	13.7	50	120.0	12	15.4	16
400 m Strip	113.9	122.4	108.3	173	35.0	14	89.6	20	13.5	15
Arey Lagoon										
Total Lagoon	7.2	6.7	26.5	59	8.5	26	4.3	38	8.7	46
400 m Strip	49.4	33.3	85.4	11	4.8	66	18.0	207	41.3	225
Simpson Cove										
Total Lagoon	19.1	65.4	206.7	17	97.4	63	4.6	218	15.0	25
400 m Strip	26.7	108.2	173.7	14	291.3	176	7.0	646	46.3	66
Tamayariak Lagoon										
Total lagoon	10.2	39.3	163.9	35	327.2	17	9.4	196	20.2	22
400 m Strip	10.4	28.0	114.7	17	619.6	18	4.1	247	16.0	0.5
Brownlow Lagoon										
Total Lagoon	3.8	31.6	52.9	3	54.3	5	7.3	57	32.9	11
400 m Strip	8.1	66.9	111.2	7	113.7	11	15.2	121	32.9	15
Total										
Total Lagoon	51.9	43.1	103.1	95	61.9	102	40.8	70	19.1	18
400 m Strip	145.6	79.8	141.2	148	211.7	303	49.0	192	41.9	44

Table 6. Area of 400 m survey strip and entire lagoons, Arctic National Wildlife Refuge.

Lagoon	Area (km2)		
	400 m strip	Total lagoon	Strip % of Total
Demarcation Bay	2.0	38.7	5
Egaksrak Lagoon	2.7	14.0	19
Nuvagapak Lagoon	5.9	31.2	19
Oruktalik Lagoon	2.2	8.8	25
Tapkaurak Lagoon	4.3	20.5	21
Jago Lagoon	5.4	47.3	11
Arey Lagoon	5.4	40.6	13
Simpson Cove	6.7	44.4	15
Tamayariak Lagoon	7.5	15.9	47
Brownlow Lagoon	6.2	13.1	47
Total	48.3	274.5	17.6

Table 7. Relationship between number and density of oldsquaw in 400 m transect and entire lagoons, Arctic National Wildlife Refuge, Alaska, 1981, 1982, 1983.

Survey period	Variable	R^2	Fitted regression equation	Observed significance level	n	Correlation coefficient	Observed significance level
23 July 1981 and 25-26 July 1982	Numbers	0.41	Y = 540.98 + 1.4X	0.01	20	0.64	0.01
3-4 August 1981 7 & 13 August 1982 4 August 1983 10 August 1983	Numbers	0.59	Y = 1072.03 + 1.44X	0.001	40	0.77	0.001
24 & 26 August 1981 22 August 1982 20 August 1983	Numbers	0.76	Y = 256.5 + 2.05X	0.001	30	0.87	0.001
6 & 8 September 1983	Numbers	0.86	Y = 180.75 + 1.47X	0.001	10	0.93	0.001
23 July 1981 25-26 July 1982	Density	0.61	Y = 19.10 + 0.21X	0.001	20	0.78	0.01
3-4 August 1981 7 & 13 August 1982 4 August 1983 10 August 1983	Density	0.40	Y = 70.6 + 0.09X	0.001	40	0.63	0.001
24 & 26 August 1981 22 August 1982 20 August 1983	Density	0.46	Y = 16.65 + 0.26X	0.001	30	0.68	0.001
6 & 8 September 1983	Density	0.62	Y = 8.18 + 0.15X	0.02	10	0.79	0.02

Table 8. Number of oldsquaw observed in Barrier Island, Mid-lagoon, shoreline survey segments and total lagoon survey in 8 selected coastal lagoons of the Arctic National Wildlife Refuge, Alaska, 1983.

Survey area	4 August		10 August		20 August		6-8 September	
	Total B.I.,[a] Mid & Shore	Total Lagoon	Total B.I., Mid & Shore	Total Lagoon	Total B.I., Mid & Shore	Total Lagoon	Total B.I., Mid & Shore	Total Lagoon
Demarcation Bay	4305	8116	8340	11319	333	1301	203	293
Egaksrak lagoon	293	324	314	314	175	205	6	6
Nuvagapak lagoon	2167	5689	2975	4572	645	1076	62	222
Oruktalik lagoon	1206	1524	3206	3206	179	335	68	84
Tapkaurak lagoon	864	884	1812	2102	211	647	65	78
Jago lagoon	3008	5757	1000	2342	273	551	171	761
Arey lagoon	1423	2410	656	1055	1117	1548	1688	1886
Simpson Cove	380	750	1522	2792	8825	9678	871	1119

[a]B.I. = barrier island, mid = mid lagoon, shore = shoreline 400 m transects

proportions of the lagoon area in each category (Table 6). Chi-square was used to make these comparisons (Conover 1971). In all instances, there was a significant (P 0.05) difference between the numbers of oldsquaw in the 400 m transect and the entire lagoon. Usually, a disproportionate number of oldsquaw occurred in the 400 m transect than in the entire lagoon (Table 2). These data confirm the hypothesis that oldsquaw are not randomly distributed within lagoons.

The relationship between the number and density of oldsquaw observed in the 400 m strip and corresponding number (Table 2) and density (Table 5) of oldsquaw observed in the total lagoon was examined using regression analysis (Draper and Smith 1966). Comparable survey periods in 1981, 1982, and 1983 were combined in these analyses. During most survey periods, the linear relationship between number and density of oldsquaw in the 400 m transect and the entire lagoon was statistically significant as was the associated correlation coefficient (Table 7). This relationship was more definitive for density than it was for numbers of oldsquaw (re. R^2 values in Table 8). However, due to the relatively large amount of variation not accounted for by the fitted regression equations (ranging from 60% to 13%), the predictability of these equations is questionable.

In 1983, the number of oldsquaw observed in the 400 m barrier island strip was added to a 400 m mid-lagoon strip and a 400 m mainland strip (Table 8). If this 3 strip survey method (Johnson 1983) could adequately describe oldsquaw populations, flying time for lagoon survey could be reduced. The 3 strip survey was compared to the survey of the entire lagoon surface using Chi-square (Conver 1971). There was a significant difference between the 2 survey methods (P 0.05). The 3 pass survey evidently missed a great many oldsquaw (Table 8).

The effects of numerous other physical and environmental variables (wind direction, velocity, lagoon orientation, lagoon configuration, bottom configuration, cloud cover, barometric pressure, invertebrate populations, etc.) may be influencing numbers and distribution of oldsquaw using a lagoon at any point in time. However, each lagoon is unique, and a single standardized strip survey does not produce information useful in population trend analysis. Consequently, by sampling the entire lagoon surface, differences between oldsquaw distributional patterns within lagoons can be eliminated. The problem then becomes defining and selecting which lagoons are representative of the system.

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APPENDIX

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Table A-1. Migratory bird species and numbers observed during aerial surveys of Brownlow lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Species	Survey dates									
	22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	24&26 Aug 1981	22 Aug 1982	20 Aug 1983	6 & 8 Sep 1983
Common Loon						1			1	
Yellow-Billed Loon							2		2	
Arctic Loon		2	1		5		2		2	2
Red-throated Loon			1	1		13	1		6	
Loon spp.						1	5	2	2	1
Red-necked Grebe										
Tundra Swan										
Brant								21		
Snowgoose										
Goose spp.										
Northern Pintail										
Scaup spp.										
Oldsquaw	50	415	693	45	711	70	95	204	750	37
Common Eider										
King Eider										
Spectacled Eider										
Eider spp.			38							
White-winged Scoter										
Surf Scoter										
Black Scoter										
Scoter spp.										
Red-breasted Merganser			2							
Duck spp.		8						8		
Sandhill Crane										
Plover spp.										
Phalarope spp.										
Shorebird spp.				3	25					
Parasitic Jaeger										
Pomarine Jaeger										
Jaeger spp.										
Glaucous Gull	2	21	8	8	3	8	6	2	39	27
Herring-Thayer's Gull										
Black-legged Kittiwake									6	
Sabines Gull										
Arctic Tern				1					15	97
Black Guillemot					4					
Tufted Puffin										
Passerine spp.										
Snowy Owl										
Seal										

Table A-2. Migratory bird species and numbers observed during aerial surveys of Tamayariak lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Species	Survey dates 22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	24&26 Aug 1981	22 Aug 1982	20 Aug 1983	6 & 8 Sep 1983
Common Loon										
Yellow-Billed Loon			2							
Arctic Loon	1					2	1	1		9
Red-throated Loon				2	1	6	3	2		
Loon spp.								1	3	2
Red-necked Grebe									1	
Tundra Swan										
Brant	9		29				9	4		
Snowgoose										
Goose spp.										
Northern Pintail			4				1			
Scaup spp.										
Oldsquaw	162	625	2606	565	5202	276	150	321	3116	344
Common Eider				1						
King Eider		3								
Spectacled Eider										
Eider spp.	1		81		1		1			
White-winged Scoter						2				
Surf Scoter		269								
Black Scoter						1				
Scoter spp.									10	1
Red-breasted Merganser		1								
Duck spp.		4	80	5						
Sandhill Crane										
Plover spp.										
Phalarope spp.			38			4				
Shorebird spp.			3		11		40		3	
Parasitic Jaeger										
Pomarine Jaeger										
Jaeger spp.										
Glaucous Gull		12		9	5	22		8	27	28
Herring-Thayer's Gull										
Black-legged Kittiwake										
Sabines Gull		2								
Arctic Tern			3		1				12	62
Black Guillemot					1					
Tufted Puffin										
Passerine spp.										
Snowy Owl										
Seal										

Table A-3. Migratory bird species and numbers observed during aerial surveys of Simpson Cove along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Species	Survey dates									
	22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	24&26 Aug 1981	22 Aug 1982	20 Aug 1983	5 & 8 Sep 1983
Common Loon						2				
Yellow-Billed Loon								1	1	
Arctic Loon			10	2	1	2		1	4	1
Red-throated Loon	1		11	1		5			1	5
Loon spp.			1			3	5	2	9	9
Red-necked Grebe										
Tundra Swan					2			1		
Brant							10	11		
Snowgoose										
Goose spp.										
Northern Pintail										
Scaup spp.									2	
Oldsquaw	850	2906	9187	750	4326	2792	205	665	9678	1119
Common Eider										
King Eider										
Spectacled Eider										
Eider spp.	25	9	12		12	6	10			60
White-winged Scoter										
Surf Scoter			7							
Black Scoter		40								
Scoter spp.	12			1		4				11
Red-breasted Merganser	1								50	
Duck spp.	3	6	4	12						5
Sandhill Crane										
Plover spp.										
Phalarope spp.	3		1		2	2				
Shorebird spp.		8	20				55			
Parasitic Jaeger					1					
Pomarine Jaeger										
Jaeger spp.				1						1
Glaucous Gull	15	46	43	50	25	64	32	26	36	9
Herring-Thayer's Gull						1				
Black-legged Kittiwake										
Sabines Gull										
Arctic Tern										2
Black Guillemot										
Tufted Puffin										
Passerine spp.										
Snowy Owl										
Seal										

Table A-4. Migratory bird species and numbers observed during aerial surveys of Arey lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Species	22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	24&26 Aug 1981	22 Aug 1982	20 Aug 1983	6 & 8 Sep 1983
	Survey dates									
Common Loon										
Yellow-Billed Loon						1				2
Arctic Loon	1	3	7	15		2		3	5	2
Red-throated Loon	2		5	2		3		2	1	1
Loon spp.	1	7	3	7	1	10	1	2	3	6
Red-necked Grebe										
Tundra Swan					7	2				3
Brant						25		76	135	223
Snowgoose										
Goose spp.										
Northern Pintail			47			1	2	10		
Scaup spp.										
Oldsquaw	293	274	1016	2410	347	1055	174	352	1548	1886
Common Eider					4					
King Eider										
Spectacled Eider										
Eider spp.			14		40	13				6
White-winged Scoter									10	
Surf Scoter						50				
Black Scoter									50	
Scoter spp.			50	81		4		11		29
Red-breasted Merganser										
Duck spp.								4		
Sandhill Crane										
Plover spp.	1									
Phalarope spp.			100		4	1			20	
Shorebird spp.	46		2	4	48				10	
Parasitic Jaeger										
Pomarine Jaeger										
Jaeger spp.										1
Glaucous Gull	25	22	75	22	149	66	32	6	67	413
Herring-Thayer's Gull										
Black-legged Kittiwake										
Sabines Gull										
Arctic Tern	4				3					57
Black Guillemot										
Tufted Puffin										
Passerine spp.										
Snowy Owl										
Seal										

Table A-5. Migratory bird species and numbers observed during aerial surveys of Jago lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Species	Survey dates									
	22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	24&26 Aug 1981	22 Aug 1982	20 Aug 1983	6 & 8 Sep 1983
Common Loon										
Yellow-Billed Loon			5							
Arctic Loon	2			9						
Red-throated Loon		2		6	2			2	1	2
Loon spp.	1	7	5	14	2	7				1
Red-necked Grebe										
Tundra Swan										
Brant										
Snowgoose										
Goose spp.										
Northern Pintail	3									
Scaup spp.		46								
Oldsquaw	3988	3845	5814	5757	650	2342	5674	727	551	767
Common Eider										
King Eider		5			1			1		
Spectacled Eider										
Eider spp.			11							
White-winged Scoter										
Surf Scoter	30	111	5	158			5	32	8	
Black Scoter				1	11	70		3	46	
Scoter spp.			16	86	6	7			63	4
Red-breasted Merganser		1								
Duck spp.		2			6					
Sandhill Crane										
Plover spp.										
Phalarope spp.	1					45				25
Shorebird spp.	33			27	2		2	34		
Parasitic Jaeger										
Pomarine Jaeger										
Jaeger spp.	1									
Glaucous Gull	68	170	36	134	126	210	304	251		1
Herring-Thayer's Gull										
Black-legged Kittiwake										
Sabines Gull										
Arctic Tern	4		3				1		7	60
Black Guillemot								3		
Tufted Puffin										
Passerine spp.										
Snowy Owl										
Seal										

Table A-6. Migratory bird species and numbers observed during aerial surveys of Tapkaurak lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Species	Survey dates									
	22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	24&26 Aug 1981	22 Aug 1982	20 Aug 1983	6 & 8 Sep 1983
Common Loon										
Yellow-Billed Loon	1									
Arctic Loon		1	1							2
Red-throated Loon					2					
Loon spp.	1	9	2			3		3		1
Red-necked Grebe										
Tundra Swan										
Brant										
Snowgoose										
Goose spp.										
Northern Pintail	3					20	6			
Scaup spp.										
Oldsquaw	2688	1237	2867	884	642	2102	2150	71	647	78
Common Eider										
King Eider					1					
Spectacled Eider										
Eider spp.										
White-winged Scoter										
Surf Scoter										1
Black Scoter									3	
Scoter spp.	6		2	3	20				4	43
Red-breasted Merganser										
Duck spp.					30			3		
Sandhill Crane										
Plover spp.										
Phalarope spp.			20							560
Shorebird spp.										
Parasitic Jaeger										
Pomarine Jaeger										
Jaeger spp.										
Glaucous Gull	21	21	5		8		3	6	15	
Herring-Thayer's Gull										
Black-legged Kittiwake										
Sabines Gull										
Arctic Tern										
Black Guillemot										
Tufted Puffin								2		
Passerine spp.										
Snowy Owl										
Seal										

Table A-7. Migratory bird species and numbers observed during aerial surveys of Oruktalik lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Species	Survey dates									
	22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	24&26 Aug 1981	22 Aug 1982	20 Aug 1983	6 & 8 Sep 1983
Common Loon										
Yellow-Billed Loon	1					2				
Arctic Loon	2									
Red-throated Loon						3			1	
Loon spp.	3			7	3	1	2			
Red-necked Grebe										
Tundra Swan										
Brant								6		10
Snowgoose										
Goose spp.										
Northern Pintail	3									
Scaup spp.										
Oldsquaw	1997	1657	1698	1524	1906	3206	38	508	335	84
Common Eider										
King Eider										
Spectacled Eider										
Eider spp.	1									
White-winged Scoter										
Surf Scoter										
Black Scoter										
Scoter spp.	1			1					5	
Red-breasted Merganser										
Duck spp.								2		
Sandhill Crane										
Plover spp.										
Phalarope spp.			5			10				50
Shorebird spp.	2	25								
Parasitic Jaeger										
Pomarine Jaeger										
Jaeger spp.										
Glaucous Gull	21	22	11	1	49	4		29	26	6
Herring-Thayer's Gull										
Black-legged Kittiwake										3
Sabines Gull										78
Arctic Tern	1						1			18
Black Guillemot										
Tufted Puffin										
Passerine spp.										
Snowy Owl										
Seal										

Table A-5. Migratory bird species and numbers observed during aerial surveys of Nuvagapak lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Species	Survey dates									
	22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	24&26 Aug 1981	22 Aug 1982	20 Aug 1983	6 & 8 Sep 1983
Common Loon										
Yellow-Billed Loon	1		1		1					
Arctic Loon	5			5	1	4		5		2
Red-throated Loon	1		1	1	4	1		1	8	1
Loon spp.	1		5	2	3	4	1	1	1	1
Red-necked Grebe										
Tundra Swan	2	5	3	5						
Brant					60			810	580	20
Snowgoose										
Goose spp.										50
Northern Pintail							25			
Scaup spp.				4					3	40
Oldsquaw	1427	126	2448	5689	2669	4572	1004	1422	1076	222
Common Eider				1						
King Eider										
Spectacled Eider										
Eider spp.		6			10	10				10
White-winged Scoter										
Surf Scoter				1						
Black Scoter	4							10		
Scoter spp.				11					2	
Red-breasted Merganser	13				15				13	6
Duck spp.	4		8		5		1			
Sandhill Crane	2									
Plover spp.						5				
Phalarope spp.			5		50					
Shorebird spp.	2		1	3				20		
Parasitic Jaeger										
Pomarine Jaeger										
Jaeger spp.					1					
Glaucous Gull	14	8	14	19	25	58	29	17	69	9
Herring-Thayer's Gull										
Black-legged Kittiwake										
Sabines Gull										
Arctic Tern	1			5	1				3	174
Black Guillemot										
Tufted Puffin										
Passerine spp.										
Snowy Owl										
Seal										

Table A-9. Migratory bird species and numbers observed during aerial surveys of Egaksrak lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Species	22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	24&26 Aug 1981	22 Aug 1982	20 Aug 1983	6 & 8 Sep 1983
Common Loon										
Yellow-Billed Loon										
Arctic Loon	1			1		9		1		
Red-throated Loon	1	1		3		1	3		1	1
Loon spp.	1		1	5		2	3	9		
Red-necked Grebe										
Tundra Swan	55		14	14		10	11	4	3	
Brant			3		708		350	505	1265	20
Snowgoose										
Goose spp.										
Northern Pintail	19						4			
Scaup spp.			1				10			
Oldsquaw	107	82	355	324	234	314	97	61	205	6
Common Eider	10	4								
King Eider		10								
Spectacled Eider										
Eider spp.										
White-winged Scoter										10
Surf Scoter										
Black Scoter										
Scoter spp.				1						
Red-breasted Merganser	3									
Duck spp.	18									
Sandhill Crane										
Plover spp.										
Phalarope spp.			55		12	45			25	
Shorebird spp.	321		2	16			210			
Parasitic Jaeger										
Pomarine Jaeger										
Jaeger spp.										
Glaucous Gull	8	14	10	71	12	30	12		53	9
Herring-Thayer's Gull										
Black-legged Kittiwake										
Sabines Gull										
Arctic Tern	2				1					174
Black Guillemot										
Tufted Puffin										
Passerine spp.										
Snowy Owl	1									
Seal										

Table A-10. Migratory bird species and numbers observed during aerial surveys of Demarcation Bay along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982, and 1983.

Species	Survey dates 22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	24&26 Aug 1981	22 Aug 1982	20 Aug 1983	6 & 8 Sep 1983
Common Loon										2
Yellow-Billed Loon	1									
Arctic Loon	3	3	1	5		6			2	1
Red-throated Loon	3	1	1	3		2		5		1
Loon spp.	1	3	2	8		6	4		4	1
Red-necked Grebe										
Tundra Swan			2							2
Brant										350
Snowgoose									52	
Geese spp.										
Northern Pintail				1						
Scaup spp.	16		1						5	
Oldsquaw	2678	617	1557	8116	229	11319	1611	919	1301	293
Common Eider					13				[illegible]	
King Eider					1					
Spectacled Eider										
Eider spp.	3		11		9	15				
White-winged Scoter						5				
Surf Scoter	4	165		61	38	60		69	63	74
Black Scoter		15				1			1	
Scoter spp.	137	30	29	41		143	1	24	12	29
Red-breasted Merganser				6			5			
Duck spp.	5	8						4		
Sandhill Crane										
Plover spp.										
Phalarope spp.					7		35		5	
Shorebird spp.	5			1						
Parasitic Jaeger										
Pomarine Jaeger										
Jaeger spp.										
Glaucous Gull	8	7	5	57	155	29	11	40	30	15
Herring-Thayer's Gull										
Black-legged Kittiwake										
Sabines Gull										
Arctic Tern	1									108
Black Guillemot										
Tufted Puffin										
Passerine spp.										
Snowy Owl										
Seal				1						

Table A-11. Species and numbers of migratory birds observed in 400 m offshore transect along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981, 1982 and 1983.

Species	22-23 July 1981	25-26 July 1982	3-4 Aug 1981	4 Aug 1983	7&13 Aug 1982	10 Aug 1983	22&26 Aug 1981	22 Aug 1983	20 Aug 1982	6 & 8 Sep 1983
	Survey dates									
Common Loon						1				
Yellow-Billed Loon	8		3			2			1	1
Arctic Loon		6	14	16	3	18	2	14	11	
Red-throated Loon	4	4	20	10		23	2	14	26	7
Loon spp.	2		23	23	8	42	3	14	29	11
Red-necked Grebe										
Tundra Swan										
Brant								220		95
Snowgoose									30	
Goose spp.										2
Northern Pintail			12							
Scaup spp.	1				2		82			
Oldsquaw	1696	1339	2868	4207	1911	5632	824	3867	8255	2808
Common Eider		3	4	47	2	19		1		1
King Eider		8								
Spectacled Eider										
Eider spp.	122	20	51	52	17	74	12	1	38	129
White-winged Scoter	20									
Surf Scoter	1	311		9		12		26	27	
Black Scoter		4				2			11	
Scoter spp.	27	14	4	126		15			226	48
Red-breasted Merganser	1			2						
Duck spp.		84	3	8	5			46		
Sandhill Crane			2							
Plover spp.										
Phalarope spp.			29		7				82	16,425
Shorebird spp.		91	28	2	24		46	7		
Parasitic Jaeger								1		
Pomarine Jaeger										
Jaeger spp.						1				
Glaucous Gull	52	43	194	147	57	36	115	54	158	488
Herring-Thayer's Gull										
Black-legged Kittiwake			1						5	
Sabines Gull								1		408
Gull spp.								4		
Arctic Tern	8		1	1	1	4		4	26	961
Black Guillemot	5			17	9				2	
Tufted Puffin										
Passerine spp.										
Snowy Owl										
Seal									2	

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DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF TUNDRA SWANS IN THE COASTAL WETLANDS OF THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1983

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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, 1983

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Abstract:
Two aerial surveys of tundra swans utilizing coastal wetlands of Arctic National Wildlife Refuge were conducted in 1983. The first survey, a breeding pair/nesting survey, was conducted on 2-3 June; a second survey to determine productivity, was conducted on 21 August. These surveys are used to describe the distribution, abundance, and productivity of the tundra swan population. Survey methods were those described by Bartels et al. (1983). The nesting population was estimated to be a minimum of 105 pairs. Total swan numbers in 1983 increased 13% and 67% over 1981 and 1982, respectively. Adults in 1983 declined 2% over 1981, and increased 31% over 1982. Cygnet production in 1983 increased 70% and 316% respectively over 1981 and 1982. Swans on 1 concentration area were stable over 3 years. A second area had an increase in 1983 over 1982, with 1981 numbers comparable to 1983. The third major area in 1983 had numbers exceeding both previous years. Swans in the fourth area declined over 1981, but increased over 1982. Since air traffic and human disturbance was equally high in 1982 and 1983, the milder weather of 1983 probably contributed to greater production.

Distribution, abundance, and productivity of tundra swans in the coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1983.

The Congressionally mandated seismic exploration program 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 an excellent indicator species for the overall well being of all waterfowl in a given habitat (King 1973).

Limited aerial surveys of tundra swans on the Arctic National Wildlife Refuge coastal plain were initiated in 1977 and included 1 wetland area. In 1978, an additional wetland area was added. Then, a portion of the entire coastal wetland area was sampled in 1979. These initial tundra swan surveys were summarized by Jacobsen (1979). Spindler (1981) reported on an expanded coastal aerial survey conducted in 1981. The 1982 and 1983 surveys included identical areas as covered in 1981.

Materials and Methods

The 4 major swan concentration areas were described in the 1982 Update to Baseline Report (Bartels et al. 1983). The survey methods for tundra swans were described in the 1982 Update to the Baseline Study (Bartels et al. 1983). In 1983, a Helio-courier aircraft was used instead of a Cessna 185. Also in 1983, 2 complete aerial surveys of swans were conducted. The first survey (new in 1983) was conducted in mid-June. This survey was a breeding pair/nesting survey. The second survey, conducted in mid-August, during molt, was a production survey.

One change in the methods described for 1982 was initiated. Swan locations were plotted on USGS 1:63,360 scale maps instead of 1:250,000 scale previously used. This refinement in the mapping effort better delineated wetlands utilized. A second benefit was that survey data collection was compatible with other statewide swan surveys.

Results and Discussion

Nesting Distribution

The distribution of nesting swans observed on the coastal concentration areas is illustrated in Fig. 1. The number of nests observed plus the number of pairs observed without nests was assumed to be the breeding population. It is possible that some of the single birds could have been members of a nesting pair, of which the nest was missed. However, due to this uncertainty, they will not be considered as breeding birds.

The Canning-Tamayariak delta area and the Aichilik-Egaksrak-Kongakut delta respectively held the highest number of nests. These 2 areas contained 69% of nests found during the survey (Table 1). Successive years' data from this new survey should yield information on temporal changes in nesting attempts, distribution of nests, and nesting success.

Table 1. Tundra swan population statistics for 1983 nesting survey, 21 June 1983.

Area	Total Adults	No. Nests	No.Pairs w/o nests	Breeding Population (# pairs)	Singles	No.birds in grps 3
Canning/ Tamayariak Delta	98	25	11	36	16	10
Hulahula Delta	36	11	3	14	4	4
Jago Delta & Wetlands	13	5	1	6	1	-
Aichilik/Egaksrak/ Kongakut Delta	74	29	6	35	4	-
Demarcation Bay	16	2	1	3	2	8
Other areas	27	6	5	11	5	-
Totals	264	78	27	105	32	22

Distribution

The Canning-Tamayariak delta accounted for 186 swans (34% of total) during the post-breeding survey. This was a 250% increase over 1982, and the 1983 number was almost identical to numbers observed in 1981. (Table 2). The Aichilik-Egaksrak-Kongakut delta accounted for 164 swans (30% of total) in 1983. This area has exhibited a remarkable consistency in total numbers

Fig. l. Tundra swan survey area and routes
Nesting survey — 23 June 1983

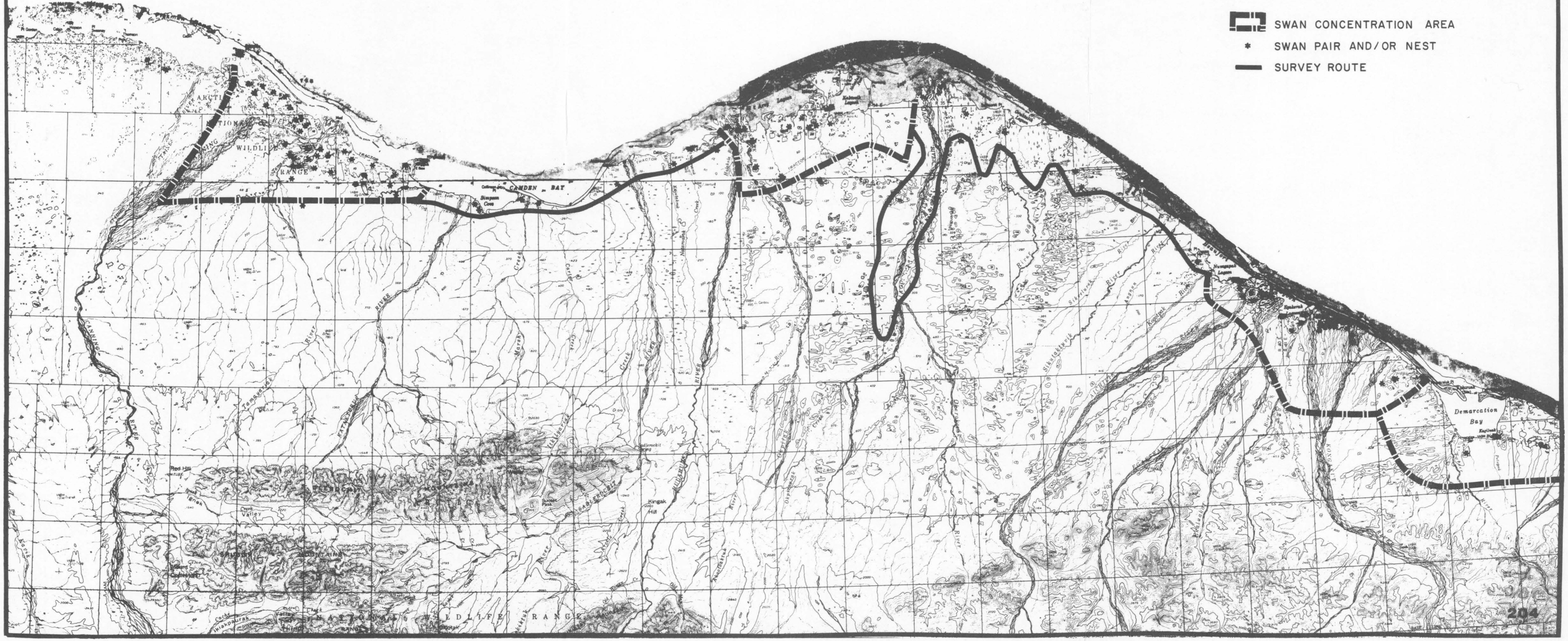

Table 2. Tundra swan population statistics for Arctic National Wildlife Refuge coastal areas during production surveys, 1981, 1982, and 1983.

Area	Number: Total	Adults	Cygnets	Pairs	Singles	Flocks	Swans in flocks	%: Paired	Prs. w Yng	Yng	Number Broods	Mean Brood Size	Cygnets/ Adults	Swans/ KM²
Canning/Tamayariak Delta: (490)[a]														
1981	186	140	46	30	3	10	77	43	57	25	17	2.7	1:3.0	0.38
1982	75	63	12	21	3	4	18	67	29	16	6	2.0	1:5.3	0.15
1983	188	125	63	48	7	4	22	77	52	50	25	2.5	1:2.0	0.38
Hulahula/Okpilak Delta: (168)[a]														
1981	80	67	13	9	0	8	49	27	44	16	4	0.3	1:5.2	0.48
1982	39	35	4	10	1	3	14	57	20	10	2	2.0	1:88	0.23
1983	94	62	32	20	5	3	17	65	45	52	9	3.5	1:2.1	0.56
Aichilik/Egaksrak/ Kongakut Delta (259)[a]														
1981	171	139	32	17	2	11	101	24	76	19	14	2.3	1:4.3	0.66
1982	171	157	14	19	2	7	97	37	21	8	6	2.3	1:11.2	0.66
1983	164	112	52	36	6	7	34	64	50	46	18	2.9	1:2.2	0.63
Jago Delta and Wetlands (357)[a]														
1981	12	8	4	2	1	1	3	50	50	33	1	4.0	1.2.0	0.03
1982	4	4	0	2	0	0	0	100	0	0	0	0	0	0.01
1983	37	29	8	10	1	2	8	69	30	28	3	2.7	1.3.6	0.10
Demarcation Bay (158)[a]														
1981	24	18	6	6	0	1	6	67	33	25	2	3.0	1:3.0	0.15
1982	16	9	7	1	3	1	4	22	100	44	3	2.3	1:1.3	0.10
1983	20	14	6	6	2	0	0	86	33	43	2	3.0	1:2.3	0.13
Other Areas: (171)[a]														
1981	15	13	2	3	2	1	5	46	33	13	2	1.0	1:6.5	0.09
1982	25	20	5	3	1	3	15	20	100	20	2	2.5	1:5.0	0.15
1983	49	35	14	12	5	2	6	69	50	40	6	2.3	1:2.5	0.29
Total Coastal area sampled: (1603)[a]														
1981	488	385	103	67	8	32	241	35	57	21	40	2.6	1:3.7	0.30
1982	330	288	42	65	10	18	148	45	29	13	19	2.2	1:6.9	0.21
1983	552	377	175	132	26	18	87	70	48	46	63	2.8	1:2.2	0.34

[a]area surveyed (km²) within each survey area.

observed over the 3 year period (Table 2). However, the composition of the numbers observed changed. There were fewer adults and more cygnets present in 1983 than observed in both 1981 and 1982. The 1983 survey showed more paired birds in the area than previous years. However, the number of paired birds located on the nesting survey (Table 1, 35 pairs) is almost identical to pairs present during the post-breeding survey (Table 2, 36 pairs). It is likely that unsuccessful pairs were still in the area; however, it is not possible to identify these pairs as the same pairs observed in the nesting survey, or explain why other unsuccessful pairs did not move into this preferred area.

The Hulahula-Okpilak delta, Jago delta and wetlands, Demarcation Bay, and other areas all had increases in swans over those observed in 1982. With the exception of Demarcation Bay, the numbers of swans in these areas, also, exceeded the 1981 totals. Demarcation Bay showed an increase in swans over 1982, but a decline over that observed in 1981. However, the proportion of swans using the Demarcation Bay area in any given year is low and does not exhibit a great deal of variation between years.

Total adult swans observed during the production survey (Table 2) is increased 124 birds over total adults observed during the nesting survey (Table 1). Of this increase, 56% was in the form of paired birds (35 pairs). These swans are presumably, unsuccessful breeders moving to the refuge. It can be speculated that these pairs came from unsuccessful nests west of the refuge. Bellrose (1976) and Salter et al. (1980) indicated that swans arrive on the Alaskan coast from the east and depart to the east.

Productivity

Tundra swan productivity for 1983 was the highest recorded in the 3 years of the present study (Table 2). Total broods, mean brood size, total young, and proportion (%) young in the population all increased over both 1981 and 1982. The percent pairs with young in 1983 exceeded that of 1982, but was lower than 1981. The total number of pairs observed in 1983 (132) was approximately twice the number of pairs observed in 1981 (67) or 1982 (65). However, as discussed previously, it is likely that up to 35 pairs of swans may have been unsuccessful pairs moving to ANWR to molt. Nevertheless, the total pairs nesting in the area (Table 1) is still greater than 1981 or 1982.

The total number of nests observed during the nesting survey plus the pairs present with no observed nests is an estimate of the total possible nesting population (Table 1). Nesting success can be estimated in 2 ways. First, using the number of actual nests observed and the number of broods observed (Table 2), the nesting success is 81%. If the number of nests plus pairs present is used, the nesting success is 60%. Assuming that some of the pair without observed nests may not have nested, the nesting success, is probably between 60% and 81%.

The all time high number of cygnets produced in 1983 is probably a function of mild weather during the nesting period. As in 1982, there was considerable air traffic along the coast. Therefore, the 1982 snowstorm (Bartels et al. 1983) may have had a greater effect on production than the aircraft disturbance. Refuge special use permit stipulations require all helicopters operating on the coastal plain to maintain 1500 feet altitude. This may be providing needed separations from nesting swans. Successive years data should confirm or reject this theory.

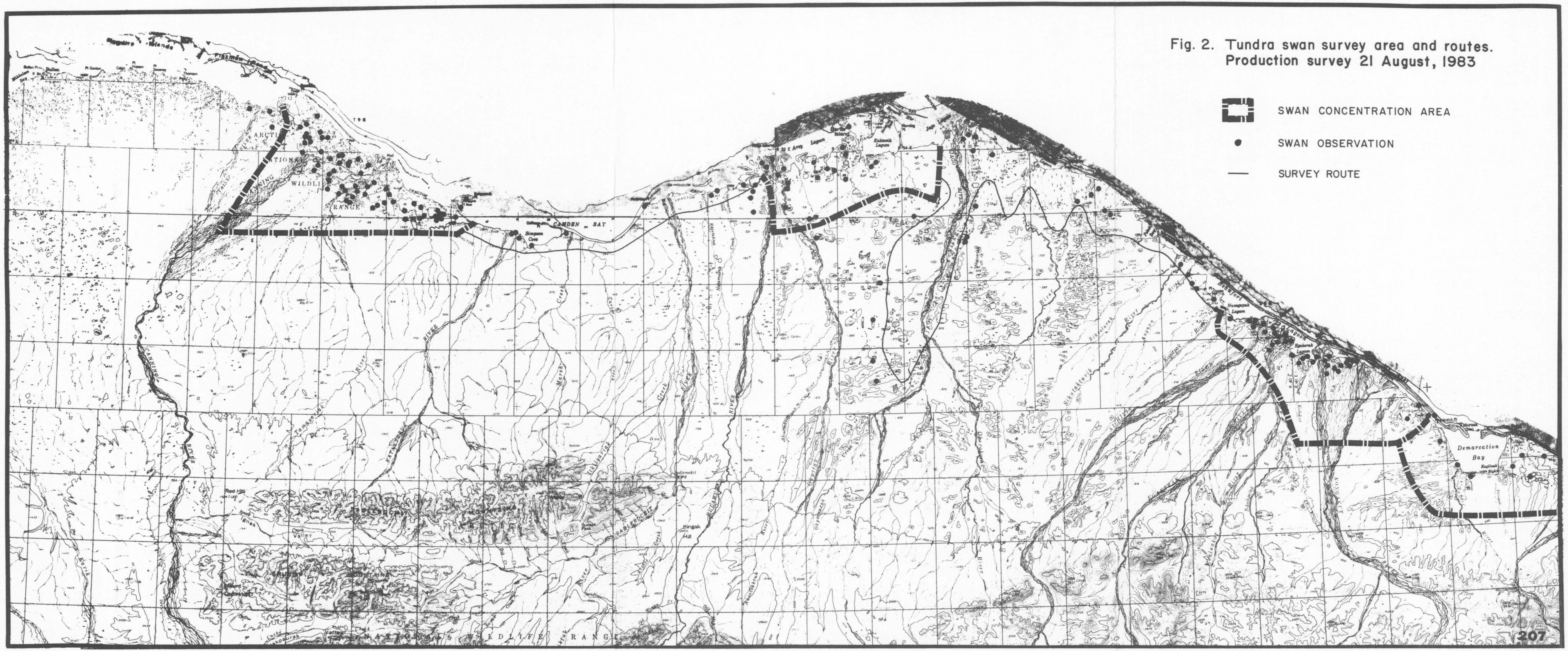

Fig. 2. Tundra swan survey area and routes. Production survey 21 August, 1983

Population

A total of 377 adults and 175 cygnet tundra swans were observed on the ANWR coastal plain in 1983. The adult population represents a 31% increase over 1982, with cygnets increasing 316%. However, the 1983 adult population is approximately the same as observed in 1981, while cygnets produced in 1983 represent a 70% increase over the cygnet population of 1981.

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

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

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

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Abstract: Birds were censused on 41 10 ha plots representing 7 habitat types at 3 sites on the coastal plain of the Arctic National Wildlife Refuge, Alaska, June-August 1983. Variability in bird populations due to location was primarily attributed to differences in habitat types available at coastal versus inland sites. Habitat type was found to be one of the most significant factors controlling densities of passerines, shorebirds, Lapland longspurs, red-necked phalaropes, pectoral sandpipers, and semipalmated sandpipers, as well as mean total populations and number of species. Flooded tundra, Riparian, and Moist/Wet Sedge (Mosaic) habitats showed significantly higher total densities and greater diversity of species than Moist Sedge-Shrub, Wet Sedge, Tussock Dwarf Shrub, and Moist Sedge habitats. For breeding bird populations, however, Riparian habitat was found to have significantly higher densities than any other habitat. Season (date of census) was a significant source of variability in levels of habitat use by birds. The Wet Sedge, Moist/Wet Sedge, and Moist Sedge-Shrub types showed the most constant pattern of total population density through the season; in contrast, Flooded, Tussock Dwarf Shrub, and Riparian types showed distinct peaks and troughs in density. Some inland habitats (notably Wet Sedge) showed initially high density which dropped drastically late in the season while some coastal habitats (especially Flooded, Riparian, and Wet Sedge) showed a later distinct and possibly related peak in population. Analysis of annual variability for 1978, 1982, and 1983 at Okpilak delta indicated that there were significant population changes between years but these were not consistent for each habitat. Annual variability of total breeding bird and total shorebird breeding populations was most significant in Flooded and Moist/Wet Sedge habitats. Significant annual differences were found for breeding densities of red-necked phalarope and red phalarope in Flooded and semipalmated sandpiper in Moist/Wet Sedge which contributed to overall significant inter-year densities. Largest inter-year differences in importance were seen for breeding populations in Flooded Tundra. Moist/Wet Sedge tundra consistently had the highest breeding population density. Annual changes in habitat importance were not detected when mean total population density, rather than breeding density, was used as the variable tested, suggesting that the former variable, though more difficult to analyze statistically (due to larger, more cumbersome data sets) may be preferable because it may not be as subject to annual changes. For 3 years at Okpilak, Flooded Tundra consistently supported the highest total bird densities, followed by Moist/Wet Sedge (Mosaic), Moist Sedge-Shrub, and Wet Sedge Tundra. Although similarity was found in rank of breeding and total bird densities for habitats studied at Okpilak River delta for 3 years, repeated study of the complete array of habitats on the coastal plain of ANWR is needed.

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 locations (mostly coastal), 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 (in prep.) 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 the more common species: 1) varied spatially between differing habitats and within the same habitat type and, 2) varied seasonally and annually within the same habitat type (USFWS 1982). Major data gaps identified were insufficient intensive coverage for inland and riparian habitats and insufficient sample size for several of the habitat types that would allow ranking of habitats according to levels of bird use (USFWS 1982). To assess seasonal and annual variation in habitat use with statistical validity, geographically dispersed replicates within each habitat over several years is desirable (Bell et al. 1973, States et al. 1978, Myers and Pitelka 1980, Anderson et al. 1981, Hildén 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 (1 coastal and 1 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[1] and Moist/Wet Sedge Tundra (Mosaic) types (Spindler and Miller 1983). Additionally, variability within a habitat type differed among habitat types, with Wet Sedge and Tussock Dwarf Shrub 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.

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

Objectives of the 1983 sample design and field work were to:

1. Determine and compare habitat occupancy[2] levels of breeding, resident, and transient birds using the major habitat classes defined by recent Landsat mapping of the ANWR coastal plain.

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).

Study Areas

Terrestrial bird studies were conducted at 3 study areas on the coastal plain of the Arctic National Wildlife Refuge in 1983. The arctic coastal plain is a relatively flat 790,000 ha portion of the 7,300,000 ha ANWR, extending from the northern foothills of the Brooks Range to the Beaufort Sea coastline. Study sites were chosen for their accessibility and for availability of several (4 to 5) Landsat habitats in close proximity to one another.

The Okpilak River delta study area was the only coastal study site in 1983. It 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. 1). The Okpilak River delta study area included large lake and wetland areas and was the site of previous bird censuses in 1978 (Spindler 1978) and 1982 (Spindler and Miller 1983).

The Katakturuk River study area was an inland site about 75 km west - southwest of Kaktovik (Fig 2). 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 was the site of previous bird censuses in 1982, and differed from the Okpilak River delta study area by the presence of more extensive and erect willow (*Salix* spp.) cover in the Riparian habitat, 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).

The Jago River-Bitty study area, 45 km south of Kaktovik, was an inland site which was established and censused for the first time in 1983. It was located 37-43 km south of the Beaufort Sea and 30-36 km north of the Brooks Range, on the Jago River (Fig. 3). It was similar to the Katakturuk River study area in extent of willow cover in the Riparian habitat, extent of shrub cover in the Moist Sedge-Shrub and Tussock Dwarf Shrub Tundra, absence of wetlands, and amount of topographic relief. It differed from the Katakturuk River study area in that the thaw lake plain was 4 km to the

[2]Habitat occupancy refers to the population being supported by a habitat, indicated by number of individuals. It is defined here so as not to be confused with habitat productivity, which reflects levels of annual productivity of new biomass. Productive habitats, however, generally have high occupancy levels (see West 1979, Wiens and Rotenberry 1981).

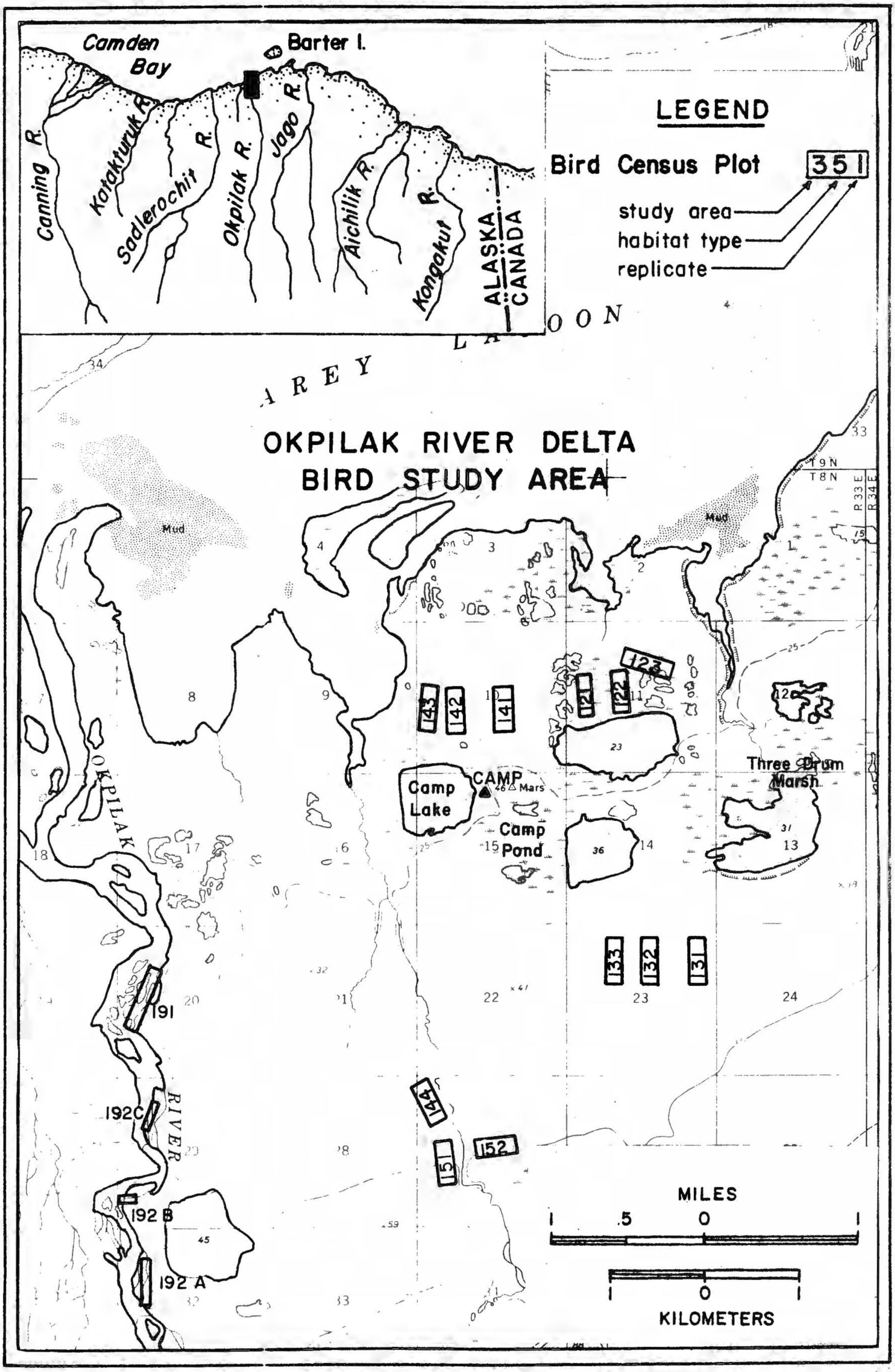

Fig. 1. Okpilak River delta study area, Arctic National Wildlife Refuge, Alaska.

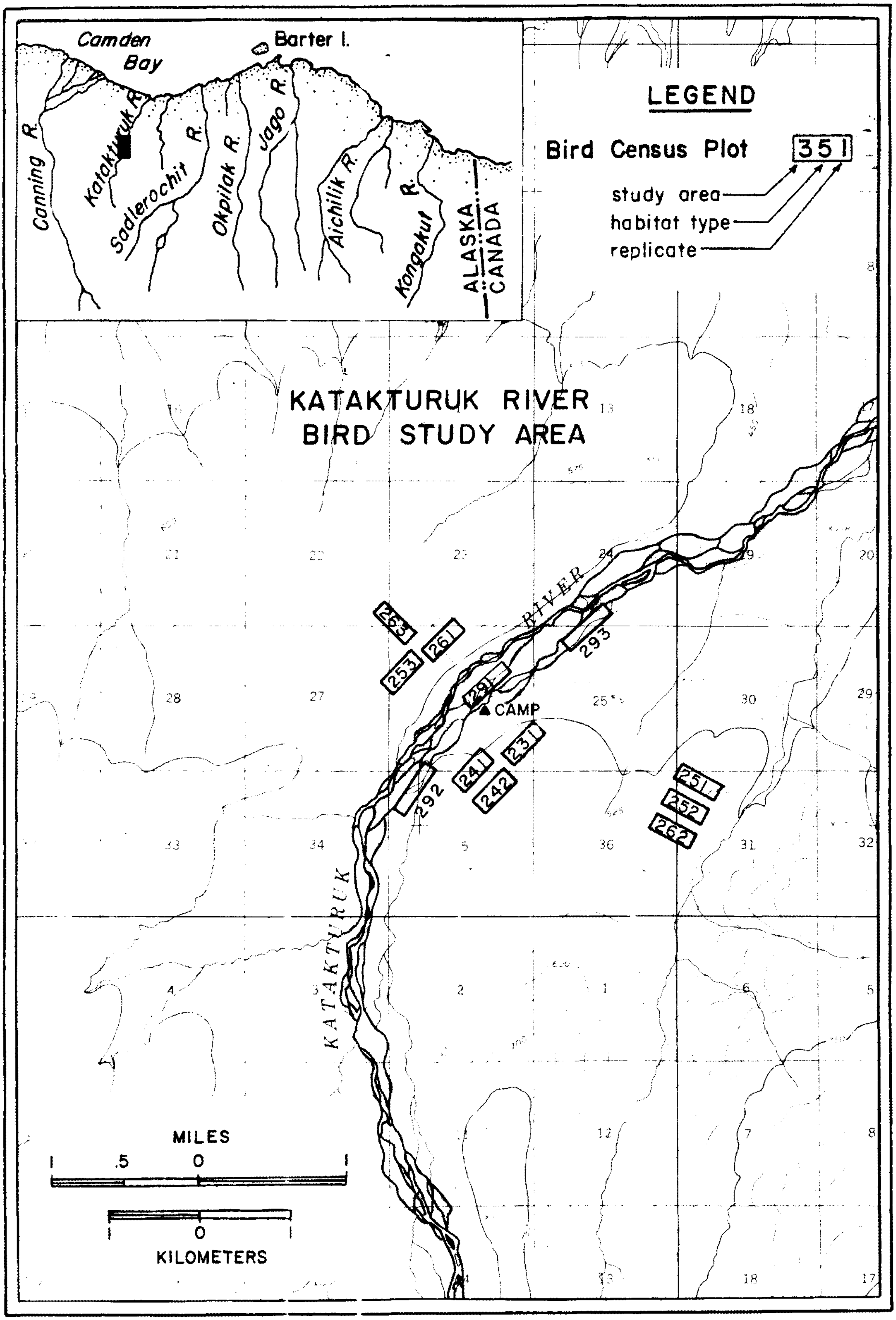

Fig. 2. Katakturuk River study area, Arctic National Wildlife Refuge, Alaska.

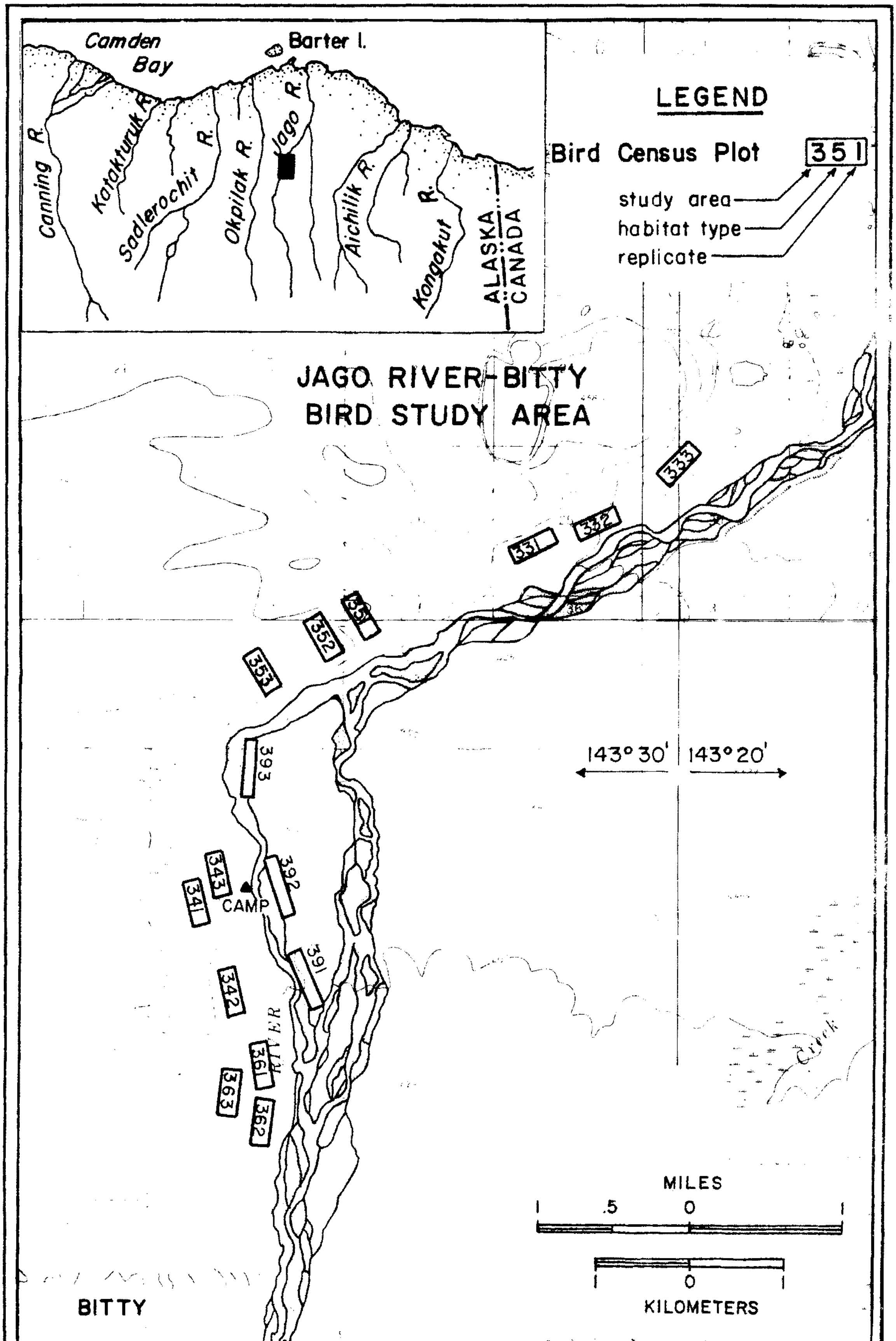

Fig. 3. Jago River-Bitty study area, Arctic National Wildlife Refuge, Alaska.

north, hence the area included some large lakes and extensive Wet Sedge Tundra nearby. Moist Sedge habitats contained more erect willow cover than Katakturuk yet willows in Riparian habitats at Jago-Bitty had lower heights than at Katakturuk.

Three new study areas were surveyed in 1983 for use in 1984. A third inland site was located on the Aichilik River, 32-37 km inland from the Beaufort Sea and 10-15 km from the Brooks Range (Fig. 4). The Aichilik site differed from the Katakturuk River and Jago-Bitty study sites in having less topographic relief. The other 2 additional sites established were coastal, 1 at the mouth of the Sadlerochit River, 0.5-6 km from the Beaufort Sea (Fig. 5), and 1 on the east side of the Jago River delta, 2-7 km from the Beaufort Sea (Fig. 6). The Jago River delta site had extensive wetlands but fewer large lakes than the Okpilak River delta site, while the Sadlerochit River delta site was relatively dry for a coastal site.

Methods

Weather

Weather data were recorded at the 3 study areas twice daily at approximately 0800 and 2300h. Taylor maximum-minimum thermometers were used for measurement of current as well as daily maximum-minimum temperatures. Wind velocities were measured with hand-held Dwyer portable wind meters. Wind direction was determined with compass or Airguide Windial wind-speed indicator and hand compass. Cloud cover was recorded in the following classes: clear 0-9%; scattered 10-49%; broken 50-89%; overcast 90-100%. Type of precipitation, if any, was recorded. Weather data were summarized for the time periods censuses were conducted (18-30 June, 1-18 July, 9-15 August).

Habitat Descriptions

Botanical data were collected in the form of species lists noting time of flowering and habitat where observed. Qualitative descriptions of plant communities were made for all census plots newly established and censused in 1983 (4 at Okpilak, 6 at Katakturuk, and 15 at Jago-Bitty). Communities were identified to the Level IV specification of Viereck et al. (1982). Percent cover in each Level IV class was visually estimated for each 50 m wide transect strip on each plot. Plant names are from Hultén (1968), except for the genus Salix which follows Viereck and Little (1972).

Plot selection and surveying

Plots were chosen randomly within each habitat at each location whenever sufficient habitat existed to do so. If available habitat extent 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. Representation of sampled and surveyed plots within each habitat type is shown in Fig. 7.

All bird census plots were 10-ha in area, and whenever possible, plot dimensions were 200 m wide by 500 m long. Most Riparian plots were 150 m x 667 m because the habitat tended to occur in narrow strips along rivers. One Riparian plot had to be composed of 3 smaller than 10 ha- units because of limited habitat (see below).

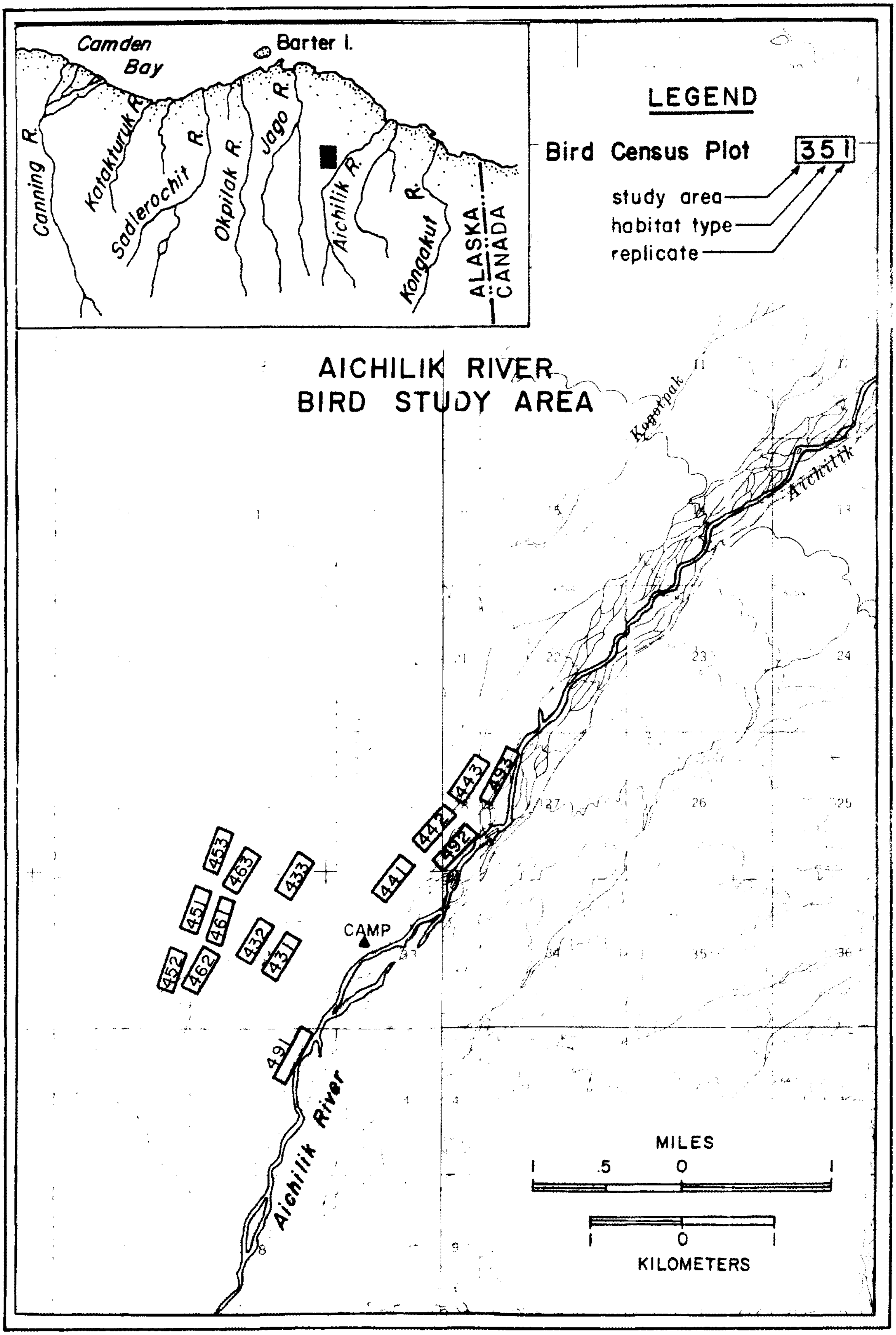

Fig. 4. Aichilik River study area, Arctic National Wildlife Refuge, Alaska.

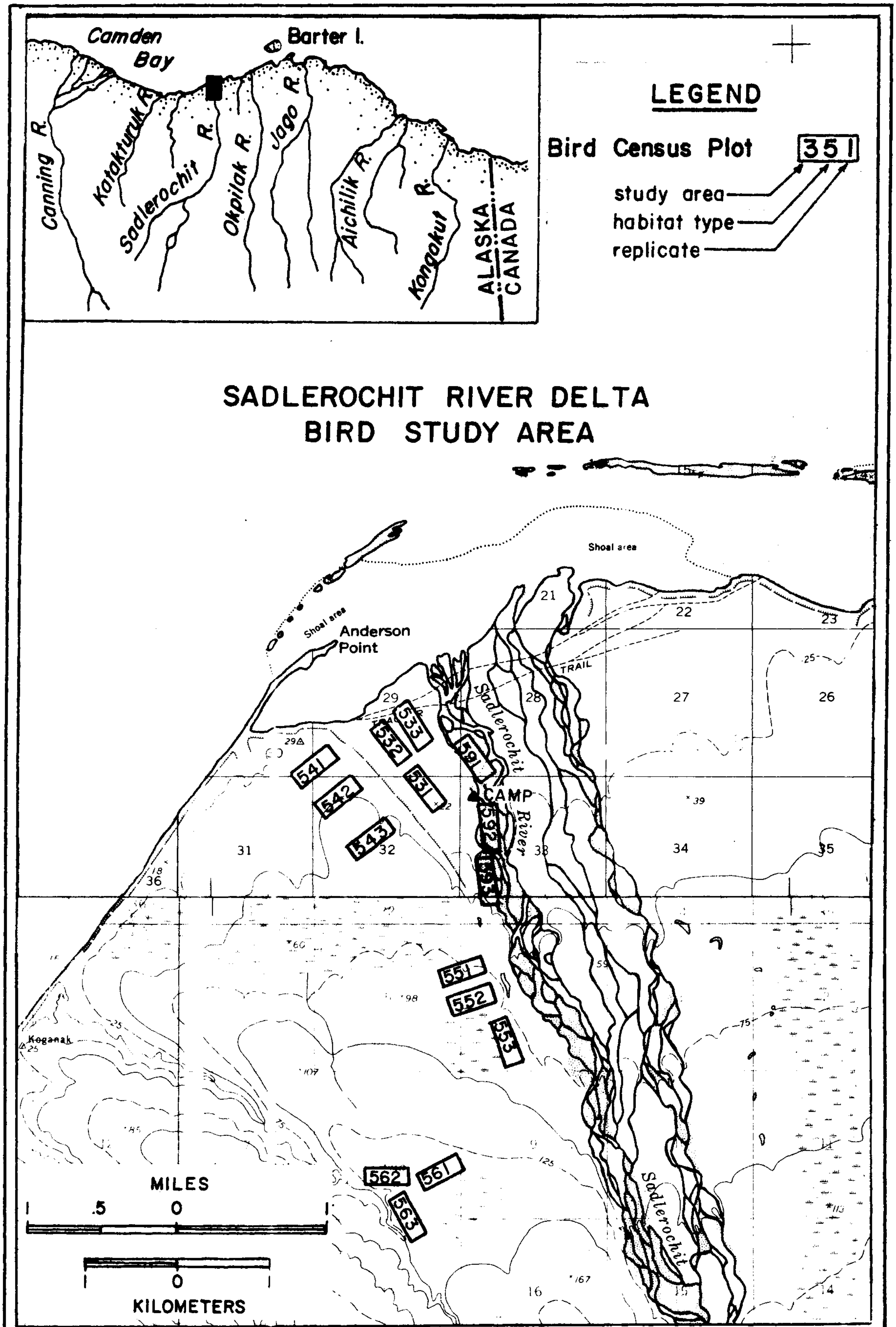

Fig. 5. Sadlerochit River delta study area, Arctic National Wildlife Refuge, Alaska.

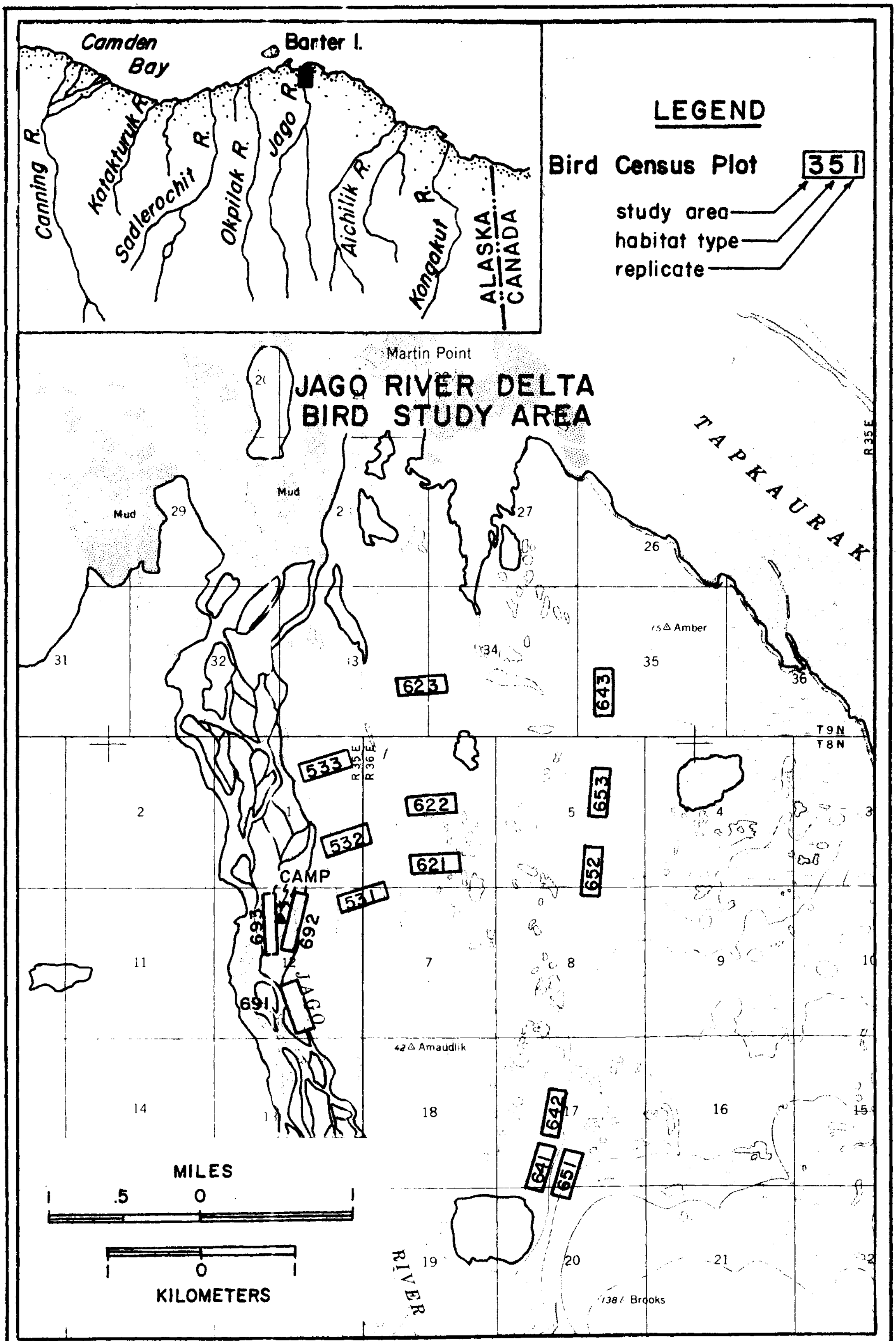

Fig. 6. Jago River delta study area, Arctic National Wildlife Refuge, Alaska.

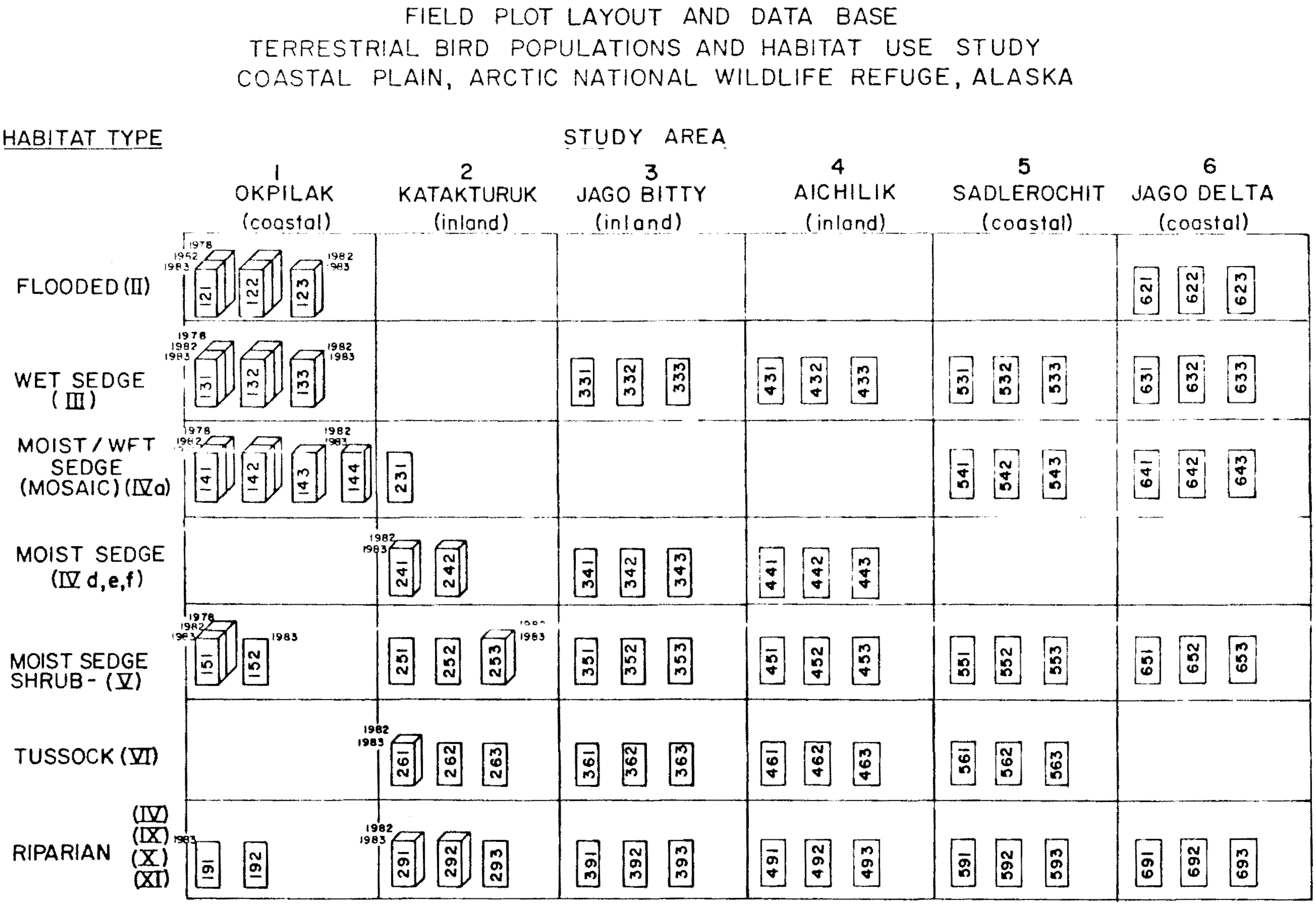

Fig. 7. Layout and allocation of 10 ha bird census plots in 6 study areas and 7 habitat types. All plots in study areas 1, 2, and 3 were censused in 1983. Plots in study areas 4, 5, and 6 were surveyed in 1983 but have not been censused. Numerals within plots indicate plot abbreviation (first digit = study area, second digit = habitat type number, third digit = replicate number). Numerals outside plots and perspective indicate additional census years prior to 1983 in study areas 1 and 2.

At the Okpilak River delta study area, 3 replicate 10-ha census plots were established in each of the 4 habitats that had been censused in 1978 and 1982: Flooded (Landsat type II), Wet Sedge (Landsat type III), Moist/Wet Sedge (Mosaic) (Landsat type IV), and Moist Sedge-Shrub (Landsat type V). One 10-ha plot in each habitat (except V) was identical to the 10-ha plots censused in 1982; the other 2 10-ha plots in each habitat were randomly selected and surveyed to fall within the boundaries of the 25- or 50-ha plots censused in previous years. In addition, 2 10 ha plots were established in the Riparian habitat (Landsat types IV, IX, X, XI) along the Okpilak River. One of these (plot 192) was actually composed of 3 smaller isolated subplots which together totaled 10-ha, due to a lack of Riparian areas of adequate size for a single 10-ha plot.

At the Katakturuk River study area, 12 10-ha bird census plots were established in 1983, 6 of which were identical to plots censused in 1982. One plot was established in Wet Sedge (III) habitat, 2 in Moist Sedge (IV), and 3 each in Moist Sedge-Shrub (V), Tussock Dwarf Shrub (VI) and Riparian (IV, IX, X, XI).

At the Jago-Bitty study area, 3 replicate 10-ha bird census plots were established in each of 5 habitats: Wet Sedge (III), Moist Sedge (IV), Moist Sedge-Shrub (V), Tussock Dwarf Shrub (VI), and Riparian (IV, IX, X, XI). At each of the 3 new study sites surveyed for use in 1984, 3 replicate 10-ha census plots were established in each of 5 habitats. The Landsat types represented at each site were as follows: Aichilik III, IV, V, VI, IX; Sadlerochit Delta III, IV, V, VI, IX; and Jago Delta II, III, IV, V, IX, (and see Fig. 7).

At the Katakturuk, Jago-Bitty, and Sadlerochit Delta study areas plots were surveyed using a Silva Ranger hand-held compass and 50 m surveyor's chain. At the Okpilak, Aichilik, and Jago River delta areas 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 at each intersection. Plot corners were also marked with 46 cm long steel re-bar labeled with aluminum tags. Census 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 territories to estimate breeding bird density. Plots at Okpilak and Katakturuk were censused twice in June, and plots at Jago-Bitty were censused 3 times in June. Plots at all 3 sites were censused twice in July and once in August. Methods described by Spindler (1978), Martin and Moitoret (1981), and Spindler and Miller (1983) were used to allow comparison with previous studies. Each census was performed by 3-4 people walking abreast, evenly spaced between the grid lines. For all birds seen, species, sex, behavior, direction of flight, and location were recorded on a scaled map of the plot (Williams 1936). Notes were made of any behavior suggesting a nearby nest, and extra effort was made to find nests in such situations. Incubated eggs in unoccupied nests were identified using Harrison (1978). Censuses were not initiated during adverse weather conditions of strong wind, precipitation, or fog. If weather conditions deteriorated, censuses already initiated were completed but no new censuses were initiated until conditions improved.

All nests found were marked with a numbered tongue depressor placed in the ground 1 m north of the nest. Nest information, including 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, how nest was found, and any hatching success/predation information were recorded on a card kept for each nest. All known nests were relocated and checked on subsequent censuses. Nest information was transferred onto computer code forms and submitted to the North American Nest Record Card Program (maintained by Cornell University, Ithaca, N.Y.). Bird names and phylogenetic order follow the American Ornithologists' Union (1983).

Analytical

Breeding bird population. Breeding bird population estimates for arctic tundra species have usually been based on number of nests found in intensive nest searches of plots, supplemented by territory mapping for Passerines and some other species (Myers and Pitelka 1975, Jones et al. 1980). Accordingly, breeding population density estimates in this study were based on a similar system. For species with particularly difficult nests to find (e.g. pectoral sandpiper, long-billed dowitcher, yellow wagtail, savannah sparrow) probable nest locations, as determined by behavioral observations, were also considered.

Total bird population. 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 5 censuses. Bird densities from the 10-ha plots were expressed as birds/km^2. Total counts (not means) on each census on each plot comprised the raw data used in the statistical tests described below.

Sample design. The sampling protocol dictated a nested analysis of variance (ANOVA) with replicate plots nested within habitat type and habitat type nested within location (study area). Each replicate was censused 5 times during the field season, and replicates were treated as split-plots through time (Steel and Torrie 1982, Fig. 7). Analyses of location, habitat, and seasonal difference were performed using the SPSS MANOVA computer program (Hull and Nie 1981). Variables tested were total birds, total shorebirds, total passerines, number of species, and individual totals of 5 key species: lesser golden-plover, red-necked phalarope, semipalmated sandpiper, pectoral sandpiper, and Lapland longspur. Analyses were performed on both total and breeding bird populations of these species and species groups.

The Student-Newman-Keuls multiple comparisons procedure (Steel and Torrie 1982) was used to determine differences between mean bird populations of individual habitats, when overall significance was indicated by the MANOVA analysis. In the strictest sense, the Student-Newman-Keuls (SNK) procedure is designed for testing for significant differences between means of groups with equal sample sizes. However, it is generally accepted that SNK is a conservative procedure if the smallest group sample size is chosen for tests involving unequal sample size (D. Thomas, pers. comm.).

Graphics and simple 2-way ANOVA for analyses of seasonal variability were obtained using the program BMDP 7D (Dixon et al. 1981).

Data from previous studies at Okpilak by Spindler (1978) and Spindler and Miller (1983) were reanalyzed to allow multi-year comparisons of annual variation. Breeding and total bird densities from the larger 50-ha plots for each 1978 and 1982 census were retabulated for those sections which corresponded to 10-ha plots censused in 1983. Data from only censuses 1-4 were considered in these analyses since census 5 was not conducted in 1978.

Annual variation of total breeding populations was examined using a 2-way ANOVA, program BMDP 2V (Dixon et al 1981) with F statistics computed with habitat as a fixed variable and year as a random variable (Zar 1974). A series of Kruskal - Wallis non-parametric 1-way ANOVA tests (Zar 1974) were used to examine inter-year differences in means of total breeding, Lapland longspur, pectoral sandpiper, and total shorebird populations in Flooded, Wet Sedge, and Moist/Wet Sedge (Mosaic) habitats; and red-necked phalarope and red phalarope populations in Flooded; and red phalarope and semipalmated sandpiper populations in Moist/Wet Sedge habitat.

Annual variation of total population was examined using the non-parametric Friedman's test (Conover 1980) on mean numbers of birds/km^2 for plots sampled in all years. A series of Kruskal-Wallis non-parametric 1-way ANOVA tests were used to examine inter-year differences within habitats for each census.

Results and Discussion

Weather

During the periods when censuses were conducted, lower minimum and maximum mean temperatures were registered at Okpilak compared with the inland sites. A larger temperature range occurred at the Katakturuk and Jago sites where there were lower minimum and higher maximum mean temperatures for all months except August (Appendix Table A-1).

Prevailing winds were from the northeast at Okpilak and Katakturuk except in August when northeast and west winds were equally prevalent at Okpilak and east winds prevailed at Katakuruk. The Jago-Bitty area differed by having prevailing east winds except in August when there were equal records of east and northeast winds. It should be noted that several 4-5 day periods of strong west winds were recorded before and after the census period and therefore were excluded from this analysis.

Higher monthly mean wind speeds (9.5-14.0 km/h) as well as a higher proportion of wind speeds greater than 16 km/h were recorded for the coastal Okpilak study area than at the inland sites. Lowest average wind speeds were noted at the Jago-Bitty study area except in July when it was lower at Katakturuk. High wind speeds (in excess of 16 km/h) occurred at Jago-Bitty only during June with highest wind speeds 24-40 km/h recorded during a storm which occurred on 6 June, prior to the census period. In all areas the majority of wind speed records were in the 9-16 km/h range during June and August but were more commonly in the 0-8 km/h range in July when there were more periods of calm weather.

Cloud cover and precipitation levels were fairly similar between the study areas, with an extended period of clear weather from 3-9 July. A mid-summer snow storm on July 15 at Katakturuk and Okpilak covered the tundra with about 10 cm of snow which melted within 12 h. All areas experienced more rain and fog in late July and August, although at Okpilak there were fewer days with rain than at the inland areas during this period.

Snow melt occurred during the first week of June on the coastal plain, with rapid breakup at Jago-Bitty progressing on 1 June due to high air temperature and clear sunny skies. Snow cover at the Jago-Bitty camp on 1 June was 80%. By 2 June it had dropped to 50% in the camp vicinity and 10% on the Bitty foothills. By 3 June, snow cover was less than 5%. Comparison of snow melt chronology between study areas in 1983 is not possible because researchers were not present in the other areas until a later date (12 June). Some comparisons of snow melt chronology between 3 years of study may be drawn for the Okpilak area. Snow melt in 1983 was earlier than in 1982 or 1978. By 12 June 1983, the tundra was free of snow and ice except along river and creek banks and along larger lake shores. In 1983 Camp Lake had 60% ice cover and was unsafe for ski-equipped aircraft landing on 12 June and completely ice free on 3 July. This contrasts with 1982 when snow cover was 60-80% on 12 June; the area was not 95% snow free until 19 June. Camp Lake remained safe for aircraft landing until 24 June and was not completely ice free until 19 July 1982. In 1978 the tundra was 95% snow free by 8 June but a snow storm with cold weather on 23 June left an appreciable accumulation of snow. Camp Lake remained safe for aircraft landing until 28 June and was not free of ice until 15 July 1978.

Plant phenology

First flowering dates for common plant species were compared to assess phenological differences between 3 study areas censused in 1983 (Appendix Table A-2) and between the 3 years of census at Okpilak River delta (Appendix Table A-3). Julian dates of first flowering of 22 species found in all 3 study areas in 1983 were not significantly different ($p > 0.05$ Friedman test.), however, a greater number of earliest (for the 3 areas) flowering dates were recorded at Jago-Bitty (11 species) compared with Katakturuk (6 species) or Okpilak (2 species). The peak of first flowering activity of all species found at each area was also earliest at Jago-Bitty, with 12 species first observed in flower on 29 June, compared to a peak on 3 July at Okpilak (10 species first flowering), and on 4 July at Katakturuk (9 species first flowering).

Julian dates for 25 species found flowering in all 3 years at Okpilak were significantly different between years ($p = 0.0556$ Friedman test). A total of 13 species was recorded flowering earliest in 1983, 5 species had earliest dates in 1982 and only 2 species flowered earliest in 1978. Significantly earlier dates were found in 1983 at Okpilak compared with 1978 ($p < 0.05$ Wilcoxon signed-ranks test). In 1983 a total of 17 species was found flowering an average of 5.8 days earlier than 1978 dates, whereas only 6 species were found flowering an average of 4.3 days earlier in 1978. Dates for the peak of first flowering activity of all species found at each area were similar for all 3 years. In 1978 the peak number of first flowering species (10) was on 1 July, in 1982 the peak number of species (16) occurred on 2 July, and in 1983 the peak number of species (10) first flowered on 3 July.

In conclusion, there was no significant difference among first flowering dates of 22 species between the 3 study areas in 1983, but the greatest number of earliest dates was observed at Jago-Bitty in 1983. In the Okpilak River delta study area for which 3 years data are available, there were significant yearly differences in first flowering dates of 25 species, with 1983 the earliest, followed by 1978, and 1982 the latest. The date on which the greatest number of species first flowered was similar among the 3 years, varying between 1 and 3 July.

Habitat Descriptions

To meet the objectives of this study, it was necessary to establish 3 replicate census plots in each Landsat-identified habitat type (Walker et al. 1982) at each study area. Based on the habitat classification according to the Landsat map, it was anticipated that estimates of bird densities derived from sample plots could be extrapolated to like Landsat classes elsewhere on the coastal plain of the Refuge. Unfortunately this goal was unattainable using the present (Walker et al. 1982) Landsat map, because numerous problems of misclassification or overlap of habitat types on the Landsat map became apparent during ground-truthing of vegetation on the study plots.

Landsat imagery is based on spectral reflectance, and thus is primarily influenced by the amount of water on the ground surface and the percentage of shrubs in the vegetation canopy (Walker et al. 1982). The major problem encountered with using Landsat mapping to define bird habitats was that most important distinguishing characteristics of bird habitats (micro-relief, interspersion of other types, etc.) were not distinguishable by Landsat imagery. Although the Landsat map fairly accurately represented differences in habitat based on a moisture gradient, it was notably insensitive to differences in habitat based on vegetation type, microrelief, and degree of homogeneity. Also, whereas height and erectness of shrubs play a major role in determining bird community species composition (Lack 1933, MacArthur 1964, Cody 1968, James 1971), relative percent cover of these shrub components is similar, and hence the community differences were not separable by Landsat.

To adequately describe between-habitat type differences in bird populations it was necessary to subdivide some Landsat classes and to designate additional habitat types not identified by Walker et al. (1982) (Table 1). This occurred primarily in group IV, where Walker et al. (1982) identified only 2 habitats, IVa Moist/Wet Sedge Tundra Complex and IVb Dry Prostrate Shrub, Forb Tundra. Extensive areas shown on the Landsat map as type IV did not fit either category or other Landsat categories, making it necessary for us to designate 4 additional type IV categories (c,d,e,f, in Table 1).

Classification of Landsat types III and IV overlapped in terms of bird habitats. Both types included a "complex" of moist/wet tundra (IIIc and IVa) and both types include a "noncomplex" of uniform sedge tundra (IIIa and IVf). The distinction between IIIc and IVa or between IIIa and IVf was a difference in moisture, a difference which appeared more evident to Landsat than to the birds. Type IIIc was defined by Walker et al. (1982) as wet tundra with up to 40% moist tundra, while Type IVa was defined as moist tundra with up to 40% wet tundra. A moist/wet complex which is 50% moist and 50% wet cannot be classified in the Walker et al. (1982) system, as it

Table 1. Vegetation types within 1983 terrestrial bird census plots, Arctic National Wildlife Refuge, Alaska. Vegetation type names correspond to the dominant Landsat cover units described by Walker et al.(1982) unless otherwise noted. Abbreviated plot names are those used to describe specific habitat types as censused by 10-ha plots in this study.

Landsat Cover Unit		Abbreviated Plot Name
II. a.	Pond/Sedge Tundra Complex	)--Flooded
b.	Aquatic Tundra	)
III.a.	Wet Sedge Tundra	------Wet Sedge
c.	Wet Sedge Tundra (moist complex)	)
		)--Moist/Wet Sedge(mosaic)
IV. a.	Moist/Wet Sedge Tundra Complex	)
b.	Dry Prostrate Shrub, Forb Tundra (*Dryas* river terraces)	)--Riparian[f]
c.	Moist Low Willow(Riparian Willow)[a]	)
d.	Moist Willow-Sedge Tundra[b]	)
e.	Moist Sedge-Willow Tundra[c]	)--Moist Sedge
f.	Moist Sedge Tundra[d]	)
V. a.	Moist Sedge, Prostrate Shrub Tundra(wet-complex)[e]	)
		)--Moist Sedge-Shrub
b.	Moist Sedge/Barren Tundra Complex (frost-scar Tundra)	)
VI.	Moist Sedge Tussock, Dwarf Shrub Tundra.	------Tussock Dwarf Shrub
IX.	Partially Vegetated areas-River bars;	)
		)--Riparian[f]
X.	Barren Gravel or Rock	)
XI.	Barren Mud or Wet Gravel	)

[a]Described in Viereck et al. (1982); large stands on ANWR were mapped as Type IV, however riparian plots usually contained only small (less than pixel size) willow clumps which were most often included among mapped areas of type IX, X, and XI and are hence censused and analyzed along with those units as "Riparian".

[b]Erect low (<20 cm) willow-dominated community with sedges described in Viereck et al.(1982), except "moist" adjective added to conform with Walker et al.(1982) nomenclature. Most often mapped in type IV.

[c]Moist Sedge meadow with low (<20 cm) erect or prostrate willows, described by Viereck et al.(1982) except "moist" adjective added to conform with Walker et al.(1982) nomenclature. Most often mapped in type IV.

[d]Homogeneous moist sedge meadow with little or no micro-relief.

[e]"Wet Complex" denotes frequent association of wet sedge within polygon troughs and centers, along with previously described sedge, prostrate shrub communities (Walker et al. 1982)

[f]Riparian communities as censused in 10 ha plot sizes most often consisted of a mosaic of IX, X, XI types as well as IVb *Dryas* Terrace and IVc Moist Low Willow.

falls in neither type III nor IV. In terms of bird use the type IIIc and type IVa moist/wet complexes were more similar to each other than to any of the noncomplex types III or IV. Therefore, for purposes of this study all moist/wet complex habitats were classified as type IV, even though some appeared on the Landsat map as type III. Thus type III plots included only 1 habitat type, IIIa Wet Sedge Tundra (noncomplex), but there were 2 basic categories of type IV plots: moist complex (mosaic including IVa Moist/Wet Sedge Tundra Complex) and moist non-complex (including IVd Moist Willow-Sedge Tundra, IVe Moist Sedge Willow Tundra, and IVf Moist Sedge Tundra) (See Table 1).

Similar problems were encountered in the Landsat classification of type V Moist Sedge, Prostrate Shrub Tundra and type VI Moist Sedge Tussock, Dwarf Shrub Tundra. Although Walker et al. (1982) defined the tussock cover of type V as less than 20%, and type VI as 20-70%, extensive areas shown by the Landsat map as type VI were found which contained no tussocks, and large areas shown to be type V were dominated by tussocks. To clarify the distinction between these 2 types, type V plots were defined for this study slightly differently from Walker et al. (1982) as having up to 50% tussock cover, but usually 20-30%, with a high degree of prostrate shrub cover, interspersion of wet sedge in polygon troughs and occasional low centers, and a high degree of grass cover, usually Arctagrostis latifolia. Type VI plots were dominated by tussock tundra (50-90%). Due to the inconsistency of Landsat mapping for these types, it was necessary to designate type V and VI plots based on interpretation of the habitat rather than on Landsat designations.

On-the-ground interpretation of habitats was appropriate for purposes of analyzing use by birds, however, the lack of agreement with the Landsat map made extrapolation of study results to other areas using Landsat mapping impractical, unless the Landsat identification of habitats can be refined to separate type IV subtypes and eliminate substantial overlap in types V and VI. Ground truthing of plots for Landsat type is summarized in Table 2 for the 3 1983 study areas as well as for the 3 new study areas surveyed for use in 1984. This table compares Landsat mapping (unsmoothed data) to types actually observed on the plots. The sections which follow include a more detailed discussion of each habitat type.

Qualitative estimates of percent cover for each vegetation type on each study plot at the 3 study areas in 1983 are listed in Tables 3, 4, and 5. For plots established in 1982, data are reported from that year; for new plots established in 1983 vegetation data were collected in 1983. Three 1982 plots at Okpilak and Katakturuk were reclassified after vegetation typing in 1983 (plots 144, 261 and 253), therefore results differ from those reported in Spindler and Miller (1983).

Landsat Type IIa and b - Pond/Sedge Tundra Complex and Aquatic Tundra (Flooded). This habitat type occurred only at Okpilak and the new Jago Delta study area. The plots at Okpilak have been described in detail (Flooded Plots) in Spindler and Miller (1983). There appeared to be no misclassification with Landsat typing of these plots. At Okpilak these plots consisted of 95% wet sedge meadow tundra and fresh grass marsh, with 5% grass-herb meadow tundra (Table 3, Plate 1).

Landsat Type IIIa - Wet Sedge Tundra. This habitat type occurred at all 6 study areas. There was a classification problem with Landsat mapping in confusion between Landsat types III and IV. All type III plots were

Table 3. Relative percent coverage of Viereck et al. (1982) Level IV vegetation classes on Flooded, Wet Sedge, and Moist/Wet Sedge bird census plots surveyed in 1982 and 1983, coastal plain, Arctic National Wildlife Refuge, Alaska.

Viereck et al. (1982) Level IV vegetation classes	Flooded			Wet Sedge							Moist/Wet Sedge			
Habitat Abbreviation	II			IIIa							IVa/IIIc			
Study area	Okpilak			Okpilak			Katak.	Jago-B.			Okpilak			
Plot number	121*	122*	123*	131*	132*	133*	231	331	332	333	141*	142*	143*	144*
2 B 1 a Closed tall shrub scrub (willow)														
C 1 b Closed low shrub scrub (low willow)														
2 a Open low shrub scrub (dwarf birch)														
b (low willow)														
r (willow-sedge tundra)														
s (willow-grass tundra)				10	10	10								
D 1 d Closed dwarf shrub scrub (<u>Cassiope</u> tundra)														
g (low ericaceous shrub tundra)														
D 2 b Open dwarf shrub scrub (<u>Dryas</u>-lichen tundra)											5	5	5	
c (<u>Dryas</u>-herb tundra)														
e (low-willow tundra)														5
3 A 2 d Mesic graminoid herbaceous (tussock tundra)														
g (grass-herb meadow tundra)	5	5	5											
h (sedge-willow tundra)				30	30	10	35	19	8	5	5	5	5	65
i (sedge-birch tundra)								6						
j (sedge-<u>Dryas</u> tundra)											10	10	5	5
3 a Wet graminoid herbaceous (wet sedge meadow tundra)	60	60	25	60	60	80	65	71	91	88	80	80	85	25
b (wet sedge-grass meadow tundra)														
e (fresh grass marsh)	35	35	70											
B 1 a Dry forb herbaceous (seral herbs)														
water								4	1	7				
sand, gravel, mud														

*Data derived from 50 ha plots in 1982; data for all other plots derived from 10 ha plots in 1983.

Table 4. Relative percent coverage of Viereck et al. (1982) Level IV vegetation classes on Moist Sedge and Moist Sedge-Prostrate Shrub bird census plots surveyed in 1982 and 1983, coastal plain, Arctic National Wildlife Refuge, Alaska.

Viereck et al. (1982) Level IV vegetation classes	Habitat	Moist Sedge					Moist Sedge-Prostrate Shrub							
	Abbreviation	IVd,e,f					V							
	Study area	Katakturuk		Jago-B.			Okpilak		Katakturuk			Jago-B		
	Plot number	241*	242*	341	342	343	151*	153	251	252	253	351	352	353
2 B 1 a Closed tall shrub scrub (willow)														
C 1 b Closed low shrub scrub (low willow)														
2 a Open low shrub scrub (dwarf birch)														7
b (low willow)														
r (willow-sedge tundra)					3	26								
s (willow-grass tundra)														
D 1 d Closed dwarf shrub scrub (*Cassiope* tundra)							5							
g (low ericaceous shrub tundra)								7						
D 2 b Open dwarf shrub scrub (*Dryas*-lichen tundra)														
c (*Dryas*-herb tundra)														
e (low-willow tundra)							5	3			13			
3 A 2 d Mesic graminoid herbaceous (tussock tundra)				9	11	1		3	37	42	18	49	29	15
g (grass-herb meadow tundra)														
h (sedge-willow tundra)				89	74	63	50	82	48	46	46	20	27	25
i (sedge-birch tundra)												5	18	13
j (sedge-*Dryas* tundra)		15	15		6		5							
3 a Wet graminoid herbaceous		85a	85a	2	6	10	35	5	15	12	23	21	26	40
(wet sedge meadow tundra)												5		
b (wet sedge-grass meadow tundra)														
e (fresh grass marsh)														
B 1 a Dry forb herbaceous (seral herbs)														
water														
sand, gravel, mud														

*Data derived from plots in 1982; data for all other plots derived from 1983.
[a]1982 was a wet year; in 1983 this appeared to be primarily type 3A2h (sedge-willow tundra).

Table 5. Relative percent coverage of Viereck et al. (1982) Level IV vegetation classes on Tussock-Dwarf Shrub and Riparian bird census plots surveyed 1982 and 1983, coastal plain, Arctic National Wildlife Refuge, Alaska.

Viereck et al. (1982) Level IV vegetation classes	Habitat	Tussock-Dwarf Shrub						Riparian							
	Abbreviation	VI						IX, X, XI, IVb, IVc							
	Study area	Katakturuk			Jago-B.			Okpilak		Katakturuk			Jago-B.		
	Plot number	261	262	263	361	362	363	191	192	291*	292*	293	391	392	393
2 B 1 a Closed tall shrub scrub (willow)										25a	15a				
C 1 b Closed low shrub scrub (low willow)												10			
2 a Open low shrub scrub (dwarf birch)					3	5	3								
b (low willow)					4	5	4	30	33	35	40	53	47	25	32
r (willow-sedge tundra)						4	4		1				22	20	13
s (willow-grass tundra)															
D 1 d Closed dwarf shrub scrub (Cassiope tundra)					3	2	4								
g (low ericaceous shrub tundra)					4	4	2								
D 2 b Open dwarf shrub scrub (Dryas-lichen tundra)															
c (Dryas-herb tundra)								3	15	25	25	11		38	45
e (low-willow tundra)								18	12			8			
3 A 2 d Mesic graminoid herbaceous (tussock tundra)		58	57	51	84	80	75								
g (grass-herb meadow tundra)															
h (sedge-willow tundra)		28	37	47			5	12					22	5	7
i (sedge-birch tundra)															
j (sedge-Dryas tundra)														3	
3 a Wet graminoid herbaceous (wet sedge meadow tundra)		14	6	2	2		3	14	1				3	2	3
b (wet sedge-grass meadow tundra)															
e (fresh grass marsh)															
B 1 a Dry forb herbaceous (seral herbs)								4	23	10	10	6	3	3	
water								16	9			3	1	2	
sand, gravel, mud								3	6	5	10	1	2	2	

*Data derived from plots in 1982; data for all other plots derived from 1983.
[a]These figures include both tall and low closed shrub scrub (2B1a and 2C1b).

Plate I. Flooded

established in areas of Landsat type IIIa Wet Sedge Tundra (noncomplex). However, at Okpilak and Jago Delta, ground-truthing revealed that areas mapped as Landsat type IIIc Wet Sedge Tundra (moist complexes) were identical to areas mapped as type IVa Moist/Wet Sedge Tundra Complex; therefore, at these sites some type IV plots were established on areas shown as type III on the Landsat map.

At Katakturuk, type III plots were not originally established; however, ground truthing of the third type IVf plot established in 1983 indicated it to be 65% wet sedge meadow, rather than the 25% as predicted by the Landsat map, (Table 3), so it was reclassified to type III (plot 231).

The type III plots at Okpilak were described in detail (Wet Sedge plots) in Spindler and Miller (1983). Plots at Okpilak and Jago-Bitty contained 60-90% wet sedge meadow tundra, the remainder consisting of sedge-willow tundra, willow-grass tundra, sedge-birch tundra (Jago-Bitty only), and ponds (Jago-Bitty only). Type III plots at Okpilak, Jago-Bitty, and Jago Delta were polygonized (Plate 2), while those at Aichilik, Sadlerochit, and Katakturuk were characterized by disjunct rims and strang features (Plate 3).

Landsat Type IVa - Moist/Wet Sedge Tundra Complex (Mosaic) and Types IVd,e,f-Moist Sedge Tundra (noncomplex). This Landsat type occurred at all 6 study areas. It presented the greatest difficulties in Landsat interpretation, because there were 6 different and distinct bird habitat types which all received the same type IV designation on the Landsat maps (Table 1). Types IVa and b were identified by Landsat (Walker et al. 1982), while IVc,d,e, and f were identified through field observations and defined in this study. Two of these types (IVb - *Dryas* river terraces and IVc - Riparian willow) were generally associated with Riparian habitats (see below) and were not represented by separate type IV plots.

Type IV plots located at the 3 coastal sites (Okpilak, Jago Delta, and Sadlerochit) were chosen to represent areas of type IVa Moist/Wet Sedge Tundra Complex (Plate 4). This habitat has been described in detail for Okpilak (Mosaic plots) by Spindler and Miller (1983). At Okpilak and Jago Delta, Landsat type IVa was indistinguishable in the field from type IIIc, so parts of some type IV plots at these sites were located in areas shown by the Landsat map to be type III. At Sadlerochit, the type IVa Moist/Wet Sedge was relatively dry with high-center polygons and small pools in the troughs. The type IVa Moist/Wet Sedge at Okpilak and Jago Delta was relatively moist with many wet low-center polygons. One plot at Okpilak (144), which was originally surveyed in 1982 as type V, was determined in 1983 to be predominantly type IVa, and thus was redesignated as type IV. Type IV (Moist/Wet Sedge Tundra Complex) plots at Okpilak contained 25-85% wet sedge meadow tundra and 5-65% sedge-willow tundra (Table 3). They also contained small smounts (5% or less) of *Dryas*-lichen tundra, low willow tundra, and sedge-*Dryas* tundra.

The 3 inland sites (Katakturuk, Jago-Bitty, and Aichilik) did not contain type IVa Moist/Wet Sedge Tundra Complex, so type IV plots at these sites were chosen to represent areas of uniform Moist Sedge Tundra (IVf) or Sedge-Willow Tundra (IVe) but also included Moist Willow-Sedge Tundra (IVd). These plots were all in areas identified by Landsat as type IV, except for 1 plot at Aichilik (443) which was designated as types IV and V

Plate 2. Wet Sedge Tundra (polygonized)

Plate 3. Wet Sedge Tundra (strang)

Plate 4. Moist/ Wet Sedge (mosaic)

on the Landsat map.

Type IV (moist sedge) plots at Katakturuk and Jago-Bitty contained 60-90% sedge-willow tundra and lesser amounts (15% or less) of sedge-Dryas tundra and wet sedge meadow tundra (Table 4, Plate 5). Plots at Jago-Bitty also contained 1-11% tussock tundra and 0-26% willow-sedge tundra.

Landsat Type V - Moist Sedge, Prostrate Shrub Tundra. This habitat type was present at all 6 study sites. At Okpilak, Jago-Bitty, and Jago Delta the Landsat map was fairly accurate in depicting type V habitat, but at Katakturuk, Aichilik, and Sadlerochit there was major confusion in the Landsat mapping between types V and VI. Walker et al. (1982) recognized that type IV habitat could be classified as either type V or type VI by Landsat, and this was the case at the latter 3 areas.

At Katakturuk, all 3 plots established in 1983 in an area shown by the Landsat map to be type V, actually contained large proportions (37-57%) of tussock habitat (Table 4). Because of the large percentage of tussock habitat (57%) on the third type V plot, it was reclassified as type VI (plot 262).

At Sadlerochit there were large areas of type V habitat (sedge-willow tundra, no tussocks) which were shown as type VI on the Landsat map, while the most extensive tussock habitat was found in areas shown as type V on the Landsat map. However, there were also areas of type V habitat which were correctly identified by the Landsat map, and the type V plots were established in such areas.

At Aichilik, all 3 type V plots were established in areas that were shown by the Landsat map to be predominantly type VI, but actually were entirely type V with 0-20% tussock cover.

The type V plots established at Okpilak, Katakturuk, and Jago Bitty contained 20-80% sedge-willow tundra, 0-50% tussock tundra, and 5-40% wet sedge meadow tundra (Plate 6). Plots at Okpilak also contained minor amounts of Cassiope tundra, low ericaceous shrub tundra, low (dwarf) willow tundra, and sedge-Dryas tundra. One type V plot at Katakturuk (253) contained 13% low (dwarf) willow tundra. The type V plots at Jago-Bitty differed from the other 2 sites in the presence of significant amounts of dwarf birch, with 5-20% sedge-birch tundra or dwarf birch scrub.

Landsat Type VI - Moist Sedge Tussock, Dwarf Shrub Tundra. This habitat type was present at the 3 inland sites, Katakturuk, Jago-Bitty and Aichilik, and at 1 coastal site, Sadlerochit. Although fairly well defined by the Landsat map at Jago-Bitty, confusion with type V at the other 3 sites has already been mentioned in the discussion of Type V. At all sites, type VI plots were established in areas shown by Landsat to contain both VI and V. At Katakturuk, 1 plot (plot 253) surveyed in a Landsat-defined type VI area in 1982 was reclassified in 1983 as type V because it contained only 18% tussock cover (Table 5). At Sadlerochit the type VI plots had to be established in areas shown predominantly as Type V on the Landsat map but which actually contained extensive tussock cover and resembled Type VI more than Type V.

Tussock Dwarf Shrub plots at Katakturuk contained 51-58% tussock tundra,

Plate 5. Moist Sedge

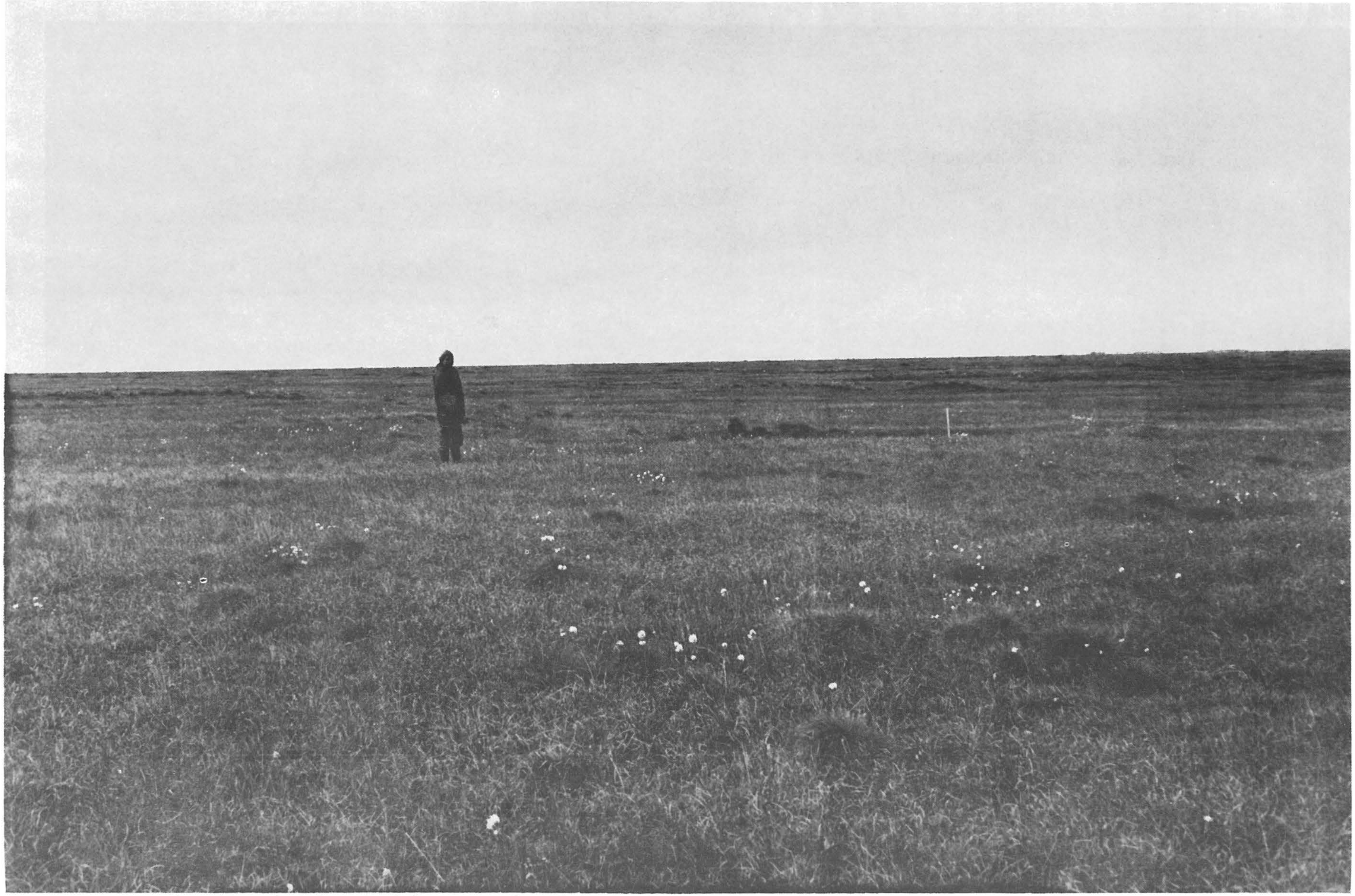

Plate 6. Moist Sedge-Shrub

28-47% sedge-willow tundra, and 2-14% wet sedge meadow tundra (Table 5, Plate 7). At Jago-Bitty the tussock plots contained a greater tussock cover (75-84% tussock tundra), very little sedge-willow tundra (0-5%), or wet sedge meadow tundra (0-3%), and small amounts (5% or less) of dwarf birch scrub, low willow scrub, willow-sedge tundra, Cassiope tundra, and low ericaceous shrub tundra.

Landsat Types IVb and c, IX, X, XI - Riparian Plots. Plots were established at all 6 study sites in a habitat type designated "Riparian", which was defined by the presence of low to medium height (0.2 - 2.5 m tall) willows along watercourses. Although ground-truthing revealed this to be a distinct, well-defined, and important habitat to birds, it did not appear as a distinct habitat on the Landsat map. Riparian plots were shown as a mosaic of Landsat types IX (partially vegetated areas - river bars), X (barren gravel or rock), XI (barren mud or wet gravel) and types I,II,III,IV and V. Although portions of these plots are represented by types IVb (Dry Prostrate Shrub, Forb Tundra, Dryas river terrace) and IVc (Moist Low Willow-Riparian Willow) (Table 1), it was impossible to distinguish these from the other type IV habitats on the Landsat map. On the ground, all riparian plots were dominated by willow cover, which ranged from dense willows up to 2 m high at inland sites to widely-scattered willows less than 50 cm high at coastal sites.

Riparian plots at Katakturuk have been described in Spindler and Miller (1983). At Okpilak, Katakturuk, and Jago-Bitty, riparian plots contained 45-79% willow or willow-sedge, 0-45% Dryas-herb tundra, 0-23% seral herbs (partially vegetated areas), 0-22% sedge-willow tundra, 0-14% wet sedge tundra, 0-10% sand, gravel, or mud, and 0-16% water (Table 5). Riparian habitats at the 3 study areas differed mostly in erectness and extent of willow coverage. Katakturuk had the tallest willows (up to 1.5 m tall), but of moderate extent (Plate 8); Jago had intermediate height willows (about 0.5 m tall), but the greatest extent of coverage (Plate 9); Okpilak had the lowest heights (less than 0.3 m tall) and least extensive coverage of willows (Plate 10).

Breeding and total bird populations

To determine the relative importance of various habitat types for birds according to rank in occupancy (breeding and total density) an understanding of the major sources of variation present is also required. Previous studies on the Alaska north slope and ANWR coastal plain have identified spatial and temporal variation as major factors (Magoun and Robus 1977, Myers and Pitelka 1980, Martin and Moitoret 1981, Spindler and Miller 1983). Spatial variation can further be divided into 3 component sources: between habitat, within habitat (replicates), and geographical (locational) all 3 of which were identified as important on ANWR (Spindler and Miller 1983). Temporal variation can be subdivided into seasonal, e.g. within a breeding or summer season as reflected by census period, and annual or inter-year. Again, both temporal factors have previously been identified as highly significant (Myers and Pitelka 1980, Martin and Moitoret 1981, Spindler and Miller 1983).

Differences Due to Location. The preliminary multi-way analysis of variance (MANOVA) on bird plot census data tested the significance of location in explaining differences between bird populations. The results indicated that

Plate 7. Tussock Dwarf Shrub

Plate 8. Riparian (medium-height willow, Katakturuk)

Plate 9. Riparian (low willow, Jago River-Bitty)

Plate 10. Riparian (sparse low willow, Okpilak)

location of study sites was not a significant factor, relative to habitat, in determining the size of breeding bird populations (Table 6), i.e. differences due to habitat were significantly greater than differences due to location.

The only groups for which location was a significant factor relative to habitat (at p=0.05) in total bird populations were shorebirds in general and pectoral sandpipers in particular (Table 7). This difference probably reflected the greater abundance of shorebirds in coastal areas as compared to inland sites, which may have been attributed to the availability of certain habitats in coastal areas which were not present at the inland sites. Shorebirds dominated the bird community in Flooded (II) and Moist/Wet Sedge (IVa) habitats (Fig. 8), which only occurred at Okpilak, the coastal study site. Likewise, pectoral sandpipers were in dominant positions in the communities of these same 2 habitats (Figs. 9 and 10).

Total populations of red-necked phalaropes showed a marginally significant difference due to location, a result which must be interpreted with caution because of the low numbers of these birds present in 1983 compared to other years. It is likely that in a year with higher population levels, a greater difference due to location would be observed for this species.

Since the preliminary MANOVA analysis indicated no difference in total bird populations due to location for all habitats, the next logical question was whether significant differences due to location were present within any single habitat type. This question was tested using a series of MANOVA analyses for differences due to location within the 3 habitat types which occurred at all 3 study sites: Wet Sedge (III), Moist Sedge-Shrub (V), and Riparian (IV, IX, X, XI)(Table 8).

Breeding bird populations showed no significant differences due to location within any of the 3 habitat types, for total birds, total species, shorebirds, or passerines; hence individual species were not tested. Total bird populations showed no significant differences due to location within the Moist Sedge-Shrub (V) habitat, but some significant differences due to location were noted within the other 2 habitats (Table 8). In those cases where significant differences were indicated by the MANOVA analysis, Student-Newman-Kuels (SNK) tests were used to determine which locations had mean populations that were significantly different from other locations.

In Wet Sedge (III) habitat there were significant differences due to location for total birds and for passerines, and for Lapland longspurs (Table 8). This result reflected the greater numbers of birds in Wet Sedge (III) habitat at Okpilak, the coastal site, compared to the 2 inland sites (Fig. 11). The SNK test for total birds showed mean total populations at Okpilak to be significantly higher than those at the 2 inland study sites. The SNK tests for passerines and Lapland longspurs showed Okpilak significantly higher than Jago Bitty, but neither Okpilak nor Jago-Bitty significantly different from Katakturuk, which was intermediate between them. Small sample size (1 plot) at Katakturuk may have caused the ambiguity in results for Katakturuk.

Riparian (IVb, IX, X, XI) habitat showed the most difference due to location; it was significant for total birds, passerines, red-necked phalaropes, and semipalmated sandpipers, and for total species (Table 8).

Table 6. Results of MANOVA analyses testing for differences in mean breeding bird populations due to study area location and habitat type over all locations, coastal plain, Arctic National Wildlife Refuge, Alaska, 1983.

Variable	Location	Habitat
Total birds	P=0.848	$0.001 < P < 0.0025$
Total species	P=0.975	$0.10 < P < 0.25$
Lesser golden-plover	P=0.652	$0.25 < P$
Red-necked phalarope	P=0.095	$0.10 < P < 0.25$
Semipalmated sandpiper	P=0.892	$0.005 < P < 0.01$
Pectoral sandpiper	P=0.217	$0.01 < P < 0.025$
Lapland longspur	P=0.847	P=0.000
Shorebirds	P=0.162	$0.25 < P$
Passerines	P=0.814	P=0.000

Table 7. Results of MANOVA analyses testing for differences in mean total bird populations due to location, habitat, and season over all locations, coastal plain, Arctic National Wildlife Refuge, Alaska, 1983

Variable	Location	Habitat	Season
Total birds	P=0.227	P=0.000	P=0.000
Total species	P=0.226	P=0.000	P=0.100
Lesser golden-plover	P=0.138	P=0.250	P=0.038
Red-necked phalarope	P=0.054	P=0.000	P=0.000
Semipalmated sandpiper	P=0.755	P=0.000	P=0.000
Pectoral sandpiper	P=0.014	P=0.000	P=0.000
Lapland longspur	P=0.613	P=0.000	P=0.000
Shorebirds	P=0.022	P=0.000	P=0.000
Passerines	P=0.534	P=0.000	P=0.000

Table 8. Results of MANOVA analyses testing for differences in mean total and breeding bird populations due to study area location within 3 habitat types, coastal plain, Arctic National Wildlife Refuge, Alaska, 1983.

Variable	Wet Sedge(III)	Moist Sedge-Shrub(V)	Riparian (IVb,IX,X,XI)
Total Bird Populations:			
Total birds	P=0.037	P=0.347	P=0.020
Total species	P=0.239	P=0.095	P=0.009
Shorebirds	P=0.180	P=0.281	P=0.194
Passerines	P=0.023	P=0.535	P=0.029
Lesser golden-plover	P=0.129	P=0.845	P=0.526
Red-necked phalarope	P=0.192	P=0.277	P=0.031
Semipalmated sandpiper	(no variance)	P=0.127	P=0.052
Pectoral sandpiper	P=0.183	P=0.298	P=0.189
Lapland longspur	P=0.006	P=0.364	P=0.142
Breeding Bird Populations:			
Total birds	P=0.599	P=0.265	P=0.357
Total species	P=0.923	P=0.790	P=0.663
Shorebirds	P=0.320	P=0.473	P=0.352
Passerines	P=0.583	P=0.277	P=0.155

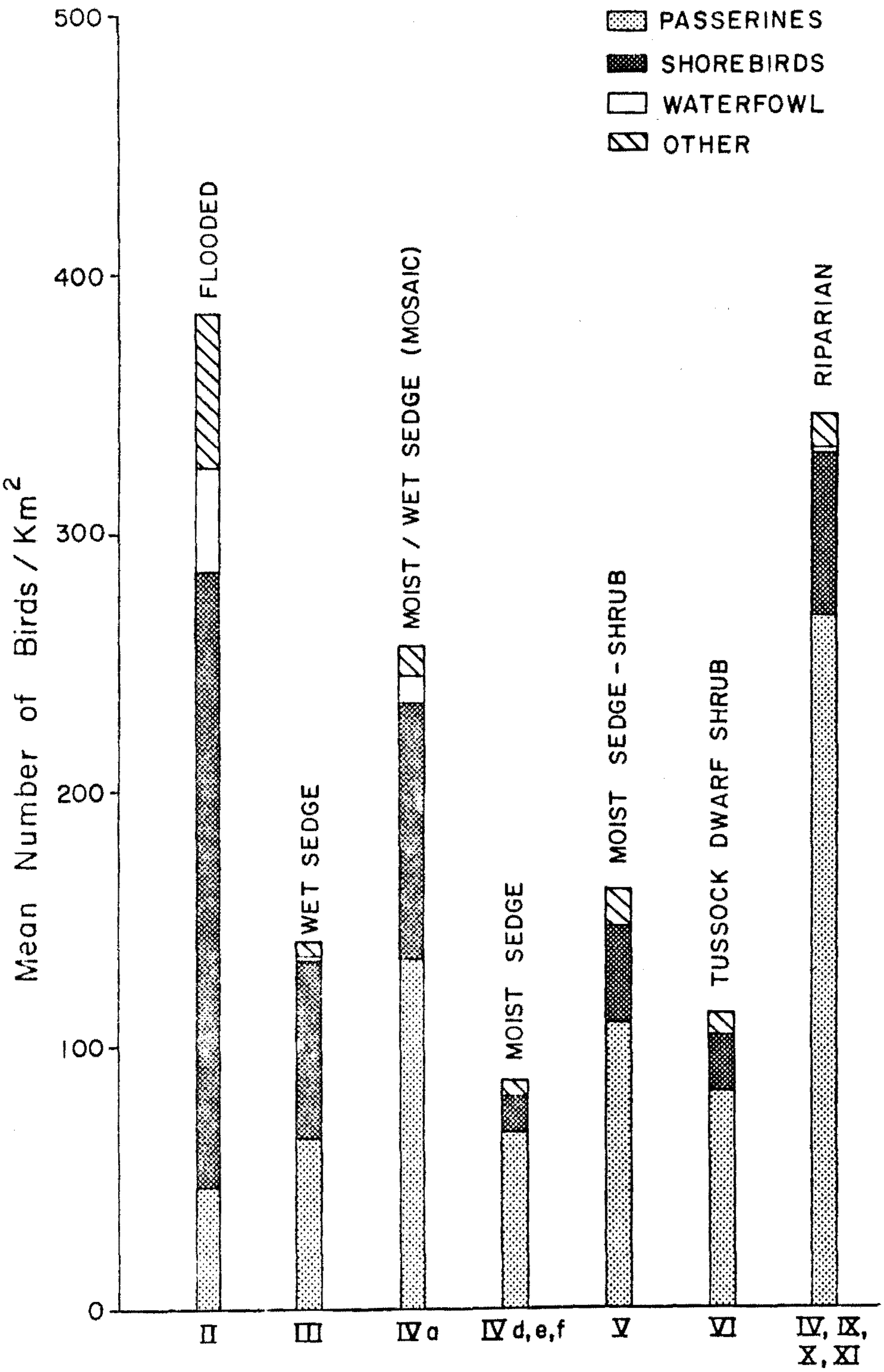

Fig. 8. Mean total densities of 4 bird groups in 7 habitat types on the arctic coastal plain, Arctic National Wildlife Refuge, Alaska, June-August 1983.

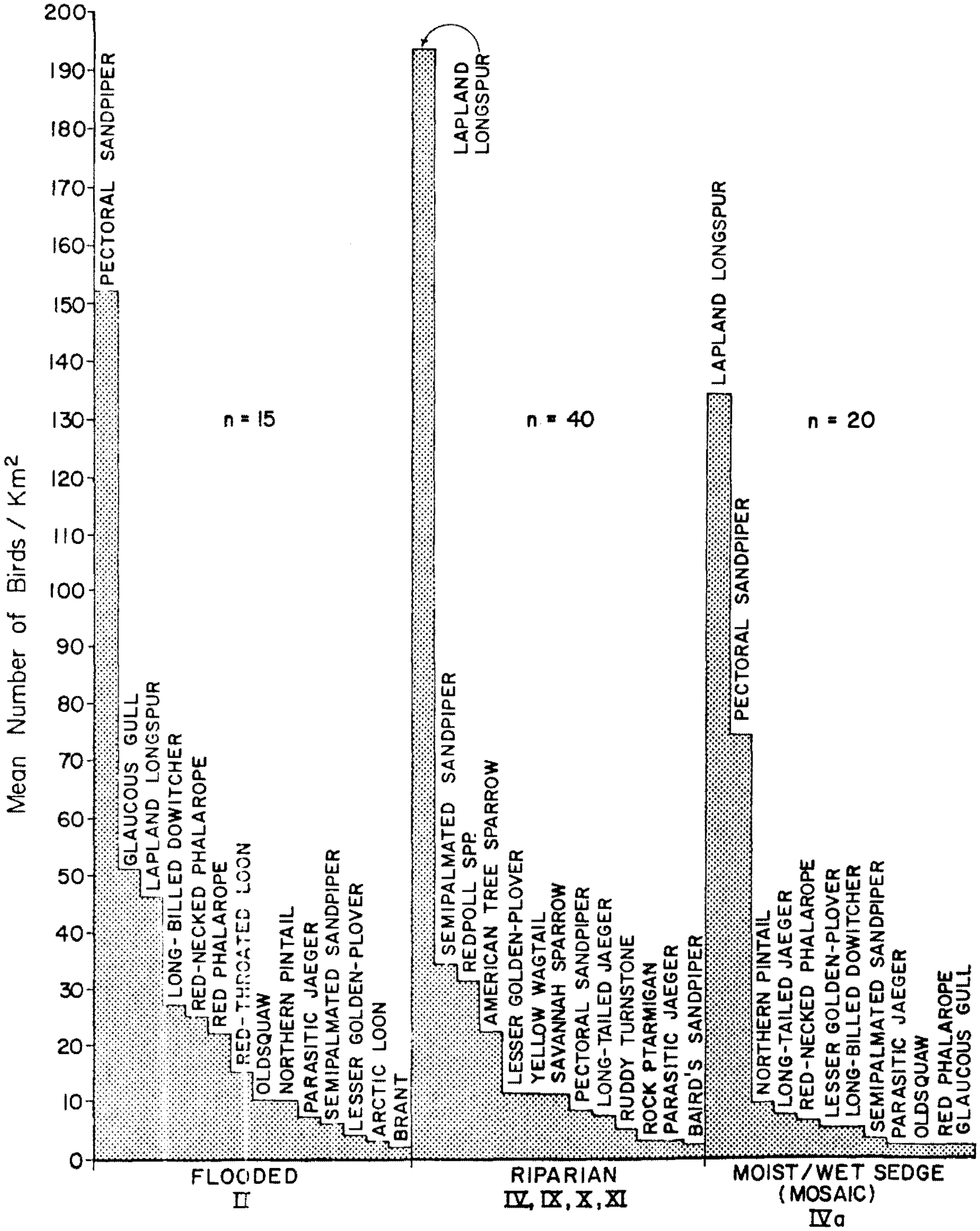

Fig. 9. Density-dominance structures for mean total densities of birds in the 3 most diverse coastal plain habitats censused in the Arctic National Wildlife Refuge, Alaska, June-August 1983. Only species with densities of 2/km^2 or greater are shown.

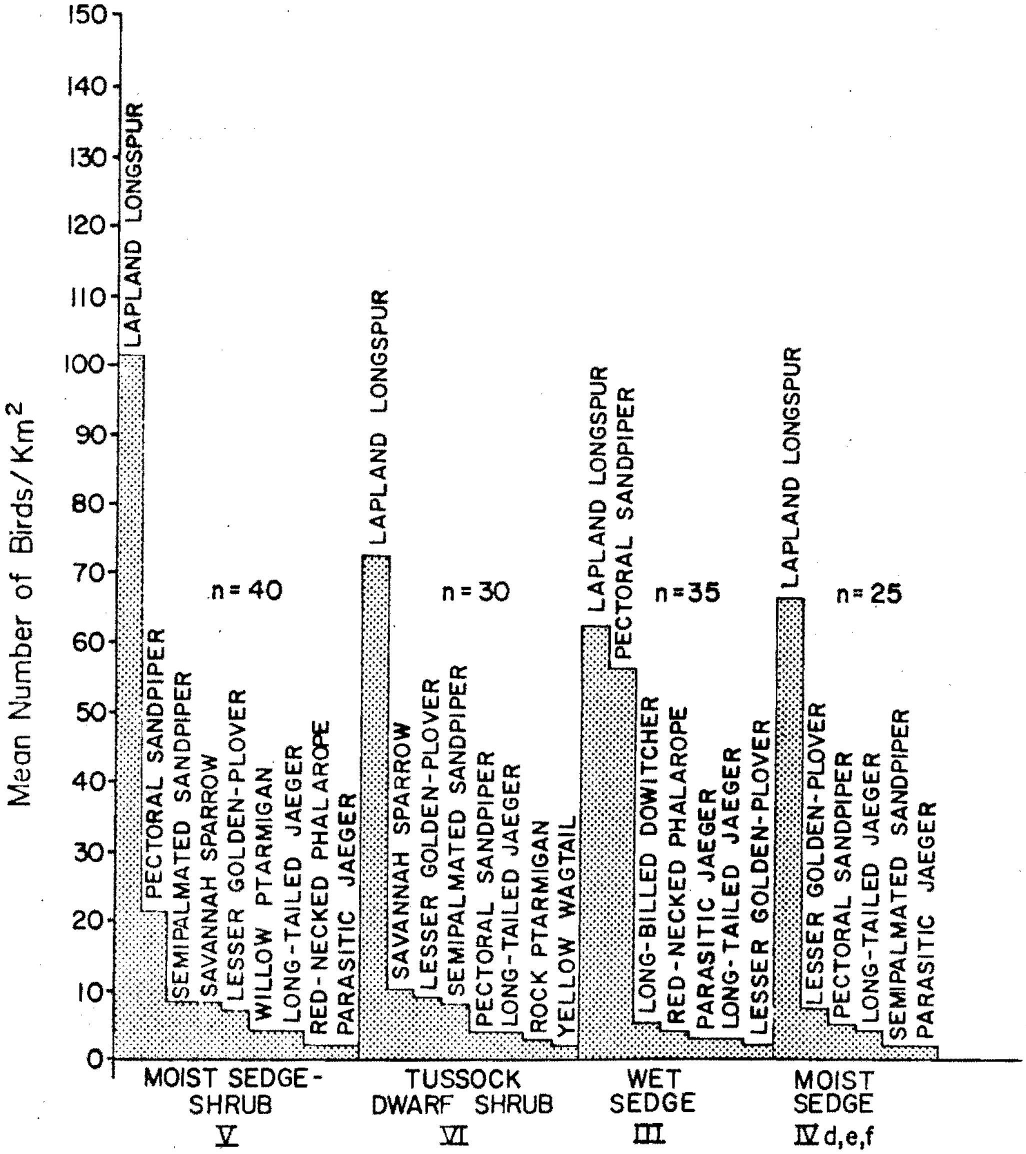

Fig. 10. Density-dominance structures for mean total densities of birds in the 4 coastal plain habitats of low density and diversity, Arctic National Wildlife Refuge, Alaska June-August 1983. Only species with densities of $2/km^2$ or greater are shown.

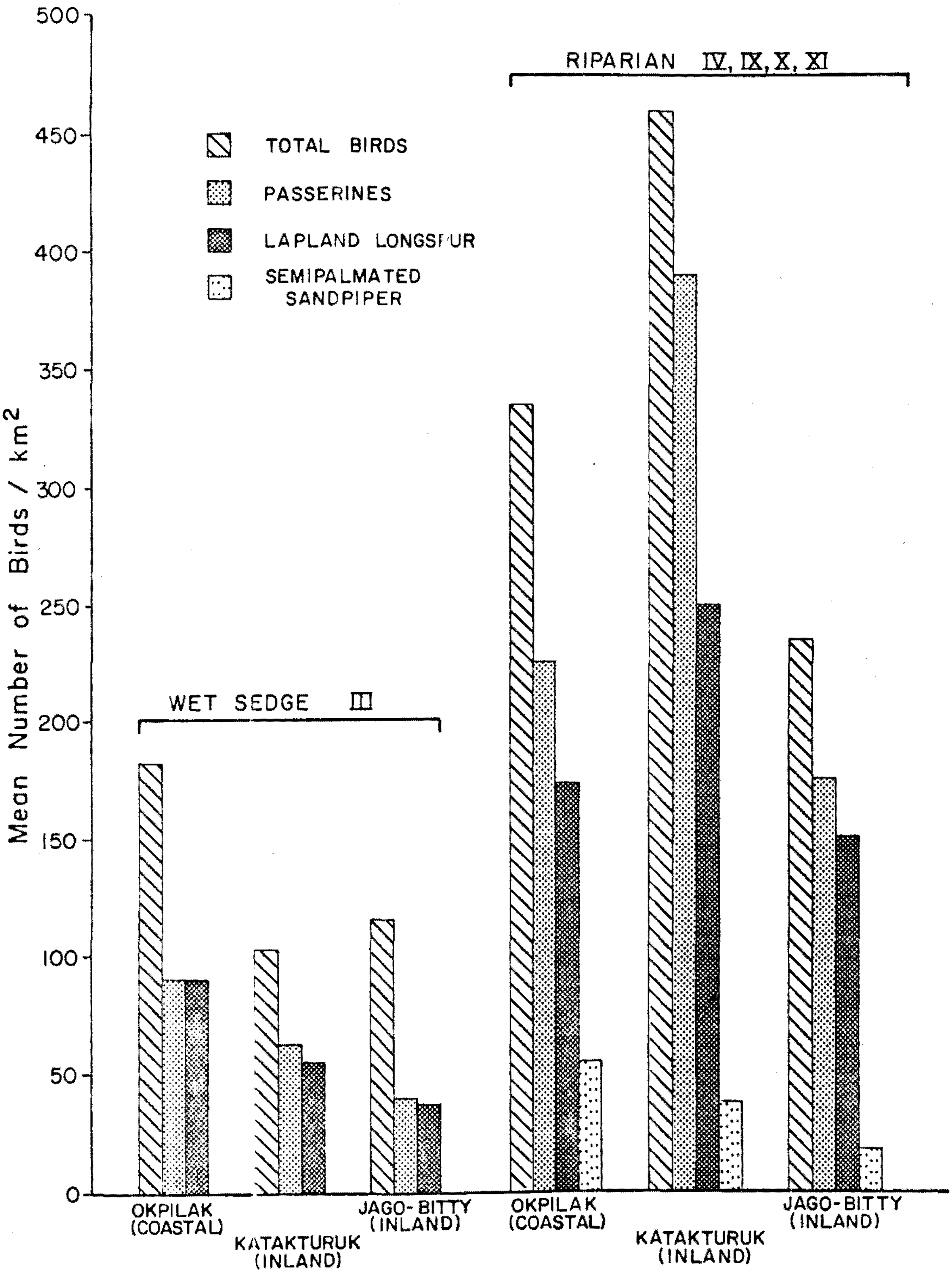

Fig. 11. Mean total densities of passerines, Lapland longspur, and semipalmated sandpiper in 2 coastal plain habitats at 3 sites, Arctic National Wildlife Refuge, Alaska, June–August, 1983.

Katakturuk had the highest mean populations of total birds and passerines in Riparian habitat , while Okpilak had the highest mean populations of semipalmated sandpipers and red-necked phalaropes in Riparian habitat (Fig. 11). The SNK tests for total birds and total species showed Katakturuk significantly higher than Jago-Bitty with Okpilak intermediate (not significantly different from either Katakturuk or Jago-Bitty). The SNK for semipalmated sandpiper showed Okpilak significantly higher than Jago-Bitty, with Katakturuk intermediate. The SNK for passerines showed Katakturuk significantly higher than the other 2 sites, and for red-necked phalarope Okpilak was significantly higher than the other 2 sites. Significantly higher densities at Katakturuk than the other 2 sites for passerines but not for Lapland longspurs was probably due to the large numbers of other passerines (American tree sparrows, redpolls, yellow wagtails) present in Riparian habitat at Katakturuk.

In summary, differences in bird populations due to location could be primarily attributed to the availability of different habitats at different locations, but there were also some differences due to location within habitat types. Riparian habitat showed the most variation in bird populations between locations, which is understandable due to variation in shrub height and extent between the 2 locations. Overall, the differences between locations mainly reflected higher densities of shorebirds and waterfowl in all habitats at Okpilak, the coastal site, and higher densities of passerines in Riparian habitat at Katakturuk, the inland site with the most extensive riparian willow thickets.

In evaluating effects of location, the significance of seasonal variation should also be considered, as it could have some relationship with location (see "seasonal variability" below); for example, the difference between inland and coastal locations may be more significant in the fall when there is a movement of birds to coastal areas (Myers and Pitelka 1980, Spindler and Miller 1983).

Differences Due to Habitat. The MANOVA analysis of bird plot census data indicated that habitat was a significant factor in the variation of total bird populations (ie. differences between habitat types were significantly greater than differences within habitat types due to replicates) for total birds, number of species, and for all individual species tested except lesser golden-plover (Table 7). For breeding bird populations, the results of the MANOVA analysis were less clear-cut, with habitat being significant for total birds, passerines, semipalmated sandpiper, pectoral sandpiper, and Lapland longspur; and not significant for number of species, total shorebirds, lesser golden-plover, and red necked phalarope (Table 6).

In order to clarify the significance of variation between habitats, SNK tests were performed on each group of means which the MANOVA analysis indicated were significant. These results are discussed below for each species or species group. In the accompanying tables, solid lines underline groups of habitats for which the SNK test indicated no significant difference in means (p=0.05).

The SNK for total birds indicated that the Flooded (II), Riparian (IX), and Moist/Wet Sedge (IVa) habitats had significantly higher mean total bird populations than the other 4 habitats, whose means were not significantly different from each other (Table 9).

Table 9. Results of SNK tests for differences between habitats for mean total bird density and mean number of species (P=0.05).

Variable	Habitat type/ n						
	II 15	IX 40	IVa 20	V 40	III 35	VI 30	IVd,e,f 25
Mean total birds/km^2	384	345	256	161	142	113	87
Mean number of species	8.1	5.9	5.0	3.7	3.4	3.1	2.2

The SNK for number of species showed considerable overlap between habitats, but the Flooded (II) habitats contained significantly more species than any other, and the ordering of habitats was identical to that for total birds (Table 9).

The SNK for total breeding birds revealed a different pattern, in which only Riparian had a mean total population which was significantly higher than those of the other 6 habitats (Table 10).

Table 10. Results of SNK test for difference between habitats for mean total breeding bird density (P=0.05).

Variable	Habitat/n						
	IX 8	IVa 4	VI 6	V 8	II 3	III 7	IV d,e,f 5
Mean total nests and territories/km^2	117	70	59	56	55	54	40

The SNK's for total passerines and Lapland longspurs were quite similar. The mean total populations were significantly greater in Riparian (IX), and for Lapland longspurs Moist/Wet Sedge (IVa) also showed a significantly greater mean total population than the other 5 habitats (Table 11).

The SNK's for breeding populations of passerines and Lapland longspurs were identical, and followed the same ranking as total populations of these groups. The mean breeding populations of passerines and of Lapland longspurs were significantly greater in Riparian (IX) than in all other habitats (Table 12). In the other 6 habitats mean breeding populations of passerines and of Lapland longspurs were not significantly different from each other.

Table 11. Results of SNK tests for differences between habitats for mean total passerine and Lapland longspur densities (P=0.05).

Variable	Habitat type/n						
	IX	IVa	V	VI	IV d,e,f	III	II
	40	20	40	30	25	35	15
Mean total passerines/km^2	268	134	109	83	67	65	46
Mean total Lapland longspurs/km^2	193	134	101	72	66	62	4[illegible]

Table 12. Results of SNK tests for differences between habitats for mean total breeding passerine and breeding Lapland longspur densities (P=0.05).

Variable	Habitat type/n						
	IX	IVa	VI	V	IV d,e,f	III	II
	8	4	6	8	5	7	3
Mean passerine nests and territories/km^2	91	42	42	35	30	25	22
Mean Lapland longspur nests and territories/km^2	65	42	35	32	30	24	22

The SNK for total shorebirds showed considerable overlap between habitats, but Flooded (II) contained significantly more shorebirds than any other habitat (Table 13). There was no significant difference between habitats for mean total breeding populations of shorebirds, as shown by the overall MANOVA analysis (Table 6).

Table 13. Results of SNK tests for differences between habitats for mean total shorebird density (P=0.05).

Variable	Habitat type/n						
	II	IVa	III	IX	V	VI	IV d,e,f
	15	20	35	40	40	30	25
Mean total shorebirds/km^2	239	99	69	62	38	21	14

Total and breeding populations of red-necked phalaropes showed identical patterns, with Flooded (II) containing significantly higher mean populations than any other habitat (Table 14). In the other 6 habitats, mean total and breeding populations of red-necked phalaropes were not significantly different. Numbers of red-necked phalaropes were extremely low in 1983, so the significance of these results could be expected to differ in a year of higher population levels (see section on "annual variation" below).

Table 14. Results of SNK tests for differences between habitats for mean red-necked phalarope total and breeding densities (P=0.05).

Variable	Habitat type						
	II	IVa	III	V	IX	VI	IV d,e,f
Mean total red-necked phalaropes/km^2	25	6	4	2	1	0	0
n	15	20	35	40	40	30	25
Mean red-necked phalarope nests and territories/km^2	7	2	0	0	0	0	0
n	3	4	7	8	8	6	5

The SNK for mean total populations of pectoral sandpipers indicated 3 distinct groupings of habitats (Table 15). Flooded (II) showed significantly higher mean density of pectoral sandpipers than all other habitat types. Moist/Wet Sedge (Mosaic) (IVa) and Wet Sedge (III) habitats had mean densities which were not significantly different from each other, but were significantly lower than that of Flooded and significantly higher than those of the other 4 habitat types.

Table 15. Results of SNK test for differences between habitats for mean total pectoral sandpiper density (P=0.05).

Variable	Habitat type/n						
	II	IVa	III	V	IX	IVdef	VI
	15	20	35	40	40	25	30
Mean total pectoral sandpipers/km^2	152	74	56	21	8	5	4

Although the SNK for total population of pectoral sandpipers showed significant grouping of habitats at 3 levels of density (Table 15), the SNK for breeding pectoral sandpipers showed no such clear distinction between habitats (Table 16). Highest densities were found in Wet Sedge (III), Moist/Wet Sedge (IVa), Moist Sedge - Shrub (V), and Flooded (II), but the population densities of these 4 types were not significantly different from each other.

Table 16. Results of SNK test for differences between habitats for mean breeding pectoral sandpiper density (P=0.05).

Variable	Habitat type/n						
	III 7	IVa 4	V 8	II 3	IV d,e,f 5	VI 6	IX 8
Mean pectoral sandpiper nests and territories/km^2	27	20	12	10	6	3	2

Total and breeding populations of semipalmated sandpipers showed identical patterns, with Riparian (IX) containing significantly higher mean populations than any other habitat (Table 17). In the other 6 habitats mean total and breeding populations of semipalmated sandpipers were not significantly different. Semipalmated sandpiper numbers appeared lower in 1983 than in previous years; though the difference was not as pronounced as for red-necked phalaropes, this could affect the significance of these results (see section on "annual variation", below).

Table 17. Results of SNK test for differences between habitats for mean semipalmated sandpiper total and breeding densities (P=0.05).

Variable	Habitat type						
	IX	VI	V	II	IVa	IV d,e,f	III
Mean total semipalmated sandpipers/km^2	34	8	8	6	3	2	0
n	40	30	40	15	20	25	35
Mean semipalmated sandpiper nests and territories/km^2	17	7	4	0	0	0	0
n	8	6	8	3	4	5	7

SNK's were not applied to data for lesser golden-plover, as the MANOVA analysis revealed no significanct differences due to habitat for this species (Table 7). Lesser golden-plovers were generally found in low numbers in all habitats.

From the foregoing analyses it is apparent that certain habitats had significantly higher bird populations than others. The 3 habitats which had significantly higher mean total bird densities than others were (Flooded II), Riparian (IX), and Moist/Wet Sedge (Mosaic) (IVa). These 3 habitats also appeared repeatedly in the analyses as having significantly higher densities of individual species and species groups than other habitats.

Flooded (II) was significantly higher than all other habitats for number of species and for densities of total shorebirds, pectoral sandpipers, red-necked phalaropes, and breeding densities of red-necked phalaropes. Flooded Tundra also had a higher density of waterfowl than any other habitat (Fig. 8). Riparian (IX) was significantly higher than all other habitat types for densities of total nests (Appendix A-5), total and breeding passerines, total and breeding Lapland longspurs, and total and breeding semipalmated sandpipers Moist/Wet Sedge (Mosaic) (IVa) showed significantly higher densities of total shorebirds, pectoral sandpipers, and Lapland longspurs, second only to Flooded (II) and Riparian (IVb, IX, X, XI). Wet Sedge (III) and Moist Sedge-Shrub (V) were of equal significance for pectoral sandpiper breeding as Flooded (II) and Moist/Wet Sedge (IVa). The only 2 habitats which did not show significantly higher densities for any species or species group tested were Moist-Sedge (IVd,e,f,) and Tussock Dwarf Shrub (VI). These 2 habitats tended to fall at the lower end of the range of mean densities for shorebirds, and near the middle of the range for passerines.

In addition to total numbers of birds present in each habitat, the diversity pattern of the entire community was examined using the density-dominance structure of species (Figs. 9 and 10). Every habitat was dominated by a single species or pair of species (Lapland longspur and/or pectoral sandpiper), but the density and diversity of the other species varied between habitats. Flooded (II), Riparian (IX), and Moist/Wet Sedge (IVa) clearly contained the greatest diversity of species (Fig. 9), while Moist Sedge-Shrub (V), Tussock Dwarf Shrub (VI), Wet Sedge (III), and Moist Sedge (IVd,e,f) were depauperate by comparison (Fig. 10). Therefore, the habitats which had significantly higher densities also showed highest overall species diversity. Every species found in these latter 4 habitats could be found with equal or greater density in 1 of the 3 "prime" habitats, with the exception of willow ptarmigan which had greatest density in Moist Sedge-Shrub (V) and savannah sparrow which had greatest densities in Tussock Dwarf Shrub (VI) and Moist Sedge-Shrub (V). The most populous and diverse habitat, Flooded, had the most even distribution of species abundance, while habitats of lesser density and diversity showed more drastically declining abundance distributions (Figs. 9 and 10).

<u>Variation Due to Season.</u> The MANOVA analysis of bird plot census data indicated that season (date of census) was a highly significant factor in the variation of total bird populations for all species tested (Table 7). Season was not a significant factor, however, in the variation of number of species present. Analyses of seasonal variation indicated differences in density and species composition due to habitat type, distance from coast, and flocking.

Patterns of seasonal variability in total bird population density differed by habitat type (Fig. 12) In all study areas the Wet Sedge (III), Moist/Wet Sedge (Mosaic)(IVa), and Moist Sedge-Shrub (V) habitat types showed the most even distribution of total density among the 5 censuses (Fig. 12). In contrast, the Flooded (II), Tussock Dwarf Shrub (VI), and Riparian (IX) habitat types showed uneven distribution of density among censuses. Flooded habitat showed the most uneven distribution, with moderately high density the first census followed by a gradual decline to a minimum density observed on census 4 and a subsequent sharp rise in density at the last census. A different pattern in total density was observed in Tussock Dwarf Shrub (VI), with a peak on census 2 followed by a decline to census 4 and a small increase on census 5 (Fig. 12). The Riparian (IX) habitat maintained

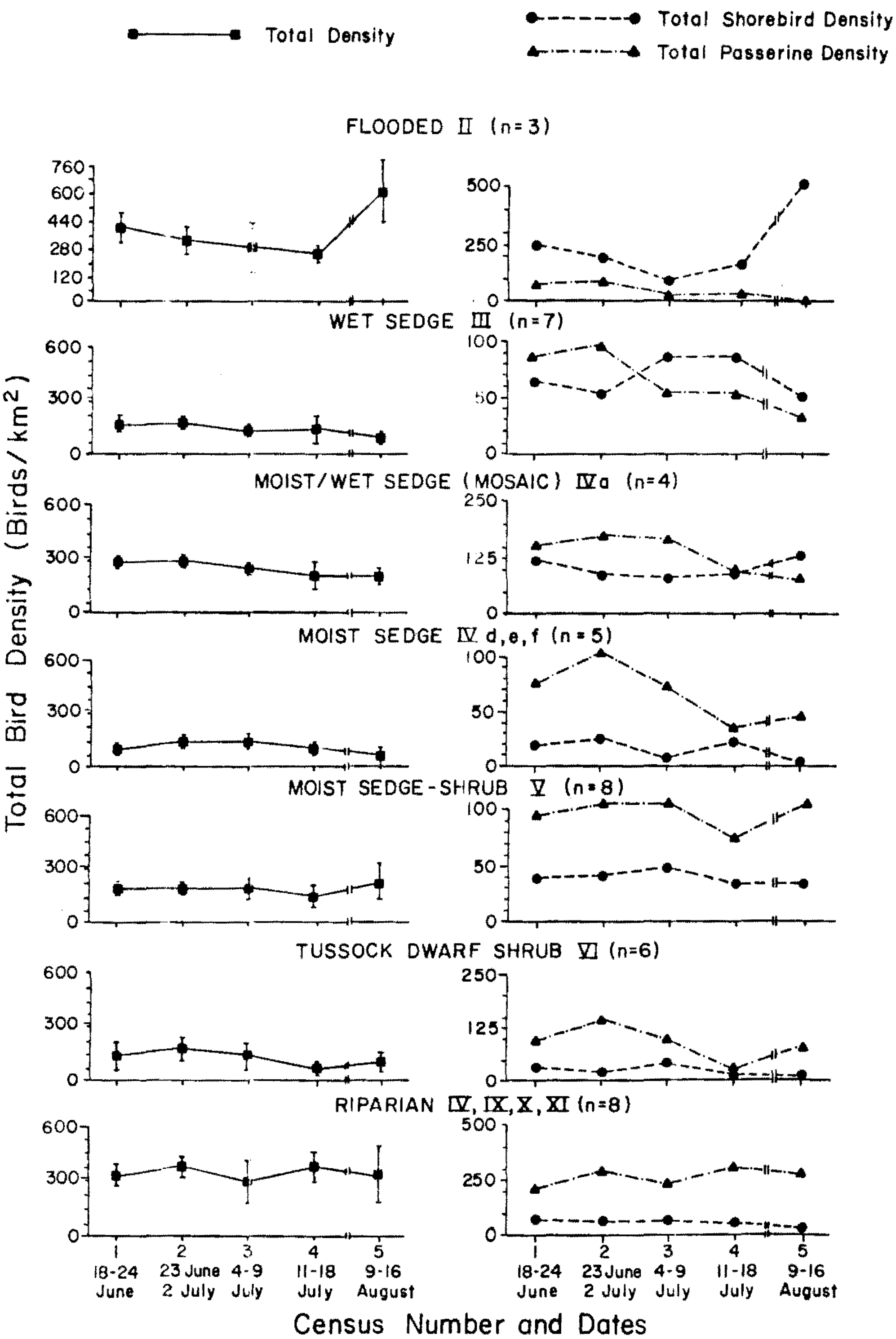

Fig. 12. Seasonal variability curves for total density in 7 coastal plain habitat types on all study areas combined, Arctic National Wildlife Refuge, Alaska, June-August, 1983. Ranges given for data points represent 1 standard deviation.

overall high total density but with small peaks at census 2 and 4 surrounding a trough at census 3.

There were some major differences in seasonal distribution of the passerine versus shorebird components of the bird community in habitats with uneven as well as even overall population distributions (Fig. 12). Peak densities in Flooded (II) habitat occurred as a final rise on census 5, which was attributable to an increase in shorebirds involved in fall migration and premigratory staging (Fig. 12). This pattern was also reported in coastal Moist/Wet Sedge (Mosaic) and Wet Sedge at Canning River delta (Martin and Moitoret 1981) and in coastal Wet Sedge at Barrow (Myers and Pitelka 1980). This increased fall shorebird density was more pronounced in Flooded (II) compared to other habitats, and contributed to the overall seasonal change in density. In other habitats with marked seasonal overall density fluctuations, Tussock Dwarf Shrub (VI) and Riparian (IX), these changes were largely due to the passerine component of the bird community (Fig. 12). In Wet Sedge (III) and Moist/Wet Sedge (IVa) habitats, there were not large overall seasonal fluctuations in total densities, primarily due to opposite trends in abundance of shorebird and passerine components. In Wet Sedge (III), passerines were initially more abundant, but between census 2 and 3, shorebirds became more abundant. Both components declined significantly from census 4 to 5 (Fig. 12). A similar change in seasonal rank was observed in the Moist/Wet Sedge (IVa) type except that a later change occurred, between censuses 4 and 5 (Fig. 12). In Moist Sedge (IVd,e,f), a change in rank of the passerine versus shorebird components did not occur, but a steady decline in passerine densities occurred after census 2, whereas shorebird densities remained relatively stable at low levels (Fig. 12).

Inland versus coastal seasonal patterns in total population density were compared for those habitats occurring at both inland and coastal sites (Fig. 13). Extremes of seasonal variation were found to be greater in all 3 habitats along the coast than on the same habitats inland (Fig. 13). In Wet Sedge (III), total density declined inland on census 4 whereas it increased coastally on the same census, an increase attributable mainly to greater shorebird densities (Fig. 13). A change in comparative rank of shorebirds and passerines in Wet Sedge (III) occurred between census 2 and 3 inland and census 3 and 4 coastally as shorebird density increased while passerines (mostly Lapland longspurs) departed the habitat (Fig. 13). The Moist Sedge-Shrub (V) type near the coast showed an increase in passerines (mostly Lapland longspurs) on census 3, which may have been attributed to an increase in conspicuousness as incubation was completed (Figs. 13 and 14). A terminal peak in total density in Moist Sedge - Shrub (V) occurred both inland and coastally, but was composed mostly of passerines inland whereas it included passerines and shorebirds coastally (Fig. 13). Both peaks were associated with premigratory staging and fall migration. A peak in shorebirds also occurred in Riparian (IX) habitats coastally on census 4, and inland on census 5. This peak was associated with migration, however the difference in timing between inland and coastal sites was unexplained.

The decline in shorebird densities late in the season at inland coastal plain sites and the corresponding increase in densities coastally, observed in this and other studies (Myers and Pitelka 1980, Spindler and Miller 1983) is probably related to a coastward shift of shorebirds (Myers and Pitelka 1980). However, the association is largely circumstantial, as specific studies using marked birds have not been done.

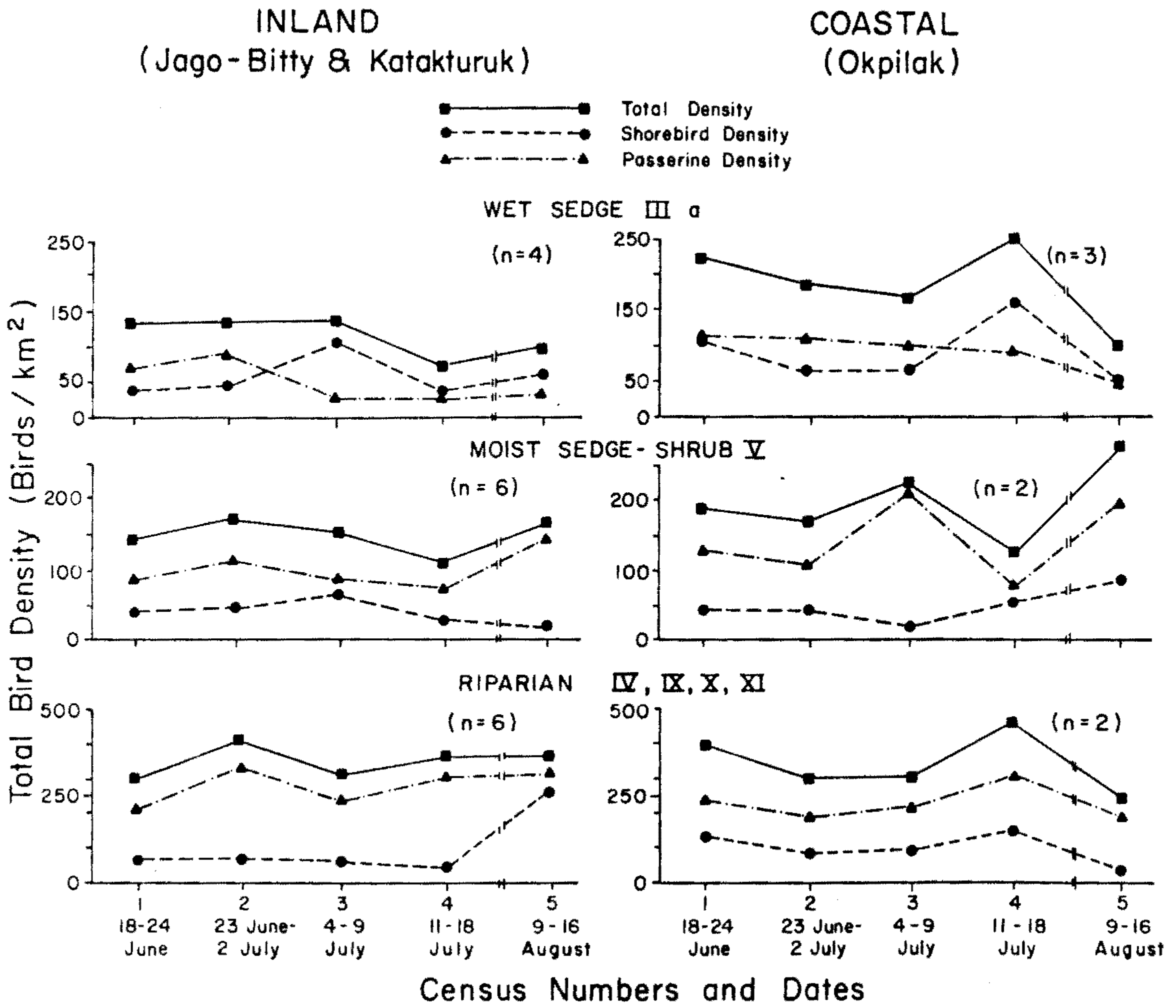

Fig. 13. Differential patterns in seasonal variability of total density, shorebird density, and passerine density on three habitat types occurring on both near-coast and inland study areas, coastal plain, Arctic National Wildlife Refuge, Alaska, June-August, 1983.

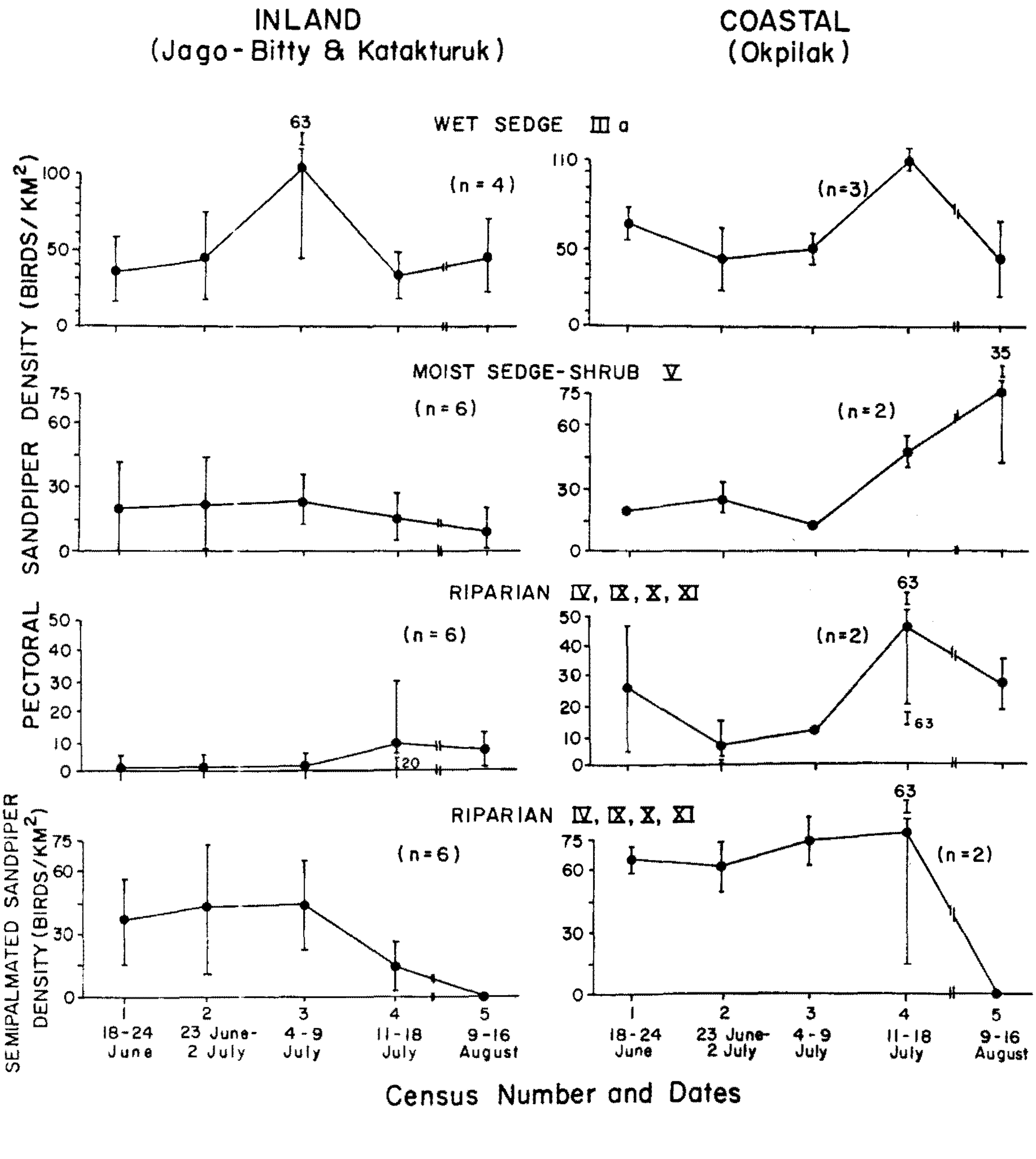

Fig. 14. Differential patterns in seasonal abundance of pectoral and semipalmated sandpipers on 3 habitat types occurring on both near-coast and inland study areas, coastal plain, Arctic National Wildlife Refuge, Alaska, June-August, 1983. Ranges given for data points represent 1 standard deviation.

Variation among replicates (as evidenced by size of standard deviation ranges in Fig. 12) increased for the 2 to 3 latest censuses in all habitat types except Moist Sedge (IV d, e, f) and Tussock Dwarf Shrub (VI). This could have been caused by an apparent increased spatial patchiness due to flocking, especially in pectoral sandpipers (Fig. 14), long-billed dowitchers, and Lapland longspurs (Fig. 15). The pattern was especially noticeable for pectoral sandpipers in Wet Sedge (III) inland on census 3 and coastally in Moist Sedge-Shrub (V) on census 5, and Riparian (IX) inland and coastally on census 4 (Fig. 14). Low spatial variation, conversely, tended to occur in the earliest censues (Figs. 12 and 14).

These differing amounts of spatial variability according to species, distance from coast, habitat, and season likely indicated where and when flocking due to staging and migration was occurring, as well as where and when conspicuousness of a species was changing. Semipalmated sandpipers showed the highest spatial variation on Census 4 in coastal Riparian (IX) habitats, but showed higher variation on earlier censuses in inland Riparian habitat (Fig 14). Lapland longspurs showed the greatest spatial variation on censuses 3, 4 and 5 in inland Moist Sedge-Shrub (V) and Riparian (IX) and on census 3 in coastal Moist Sedge-Shrub (V) (Fig. 15). The inland seasonal distribution of Lapland longspurs (Fig.15), suggested a departure from Wet Sedge (III) and flocking to adjacent Riparian (IX) and Moist Sedge-Shrub (V) types after census 3. The somewhat different pattern for coastal habitats suggested gradual departure of longspurs from Wet Sedge (III) after Census 2, increased but highly variable conspicuousness of pairs as incubation was completed and young were fed in Moist Sedge-Shrub (V) types on census 3, and a departure of longspurs from the latter 2 habitats to adjacent creek and Riparian (IX) habitats on census 4 (Fig. 15).

Annual Variation

Annual variation in bird populations was investigated for the Okpilak River delta study area where data had been collected during 3 years, the longest period of intensive bird census at ANWR. Comparison of populations between years was complicated by differences in the sampling effort between years, particularly the small number of plots (7) which were censused in all 3 years and lack of replication for Moist Sedge-Shrub (V) habitat.

Breeding populations. Marginally significant differences between years in breeding bird populations (nests and/or territories/km^2) (Table 18) were detected ($0.05 < p < 0.10$), using 2-way ANOVA. A 2-way ANOVA model was used to determine if annual variation was of the same level of significance as variation between habitats, because the multi-year data set was different than the 1983 set analyzed by MANOVA and discussed previously. Similarly significant differences were found in breeding bird populations by habitat ($0.05 < p < 0.10$) as by year. The interaction of habitat with year was not significantly different between years ($p > 0.50$), meaning that population changes between years were not consistent for each habitat.

Further comparisons between the 3 years studied were for each habitat separately for breeding populations with sufficient data: total birds, total shorebirds, Lapland longspur and pectoral sandpiper in Flooded (II), Wet Sedge (III), and Moist/Wet Sedge (mosaic) (IVa) habitats; red-necked phalarope and red phalarope in Flooded (II) habitat; and red phalarope and semipalmated sandpiper in Moist/Wet Sedge (IVa) habitat. A series of Kruskal-Wallis tests (Table 18) indicated that annual variation was

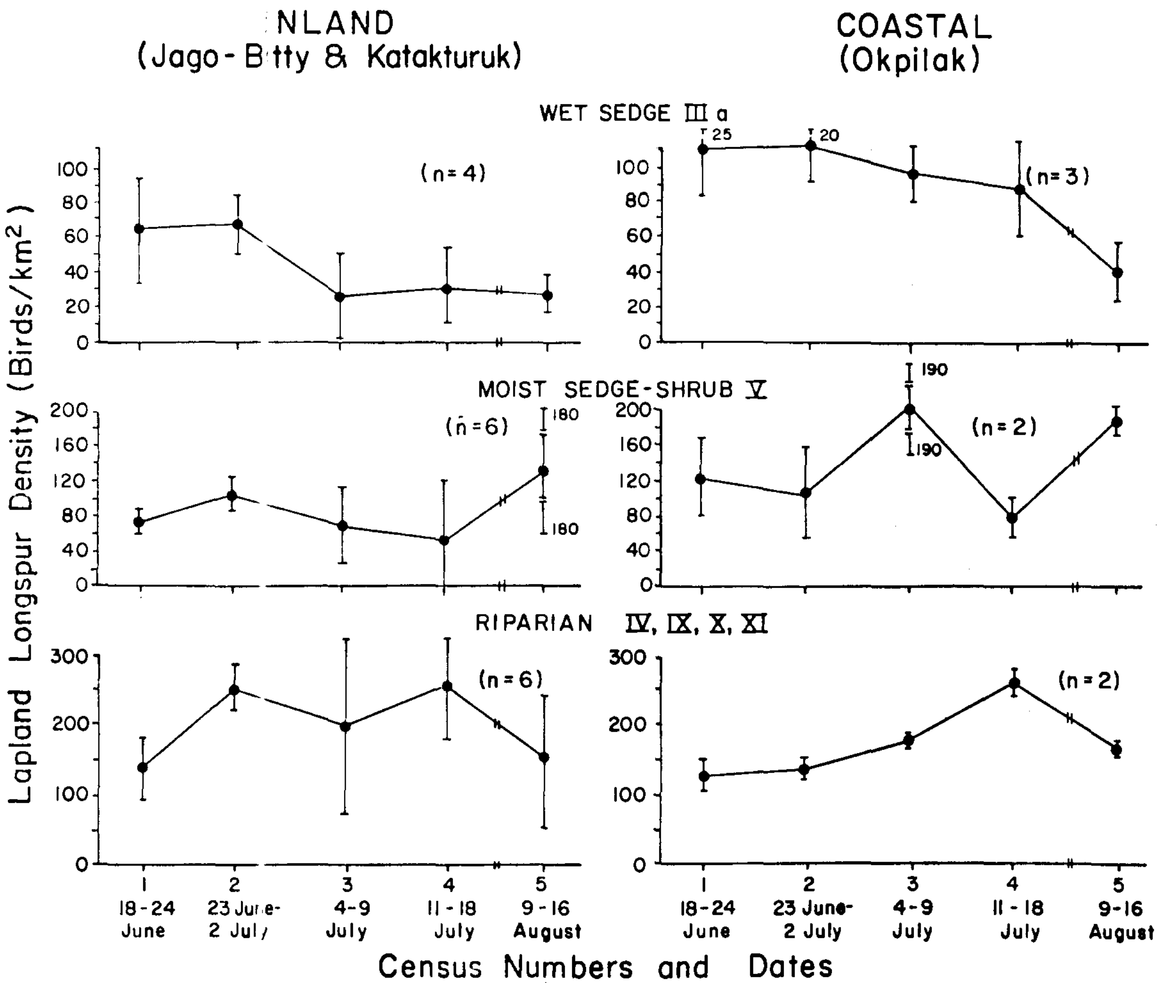

Fig. 15. Differential patterns in seasonal abundance of Lapland longspurs on 3 habitat types occurring on both near-coast and inland study areas, coastal plain, Arctic National Wildlife Refuge, Alaska, June-August, 1983. Ranges given for data points represent 1 standard deviation.

Table 18. Summary of mean breeding bird density (number of nests or territories/km^2) and significance of inter-year differences on 4 habitat types at Okpilak River delta, Arctic National Wildlife Refuge, Alaska, 1978, 1982, and 1983

Variable	Habitat type[1]	Density (mean ± S.D.) 1978	1982	1983	Kruskal Wallis (H)	Probability
Total Breeders	Flooded	50.0±12.7	70.2± 5.6	55.0± 8.7	5.0706	$0.05 < P < 0.10$
	Wet Sedge	43.0± 4.3	48.2±10.6	60.0±20.0	1.0018	$0.50 < P < 0.75$
	Moist/Wet Sedge	66.0±21.2	94.2± 9.9	73.3± 2.9	4.9307	$0.05 < P < 0.10$
	Moist Sedge Shrub	41.0	54.1	62.5± 3.5		
Total Shorebirds	Flooded	35.0± 5.7	47.7±10.9	23.3±11.5	5.491	$0.05 < P < 0.10$
	Wet Sedge	13.0± 4.2	18.0± 2.6	26.7±15.3	0.5977	$0.50 < P < 0.75$
	Moist/Wet Sedge	12.0±12.7	44.8± 7.7	33.3± 5.8	5.2946	$0.50 < P < 0.10$
	Moist Sedge-Shrub	0	16.5	10.0		
Semipalmated Sandpiper	Moist/Wet Sedge	0	4.5± 4.3	0	6.393	$P < 0.05$
Pectoral Sandpiper	Flooded	20.0± 1.4	27.7±10.9	10.0±10.0	2.8021	$0.10 < P < 0.25$
	Wet Sedge	8.0± 2.8	14.7± 4.5	26.7±15.3	1.026	$0.10 < P$
	Moist/Wet Sedge	7.0± 5.7	27.0± 5.2	26.7±11.6	4.2225	$0.10 < P < 0.25$
	Moist Sedge-Shrub	0	16.5	7.5±10.6		
Red-necked phalarope	Flooded	0	20.0±0	6.7± 5.8	5.765	$P < 0.05$
Red phalarope	Flooded	15.0± 7.1	0	3.3± 5.8	4.7706	$0.05 < P < 0.10$
	Moist/Wet Sedge	5.0± 7.1	6.7± 5.8	0	2.479	$0.25 < P < 0.50$
Lapland Longspur	Flooded	15.0± 7.1	12.5± 3.9	21.7±18.9	0.4854	$0.75 < P < 0.90$
	Wet Sedge	30.0±0	31.7±10.8	33.3± 5.8	0.1480	$0.90 < P < 0.95$
	Moist/Wet Sedge	54.0±8.5	49.3±10.7	38.3± 2.9	3.1639	$0.10 < P < 0.25$
	Moist Sedge-Shrub	41.0	37.6	45.0±14.2		

[1]n = 1 for Moist Sedge-Shrub in 1978 and 1982
n = 2 for Flooded, Wet Sedge, and Moist/Wet Sedge in 1978; and for Moist sedge-shrub in 1983
n = 3 for Flooded, Wet Sedge, and Moist/Wet Sedge in 1982 and 1983.

highest for Flooded (II) and Moist/Wet Sedge (IVa) habitats and was marginally significant ($0.05 < p < 0.10$) between years for total breeding populations and total shorebird breeding populations in Flooded (II) and Moist/Wet Sedge (IVa) habitats.

The year when maximum total breeding and total shorebird breeding populations was observed varied by habitat type (Fig. 16). In the habitats for which significant differences were described above, Flooded (II) and Moist/Wet Sedge (IVa), these densities were highest in 1982. In the other habitats, Wet Sedge (III) and Moist Sedge-Shrub (IV), peak densities were achieved in 1983. The peak total breeding densities for Flooded (II), Wet Sedge (III) and Moist/Wet Sedge (mosaic) (IVa) corresponded with peaks in shorebird densities, while the highest total breeding population density in the drier Moist Sedge-Shrub (V) habitat seemed to be most affected by Lapland longspur densities (Fig. 16), although statistically significant annual differences in the longspur populations were not detected (Table 18).

Significant annual differences were not shown by Kruskal-Wallis tests (Table 18) for breeding populations of either Lapland longspur or pectoral sandpiper, the most abundant species found in all habitats. For pectoral sandpipers this lack of significance may be due to the high spatial variation as revealed in high standard deviations associated with mean numbers of total breeding populations by habitat (Table 18 and Fig. 16), because densities on some individual plots were substantially different between years. Pectoral sandpipers have been shown to have patchy nest distribution with compressed territories to take advantage of locally favorable areas (Pitelka 1959, Holmes 1966, Spindler et al. 1984). Species that were restricted to specific habitats for breeding showed significant annual differences by Kruskal-Wallis tests (Table 18): red-necked phalarope in Flooded (II) ($P < 0.05$), and semipalmated sandpiper in Moist/Wet Sedge (mosaic) (IVa) ($P < 0.05$). Marginally significant inter-year variation was detected for red phalarope ($0.05 < P < 0.10$) in Flooded (II) (Table 18). Red-necked phalarope, red phalarope and semipalmated sandpiper densities in these particular habitats exemplified some of the most dramatic breeding population fluctuations we have observed in coastal plain tundra habitats, and contributed to significant annual variation in total breeding populations.

Perhaps the most critical question about annual variation of total breeding populations is whether or not the ranking among habitats for bird use changes in various years. Mean total number of nests and/or territories per km^2 (Table 18) were listed by habitat from highest to lowest densities (Table 19). Moist/Wet Sedge (IVa) tundra consistantly had the highest mean breeding population in all 3 years of study at Okpilak. Martin (1983) found highest breeding densities in this habitat type and theorized that the high micro-habitat diversity and wetness of this habitat type provided the most optimum conditions for breeding requirements of shorebirds and longspurs: drier habitats which provided nesting sites and a food source early in the season, and polygon troughs and pools which provided important food items later in the season. The largest change in rank of density occurred for Flooded (II) in 1983, when this habitat ranked lowest in total breeding populations, compared with the 2 previous years of study when it ranked second highest. This change appeared to be due to a decrease in 1983 in total numbers of breeding shorebirds, particularly fewer pectoral sandpipers, a virtual absence of red phalaropes and fewer red-necked phalaropes. Another usually consistant pattern was higher total breeding

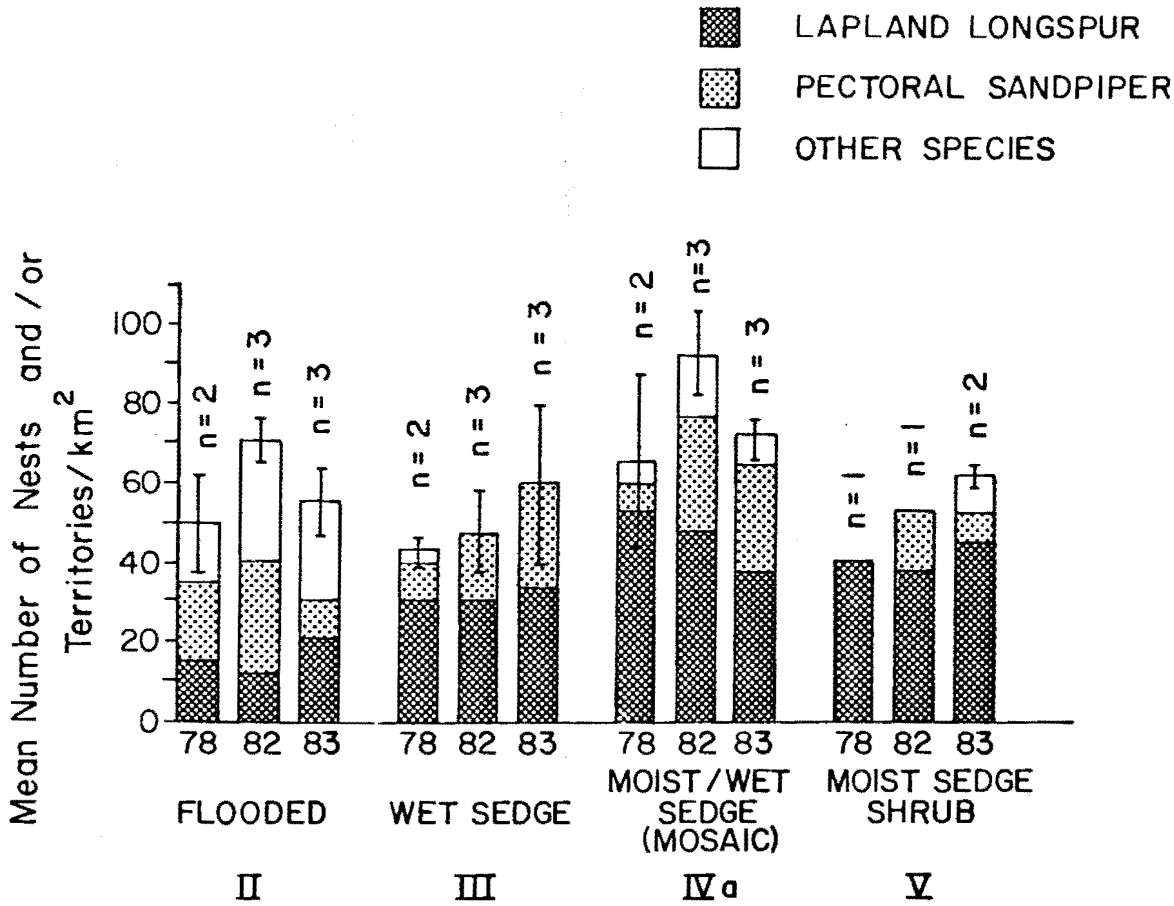

Fig. 16. Annual variability in breeding population of Lapland longspur, pectoral sandpiper and other species combined in 4 coastal plain habitat types, Okpilak River delta study area, Arctic National Wildlife Refuge, June-July, 1978, 1982, and 1983. Ranges given for each species group represent 1 standard deviation of total breeding density.

densities for Moist Sedge-Shrub (V) habitat compared to Wet Sedge (III), but in 1978 the ranks were reversed, probably due to virtual lack of nesting by pectoral sandpipers and other shorebird species in Moist Sedge-Shrub (V).

Table 19. Ranking of total breeding population densities for 4 habitats (II-Flooded, III-Wet Sedge, IVa-Moist/Wet Sedge-Mosiac, V-Moist Sedge-Shrub) during 3 years of study at Okpilak River Delta, Arctic National Wildlife Refuge, Alaska.

	Total breeding population density rank			
Year	highest			lowest
1978	IVa	II	III	V
1982	IVa	II	V	III
1983	IVa	V	III	II

Total bird populations. Significant inter-year differences in total bird populations (mean number of birds/km^2 considering censuses 1-4) were detected (P = 0.05) using Friedman's nonparametric test. The sources of this variation are difficult to detect. Most researchers have focused their discussions of inter-year variation on breeding bird populations largely because this is less complicated to analyze statistically since there are not separate results of censuses through time. Myers and Pitelka (1980) did some analyses of inter-year differences in habitat use by total bird populations and found high levels of inter-year differences in habitat use by individual species.

Investigation of some aspects of inter-year variations of total bird densities in each habitat was done using a series of Kruskal-Wallis ANOVA. The most significant inter-year differences of mean total bird populations were detected in Wet Sedge (III) and Moist/Wet Sedge (mosaic) (IVa) habitats only for census 4 ($0.10 < P < 0.05$) (Table 20). In these cases the inter-year differences for census 4, parallelled the findings for mean total number of birds considering censuses 1-4 (Fig. 17), which could point to an important contribution of census 4 to overall variation in mean densities.
This difference may be accounted for by different contributions of non-breeding migrant birds which were more numerous on census 4 than earlier ones. The proportions of migrant birds may be influenced by many factors such as breeding chronology, snow melt chronology, and weather throughout the season. Similarly, Myers and Pitelka (1980) found largest inter-year differences in densities of individual species during the final third of the season. Inter-year differences in timing, habitat and spatial differences throughout the coastal plain and densities of migrant populations need to be investigated in greater depth, considering samples from a greater number of replicates in inland and coastal areas throughout the coastal plain and during a more extensive period after the breeding season, to obtain a more adequate assessment of variation in bird use.

Table 20. Summary of mean total population densities (birds/km^2) of total birds, shorebirds, pectoral sandpiper, red-necked phalarope, and Lapland longspur on 4 habitat types at Okpilak River delta, Arctic National Wildlife Refuge, Alaska, 1978, 1982, 1983. Significance of inter-year differences in total bird densities is given for each census period.

	Number of birds/km^2 mean ± S.D.[1]			Kruskal-Wallis H			
Variable/habitat	1978	1982	1983	cen 1	cen 2	cen 3	cen 4
Total birds:							
Flooded	251.3 ± 5.3	309.2 ± 52.8	328.3 ± 75.9	4.3080	1.0486	0.8880	2.7690
Wet Sedge	112.5 ± 0.0	149.2 ± 57.8	203.3 ± 27.9	4.1747	0.6050	3.4747	4.8720*
Moist/Wet Sedge	117.5 ± 81.3	250.8 ± 44.0	253.3 ± 34.5	4.4213	0.1050	3.2962	4.6298*
Moist Sedge-Shrub	166.8	165.0	210.0				
Total							
Shorebirds:							
Flooded	217.5 ± 3.5	220.0 ± 84.3	169.2 ± 43.5				
Wet Sedge	45.0 ± 0.0	53.3 ± 14.2	100.0 ± 31.9				
Moist/Wet Sedge	60.0 ± 42.4	101.7 ± 24.0	106.7 ± 23.8				
Moist Sedge-Shrub	30.0	50.0	37.5				
Pectoral Sandpiper:							
Flooded	82.5 ± 7.1	81.7 ± 51.4	84.2 ± 28.1				
Wet Sedge	31.3 ± 5.3	31.7 ± 7.6	67.5 ± 24.1				
Moist/Wet Sedge	36.3 ± 26.5	53.3 ± 7.6	75.0 ± 15.2				
Moist Sedge-Shrub	0	22.5	25.0				
Red-necked phalarope:							
Flooded	57.5 ± 10.6	38.3 ± 22.7	25.8 ± 15.3				
Wet Sedge	0	3.8 ± 5.3	1.3 ± 1.8				
Moist/Wet Sedge	8.8 ± 1.8	10.0 ± 15.2	5.0 ± 6.6				
Moist Sedge-Shrub	6.7	27.5	0				
Lapland longspur:							
Flooded	10.0 ± 3.5	20.0 ± 0	54.1 ± 26.3				
Wet Sedge	60.0 ± 10.6	80.8 ± 32.6	90.8 ± 24.3				
Moist/Wet Sedge	102.5 ± 35.4	108.3 ± 23.2	131.7 ± 3.8				
Moist Sedge-Shrub	116.7	97.5	157.5				

* indicates significance ($0.05 < P < 0.10$)

1 n = 1 for Moist Sedge Shrub 1978, 1982, 1983.
n = 2 for Flooded, Wet Sedge, and Moist/Wet Sedge in 1978.
n = 3 for Flooded, Wet Sedge and Moist/Wet Sedge in 1982 and 1983.

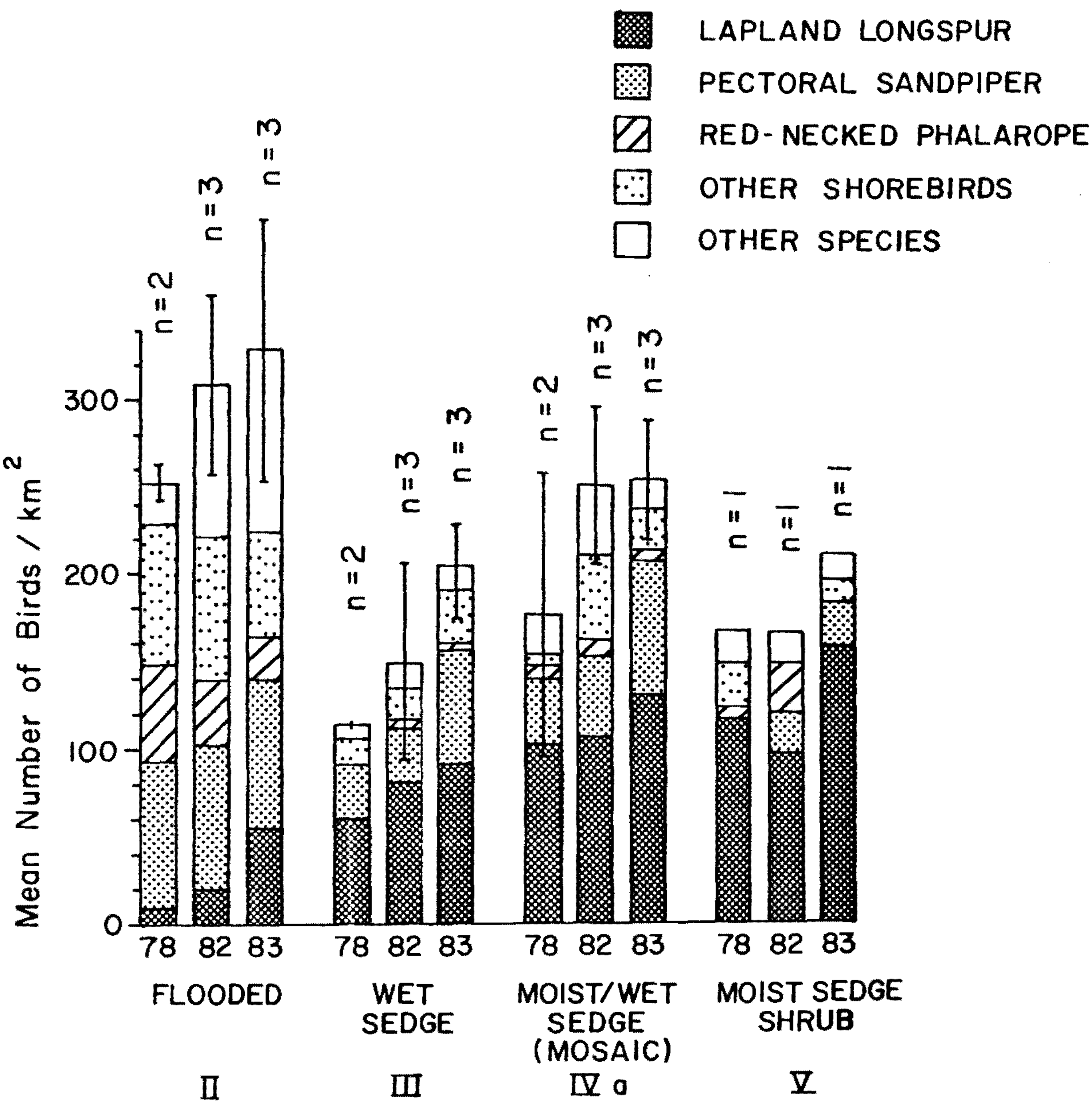

Fig. 17. Annual variabilty in mean summer (June–July) density of Lapland longspur, pectoral sandpiper, red-necked phalarope, other shorebirds, and other species in 4 coastal plain habitats, Okpilak River delta, Arctic National Wildlife Refuge, Alasks, June–July 1978, 1982 and 1983. (Note: density calculations based on 4 censuses, June–July, because census 5 in August was not conducted in 1978). Ranges given for each species group represent 1 standard deviation of total breeding density.

Inter-year variations by habitat for species or species groups and their contribution to proportions of total bird densities was not tested statistically, but some apparent differences may be highlighted. For Wet Sedge (III) and Moist/Wet Sedge (mosaic) (IVa) it may be graphically seen that differences in pectoral sandpipers were apparent between years of highest and lowest densities (Fig. 17). Mean breeding pectoral sandpiper populations were higher, and constituted a larger proportion of the total bird populations in Wet Sedge (III) , Moist/Wet Sedge (Mosaic) (IVa) and Moist Sedge-Shrub (V) in 1983 over other years. There were less distincitve differences in mean pectoral sandpiper total populations, as well as less change in their proportions of total bird populations, in Flooded (II) habitat and Moist Sedge-Shrub (IV), for years when they were present. However, during 1 year, pectoral sandpipers were virtually absent from Moist Sedge-Shrub (V).

Inter-year changes in Lapland longspur densities and their proportion of total bird densities were found for some habitats (Fig. 17). In Moist/Wet Sedge (IVa) there was a proportional increase in Lapland longspurs in 1983, in addition to the increase in pectoral sandpipers already discussed. In Moist Sedge-Shrub (V) a substantially larger number and proportion of longspurs were found in the population in the year with highest total densities, 1983. In Flooded (II) habitat a proportional increase, as well as absolute increase, in Lapland longspur densities was found in 1983 compared to previous years of study.

Red-necked phalarope had consistant inter-year differences by habitat, with lowest mean total population densities, as well as proportion of total densities, in 1983. Highest densities were found in 1978 except in Moist Sedge-Shrub, where higher numbers occurred in 1982.

Some inter-year population differences were noted for species which did not have dominant status in breeding or total bird communities. See also Spindler et al. (1984) for more detailed discussion. Greater numbers of red-throated loons and tundra swans were found nesting in 1983 compared to 1982, which could be due to earlier melt-off in the later year and thus more exposed nesting sites in Flooded (II) tundra at an earlier date. Northern pintails had higher breeding densities in Moist-Sedge Shrub (V) and Moist/Wet Sedge (III) Tundra at Okpilak in 1983 compared to 1982 or 1978, and corresponded with 1983 drought conditions on North American prairie pothole breeding areas (Derkson and Eldridge, 1980). Predators were less frequently seen in 1983, particularly northern harrier, snowy owl, short-eared owl, and pomarine jaeger at Okpilak and Katakturuk. Fewer rough-legged hawks were observed at Okpilak though similar levels of rough-legged hawk were seen at Katakturak and increased sightings of golden eagles were made at Okpilak in 1983. It should be noted that microtines were rarely seen in 1983 during censuses, compared with 1982 or 1978 findings. Willow ptarmigan were absent and rock ptarmigan were found in decreased numbers at Okpilak in 1983 compared with other years, though levels at Katakturak were similar for 1983 compared with 1982. Buff-breasted sandpipers were rarer in 1983 than in previous years of study at Okpilak. Long-billed dowitchers were present at Okpilak in higher densities earlier in the season in 1983, had higher mean summer population densities in all habitats except Moist Sedge-S rub (V), but were found in lower densities in the fall of 1983 compared with peak fall densities in 1982. Dowitchers may have migrated earlier in 1983, or there may have been a later fall migration which was recorded in 1982 due to the later date of census in that year, but was not observed in 1983 due to earlier fall census date.

Ranking of mean total bird population densities by habitat for each of 3 years was done as it was for breeding bird populations. When the habitats were listed in order of highest to lowest densities (mean total numbers of birds/km^2) a consistant order was exhibited for each year, (Type II, IVa, V, and III, in descending order of density). Flooded (II) consistantly had highest total population densities and Wet Sedge (III) the lowest densities. The Flooded (II) habitat supported high densities of shorebirds including higher densities of phalaropes and migrants of all species than in other habitats. Flooded (II) also supported a larger component of other species such as loons, waterfowl, jaegers and gulls compared to other areas, which more than offset low Lapland longspur densities (Fig. 17). At the opposite extreme, Wet Sedge (III) supported intermediate densities of shorebirds and other species compared to other habitats, along with having second lowest Lapland longspur densities.

Comparisons between the ranks of total bird densities (Fig. 17) and breeding bird densities (Table 17) for the 3 years of study at Okpilak River delta reveal that the ranks of most habitats generally follow the same pattern. The largest differences were in Flooded (II) habitat which had highest mean total bird densities of all habitat over all 3 years, but ranked below Moist/Wet Sedge (IVa) in breeding densities for all years and even ranked the lowest in 1983. This difference between breeding and total bird densities brings out the substantial importance of Flooded (II) habitat to migrant and summer visitant birds, not considering the period of greatest migratory use (census 5, discussed in "seasonal variation" above). Martin (1983) correlated intense use by late summer migrants with presence of shallow ponds and very wet tundra, habitat features which characterized Flooded Tundra.

Peak total bird densities over all years studied were consistant by habitat, with all habitats having highest numbers in 1983 and lowest in 1978. This could be due to biological or climatic factors such as time of breakup. Problems inherent in consistancy of census technique could also have affected the results; different effort in terms of person hours/census, or, retabulation of previous years data from census maps may have led to more conservative counts because not all bird movements onto the plot may have been shown because the original data were collected from a larger area. In contrast, breeding densities did not show the same pattern of peaks in 1983. It is possible that the census method was more precise for determination of breeding densities, at least in recalculation of data from previous years, since nests had only 1 location, and couldn't move on and off the plot.

In summary, marginally significant inter-year differences were found in breeding bird populations and significant differences were detected in total bird populations over all habitats at Okpilak River delta. Annual variation of total breeding bird and total shorebird breeding populations was most significant in Flooded (II) and Moist/Wet Sedge (IVa) habitats. Significant annual differences were found for breeding densities of red-necked phalarope and red phalarope in Flooded (II) and semipalmated sandpiper in Moist/Wet Sedge (IVa) which contributed to signigicant overall differences in inter-year densities. Annual variation in breeding populations of Lapland longspur and pectoral sandpiper in each habitat were not significant, but this could be due to high spatial variation of nesting, particularly for pectoral sandpipers.

The ranking of habitats according to mean total bird density was identical between years and ranking of mean breeding bird densities was generally consistent between years. Largest inter-year differences were seen in importance of Flooded Tundra for breeding populations. Moist/Wet Sedge (IVa) tundra consistently had the highest breeding population density. Flooded tundra consistantly had highest total bird densities for all years studied, largely due to high densities of non-breeding and migrant shorebirds, as well as a larger component of other species such as loons, waterfowl, jaegers and gulls.

Although similarity was found in rank of breeding and total bird densities for habitats studied at Okpilak River delta for 3 years, repeated studies which includes censuses of additional habitats are needed. The habitat with highest total bird densities, Riparian (IX), as well as the habitat with the lowest total bird densities, Moist Sedge (IV d, e, f), over the entire ANWR coastal plain studied in 1983, could not be included in the preceeding analyses for inter-year variation because of limited sample years. These habitats, however, could have significantly different levels of variation. The complete array of major habitat types on the coastal plain of ANWR, with sufficient replication by study area and plots, needs to be censused over several years to provide a study design from which the question of inter-year variation in bird populations and habitat use of tundra habitats could be more comprehensively addressed.

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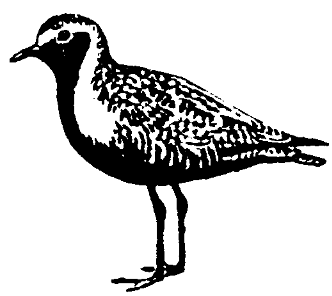

APPENDIX

ANWR Progress Report Number FY84-9

Table A-1. Temperature, wind, cloud cover and precipitation conditions at Okpilak River Delta, Katakturuk River and Jago River-Bitty, Arctic National Wildlife Refuge, Alaska, 18-30 June, 1-18 July, 9-15 August, 1983. wind and cloud cover observations made twice daily

	Okpilak			Katakturuk			Jago-Bitty		
	June	July	August	June	July	August	June	July	August
Temperature (°C)									
minimum	-0.5	0.0	-0.5	-4.4	-0.5	0.6	-2.2	-2.2	0.0
mean minimum	1.5	2.5	3.3	1.7	2.1	3.8	1.3	2.8	2.7
maximum	21.7	20.6	18.9	22.2	20.0	16.1	22.8	23.3	18.9
mean maximum	11.3	11.9	10.7	13.9	13.6	10.8	13.1	15.4	12.6
Wind speed(km/h)									
mean	14.0	9.5	12.0	12.0	6.0	10.6	10.5	6.7	9.9
% observations									
0-8(km/h)	19.2	50.1	28.5	26.8	71.4	35.6	38.3	67.9	33.3
9-16(km/h)	57.6	41.8	57.1	65.4	25.7	64.3	57.7	32.1	66.7
16(km/h)	22.9	8.4	14.2	7.6	2.9	0.0	3.8	0.0	0.0
Wind direction %									
N	11.5	5.6	7.1	4.0	12.5	0.0	4.0	4.3	0.0
NE	38.5	36.1	28.6	72.0	58.3	8.3	20.0	30.4	30.0
E	23.1	19.4	28.6	12.0	12.5	58.3	56.0	39.1	30.0
SE	3.8	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0
S	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SW	7.7	8.3	14.3	0.0	0.0	8.3	0.0	0.0	0.0
W	7.7	13.9	21.4	8.0	8.3	25.3	12.0	0.0	20.0
NW	3.8	16.7	0.0	4.0	8.3	0.0	8.0	21.7	20.0
Cloud cover %									
clear	30.8	44.4	7.1	38.5	34.3	7.1	30.8	39.3	8.3
scattered	15.4	11.1	14.3	19.2	28.6	0.0	15.4	3.6	0.0
broken	26.9	8.3	0.0	23.1	5.7	0.0	15.4	14.3	8.3
overcast	26.9	36.1	78.6	19.2	31.4	92.9	38.5	42.9	8.3
Precipitation (days)									
none	7	10	1	7	11	1	7	10	10
rain	2	3	0	3	4	4	3	3	3
snow,sleet	0	1	0	2	2	0	1	2	0
fog	4	6	6	1	2	5	4	4	6

Table A-2. First observed flowering dates for plant species found in all 3 study areas; Okpilak River Delta, Katakturuk River and Jago-Bitty; Arctic National Wildlife Refuge, Alaska, June-July 1983.

Species	Okpilak	Katakturuk	Jago-Bitty
Androsace chamaejasme Lehmanniana	3 July	8 July	12 July
Astragalus umbellatus	3 July	3 July	29 June
Caltha palustris arctica	26 June	25 June	26 June
Cassiope tetragona tetragona	26 June	26 June	26 June
Castilleja caudata	9 July	5 July	14 July
Dodecatheon frigidum	18 July	5 July	2 July
Dryas integrifolia integrifolia	26 June	26 June	26 June
Lagotis glauca	2 July	26 June	28 June
Lupinus arcticus	2 July	3 July	29 June
Minuartia arctica	28 June	3 July	27 June
Oxytropis nigrescens	24 June	22 June	5 July
Papaver Macounii	3 July	2 July	6 July
Parrya nudicaulis	24 June	23 June	21 June
Pedicularis capitata	5 July	4 July	5 July
Pedicularis Kanei Kanei	20 June	19 June	27 June
Pedicularis sudetica	4 July	4 July	29 June
Petasites frigidus	22 June	25 June	21 June
Polemonium boreale	2 July	2 July	28 June
Polygonum bistorta	29 June	4 July	29 June
Saxifraga hieracifolia	1 July	6 July	29 June
Saxifraga punctata	3 July	2 July	26 June
Valeriana capitata	9 July	7 July	6 July

Table A-3. First observed flowering dates for plant species found during 3 years of study at Okpilak River Delta, Arctic National Wildlife Refuge, Alaska, June-July 1978, 1982 and 1983.

Species	1978	1982	1983
Androsace chamaejasme Lehmanniana	2 July	2 July	3 July
Anemone parviflora	4 July	20 June	24 June
Astragalus alpinus alpinus	9 July	8 July	4 July
Astragalus umbellatus	5 July	2 July	3 July
Betula nana	6 July	30 June	8 July
Caltha palustris arctica	3 July	29 June	26 June
Corydalis pauciflora	6 July	8 July	6 July
Draba alpina	6 July	2 July	20 June
Lagotis glauca	1 July	29 June	2 July
Oxyria digyna	1 July	26 June	22 June
Oxytropis Maydelliana	4 July	2 July	1 July
Oxytropis nigrescens bryophila	28 June	29 June	24 June
Parrya nudicaulis	28 June	29 June	24 June
Pedicularis Kanei Kanei	22 June	24 June	20 June
Petasites frigidus	1 July	2 July	22 June
Polemonium boreale boreale	3 July	2 July	2 July
Potentilla pulchella	3 July	2 July	3 July
Primula borealis	1 July	2 July	3 July
Ranunculus nivalis	22 June	24 June	18 June
Ranunculus pedatifidus affinis	15 June	2 July	3 July
Salix phlebophylla	29 June	24 June	20 June
Salix planifolia pulchra	30 June	27 June	26 June
Saxifraga punctata Nelsoniana	1 July	25 June	3 July
Silene acaulis acaulis	5 July	2 July	28 June
Vaccinium uliginosum	5 July	8 July	2 July

Table A-4. Ranges in dates of bird censuses in each habitat type for all study areas, coastal plain, Arctic National Wildlife Refuge, Alaska, 1983.

Habitat	Census Number 1	2	3	4	5
Flooded	22 June	27 June	7 July	13 July	10 Aug
Wet Sedge	18-23 June	24-29 June	6-7 July	12-18 July	9-11 Aug
Moist/Wet Sedge (Mosaic)	19-23 June	28-29 June	5-9 July	14-15 July	11-12 Aug
Moist Sedge	17-18 June	23-24 June	4-5 July	11-13 July	9-10 Aug
Moist Sedge Shrub	19-23 June	25-29 June	6-9 July	13-16 July	10-12 Aug
Tussock Dwarf Shrub	19-21 June	25-26 June	6-8 July	13-15 July	9-11 Aug
Riparian	18-24 June	23-25 June 2 June	4-9 July	10-16 July	9-16 Aug
Range	18-24 June	23 June-2 July	4-9 July	11-18 July	9-16 Aug

Table A-5. Summary of mean (± SD)[a] breeding bird densities (nests or territories/km^2) observed by habitat by study area June-July 1983, Arctic National Wildlife Refuge, Alaska.

Habitat type	Study			
	Okpilak	Katakturuk	Jago-Bitty	Overall
II Flooded	55.0±8.7			55.0±8.7
III Wet Sedge	60.0±20.0	30.0[b]	55.0±27.8	53.6±22.5
IVa/IIIc Moist/Wet Sedge	67.5±8.7[c]			67.5±8.7
IVd,e,f, Moist Sedge		27.5±10.6	48.3±5.8	40.0±13.2
V Moist Sedge-Shrub	62.5±3.5[d]	33.3±5.8	74.0±42.6	55.9±30.0
VI Tussock Dwarf Shrub		58.3±58.0	60.0±8.7	59.2±37.1
IX,X,XI,IVb,c Riparian	92.5±17.7[d]	135.0±52.7	128.3±5.8	121.9±34.4

[a]Sample size (n) is 3 per area per habitat except for notes below
[b]n=1
[c]n=4
[d]n=2

Table A-6. Breeding bird densities, numbers of nests, displaying males, and territories on 15 10-ha plots in the Jago River-Bitty study area, Arctic National Wildlife Refuge, Alaska, June-July 1983.

Plot #	Species	Number: nests	Number: displaying males[a]	Number: territories[b]	Breeding density nests or territories/km²
331	Pectoral sandpiper	1	1	3.0	30
	Parasitic jaeger	1			10
	Savannah sparrow		1	1.0	10
	Lapland longspur	2	1	3.5	35
332	Pectoral sandpiper	1	3	3.5	40
	Lapland longspur	1	1	1.0	10
333	Pectoral sandpiper	2	1	3.0	30
341	Pectoral sandpiper	2		2.0	20
	Lapland longspur	1	6	2.5	25
342	Lapland longspur	4	8	4.5	45
343	Lesser golden-plover	1			10
	Pectoral sandpiper	1		1.0	10
	Lapland longspur	1	4	3.5	35
351	Lapland longspur	3	2	3.0	30
352	Semipalmated sandpiper	1			10
	Pectoral sandpiper	1		1.2	12
	Savannah sparrow		1	1.0	10
	Lapland longspur	1	2	4.5	45
353	Willow ptarmigan	1			10
	Semipalmated sandpiper	2			20
	Pectoral sandpiper	5		5.0	50
	Lapland longspur	3	1	3.5	35
361	Lesser golden-plover	1			10
	Semipalmated sandpiper	1			10
	Savannah sparrow	1	1	1.0	10
	Lapland longspur		4	2.0	20
362	Rock ptarmigan	1			10
	Lapland longspur	4	1	5.5	55
363	Willow ptarmigan	1			10
	Savannah sparrow		2	1	10
	Lapland longspur		7	4.5	45
391	Northern pintail	1			10
	Savannah sparrow	3	1	3.0	30
	Lapland longspur		7	8.5	85
392	Northern pintail	1			10
	Semipalmated sandpiper	2,1[c]			30
	Savannah sparrow		1	1.0	10
	Lapland longspur	1	13	8.5	85
393	Semipalmated sandpiper	1		0.5	15
	Pectoral sandpiper			1.0	10
	Savannah sparrow	1	1	2.0	20
	Lapland longspur	2	3	6.5	65
	Redpoll sp.	1		1.0	10

[a]seen during census 0 and 1, 9-23 June 1983.
[b]Territories as mapped for passerine species and activity clusters of semipalmated sandpiper and pectoral sandpiper during first 3 censuses.
[c]Probable nest.

Table A-7. Breeding bird densities, and number of nests, displaying males, and territories on twelve 10-ha plots in the Katakturuk River study area, Arctic National Wildlife Refuge, Alaska June-July 1983.

Plot #	Species	Number: Nests	Displaying males [a]	Territories[b]	Breeding density nests or territories km^2
231	Pectoral sandpiper	1[c]			10
	Lapland longspur		2	2	20
241	Lesser golden-plover	1			10
	Lapland longspur	2	3	2.5	25
242	Lapland longspur	2	1	2	20
251	Pectoral sandpiper	1[c]			10
	Lapland longspur		2	2	20
252	Rock ptarmigan	1[c]	1	1	10
	Pectoral sandpiper	1			10
	Lapland longspur		1	1	10
253	Savannah sparrow	1			10
	Lapland longspur	1+1[d]		3	30
261	Lesser golden-plover	1			10
	Semipalmated sandpiper	3			30
	Pectoral sandpiper	1		1	10
	Yellow wagtail	1[d]		0.5	5
	Savannah sparrow	2[c]		2	20
	Lapland longspur	3	4	5	50
262	Pectoral sandpiper	1		1	10
	Lapland longspur		1	1	10
263	Lapland longspur	2	1	3	30
291	Ruddy turnstone	1			10
	Semipalmated sandpiper	2			20
	Yellow wagtail	1[cd]		0	0
	Tree sparrow	1	2	2	20
	Lapland longspur	2	5	9	90
	Redpoll sp.	2		2	20
292	Semipalmated sandpiper	1+1[d]			15
	Yellow wagtail	1[c]		1	10
	Lapland longspur	1	2	5	50
	Redpoll sp.			1	10
293	Lesser golden-plover	1			10
	Semipalmated sandpiper	1			10
	Yellow wagtail	1[c]		1	10
	Lapland longspur	2	4	7	70
	Redpoll sp.	2		3	30

[a]Seen during census 1, 17-20 June, 1983 or census 2, 23-26 June, 1983.
[b]Territories mapped as activity clusters for passerine species, pectoral sandpiper, and rock ptarmigan during first 3 censuses.
[c]Probable nest.
[d]Nest on border or just outside of plot.

Table A-8. Breeding bird densities, and number of nests and territories on 14 10-ha plots in the Okpilak River delta study area, Arctic National Wildlife Refuge, Alaska, June-July 1983.

Plot #	Species	Number: nests	Number: territories[a]	Breeding density nests or territories/km²
121	Red-necked phalarope	1		10
	Parasitic jaeger	1		10
	Lapland longspur	2	3.0	30
122	Pectoral sandpiper	2		20
	Long-billed dowitcher	1[b]		10
	Lapland longspur	2	3.5	35
123	Red-throated loon	1		10
	Pectoral sandpiper	1[b]		10
	Red-necked phalarope	1		10
	Red phalarope	1		10
	Glaucous gull	1		10
131	Pectoral sandpiper	4		40
	Lapland longspur	2,1[b]	4.0	40
132	Pectoral sandpiper	3		30
	Lapland longspur	1	3.0	30
133	Pectoral sandpiper		1.0	10
	Lapland longspur	2	3.0	30
141	Lesser golden-plover	1		10
	Pectoral sandpiper	2		20
	Lapland longspur	1	4.0	40
142	Northern pintail	1		10
	Pectoral sandpiper	3,1[b]		40
	Lapland longspur	1	3.5	35
143	Pectoral sandpiper		2.0	20
	Red-necked phalarope	1[b]		10
	Lapland longspur	3	4.0	40
144	Lapland longspur	4	5.5	55
151	Lesser golden-plover	1		10
	Lapland longspur	4	5.5	55
152	Northern pintail	1		10
	Pectoral sandpiper	1	1.5	15
	Lapland longspur	1	3.5	35
191	Semipalmated sandpiper	3		30
	Pectoral sandpiper	1[b]		10
	Lapland longspur		4.0	40
192	Ruddy turnstone	1		10
	Semipalmated sandpiper		2.0	20
	Savannah sparrow		0.5	5
	Lapland longspur	3	4.0	40
	Redpoll sp.	2	3.0	30

[a]Territories as mapped for passerine species and activity clusters of semipalmated sandpiper and pectoral sandpiper during first 3 censuses.
[b]Probable nest.

Table A-9. Mean (±SD)[a] total summer bird densities (birds/km^2) observed by habitat by study area June-July 1983, Arctic National Wildlife Refuge, Alaska. These data are included for comparison purposes with previous studies which summarized mean total summer densities for 4 censuses in June and July.

Habitat type	Study area			
	Okpilak	Katakturuk	Jago-Bitty	Overall
<u>Habitat type</u>				
II Flooded	328.3±75.9			328.3±75.9
IIIa Wet Sedge	203.3±27.9	100.00[b]	120.8±27.9	153.2±52.6
IVa, IIIc Moist/Wet Sedge	263.6±35.0[c]			263.6±35.0
IVd,e,f, Moist Sedge 94.6±40.6		71.5± 9.2		110.0±48.7
V Moist Sedge-Shrub	175.0±49.5[d]	102.0±24.3	189.2±50.6	152.9±55.4
VI Tussock Dwarf Shrub		144.7±132.9	90.0±6.6	117.3±89.3
IX,X,XI,IVb,c Riparian	366.0±22.6[d]	428.3±92.5	260.0±10.0	349.6±93.4

[a]Sample size (n) is 3 per area per habitat except for notes below:
[b]n=1
[c]n=4
[d]n=2

Table A-10. Summary of mean (± SD)[a] total bird densities (nests or territories observed by habitat by study area in June-July, Arctic National Wildlife Refuge, Alaska, 1983.

Habitat type	Area			
	Okpilak	Katakturuk	Jago Bitty	Overall
II Flooded	384.0±113.4			384.0±113.4
III$_a$ Wet Sedge	236.7± 82.4	102.0[b]	116.0±15.1	165.7± 82.3
IVa/IIIc Moist Wet Sedge	256.5± 32.5[c]			256.5± 32.5
IVd,e,f, Moist Sedge		69.0± 21.2[c]	100.7±42.0	88.0± 36.0
V Moist Sedge-Shrub	196.0± 33.9[d]	128.7± 52.3	172.0±49.3	161.8± 49.9
VI Tussock Dwarf Shrub		141.3±132.4	84.0± 7.2	112.7± 89.5
IX,X,XI,IVb,c Riparian	336.0± 48.1[d]	461.3± 93.5	235.3±19.0	345.3±117.9

[a]sample size (n) is 3 per area per habitat except for notes below
[b]n=1
[c]n=4
[d]n=2

Table A-11. Summary of breeding, mean total summer (June-July), mean total (June -August) and fall (August) bird densities, number of nests found, and species richness on bird census plots at the Okpilak River delta study area, Arctic National Wildlife Refuge, Alaska, 1983.

Plot #	Number nests	Breeding density (nests or terr/km^2)	Mean summer total pop. density (birds/km^2) (June-July)	Mean summer total pop. density (birds/km^2) (June-Aug)	Fall population density (birds/km^2)	Number of Species: Breeding	Number of Species: Breeding, summer & visiting	Number of Species: Fall	Number of Species: Total (breeding, summer, fall)
121	4	50	260	296	440	3	14	8	14
122	4	65	315	344	460	3	9	6	11
123	4	50	410	512	920	5	15	9	16
131	6	80	235	214	130	2	8	2	8
132	4	60	182	328	90	2	8	4	9
133	2	40	192	168	70	2	7	4	8
141	4	70	240	226	170	3	10	5	11
142	5	75	292	266	160	3	9	4	11
143	3	70	227	236	270	3	8	7	11
144	5	55	295	298	310	1	11	4	11
151	5	65	210	220	260	2	5	3	6
153	3	60	140	172	300	3	6	3	7
197	3	80	350	302	150	3	11	3	12
192	6	105	382	370	340	5	12	6	13

Table A-12. Summary of breeding, mean total summer (June-July), mean total (June-August) and fall (August) bird densities, number of nests found, and species richness on bird census plots at the Katakturuk River study area, Arctic national Wildlife Refuge, Alaska, 1983.

Plot	Nests	Estimated breeding densities (nests or terr/km^2)	Mean total pop. density (birds/km^2)		Fall population density (birds/km^2)	Number of species			
			(June-July)	(June-Aug)		Breeding	Breeding & summer visitors	Fall	Total (breeding, summer & fall)
231	0	30	100	102	110	2	5	5	6
241	3	35	78	84	110	2	4	3	5
242	2	20	65	54	10	1	4	1	5
251	0	30	98	184	530	2	6	2	6
252	1	30	80	80	80	3	4	2	5
253	2	40	128	122	100	2	8	2	8
261	8	125	298	294	270	6	8	4	8
262	1	20	63	58	40	2	5	2	5
263	2	30	73	72	70	1	3	2	4
291	8	160	520	540	620	6	12	6	12
292	3	85	335	358	460	4	11	6	12
293	6	130	430	486	710	5	10	7	11

Table A-13. Summary of breeding, mean total summer (June-July), mean total (June-August), and fall (August) bird densities, number of nests found, and species richness on bird census plots at the Jago River-Bitty study area, Arctic National Wildlife Refuge, Alaska, 1983

Plot #	Nests	Estimated breeding densities (nests or terr/km^2)	Mean Summer total pop. density (birds/km^2)		Fall population density (August) (birds/km^2)	Number of species			
			(June-July)	(June-Aug)		Breeding	Breeding & summer visitors	Fall	Total (breeding, summer, fall)
331	3	85	152	132	50	4	7	3	7
332	2	50	100	102	110	2	3	4	4
333	2	30	110	114	130	2	4	4	6
341	3	45	72	68	50	2	5	1	5
342	4	45	92	86	40	1	7	2	7
343	3	55	165	148	70	3	3	1	3
351	3	30	132	120	70	1	7	3	8
352	3	77	230	218	150	4	8	3	8
353	11	115	205	178	70	4	9	3	9
361	3	50	97	92	50	4	9	3	10
362	5	65	87	82	40	2	5	2	5
363	1	65	85	78	70	3	5	1	5
391	4	125	270	254	50	3	9	5	9
392	4	135	260	236	110	4	8	4	9
393	5	125	250	216	130	5	8	4	9

Population dynamics and distribution of muskoxen in the Arctic National Wildlife Refuge, Alaska.

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Key Words: Muskoxen, population size, composition, productivity mortality, herd dynamics, distribution, movements, habitat use, Arctic National Wildlife Refuge, Arctic-Beaufort

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Population dynamics and distribution of muskoxen in the Arctic National Wildlife Refuge, Alaska

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Abstract: Numbers of muskoxen in the Arctic National Wildlife Refuge in northeastern Alaska were estimated to be 257 animals prior to calving in April 1983. In November 1983, 311 muskoxen were counted. An estimated 64 calves were born between late April and late June 1983. In August 1983, 66 calves per 100 cows (3 yr+) were observed and calves comprised 22% of the population. Yearling recruitment was high in both 1982 and 1983 and mortality appeared to be low. Nine adult mortalities, including 4 adult bulls killed by hunters and 2 adult bulls killed or scavenged by a grizzly bear, were recorded between April 1982 and November 1983. Herd dynamics were similar in 1982 and 1983. Herd stability and size changed seasonally and may be related to the proximity of other herds. In 1982 and 1983 muskoxen in the Okerokovik area calved along the Niguanak River, the Sikrelurak River and the Angun River. In 1983 most muskoxen from the Sadlerochit area calved in the hills between Marsh Creek and the Katakturuk River, about 12km west of the Carter Creek hills calving area used in 1982. Animals from the Tamayariak area which calved with Sadlerochit animals in the Carter Creek hills in 1982, calved on bluffs near forks of the Tamayariak River in 1983. Habitat use changed seasonally and could be correlated with seasonal movements in some areas. Some long range movements by radio-collared animals in 1982 and 1983 may be related to dispersal. As the population is rapidly expanding, movement into new areas apparently is occurring. Dispersal of at least one young-aged herd into a new area on the Katakturuk River in 1982 and 1983 was documented.

Population dynamics, and distribution of muskoxen in the Arctic National Wildlife Refuge, Alaska.

Muskoxen (Ovibos moschatus), reintroduced to the arctic coast in 1969 and 1970, are year-round residents of the Arctic National Wildlife Refuge (ANWR) coastal plain and are susceptible to impending petroleum exploration activities in all seasons. Reproduction and survival in recent years have been high; however, continuing data collection on population size and composition is essential to monitor changes which may occur in the presence or absence of potential disturbances. In this population where large herds have become established and may be fracturing, an understanding of herd dynamics is a necessary element for evaluating the role that dispersal, movement, and distribution plays in population dynamics of this species. Seasonal use of specific areas, particularly calving areas, needs to be documented to insure adequate habitat protection. This report summarizes data collected during the first 2 years of an on-going study. Results should be viewed as preliminary.

The objectives of this study were:

1. determine population size and composition and dynamics of muskox herds on ANWR.
2. document seasonal distribution patterns, movements and habitat use of muskox herds on ANWR.
3. locate and define calving grounds of the muskox herds using the coastal plain of ANWR.

Methods and Materials

The principle study area was located in northeastern Alaska between the Canning River and Aichilik River, from the arctic coast south to 69°30'N latitude (Fig. 1). A detailed description of this area was presented in the Initial Report - Baseline Study of the ANWR Coastal Plain (USFWS 1982). Muskoxen were also seen west of the Canning River along the Kavik River, along the Kongakut River, and east of the Kongakut River to the Malcolm River in northwestern Canada. For purposes of this study, the principle study area was subdivided into the Tamayariak area, the Sadlerochit area and the Okerokovik area (Fig. 1).

Twenty nine different muskoxen were captured in the ANWR between April 1982 and November 1983. All muskoxen were darted from a Jet Ranger helicopter using a Cap-Chur rifle, 7.5 cc syringes, 3.8 cm barbed needles and low power charges (Palmer Chemical Company, Douglasville, GA). Herds were first overflown at low level to select which animals would be darted. A small group containing the selected animals was separated from the main herd and 2 to 4 animals were darted in quick succession. Drugging more than 1 individual at a time permitted several animals to be immobilized quickly, reduced the number of passes over a herd, and insured that drugged muskoxen would not be alone after recovering from the drug.

Body measurements including length of body, tail, ear, foreleg, hindleg, horn width, length and circumference, skull width and length, 1/2 girth shoulder height and neck circumference were made using methods described by Langvatn (1977). In 1982, samples (4 cm^2) of guard hair and underwool were clipped from the right front shoulder of each animal for mineral analysis and a canine tooth was collected from 2 individuals for aging by Alaska Department of Fish and Game (ADF&G). Blood was collected from one 3 year old cow in 1983 for analysis by ADF&G and University of Alaska (UAF). Captured muskoxen were individually identified by numbered plastic roto-tags (Nasco, Ft. Atkinson, WS) placed in each ear. Visual markers, consisting of streamers of colored safety flagging (Safety Flag Co. of America, Pawtucket, RI) were attached to horns with hose clamps (Jonkel et al. 1975).

In April 1982, 14 animals were radio-collared using mortality-sensing transmitters made by Telonics (Mesa, Arizona). One of these animals whose transmitter had failed was recollared in April 1983 when an additional 12 radio-collars were put on animals. Two of the 3 bulls captured in November 1983 were also radio-collared. In 1982, 3 of the 14 radio-collars put on ceased functioning after 10 to 13 months, and one cow lost her collar. In 1983, 3 radio-collars on bull muskoxen malfunctioned within 5 months.

In 1982 radio-collared animals were relocated 19 times between mid-April and late October using fixed-wing aircraft outfitted with wing-mounted "H" antennas, and a scanner-receiver (Telonics, Mesa, AZ). Locations were plotted on 1:63,360 scale USGS topographic maps. Herd size, number of calves, habitat type, reation to aircraft, and elevation of aircraft above ground level (AGL) were recorded on form sheets. After each flight, locations were transferred to a set of master maps, information was entered in a chronological log book, and data for each animal were summarized on maps and form sheets. In 1983, radio-collared muskoxen were relocated 3 times between January and mid-March and 22 times between late March and early November using the same methods.

Precalving surveys were conducted in mid-April 1982 and late March 1983. Muskox herds were located using reconnaissance flights by fixed-wing aircraft over the study area. Overflights were made at 350-1000 m AGL to minimize disturbance to the animals. Aerial photographs were taken using a 6 x 7 format SLR camera (Mamiya RB-67) with a 200 mm lens and a 35 mm camera (Nikon F-2) with a 500 mm lens and motor drive. Sex and age composition counts of small herds (10 animals) were made from the air. Differentiation of sex and age of muskoxen was determined by body size and horn boss development (Smith 1976). Portions of large herds were classified from the ground using a spotting scope and Questar telescope.

Composition counts were made in mid-June and late August 1983. Animals were classified from the ground using a Questar telescope. In June, 234 animals were classified, including all muskoxen observed in mixed sex herds except 1 herd of about 30 animals in the Tamayariak area. In August all muskoxen in about 73% of observed mixed sex herds were classified. Fall surveys were made in late October and early November in 1982 and 1983. Major drainages between the Canning River and the Kongakut River were searched using fixed-wing aircraft and all radio-collared muskoxen were located. In 1983, the survey was expanded to include the Kavik River west of the Canning River and the Turner River and Clarence River between the Kongakut River and the Canadian border. Snow cover made sighting animals much easier than in summer. Poor weather conditions precluded landing and determining the composition of large herds, but numbers of calves were counted from the air. Initial overflights were made at 350 m AGL or greater to prevent animals from aggregating into a defensive formation from which it was difficult to distinguish calves.

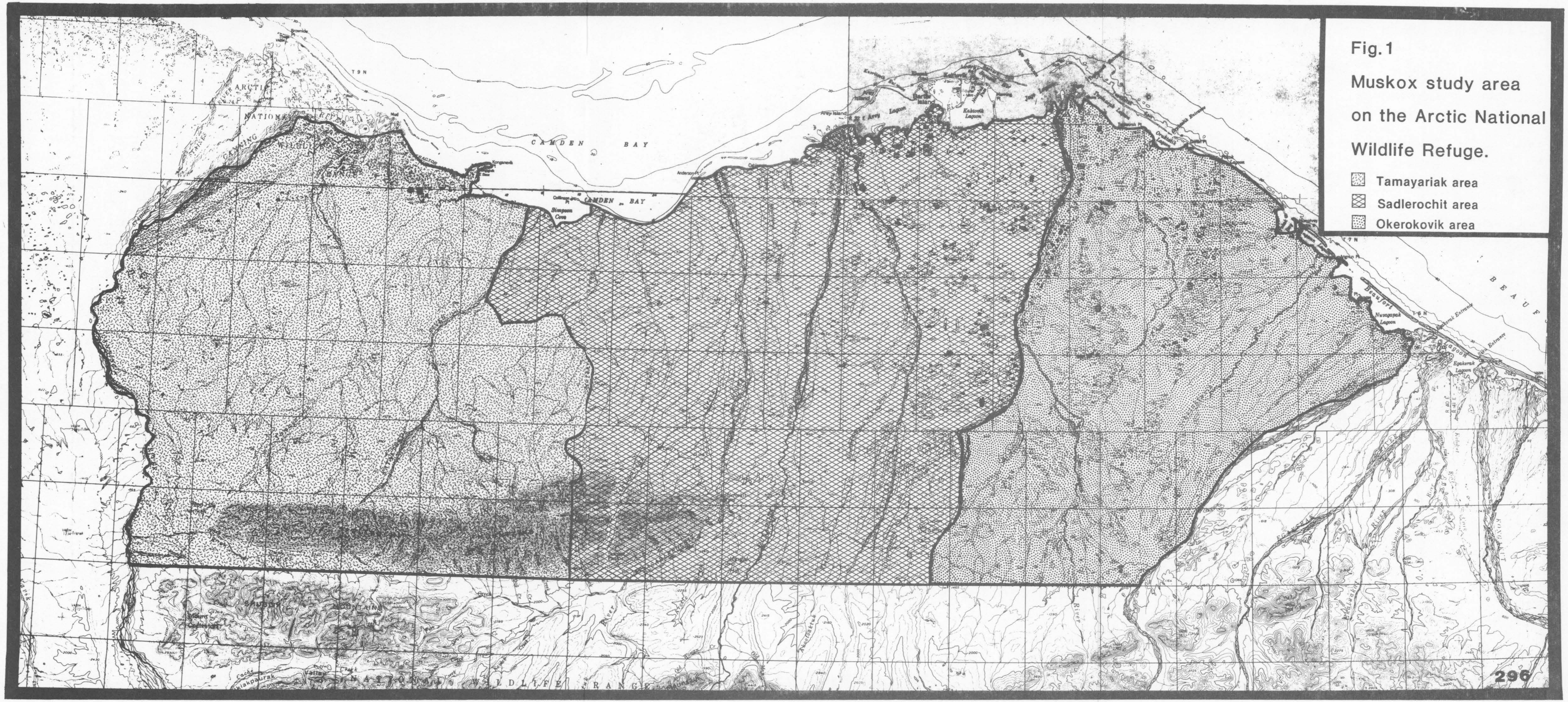

Fig. 1
Muskox study area on the Arctic National Wildlife Refuge.

Results and Discussion

Immobilization Procedures

Fifteen muskoxen were captured in April 1982, 12 animals were captured in April 1983, 2 adult cows were recaptured in June and August 1983, and 3 adult bulls were captured in November 1983 (Table 1). A total of 19 cows and 10 bulls were marked in the first 2 years of the study (Table 2). All animals were 3 years of age or older.

Table 2. Sex and age of muskoxen captured and marked in the Arctic National Wildlife Refuge, 1982 - 1983.

Capture dates	Adult bull	Adult cow	3 year bull	3 year cow	Total
13-16 April 1982	1	8	1	5	15
2-3 April 1983	3	5[a]	2	2	12[a]
1-2 Nov 1983	3				3
Total	7	13[a]	3	7	30[a]

[a] Including 1 recollared cow; 2 other cows were recaptured in June and August 1983, respectively, when their collars needed adjustment.

Muskoxen were drugged with M-99 (Etorphine, 1 mg/ml, D-M Pharmaceuticals, Rockville, MD) (Table 3). All recovered after injection of the antidote M-50-50 (Dipremorphine, 0.2 mg/ml, D-M Pharmaceuticals, Rockville MD) administered intermuscularly in the rump, at the same dosage as the M-99. Drug dosages required for adequate immobilization varied from year to year (Reynolds and Garner 1983). In 1982, 12 of 15 were completely immobilized in sternal recumbency with a 7.3 cc dose of M-99 mixed with 0.2 cc Rompun (Xylazine hydrochloride 100 mg/ml, Cutter Laboratories, Shawnee, KN). All but 2 animals recovered completely within 4-13 min after injection of the antagonist. Two of the cows had some difficulty during recovery. One staggered for a short time before recovering completely. Another did not recover completely for 28 min and had to be helped to her feet. This individual gave birth to a still-born calf about 2 weeks later. In 1982, 2 of the 15 animals received 5.0 cc M-99 with Rompun, and were not completely immobilized. They were not able to stand, but were able to move enough so that making physical measurements was not possible. One muskoxen received 8 to 14 cc of M-99 when it was accidently darted twice and did not recover for 20 min following the injection of 7.3 cc of M-50-50. An additional 5.0 cc injection of M-50-50 resulted in complete recovery in another 20 min.

In April 1983, muskoxen responded quite differently to drug dosages used in 1982. Seven of 12 including 3 adult bulls and 4 cows were not completely immobilized with an initial dose of 7.3 cc M-99 and 0.2 cc Rompun. Additional injection(s) of M-99 ranging from 2.0 cc to 5.0 cc were required before they could be handled. Two animals were also immobilized without Rompun. In November 1983, 3 adult bull muskoxen required dosages of at least 15.0 cc M-99 for immobilization. Increased dosages in 1983 may have

Table 1. Body measurements (cm) of muskoxen captured on the Arctic National Wildlife Refuge in 1982 and 1983.

Capture date	ID#	Age	Sex	Total length	Body length	Tail	Ear	Neck	Half girth	Shoulder height	Hind leg	Fore leg	Skull width	Skull length	Width between horns	Inside horn length	Horn circumference 1/4	Horn circumference 1/2	Horn circumference 3/4
4/13/82	1[a]	14	F	214.0	210.0	4.0	11.0	90.0	72.5	109.0	39.5	33.0	21.0	45.0	43.0	56.8	-	-	14.0
4/13/82	3[a]	14	F	217.5	211.5	6.0	12.5	-	72.0	112.0	41.3	33.3	22.1	51.3	43.5	42.5	-	-	15.3
4/13/82	4	4+	F	204.9	201.9	3.0	14.0	113.0	79.5	117.0	44.0	33.0	25.7	52.0	61.0	43.5	-	-	15.9
4/13/82	5	4	F	206.9	201.9	5.0	13.0	102.0	77.0	120.0	42.5	31.5	21.5	54.5	- -	31.5	-	-	13.0
4/15/82	6	4+	F	205.1	201.1	4.0	11.5	98.0	72.5	113.0	39.5	34.8	18.5	47.0	57.5	43.0	-	-	14.8
4/15/82	8	3	F	204.2	200.2	4.0	12.8	88.5	80.0	114.5	43.0	32.0	19.0	44.5	53.0	40.2	-	-	-
4/15/82	9	4+	F	206.8	200.8	6.0	11.5	99.0	75.5	111.0	39.0	36.0	21.0	47.0	61.0	43.0	-	-	15.1
4/15/82	10	4+	F	205.4	200.4	5.0	13.0	107.5	73.5	103.5	38.2	33.0	20.2	49.0	55.5	45.5	-	-	13.0
4/15/82	11	3	F	193.6	187.6	6.0	13.2	80.5	83.5	119.0	42.0	32.3	18.9	47.0	53.0	38.2	-	-	16.0
4/16/82	14[a]	16	F	207.8	201.8	6.0	13.0	114.0	86.0	117.0	41.5	35.0	21.6	55.8	52.0	43.2	-	-	13.6
4/16/82	15	3	F	205.4	200.4	5.0	13.0	87.0	80.0	98.0	38.0	32.0	19.1	53.0	54.0	41.0	-	-	15.4
4/2/83	16	4+	F	209.3	202.3	7.0	11.5	91.5	71.0	10.7	39.5	—	20.5	47.5	53.5	40.0	7.6	12.5	16.0
4/2/83	17	4+	F	216.0	208.0	8.0	12.0	107.0	77.0	103.0	40.5	—	20.6	44.0	61.0	44.5	6.7	11.0	15.2
4/3/83	25	4+	F	224.0	216.5	7.5	11.5	98.0	72.5	96.5	39.0	28.0	19.5	54.0	57.0	46.0	7.0	12.0	14.0
4/3/83	23	4+	F	214.0	204.0	10.0	11.5	89.0	75.4	106.0	33.1	24.5	18.0	50.2	48.5	41.0	8.5	11.6	12.1
4/3/83	21	3	F	219.0	210.5	8.5	12.0	82.5	75.0	118.0	28.0	22.0	21.0	55.5	53.0	44.0	7.0	10.0	14.0
4/3/83	22	3	F	224.5	216.0	8.5	12.5	109.2	76.0	109.0	26.0	36.0	18.5	50.0	53.0	40.0	6.5	10.0	13.0
Female	X			210.5	204.4	6.0	12.3	97.3	76.4	110.2	38.5	31.8	20.4	48.8	53.7	42.3	7.2	11.2	14.4±1.2
	S.D.			8.0	7.0	2.0	0.8	10.7	4.2	7.1	5.0	5.0	1.9	3.9	5.4	5.0	.7	1.0	1.2
4/13/82	2	3	M	211.0	201.0	10.0	14.0	93.5	80.0	130.0	44.0	34.4	22.8	54.5	66.0	57.3	-	-	24.9
4/15/82	7	4+	M	208.6	203.6	5.0	13.5	103.5	82.0	129.0	46.0	34.3	24.0	58.0	68.0	65.0	-	-	26.0
4/2/83	18	4+	M	240.0	235.5	6.5	—	99.0	88.0	114.5	42.0	38.0	27.1	67.0	74.0	59.0	14.1	19.0	25.1
4/2/83	19	4+	M	242.6	237.0	5.6	11.0	122.5	86.0	116.0	—	36.5	28.7	62.8	78.0	60.0	11.5	18.5	22.4
4/2/83	20	4+	M	250.8	245.0	5.8	12.0	139.5	92.0	112.0	—	39.0	27.7	64.5	78.5	58.0	10.0	16.5	20.5
4/3/83	24	3	M	220.5	212.0	8.5	11.0	92.0	75.0	102.0	32.0	28.0	—	54.8	68.0	54.0	9.5	20.0	25.0
4/3/83	26	3	M	222.8	214.3	8.5	13.5	88.0	82.0	96.5	29.8	34.0	23.0	46.5	59.0	51.0	10.0	15.0	23.0
11/1/83	27	4+	M	—	—	5.0	—	—	80.0	106.0	39.0	32.0	28.0	64.0	69.0	62.0	9.5	17.0	25.0
11/1/83	28	4+	M	244.0	239.0	5.0	18.0	112	87.0	104.0	36.0	32.0	32.0	57.0	74.0	62.0	9.0	17.0	22.8
11/1/83	29	4+	M	—	—	8.0	12.0	127	88.0	112.0	41.0	34.0	28.0	62.5	71.0	66.0	11.0	16.0	21.0
Male	X			232.5	226.0	6.8	13.1	108.6	84.0	112.2	38.7	34.2	26.8	59.1	70.6	59.4	10.6	17.4	23.6
	S.D.			16.9	18.3	1.8	2.3	17.8	5.1	10.9	5.7	3.2	3.0	6.2	5.9	4.7	1.6	1.7	1.9

[a]estimated age.

been related to stress or overheating associated with higher air temperatures and multiple helicopter passes. Sex of the animal and physical condition also may have been factors in 1983. Seven of 8 bulls required high drug dosages in 1983. Bulls captured in the fall of 1983 appeared to be very fat and in excellent condition.

Table 3. Drugs used to immobilize muskoxen on the Arctic National Wildlife Refuge, 1982 - 1983.

Drug Dosages Used (cc)		Number of Muskoxen Drugged	
M-99 / M-50 50 +	Rompun	1982	1983
5.0	0.2	2	0
7.3	0.2	12[a]	3[c]
7.5 - 11.5	0.0	0	2
10.3 - 12.3	0.2	1[b]	7
15.0 - 15.5	0.0	-	3

[a]Two animals had difficulty standing and walking during initial recovery.
[b]Animal accidently darted twice; recovery was prolonged.
[c]One animal was not completely immobilized.

Induction times ranged from 3 to 16 min in 1982 and 8 to 38 min in 1983. Recovery times were shorter in 1983 primarily because all animals recovered rapidly with no difficulties (Table 4). Eleven cows and 2 bulls were measured in 1982 and six cows and 8 bulls were measured in 1983 (Table 4). Minimum drug dosages used in this study were approximately twice the amount used to immobilize captive muskoxen at the University of Alaska (Don Hartbauer, per. comm.). These captive animals are quite active and have to be restrained. Patenaude (1982) reported dosages of 2.2 to 3.0 mg/100 kg M-99 used with transplanted muskoxen in northern Quebec and recommended dosages of 7 mg for cows and 8 mg for bulls.

Table 4. Time required for induction and recovery of immobilized muskoxen, Arctic National Wildlife Refuge, 1982 - 1983.

Capture Date	Number of Muskoxen	Induction Time (Min.) Mean	Induction Time (Min.) Range	Recovery Time (Min.) Mean	Recovery Time (Min.) Range
April 1982	11	10.9	3 - 16	9.1	4 - 13
	3[a]	6.0	5 - 7	20.7	13 - 28
April 1983	7[b]	20.0[c]	10 - 28	5.0	3 - 8
	5	9.8	8 - 11	5.2	4 - 7
Nov 1983	3[b]	22.3[c]	13 - 38	4.7	3 - 6

[a]Animals had difficulty with recovery
[b]Animals drugged with more than 7.5cc M-99
[c]Animal sitting after injection of initial drug dose.

Table 5. Estimated numbers of muskoxen in the Arctic National Wildlife Refuge, 1972 - 1983.

Date	Tamayariak area		Sadlerochit area		Okerokovik area		Total		Data source
	no.	r	no.	r	no.	r	no.	r	
Summer 1972	10	--	14	--	12	--	36	--	Roseneau and Warbelow 1974
Summer 1973	11	0.09	11	--	14	0.14	36	0.08	Roseneau and Warbelow 1974
Summer 1974	14	0.21	12	--	12	--	38	0.05	USFWS 1982
Summer 1976	24	0.21	27	0.28	16	0.25	67	0.22	USFWS 1982
Summer 1977	31	--	40	--	19	--	90	--	USFWS 1982
Spring[a] 1978	32	0.25	36	0.25	18	0.11	86	0.22	Ross 1978
Summer 1978	42	--	46	--	20	--	108	--	Ross 1978
Spring[a] 1979	44	0.27	42	0.14	26	0.23	112	0.23	Ross 1979
Spring[a] 1980	54	0.18	65	0.35	29	0.10	148	0.24	Ross 1980
Spring[a] 1981	72	0.25	78	0.17	36	0.19	186	0.20	Ross 1981
Spring[a] 1982	97	0.26	79	0.01	43	0.16	219	0.15	Current study
Fall 1982	111	--	80	--	49	--	240	--	Current study
Spring[a] 1983	119[b]	0.18	81	0.02	57[c]	0.25	257	0.15	Current study
Fall 1983	137[b]		110		64[d]		311		Current study

r = rate of increase per year $\frac{(n2 - n1)}{(n2)}$, calculated from pre-calving (spring) population estimates only.

[a]pre-calving survey which represents over-winter survival of the previous year's population.

[b]includes 8 muskoxen on the Kavik River.

[c]includes 14 bulls from Kongakut River and Yukon Territories.

[d]includes 15 muskoxen between the Egaksrak River and the Canadian border.

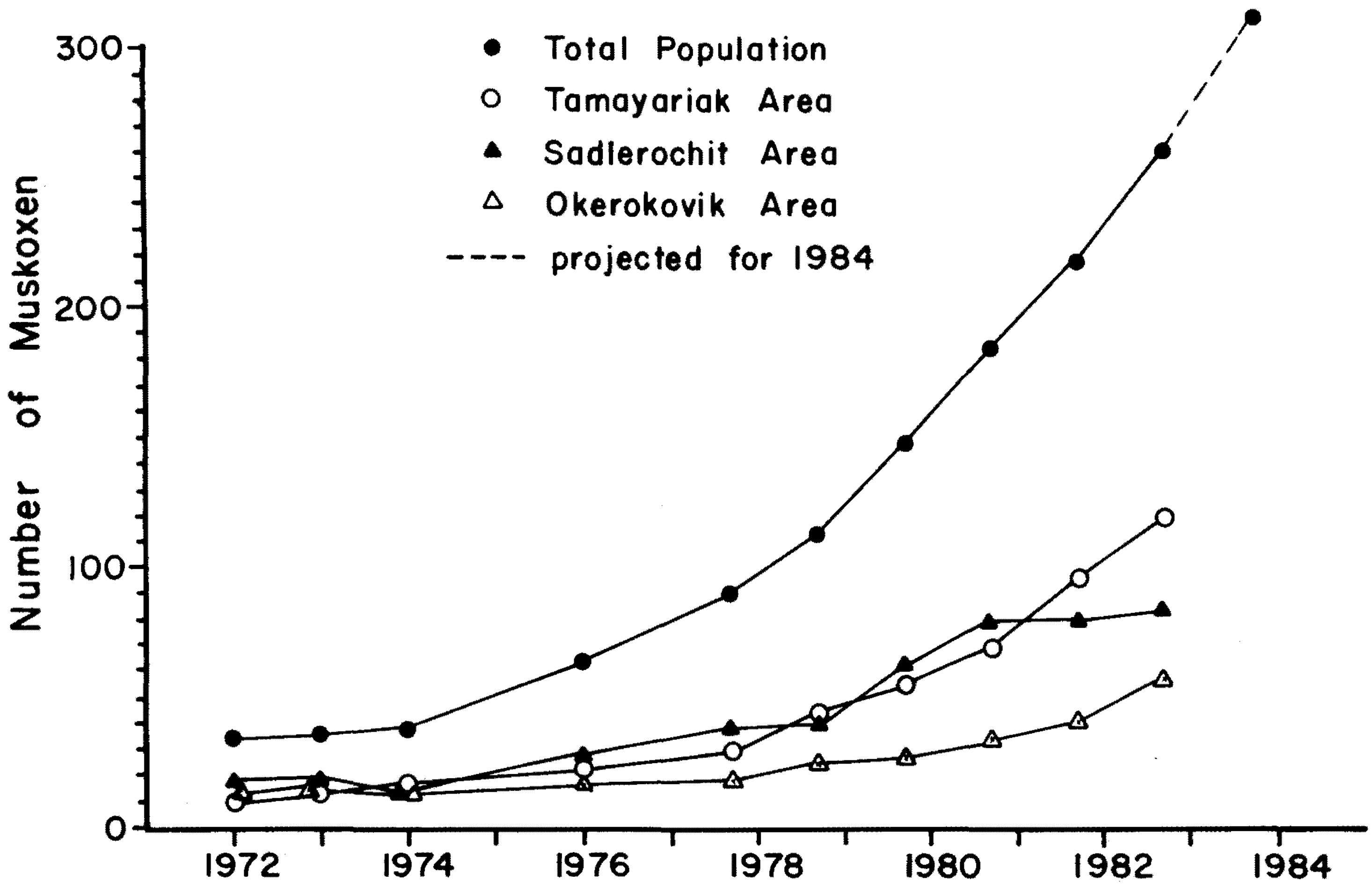

Fig. 2. Estimated numbers of muskoxen in the Arctic National Wildlife Refuge, 1972 - 1983.

Table 6. Observed composition of muskoxen herds on the Arctic National Wildlife Refuge, 1983

Age-sex class		Tamayariak area			Sadlerochit area			Okerokovik area			Totals		
		1-3 Apr	16-20 Jun	26-28 Aug	1-3 Apr	16-20 Jun	26-28 Aug	1-3 Apr	16-20 Jun	26-28 Aug	1-3 Apr	16-20 Jun	26-28 Aug
Adult bulls	#	15	7	15	10	8	8	3	1	4	28	16	27
	%		8	15		8	11		2	12		7	13
Adult cows	#	6	14	24	8	16	18	4	13	6	18	43	48
	%		17	24		15	24		29	18		18	23
3 yr. bulls	#	2	3	6	5	16	2	5	5	2	12	24	10
	%		4	6		15	3		11	6		10	5
3 yr. cows	#	3	16	10	9	14	8	6	4	4	18	34	22
	%		19	10		13	11		9	12		15	10
2 yr. bulls	#	1	7	8	4	8	7	6	3	4	11	18	19
	%		8	8		8	9		7	11		8	9
2 yr. cows	#	1	9	5	2	7	4	2	4	2	5	20	11
	%		11	5		7	5		8	6		9	5
Yearlings	#	15	12	12	13	17	12	11	7	4	39	36	28
	%		14	12		16	16		16	12		15	13
Calves	#		15	21		20	17		8	8		43	46
	%		18	21		58	67		18	24		18	22
Totals		43	83	101	51	106	76	37	45	34	131	234	211

Population estimates and composition of ANWR muskoxen herds observed in 1982 were reported by Reynolds et al. (1983). The post calving population was estimated to be between 240 and 257 animals in 1982.

1983 Population Estimate. During the pre-calving survey in early April 1983, 235 muskoxen were counted between the Canning River and the Kongakut River. Fourteen additional bulls were seen east of the Kongakut River June 1983 and 8 muskoxen older than calves were seen on the Kavik River in November 1983 indicating that the 1983 pre-calving population was at least 257 animals.

In early November 1983, 311 muskoxen were observed in and adjacent to the ANWR. These animals probably closely approximate the total ANWR muskox population. A total of 288 muskoxen were counted in the major study area between the Canning River and the Aichilik River. The 23 animals seen in locations adjacent to the major study area included 18 adult bulls, 3 adult cows and 2 subadults.

The total population increased at a rate of 15% between 1982 and 1983 (Table 5; Fig. 2). Population growth was slow for 3 to 4 years following the 1969 and 1970 transplants, after which it began to increase, reaching a maximum of 24% in 1980. The growth rate may now be stabilizing at about 15%. Post calving population estimates for 1983 suggest that recruitment between 1983 and 1984 will be similar if overwintering mortality remains low. The ANWR muskox population has more than doubled since 1979. Pre-calving (spring) population estimates for 1983 are higher than those observed in the fall of 1982 because some animals were missed in the fall survey. Also, some of the 15 animals east of the Aichilik River and the 8 animals on the Kavik River seen in 1983 may not have been counted in previous years.

1983 Composition: Of the 235 animals observed during the pre-calving survey in April 1983, 131 (56%) were classified. In mid-June 1983, 234 animals were classified and in late August 1983, 211 animals were classified (Table 6). Comparison of composition counts made in April, June, and August 1983 indicate seasonal differences may occur in herd composition. In April because only a relatively small percentage of the population was classified, percentages of most sex and age classes may not reflect the true frequency of occurrance in the population. Adult bulls and yearlings are exceptions as they can be distinguished from the air and were often the first or only animals classified in a herd. Numbers of bulls seen in April represent 12% of the 235 muskoxen observed during the pre-calving survey, which included mixed sex herds consisting of bulls, cows and young, as well as bull groups. The percentage of bulls observed was only 7% in June, but increased to 13% in August. Most adult bulls appeared to be segregated in bull groups except during the rut in August (Table 7).

Numbers of 3 year old bulls in mixed sex herds declined between June and August (Tables 6 and 7) suggesting displacement by adult bulls during the rut. One adult male was observed sparring with a 3 year old radio-collared bull which then moved away from the herd on 28 August 1983. A 3 year old radio-collared bull moved 52km from the Okerokovik River to the Sadlerochit River between 13 and 22 August 1982 (Reynolds et al. 1983). Therefore, composition counts made in August may underestimate the numbers of 3-year old males in the population.

Table 7. Seasonal changes in the number of adult and 3-year old bull muskoxen associated with mixed sex herds and bull groups, Arctic National Wildlife Refuge, 1983.

Group type	Number of adult bulls	Number of 3-year old bulls
Mixed sex herds		
April	6	
June	6	20
August	22	10
Bull groups		
April	22	
June	10	4
August	5	0

Adult cows and 3-year old cows were sometimes difficult to distinguish. Some adult cows were probably misclassified as 3 year old cows in June (Table 6). The percentage of adult plus 3 year old cows was 33% of the sample population classified in both June and August. The number of cows 3 years of age and older (3 yr +) was estimated to be 95 in the population of 288 muskoxen seen in the major study area (288 x 33%=95). As 2 other cows (3 yr+) were seen on the Kavik River, the total number of cows in the population was estimated to be 97.

The 39 yearlings observed in April 1983 comprised 17% of the 235 muskoxen seen during the spring survey, but only 13% of the 211 muskoxen classified in August 1983 were yearlings. Percentages of 2 year old females and yearlings appeared to have declined between June and August. More calves were observed in August 1983 than in June 1983, suggesting that some calves were born after the June composition counts (Table 6).

Geographic differences in composition described in 1982 (Reynolds et al. 1983) were not as apparent in 1983 and may have been an artifact of the smaller sample classified in 1982.

Productivity. The 1983 calf crop was estimated to be 64 calves, based on the calf:cow ratio and percentage of calves seen during the August composition count (Table 6). Although some 2 year old cows were observed with calves on the Sadlerochit River in the highly productive year of 1979 (Jingsfor and Klein 1982), in this study, productive cows were assumed to be 3 years of age and older. Assuming the total number of cows in the population was 97 (paragraph 1, page), the number of calves was estimated as follows:

$$\frac{\text{\# calves seen in Aug}}{\text{\# cows seen in Aug}} = \frac{\text{total \# calves in the population}}{\text{total \# cows in the population}}$$

$$\frac{46}{70} = \frac{X}{97}$$

$$X = 63.7$$

Calves also comprised 22% of the animals classified during August composition counts (Table 6). Assuming the sample of 211 animals classified in August was representative of the 288 muskoxen seen in the study area in November (no calves were seen among the 23 animals adjacent to the study area), the numer of calves was estimated to be:

$$\% \text{ calves (Aug)} \times \text{total no. (Nov)} = \text{est. no. calves}$$

$$0.22 \times 288 = 63.4$$

In 1983 the first calf was seen on 29 April, 21 were seen on 10 May, and 35 were seen on 1 June. A total of 43 calves were classified during June composition counts, and an estimated 7 calves were seen in a non-classified herd of 30 indicating that a total of 50 calves were present by mid-June.

In mid-July, 55 calves were counted. During August composition counts, 46 calves were seen when 73% of all mixed herds were classified, suggesting that the total in August may have been about 63 calves (Table 6). A minimum of 51 calves were seen from the air in the November survey.

Calf production and yearling recruitment were high in 1982 and 1983 (Table 8). About 95% of all calves observed in 1982 apparently survived until at least June 1983. More 2 year olds were seen in 1983 than yearlings in 1982 including that not all yearlings had been seen in 1982. Yearling/cow and calf/cow ratios seen in 1983 are probably more accurate than those recorded in 1982 when a smaller sample of the population was classified. Production in ANWR muskoxen herds was similar to that seen by Lassen (1984) in Jameson Land, northeast Greenland, where 57 to 64 calves per 100 cows (3 yr+) were observed, yearlings comprised 15% to 18% of the population, and calves comprised 19% to 21% of the population in 1981 and 1982.

Table 8. Muskox productivity and survival on the Arctic National Wildlife Refuge, 1982 - 1983.

	2 year olds	Yearlings		Calves	
Category	1983[a]	1982[b]	1983[a]	1982[b]	1983[c]
Number observed	38	27	36	38	46
Number per 100 cows(3+)	49	61	47	63	66
% sample classified	17	19	15	16	22

[a]from June 1983 composition data, before dispersal of young-aged animals (Table 6).
[b]extrapolated from ANWR Progress Report No. FY83-7 (Reynolds et al. 1983).
[c]from August 1983 composition data, after completion of calving (Table 6).

Productivity of radio-collared cows was compared in 1982 and 1983 (Table 9). Cows were considered to have a calf if they were seen alone with a calf, or if maternal behavior such as licking or nursing was observed. Cows in herds without calves were assumed to be barren. Probabilities were calculated for each cow whose reproductive status was unknown based on numbers of cows and calves accompanying the radio-collared animal. In 1982 when 11 cows were captured in mid-April only 2 weeks before the onset of the calving season a minimum of 3 calves (.27 calves per cow) and a maximum of 7 calves (.64 calves per cow) were born. By comparison, in 1983 when they were not captured, 8 of these animals produced a minimum of 5 calves (.63 calves per cow) and a maximum of 6 calves (.75 calves per cow). In 1983, when animals were captured on 2-3 April, 4 weeks before the calving season began, a minimum of 4 calves (.67 calves per cow) and a maximum of 6 calves (1 calf per cow) were born to the 6 cows captured (Table 9).

In 1982, one cow, who had difficulty recovering from the immobilization procedures, gave birth to a still-born calf within 15 days of being drugged and handled. Conversely, in late May 1983, a 15 year old female gave birth to a live calf within 1 week of being immobilized when her radio collar needed readjustment. Of the 8 radio-collared cows seen in 1982 and 1983, 1 cow (a 15 year old animal) gave birth to a calf in both years, 3 cows gave birth in one year and had a 50% probability of having a calf the other year, 3 cows successfully gave birth in 1 of 2 years, and a 4 year old cow did not give birth either year (Table 9).

Mortality. Annual increases to the ANWR muskox population exceeded the numbers of yearlings observed from 1978 until 1982 (Fig. 3). As reproduction is the only source of recruitment to this transplanted muskox population, not all short yearlings were counted during these years. Mortality must have also been low between 1978 and 1982. In 1983 when more accurate estimates of population size were made, the estimated number of short yearlings exceeded the annual increase to the population by 6 animals. The 1983 estimated calf crop also exceeded the projected 1984 increase in population size by 8 animals (before any over-winter mortality). These differences may represent a mortality rate of 3% or less, assuming that yearling numbers and population estimates are accurate. These differences may also be due to some animals dispersing into new areas. As discussed previously, overwintering mortality of calves and yearlings was low in 1982 and 1983.

Mortality of old-age animals may be expected to increase. Survivors of cohorts transplanted in 1969 and 1970 are now 14 to 17 yeas old and may soon die of old age. Three radio-collared cows which are part of this cohort were still alive in January 1984. At least 9 adult mortalities occurred in the ANWR muskox population between April 1982 and November 1983 (Table 10).

Table 10. Muskox mortalities observed on the Arctic National Wildlife Refuge, 1982 - 1983.

Date	Number of muskoxen	Cause of mortality
March 1982	1 adult bull	injuries caused from fighting
May 1982	1 cow (3 yr.)	unknown (died 1 month after capture
Oct 1982	1 adult cow	malnutrition
March 1983	4 adult bulls	hunter kills
Aug 1983	2 adult bulls	probable predation (grizzly bear)

Table 9. Reproductive status of radio-collared muskox cows in 1982 and 1983.

	ID No.	Est.Age in 1983	1982 Date Observed	1982 Status	1982 Probability of having calf	1983 Date Observed	1983 Status	1983 Probability of having calf	
	1	14	6/21	no calf	.00	6/27	calf	100	
Cows	3	14	5/25	calf	1.00	6/1	calf	100	
collared	4	4+	6/25	2 cows 1 calf	.50		dead		
in	5	4+	8/5	no calf	.00		lost collar		
1982	6	4+	6/27	8 cows, 4 calves	.50	6/16	calf	100	
	8	4+	7/2	4 cows, 2 calves	.50	8/27	calf	100	
	9	4+	4/30	stillborn calf	.00	8/27	calf	100	
	10	4+	6/21	calf	1.00	8/26	2 cows,1 calf	50	
	11	4	7/2	no calf	.00	6/18	no calf	0	
	14	17-18	6/25	calf	1.00	8/27	no calf	0	
	15	4	6/27	8 cows, 4 calves	.50		collar out		
No. of calves per cow				range = .27 - .64 mean = .46			range = .63 - .75 mean = .69		
	16	4+				8/27	4 cows,2 calves	.50	1
	17	4+				8/27	calf	1.00	1
Cows	21	3				8/27	8 cows,7 calves	.88	1
collared	22	3				8/27	8 cows,7 calves	.88	1
in	23	4+				8/27	8 cows,7 calves	.88	1
1983	25	3				8/27	8 cows,7 calves	.88	0
No. of calves per cow							range = .67 - 1.00 mean = .84		

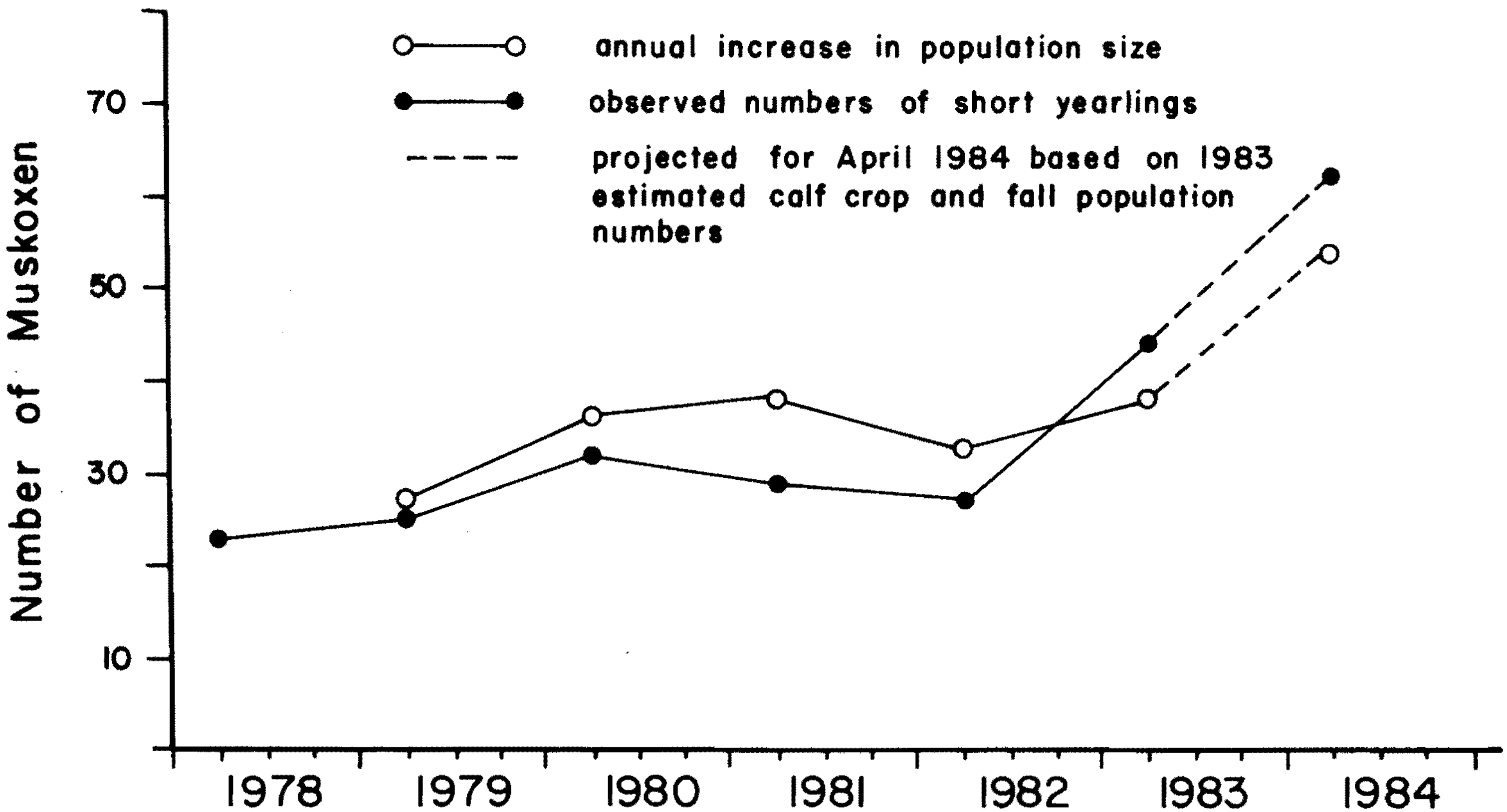

Fig. 3. Comparison of annual population increase with numbers of short yearlings observed in the Arctic National Wildlife Refuge muskox population, 1978 - 1984.

At least 6 adult bulls were removed from the population in 1983. In March 1983 a hunting season which permitted the taking of 5 adult bulls was opened for the first time by the Alaska Department of Fish and Game. Four bulls were killed. Two adult bulls were killed or scavenged by a radio-collared grizzly in northeastern Canada in August 1983 on coastal plain portions of the Backhouse River and Firth River. This bear was observed near another single muskoxen in late September on the Malcolm River. Another bear was observed stalking a herd of muskoxen on the Okerokovik River in August 1983.

Herd Dynamics

Herd interactions and movements were derived from herd association of radio-collared muskoxen. Muskoxen herds observed between April 1982 and November 1983 showed variation in herd stability. Total numbers and marked individuals within a herd remained the same in some instances for several weeks, and then changed as herds encountered one another and intermixed.

In the Tamayariak and Sadlerochit areas in January, February and early March 1983, herds were relatively stable in space and time. Only one of 9 radio-collared animals (#6 AF) made major movements between different herds either alone or accompanied by a small group of animals. (Fig. 4). During late April and May 1982 (Fig.5) and 1983 (Fig.4) as animals congregated in calving areas, herds became intermixed. Most herds appeared to be relatively stable in early June as they dispersed from calving areas. In July when animals moved back to major rivers after emergence of willows, herds again intermixed. During the rut in August, muskoxen were generally associated with small harem groups. On the Sadlerochit river in August 1983, however, muskoxen congregated in a herd of about 60 animals for at least 2 weeks. By late September, large herds again formed along major rivers (Figs. 4 and 5).

In the Okerokovik area, herds were also stable during the late winter from January to mid-March 1983 (Fig 6). An intermixing of herds occurred in late March 1983 similar to that observed in the Tamayariak area. The herds were segregated in different areas during calving in 1983 and did not intermix. But in June and July 1982 (Fig. 7) and 1983 (Fig. 6) herds were less stable as they moved between the upper Angun River and the Okerokovik River. During the rut in August in both years less intermixing between herds occurred, but in September and October 1982 and 1983 muskoxen congregated on the Okerokovik river. In late October 1982 and 1983, herds were segregated in 3 different areas (Figs. 6 and 7). Herds in the Okerokovik area appeared to be more stable than herds in the Tamayariak and Sadlerochit areas. Three main herds within the geographic area were identifiable throughout much of 1983 (Fig 6).

Mean herd size varied with the season in 1982 and 1983 (Fig. 8). The largest herds were seen in mid-April, late October and early November, and the smallest herds were seen in August during the rut. Seasonal variations in herd size were similar to results reported by Gray (1973), who found monthly mean herd size changed from a low in July-August to highs in October, February and April on Bathurst Island. Miller et al. (1977, as cited in Gunn 1982) also observed a decrease in average herd size from 17.2 in March-April to 10.0 in July-August on Melville Island.

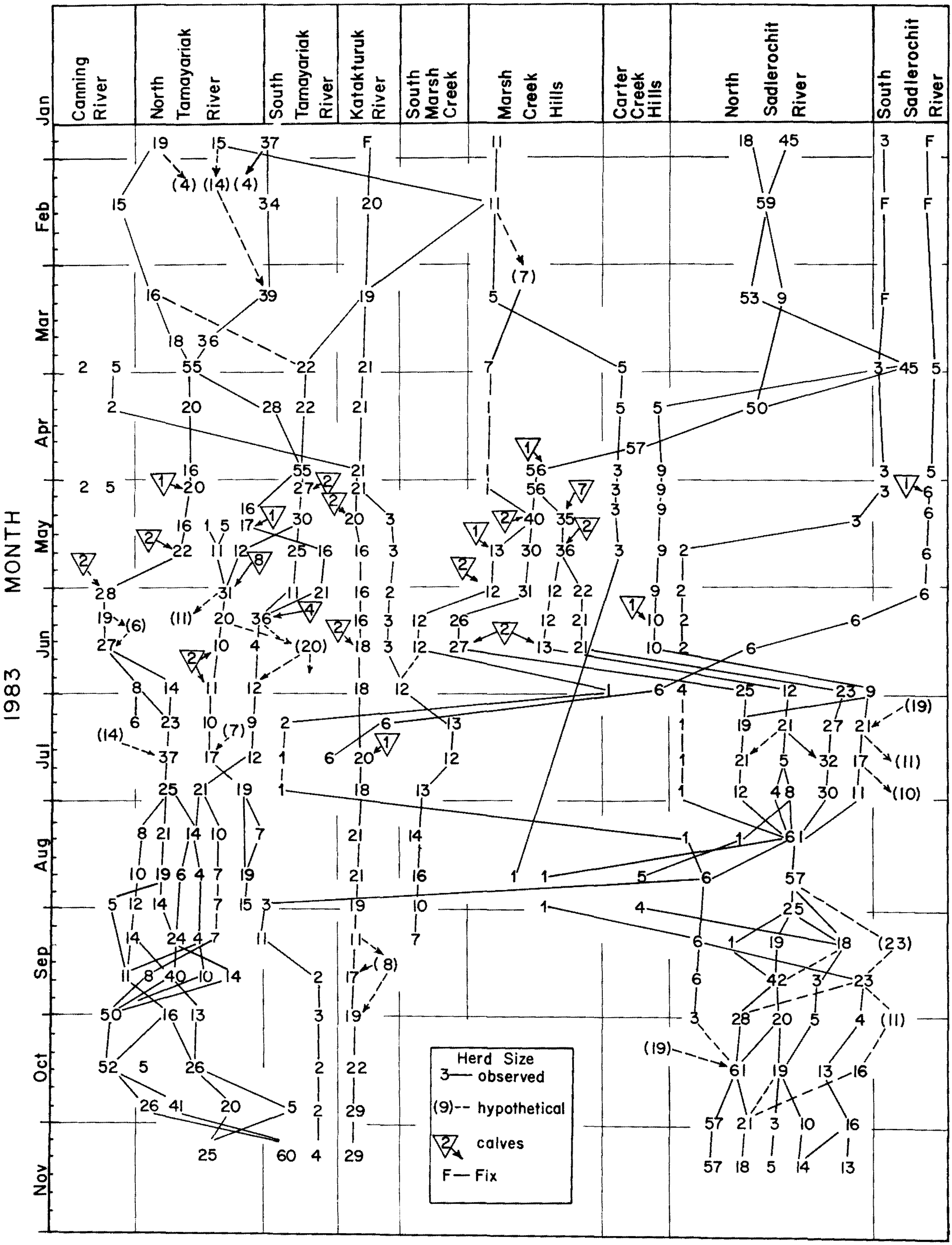

FIG. 4. MOVEMENTS AND INTERACTIONS OF MUSKOX HERDS WEST OF THE HULAHULA RIVER IN THE SADLEROCHIT AND TAMAYARIAK AREAS, JANUARY-NOVEMBER 1983.

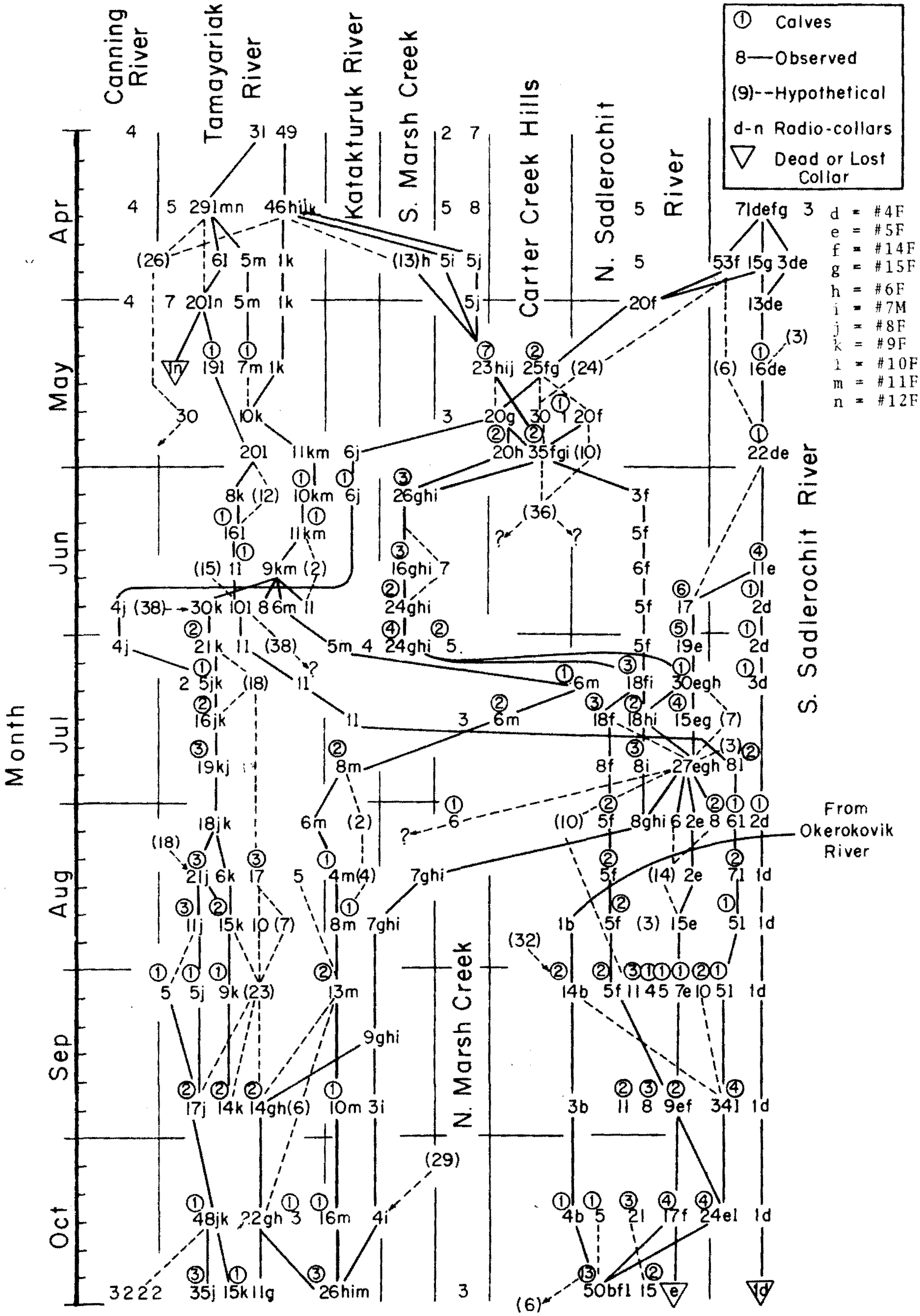

FIG. 5. MOVEMENTS AND INTERACTIONS OF MUSKOX HERDS WEST OF THE HULAHULA RIVER IN THE SADLEROCHIT AND TAMAYARIAK AREAS, APRIL - OCTOBER 1982.

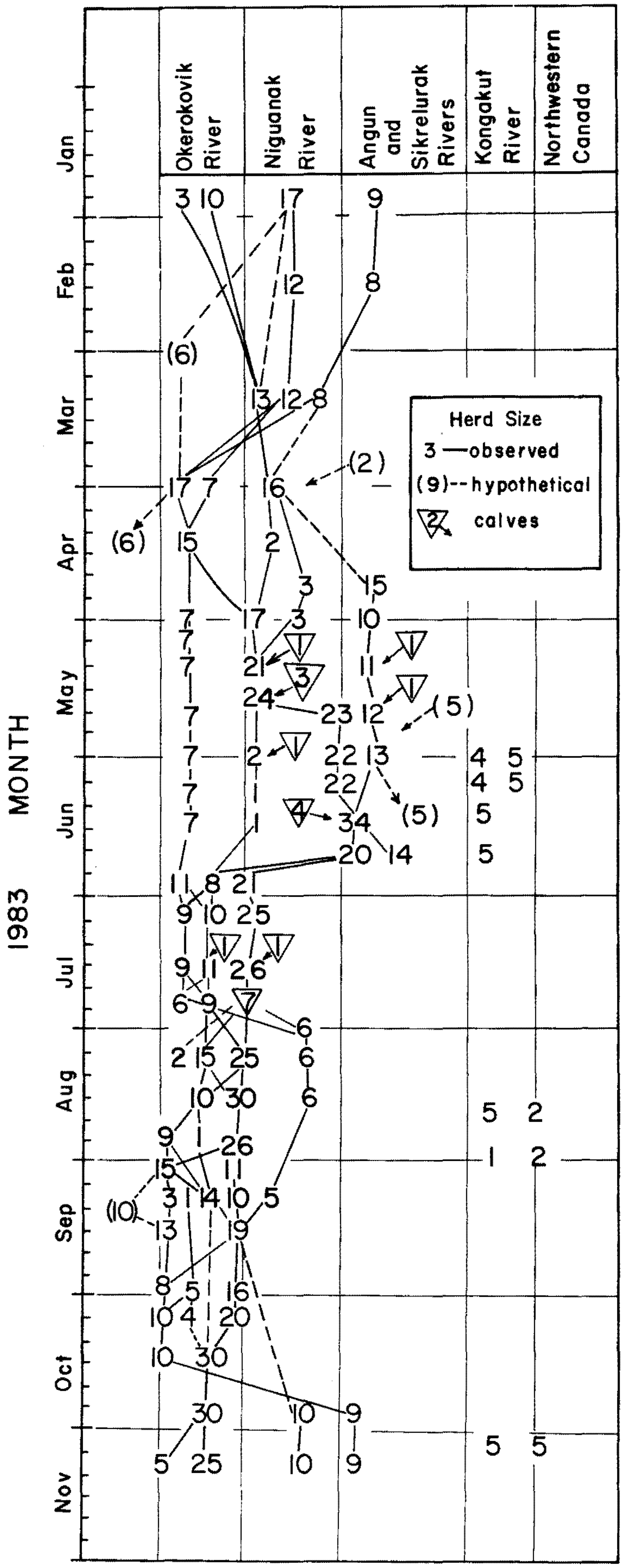

FIG. 6. MOVEMENTS AND INTERACTIONS OF MUSKOX HERDS EAST OF THE JAGO RIVER IN THE OKEROKOVIK AREA, JANUARY-NOVEMBER 1983.

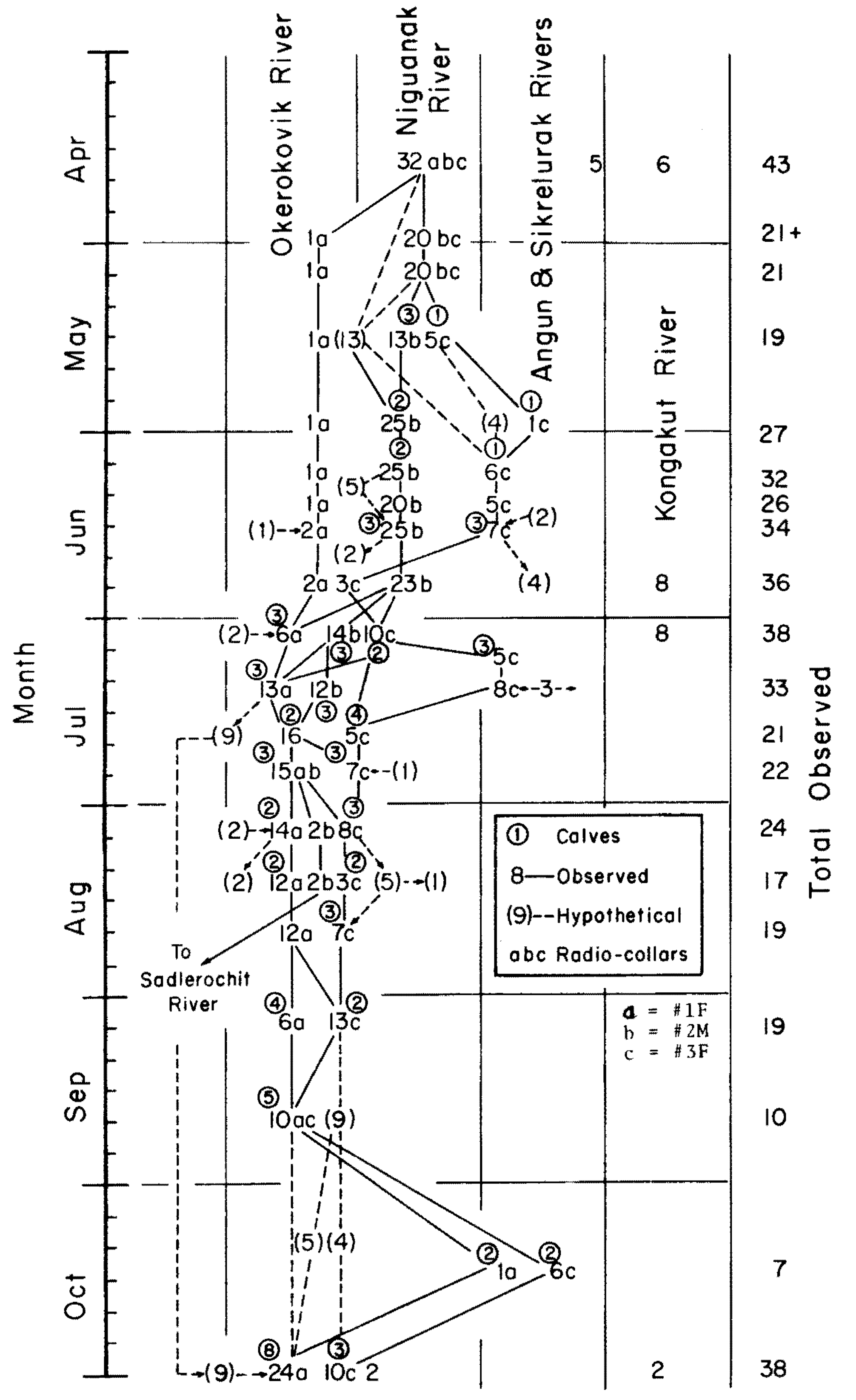

FIG. 7. MOVEMENTS AND INTERACTIONS OF MUSKOX HERDS EAST OF THE JAGO RIVER IN THE OKEROKOVIK AREA, APRIL - OCTOBER 1982.

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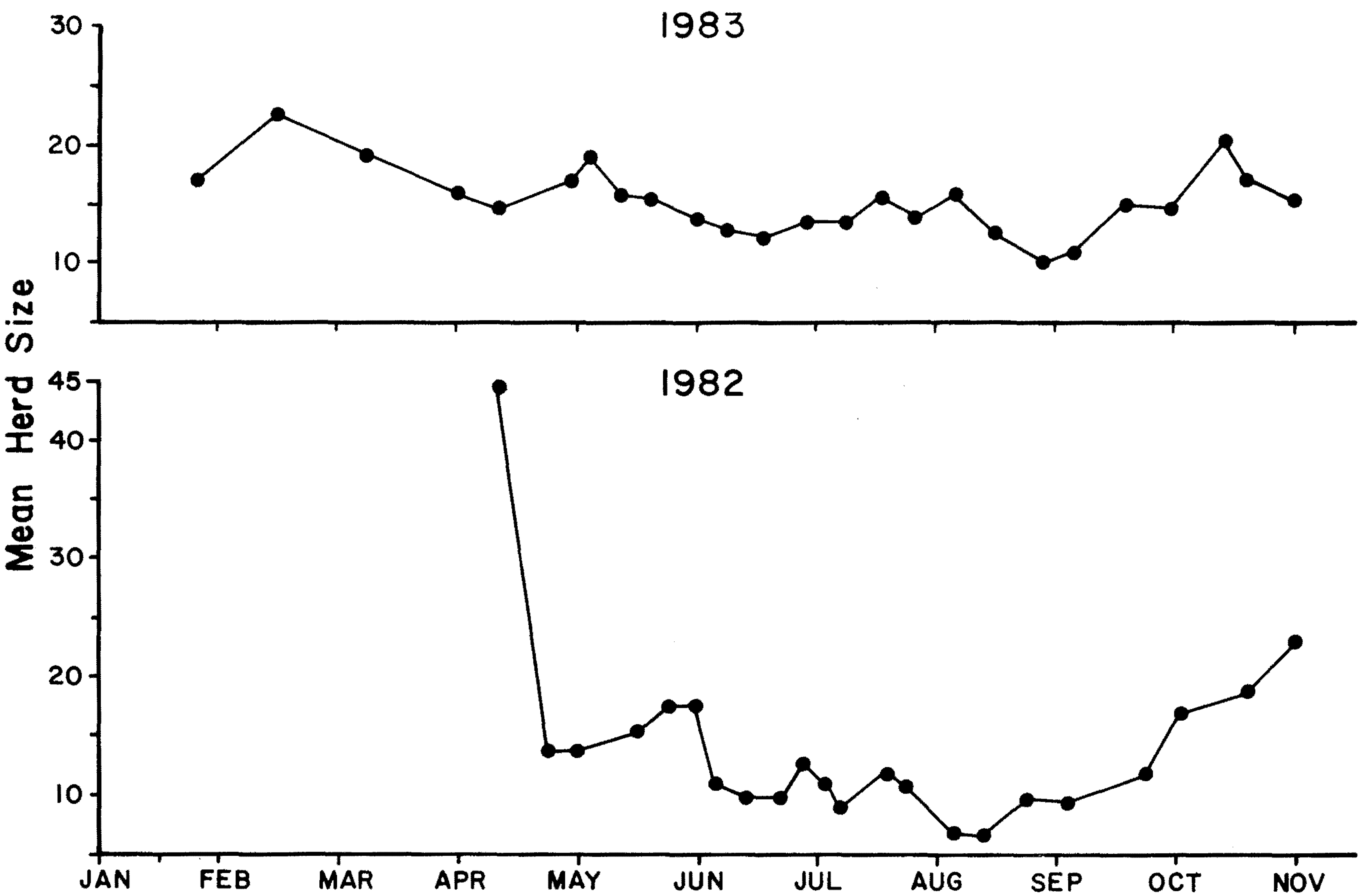

Fig. 8. Seasonal variation in the size of muskox herds observed in the Arctic National Wildlife Refuge in 1982 and 1983.

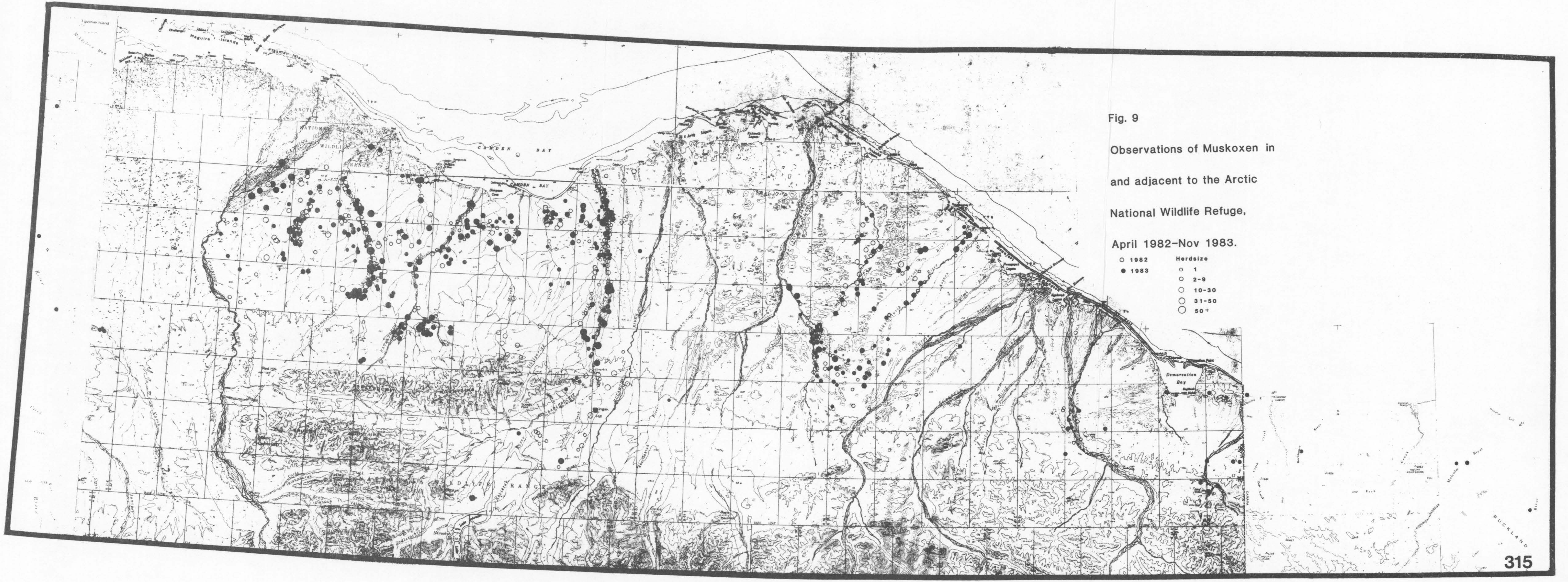

Fig. 9

Observations of Muskoxen in and adjacent to the Arctic National Wildlife Refuge, April 1982–Nov 1983.

In past years, a large herd on the Sadlerochit River appeared to have been a stable unit, although in 1979 this herd split temporarily several times during rut. In 1979-80 this herd was larger than most herds reported elsewhere and fracture into smaller groups seemed inevitable (Jingfors and Klein 1982). A similar situation may have existed with the other 2 large herds observed in past years (USFWS 1982). In the summers of 1982 and 1983 no large stable herds were observed in the study area. Population numbers suggested that some animals had dispersed into small herds, making them more difficult to count (Reynolds and Ross 1984).

At least 1 herd apparently dispersed from the Tamayariak area in 1982 A herd of 16 to 30 animals including a 3 year old radio-collared cow moved into a new area on the upper Katakturuk River by late October 1982 and remained there throughout 1983 (see discussion below). This herd, which remained relatively stable throughout 1983, was comprised primarily of young aged animals. Of the 19 animals classified in August 1983, 6 (32%) were 2 year olds, 2 were yearlings and 4 were calves. One adult (4^+) bull and 6 cows (all of which appeared to be 3 or 4 years old) were also present.

Distribution, Movements and Habitat Use

Distribution and Movements. General distribution of muskoxen observed in the ANWR was similar in 1982 and 1983 (Fig. 9). Animals were concentrated in the same geographic locations along the Tamayariak River, the Sadlerochit River and the Okerokovik River which were described in earlier studies (Jingfors 1982, Roseneau & Warbelow 1974, USFWS 1982). At least 1 adult bull was seen near the Kuparuk River (J. Curtolo per. com.) and 1 adult bull was reported near Galbraith Lake (W. Smith per. com.) in 1983.

Seasonal distribution and major movements of muskoxen varied between geographic areas but trends were apparent in 1982 and 1983 (Reynolds 1984). In the Okerokovik area between Jago River and the Aichilik River, seasonal use areas were identified in both 1982 and 1983. (Fig. 10 and 11). In both years from mid to late April through May (the peak of the calving season) about 30 muskoxen utilized the bluffs adjacent to the Niguanak River, the Sikrelurak River and the Angun River (mis-identified as the Sikutaktuvik River on the map). A herd of 9 cows with no calves remained on the Okerokovik River during April and May 1983. From mid to late June until November muskoxen used the area between the Okerokovik River and the head waters of the Angun River in both 1982 and 1983. Animals oscillated from east to west throughout the summer. In mid October during 1982 and 1983, at least 6 to 9 animals traveled to the Arctic coast probably following the Angun River or Sikrelurak River where they remained less than 2 weeks. A similar movement to the coast by about 30 animals was also observed in June 1983. Winter distribution of 3 herds observed in January, February and early March, was in or adjacent to either the summer/fall use area or the calving area. One herd of 6 also spent most of June 1983 along the Niguanak River.

In the Sadlerochit area, seasonal use areas were also apparent in 1982 and 1983 (Fig. 12 and Fig. 13). In mid-April of both years, 40 to 50 muskoxen were observed on the ridge systems southeast of the upper Sadlerochit River. These wind-swept ridges may provide late winter forage. Temperatures were 15° to +20°C warmer here than along the river on 3 April 1983. The use of this area may be relatively brief. In 1983, 45 muskoxen moved 45 km in 5 days from the lower Sadlerochit River to Kingak hill. After moving along the ridge system for 4 days they moved 47 km in 2 days back to the lower Sadlerochit River.

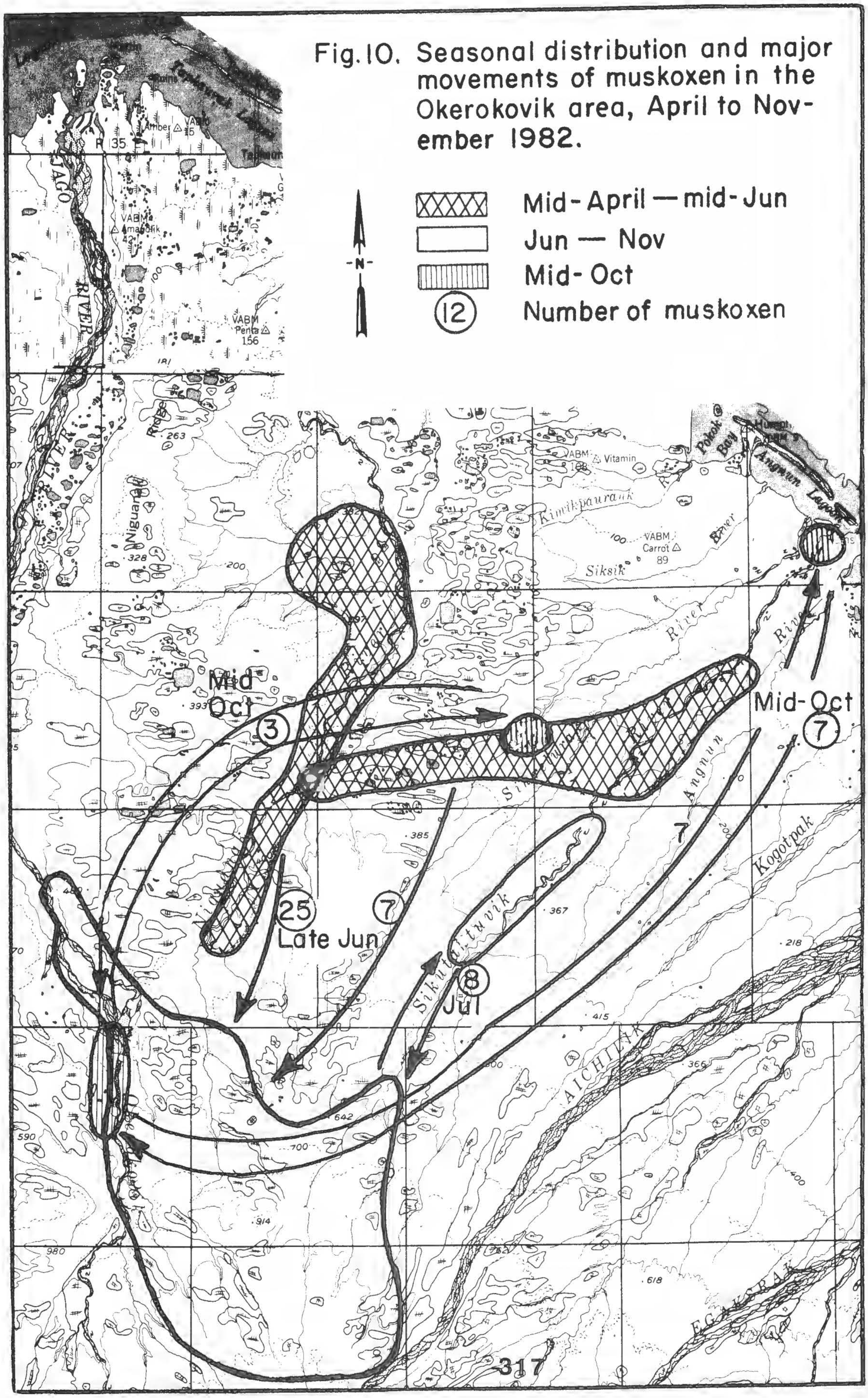

Fig. 10. Seasonal distribution and major movements of muskoxen in the Okerokovik area, April to November 1982.

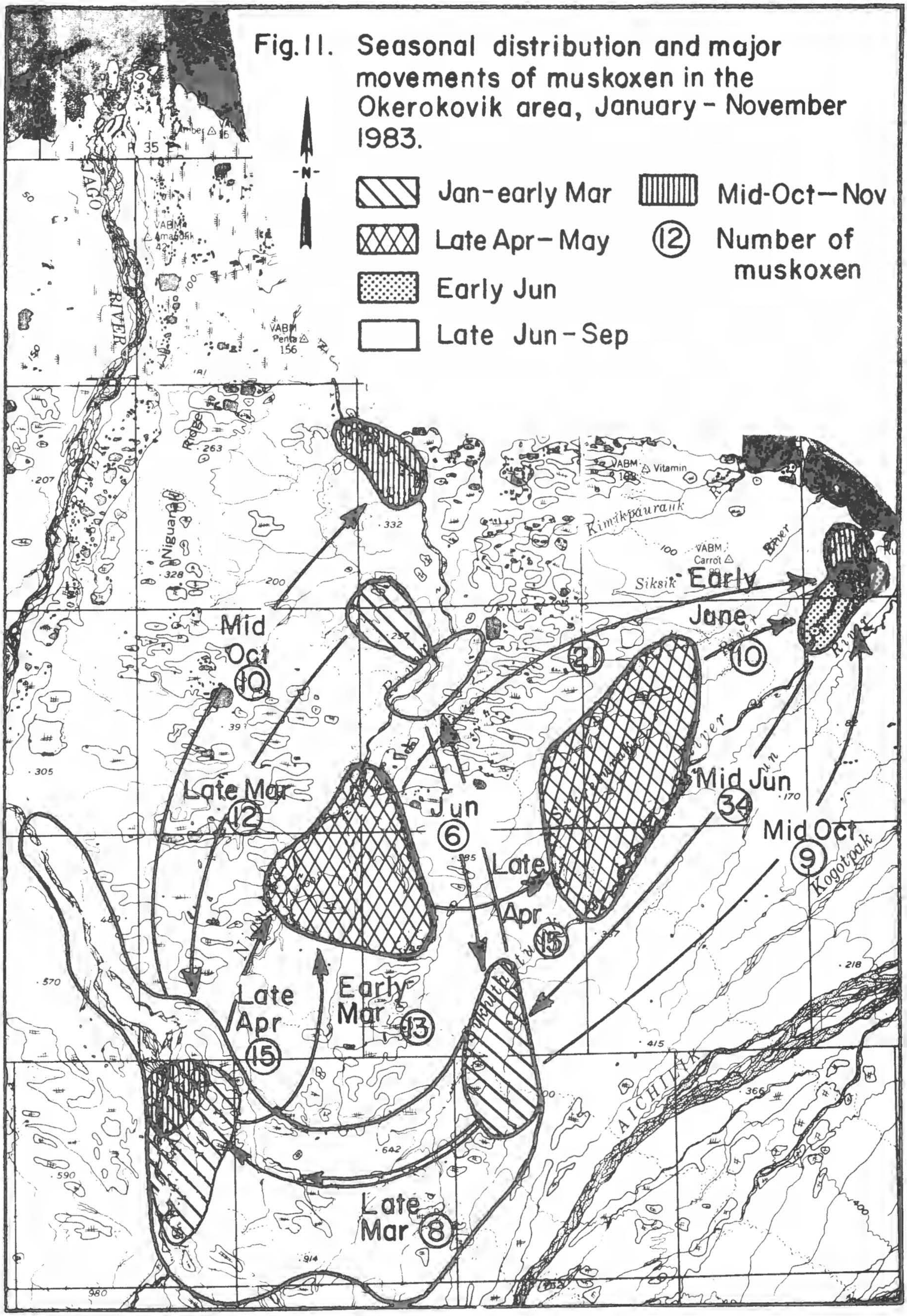

Fig. 11. Seasonal distribution and major movements of muskoxen in the Okerokovik area, January - November 1983.

Major movements to calving areas west of the Sadlerochit River were made by at least 50 Sadlerochit animals in late April 1982 and 1983 (Fig. 12 and 13). In 1982, these muskoxen calved in the hills east of Carter Creek. In 1983 most animals moved further west and calved in the hills between the Katakturuk River and Marsh Creek, although a herd of 9 calved in the hills east of Carter Creek. Twenty-two animals remained in the upper Sadlerochit drainage to calve in 1982. In 1983, a herd of 5 cows calved on the mountain southwest of the upper Sadlerochit River where they had spent the winter. In late May or June 1982 and 1983, at least half the muskoxen calving in the hills east of Carter Creek moved to new areas along upper Marsh Creek and adjacent drainages. In 1982, this herd including animals from both the Tamayariak and Sadlerochit areas. In late June or early July 1982 and 1983, when the riparian willows emerged, animals moved to the Sadlerochit River where they spent the remainder of the summer and fall except for minor movements in August when at least 26 muskoxen utilized areas adjacent to the river.

About 60 muskoxen remained on the Sadlerochit River from January through early March 1983. One bull group of 3, including a 3 year old radio-collared male, overwintered on the south-facing talus slopes of the Sadlerochit Mountains. One herd of 5 muskoxen overwintered southwest of the upper Sadlerochit River on a mountain north of Schrader Lake.

In the Tamayariak area, similar seasonal distribution and movements were observed in 1982 and 1983 (Fig. 12 and 13). In mid-April, animals utilized an area which was included as part of their summer range in both 1982 and 1983. Animals calved on the upper Tamayariak bluffs in 1982 and 1983. An estimated 20-30 muskoxen from the Tamayariak areas also calved with Sadlerochit animals in the Carter Creek hills in 1982 and at least 19 calved near the west fork of the Tamayariak in 1983. Movements away from calving areas to the coast and along the lower Canning River occurred in late May and early June in 1982 and 1983. Throughout the summer months, from late June through October, distribution was concentrated in an area between the main forks and the west fork of the Tamayariak River. Riparian willow areas on the west fork were heavily utilized in both 1982 and 1983. In 1983 at least 2 herds returned to the Canning River during late September. One herd of 18 animals apparently wintered within the range observed in summer. Another herd of 36 animals was seen in January through early March along a drainage less than 6 km from the coast south west of Camden Bay (Fig 13).

Differences in distribution and movements observed between 1982 and 1983 included some changes in the use of calving areas (Table 11). The same general areas were used during both years by muskoxen in the Okerokovik area. In the Sadlerochit area, most of the animals from the Sadlerochit River which had calved in the hills east of Carter Creek in 1982, moved at least 12 km west and calved in the hills between Marsh Creek and the Katakturuk River in 1983. The Carter Creek hills area apparently had been used by Sadlerochit muskoxen since at least 1978 (Jingfors 1982, USFWS 1983). This shift to the west may be an expansion of a traditional area. The herd of 5 muskoxen calving on the upper Sadlerochit drainage in 1983 had been in this area on a mountain north of Schrader Lake throughout the winter.

In 1982, at least 20 to 30 animals from the Tamayariak area calved with Sadlerochit animals in the Carter Creek hills. In 1983 these animals calved on bluffs near the main fork or the west fork of the Tamayariak River.

Fig. 12. Seasonal distribution and major movements of muskoxen in the Tamayariak area and the Sadlerochit area, April to November 1982.

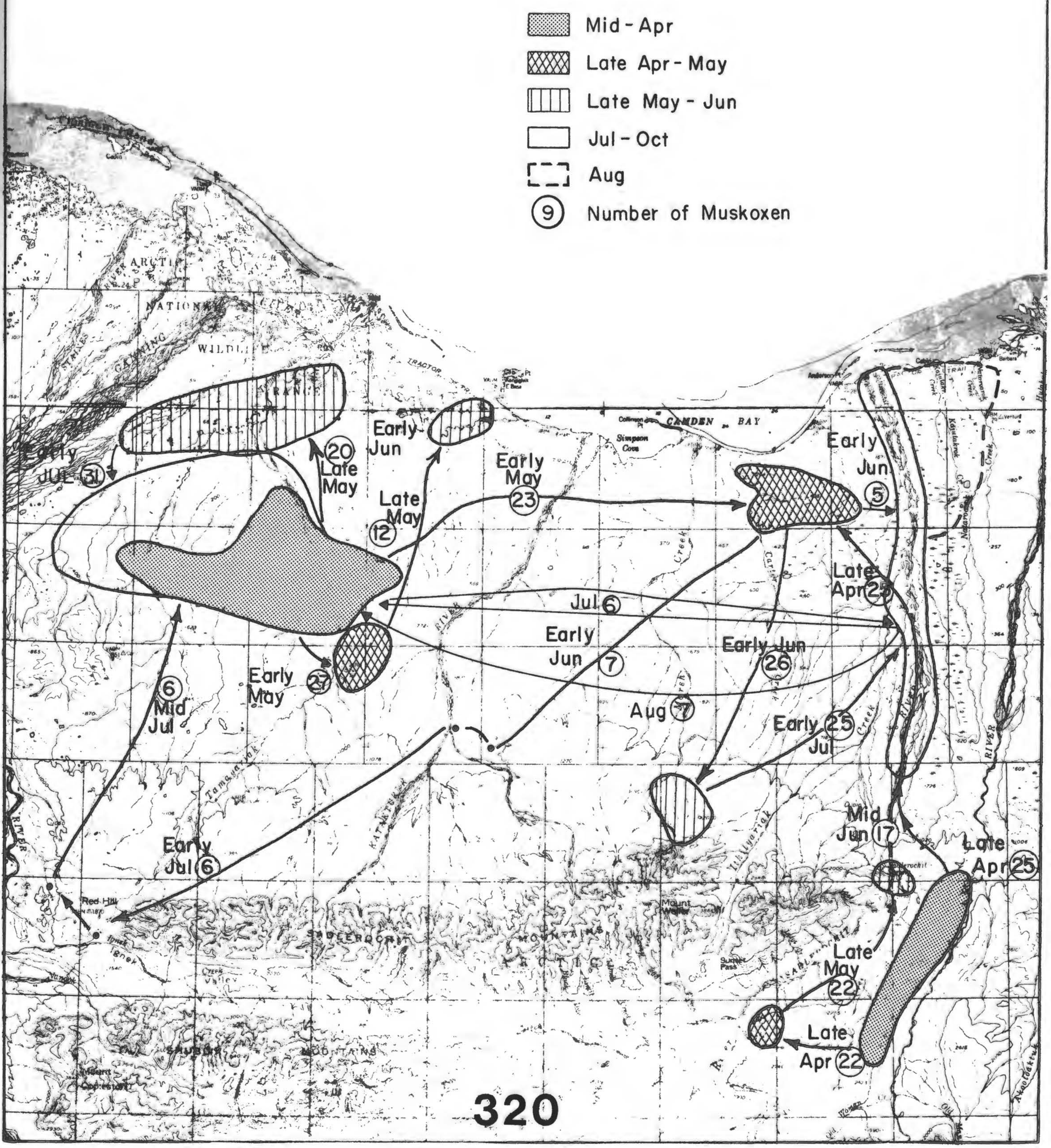

Fig. 13. Seasonal distribution and major movements of muskoxen in the Tamayariak area and the Sadlerochit area, January to November 1983.

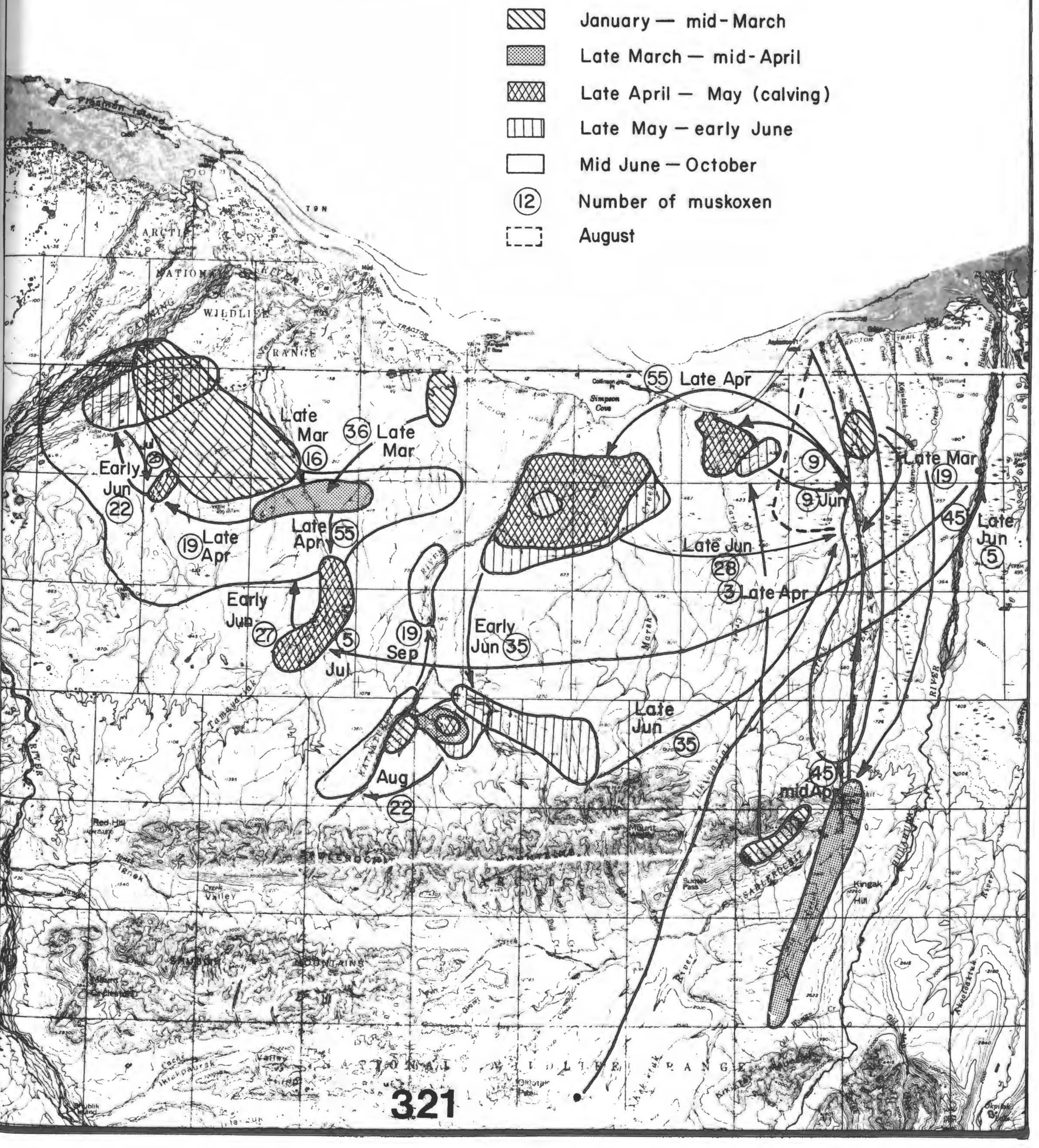

Table 11. Calving areas used by muskoxen on the Arctic National Wildlife Refuge, 1982 - 1983.

Location	Estimated numbers of muskoxen	
	1982	1983
Okerokovik area:		
Niguanak River	25	21
Angun River	6[a]	10
Okerokovik River	1[b]	7[b]
Sadlerochit area:		
Carter Creek hills	70[c]	9
Marsh Creek hills		55
Upper Sadlerochit drainage	22	5
Tamayariak area:		
Tamayariak bluffs	26	55
West fork bluffs		19
Upper Katakturuk River		21
Totals	150	202

[a] on Niguanak River until late May
[b] no calves in herd by late June
[c] including animals from both Tamayariak and Sadlerochit areas

Calving areas used by radio-collared cows in the Sadlerochit and Tamayariak areas were also different in 1982 and 1983 (Table 12). Five of 9 (56%) did not calve in the same location (within 13 km) in 1982 and 1983 (Reynolds 1984). The shift from the hills east of Carter Creek in 1982 to the hills west of Marsh Creek in 1983 was not considered a change in calving area location.

Another difference in distribution of muskoxen observed between 1982 and 1983 was the dispersal of animals into new areas. A 3 year old radio-collared cow moved in a herd of 6 animals from the Tamayariak River to the Sadlerochit River in late June 1982. This herd returned to the Tamayariak area in late July, but then moved to the Katakturuk River in late August 1982, where they were joined by other animals. The herd, which ranged in size from 16 to 30 muskoxen, utilized a new area between the main forks of the upper Katakturuk River from October 1982 until July 1983 when the animals moved to the central part of the Katakturuk River (Fig. 13). In August 1983 they were on the upper west fork of the Tamayariak River and in September and October 1983 they returned to the Katakturuk River. Small bull groups and solitary bulls were seen in this area prior to 1983, but no long term use by a mixed sex herd was observed until this herd moved into the area.

Another herd of 6 animals including an adult bull, 2 adult cows, one 2 year old and 2 yearlings was seen in late May 1983 and early November 1983 on the Kavik River, about 30 km west of the Canning River. Although this area was not surveyed in 1982, it is possible that this is a small herd which has dispersed from the Tamayariak area. No muskoxen herds have been seen along the Kavik drainage during the past several years in spite of numerous overflights by biologists working in the area (K. Whitten per. com.).

More muskox sightings were made east of the Okerokovik area between the Kongakut River and the Firth River in northwest Canada in 1983 than in 1982. Many of these sightings were acquired during frequent overflights of the area during caribou studies in June 1983. Although this area has been used by muskoxen since at least 1972 (Roseneau and Warbelow 1973), numbers of animals in this area appear to have increased and may be dispersing from the Okerokovik area.

Movements of individuals between geographic areas occurred in 1982 and 1983. Three of 4 adult radio-collared bulls made long range movements between the Tamayariak River and the Sadlerochit River during the rut in August 1983. One adult bull also traveled from the Tamayariak area to the hills east of Carter Creek in April 1982 and 1983. Two 3 year old bulls collared in 1983 remained within the areas which they had been collared, but one 3 year old male (#2) moved from the Okerokovik River to the Sadlerochit River in August 1982.

Five of 16 radio-collared cows also made long range movements between geographic areas. Four of these had been captured in the Tamayariak area and 3 were estimated to be 3 or 4 years old. Some of these movements may be related to dispersal. One cow (#10) moved alone with her calf from the Tamayariak River to the Sadlerochit River in July 1982 where she remained until October 1982. By January 1983, she had moved with a herd of 5 cows to a mountain southwest of the upper Sadlerochit River near Schrader Lake where they stayed throughout the winter. Eventually this herd returned to the

Table 12. Yearly variations in use of calving areas by radio-collared muskoxen cows on the Arctic National Wildlife Refuge, 1982 - 1983.

Muskox	Location of calving 1982	Location of calving 1983	Distance between locations
#1	Okerokovik River	Okerokovik River	7km
#3	Niguanak River	Niguanak River	8km
#14	Carter Creek Hills	Marsh Creek Hills	12km
#15	Carter Creek Hills	Tamayariak Bluffs	40km
#6	Carter Creek Hills	Tamayariak Bluffs	40km
#8	Carter Creek Hills	Tamayariak Bluffs	40km
#9	Tamayariak Bluffs	Tamayariak Bluffs	10km
#10	Tamayariak Bluffs	Mountain above Schrader Lake	47km
#11	Tamayariak Bluffs	Katakturuk River	13km

Sadlerochit River in June, and the Tamayariak River in July 1983. As described previously, another cow (#11) moved from the Tamayariak River to the Sadlerochit River and back in 1982 and then moved with a herd of 6 to a new area on the Katakturuk River in October 1982, remaining there until November 1983. In 1982, 2 cows (#6 and #8) moved from the Tamayariak River to calve in the hills east of Carter Creek. Both traveled to the Sadlerochit River with different herds before returning to the Tamayariak River. A cow (#15) collared on the Sadlerochit River moved to the Tamayariak River in August 1982. One of these cows (#6) also moved from the Tamayariak River, to the hills west of Marsh Creek, and then to the upper Katakturuk River in January and March 1983.

Habitat Use. A preliminary analysis of muskox association with terrain features and land cover types identifiable from the air showed that seasonal shifts in habitat use occurred in 1982 and 1983 (Tables 13 and 14). Snow-covered areas along drainages or ridges were used in late winter 1983. Ridges and bluffs partially blown free of snow were used from late March until mid-or late May in both 1982 and 1983. Use of this land cover - terrain type corresponded to movements made by Sadlerochit muskoxen to the ridge system southeast of the upper Sadlerochit River, in late March, and movements of other muskoxen to bluffs above the Tamayariak River, the Niguanak River, and the Carter Creek and Marsh Creek hills at the onset of calving in late April. In early June 1982 and 1983, animals were utilizing bare areas or low vegetation along drainages or ridges. Movements to the Canning River delta, the upper Marsh Creek hills, and the mouth of the Angun took place during this time. In late June and early July muskoxen began using willows as they moved into major river drainages. Use of riparian willow stands and adjacent communities continued through July. In August 1982 muskoxen were associated with tussock communities along rivers and in flat areas. In August 1983, 50% to 73% of muskoxen observed were utilizing wet sedges along small drainages adjacent to major rivers. In September and October during both years either willows or low vegetation along rivers were used. By mid-October and early November 1982 and 1983, snow again covered the vegetation.

Summary

Transplanted muskox herds in the ANWR appear to be in a state of change. High productivity and low mortality have resulted in a population rapidly expanding in size which may be beginning to exploit new geographic areas. Until 1981, muskoxen were associated with large stable herds occupying descrete geographic ranges. In 1982 and 1983 herds were generally smaller units which intermixed during different times of the year. Movements of marked individuals between geographic areas were documented and dispersal of at least one herd of young aged animals into a new area on the Katakturuk River occurred. This dispersal was preceeded by long range movements between the Tamayariak River and the Sadlerochit River by at least one individual associated with the new herd. Other long range movements by radio-collared cows resulted in temporary relocations into new areas. Although these animals eventually returned to the area from which they had come after several weeks or several months, these movements may be indicative of a population expanding into new geographic areas. The westward extension of calving into the Marsh Creek hills in 1983 from the Carter Creek area which had been used for at least 4 previous years may be another indication of range extension.

Table 13. Seasonal changes in habitat use by muskoxen on the Arctic National Wildlife Refuge, 1982.

Date	No. of Muskoxen Observed	% of muskoxen in each land cover - terrain type										
		Snow/parital snow veg unknown			Bare or low veg		Willows	Tussocks			Wet sedge/ tussocks	
		d	r	f	d	r	d	d	r	f	d	f
16 Apr	202	29	66									
23 Apr	110	10	85									
30 Apr	86	47	44									
14 May	126		94									
25 May	113	19	81									
29 May	129	84		16								
6 Jun	84				11	76	13					
10 Jun	72				38	39	17					
21 Jun	121				46	54						
28 Jun	155				11			15	25		15	
2 Jul	143				21	25	16					12
11 Jul	154				23		65				13	
16 Jul	124				10		54		26			
23 Jul	87						81			10		
5 Aug	103				27			24	10		11	
13 Aug	108				13		29	41				
22 Aug	114						49			37		
5 Sep	107						70					
23 Sep	157						87				12	
16 Oct	227	98										
31 Oct	242	99										

Terrain Types
d = drainages: riverbar or terrace, creek bed or bench
r = ridge, bluff or hillside
f = flat tundra

Table 14. Seasonal changes in habitat use by muskoxen on the Arctic National Wildlife Refuge, 1983.

Date	No. of Muskox Observed	% of muskoxen in each land cover - terrain type										
		Snow			Snow/low veg/tussocks		Bare or low veg		Willows	Tussocks	Wet sedge/ tussocks	
		d	r	f	r	d	d	r	d	d	d	f
29 Jan	187	47	41									
14 Feb	159	47	34									
8 Mar	174	72	28									
29 Mar	230	16	17	29	36							
11 Apr	151	52	25	15								
29 Apr	207		14	12	72							
3 May	201	22		46		23						
10 May	234	21	32		27							
22 May	251	68		14								
1 Jun	262						35	39				
8 Jun	228						48				20	
16 Jun	195						46		16		32	
27 Jun	183								59		32	
7 Jul	213								75	12		
16 Jul	276						21		28		27	
24 Jul	235						16		34	12	11	
6 Aug	231								39		50	11
17 Aug	229						14				48	25
26 Aug	187										73	
6 Sep	189								87			
15 Sep	231						35		10	34		
30 Sep	189					10	75		15			
13 Oct	269								90			
25 Oct	303	20			42	19						
31 Oct	310	98										

Terrain Types
d = drainages: river bars or terrace, creek bed or bench
r = ridge, bluff, hillside
f = flat tundra

Although the total population grew by 15% between 1982 and 1983, the growth rate within the core study area was only 7% in spite of a yearling crop of 39 animals (15% of the population). These figures also indicate disperal of muskoxen from major use areas. Young bulls ejected from harem groups during the rut, as well as some young-aged females, and yearlings may be forming small herds which move into new areas.

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ECOLOGY OF BROWN BEARS INHABITING THE COASTAL PLAIN AND ADJACENT FOOTHILLS AND MOUNTAINS OF THE NORTHEASTERN PORTION OF THE ARCTIC NATIONAL WILDLIFE REFUGE

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Key words: brown bear, denning, movements, reproduction, populations, Arctic-Beaufort, Arctic National Wildlife Refuge

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Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge.

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Abstract: Fifty brown bears (*Ursus arctos*) were captured between 23 June and 3 July 1982 and an additional 30 bears were captured between 28 May and 16 June 1983 in the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge (ANWR). Radio-transmitters were attached to total of 60 different bears during this time period and these bears were monitored through denning (October-November) in both years. More males were captured in age classes 5.5 years of age or less, while females were more abundant in age classes 6.5 years old and older. The sex ratio for captured bears was equal. No natural mortalities occurred in 1982 among sample bears, however in 1983, 10 apparent mortalities occurred among 17 young bears (cubs and yearlings). Reasons for this high mortality rate (58.9%) among young bears is undetermined. Brown bears were observed feeding on muskox (*Ovibos moschatus*) carcasses on 2 occasions, and were observed stalking or chasing muskox on 2 other occasions in 1983. No muskox/brown bear interaction was recorded in 1982. Brown bears were observed feeding on caribou (*Rangifer tarandus*) carcasses on 6 occasions in 1982 and 15 occasions in 1983. Bears were observed chasing caribou once in 1982, and 15 times in 1983, with 3 of the 1983 chases being successful (calf kills). Preliminary analysis of radio-relocation data indicate that brown bears appear to shift habitat use patterns to coastal areas in June to coincide with occupancy of these habitats by calving and post-calving caribou. Emergence from winter dens occurred from mid-April throughout May, with early emergence by males and non-paturient females and later emergence of females with cubs and females with young. Twenty-nine den sites were inspected in the spring and summer of 1983. Elevation of den sites averaged 816.2 $\pm$ 61.4 m (SE), and slope at den sites averaged 53.6 $\pm$ 3.8% (SE). Den sites were predominantly located on southeast facing slopes (mean aspect 145° $\pm$ 20° SE). In late September, October, and early November 1983, 58 den sites of radio-collared and unmarked bears were located. Bears again moved south into the foothills and mountainous habitats to den. Three bears denned during the first half of October, 52 bears denned during the last half of October, and 3 bears denned in early November 1983. One radio-collared bear and 1 unmarked bear denned in coastal plain habitats within the 1002c study area. Preliminary estimates of population size and productivity of brown bears in and adjacent to the 1002c study area were developed from capture and movement data. A minimum of 87 brown bears occurred in the area in 1983, with a total population estimate of 108 bears (density of 1 bear/80 km^2 for the 8300 km^2 study area). Estimated average age at first reproduction was 7.4 years, with a potential reproductive life of at least 16 years. Mean litter size was 1.9 young and minimum reproductive interval was estimated at 3.6 years. Theoretically, females could produce a total of 8.4 young during their lifespan. This relatively high reproductive rate, if accurate, may be related to the seasonal accessibility by bears on ANWR to the Porcupine caribou herd as a food source.

ANWR Progress Report No. FY84-11

Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge.

Brown bear (Ursus arctos) are year-round residents of the Arctic National Wildlife Refuge (ANWR) and use the coastal plain of ANWR during portions of their life cycle. Knowledge specific to ecology of brown bears using the coastal plain of ANWR are limited (USFWS 1982). Impending petroleum exploration on the coastal plain and the potential impacts of this activity upon brown bears using the coastal plain requires expanded knowledge of brown bear ecology in the area. Of specific concern is the potential for disturbance during dennning, which is postulated to have adverse effects of brown bear populations (Watson et al. 1973, Harding 1976). A study of brown bear ecology was initiated in 1982. The objectives of this study were as follows:

1. Determine location of denning and ecology of denning for brown bears using the coastal plain of ANWR.
2. Determine seasonal habitat use patterns of brown bear using the coastal plain of ANWR.
3. Determine seasonal interrelationships between brown bears and other wildlife species, especially caribou (Rangifer tarandus), occupying the coastal plain and adjacent foothills and mountains of the northeastern portion of ANWR.
4. Determine the structure, size, status, and reproductive biology of brown bear populations on the northern slope of the eastern Brooks Range.

This project is a cooperative effort between the USFWS and the Alaska Department of Fish and Game (ADF&G), with FWS having primary responsibility for the first 3 objectives and ADF&G being primarily responsible for objective 4.

Methods and Materials

The study area is located between the Canning River and the Canadian border, and extends southward to the Brooks range. A detailed description of the study area was presented in the Initial Report - Baseline Study of the ANWR Coastal Plain (USFWS 1982).

Field work was based at Barter Island and extended from 24 April through 5 November 1983. Bears were captured between 28 May and 11 July using a Hughes 500D helicopter. Fixed-wing aircraft were used to locate bears and direct the helicopter with the capture crew to the site. Capture procedures followed standard helicopter immobilization techniques used on brown bears in northern Alaska (Reynolds 1974, 1976). M-99 (Etorphine, 1 mg/ml, D-M Pharmaceuticals) was injected into the rump using Cap-Chur equipment (Palmer Chemical and Equipment Co., Douglasville, GA). All animals recovered after the antidote (M50-50, Dipremorphine, 0.2 mg/ml, D-M Pharmaceuticals, Rockville, MD) was administered intramuscularly in the rump, at 1.5 the dosage of M-99. Captured animals were measured, weighed, tattooed for permanent identification, ear-tagged, and marked with color-coded visual ear flags (Reynolds 1974). In addition, certain bears were fitted with collars containing radio-transmitters (Telenics, Inc., Mesa AZ). Young age animals were fitted with expandable breakaway collars. These animals will be recaptured in 1984 and the collars replaced. Also, young bears (3-4 years) of radio-collared females were captured and collared in late May to document disruption and dispersal of the family unitduring the breeding season..

The 2 vesitgial premolars of the lower jaw were extracted for age determination based on cementum layering (Mundy and Fuller 1964, Stoneburg and Jonkel 1966, Craighead et al. 1970). Teeth were sectioned, stained and mounted for reading as described by Glenn (1972). Whole blood was collected from femoral arteries using Vacutainers (Bection-Dickinson, Rutherford, NJ) for seriological study by ADF&G personnel.

Movements and range size were determined by aerial surveys using fixed-wing aircraft to relocate radio-collared bears. Radio-relocations were attempted on a weekly basis; however, inclement weather and extensive movements of radio-collared bears increased intervals between relocations to 7-10 days. Attempts were made to visually observe each bear during a relocation; however, terrain, cover, and weather conditions did not always permit visual observation. Therefore, when visual relocations were not possible, radio-fixes were determined by triangulation or by abrupt changes in radio-signal strength. Radio-relocations and fixes were recorded in 1:630,360 scale topographic maps and other relevant information was recorded on form sheets.

Range sizes will be calculated using Curatolo and Moore's (1975) modification of the exclusive boundary strip method (Stickel 1954). This method uses the approximate size of daily movements to define the range area. Grid size will be a 4.83 km square (Reynolds 1980). These determinations will be used for comparing this study's results with results of other studies of brown bear in northern Alaska. Additionally, range sizes will be calculated using the minimum area method described by Mohr (1947). Radio-relocations will be digitized and computer graphic techniques will be used to analyze home range and species interrelationships. Movement distances between consecutive radio-relocations will be measured on 1:630,360 scale topographic maps. Winter dens were located by relocating radio-collared bears throughout October and early November. During these den surveys, dens of non-radio-collared bears were often sighted and their locations were recorded on 1:630,360 scale topographic maps.

Movement and home range data will be used to determine seasonal shifts in range use and an attempt will be made to relate these shifts to food availability. Concurrent observations of other species (especially caribou) will be used to evaluate the interrelationship between brown bear and their potential prey species. Upon completion of an extensive vegetation mapping effort in the study area (Walker et al. 1982, USF&WS 1982) the locational information for brown bear will be integrated into the digital data base of vegetation/land cover types. These integrated data sets will be examined statistically to determine habitat correlates. These data will be used to evaluate the suitability of using Landsat-derived land cover maps for identifying and assessing brown bear habitat in arctic Alaska. Movement, range size and habitat use data analyses are ongoing and will be presented in later progress reports.

Data on various parameters of den sites were recorded at the time of denning (October-November) and at the time of emergence in the spring (April-May). Each den site was visited in mid-summer (July) and the vegetation and soil characteristics of the site were documented. Variables measured during the 3 den sample periods were based on densite studies of arctic fox (Chesmore 1969), brown bear (Craighead and Craighead 1972), Harding 1976, Reynolds et al. 1976, Vroom et al. 1980) and black bear (Johnson and Pelton 1980, Tietje and Ruff 1980, Johnson and Pelton 1981).

At each densite, 2 30.5-m (100 feet) bisecting lines were established, with 1 line along the axis of the slope (up-slope line) and the other line (cross-slope line) perpendicular to the first. The densite will be located at the midpoint of each line (the bisection point) in the manner described by Reichelt (1973). A sharpened surveyor's pin was lowered vertically to ground line at 30.5 cm (1 foot) intervals along each line and the point contact and the plant nearest to the pin at ground level was recorded at each point (200 total points per densite). Species composition data will be analyzed using analysis of variance and linear correlations analysis. Analysis of vegetational data is ongoing and will be presented in later progress reports.

Snow depth in spring and depth of permafrost in the summer at each densite and at non-densite locations adjacent to the densites were recorded. Soil samples were taken at all sample locations to determine soil texture (Brady 1974). Non-densite locations will include 3 sites adjacent to each densite at a similar elevation, but with aspects at 90°, 180°, and 270° angle deviations from the densite aspect. Regression analyses will be used to determine interrelationships between snow depth, soil texture, permafrost depths, and aspects. These data will be useful in more clearly defining denning habitat in the study area.

Results and Discussion

A total of 50 brown bear were captured and marked between 23 June and 3 July 1982 (Table 1). An additional 30 bear were captured and marked between 28 May and 16 June 1983 (Table 1). In addition, 11 bears captured in 1982 were recaptured in 1983 and refitted with new radio-collars. A total of 60 different bear were outfitted with radio-collars during 1982-1983. Distribution of 41 bears captured in 1983 included 27 (9 males, 18 females) in coastal plain habitats, 9 (7 males, 2 females) in foothills habitats, 3 (1 male, 2 females) in mountainous habitats, and 2 females in river valley habitats in mountainous terrain (Fig. 1).

Average weights of captured adult bears in 1982 and 1983 were comparable to weights of adult bears in the interior of the southern Yukon Territory, but were less than average weights recorded for adult brown bears in other localities of northern Alaska and the Yukon Territory (Table 2). It should be noted that weights recorded in other studies were for bears captured throughout the year, and included fall captured bears which are considerably heavier than bears captured in the spring (Pearson 1976).

Productivity

Age structure of 78 captured bears and 13 associated unmarked young (Fig. 2) that were theoretically alive in late winter 1983 indicated a preponderance of males in age classes 5.5 years or less (19 males versus 11 females, plus 13 unidentified bears), while females predominated in age classes 6.5 years

Table 1. Physical characteristics of brown bears captured on the Arctic National Wildlife Refuge, Alaska, May June and July 1982 and 1983 (Measurements shown in cm, except as noted).

Bear number	Sex	Cementum age	Weight (lbs./kg)	Total length	Body length	Hind foot	Neck	Girth	Head width	Head length	Shoulder height	Upper left canine	Lower left canine	General capture location	Date
1056	M[a]	20.5	365/166	181	129	29	74	126	22.5	35.7	118	3.9	3.2	Old Man Ck.	26 June 1982
1182	F[a]	15.5	170/ 77	170	92	27	57	92	18.3	34.0	104	3.0	2.7	Jago R.	23 June 1982
1183	F	0.5	14/ 6	74	34	18	22	35	9.4	15.6	41	0.3	0.3	Jago R.	23 June 1982
1184	F	0.5	14/ 6	72	35	13	22	36	9.2	16.0	46	-	-	Jago R.	23 June 1982
1185	F[a]	18.5	215/ 98	163	99	27	57	99	19.5	31.0	103	2.8	2.8	Aichilik R.	23 June 1982
1186	M[a]	6.5	205/ 93	155	99	28	57	102	17.9	32.2	97	3.3	3.0	Siksikpalak R.	23 June 1982
1186	M[a]	7.5	250e/113	174	102	31	63	104	18.6	31.6	113	3.4	3.1	Kongakut R.	10 June 1983
1187	F[a]	6.5	168/ 76	147	93	24	52	99	17.0	29.8	98	3.1	2.9	Egaksrak R.	23 June 1982
1187	F[a]	7.5	180e/82	158	96	28	56	102	17.0	27.6	107	3.0	2.8	Siksikpalak R.	10 June 1983
1188	M[a]	4.5	285/129	201	95	22	67	110	19.5	36.0	102	1.5	1.5	Kongakut R.	23 June 1983
1189	F[a]	5.5	- -	168	94	26	55	99	17.1	32.1	100	3.4	2.8	Kongakut R.	23 June 1982
1189	F[a]	6.5	230/104	170	40	28	57	101	17.7	33.1	107	3.0	3.0	Turner R.	13 June 1983
1190	F[a]	7.5	220/100	171	109	24	58	102	18.1	31.9	97	3.1	2.8	Turner R.	24 June 1982
1191	M	0.5	19/ 9	69	42	15	26	43	10.2	15.7	46	-	-	Turner R.	24 June 1982
1192	M	0.5	20/ 9	88	33	14	25	43	9.8	16.5	41	-	-	Turner R.	24 June 1982
1193	F[a]	8.5	190/ 86	177	90	19	63	114	21.0	32.5	68	2.8	2.8	Clarence R.	24 June 1982
1194	M[a]	11.5	305/138	191	99	23	74	116	21.0	37.0	41	3.8	3.3	Clarence R.	24 June 1982
1195	M[a]	4.5	210/ 95	174	83	22	62	-	18.4	32.2	80	3.4	3.2	Kongakut R.	24 June 1982
1196	M[a]	6.5	- -	155	78	25	62	104	17.0	30.3	98	3.0	2.9	Ekaluakat R.	24 June 1982
1196	M[a]	7.5	220e/100	175	86	25	66	99	18.0	31.2	104	3.1	3.1	Siksikpalak R.	11 June 1983
1197	F[a]	8.5	190/ 86	163	92	27	57	100	19.2	30.9	96	2.9	3.0	Jago R.	24 June 1982
1198	M[a]	5.5	205/ 93	167	89	29	60	107	16.9	33.0	94	3.5	3.1	Sadlerochit R.	25 June 1982
1198	M[a]	6.5	245/111	184	118	30	65	108	19.1	33.5	111	3.6	3.3	Akootoaktuk R.	10 June 1983
1199	M[a]	6.5	220/100	175	86	30	61	100	18.8	33.0	103	3.2	3.3	Katakturuk R.	25 June 1982
1200	M[a]	13.5	335/152	189	90	32	76	120	22.5	35.5	108	3.4	3.2	Katakturuk R.	25 June 1982
1201	F	5.5e[b]	190/ 86	159	80	28	62	97	18.3	31.1	92	2.8	2.7	Katakturuk R.	25 June 1982
1202	F[a]	16.5	215/ 98	160	97	24	60	109	18.2	31.6	98	3.1	2.8	Marsh Cr.	25 June 1982
1203	M	1.5	30/ 14	90	51	16	33	53	11.0	18.6	57	0.6	1.0	Marsh Cr.	25 June 1982
1204	M	1.5	55/ 25	97	64	19	39	75	12.2	21.5	68	1.0	1.2	Marsh Cr.	25 June 1982
1205	M	1.5	46/ 21	101	62	20	39	66	11.2	20.4	61	1.1	1.0	Marsh Cr.	25 June 1982
1206	F[a]	7.5	165/ 75	161	78	25	54	100	17.6	29.3	95	2.6	2.2	Hulahula R.	26 June 1982
1206	F[a]	8.5	190e/86	-	-	-	-	-	17.9	29.7	-	-	-	Itkilyariak Cr.	10 June 1983

Table 1. (Continued).

Bear number	Sex	Cementum Age	Weight (lbs./kg)	Total length	Body length	Hind foot	Neck	Girth	Head width	Head length	Shoulder height	Upper left canine	Lower left canine	General capture location	Date
1207	M	5.5	190/ 86	157	104	28	61	93	18.8	32.2	109	3.7	3.5	Hulahula R.	26 June 1982
1208	F[a]	7.5	180/ 82	160	105	28	58	102	17.7	31.7	93	2.9	2.8	Old Man Cr.	26 June 1982
1209	M	3.5	125/ 57	139	85	27	49	81	15.5	29.0	86	3.0	2.9	Hulahula R.	26 June 1982
1210	F[a]	3.5	151/ 69	154	83	23	53	94	16.7	29.3	91	2.6	2.6	Okpilak.R.	27 June 1982
1210	F[a]	4.5	175/79	156	90	26	55	92	18.0	30.0	99	2.7	2.6	Jago R.	10 June 1983
1211	M[a]	4.5	152/ 69	143	81	27	53	91	15.8	28.0	84	3.0	2.9	Okpilak R.	27 June 1982
1212	F[a]	13.5	235/107	166	98	25	58	103	21.0	31.7	99	3.0	2.4	Old Man Cr.	28 June 1982
1213	F[a]	12.5	210/ 95	170	103	27	61	105	19.7	31.9	92	3.2	2.8	Marsh Cr.	28 June 1982
1214	F	2.5	80/ 36	109	66	22	44	74	14.0	24.6	74	1.2	1.7	Marsh Cr.	28 June 1982
1214	F[a]	3.5	115/52	143	77	26	45	76	14.8	27.7	86	2.3	2.6	Marsh Cr.	28 May 1983
1215	M	18.5	400/181	194	121	33	83	133	22.7	37.3	112	4.3	3.5	Jago R.	28 June 1982
1216	F[a]	5.5	195/ 88	163	102	26	65	107	17.5	28.9	100	2.6	2.7	Jago R.	28 June 1982
1217	F[a]	12.5	250/113	150	107	30	58	98	18.8	29.9	103	2.7	2.5	Jago R.	29 June 1982
1218	M	2.5	144/ 65	154	93	29	48	87	14.6	27.7	88	2.3	2.5	Egaksrak R.	29 June 1982
1219	M	4.5	170/ 77	159	89	27	53	87	16.2	29.6	101	3.2	2.9	Jago R.	30 June 1982
1220	F	10.5	230/104	168	100	25	58	110	19.4	29.5	101	2.9	2.6	Jago R.	30 June 1982
1220	F[a]	11.5	235/107	163	88	26	66	102	20.3	30.9	109	3.0	2.6	Jago R.	8 June 1983
1221	M[a]	3.5	150/ 68	145	80	26	50	96	15.8	27.3	88	2.8	2.9	Jago R.	30 June 1982
1222	M	3.5	120/ 54	148	82	25	47	87	15.2	26.2	91	3.0	2.7	Clarence R.	30 June 1982
1223	M	6.5	250/113	176	98	27	66	109	19.1	34.6	109	3.1	2.9	Kongakut R.	30 June 1982
1223	M[a]	7.5	245/111	182	97	28	63	99	19.2	33.5	108	3.0	2.7	Jago R.	10 June 1983
1224	M	3.5	190/ 86	155	99	27	62	96	16.7	31.2	94	3.1	3.1	Beaufort L.	1 July 1982
1225	M[a]	17.5	310/141	185	114	28	72	117	22.3	34.2	114	3.7	3.5	Sadlerochit R.	1 July 1982
1226	M[a]	10.5	385/175	203	116	28	78	135	22.9	36.8	123	4.1	3.3	Kongakut R.	2 July 1982
1227	F[a]	13.5	255/116	176	120	33	61	113	20.3	32.9	97	3.4	3.0	Kongakut R.	2 July 1982
1228	M[a]	6.5	230/104	167	99	26	59	97	18.7	31.4	95	3.1	2.8	Okpilak R.	3 July 1982
1229	M[a]	4.5	- -	143	92	29	53	102	16.2	30.2	109	4.0	3.5	Kongakut R.	3 July 1982
1229	M[a]	5.5	190/86	165	94	31	57	90	16.9	32.0	105	3.8	3.5	Turner R.	13 June 1983
1230	F[a]	7.5	170/ 77	163	93	25	54	96	17.9	30.3	99	2.9	2.6	Kongakut R.	3 July 1982

Table 1. (Continued).

Bear number	Sex	Cementum Age	Weight (lbs./kg)	Total length	Body length	Hind foot	Neck	Girth	Head width	Head length	Shoulder height	Upper left canine	Lower left canine	General capture location	Date
1231	F[a]	2.5	75/34	129	65	23	45	67	14.1	25.6	75	2.6	2.8	Aichilik R.	28 May 1983
1232	M[a]	2.5	85/39	136	75	24	47	69	14.4	26.8	90	2.1	2.4	Aichilik R.	28 May 1983
1233	M[a]	12.5	375e/170	186	104	32	63	110	22.4	33.4	109	3.8	3.2	Sadlerochit R.	28 May 1983
1234	F[a]	2.5	90/41	136	75	25	46	79	14.7	26.4	84	2.7	2.8	Turner R.	29 May 1983
1235	F[a]	2.5	95/43	138	74	24	43	69	14.6	27.4	85	2.7	2.8	Turner R.	29 May 1983
1236	F[a]	8.5	195/88	167	97	23	54	110	18.5	31.1	107	2.9	2.5	Okpilak R.	8 June 1983
1237	F[a]	2.5	110/50	136	82	20	49	87	15.4	24.7	79	2.8	2.6	Okpilak R.	8 June 1983
1238	F	2.5	95/43	127	63	21	47	86	143.	23.8	76	2.6	2.6	Okpilak R.	8 June 1983
1239	F[a]	8.5	230e/104	167	83	27	60	116	19.1	32.5	105	3.2	2.6	Jago R.	8 June 1983
1240	M[a]	6.5	228/103	165	103	30	59	102	18.3	32.9	108	3.7	3.1	Okpilak R.	9 June 1983
1241	M[a]	18.5	355/161	185	106	25	70	123	23.0	35.7	120	3.8	3.2	Okpilak R.	9 June 1983
1242	F[a]	5.5	160/73	163	88	24	53	111	16.2	29.5	101	3.1	3.0	Okerokovik R.	9 June 1983
1243	F[a]	11.5	235/107	170	92	28	59	109	18.4	32.4	110	3.0	2.8	Okerokovik R.	9 June 1983
1244	M[a]	11.5	310/141	194	115	25	73	117	21.0	33.0	105	3.2	2.7	Okerokovik R.	9 June 1983
1245	F[a]	14.5	215/98	168	94	28	58	99	19.1	33.4	109	2.9	2.6	Itkilyariak R.	10 June 1983
1246	M[a]	10.5	340/154	190	107	31	70	113	21.1	35.8	126	3.6	3.1	Itkilyariak R.	10 June 1983
1247	F[a]	18.5	220/100	174	100	27	61	109	19.4	31.4	110	3.0	2.3	Katakturuk R.	10 June 1983
1248	F[a]	10.5	180/82	158	88	25	55	93	19.1	30.7	92	-	-	Kongakut R.	12 June 1983
1249	F	3.5	110/50	122	74	22	53	86	15.2	28.1	83	-	-	Kongakut R.	12 June 1983
1250	M[a]	20.5	405/184	197	114	28	80	131	23.0	36.0	124	3.5	2.8	Turner R.	12 June 1983
1251	M[a]	19.5	330/150	182	111	29	77	114	23.9	35.9	113	2.9	3.2	Turner R.	12 June 1983
1252	F[a]	7.5	195/88	160	98	28	61	99	18.9	31.5	97	2.8	2.7	Kongakut R.	13 June 1983
1253	M	1.5e	62/28	109	58	-	42	61	12.7	23.1	67	-	-	Kongakut R.	13 June 1983
1254	M	12.5	255e/116	174	104	27	66	93	21.8	34.0	111	3.4	2.8	Old Man Cr.	14 June 1983
1255	M[a]	1.5	48/22	107	62	19	32	52	12.2	21.2	68	0.9	0.5	Old Man Cr.	14 June 1983
1256	M[a]	4.5	220/100	172	98	30	56	94	18.1	32.8	111	3.7	3.3	Jago R.	15 June 1983
1257	F[a]	8.5	160/73	163	101	27	54	86	18.5	31.3	98	3.0	2.8	Okpilak R.	15 June 1983
1258	F[a]	9.5	195/88	195	163	26	57	98	17.6	30.8	93	3.1	2.9	Akootoaktuk R.	15 June 1983
1259	F[a]	23.5	215/98	153	103	25	58	102	19.3	31.4	106	3.4	3.1	Hulahula R.	15 June 1983
1260	F[a]	10.5	220/100	166	107	28	59	108	19.8	32.1	107	3.2	2.9	Egaksrak R.	16 June 1983

[a]Radio-collared
[b]e=estimated

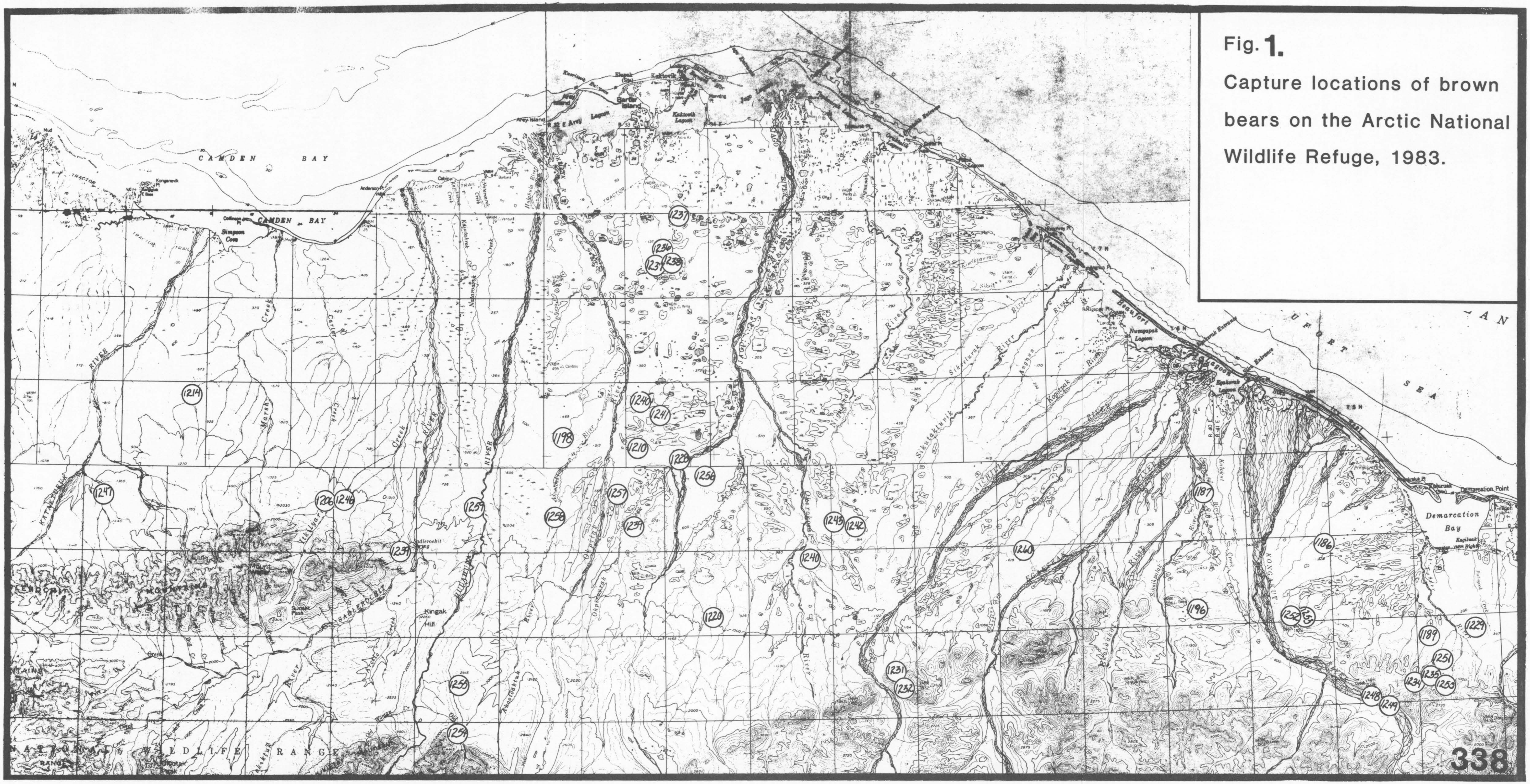

Fig. 1. Capture locations of brown bears on the Arctic National Wildlife Refuge, 1983.

Table 2. Average weights (kg) of adult brown bears in northern Alaska and Yukon Territory.

Sex	Sample Size	Weight Average	Weight Range	Location	Reference
Male	40	139	106-240	interior-southern Yukon Territory	Pearson 1975
Female	21	95	74-124	interior-southern Yukon Territory	Pearson 1975
Male	25	169	-	northern Yukon Territory	Pearson 1976
Female	31	111	-	northern Yukon Territory	Pearson 1976
Male	-	180	136-268	Canning R. drainage, northeast Alaska	Reynolds 1976
Female	18	109	88-41	Canning R. drainage, northeast Alaska	Reynolds 1976
Male	19	167	107-218	northwestern Alaska, NPR-A	Reynolds 1980
Female	24	111	84-177	northwestern Alaska, NPR-A	Reynolds 1980
Male	22	135	86-184	north slope, ANWR	This study 1982-1983
Female	32	93	73-116	north slope, ANWR	This study 1982-1983

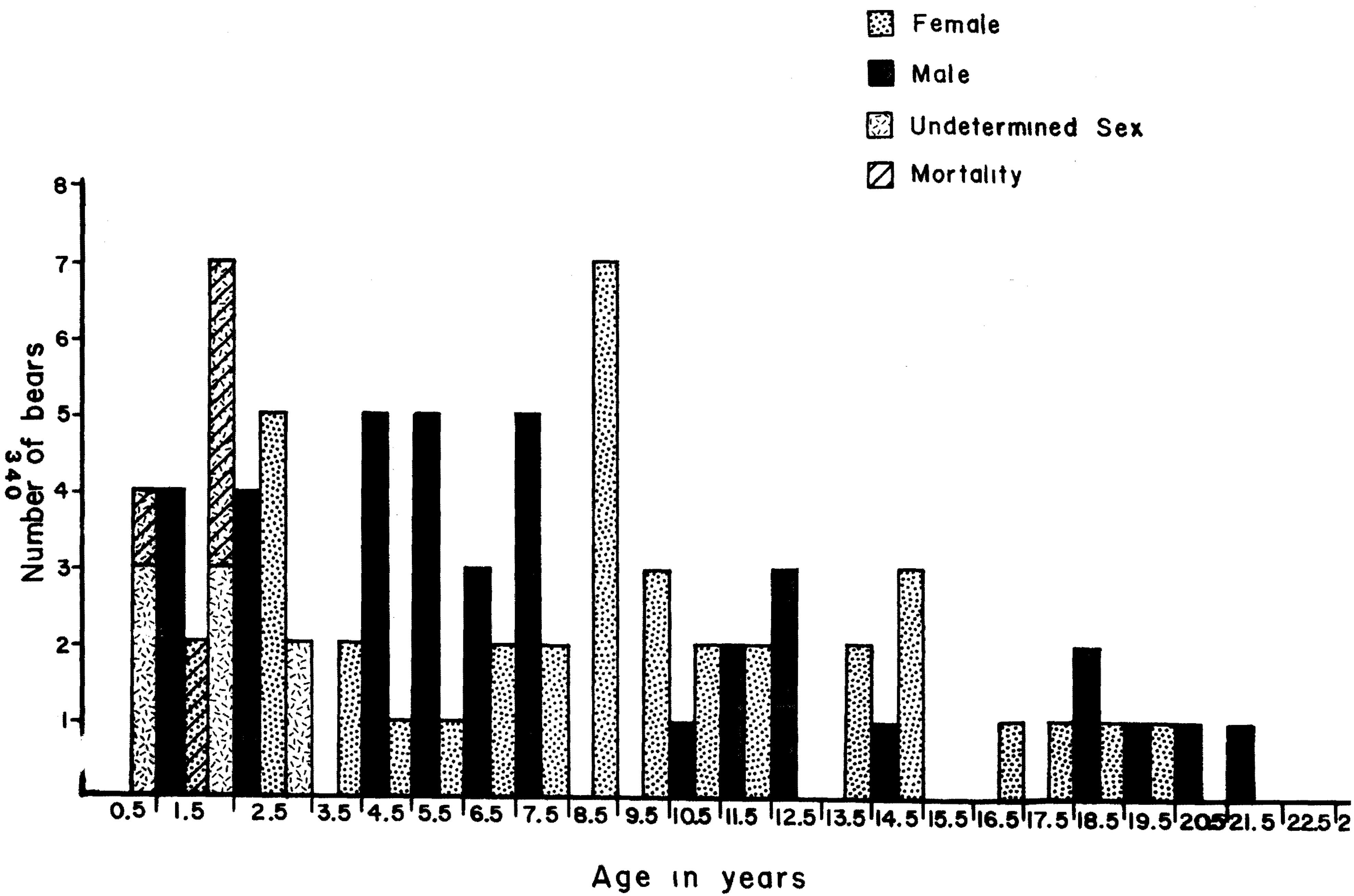

Fig. 2. Age structure of 78 brown bears based upon known denning in fall 1982 and subsequent capture of new bears in May and June 1983 on the Arctic National Wildlife Refuge.

and older (28 females versus 20 males). Immature bears (4.5 years old or less) comprised 40.7% of the theoritical population in late winter 1983, with cubs, yearlings, 2.5 year olds, 3.5 year olds, and 4.5 year old comprising 4.4%, 14.3%, 12.1%, 3.3%, and 6.6% respectively. Adults comprised 59.3% of captured bears and associated young. The sex ratio for the 78 captured bears was equal (39 males, 39 females). This age structure differs from that presented for bears in northeast Alaska along the Canning River (Reynolds 1976), however the Canning River data were more complete than the current study. On the coastal plain and adjacent foothills and mountains of ANWR, 44 bears were captured that were aged 3.5-11.5 years old in contrast, only 19 bears were aged 12.5 years and older. Reynolds (1976) indicated that more older age class bears (12.5+years, n=43) were captured than younger age classes (3.5-11.5 years old, n=29). If the age structure of captured bears is representative of the population, these data indicate a shift from a declining population identified by Reynolds (1980) to a poplation status of uncertain or increasing. It should be noted that search and capture efforts during the current study were focused on the coastal plain and adjacent foothills, and intensive search efforts were not conducted in mountainous terrain. Therefore, these data are biased towards bears using the coastal plain and foothill habitats.

Age structure for immature bears in 1982 indicated there was relatively good survival of young bears through the first 4 years of life. During 1982, 9 females were captured that had young. All young survived throughout the 1982 monitoring period and all young apparently denned with the maternal female, except bear 1221 (Garner et al. 1983). The age structure presented in Fig. 2 is based upon known denning in the fall of 1982 (Garner et al. 1983) and subsequent capture of new bears in May and June 1983. In 1982, mortalities were recorded for only 2 study related deaths and those data indicated a high survival rate for young bears from 1 year to the next (Garner et al. 1983). The 1983 survival data were not consistent with the 1982 data (Table 3). During 1983, 9 of 17 young brown bears (cubs and yearlings), either died or disappeared from the maternal sow and are assumed dead. One radio-collared yearling (#1225) was killed by another bear in late June (Table 3, Fig. 2). This apparent mortality represents a 58.9% mortality rate among the cubs and yearling cohorts. Reasons for this high mortality among young bears is undetermined at this time.

Breeding season normally extends from May through approximately 10 July, with peak of breeding occurring between 10 and 20 June (Reynolds pers. comm.). Observations of pairs was common during this period in 1983 (Fig. 3). Pairs observed after mid-July were probably short term reassociations of siblings and/or family groups. Sexual maturity in females evidently occurs at 6 years of age, with 7 of the 18 females with young apparently breeding when 6.5 years old (Table 4). Two females (#1236 and 1252) apparently bred when 5.5 years of age (Table 4).

Interactions Between Brown Bears and Other Species

Brown bears were observed in the vicinity of dall sheep (Ovis dalli) on 2 occasions, moose (Alces alces) on 5 occasions, and wolf (Canis lupus) on 1 occasion. No interaction between bears and these species were observed, except bear (#1196) was following a lone moose on 14 October in a mountainous region along the Egaksrak River. In contrast to 1982, bear (#1250) was observed feeding on a muskox carcass (adult bulls) on 2

Table 3. Maternal females captured on the ANWR study area in 1982 and 1983 and their associated offspring.

Bear #	1983 Offspring Numbers/age/sex	Time period with female	Offspring marked/bear#
1182	2/yearlings/FF	both disappeared-9 June 83	Yes/1182,1183
1185	2/2.5-year olds/FM	all season	Yes/1231,1232
1190	2/yearlings/MM	1 yearling-did not emerge from den, 1 yearling disappeared-9 June 83	Yes/1191,1192
1193	2/cubs	at least through 7 Aug 83	No
1197	2/2.5-year-olds	2 disappeared 27 June 83	No
1202	3/2.5-year-olds/MMM	all season	Yes/1203,1204, 1205
1208	2/yearlings	1 disappeared-9 June 83 1 disappeared-15 June 83	No
1212	1/cub	all season	No
1213	1/3.5-year old/F	all season	Yes/1214
1217	1/cub	disappeared-8 May 83	No
unknown	1/3.5-year old/M	last seen-26 June 83	Yes/1218
1227	2/2.5-year olds/FF	1 separated from sow-9 June 83 1 separated from sow-30 May 83	Yes/1234,1235
1236	2/2.5-year olds/FF	2 disappeared-9 June 83	Yes/1237,1238
1239	2/yearlings	all season	No
1245	2/yearlings	1 disappeared-5 Sept 83 1 all season	No
1248	1/3.5-year old/F	disappeared-17 June 83	Yes/1249
1252	1/yearling/M	1 all season	Yes/1253
unknown	1/yearling/M	killed-26 June 83	Yes/1255
1257	1/yearling	disappeared-date undetermined	No

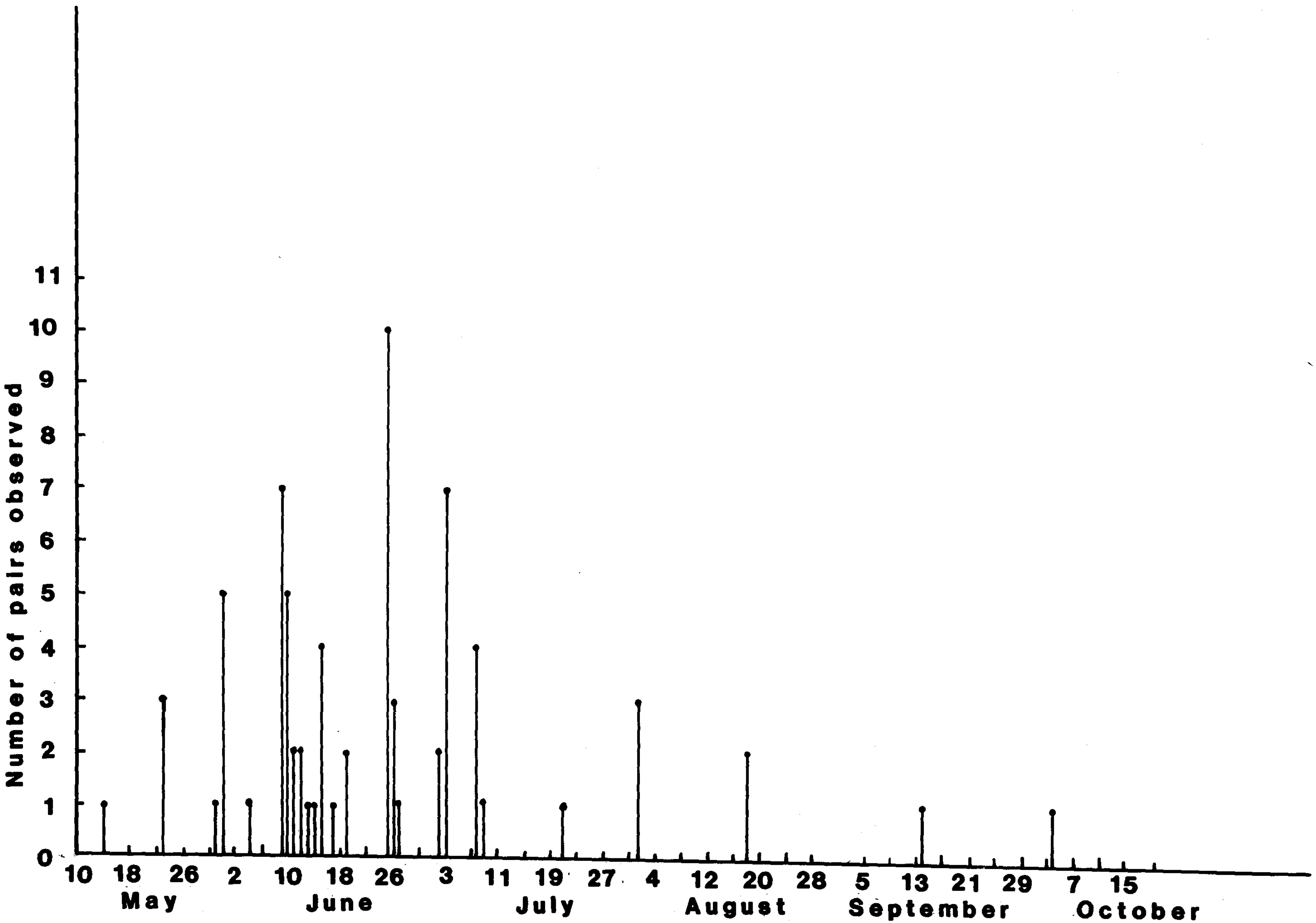

Fig. 3. Chronology for observations of brown bear pairs on the Arctic National Wildlife Refuge, 1983.

Table 4. Age at breeding for 9 radio-collared female brown bears on the ANWR study area, 1982-1983.

Bear #	Cementum age	Reproductive status - winter 1982-1983	Age at breeding
1182	16.5	2 yearlings	14.5
1185	19.5	2 3.5 year olds	15.5
1190	8.5	2 yearlings	
1193	9.5	2 cubs	8.5
1197	9.5	2 2.5-year olds	6.5
1202	17.5	3 2.5-year olds	14.5
1208	8.5	2 yearlings	6.5
1212	14.5	1 cub	13.5
1213	13.5	1-3.5-year old	9.5
1217	13.5	1 cub	12.5
1220	11.5	1-4.5-year old	6.5
1227	14.5	2-3.5-year olds	10.5
1236	8.5	2-2.5-year olds	5.5
1239	8.5	2 yearlings	6.5
1245	14.5	2 yearlings	12.5
1248	10.5	1-3.5-year old	6.5
1252	7.5	1 yearling	5.5
1257	8.5	1 yearling	6.5

occasions and other bears were observed either stalking or chasing muskox on 2 other occasions in 1983. On 5 occasions bears were observed in close proximity to muskoxen herds, but no reaction was evident. In both cases of a bear feeding on a muskox carcass, other muskox were not known to occur in the area, and the muskox were apparently lone bulls.

Caribou were in the vicintiy of bears on 98 occasions and interactions were recorded on 32 of these observations. Caribou did not react to nearby brown bear on 66 sightings of the 2 species in close proximity. Bears were observed on 11 caribou carcasses during May, June, and July and were seen on 4 carcasses in August, September and October 1983. The majority of bear sightings at caribou carcasses (10) occurred in late May and June when the Porcupine caribou herd was calving on the coastal plain of ANWR (Whitten et al. 1984). Bears were observed chasing caribou on 15 separate occasions, and 3 of these chases were successful, with 3 caribou calves being killed by bears. During capture operations between 4-16 June, 7 of 25 bears captured in the foothills and coastal plain had either dried blood or fresh blood on their muzzle. Eight field observations of brown bears either killing or feeding upon caribou calves were made between 4-16 June (P. miller pers. comm., Phillips 1984). Preliminary inspection of radio-relocations of bears in the Caribou Pass area of the Kongakut River, indicate that most radio-collared bears shifted their areas of use in June 1983 to the coastal plain between the Kongakut and the Clarence Rivers. Radio-collared bear locations were abundant in the VARM Bitty area of the Jago River during June. This area was considered a high density calving area in 1983 (Whitten et al. 1984).

Observations of brown bear feeding on caribou carcasses and killing calves during June 1983 indicate that caribou are probably an important food source during this time period for certain bears. However, this use appears to be limited to the time period caribou occupy the coastal plain and adjacent foothills of ANWR. Detailed analyses of bear movement patterns and home range use may clarify this temporal relationship.

Denning

During the fall of 1982 dens were located for 28 radio-collared bears and 10 dens of unmarked bears (Garner et al. 1983). Beginning on 24 April 1983, den sites of radio-collared bears were monitored regularly to determine approximate dates of emergence (Table 5). Ten bears were out of the den on 24 April (5 males, 5 females) when these surveys were initiated. An additional 8 bears were out of the den on 1 May (3 males, 5 females). The remaining 10 bear emerged from their dens throughout May and these bears were predominantly females with young (Table 5). Of the 18 bears emerging from dens by 1 May, 13 were single males or non-parturient females. Four females with yearlings or older also were in this early emergence group. One female (#1217) was at the den mouth on 24 April. She remained at the den site until 1 May when she was accompanied by 1 cub. On 8 May she was 2 km from the den site without the cub. Two weeks later (23 May), she was accompanied by male #1056. This female evidently emerged from the den with 1 cub, lost it in early May, and then initiated breeding activity in late May. Den emergence among radio-collared bears followed the general patterns of early emergence by males and non-parturinet females and later emergence of females with new cubs and females with young (Quimby 1974, Ruttan 1974, Harding 1976).

Table 5. Approximate dates of emergence from winter dens for 28 radio-collared brown bears in the Arctic National Wildlife Refuge, 1983.

Bear #	Age/Sex	Date 1st observed out of den	Den type	Associated bears number/age/sex/bear#
1056	21/M	24 April	Dug	None
1185	19/F	24 April	Dug	2/3.5-year olds/FM/ 1231,1232
1188	5/M	24 April	Dug	None
1195	5/M	24 April	Dug	None
1198	6/M	24 April	Dug	None
1210	4/F	24 April	Dug	None
1217	13/F	24 April	Dug	1/cub
1227	14/F	24 April	Dug	2/2.5-year olds/FF/ 1234,1235
1229	5/M	24 April	Dug	None
1230	8/F	24 April	Dug	None
1186	7/M	1 May	Dug	None
1189	6/F	1 May	Dug	None
1196	7/M	1 May	Dug	None
1206	8/F	1 May	Dug	None
1208	8/F	1 May	Dug	2/yearlings
1213	13/F	1 May	Dug	1/3.5-year old/F/1214
1216	6/F	1 May	Dug	None
1226	11/M	1 May	Dug	None
1200	14/M	7 May	Dug	None
1194	12/M	8 May	Dug	None
1190	8/F	14 May	Dug	1/yearling/M/1191 or 1192
1193	9/F	14 May	Dug	2/cubs
1202	17/F	15 May	Cave	3/2.5-year olds/MMM/ 1203, 1204, 1205
1212	14/F	15 May	Dug	1/cub
1197	9/F	22 May	Dug	2/2.5-year olds
1187	7/F	23 May	Dug	None
1182	16/F	30 May	Cave	2/yearlings/FF/1183, 1184
1225	18/M	30 May	Dug	None

Den sites of 18 radio-collared bears and 11 unmarked bears were inspected in late May and early June 1983 and physical characteristics of each den were measured. Each den site was revisited in late July 1983 and the vegetational and soil characteristics of the densite were sampled. In addition, 6 densites used during the winter of 1982-1983 were visited in late July and August and their physical characteristics were measured (Table 6). All dens were located in mountainous terrain, except 3 dens which were located in coastal plain tundra habitats (#83-11, #83-15, and #83-22). Elevation of all densites averaged 816.2 $\pm$ 61.4m (SE) with a range of 48.8 - 1341.1 m. Average den elevation is similar to that found along the Canning River (975m) by Reynolds et al. (1976). The 3 coastal plain dens had an average elevation of 139.3 m in elevation, whereas the 26 mountain dens have an average elevations of 894.3 m. Densites were equally divided between slope positions of lower 1/3 (14) and middle 1/3 (15), with no densites occurring in the upper 1/3 slope position. Of the 23 dens inspected in late May and early June, 18 were either intact or partially collapsed. Two of these dens were rock caves. In contrast, 1 dug den was intact in late July, with the remaining 25 dug dens being collapsed (Table 6). These data are similar to results reported by Reynolds et al. (1976) and Reynolds (1980).

Soil textures at densites in northern Alaska have been described generally as coarse (Reynolds et al. 1976, Reynolds 1980). Texture of soils at 29 densites (Table 6) were in the lower portions of the soil texture triangle (Brady 1974) and were predominantly silt loams (12) and sandy loams (9). Also, all densites, except the coastal plain sites (#83-11, #83-15, #83-22) had numerous rock fragments and small boulders in the tailings pile below the den opening. All densites, except #83-11, were located on well drained soils with average slopes at densites being 53.6 $\pm$ 3.8% (S.E.), range 2% to 103% (Table 6). The incidence of collapsed dens in July agrees with Pearson's (1978) and Reynolds (1980) conclusions that soil texture and moisture content are important factors in densite selection by northern brown bears.

Aspects of den sites (Table 6) were examined using circular statistics (Batshelet 1981, Zar 1984). Aspects of densites were concentrated in a southeast direction (Fig. 4). Mean aspect of 29 densites was 145° (95% C.I, 125°-165°) with an angular dispersion of 46°. Bear den aspects were not uniformly distributed in all directions (Raleigh's test, $P \ll 0.001$) and were strongly oriented in a southeast direction (mean aspect 145°; V-test, $P < 0.0005$). Reynolds et al. (1976) reported that 47 of 52 dens (90%) were located on southerly slopes along the Canning River. These data indicate that aspect of brown bear densites in the northeastern Brooks Range are strongly oriented in a southeasterly direction. Continued documentation of densites in future years should provide data to more clearly define this relationship.

During late September, October, and early November 1983, densites of 46 radio-collared brown bears and 12 unmarked brown bears were recorded during den surveys. Distribution of located dens was 1 on the coastal plain, 13 in foothills, and 44 in mountainous terrain (Fig. 5). In general, all radio-collared bears captured on coastal plain or foothills habitats denned south of their capture sites (Figs. 1 and 5). Twenty seven bears were captured in coastal plain habitats, but only 1 radio-collared bear denned in this habitat type. Chronology of denning indicated that 3 bears denned

Table 6. Physical Characteristics of 29 densites used by brown bears during the winter of 1982-1983 in the northeast portions of the Arctic National Wildlife Refuge, Alaska.

					Elevation(m)			Slope		Den status		Soil
						Valley		position				
Den#	Bear #	Date-1983	Slope (%)	Aspect(°)	Den	floor	Crest	(1/3)	Topography	May	July	texture
83-1	1217	25 May	60	164	1069.9	871.7	1176.5	mid	mountains	partially collapsed	partially collapsed	silt loam
83-2	unmarked	25 May	41	125	1100.3	810.8	1277.1	mid	mountains	intact	collapsed	sandy loam
83-3	unmarked	25 May	49	170	984.5	905.3	1709.9	low	mountains	intact	intact	loamy sand
83-4	1185	25 May	62	118	682.8	502.9	972.3	mid	mountains	partially collapsed	collapsed	sandy loam
83-5	unmarked	26 May	43	112	1018.0	743.7	1414.3	mid	mountains	intact	collapsed	silt loam
83-6	1208	30 May	45	117	920.5	786.4	1371.6	low	mountains	intact	collapsed	loamy sand
83-7	unmarked	30 May	45	117	920.5	786.4	1371.6	low	mountains	partially collapsed	collapsed	sandy loam
83-8	unmarked	30 May	58	280	981.5	853.4	1133.9	mid	mountains	partially collapsed	collapsed	sandy loam
83-9	1210	30 May	71	158	1225.3	1079.0	2304.3	low	mountains	intact	partially collapsed	silt
83-10	1202	31 May	99	86	746.8	634.0	1158.2	low	mountains	cave	cave	silt loam
83-11	1213	31 May	2	153	189.0	140.2	265.2	mid	tundra	collapsed	collapsed	silt loam
83-12	1056	31 May	59	120	1054.6	944.9	1426.5	low	mountains	collapsed	collapsed	sandy loam
83-13	1212	31 May	73	121	1307.6	1237.5	1475.2	low	mountains	intact	collapsed	silt loam
83-14	1182	31 May	103	171	1341.1	1194.8	1426.5	mid	mountains	cave	cave	loamy sand
83-15	1225	1 June	40	220	180.0	137.2	516.3	low	tundra hills	intact	collapsed	silt loam
83-16	1230	1 June	56	279	661.4	378.0	914.4	mid	mountains	collapsed	collapsed	silt loam
83-17	1226	1 June	54	116	420.6	396.2	944.9	low	mountains	collapsed	collapsed	sand
83-18	1188	1 June	50	152	570.0	310.9	798.6	mid	mountains	intact	collapsed	silt loam
83-19	1194	1 June	31	41	365.8	189.0	664.5	mid	mountains	intact	collapsed	silt loam
83-20	1189	1 June	49	88	640.1	512.1	1005.8	low	mountains	intact	collapsed	silt loam
83-21	1227	1 June	59	222	798.6	682.8	1066.8	low	mountains	partially collapsed	collapsed	loamy sand
83-22	1197	2 June	23	165	48.8	42.7	64.0	low	tundra hills	intact	collapsed	sandy loam
83-23	1229	2 June	72	182	658.4	469.4	1423.4	low	mountains	collapsed	collapsed	silt loam
83-24	unmarked	21 July	55	188	926.6	871.7	1176.5	low	mountains	collapsed	collapsed	silt loam
83-25	unmarked	21 August	78	72	902.2	795.5	1002.8	mid	mountains	-	cave	sandy loam
83-26	unmarked	21 August	40	160	960.1	393.2	1376.2	mid	mountains	-	collapsed	loamy sand
83-27	unmarked	21 August	44	138	955.5	393.2	1376.2	mid	mountains	-	collapsed	loam
83-2[illegible]	unmarked	23 August	39	151	1080.5	995.2	1222.2	mid	mountains	-	collapsed	sandy loam
83-[illegible]	unmarked	23 August	56	176	958.6	795.5	1100.3	mid	mountains	-	collapsed	silt loam

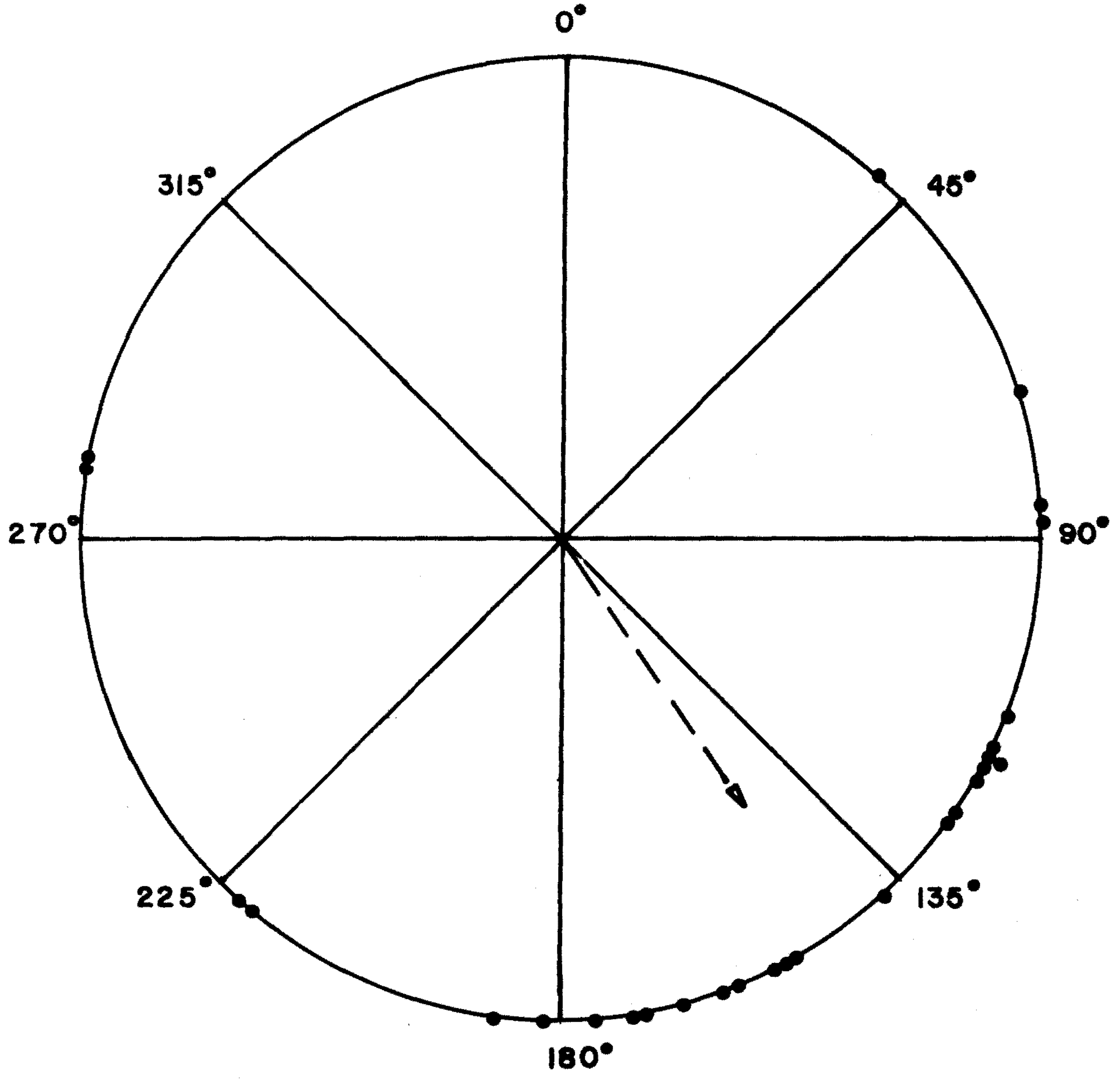

Fig. 4. Aspects and mean aspect (dotted arrow) of 29 bear dens used during winter 1982-1983 on the Arctic National Wildlife Refuge.

during the first half of October, while 52 bears denned during the last half of October and early November (Table 7). Three bears denned in early November. Elevations and aspects of the 58 fall densites were estimated from 1:633360 scale topographic maps (Table 7). Average estimated elevation was 894 $\pm$ 42 m (SE) and is comparable to average elevations of 28 densites in summer 1983. Estimated aspects for the 58 fall densites are depicted in Fig. 6. In general, estimated aspects of these 58 dens show a wider disperison than the 28 densites visited during summer 1983 (Fig. 4 and Fig. 6). However, the southeast and the southwest quandrats contained a majority of the estimated aspects of densites (25 southeast and 14 southwest, respectively). These densites will be inspected in early summer 1984 and actual aspects and elevations will be determined at that time.

Population Characteristics

Conclusions based on the data presented here should be viewed as preliminary and contingent upon further observations. Because arctic brown bears are generally solitary, wide-ranging, and have low population densities, accurate population estimates and density calculations require intensive capture programs coupled with detailed movements and home range use data collected over a 3 or 4 year period. Similarly, parameters describing population dynamics and productivity, especially litter size, reproductive interval, and survival of young must be recorded for more than 3 years in order to be accurate (Reynolds 1980, Reynolds and Hechtel 1983).

Population Size. Eighty bears were captured in the area of intensive study; an additional 17 unmarked but identifiable bears were observed. These unmarked bears included 9 offspring of marked females, 1 adult male, 1 female with 3 yearlings, and 1 female with 2 2-year-olds. Since 10 mortalities were observed in 1982-83, the minimum number of bears in the study area in 1983 was 87 bears. If 80% is used as a reasonable approximation of the proportion of bears which were captured in the 8300 km^2 area, the calculated population would be 108 bears or a density of 1 bear/80 km^2. Again, this figure is preliminary and subject to the following biases: 1) the proportion of bears marked in the area may be inaccurate, 2) the proportion of bears which are resident in the area year-round has not been established; and 3) the degree to which population size is influenced by movement of bears from the south and east is not known. Additional research and data analysis from the 1984 field season, should help to reduce the effects of these biases and increase the accuracy of population estimates.

Reproductive Biology. Reproductive rates for brown bears are dependent upon the following measures of reproductive biology: age at first production of young, length of the productive life for females, average litter size, and length of the reproductive cycle or reproductive interval, (Craighead et al. 1974, Bunnell and Tait 1980, 1981). Arctic brown bears have low reproductive rates (Reynolds, 1980, In press). Because the proportion of females with offspring in arctic populations is low and reproductive cycles may be 6 years or longer (Reynolds In press, Reynolds and Hechtel 1983), accurate measures of reproductive rates require long-term observations. Calculations presented here require extrapolation and should be viewed as preliminary.

Based on data from 11 females (Table 8), the average minimum age at which females are first observed with young is 7.4 years and range from 6.5 years

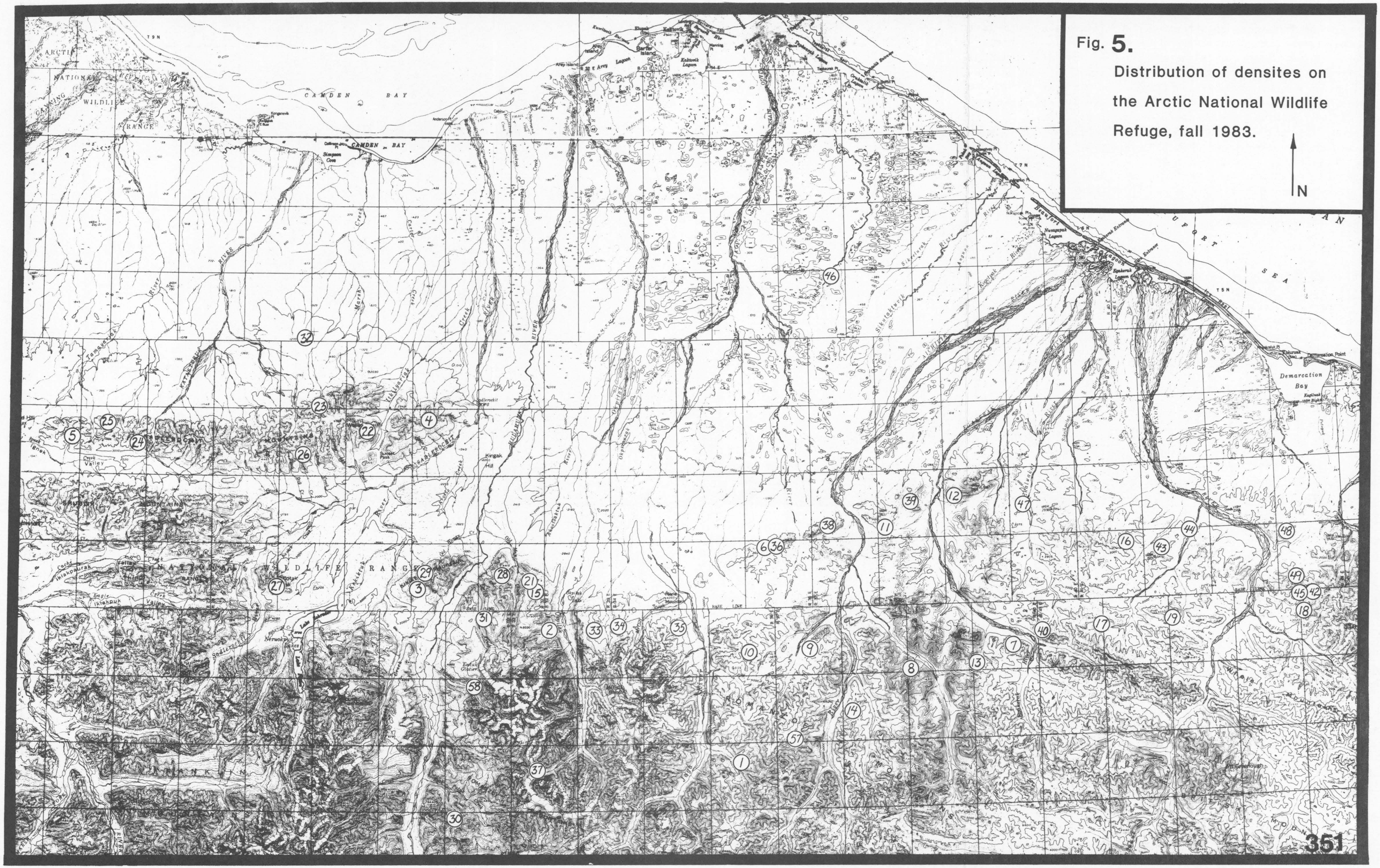

Fig. 5. Distribution of densites on the Arctic National Wildlife Refuge, fall 1983.

Table 7. Fall denning characteristics of 58 brown bears in the northeastern portion of the Arctic National Wildlife Refuge, 1983.

Bear #	Reproductive status	Terrain	Date observed denned	Estimated aspect(°)	Estimated elevation(m)
1056	male	mountainous	20 Oct	118	1250
1182	potential breeder	mountainous	21 Oct	152	1219
1185	2 2.5-year olds	foothills	14 Oct	114	762
1188	male	foothills	26 Oct	162	732
1189	potential breeder	mountainous	26 Oct	300	549
1190	potential breeder	mountainous	26 Oct	260	732
1194	male	mountainous	26 Oct	90	732
1196	male	mountainous	24 Oct	74	1067
1197	potential breeder	foothills	24 Oct	35	579
1198	male	mountainous	6 Nov	193	1311
1200	male	mountainous	undetermined	171	808
1202	3 2.5-year olds	mountainous	15 Oct	99	960
1206	potential breeder	mountainous	26 Sep	34	1356
1208	potential breeder	mountainous	6 Nov	119	945
1210	immature female	mountainous	24 Oct	192	1585
1212	1 cub	mountainous	13 Oct	166	1097
1213	1 2.5-year old	foothills	20 Oct	335	381
1216	young female	mountainous	6 Nov	240	1158
1217	potential breeder	foothills	14 Oct	274	610
1220	potential breeder	mountainous	13 Oct	238	1250
1223	male	foothills	24 Oct	89	488
1225	male	foothills	21 Oct	139	610
1226	male	foothills	25 Oct	118	427
1229	male	mountainous	24 Oct	289	1524
1230	potential breeder	foothills	15 Oct	148	762
1233	male	mountainous	14 Oct	169	853
1234	immature female	mountainous	24 Oct	144	792
1235	immature female	mountainous	15 Oct	230	732
1236	potential breeder	mountainous	15 Oct	53	1006
1239	2-yearlings	mountainous	14 Oct	57	1341
1240	male	mountainous	2 Oct	190	777
1241	male	mountainous	15 Oct	157	1356
1243	potential breeder	mountainous	14 Oct	106	914
1244	potential breeder	mountainous	20 Oct	77	1219
1245	1-yearling	mountainous	15 Oct	115	1280
1246	male	mountainous	15 Oct	191	945
1247	potential breeder	mountainous	15 Oct	51	762
1248	potential breeder	foothills	25 Oct	239	488
1250	male	foothills	26 Oct	70	610
1251	male	mountainous	26 Oct	236	762
1252	1-yearling	mountainous	15 Oct	172	884
1257	young female	mountainous	21 Oct	98	1585
1259	potential breeder	mountainous	15 Oct	92	792
1260	young female	foothills	14 Oct	148	442
unmarked	unknown	mountainous	14 Oct	95	823
unmarked	unknown	mountainous	14 Oct	237	853
unmarked	unknown	mountainous	14 Oct	85	1250
unmarked	unknown	mountainous	15 Oct	168	945
unmarked	unknown	mountainous	15 Oct	42	884
unmarked	unknown	mountainous	15 Oct	115	1097
unmarked	unknown	mountainous	21 Oct	326	1372
unmarked	unknown	mountainous	25 Oct	178	640
unmarked	unknown	coastal plain	25 Oct	301	98
unmarked	unknown	foothills	26 Oct	150	553
unmarked	unknown	mountainous	26 Oct	195	549
unmarked	unknown	mountainous	26 Oct	88	945
unmarked	unknown	mountainous	26 Oct	270	732
unmarked	unknown	mountainous	20 Oct	267	975

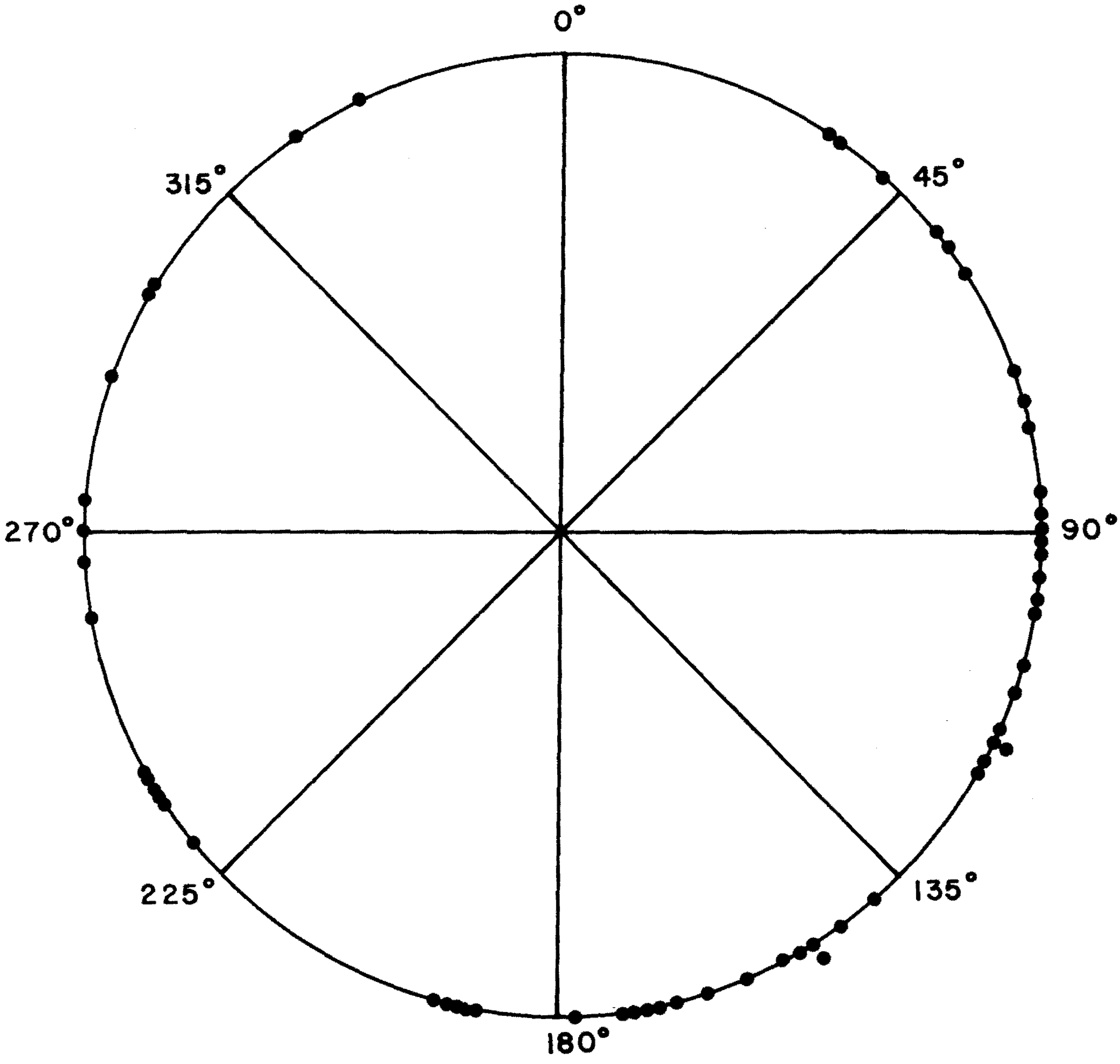

Fig. 6. Estimated aspects of 58 brown bear den sites located on the Arctic National Wildlife Refuge in October and November 1983.

Table 8. Reproductive history and litter size for female brown bears in the Arctic National Wildlife Range, 1982-83.

Bear #	Age[b] 1983	# offspring	Offspring prior to capture	Reproductive history/litter size 1981	1982	1983	Comments
1182	16.5	1283F,1284F	yes	B	2 cub	2 ylg/B	Mort 2ylg 83
1185	19.5	1231F,1232M	yes	2 cub	2 ylg	2 2yr/B	w/2 yr after B?
1187	7.5		no		B?	B	
1189	6.5				B?	B	
1190	8.5	1191M,1192M	yes	B	2 cub	1 ylg/B	Mort 1 ylg 83
1193	9.5		yes		B	2 cub	
1197	9.5	2 UM	yes	2 cub	2 ylg	2 2-yr/B	
1201	5.5e		no		B		Capture mortality
1202	17.5	1203M,1204M, 1205M	yes	3 cub	3 ylg	3 2-yr	
1206	8.5		yes		B	B	
1208	8.5		yes	B	2 cub	2 ylg/B	w/ylg after B 1 ylg mort
1210	4.5		no		NB	B	
1212	14.5		yes		B	1 cub	
1213	13.5	1214F	yes	1 ylg	1 2-yr	1 3y/B	w/3yr. after breed
1216	6.5		no		B?	B	
1217	12.5		yes		B	1 cub/B	
1220	11.5	1221M	yes	1 2 yr	1 3-yr	1 4 yr/B	
1227	14.5	1234F,1235F	yes	2 cub	2 ylg	2 2yr/B	
1230	8.5		yes		B	B	
1236	8.5	1237F,1238F	yes	2 cub	2 ylg	2 2yr/B	Capture-related weaning
1239	8.5	2UM ylg	yes	B	2 cub	2 ylg	
1242	5.5		no			B	
1243	11.5		yes			B	
1245	14.5	2 UM ylg	yes	B	2 cub	2 ylg	1 ylg mort 83
1247	18.5		yes			B	
1248	10.5	1249F	yes	1 cub	1 2 yr	1 3 yr/B	
1249	3.5		no				
1252	7.5	1253M	yes	B	1 cub	1 ylg	
1254	12.5						
1257	8.5	1 UM ylg	yes	B	1 cub	1 ylg	Capture, 1 ylg mort
1258	9.5		yes				
1259	23.5		yes			B	
1260	10.5					B	
UM Hulahula			yes		3 cub	3 ylg	
UM Kongakut			yes	2 cub	2 ylg	2 2-yr	

[a]Designations are as follows: UM-unmarked; UN=unobserved; B=bred during that season; NB-did not breed; cub, yrlg, 2 yr, 3 yr=female accompanied by cub, yearling, 2 year old, or 3 year old young; cut/B=cubs lost prior to breeding season, subsequent breeding by female; yrlg/B, 2 yr/B, etc. =offspring weaned, then subsequent breeding by female.
[b]These ages were determined from cementum annuli during the year of capture, but the ages reported here include years subsequent to the bear's capture. However, in cases of bears known or presumed dead, the data listed represent their ages when last known to be alive.
[c]Litter sizes should be viewed as minimum since mortality to other offspring may have occured prior to observation.

to 8.5 years. This calculation is based on 2 females which had their first litter of cubs at 6.5 years and 6 which had their first litter at 7.5 years; for 1 female the earliest age was 8.5 years. However, since this sample size is low and is a minimum figure, subsequent data may show a higher average age, probably between 7.5 and 8.0 years. In calculating these ages, it is assumed that bears did not have young before age 5.5 because no females were observed breeding: 2 of 6 were observed with males at age 4.5 years and at least 5 of 8 bred at age 5.5 years (Table 8).

The actual ages at which females had litters in many cases were extrapolated from observations of bears with older offspring. For example, bear #1236 was captured with 2-year-old young as an 8.5-year-old; therefore, she was 6.5 years old when her young were cubs of-the-year. This was presumed to have been her first litter, since no younger females were observed with cubs. Based on the observation of a 23.5 year old female breeding during 1983, the potential length of productive life for females in the ANWR is at least 16 years (23.5 years-age at first production or 7.4 years = 16.1 year). In the western Brooks Range, 7 old age females were observed with litters: 3 had offspring at age 18.5, 2 at age 19.5, and 1 at age 22.5 (Reynolds and Hechtel 1983). Litter sizes ranged from 1 to 3 cubs.

A mean litter size of 1.87 was calculated for the cubs and yearlings. These 2 age groups were combined to increase sample size and because the average litter size for cubs (10 wks/6 litters = 1.7) was smaller than the average for yearlings (18 yearlings/9 litters = 2.0). The reason for this discrepancy between the age classes in unclear, but is probably due to the small sample size in the cub age class. Only minimum values for the reproductive interval or the period between production of successive litters can be calculated at this time. Four of the females observed will have a minimum reproductive interval of 3 years, 2 bears will have a reproductive interval of 4 years and 1 bear will have a reproductive interval of 5 years for an average minimum reproductive interval of 3.6 years. This figure is very likely low since it is based on minimums and does not take into account the possibility of breeding which does not result in the production of young, a common occurrence for brown bears in the Brooks Range (Reynolds 1980, Reynolds and Hechtel 1983).

Because of the cummulative biases in reproductive parameters and the need for additional data, calculation of reproductive rate should be used only as a rough indicator of productivity on the coastal plain of the ANWR. Theoretically, the 16 year potential reproductive life of females on ANWR, females would produce an average of 1.9 offspring every 3.6 years for a total of 8.44 young during her life or an average of 0.5 young/year. This compares with 0.48 young/year for bears in the western Brooks Range during 1977-82 and 0.42 young/year for bears near the Canning River during 1973-75 (Reynolds In press). Like the western Brooks Range population, bears on the ANWR study area have access to caribou and like the western Brooks Range population, probably owe their relatively high productivity to the availability of caribou as a source of food.

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CALVING DISTRIBUTION, INITIAL PRODUCTIVITY AND NEONATAL MORTALITY OF THE PORCUPINE CARIBOU HERD, 1983

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Key Words: Caribou, Porcupine herd, calving distribution, productivity, neonatal mortality, predation, post-calving movements, Arctic-Beaufort, north slope

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Calving distribution, initial productivity and neonatal mortality of the Porcupine caribou herd, 1983.

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Abstract: A 3 year study by the Alaska Dept. of Fish and Game and the U.S. Fish and Wildlife Service of the Porcupine caribou herd's calving distribution, initial productivity and neonatal mortality was initiated in 1983. Frequent relocation surveys of 23 radio-collared adult female caribou (*Rangifer tarandus*), aerial reconnaisance surveys, and transects during late spring migration and throughout the calving season identified calving distributions on the coastal plain and foothills extending from the Sadlerochit River in Alaska to the Firth River in Canada. A major calving concentration occurred in the lower foothills and adjacent coastal plain along the Jago River. Another concentration of calving occurred on the coastal plain and foothills between the Kongakut River and Komakuk Beach. In 1983 the calving distribution of the Porcupine caribou herd was similar to that observed in 1976, 1978 and 1979, and was 8 of 11 years in which concentrations of caribou calved in the Jago River foothills area. The peak of calving occurred on 4 June and there was no discernable variation in calving chronology from west to east. Eighteen of 23 (78%) radio-collared females produced calves. Initial productivity based on aerial composition transects over calving concentrations was measured at 74 calves/100 cows. During 4-8 June 69 calves were captured at coastal plain and foothills sites in the Jago concentration area, and fitted with mortality sensing radio-transmitters. Radio frequencies of these calves were monitored at least daily and visual checks were made every 48 h during 4 June - 2 July. Monitoring was less intense during the remainder of July and continued on a monthly basis through 1983. Eighteen productive radio-collared adult females were monitored as a control group on 1-3 day intervals during 29 May - 2 July. During 4 June - 3 August, 17 study calves died. Six calves died as a result of study-induced abandonment. The mortality rate of remaining calves was 17.5%. Categories of natural mortality included: predator kills (45.5%); probable natural abandonment (27.3%); and undetermined-predation/scavenging excluded (9.1%) and predation/scavenging involved-predator/scavenger undetermined (18.2%). During 29 May to 2 July, 5 (27.8%) of the control calves died. Differences in geographic distribution of study and control groups may have contributed to the higher mortality of control calves. Golden eagles (*Aquila chrysaetos*) killed 3 study calves and were observed feeding on unmarked calves on several occasions. Brown bears (*Ursus arctos*) probably killed 2 study calves and were observed killing and/or feeding on unmarked calves on 11 occasions. Natural mortality was greatest among study calves captured on coastal plain areas (21.9%) than foothills groups (12.9%). A majority of mortalities (60%) occurred in foothills areas, however, as most of the study calves captured on the coastal plain moved into the foothills. The relative low initial mortality rate of study calves during 4 June - 2 July agreed with comparative herd composition data between peak of calving and early July which also indicated a high survival of calves. During 7-30 June 1982 a natural mortality rate of 45% was measured in radio-collared calves captured on the coastal plain south of Herschel Island. Factors associated with spring migration and geographical distribution of calving may have influenced calf mortality rates in 1983 and 1982. An additional 4 mortalities of undetermined causes were confirmed in the study group from 1 August to 10 December 1983.

Calving distribution, initial productivity and neonatal mortality of the Porcupine Caribou Herd, 1983.

Much of the coastal plain portion of the Arctic National Wildlife Refuge (ANWR) was opened to a limited oil and gas exploration program by the Alaska National Interest Lands Conservation Act (ANILCA) of 1980. If significant potential for petroleum resources are indicated, Congress may pass additional legislation to open ANWR to further exploration, leasing and development. Caribou from both the Porcupine and Central Arctic herds utilize portions of the coastal plain of the ANWR for calving, post-calving aggregations, and insect relief activities during the spring and summer (USFWS 1982). Parturient female caribou and post-parturient females with young calves are sensitive to disturbance associated with human activity (de Vos 1960, Lent 1964, Bergerud 1974, Cameron et al. 1979, Davis and Valkenburg 1979). Studies conducted annually since 1974 have shown that female caribou with young calves avoid the Prudhoe Bay oil field and adjacent Trans-Alaska Pipeline corridor (Cameron and Whitten 1976, 1980). It has been suggested that displacement of parturient female caribou and females with young from traditional areas may cause increased calf mortality which could ultimately contribute to population decline (Bergerud 1976, Calef and Lent 1976, Klein 1980).

Mortality factors and rates associated with potential displacement habitats need to be assessed to make predictions regarding calf survival and herd productivity if traditional calving habitats are further explored and developed for petroleum production. Consequences of displacement from traditional insect relief areas and preferred forage areas, and the overall impacts of human/industrial disturbances also need to be evaluated. This study focuses on determining annual calving distribution, initial productivity, and neonatal caribou calf mortality on the calving grounds and post-calving areas of the Porcupine caribou herd.

A review of current literature indicates that no significant climate-related mortality of new-born calves has been reported for the study area (USFWS 1982.) Previously reported densities of wolves (<u>Canis lupus</u>) and brown bear have been relatively low, compared to calving areas of other caribou herds in northern Canada and Alaska. Little data exists regarding current predator densities, movements, and distribution in the study area (USFWS 1982). Approximately 200 immature golden eagles have been reported in the study area during the calving season (Roseneau per. comm.). Some observations of predation on caribou calves by brown bears and golden eagles in the study area have been reported (Calef and Lortie 1973, Roseneau and Curatolo 1976). Information is not available on the incidence of still births or the occurance of diseases such as brucellosis and pneumonia among caribou in the study area.

Based on cow:calf ratios, Calef and Lortie (1973) reported a calf mortality rate of 17% for the Porcupine Herd between mid-June and late July. Similar calf mortality rates have been reported for other large herds during this period (Bergerud 1980). Using aerial survey techniques, Miller and Broughton (1974) were able to identify categories of calf mortality factors for the Kaminuriak Herd in northern Canada.

The most common technique used to evaluate caribou calf mortality is aerial survey to measure the chronology and over-all magnitude of caribou calf mortality on an annual basis (Kelsall 1968, Davis et. al. 1980). The gregarious nature of parturient and post-parturient females and the relatively high level of calving synchrony exhibited by migratory caribou, contribute to the utility of aerial survey methods (Bergerud 1974, Dauphine and McClure 1974). The achievement of accurate calf mortality estimates, however, is often complicated by difficulties in identification of age and sex classess from the air and by frequent mixing of barren females and non-productive yearlings with productive females (Miller and Broughton 1974). Another problem is that comparative cow-calf ratios developed from aerial survey data do not provide information on causes of mortality or the spatial and temporal distribution of that mortality.

Intensive searches for calf carcasses using helicopters for low-level flight over calving and post-calving areas have provided data on causes and spatial distribution of neonatal caribou calf mortality (Miller and Broughton 1974, Miller et al. 1983). However, this technique only provides data on mortalities that are found and does not provide an inference base for overall calf mortality within a given year. Recently, techniques using expandable neck collars with attached mortality sensing radio-transmitters have produced improved data on neonatal mortality rates and factors for several species of ungulates (Cook et al. 1967, 1971, Logan 1972, Beale and Smith 1973, Garner et al. 1976, Schlegel 1976, Franzmann and Peterson 1978, Franzmann et al. 1980, Ballard et al. 1981, Bjarvall and Franzen 1981).

The feasibility of using mortality sensing radiotransmitters with expandable neck collars on neonatal caribou calves of the Porcupine Caribou Herd was tested during 1982 (Mauer et al. 1983). Test results indicated that the technique was feasible, and movements of individual neonates could be followed to detect and locate mortalities in a timely manner which enables collection of information relative to cause of death. The test also confirmed that the technique provided means to obtain detailed data on the chronology and geographic location of mortalities and that potential exists for inferences on over-all mortality rates of calves in the population. The feasibility study identified logistical requirements and strategies necessary to successfully collect caribou calf mortality data using radio telemetry techniques.

ANILCA requires the evaluation of potential adverse effects that oil and gas exploration, production, and development on ANWR might have upon the Porcupine caribou herd. In addition, if petroleum development on ANWR is allowed, more information on caribou distribution and habitat use during the calving and post-calving periods is needed to formulate recommendations for leasing schedules, placement of facilities, and other mitigative measures. In particular, causes and patterns of calf mortality need to be examined with emphasis on differences among areas or habitat types, in order to assess the possible effects of displacement from development sites.

Based upon the results of the feasibility study, a 3 year investigation of caribou calving distribution, initial productivity, and neonatal calf mortality was initiated in 1983 as a joint project between the Arctic National Wildlife Refuge, U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game.

Objectives for this study are as follows:

A. Primary

1. Delineate distribution of the Porcupine caribou herd calving as part of a continuing effort to collect baseline information on wildlife resources in the portion of ANWR open to petroleum exploration; identify any annual consistencies in calving distribution and/or common characteristics among separate calving areas.

2. Determine initial calf production and extent, causes, and chronology of mortality among neonatal calves (i.e., 4-6 weeks postpartum).

3. Measure variation in calf mortality and calf mortality factors between core and peripheral areas and/or between different habitat types or localities.

B. Secondary

1. Provide productivity data for analysis of herd status.

2. Identify characteristics (i.e., habitat, snow ablation patterns, topography, etc.) of core and peripheral calving areas and/or calving areas in different habitat types or localities.

3. Provide additional collared caribou for concurrent studies of overwinter calf survival and seasonal movements.

4. Provide incidental observations of other species as part of the overall ANWR baseline studies, including casual or incidental locations of radio-collared muskoxen and bears.

This study is being conducted concurrently with studies of the status (population size, and trend), overwinter calf mortality, and winter distribution of the Porcupine Caribou Herd. Adult caribou collared in conjunction with those studies aid in the conduct of this investigation. Collectively this study is a part of a comprehensive environmental inventory and assessment of the potential petroleum developement area of ANWR. This report presents preliminary findings of the 1983 field season.

Methods and Materials

Study Area

The study area consists of the north slope of ANWR and may extend east to the Blow River in Canada and south to the southern slopes of the Brooks Range, depending on annual variations in caribou distributions. In 1983, the study area extended from the Kaktakturuk River on the west to the Firth River in Canada on the east, and from the continental divide in the Brooks Range on the south to the Beaufort Sea coast on the north.

Most study activities occurred on the coastal plain and foothills portions of the area described above. Descriptions of the physical environment, climate, geology, vegetation, and other wildlife resources of the study area are found in U.S Fish and Wildlife Service (1982). Logistical operations were based at Kaktovik, Alaska.

Age Determination

The new hoof measurement described by Haugen and Speake (1958) for aging neonatal white-tailed deer (Odocoideus virginianus) fawns was investigated for use in aging neonatal caribou calves. In late April, 3 known age reindeer calves of a captive reindeer herd at the University of Alaska-Fairbanks campus were repeatedly measured for new hoof length. Each distal hoof on both forelegs was scribed to standardize the measurements and calves were measured daily from 21 April-17 May. In late May, 6 caribou calves were captured from the Delta caribou herd and transported to the University of Alaska-Fairbanks by Alaska Department of Fish and Game personnel. Each calf was examined and an estimated age was determined using criteria described by Miller (1972). Each caribou calf had the distal hoof of both forelegs scribed as above and University personnel measured new hoof length intermittently until late June. Regression analysis was used to determine the relationship between new hoof length and age in reindeer and caribou calves.

Calving Distribution and Initial Productivity

General calving distribution was determined primarily by locating all radio-collared adult female caribou in the Porcupine Herd during late May and early June. All radio-tracking was conducted from aircraft equipped with standard tracking equipment (Telonics, Mesa, AZ.). Radio-tracking flights during calving distribution surveys were usually at altitudes greater than 1,000 m AGL. Low altitude (20-100 m AGL) aerial searches were also conducted to identify calving caribou.

Low-level transects were flown in fixed-wing aircraft over the areas where collared cows were located. Strong, easterly winds blew almost every day during calving period, and groundspeed consequently varied greatly between east and westbound flight lines. In areas of low caribou density, essentially all caribou within approximately 300 m of the flight line were counted and classified. In high density areas, and especially on downwind transects, only partial counts of caribou could be obtained, and only newborn calves and adults were classified.

Transects were also flown by helicopter to determine age/sex composition of caribou in an area of particularily high density. During these helicopter transects, all caribou within approximately 400 m of each flight line were counted and classified. In addition to determining caribou distribution and density, these surveys also provided data on initial productivity on the calving grounds. Observations of antler shedding (Lent 1965, Epsmark 1971), udder distention (Bergerud 1964), and calves at heel of radio-collared cows and unmarked cows in certain areas provided information on the progression of calving.

High altitude radio-tracking flights over the northern part of the winter range, and over the mountains and coastal plain east of the calving areas were conducted to determine the distribution of bulls and yearlings during calving. These surveys were coordinated and data were exchanged with

Canadian Wildlife Service personnel who were concurrently monitoring the distribution and movement patterns of bull caribou during spring migration.

Neonatal Mortality

Caribou calves were captured from a high density area of calving females located in the lower foothills and adjacent coastal plain along the Jago River in the Arctic National Wildlife Refuge (Fig. 1). Two calf capture sites were selected in the lower foothills portion of the high density area near VABM Bitty, 1 on the east side of the Jago River (foothills-east) and 1 on the west side (foothills-west). Two capture sites were also selected on the coastal plain portion of the high density calving area (coastal plain-north and coastal plain-south). These sites were located between the Jago and Okpilak Rivers approximately 20 km south of Barter Island.

Caribou groups were approached by helicopter (Hughes 500 D) with a capture crew of 3 persons aboard. The helicopter landed approximatedly 200 m from the caribou and 1 person took a sitting position on the left skid. The helicopter then proceeded towards the group and a calf was selected for capture. Selection from groups was standardized (calf on extreme right) to minimize sampling bias for slower, younger, and/or weaker calves.

The selected calf was pursued by flying approximately 1 m above the ground. When the helicopter was within 2-3 m of the running calf, the person on the skid stepped off to the side, ran, and grasped the calf. Sterile surgical gloves were worn by personnel handling captured calves and were discarded after each handling. When a calf was captured, the helicopter landed and the remaining members of the capture crew assisted in processing the calf.

Captured calves were sexed (Bergerud 1961), weighed, and measured for total body length, right hind foot length, and new hoof length (Haugen and Speake 1958). Characteristics of the umbilicus (moist, dry, absent), and hooves (degree of wear), were noted as described by Miller and Broughton (1974). Each calf was examined for abnormalities and fecal samples were collected from those calves with scours.

An expandable white elastic collar supporting a mortality sensing transmitter (Telonics Inc., Mesa, Az.), weighing approximately 114 g was installed around the neck of each calf. Mortality mode for transmitter units was a doubling of normal pulse rate following a 1 hour motion free period. Estimated battery life was 15 months. Each collar was constructed from 3.75 cm wide elastic band. Adjustment of the initial collar size at installation was achieved by fastening the left and right ends of the elastic collar band together with aluminum "pop" rivets. Three separate expansion folds per collar were sewn with incremental amounts of cotton thread stitching. Each expansion fold provided an additional 7 cm of collar circumference. Maximum expansion circumference of each collar was 53 cm. Collars were constructed to breakaway after the last expansion fold was used.

Helicopter-supported ground observers were used to observe reunion of cow-calf pairs following release of calves captured in portions of the foothills areas. The helicopter capture crew noted cow/calf reunions on the coastal plain area and frequent aerial relocations using fixed-wing aircraft were used to monitor reunions during the capture operation.

Aircraft (PA-18) equipped with standard radio tracking equipment were used to monitor instrumented calves, locate mortalities, determine calf locations, and movements. In those cases in which the capture crew did not observe an immediate reunion of the calf with its dam, aerial relocation and visual checks were made at 1-3 hour time intervals following release. All calf radio frequencies were monitored for mortality signals at least once daily and visual locations or locations to caribou group were made for each calf every other day from 4 June to 2 July 1983. Relocation surveys were conducted on a monthly basis from July through November 1983. All visual and group locations were plotted on a 1:250,000 scale topographic map.

All mortalities were investigated as soon as possible using a helicopter for access. Each carcass and mortality site was examined for information on the cause of death. Photographs were taken to document mortality sites. Evidence of predators/scavengers at the carcass site were noted and collected. Each carcass was placed in a plastic garbage bag, labeled, and frozen for later study. Laboratory necropsies were performed on carcasses when sufficient remains were present. In cases where only hair and bones remained, measurements of weight, right hind foot length, and new hoof length were recorded whenever possible. The location of retrieved carcasses was plotted on 1:250,000 scale topographic maps. Criteria for determining the category (Cook et al. 1971) and the cause of each mortality (Table 1) were developed from descriptions of predator kills and feeding characteristics in the literature (Murie 1948, Thompson 1949, Johnson 1951, Borg 1961, Atwell 1954, Mech 1970, Wiley and Bolen 1971, Alford and Bolen 1972, Cole 1972, White 1973, Miller and Broughton 1974, Bolen 1975, Henne 1975, Miller 1975, Mysterud 1975, Buskirk and Gipson 1978).

Carcasses of unmarked calves encountered during this and other field studies were also examined as opportunity allowed. The locations of predators observed on the calving grounds were noted and observations of interactions between caribou and predators were recorded. Concurrent field studies of brown bear ecology on the coastal plain of ANWR also provided additional information relative to this study (Phillips 1984, Garner et al. 1984).

The mortality rate of calves from the 23 radio-collared control cows were compared to the mortality rate of the study calves. The control females were radio-tracked in late May and early June 1983 as they arrived on the calving grounds and their locations were plotted on 1:250,000 scale topographic maps. Parturition status was determined by low-level aerial observations of the presence/absence of young, antler shedding (Lent 1965, Epsmark 1971), and udder distention (Bergerud 1964). Following parturition, productive members of the control group were monitored on a 24-72 hr basis until approximately 2 July.

Results and Discussion

Age Determination

New hoof length measurements (NHL) on 3 reindeer calves were linearly related to age in days (Fig. 2) and the correlation coefficient was statistically significant ($p < 0.01$, $n = 112$). The relationship between new hoof length and age in days for 6 caribou calves (to 18 days estimated age) was also significant ($p < 0.01$, $n = 32$), however there was more

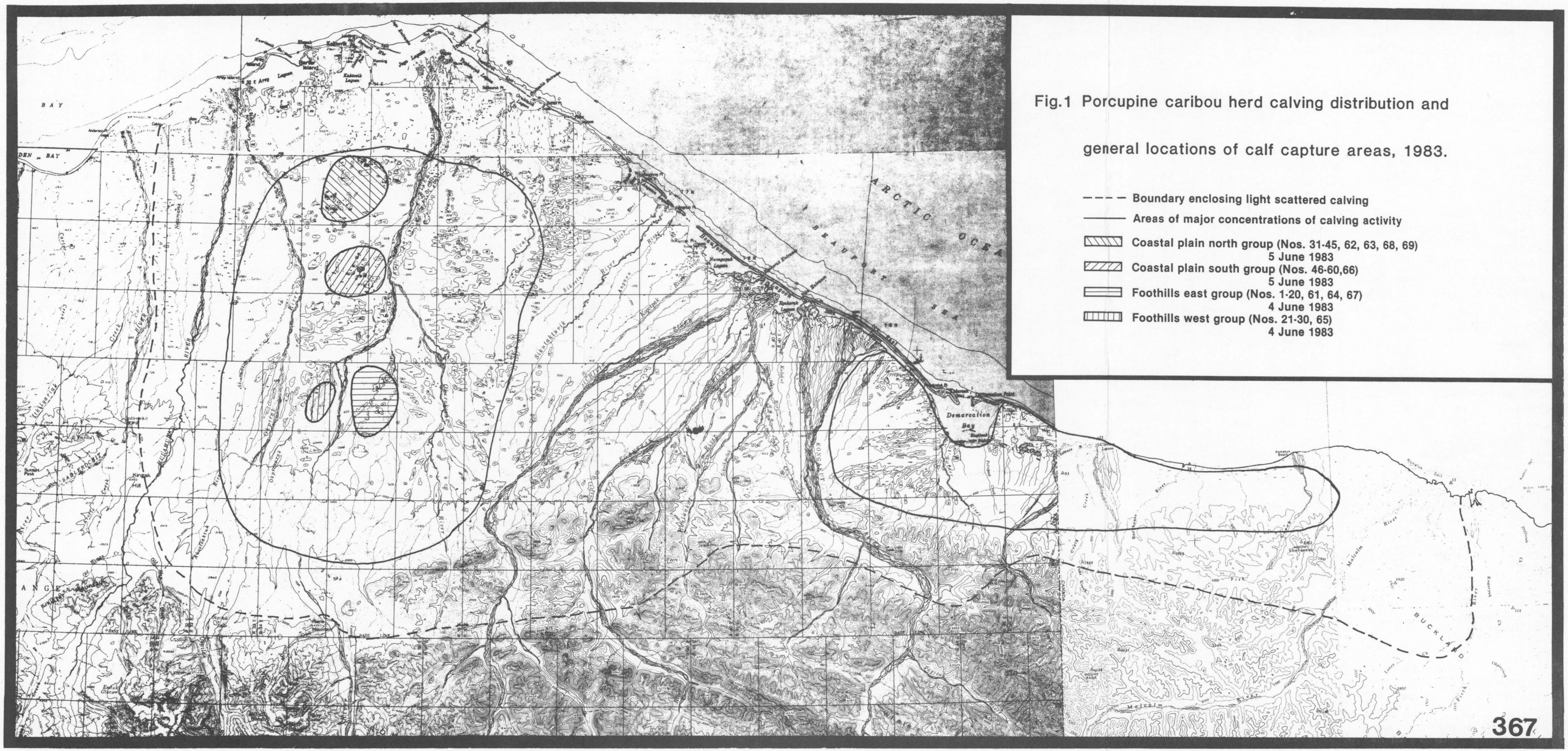

Fig.1 Porcupine caribou herd calving distribution and general locations of calf capture areas, 1983.

Table 1. Criteria for determining category of observed mortalities of neonatal caribou calves.

Criterion	Category
I. Carcass lacks sign of being bitten, chewed, or disturbed by predators.	I. Predation-excluded
1. Milk curds absent in abomasum and intestinal tract. Lack of mesentery and subcutaneous fat. Rumen may be packed with vegetation.	1. Starvation
a. No reunion with dam observed following release and subsequently observed unattended by dam prior to death.	a. Probable study-induced abandonment
b. Reunion with dam observed following release but later observed unattended by dam prior to death.	b. Probable natural abandonment
2. Milk curds present or absent from abomasum or intestinal tract. Mesentery and subcutaneous fat present. Absence of any signs of starvation.	2. Exposure
3. Disease syndrome present, or disease syndrome noted at capture.	3. Disease
4. None of the above.	4. Undetermined
II. Carcass bitten, chewed, and/or partially eaten.	II. Predation/scavenging involved.
A. Lack of blood in wounds, lack of frothy blood in nares and trachea, no bruises surrounding tooth marks, or no subcutaneous hemmorrhages present.	A. Scavenging
1. Bones gnawed and chewed, feeding pattern generally not restricted to the upper portion of carcass.	1. Mammalian scavenger(return to I.1 to determine cause of death)
2. Bones not chewed, feeding limited to upper portions of carcass.	2. Avian scavenger (return to I.1 to determine cause of death)
3. Neither of the above, or some characteristics present from both.	
B. Blood in wounds, frothy blood in nares and trachae bruises surrounding wounds and sub-cutaneous hemmorrages present.	B. Predation
1. Debilitating physical disorder, or disease syndrome present.	1. Predator kill & other factors.
2. No debilitating physical disorder or disease syndrome present.	2. Predator kill.
a. Talon wounds on back and sides of body. Talon wounds on neck. Only upper portion of carcass fed upon. Ribs broken off at backbone. Leg bone usually intact.	a. Golden eagle kill.
b. Teeth wounds on neck, sides or legs. Carcass fed upon extensively, bones chewed and carcass parts scattered.	b. Mammalian predator.
c. Extensive trauma to carcass. Large portions of carcass missing. Bones broken or crushed. Skull crushed. In older calves, rumen not consumed.	c. Brown bear.
d. None of the above.	d. Undetermined predator.

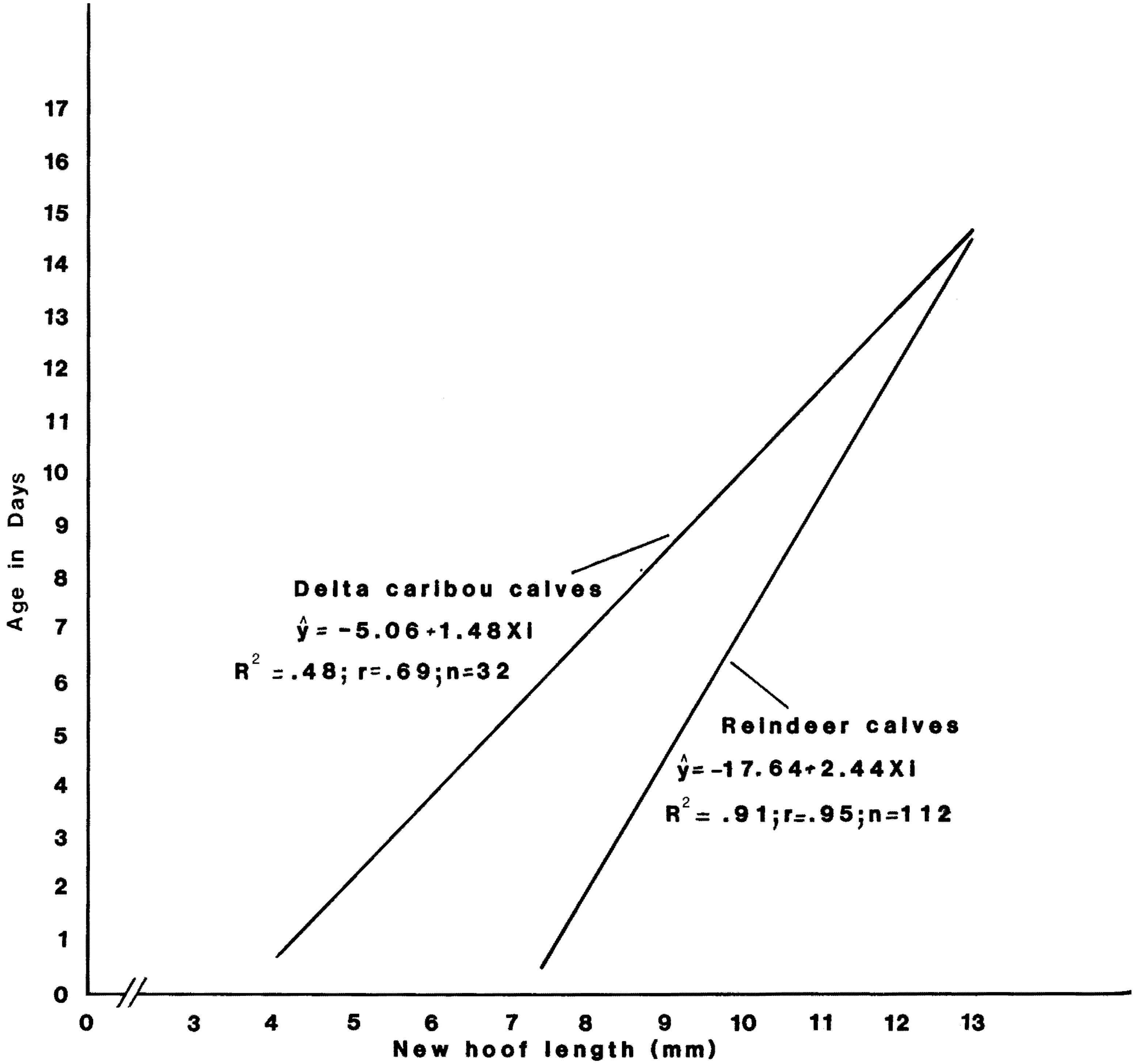

Fig.2 Relationships between new hoof growth (mm) and age in days of 3 captive reindeer calves and 6 captive caribou calves, University of Alaska-Fairbanks, 1983.

variation in these data (R^2 = .48). Several sources of error were evident in both instances. Inconsistency between measurements taken by different individuals is probably the largest source of variation. Ideally, one individual should make all measurements, however this was not possible due to other commitments by project personnel. Average growth rates of new hoof lengths in reindeer and caribou were not identical (Fig. 2). Caribou new hoof length average growth rate was 0.68 mm per day, while average growth rate for reindeer was 0.41 mm per day.

Age determination in the 69 study calves (Table 1) was calculated using a combination of the results of the above NHL calibration test and the general physical criteria described for white-tailed deer (Haugen and Speake 1958), elk (Cervus canadensis, Johnson 1951), and caribou (Miller 1972). The growth rate for caribou calves in general, and based upon the physical characteristics of the 69 captured calves, an initial NHL of 7.0 mm was assumed for the study calves. In cases where there was not general agreement between estimated age according to NHL and estimated age based on umbillicus/hoof wear criteria, the latter method superceded the NHL estimates and final age estimate was based on the umbillicus/hoof wear criteria.

Calving Distribution and Initial Productivity

The 1983 spring migration of female caribou followed traditional routes in the Richardson Mountains, across the Old Crow flats and along the southern flanks of the Brooks Range, and down the Firth River valley. The arctic foothills zone and the northern perimeter of the Brooks Range were heavily used during the final westward movements. All parturient radio-collared cows were in the foothills and coastal plain between the Malcolm and Hulahula Rivers on 29 May. Collared cows west of the Aichilik River did not move farther west during the peak calving period (3-5 June). Cows east of the Aichilik continued to move westward until calving. There was a substantial northward movement of cows onto the coastal plain along the Jago River during 30 May - 1 June.

The highest density of calving caribou was in the lower foothills (Eriophorum tussock tundra) on either side of the Jago River (40-300 m elevation). Although calving activity extended nearly to the Beaufort Sea coast, the density of calving caribou dropped off sharply, north of the high density area. The coastal plain between the Kongakut River delta and Komakuk Beach also had a high density of caribou during calving. Scattered calving activity occurred at low density adjacent to these high density areas and extended west to the Sadlerochit River, east to the Firth River, south to the northern base of the Brooks Range and north to the Beaufort Sea coastline (Fig. 1).

A southerly flow of warm air over the Brooks Range from 30 May to 2 June caused a rapid snowmelt in the foothills that also extended to some coastal plain areas. Both high density calving areas were snowfree and well-drained during peak of calving. In contrast, extensive areas of the coastal plain between the Kongakut and Jago River deltas were mostly snow-covered. Caribou density within this region was generally low, and cows with calves were usually found in small, snowfree areas. In general it appeared that most parturient cows were moving towards the northwestern part of the calving grounds. However, some cows remained east of the Kongakut River until the beginning of the post-calving movement period.

Table 1. Physical characteristics and survival related observations of radiocollared caribou calves, Arctic National Wildlife Refuge, 1983.

Calf no.	Date	Sex	Weight (kg)	Length (cm)	Hind foot length(cm)	New hoof length(mm)	Umbilicus condition	Hoof condition[a]	Estimated age[b]	Handling time(min)	Cow-calf reunion[c]	Status
1	4 June	F	5.7	80	33.0	7.1	Moist	PH/W	1	12	No	Dead (5 June)
2	4 June	F	6.1	81	32.4	7.4	Dry	PH/W	1	11	Yes(>3.52-7.77)	Alive (16 Oct)
3	4 June	M	6.0	83	33.0	7.3	Moist	PH/W	1	6	Yes(>3.25-7.68)	Unknown/collar cast(28 Oct)
4	4 June	F	5.2	72	31.0	7.3	Moist	PH/W	1	4	Yes(<4.18)	Alive(19 Oct)
5	4 June	M	8.4	87	36.0	9.2	Dry	AH/W	4	4	Yes(>8.43-49.95)	Unkown/collar cast(31 July)
6	4 June	F	6.0	81	33.4	8.1	Absent	AH/W	2	4	Yes(<2.77)	Mortality signal (19 Oct)
7	4 June	-	-	73	32.3	7.2	Dry	AH/W	1	3	Yes(>2.78-6.97)	Dead (16 Oct)
8	4 June	F	7.2	83	33.9	8.9	Moist	PH/W	3	4	Yes(<2.60)	Alive (16 Oct)
9	4 June	-	7.5	88	34.2	8.3	Dry	AH/W	3	3	Yes(<2.60)	Alive (17 Oct)
10	4 June	M	7.4	77	34.0	9.1	Dry	AH/W	4	[illegible]	Yes(<2.47)	Alive (17 Oct)
11	4 June	M	7.9	78	36.0	7.7	Dry	AH/W	2	5	Yes(<2.85)	Alive (7 July)
12	4 June	M	6.3	76	33.2	7.7	Absent	AH/	2	4	Yes(<3.78)	Alive (23 July)
13	4 June	M	8.5	87	35.2	9.2	Moist	AH/W	3	8	Yes(<3.65)	Alive (7 July)
14	4 June	F	7.8	81	34.0	8.5	Dry	AH/W	3	4	Yes(<3.65)	Dead (30 July)
15	4 June	F	6.5	77	35.5	8.2	Moist	AH/W	3	4	Yes(>7.45-22.2)	Alive (7 July)
16	4 June	F	7.7	88	35.5	8.7	Moist	AH/W	3	4	Yes(<2.93)	Alive ([illegible] Oct)
17	4 June	M	7.1	77	32.5	9.1	Dry	AH/W	4	4	Yes(<0.08)	Alive (24 Oct)
18	4 June	M	7.1	74	33.0	8.4	Absent	AH/W	3	3	No	Dead (6 June)
19	4 June	-	6.2	77	33.0	7.7	Absent	AH/W	2	4	Yes(<2.73)	Alive (7 July)
20	4 June	M	9.3	82	35.0	9.5	Absent	AH/W	5	3	Yes(<0.08)	Dead (3 Aug)
21	4 June	F	7.3	84	34.0	8.5	Absent	AH/W	3	3	Yes(>3.30-18.00)	Alive (16 Oct)
22	4 June	M	6.6	73	32.3	8.4	Dry	AH/W	3	8	Yes(<3.35)	Alive (24 Oct)
23	4 June	F	5.7	76	32.5	7.2	Absent	AH/W	1	7	Yes(>3.27-17.85)	Alive (16 Oct)
24	4 June	F	5.6	75	30.5	7.5	Dry	AH/W	2	3	Yes(<3.32)	Alive (24 Oct)
25	4 June	F	6.7	82	34.5	7.5	Dry	AH/W	2	3	Yes(<3.23)	Mortality signal(16 Oct)
26	4 June	F	5.8	81	35.0	7.2	Moist	AH/W	1	3	Yes(>2.45-16.70)	Alive (26 Oct)
27	4 June	M	5.7	77	33.0	9.0	Moist	AH/W	3	3	Yes(>2.17-16.48)	Alive (24 Oct)
28	4 June	F	8.4	83	33.5	9.1	Dry	-	4	3	No	Dead (6 June)
29	4 June	M	8.2	84	34.0	10.2	Absent	AH/W	5	4	Yes(<0.02)	Alive (7 July)
30	4 June	F	6.1	78	32.0	8.9	Dry	AH/W	4	3	Yes(>1.77-16.30)	Alive (24 Oct)
31	5 June	F	7.2	77	35.5	9.8	Moist	AH/W	3	4	Yes(<0.03)	Alive (16 Oct)
32	5 June	F	7.3	81	38.0	9.0	Absent	AH/W	4	4	Yes(<0.02)	Alive (24 Oct)
33	5 June	M	7.4	82	33.5	8.2	Dry	AH/W	3	3	No	Dead (6 June)
34	5 June	F	6.3	77	32.0	7.8	-	AH/W	2	4	No	Dead (6 June)
35	5 June	M	7.8	82	34.0	8.4	Moist	AH/W	3	3	Yes(<0.02)	Dead (16 Oct)
36	5 June	F	6.6	80	33.5	8.3	Absent	AH/W	3	3	Yes(<0.01)	Alive (16 Oct)
37	5 June	F	7.2	82	34.0	9.0	Absent	AH/W	4	5	Yes(<5.40)	Alive (24 Oct)

Table 1. Continued.

Calf no.	Date	Sex	Weight (kg)	Length (cm)	Hind foot length(cm)	New hoof length(mm)	Umbilicus condition	Hoof condition[a]	Estimated age[b]	Handling time(min)	Cow-calf reunion[c]	Status
38	5 June	M	7.8	78	36.0	9.3	Absent	AH/W	4	1	Yes(5.45)	Alive (19 Oct)
39	5 June	M	5.1	72	31.0	9.0	Moist	PH/W(slight)	3	4	Yes(<0.02)	Dead (6 June)
40	5 June	M	7.4	80	35.0	8.0	Moist	AH/W	2	4	Yes(<5.27)	Alive (24 Oct)
41	5 June	F	6.0	77	33.5	7.8	Moist	AH/W	2	4	Yes(<0.02)	Alive (16 Oct)
42	5 June	M	7.6	84	34.0	9.1	Moist	AH/W	3	3	Yes(<0.02)	Alive (24 Oct)
43	5 June	M	6.6	76	33.0	7.3	Part Dry	AH/W	1	3	Yes(<0.02)	Alive (23 July)
44	5 June	F	6.7	83	35.0	7.0	Moist	AH/W	1	3	Yes(<0.02)	Alive (7 July)
45	5 June	F	7.1	86	35.0	8.7	Moist	AH/W	3	3	Yes(<0.02)	Alive (24 Oct)
46	5 June	M	7.2	82	32.0	8.5	Dry	AH/W	3	3	(Na)	Alive (24 Oct)
47	5 June	F	6.4	76	33.0	7.7	Dry	-	2	2	Yes(>3.13-47.23)	Alive (24 Oct)
48	5 June	F	7.3	87	32.0	8.1	Moist	AH/W(slight)	2	2	Yes(<3.08)	Alive (16 Oct)
49	5 June	F	5.4	76	31.0	8.8	Absent	AH/W	4	3	Yes(>3.06-45.77)	Alive (24 Oct)
50	5 June	F	8.2	84	34.0	8.2	Dry	AH/W	3	4	Yes(<3.02)	Dead (7 June)
51	5 June	F	6.7	77	33.0	8.8	Absent	AH/W	4	3	Yes(<2.95)	Dead (13 June)
52	5 June	F	8.3	85	35.0	8.9	-	AH/W	4	4	Yes(<2.95)	Alive (24 Oct)
53	5 June	M	7.4	83	34.0	9.4	Moist	AH/W	3	4	Yes(<2.87)	Alive (7 July)
54	5 June	M	7.5	84	34.5	8.3	Moist	AH/W	3	3	Yes(<0.08)	Alive (24 Oct)
55	5 June	M	8.1	88	35.0	8.6	Dry	AH/W	3	3	Yes(<0.08)	Alive (7 July)
56	5 June	F	6.8	83	35.0	8.0	Moist	AH/W(slight)	2	3	Yes(Na)	Alive (24 Oct)
57	5 June	M	4.9	75	30.0	7.4	Moist	PH/W(slight)	1	2	Yes(Na)	Dead (13 June)
58	5 June	M	7.5	75	33.0	9.1	Bloody	PH/W(slight)	1	3	Yes(<0.08)	Alive (7 July)
59	5 June	M	7.7	86	36.0	8.8	Moist	AH/W	3	4	Yes(<2.00)	Dead (21 June)
60	5 June	M	-	86	34.0	8.1	Dry	PH/W	2	4	Yes(<1.95)	Unknown/collar cast(18 Oct)
61	5 June	M	8.0	83	33.0	8.1	Absent	AH/W	2	3	Yes(<0.05)	Alive (24 Oct)
62	7 June	F	4.8	77	32.0	7.3	Dry	AH/W	1	5	Yes(<0.02)	Dead (23 June)
63	7 June	M	6.2	78	32.5	7.6	Bloody	PH/W(slight)	1	4	No	Dead (8 June)
64	7 June	F	5.9	79	32.5	8.5	Bloody	AH/W(slight)	1	4	No	Dead (9 June)
65	7 June	F	8.1	87	37.0	8.4	Moist	AH/W	3	5	Yes(<16.92)	Dead (10 June)
66	7 June	F	7.1	73	31.5	8.7	Absent	AH/W	3	3	Yes(<0.02)	Alive (7 July)
67	8 June	F	6.2	77	32.5	8.4	Absent	AH/W	3	4	Yes(<0.05)	Unknown/collar cast(28 Oct)
68	8 June	F	5.1	89	32.0	8.4	Dry	AH/W	3	4	Yes(<0.05)	Dead (16 Oct)
69	8 June	M	9.1	84	33.0	8.3	Dry	AH/W	3	4	No	Dead (11 June)
Male averages			7.30	80.43	33.69	8.54			2.77			
Female averages			6.63	80.42	33.55	8.21			2.53			
All			6.93	80.37	33.59	8.34			2.61	3.95		

[a] AH = All hardened; PH = Partially hardened; W = Hooves worn

[b] Age rounded to nearest whole day.

[c] (xxx-xxx) = Range of time in hours for reunion.

Composition data from transects indicated that yearlings contributed considerably to the high density in the southern part of the Jago River foothills area and on the coastal plain between the Kongakut River and Komakuk Beach. Based on the density of calves along transects, the Jago hills were by far the most important calving area, followed by the Kongakut River-Komakuk Beach area.

All adult bulls, a 2-year-old cow, and most radio-collared yearlings were south of the Brooks Range during calving. Because female yearlings were not likely to have calves, no attempt was made to obtain visual relocations of yearlings on the calving grounds. Signals from approximately half of the 35 collared yearling females were heard during overflights of the calving grounds. All of these were near the mountains or east of the Aichilik River, which is consistent with the distribution of yearlings based on transect data. Four of 5 radio-collared 2-year-old females were on the calving grounds; 1 was in the southern part of the Jago foothills and 3 were found near Komakuk Beach. None were parturient.

The 1983 calving distribution of the Porcupine caribou herd was similar to that observed in 1976, 1978, and 1979, when high densities of calving also occurred in the Jago foothills and east of the Kongakut River (USF&WS 1982). In 1972, 1975, 1977, and 1981, concentrations of calving also occurred in the Jago foothills area. Thus, 8 of the past 11 years have had high density calving in the Jago foothills. One difference in the calving distribution of 1983 over that of recent years was the northern extension of calving concentrations onto the coastal plain areas as well as low density calving occurring to the coastline in some areas (Fig. 1). The rapid snow melt on the calving grounds immediately prior to peak of calving may have influenced this northern extension of calving.

Peak of calving occurred on approximately 4 June in the high density calving area of the Jago foothills. The chronology of calving for radio-collared females ranged from 30 May to 19 June, with 83% of the calves being born during the period of 30 May to 10 June (Fig. 3). The peak of calving may have been slightly earlier in 1983 than the average (5-9 June) reported for other years (U.S. Fish and Wildlife Service 1982). Difficulty in classifying adults during transect surveys prevented the determination of synchrony across the entire calving area. No obvious differences occurred in calving chronology between eastern (Kongakut/Komakuk) and western (Jago foothills) concentration areas. However, based on estimated ages at capture, there may have been a 1 day delay in peak of calving between the Jago foothills area (mean estimated age at capture 2.6 days) and areas on the coastal plain near Barter Island (mean estimated age at capture 2.7 days). The apparent uniformity of calving chronology in 1983 across the calving grounds was in contrast to that of 1982 when calving peaked earlier in leading (western or northern) groups and was later in following (eastern or southern) groups (Whitten and Cameron 1983).

There were 23 radio-collared 3+-year-old cows in the Porcupine herd during the summer of 1983, of which 22 were on the calving grounds (Fig. 4). The remaining collared cow arrived at the Firth River delta on 13 June; antler development and absence of a distended udder indicated she had not been pregnant. Four other adult cows on the calving grounds were evidently not pregnant. Five cows gave birth, but lost their calves within 2 to 7 days, and 13 cows still had viable calves at the end of June. Initial

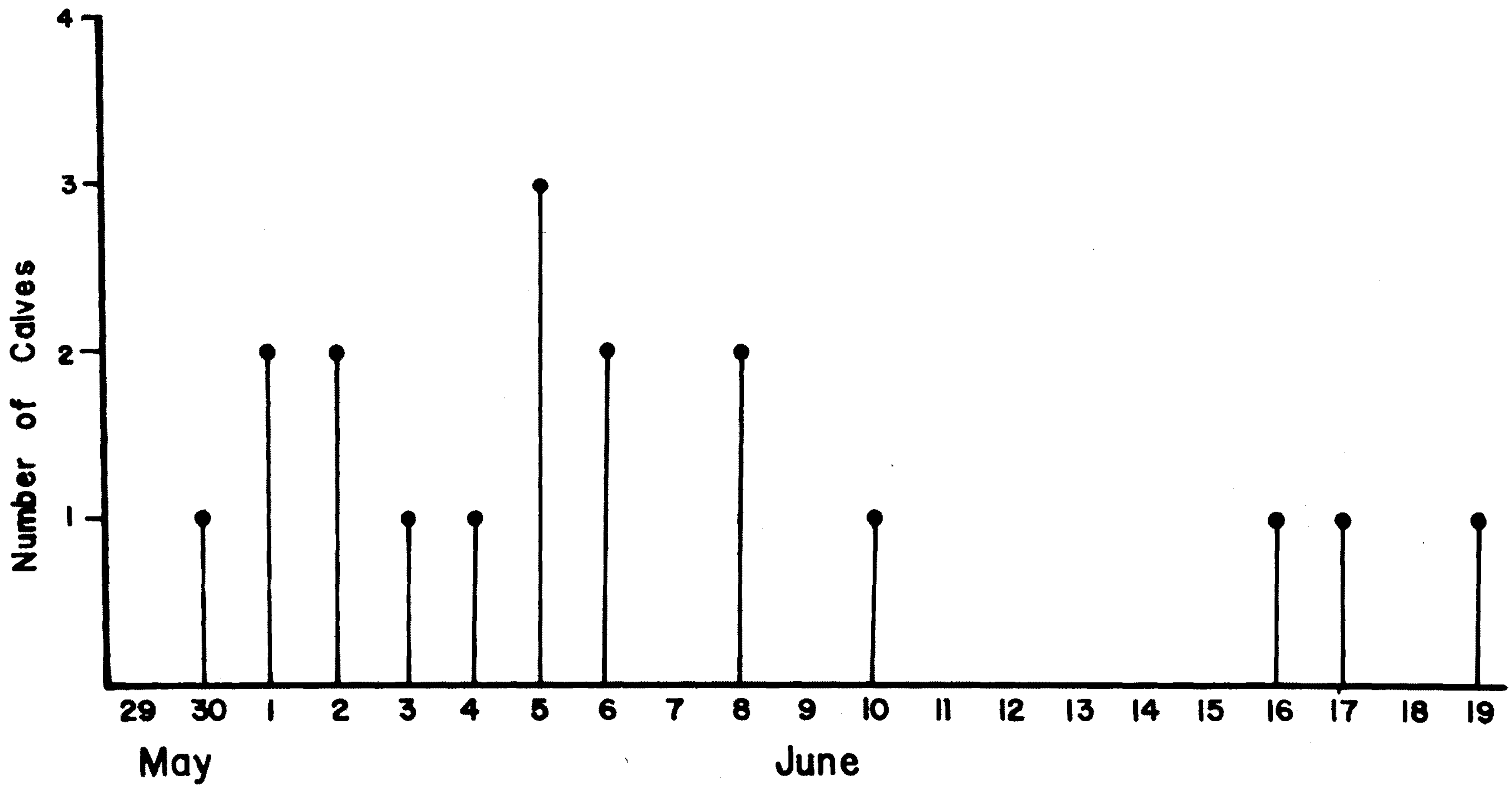

Fig. 3. Approximate dates of calving for 18 radio-collared control cows, Porcupine caribou herd, 1983.

productivity of radio-collared females was 78%. A summary of productivity status for radio-collared female caribou in 1983 is provided in Appendix Table A-1.

Composition surveys by helicopter on 6 June showed an average of 74 calves/100 cows and 24 yearlings/100 cows among 1,777 caribou counted. There were no bulls in this high density calving area. Density was higher in the southern portion of the survey area (the central Jago hills), due in part to a higher yearling/cow ratio; however, the lower calf ratio to the south suggested that barren cows near the mountains may also have contributed to higher density. In 1982, initial productivity for the Porcupine herd was an estimated 81% in an area of high density calving (Whitten and Cameron 1983). Bergerud (1980) reported an average initial productivity of 82% for 8 major North American herds. The 1983 productivity is slightly less than this reported average, however, sampling intensity was low and this estimate may not represent actual productivity.

Calf Capture

On 4 June 1983, 30 calves (# 1-20 in the foothill east area and # 21-30 in the foothill west area) were captured, processed, and released. An additional 30 calves were captured on 5 June 1983 (# 31-45 in the coastal plain north area and # 46-60 in the coastal plain south area). Both subgroups occurred within the overall area of high density calving (Fig. 1). Between 5 and 8 June 1983, 9 calves (# 61, 64 and 67 in the foothills east area, # 65 in the foothills west area; # 62, 63, 68 and 69 in the coastal plain north area; and # 66 in coastal plain south area) were captured, processed, and fitted with radiocollars that had been removed from mortality victims occurring among the initial sample of 60 (Table 1).

Cumulative time required for capture operations was 6 h, 40 min (3 h 35 min - 4 June; 3 h 5 min - 5 June and average processing time was 3.9 min. The use of ground observers to confirm reunion of cow/calf pairs was partially successful. When calves were captured from groups of caribou it was not possible to identify the dam whose calf was captured. Some reunions occurred in excess of 3 h post-capture, making it impractical to observe reunions and also achieve sampling goals during the peak of calving time interval. An alternative method using aircraft to periodically relocate each radio-collared calf and make visual observations during the first 24 hours was successful in documenting reunions and/or cases of study induced abandonment.

The estimated age of captured calves averaged 2.8 days (Table 1). A total of 30 male and 36 female calves were captured (the sex of 3 calves was inadvertently not recorded), which gives a sex ratio of 46 males: 54 females (Table 1). Sex ratios (at birth) of 53 males : 47 females (Kelsall 1968) and 51 males: 49 females (Skoog 1968) have been reported for Canadian and Alaskan caribou herds. The average weight for all calves captured was 6.9 kg (Table 1), which was 0.9 kg greater than the average weight of 23 calves measured from the same herd in 1982 (Mauer et al. 1983).

Neonatal Calf Mortality

Between 4 June and 3 August 1983, 17 calf mortalities were detected and investigated (Table 2). Case histories for each mortality are included in

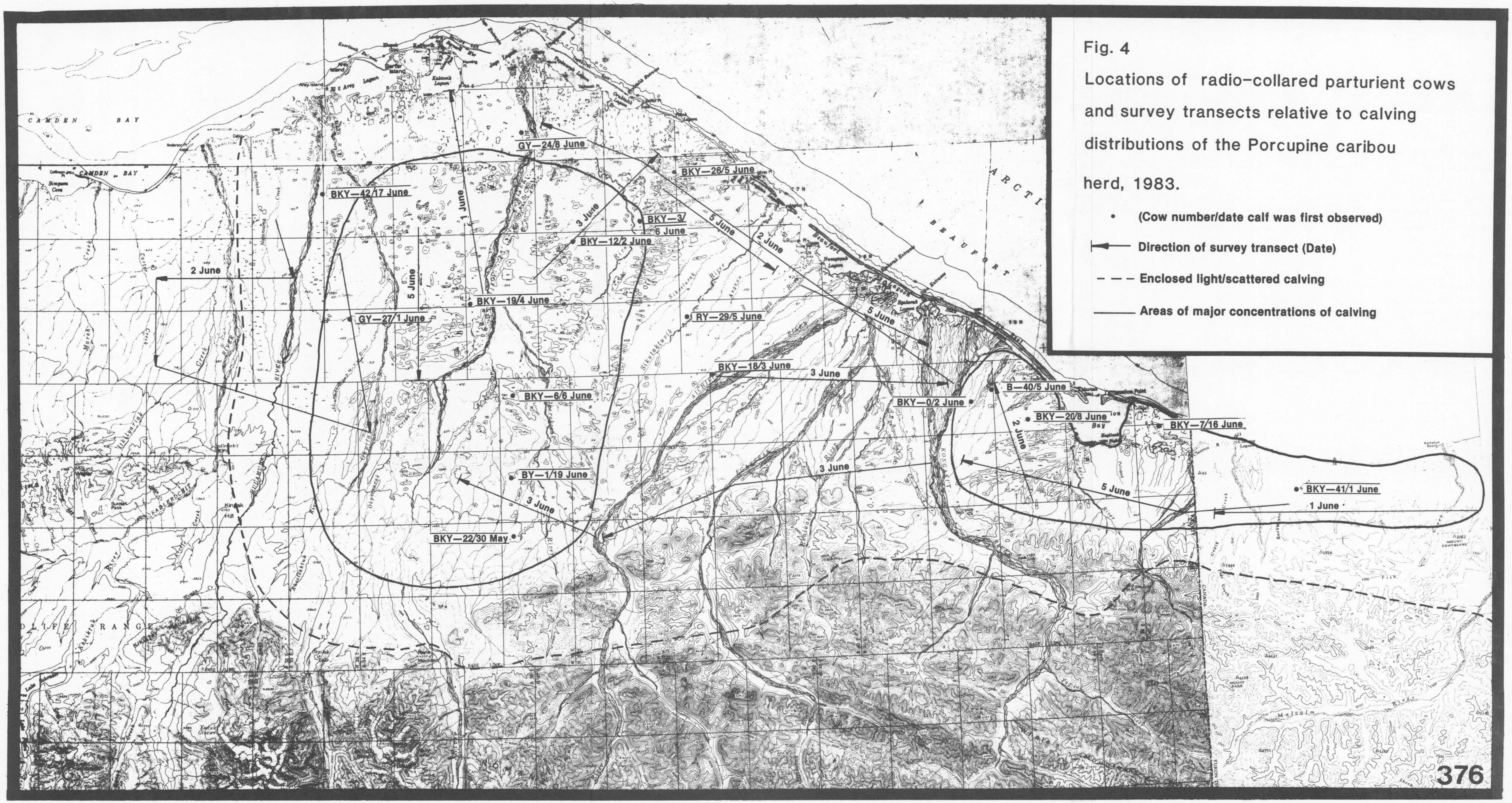

Fig. 4

Locations of radio-collared parturient cows and survey transects relative to calving distributions of the Porcupine caribou herd, 1983.

the Appendix. Probable study-induced abandonment (6 cases) accounted for 35.3% of mortality among study calves. Probable natural abandonment was determined in cases of starvation due to desertion by the dam following an observed reunion. Since 2 cases of probable natural abandonment occurred within 24 hr of capture, it is possible that those abandonments may have been study-related.

Table 2. Probable causes of mortality for 17 of 69 radio-collared caribou calves between 4 June - 3 August 1983.

Category	Number of calves	Calf #'s	% Total mortality
I. Predation-excluded deaths			
1. Starvation			
a. probable study-induced abandonment	4	18,63,64,69	23.5
b. probable natural abandonment	2	34,50	11.8
2. Exposure			
3. Disease syndrome			
4. Undetermined cause of death	1	28	5.9
II. Predation and/or scavenging involved			
1. Scavenging involved			
a. avian scavenger			
i. probable study-induced abandonment			
ii. probable natural abandonment-gulls	1	39	5.9
iii. disease syndrome			
iv. undetermined cause of death			
b. mammalian scavenger			
i. probable study-induced abandonment			
ii. probable natural abandonment			
iii. disease syndrome			
iv. undetermined cause of death			
c. undetermined scavenger			
i. probable study-induced abandonment			
ii. probable natural abandonment			
iii. disease syndrome			
iv. undetermined cause of death	1	14	5.9
2. Predation involved			
a. avian predator			
i. predisposed to predation - golden eagle	1	33	5.9
ii. not predisposed to predation - golden eagle	3	57,59,65	17.6
b. mammalian predator			
i. predisposed to predation			
ii. not predisposed to predation - brown bear	2	51,62	11.8
c. undetermined predator			
i. predisposed to predation	1	1	5.9
ii. not predisposed to predation			
3. Undetermined if predation or scavenging			
i. predisposed to predation/scavenging			
ii. not predisposed to predation/ scavenging	1	20	5.9
Totals	17		100.1

Most calves captured from foothills areas were from large groups of cows and calves; whereas calves captured from coastal plain areas were from small groups of cows and calves or single cow/calf pairs. There was a tendency for the dams to more readily flee from the capture site when calves were taken from large groups than from small groups or single cow/calf pairs. Thus, on coastal plain areas, the capture crew observed reunions of cows and calves immediately following release in 18 instances versus 3 for the foothill groups. Mortality cases indicate that probable study-induced abandonment occurred with equal frequency among foothills groups (n=2) and coastal plain groups (n=2). However, there were 3 cases of probable natural abandonment in the coastal plain groups and in 2 cases both calves died within 1 day following capture. These calves had abandonment-related symptoms and the reunions observed by the capture crew could not be confirmed through aerial relocation and observation. Although there were less immediate reunions observed in the foothills groups, those groups had a lower abandonment rate (study-induced and natural-3) the coastal plain groups (6). Apparently a majority of dams that fled the capture site ultimately returned and successfully reunited with their young.

Excluding confirmed cases of study-induced mortality, the natural mortality rate for the remaining sample group of 63 calves was 17.5%. These mortalities can be partitioned into 4 mortality categories (Table 3). Predation accounted for approximately half the observed mortality, with golden eagles and brown bears being the predators involved in these mortalities. Predation/scavenging was involved in 2 mortalities but insufficient evidence at the carcass site did not permit identifying the cause of death. Natural abandonment accounted for 27.3% of observed mortality among sample calves. This rate is higher than the proportion of detected mortality attributed to natural abandonment for calving grounds of the Kaminuriak (21%) and Beverly (6%) caribou herds in Canada (Miller and Broughton 1974, and Miller et al. 1983 respectively). Apparently natural abandonment of calves occurs for a number of possible reasons: young females lack experience and may tend to abandon their young to join other migrating adults; disturbance by predators on the calving grounds may result in some permanent separations; and physiological disorders such as mastitis may lead to abandonment or starvation of the calf (Miller and Broughton 1974). Lent (1961) documented only 1 (1%) case of study-induced abandonment resulting from a capture and ear-tagging study of neonatal caribou calves.

Table 3. Proportion of observed natural mortalities occurring among neonatal caribou calves on the Arctic National Wildlife Refuge. 1983

Mortality category	Number of calves	Proportion (%) of sample calves	Proportion (%) of natural mortality
Probable natural abandonment	3	4.8	27.3
Undetermined-predation/ scavenging excluded	1	1.6	9.1
Undetermined-predation/ scavenging involved	2	3.2	18.2
Predation	5	7.9	45.5
a. golden eagle	3	4.8	27.3
b. brown bear - probable	2	3.2	18.2
Totals	11	17.5	100.1

Golden eagles killed 4 study calves (Tables 2 and 3) during the study, however, 1 calf was abandoned and predisposed to predation.. In addition, golden eagles killed 2 unmarked calves (see mortality case histories-Appendix) and were observed feeding on other calf carcases; however, it was not possible to obtain access to these carcass sites to determine if these calves were scavenged or killed by eagles.

A partial compilation of golden eagle sightings by field personnel working in the northern part of the Arctic National Wildlife Refuge in 1983 contains 51 observations totaling 60 birds (23 adults, and 18 immatures and 9 unidentified age) during 14 May to 4 August. In previous years a preponderance of immature eagles has been observed (D. Roseneau, pers. comm.). Most golden eagle sightings were made during June (28) and were most often recorded in areas associated with caribou concentrations. No attempt was made to systematically survey golden eagle distributions and determine abundance. These sightings are biased by observer effort and location and do not represent abundance and distribution of golden eagles on the coastal plain of ANWR.

Abandonment-related mortality rates among the original sample of 60 calves was 10%, while it was 33% among calves collared with radios removed from dead calves. Replacement of collars was halted when this anomaly was detected. Reasons for the elevated abandonment rate among re-collared individuals are undetermined; however, scent may have caused the dam to reject its young.

Probable predation of study calves by brown bears was determined in 2 cases. In addition, 3 unmarked calves were killed by brown bears (see mortality case histories - Appendix). During 4-16 June, brown bears were observed killing or feeding upon unmarked calves in 11 different cases which involved a total of 11 calves (P. Miller pers. comm., G. Garner pers. comm., M. Phillips 1984). Of 25 brown bears captured in the foothills and coastal plain of ANWR during 8-16 June, 7 had either dried blood or fresh blood on their muzzle. Data gathered during concurrent studies of radio-collared brown bears indicates that bears appear to move towards areas of caribou concentration and frequent calving grounds during calving and post-calving season (Garner et al. 1983, 1984, Phillips 1984). It is apparent that caribou calves are important food items to some brown bears during the calving season; however, the magnitude of predation by brown bears on caribou calves is not known.

One unmarked calf drowned on 4 June 1983 in a meltwater drainage having perpendicular ice walls. The dam crossed the drainage successfully, however when the calf followed it was unable to climb out of the water and subsequently drowned.

There was no documented wolf predation of study calves. One black wolf was observed on 9 June 1983 being chased by the dam of a study calf in the foothills near the Okerokovik River. The observation was made from the radio-tracking aircraft (PA-18) flying towards the cow/calf pair at approximately 200 m AGL. The observation began when the wolf was seen running directly away from the female caribou. After running a short distance (50 m), the cow stopped the pursuit and allowed her calf to approach her. The wolf continued to run at a moderate speed directly away from the caribou. It is possible that the approaching aircraft caused the wolf to flee from the cow and calf at the time the observation was initiated. An active wolf den was located near Whale Mountain on the Kongakut River. At least 4 wolves, believed to be associated with this den were observed on several occasions on the coastal plain and in the foothills between the Kongakut River and Demarcation Bay, a distance of 25-35 km from the den (Phillips 1984).

Between 4 June and 3 August, 76.5% of the observed mortalities for study calves occurred within the first 9 days (Fig. 5). Six of these mortalities were study-induced, therefore 63.6% of the detected natural mortality occurred within the first 9 days of the study. Natural mortality was concentrated in calves that were estimated to be 12 days of age or less (Fig. 6). The 2 mortalities occurring in late July - early August occurred in mountains and foothills south of the coastal plain during emigration from the coastal plain and adjacent foothills of ANWR. Note that these 2 calves were last monitored on 6 July and both were in large aggregations that were emigrating from the coastal plain. They were not monitored again until late July. Therefore, timing of actual mortality is between 6 July and 3 August. All other mortalities occurred on the coastal plains or adjacent foothills during calving and post-calving aggregations.

Mortality rate (excluding study-induced mortality) were higher (21.9%-7 mortalities of 32 calves) among calves originally captured on coastal plain areas (18.8%-coastal plain north, 25.0%-coastal plain south), than mortality (12.9%-4 mortalities of 31 calves) among calves captured in the foothills areas, (10%-foothills east, 18.2%-foothills west). Most of the natural mortality of the study group, however, occurred in foothills and mountain areas (60%) compared to (40%) on the coastal plain. This was primarily due to movement of most of the coastal plain-south group to the foothills soon after capture. All documented golden eagle kills occurred in the foothills region. The 3 cases of probable natural abandonment occurred on coastal plain areas. Only one undetermined mortality occurred on the coastal plain.

Of the 18 productive females in the control group, 5 lost their calves between 30 May to 21 June (see Appendix). Chronology of this mortality was 1 June, 11 June, 16 June, 17 June, and 21 June and is in general agreement with the chronology of mortalities among study calves (Fig. 5). Assuming that all lost calves died, the calf mortality rate for the control group was 27.8%. The mortality rate for the study group (excluding study-induced mortality) between 4 June-3 August was 17.5%. These mortality rates are significantly different ($X^2 = 3.82$, df = 1, $0.05 < P < 0.10$), however, small sample size may bias these data. Also, the majority of control cows did not calve in the areas where study calves were captured (Fig. 3) and may have been exposed to different mortality risks in these areas.

Comparison of estimated initial productivity of 74 calves/100 cows with limited composition data collected during early July 1983 (72-74 calves/100 cows) indicates a high initial calf survival rate (Whitten 1984). Similar comparisons in an earlier year (1972) indicated a decline of 17% of calves between peak of calving and early July (Calef and Lortie 1973). This decline agrees with the observed natural mortality rate (17.5%) of study calves during 4 June to 3 August 1983. More extensive composition data are necessary to improve the validity of these comparisons.

During 7-30 June 1982 a natural mortality rate of 45% was measured among 23 study calves which were captured and processed on the coastal plain south of

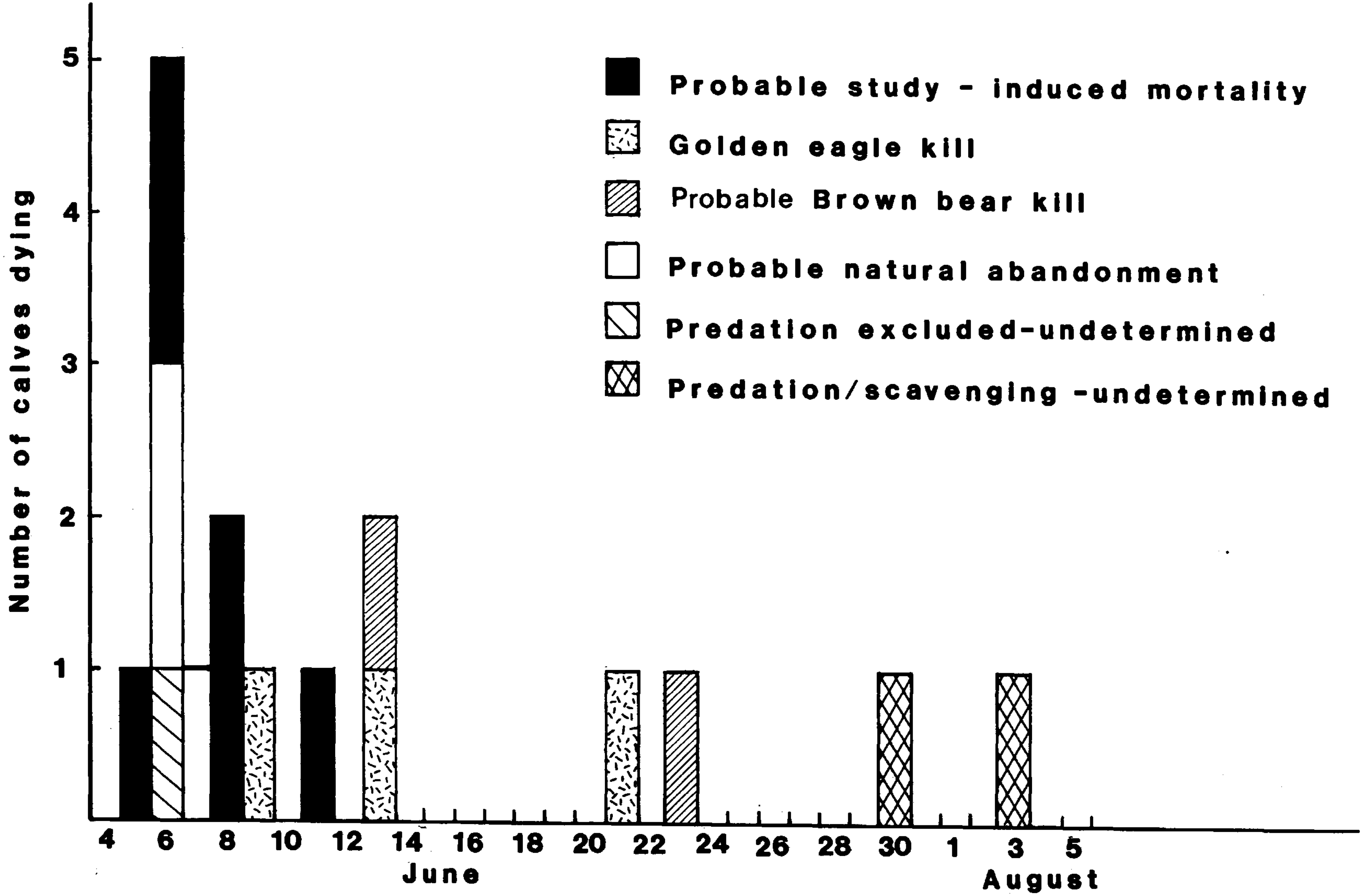

Fig.5. Chronology of observed mortalities among 17 radio-collared caribou, Arctic National Wildlife Refuge, 1983.

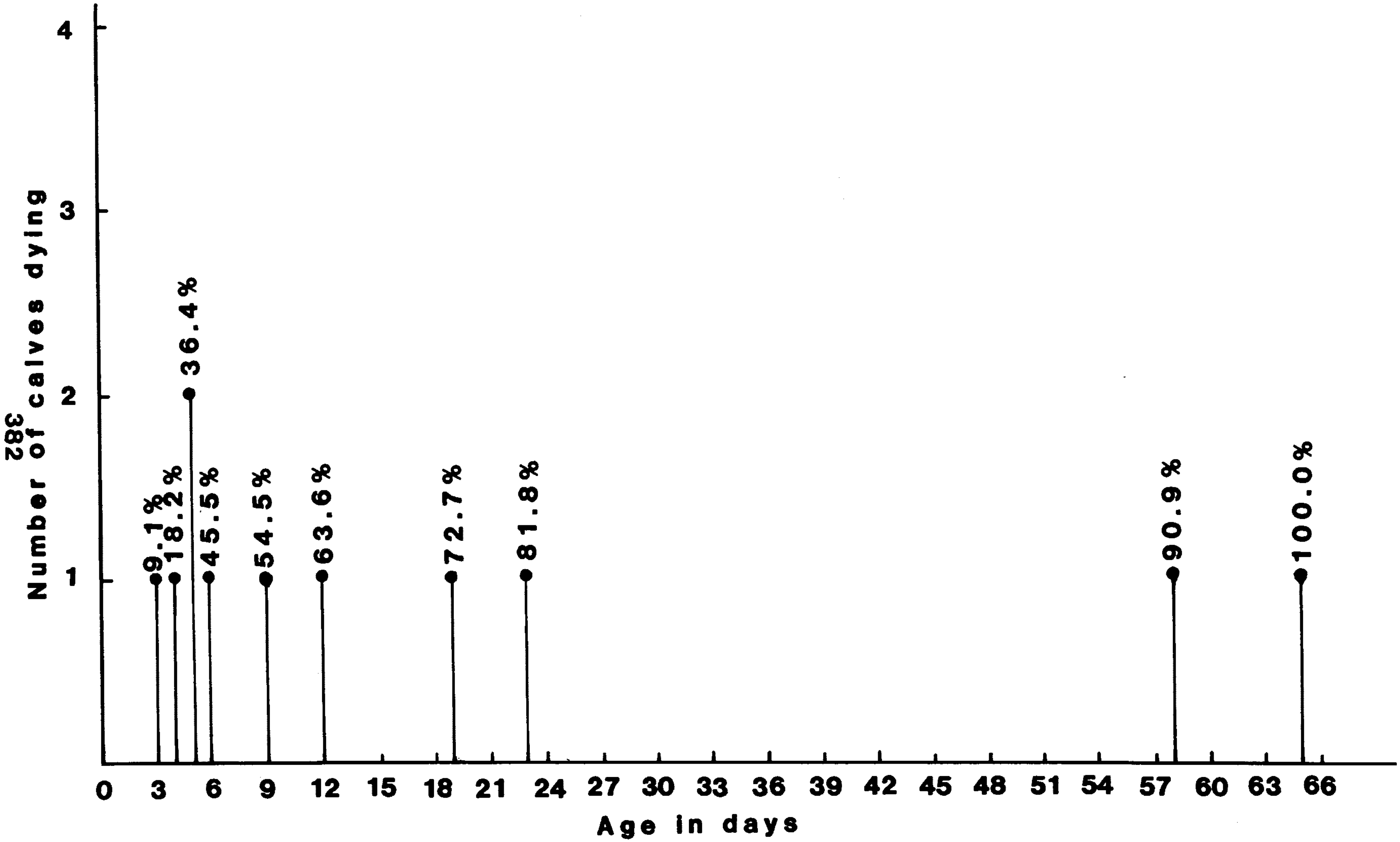

Fig.6. Number of radio collared caribou calves dying and cumulative proportion of mortality occurring within estimated age classes, Arctic National Wildlife Refuge, 1983.

Note that mortalities detected for estimated ages 23, 58, and 65 are ages when mortality was detected.

Herschel Island, Yukon Territory (Mauer et al. 1983). This rate was considerably higher than the 1983 rate of 17.5%. In the first 10 days after capture, 50% of the 1982 mortality occurred, while 81% occurred in the same period in 1983 (Mauer et al. 1983). In 1982 33% of study calf mortality occurred during late June when there was a rapid westward movement of cows and calves (Mauer et al. 1983). Rapid movement also occurred during late June 1983 in both eastern and later in western directions, however, no increase in calf mortality were apparent. Logistical limitations encountered in 1982 precluded establishment of conclusive mortality categories, however, golden eagles were associated either as a predator or as a scavenger in 75% of the natural mortalities in 1982. In 1982, calving occurred in extreme eastern and southeastern portions of the herd's traditional calving grounds (approximately 160 km from 1983 study areas). Geographic distribution of calving, post-calving movement patterns, and other factors may have influenced mortality rates between the 2 years.

Movements

Following capture there was a gradual southward shift of most study calves towards the upper foothills near the northern base of the Brooks Range (Figs. 7 and 8). This movement was consistent, directional, and coincided with increasing group size and net movement rates (Fig. 9). Most calves captured in the coastal plains-south area moved south and mixed with general distributions of the foothills study groups (Fig. 7). Those study calves which moved towards the coast did so at a slower rate and with less consistency in direction of movement. The coastal distributions tended to show lower net movement rates (4.12 km/24 hrs) than the foothills distributions (6.55 km/24 hrs) during 8-26 June. A similar relationship was observed among coastal and foothills distributions of the control cows.

Beginning 20 June, movement rates of foothills and mountain distributions increased two-fold or more, and direction of movement shifted to the east (Figs. 8 and 9). On 24 June, there was a rapid, general evacuation of the mountains and foothills, spreading onto the coastal plain along the Egaksrak and Kongakut Rivers (Fig 7 and 8). Movement continued across the Kongakut River and proceeded into Canada by 2-3 July. On 4 July, the herd shifted directions 180° and moved rapidly back into Alaska. Some groups went into the foothills and northern mountains, while the majority remained on the coastal plain. During this same period, considerable numbers of caribou also remained on the coastal plain from the Niguanak River to the Egaksrak River. These groups generally included the study calves which had shown a previous affinity to coastal areas. A mixing of groups again occurred between 4-6 July as large groups containing the original foothills study calves moved westwards. During 6-8 July, there were numerous, rapid movements of large groups on the coastal plain between the Jago and Aichilik Rivers. Many caribou moved to coastal fringes, and some groups were seen on ice pans on the lagoons. Harassment by mosquitos was apparent during this period. After 8 July, large numbers of caribou moved eastward along the coastal plain and entered Canada on 10 July. Other groups moved higher into the mountains in a southeasterly direction up the Aichilik and Egaksarak river valleys. Some scattered groups remained on the coastal plain and foothills through July and August.

Periodic radio-telemetry surveys during August, October, November, and December indicated general herd distributions in traditional fall and winter

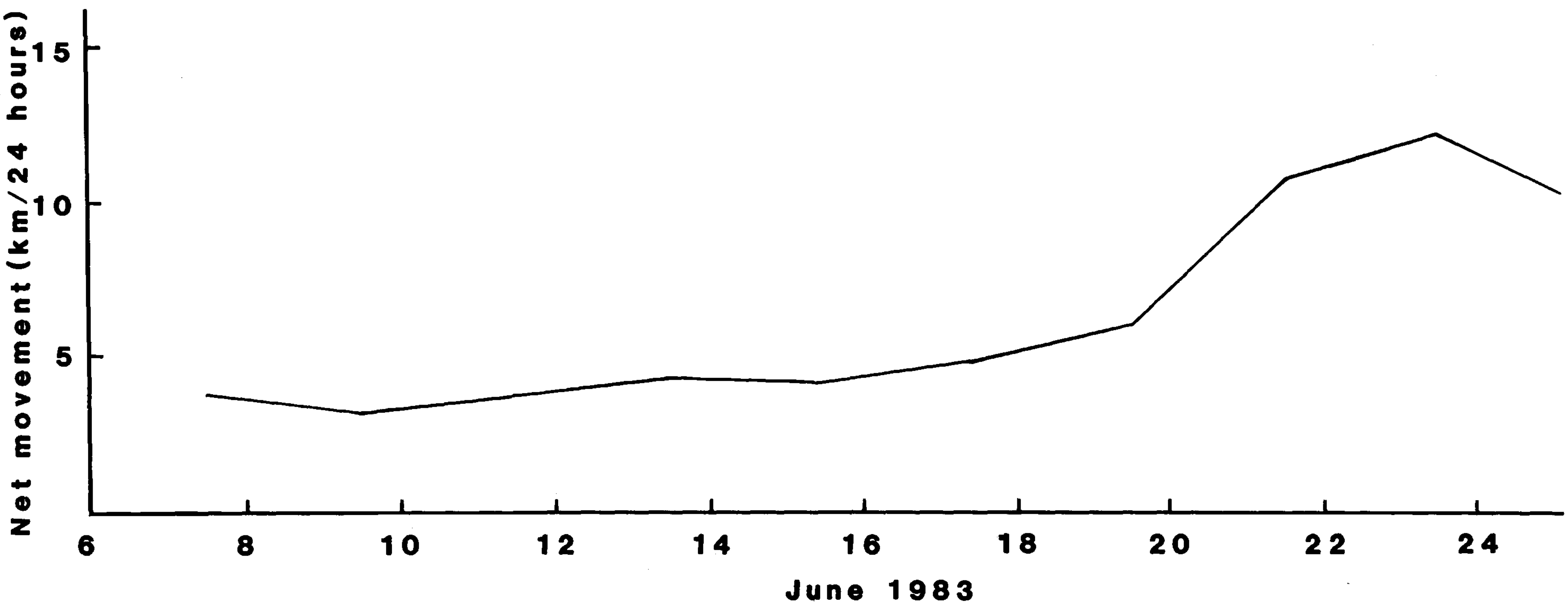

Fig. 9 Net movement rates for radio-collared caribou calves (8-25 June 1983).

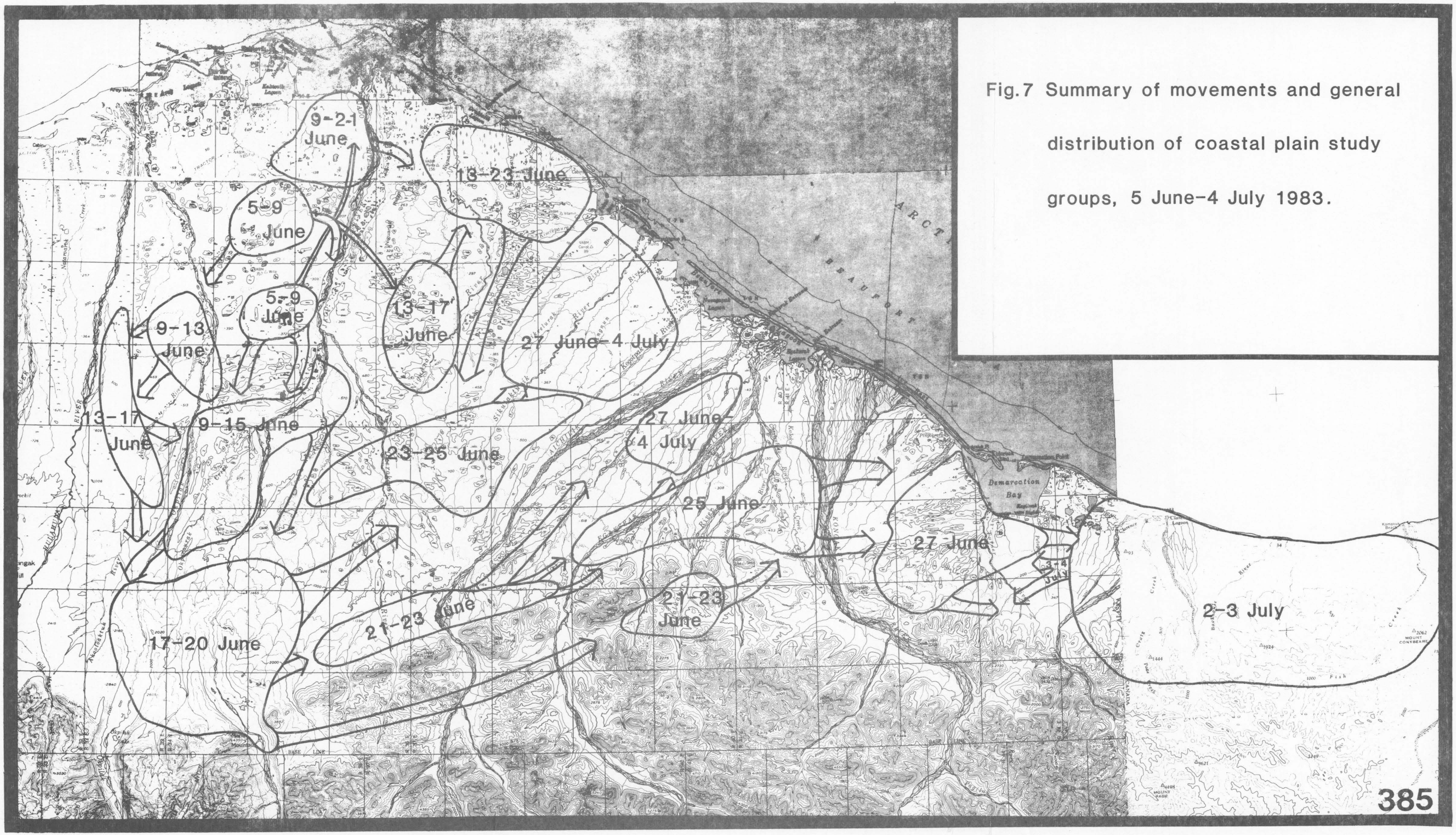

Fig.7 Summary of movements and general distribution of coastal plain study groups, 5 June-4 July 1983.

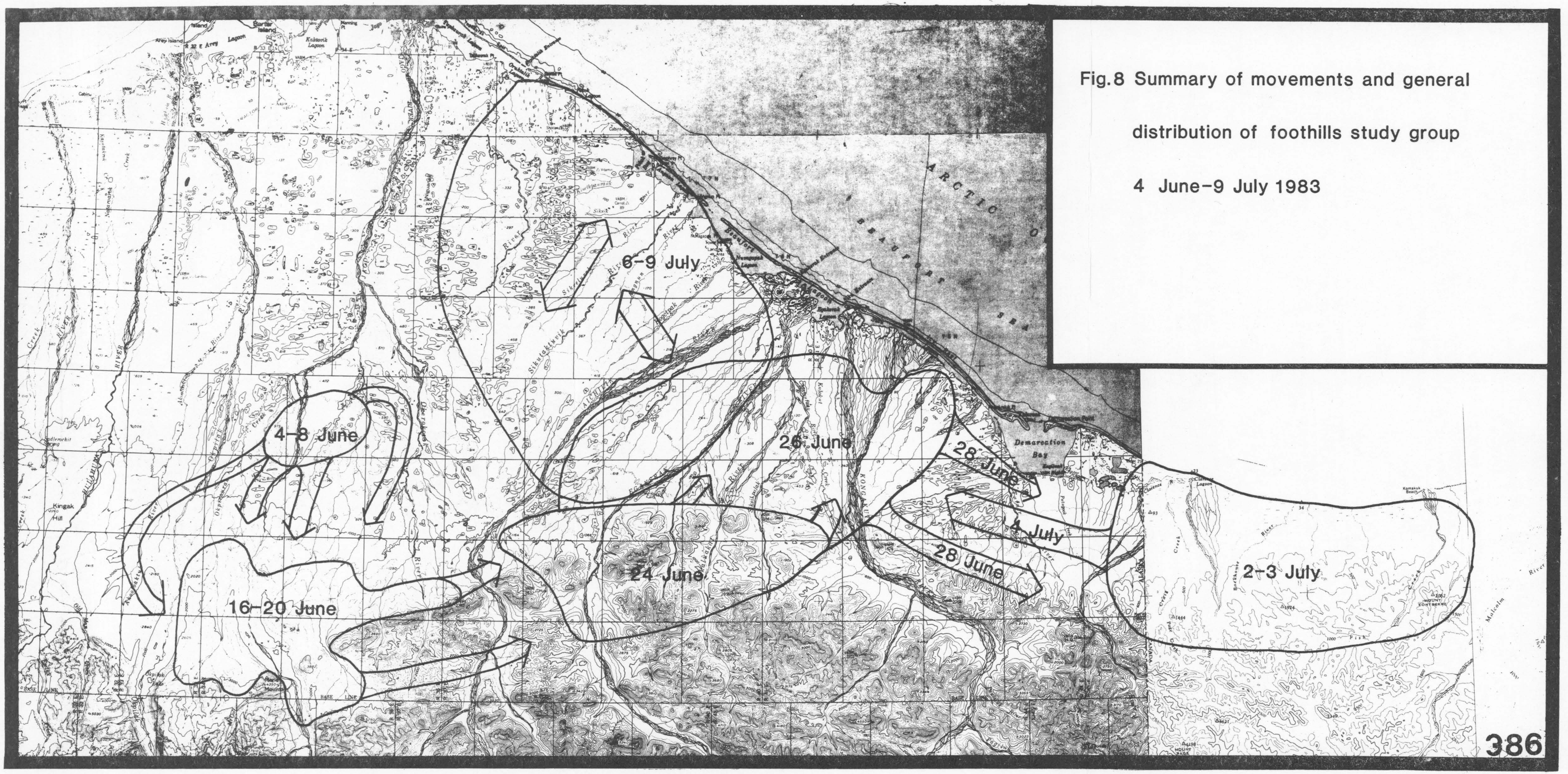

Fig.8 Summary of movements and general distribution of foothills study group 4 June-9 July 1983

areas of Alaska and Canada. It was not possible to locate all frequencies and/or detect, locate and investigate mortalities rapidly enough to collect conclusive data on causes of subsequent mortalities. During the period of 5 August to 8 December 1983, 4 mortalities were confirmed, (Appendix 1) and 4 other mortality signals were received but not investigated on the ground. A total of 17 calf frequencies were not received during this period and their status is unknown. In 4 cases radio-collars wre found dropped from the calf as a result of fraying of the elastic at rivet points. This may have been aggravated by failure of some collars to expand properly with increased neck size.

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APPENDIX

ANWR Progress Report Number FY84-12

Mortality Case History

Calf No: 1
Captured: 4 June 1983

Sex: female
Location: foothills, east of Jago River

Weight: 5.7 kg
Umbilicus condition: moist
Hoof condition: partially hardened/worn
Health status: appeared healthy at capture
Processing time: 12 min

Total length: 80.0 cm
Right hind foot length: 33.0 cm
New hoof length: 7.1 mm
Estimated age at capture: 1 day old

Cow-calf reunion: No reunion observed. Calf observed unattended by dam 5.8 hours following release.

Signal monitored: 5 times/ 2 day period
Mortality detected: 5 June 1983
Carcass collected: 5 June 1983
Carcass weight: 3.2kg
Total length:
Right hind foot length: 32.5 cm
New hoof length 7.2 mm

Number of visual relocations: 2
Location: near capture site
Distance from capture site:
Response time: 6.1 hours

Carcass condition and disposition: 60% consumed. Skeleton intact, limbs articulated and hide attached, remainder of carcass including head & neck are skinned and hide is missing, all viscera removed, back and hind leg flesh removed, lower portion of ribs are missing but ribs are not broken, tendons are stripped of flesh but they remain as string-like, puncture wound with subcutaneous hemmorrhages on right mandible (behind eye). Avian scats and scavengers (Jaegers) present.

Necropsy findings:

Mortality category: Predation and scavenging involved, undetermined predator, avian scavenger (Jaeger), starvation, probable study-induced abandonment, predator kill and subsequently scavenged by birds.

Mortality Case History

Calf No: 7
Sex:
Captured: 4 June 1983
Location: foothills, east of Jago River

Weight:
Total length: 73 cm
Umbilicus condition: dry
Right hind foot length: 32.3 cm
Hoof condition: hard/worn
New hoof length: 7.2 cm
Health status: appeared healthy at capture
Processing time: 3 min
Estimated age at capture: 1 day old
Cow-calf reunion: Reunion not observed by capture crew. Calf observed unattended by dam 6.97 hours after release and was attended 27.8 hours after release.

Signal monitored: 33 times/ 134 day period
Number of visual relocations: 3
Mortality detected: 16 October 1983
Location: Upper Kongakut River
Carcass collected:
Distance from capture site: 106 km
Carcass weight:
Response time:
Total length:
Right hind foot length:
New hoof length

Carcass condition and disposition: Over 2 weeks old, only bone fragments and hair were found near collar and transmitter.

Necropsy findings:

Mortality category: Predation/scavenging involved. Predator/scaveger-probable mammalian.

Mortality Case History

Calf No: 14
Sex: female
Captured: 4 June 1983
Location: foothills east of Jago River

Weight: 7.8 kg
Total length: 81 cm
Umbilicus condition: dry
Right hind foot length: 34 cm
Hoof condition: hard/worn
New hoof length: 8.5 mm
Health status: appeared healthy at capture
Processing time: 4 min
Estimated age at capture: 3 days
Cow-calf reunion: Reunion not observed by capture crew. Calf observed attended by dam 3.65 hr following release.

Signal monitored: 30 times/ 56 day period
Number of visual relocations: 5
Mortality detected: 30 July 1983
Location: Pagilak River
Carcass collected: 31 July 1983
Distance from capture site:
Carcass weight:
Response time:
Total length:
Right hind foot length:
New hoof length

Carcass condition and disposition: 97% consumed, rib cage and leg bones and lower jaw found scattered. Bear scats (5) in the vicinity.

Necropsy findings:

Mortality category: Predation/scavenging involved. Predator/scavenger probable brown bear.

Mortality Case History

Calf No: 18
Captured: 4 June 1983

Sex: male
Location: foothills east of Jago River

Weight: 7.1 kg
Umbilicus condition: absent
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: 3 min

Total length: 74cm
Right hind foot length: 33.0 cm
New hoof length: 8.4 mm
Estimated age at capture: 3 days

Cow-calf reunion: Capture crew did not observe reunion. Calf observed unattended by dam 5.2 and 18.3 hrs. following release.

Signal monitored: 5 times/ 2 day period
Mortality detected: 6 June 1983
Carcass collected: 6 June 1983
Carcass weight: 6.3 kg.
Total length: 83.5 cm
Right hind foot length: 34 cm
New hoof length 6.5 mm

Number of visual relocations: 2
Location: Near capture site
Distance from capture site:
Response time: 43 min

Carcass condition and disposition: Lying on right side - no signs of trauma, carcass intact. No caribou in the area.

Necropsy findings: Vegetation in abomasum and rumen, milk absent. All other internal organs normal. No marks on carcass, no trauma.

Mortality category: Predation excluded, starvation, probable study induced abandonment.

Mortality Case History

Calf No: 20
Sex: male
Captured: 4 June 1983
Location: foothills, east of Jago River

Weight: 9.3 kg
Total Length: 82 cm
Umbilicus condition: absent
Right hind foot length: 35.0 cm
Hoof condition: hard/worn
New hoof length: 9.5 mm
Health Status: appeared healthy at capture
Processing time: 3 min
Estimated age at capture: 5 days old
Cow-calf reunion: Capture crew observed reunion immediately after release.

Signal Monitored: 33 times/ 60 day period
Number of Visual relocations: 4
Mortality detected: 3 August 1983
Location: Table Mtn.
Carcass collected:
Distance from capture site:
Carcass weight:
Response time:
Total length:
Right hind foot length:
New hoof length:

Carcass condition and disposition: No carcass was found. Collar partially torn.

Necropsy findings:

Mortality category: Predation/scavenging involved. Predator/scavenger undetermined.

Mortality Case History

Calf No: 28

Sex: female

Captured: 4 June 1983

Location: foothills west of Jago River

Weight: 8.4 kg

Umbilicus condition: dry

Hoof condition:

Health status: appeared healthy at capture

Processing time: 3 min

Total length: 83 cm

Right hind foot length: 33.5 cm

New hoof length: 9.1 mm

Estimated age at capture: 4 days

Cow-calf reunion: Capture crew did not observe reunion. Calf observed with dam 16.3 hr following its release.

Signal monitored: 5 times/ 2 day period

Number of visual relocations: 2

Mortality detected: 6 June 1983

Carcass collected: 6 June 1983

Carcass weight: 9.0 kg

Total length: 90 cm

Right hind foot length: 36.8 cm

New hoof length: 9.0 mm

Location: Near capture site

Distance from capture site:

Response time: 20 min

Carcass condition and disposition: Intact, lying on right side, cow with antlers and udder standing over carcass. No indication of trauma.

Necropsy findings: All internal organs normal, milk curds and vegetation in abomasum.

Mortality category: Predation excluded, undetermined cause-natural.

Mortality Case History

Calf No: 33
Sex: male
Captured: 5 June 1983
Location: coastal plain south of Barter Island.

Weight: 7.4 kg
Total length: 82 cm
Umbilicus condition: dry
Right hind foot length: 33.5 cm
Hoof condition: hard/worn
New hoof length: 8.2 mm
Health status: scouring - otherwise appeared normal
Processing time: 3 min
Estimated age at capture: 3 days
Cow-calf reunion: Capture crew did not observe reunion. Calf observed unattended by cow twice prior to death.
Signal monitored: 3 times/ 2 day period
Number of visual relocations: 2
Mortality detected: 6 June 1983
Location: Near capture site
Carcass collected: 6 June 1983
Distance from capture site:
Carcass weight: 1.7 kg
Response time: 7 hrs
Total length:
Right hind foot length:
New hoof length: 8.6 mm

Carcass condition and disposition: 75% consumed, viscera removed, tongue and right eye removed head and vertebrae attached, ribs broken. Small wounds with hemorrhage in throat region, lower maxilla broken, hind legs and sacrum missing.

Necropsy findings:

Mortality category: Predation involved, probable golden eagle kill, probable study-induced abandonment.

Mortality Case History

Calf No: 34
Sex: female
Captured: 5 June 1983
Location: coastal plain south of Barter Is.

Weight: 6.3 kg
Total length: 77 cm
Umbilicus condition:
Right hind foot length: 32.0 cm
Hoof condition: hard/worn
New hoof length: 7.8 mm
Health status: scours - otherwise appeared healthy.
Processing time: 4 min
Estimated age at capture: 2 day
Cow-calf reunion: Capture crew observed reunion.

Signal monitored: 2 times/ 1 day period
Number of visual relocations: 0
Mortality detected: 6 June 1983
Location: Near capture site.
Carcass collected: 6 June 1983
Distance from capture site:
Carcass weight: 5.8 kg
Response time: 11 min
Total length: 87 cm
Right hind foot length: 32.5 cm
New hoof length: 6.9 mm

Carcass condition and disposition: Intact, lying on right side, no visible indication of trauma. A single cow within area and 2 other caribou.
Necropsy findings: Bruised lumbar region and right rib cage. Lungs clouded and bloody. Abomasum and rumen packed with vegetation, no milk present. All other internal organs and structures normal.
Mortality category: Predation excluded, pneumonia probable, capture related injuries or injuries due to rejection by cow, starvation, probable natural abandonment.

Mortality Case History

Calf No: 35
Captured: 5 June 1983

Sex: male
Location: coastal plain west of Barter Island.

Weight: 7.8 kg
Umbilicus condition: moist
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: 3 min
Cow-calf reunion: Capture crew observed reunion.

Total length: 82 cm
Right hind foot length: 34.0 cm
New hoof length: 8.4 mm
Estimated age at capture: 3 days

Signal monitored: 31 times/ 133 day period
Mortality detected: 16 October 1983
Carcass collected:
Carcass weight:
Total length:
Right hind foot length:
New hoof length

Number of visual relocations: 7
Location: East fork of Sheenjek River
Distance from capture site: 168 km
Response time:

Carcass condition and disposition: No carcass remains, collar intact but had tooth marks.

Necropsy findings:

Mortality category: Predation/scavenging involved. Predation/scavenger undetermined.

Mortality Case History

Calf No: 39
Captured: 5 June 1983

Sex: male
Location: coastal plain south of Barter Is.

Weight: 5.1 kg
Umbilicus condition: moist
Hoof condition: partially hard/worn slightly
Health status: appeared healthy at capture
Processing time: 4 min
Cow-calf reunion: Capture crew observed reunion.

Total length: 72 cm
Right hind foot length: 31.0 cm
New hoof length: 9.0 mm
Estimated age at capture: 3 days

Signal monitored: 2 times/ 1 day period
Mortality detected: 6 June 1983
Carcass collected: 6 June 1983
Carcass weight: 4.1 kg
Total length: 78 cm
Right hind foot length: 31.5 cm
New hoof length: 7.8 mm

Number of visual relocations: 0
Location: Near capture site.
Distance from capture site:
Response time: 38 min

Carcass condition and disposition: Lying on right side, 10% of carcass consumed, rump skinned open, sacrum flesh partially removed. Two glaucous gulls seen feeding on carcass. No cow in vicinity.

Necropsy findings: Slight congestion in lungs. Liver, heart, kidneys and bone marrow normal. Stomach and intestines not present.

Mortality category: Scavenging involved, avain scavengers (gulls), probable natural abandonment.

Mortality Case History

Calf No: 50
Captured: 5 June 1983

Sex: female
Location: coastal plain south of Barter Is.

Weight: 8.2 kg
Umbilicus condition: dry
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: 4 min

Total length: 84 cm
Right hind foot length: 34.0 cm
New hoof length: 8.2 mm
Estimated age at capture: 3 days

Cow-calf reunion: Capture crew observed reunion. Calf observed with dam 3 hrs after release.

Signal monitored: 4 times/ 2 day period
Mortality detected: 7 June 1983
Carcass collected: 7 June 1983
Carcass weight: 7.2 kg
Total length: 88 cm
Right hind foot length: 35.0 cm
New hoof length: 6.6 mm

Number of visual relocations: 2
Location: Near capture site.
Distance from capture site:
Response time:

Carcass condition and disposition: Intact - no external indication of trauma. No cow in vicinity.
Necropsy findings: No wounds on carcass. Vegetation in rumen and abomasum - no milk present. All other internal organs normal.
Mortality category: Predation excluded, starvation, probable natural abandonment.

Mortality Case History

Calf No: 51
Captured: 5 June 1983
Sex: female
Location: coastal plain south of Barter Is.

Weight: 6.7 kg
Total length: 77 cm
Umbilicus condition: absent
Right hind foot length: 33.0 cm
Hoof condition: hard/worn
New hoof length: 8.8 mm
Health status: Scouring - otherwise appeared healthy.
Processing time: 3 min
Estimated age at capture: 4 days
Cow-calf reunion: Calf attended by dam 2.95 hours after release.

Signal monitored: 13 times/ 9 day period
Number of visual relocations: 3
Mortality detected: 13 June 1983
Location: Lake south of VABM Bitty.
Carcass collected: 13 June 1983
Distance from capture site:
Carcass weight: 3.3 kg
Response time: 110 min
Total length:
Right hind foot length: 36 cm
New hoof length: 10.1 mm

Carcass condition and disposition: 90% consumed, hair, skin and bones scattered, skull crushed. Two immature golden eagles observed at carcass.

Necropsy findings: Round puncture wounds 11.4 to 22.7 mm diameter through skin of thoracic region.

Mortality category: Predation involved, mammalian predation (bear probable) and scavenging by golden eagles.

Mortality Case History

Calf No: 57
Sex: male
Captured: 5 June 1983
Location: coastal plain south of Barter Island.

Weight: 4.9 kg
Total length: 75 cm
Umbilicus condition: moist
Right hind foot length: 30.0 cm
Hoof condition: partially hard/worn slightly
New hoof length: 7.4 mm
Health status: appeared healthy at capture
Processing time: 2 min
Estimated age at capture: 1 day
Cow-calf reunion: Capture crew observed reunion.

Signal monitored: 12 times/ 9 day period
Number of visual relocations: 4
Mortality detected: 13 June 1983
Location:
Carcass collected: 13 June 1983
Distance from capture site:
Carcass weight: 4.5 kg
Response time: 1.5 hr
Total length:
Right hind foot length: 33 cm
New hoof length: 8.4 mm

Carcass condition and disposition: Head and neck intact, viscera removed, 20% of carcass consumed. One immature golden eagle at carcass.

Necropsy findings: Skull fractured below right eye, jaws broken at point of articulation. Puncture wounds and subcutaneous hemorrhages on right and left sides of skull and on right & left scapula. Flesh removed from right rib cage.

Mortality category: Predation involved, golden eagle kill.

Mortality Case History

Calf No: 59
Sex: male
Captured: 5 June 1983
Location: coastal plain south of Barter Is.

Weight: 7.7 kg
Total length: 86 cm
Umbilicus condition: moist
Right hind foot length: 36.0 cm
Hoof condition: hard/worn
New hoof length: 8.8 mm
Health status: appeared healthy at capture.
Processing time: 4 min
Estimated age at capture: 3 days
Cow-calf reunion: Calf observed with dam 2 hrs after release.

Signal monitored: 22 times/ 17 day period
Number of visual relocations: 2
Mortality detected: 21 June 1983
Location: Foothills east of Jago River.
Carcass collected: 21 June 1983
Distance from capture site:
Carcass weight: 5.6 kg
Response time: 1.27 hr
Total length:
Right hind foot length: 39 cm
New hoof length: 14.5 mm

Carcass condition and disposition: 65% consumed, tongue missing, left eye and ear missing, skeleton connected by skin, rumen and intestines 1-2 m from carcass, internal organs removed, right side of head not fed upon. Cow observed near carcass. Two immature golden eagles feeding on carcass.

Necropsy findings: Puncture wounds (3-9mm dia) on right scapula and hide of shoulder region. 3 ribs on left side removed (broken off near vertebrae). Hemorrhage in nasal cavity and around left side of skull.

Mortality category: Predation involved, golden eagle kill.

Mortality Case History

Calf No: 62

Sex: female

Captured: 7 June 1983

Location: coastal plain south of Barter Is.

Weight: 4.8 kg

Total length: 77 cm

Umbilicus condition: dry

Right hind foot length: 32 cm

Hoof condition: hard/worn

New hoof length: 7.3

Health status: appeared healthy at capture.

Processing time: 5 min

Estimated age at capture: 1 day

Cow-calf reunion: Capture crew observed reunion - subsequent monitoring not possible (transmitter not activated prior to release).

Signal monitored:________ times/__16__day period

Number of visual relocations: 0

Mortality detected: 23 June 1983

Location: Near capture site

Carcass collected: 24 June 1983

Distance from capture site:

Carcass weight: 1.5 kg

Response time: 24 hr

Total length:

Right hind foot length: 32.5 cm

New hoof length: 6.5 cm

Carcass condition and disposition: Lying on left side. Upper maxilla, rostrum and nose missing. Flesh and internal organs removed from right side of carcass, 80% consumed. Right zygomatic arch crushed. Tongue, ears and eyes removed. Bird scats present.

Necropsy findings:

Mortality category: Predation involved (probable brown bear), avian scavengers and (probable golden eagle and ravens).

Mortality Case History

Calf No: 63
Captured: 7 June 1983

Sex: male
Location: coastal plain south of Barter Is.

Weight: 6.2 kg
Umbilicus condition: bloody
Hoof condition: partially hard/worn
Health status: appeared healthy at capture
Processing time: 4 min

Total length: 78 cm
Right hind foot length: 32.5 cm
New hoof length: 7.6 mm
Estimated age at capture: 1 day

Cow-calf reunion: No reunion observed. Calf observed unattended by dam after release.

Signal monitored:________ times/__1__day period
Mortality detected: 8 June 1983
Carcass collected: 8 June 1983
Carcass weight: 5.4 kg
Total length: 81 cm
Right hind foot length: 33.5 cm
New hoof length: 8.5 mm

Number of visual relocations:
Location: Near capture site
Distance from capture site:
Response time:

Carcass condition and disposition: Sacrificed by project investigators when abandonment/starvation was apparent.

Necropsy findings: Abomasum empty - organs normal.

Mortality category: Predation/scavenging starvation (sacrifice) excluded, probable study-induced abandonment.

Mortality Case History

Calf No: 64
Sex: female
Captured: 7 June 1983
Location: foothills near Jago River.

Weight: 5.9 kg
Total length: 79 cm
Umbilicus condition: bloody
Right hind foot length: 32.5 cm
Hoof condition: hard/worn (slt)
New hoof length: 8.5 mm
Health status: appeared healthy at capture.
Processing time: 4 min.
Estimated age at capture: 1 days
Cow-calf reunion: Capture crew did not observe reunion. Calf was abandoned by dam.

Signal monitored: 2 times/ 2 day period
Number of visual relocations: 0
Mortality detected: 8 June 1983
Location: Near capture site.
Carcass collected: 8 June 1983
Distance from capture site:
Carcass weight: 5.5 kg
Response time:
Total length: 80 cm
Right hind foot length: 32.5 cm
New hoof length: 7.5 mm

Carcass condition and disposition: Sacrificed by project investigators when abandonment was apparent and starvation imminent.

Necropsy findings: Abomasum empty - all other organs normal.

Mortality category: Predation/scavenging excluded, starvation (sacrifice), probable study induced abandonment.

Mortality Case History

Calf No: 65 | Sex: female
Captured: 7 June 1983 | Location: foothills near Jago River.

Weight: 8.1 kg | Total length: 87 cm
Umbilicus condition: moist | Right hind foot length: 37.0 cm
Hoof condition: hard/worn | New hoof length: 8.4 mm
Health status: appeared healthy at capture.
Processing time: 5 min | Estimated age at capture: 3 days
Cow-calf reunion: Capture crew did not observe reunion. Calf observed with dam 16.5 hours after release.

Signal monitored: 4 times/ 2 day period | Number of visual relocations: 1
Mortality detected: 9 June 1983 | Location: Near capture site.
Carcass collected: 9 June 1983 | Distance from capture site:
Carcass weight: 3.7 kg | Response time: 2 hr
Total length:
Right hind foot length: 38 cm
New hoof length: 7.8 mm

Carcass condition and disposition: 80% consumed, flesh and viscera removed. Tongue and 1 eye removed. Bird feathers and droppings present. No caribou in area.

Necropsy findings: Puncture wounds and hemorrhage above left eye and below left ear. Right side of rib cage intact. Left side of rib cage intact. Left side of rib cage partially missing.

Mortality category: Predation involved-golden eagle kill. Scavenging involved-gulls.

Mortality Case History

Calf No: 68 | Sex: female

Captured: 8 June | Location: coastal plain S. of Barter Island.

Weight: 5.1 kg | Total Length: 89 cm

Umbilicus condition: dry | Right hind foot length: 32.0 cm

Hoof condition: hard/worn | New hoof length: 8.4 mm

Health Status: scouring-otherwise appeared normal.

Processing time: 4 min | Estimated age at capture: 3 days old.

Cow-calf reunion: Not observed by capture crew.

Signal Monitored: 25 times/ 130 day period | Number of Visual relocations: 2

Mortality detected: 16 Oct. 1983 | Location: Upper Firth River

Carcass collected: 29 Oct. 1983 | Distance from capture site:

Carcass weight: | Response time: 13 days

Total length:

Right hind foot length:

New hoof length:

Carcass condition and disposition: Only partially intact skeleton remaining. Located in small stream bed embedded in ice. 80% of carcass missing.

Necropsy findings:

Mortality category: Predation/scavenging involved.

Mortality Case History

Calf No: 69
Sex: male
Captured: 8 June 1983
Location: coastal plain south of Barter Is.

Weight: 9.1 kg
Total length: 84 cm
Umbilicus condition: dry
Right hind foot length: 33 cm
Hoof condition: hard/worn
New hoof length: 8.3 mm
Health status: appeared healthy at capture.
Processing time: 4 min
Estimated age at capture: 3 days
Cow-calf reunion: Capture crew did not observe reunion. Calf was observed unattended by a dam @ 13 and 47 hr after reunion.

Signal monitored: 4 times/ 3 day period
Number of visual relocations: 1
Mortality detected: 11 June 1983
Location: Near capture site.
Carcass collected: 11 June 1983
Distance from capture site:
Carcass weight: 7.5 kg
Response time: 6 hr
Total length: 87 cm
Right hind foot length: 35.5 cm
New hoof length: 10.0 mm

Carcass condition and disposition: Intact, no external indication of trauma. No attending cow at carcass site.

Necropsy findings: Rumen and abomasum packed with vegetation, no milk present. All other internal organs normal.

Mortality category: Predation/scavenging excluded, starvation, probable study-induced abandonment.

Mortality Case History

Calf No: unmarked 01
Captured:

Sex: undetermined
Location:

Weight:
Umbilicus condition:
Hoof condition:
Health Status:
Processing time:
Cow-calf reunion:

Total Length:
Right hind foot length:
New hoof length:

Estimated age at capture:

Signal Monitored:________ times/_____day period
Mortality detected: 4 June 1983
Carcass collected: 4 June 1983
Carcass weight:
Total length:
Right hind foot length:
New hoof length: 7.3 mm

Number of Visual relocations:
Location: southeast of VABM Bitty
Distance from capture site:
Response time:

Carcass condition and disposition: Brown bear feeding on carcass. Upper portion of head, mid-back and all viscera were missing. Carcass warm.

Necropsy findings:

Mortality category: Predation involved - brown bear kill.

Mortality Case History

Calf No: unmarked 02
Captured:

Sex: male
Location:

Weight:
Umbilicus condition:
Hoof condition:
Health Status:
Processing time:
Cow-calf reunion:

Total Length:
Right hind foot length:
New hoof length:

Estimated age at capture:

Signal Monitored:________ times/_____day period
Mortality detected: 5 June 1983
Carcass collected: 5 June 1983
Carcass weight: 5.3 kg
Total length: 76 cm
Right hind foot length: 34 cm
New hoof length: 7.5 mm

Number of Visual relocations:
Location: near VABM Willa
Distance from capture site:
Response time:

Carcass condition and disposition: Three brown bears on 2 calf carcasses (unmarked 02 & 03). Calf dead. All viscera and lower portion of rib cage missing. 15% carcass consumed.

Necropsy findings: Skull broken and large wounds on shoulders. Shoulders are also bruised. Wound below right eye. Bruises on neck and behind left ear.

Mortality category: Predation involved-brown bear kill.

Mortality Case History

Calf No: unmarked 03
Captured:

Sex: female
Location:

Weight:
Umbilicus condition:
Hoof condition:
Health Status:
Processing time:
Cow-calf reunion:

Total Length:
Right hind foot length:
New hoof length:

Estimated age at capture:

Signal Monitored:________ times/_____day period
Mortality detected: 5 June 1983
Carcass collected: 5 June 1983
Carcass weight: 6.3 kg
Total length: 89 cm
Right hind foot length: 35 cm
New hoof length: 8.8 mm

Number of Visual relocations:
Location: near VABM Willa
Distance from capture site:
Response time:

Carcass condition and disposition: Calf still alive. Appears to be scouring. Three bears were on carcasses (unmarked 02 and 03). Carcass intact, sacrificed.

Necropsy findings: Lumbar region bitten as well as neck and head. Left scapula punctured. Abomasum full of mulk curds.

Mortality category: Predation involved-brown bear kill.

Mortality Case History

Calf No: unmarked 04
Sex: undetermined
Captured:
Location:

Weight:
Total Length:
Umbilicus condition:
Right hind foot length:
Hoof condition:
New hoof length:
Health Status:
Processing time:
Estimated age at capture:
Cow-calf reunion:

Signal Monitored:________ times/_____day period
Number of Visual relocations:
Mortality detected: 9 June 1983
Location: upper Okerokovik River
Carcass collected: 9 June 1983
Distance from capture site:
Carcass weight: 6.9 kg
Response time:
Total length: 81 cm
Right hind foot length: 35.4 cm
New hoof length: 8.2 mm

Carcass condition and disposition: Carcass lying on left side. Only right side had been fed upon. Cow standing over carcass. Golden eagle sitting 30 m from carcass. Eagle casting near carcass.

Necropsy findings: Puncture wounds behind rib cage on left side. Abomasum full of milk curds. Bruise on left shoulder. Right lung missing.

Mortality category: Predation involved-golden eagle kill.

Mortality Case History

Calf No: unmarked 05
Captured:

Sex: undetermined
Location:

Weight:
Umbilicus condition:
Hoof condition:
Health Status:
Processing time:
Cow-calf reunion:

Total Length:
Right hind foot length:
New hoof length:

Estimated age at capture:

Signal Monitored:________ times/_____day period
Mortality detected: 13 June
Carcass collected: 13 June
Carcass weight: 9.9 kg
Total length:
Right hind foot length: 39 cm
New hoof length: 15.9 mm

Number of Visual relocations:
Location: S. VABM Bitty
Distance from capture site:
Response time:

Carcass condition and disposition: 15% of carcass missing. Puncture wound at rear of right orbit. Hole into body cavity right rib cage. Subcutaneous hemmorrhages around wounds.

Necropsy findings: Lung partially consumed. Milk curds in abomasum.

Mortality category: Predation involved-probable golden eagle kill. Two eagles nearby on another dead calf (#51).

Table A-1. Chronology of calving, calf mortality, udder distention, and antler drop (#) of 23 radio-collared control cows in the Porcupine caribou herd, 1983[a]

Cow #	May		June																													
and Status	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
BKY-0:																																
calf	-	-	N	Y	Y	-	Y	-	-	Y	-	Y	Y	Y	-	-	-	Y	-	-	Y	-	Y	-	-	Y	-	-	Y	-	-	-
udder	-	-	U	U	U	-	U	-	-	U	-	U	U	U	-	-	-	U	-	-	U	-	U	-	-	U	-	-	U	-	-	-
antlers	-	-	2	2	2	-	2	-	-	1	-	U	0	-	-	-	-	0	-	-	0	-	0	-	-	0	-	-	0	-	-	-
BKY-1:																																
calf	-	-	N	N	N	-	N	N	-	-	-	-	N	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
udder	-	-	U	N	N	-	N	N	-	-	-	-	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
antlers	-	-	2	2	2	-	0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BKY-2:																																
calf	-	-	N	N	N	-	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
udder	-	-	N	N	U	-	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
antlers	-	-	0	0	U	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BKY-3:																																
calf	-	-	N	N	N	N	N	Y	-	Y	Y	Y	-	Y	-	-	Y	Y	-	-	Y	-	Y	-	-	Y	-	-	Y	-	-	-
udder	-	-	U	Y	Y	N	N	U	-	U	U	U	-	U	-	-	U	U	-	-	U	-	U	-	-	U	-	-	U	-	-	-
antlers	-	-	2	2	2	2	2	2	-	2	2	2	-	2	-	-	U	0	-	-	0	-	0	-	-	0	-	-	0	-	-	-
BKY-6:																																
calf	-	-	N	N	N	N	N	Y	Y	Y	Y	Y	-	-	-	Y	-	-	Y	-	-	Y	-	-	-	Y	-	-	Y	-	-	-
udder	-	-	U	U	U	U	N	U	U	U	U	U	-	-	-	U	-	-	U	-	-	U	-	-	-	U	-	-	U	-	-	-
antlers	-	-	2	2	2	2	2	2	2	2	2	2	-	-	-	0	-	-	0	-	-	0	-	-	-	0	-	-	0	-	-	-
BKY-7:																																
calf	-	-	N	N	N	-	N	-	-	N	-	N	N	N	-	-	-	Y	-	N	N	-	N	-	-	N	-	-	-	-	-	-
udder	-	-	U	U	Y	-	Y	-	-	U	-	Y	Y	Y	-	-	-	U	-	Y	Y	-	Y	-	-	U	-	-	-	-	-	-
antlers	-	-	2	2	1	-	1	-	-	1	-	1	0	0	-	-	-	0	-	0	0	-	0	-	-	0	-	-	-	-	-	-
BKY-10:																																
calf	-	-	N	N	-	-	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
udder	-	-	N	N	-	-	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
antlers	-	-	0	0	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BKY-12:																																
calf	-	-	N	Y	Y	Y	Y	-	-	Y	Y	Y	Y	Y	-	N	-	Y	-	-	Y	-	Y	-	-	Y	-	-	N	Y	-	-
udder	-	-	U	U	U	U	Y	-	-	U	U	U	U	U	-	U	-	U	-	-	U	-	U	-	-	U	-	-	U	U	-	-
antlers	-	-	2	2	2	2	2	-	-	2	1	1	U	1	-	U	-	U	-	-	U	-	U	-	-	U	-	-	U	U	-	-
BKY-16:																																
calf	-	-	N	N	N	-	-	N	-	-	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
udder	-	-	U	N	U	-	-	N	-	-	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
antlers	-	-	2	0	0	-	-	0	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BKY-18:																																
calf	-	-	N	-	Y	-	Y	-	-	Y	Y	Y	-	Y	-	-	-	-	Y	-	Y	-	Y	-	-	Y	-	-	Y	-	-	Y
udder	-	-	U	-	U	-	Y	-	-	U	U	U	-	U	-	-	-	-	U	-	U	-	U	-	-	U	-	-	U	-	-	U
antlers	-	-	2	-	2	-	2	-	-	2	2	0	-	0	-	-	-	-	0	-	0	-	0	-	-	0	-	-	0	-	-	0

Table A-1. (Ccontinued).

Cow # and Status	May 29	May 30	June 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
BKY-19:																																
calf	-	-	N	N	N	Y	Y	-	Y	-	-	Y	-	-	-	Y	-	-	Y	-	Y	-	Y	-	-	Y	-	-	Y	-	-	Y
udder	-	-	U	U	U	U	Y	-	U	-	-	U	-	-	-	U	-	-	U	-	U	-	U	-	-	U	-	-	U	-	-	U
antlers	-	-	2	2	2	2	2	-	2	-	-	2	-	-	-	0	-	-	0	-	0	-	0	-	-	0	-	-	0	-	-	0
BKY-20:																																
calf	-	-	N	N	N	-	N	-	-	Y	-	Y	Y	Y	-	-	-	Y	-	-	Y	-	Y	-	-	Y	-	-	-	-	-	-
udder	-	-	U	Y	U	-	Y	-	-	U	-	U	U	U	-	-	-	U	-	-	U	-	U	-	-	U	-	-	-	-	-	-
antlers	-	-	2	2	2	-	2	-	-	2	-	2	2	0	-	-	-	0	-	-	0	-	0	-	-	0	-	-	-	-	-	-
BKY-22:																																
calf	N	Y	N	N	N	N	-	-	-	-	-	-	-	-	-	-	-	-	-	N	-	-	-	-	-	-	-	-	-	-	-	-
udder	U	Y	U	Y	Y	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-
antlers	2	2	U	U	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
BKY-26:																																
calf	-	-	N	N	N	-	Y	-	Y	-	Y	Y	-	Y	-	-	Y	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
udder	-	-	U	U	Y	-	Y	-	U	-	U	U	-	U	-	-	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
antlers	-	-	2	2	2	-	2	-	0	-	0	U	-	0	-	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BKY-41:																																
calf	-	-	Y	Y	Y	-	Y	-	-	Y	Y	-	Y	Y	-	-	-	Y	-	-	Y	-	Y	-	-	Y	-	-	Y	-	-	-
udder	-	-	U	U	U	-	U	-	-	U	U	-	U	U	-	-	-	U	-	-	U	-	U	-	-	U	-	-	U	-	-	-
antlers	-	-	2	2	2	-	0	-	-	0	0	-	0	0	-	-	-	0	-	-	0	-	0	-	-	0	-	-	0	-	-	-
BKY-42:																																
calf	-	-	N	N	N	N	N	N	N	-	N	N	-	N	N	N	N	N	Y	Y	Y	-	N	-	-	N	-	-	-	-	-	-
udder	-	-	U	U	U	N	N	N	Y	-	Y	Y	-	Y	N	N	Y	Y	U	U	U	-	U	-	-	U	-	-	-	-	-	-
antlers	-	-	2	2	2	2	2	2	2	-	2	2	-	1	1	1	1	1	1	1	1	-	0	-	-	0	-	-	-	-	-	-
B-40:																																
calf	-	-	N	N	N	-	Y	-	-	Y	-	Y	Y	Y	-	-	-	Y	-	-	Y	-	Y	-	-	Y	-	-	-	-	-	-
udder	-	-	U	U	U	-	U	-	-	U	-	U	U	U	-	-	-	U	-	-	U	-	U	-	-	U	-	-	-	-	-	-
antlers	-	-	2	2	2	-	2	-	-	0	-	0	0	0	-	-	-	0	-	-	0	-	0	-	-	0	-	-	-	-	-	-
BY-1:																																
calf	-	-	N	N	N	N	N	N	-	-	N	N	N	N	N	-	N	N	N	N	Y	Y	Y	-	-	Y	-	-	-	-	-	Y
udder	-	-	U	U	U	U	U	U	-	-	Y	Y	Y	Y	U	-	Y	Y	U	Y	U	U	U	-	-	Y	-	-	-	-	-	Y
antlers	-	-	2	2	2	2	2	2	-	-	2	2	2	2	2	-	2	2	2	2	2	2	2	-	-	U	-	-	-	-	-	U
RY-4:																																
calf	-	-	-	-	-	-	-	-	-	-	-	Y	Y	Y	Y	-	-	Y	-	-	Y	-	Y	-	-	Y	-	-	Y	-	-	-
udder	-	-	-	-	-	-	-	-	-	-	-	U	U	U	U	-	-	U	-	-	U	-	U	-	-	U	-	-	U	-	-	-
antlers	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	-	-	0	-	-	0	-	0	-	-	0	-	-	0	-	-	-
RY-29:																																
calf	-	-	N	N	N	-	Y	-	-	N	N	Y	N	N	N	-	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
udder	-	-	U	Y	Y	-	Y	-	-	Y	Y	U	Y	Y	U	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
antlers	-	-	2	2	2	-	2	-	-	2	2	2	2	2	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table A-1. (Continued).

Cow # and Status	May		June																														
	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
GY-24:																																
calf	–	–	N	N	N	N	N	N	N	Y	Y	Y	–	Y	–	–	Y	Y	–	–	–	–	Y	–	–	Y	–	–	Y	–	–	Y
udder	–	–	U	U	U	Y	U	Y	Y	U	U	U	–	U	–	–	U	U	–	–	–	–	U	–	–	U	–	–	U	–	–	U
antlers	–	–	2	2	2	2	2	2	2	2	2	2	–	2	–	–	U	U	–	–	–	–	U	–	–	U	–	–	U	–	–	U
GY-25:																																
calf	–	–	–	–	–	–	–	–	–	–	–	–	–	–	N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
udder	–	–	–	–	–	–	–	–	–	–	–	–	–	–	N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
antlers	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
GY-27:																																
calf	–	–	Y	Y	Y	Y	Y	–	Y	–	Y	Y	–	Y	–	–	Y	–	Y	–	Y	–	Y	–	–	Y	–	–	Y	–	–	–
udder	–	–	U	U	U	U	U	–	U	–	U	U	–	U	–	–	U	–	U	–	U	–	U	–	–	U	–	–	U	–	–	–
antlers	–	–	2	2	2	2	0	–	0	–	0	0	–	0	–	–	0	–	0	–	0	–	0	–	–	0	–	–	0	–	–	–

[a] N=no; Y=yes; U=undetermined.

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SPECIES ACCOUNTS OF MIGRATORY BIRDS AT THREE STUDY AREAS ON THE COASTAL PLAIN OF THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1983

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Key words: Anseriformes, Charadriiformes, waterfowl, shorebirds, tundra, wetlands, species accounts, habitat use, status and distribution, Arctic-Beaufort, north slope

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30 January 1984

Species accounts of migratory birds at three study areas on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1983

The following species accounts describe status, breeding chronology, migration and habitat use of bird species at 3 areas 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 1983 (Spindler et al. 1984). Each study area is considered separately, despite overlap of component species and habitat types for ease of comparison by field crews in future seasons. Information is given for 45 species of birds at Okpilak River delta study area; 51 bird species at Katakturuk river study area, down river to Simpson Cove and 56 species at Jago river-Bitty study area and the Jago River drainage upriver to the foothills. In addition, status is given for species which were present in previous years (Spindler 1978, Spindler and Miller 1983) but were not observed in 1983. Further comparisons are given for other species which had important differences in population densities or habitat use between 1983 (Spindler et al. 1984) and previous years at the Katakturuk and Okpilak study areas (Spindler 1978, Spindler and Miller 1983), or suggested a change in overall status on the coastal plain of the ANWR (U.S.F.W.S. 1982)

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 approximately 1 June and 18 August with some breaks during the season when researchers visited 3 other areas. Therefore first and last dates of observations and first dates of hatching or young may not be all inclusive.

Status and abundance terminology for birds follows Kessel and Gibson (1978) using these categories: abundant, common, fairly common, uncommon, rare, casual, accidental, resident, migrant, breeder, and visitant. Species accounts are presented in phylogenetic order with nomenclature following American Ornithologist's Union (1983). The 2 redpoll species (common redpoll and hoary redpoll) were lumped for the purposes of this report due to confusion in field identification and because several investigators have considered them to be conspecific (Williamson 1961, and Troy 1980). Habitat types follow Walker et al. (1982) with modifications described in Spindler et al. (1984).

Status and distribution data and life history information for species in the following list and from 3 additional study areas where new plots were surveyed in 1983 as well as from Barter Island and other areas with limited observations or information was entered on computer tape using "Quick Data Base" and will be synthesized in subsequent reports. Bird species observed at Sadlerochit Delta, Jago Delta and Aichilik River study areas and on Barter Island are listed on Table 1 with breeding species indicated.

Table 1. Bird species observed at Aichilik River, Sadlerochit Delta, and Jago Delta study areas and Barter Island, Arctic National Wildlife Refuge, Alaska, May-November 1983. Presence (X), breeding (B) or probable breeding (prob B), and species found only in the foothills region of the Aichilik River drainage upstream from the study area (F) are indicated.

Species	Aichilik River	Sadlerochit Delta	Jago Delta	Barter Island
Common loon				X
Yellow-billed loon			X	X
Red-throated loon	X	X-B	X-B	X
Arctic loon			X-B	X
Short-tailed shearwater				X
Tundra swan			X	X-B
Greater white-fronted goose				X
Snow goose				X
Brant		X		X
Canada goose				X
Green-winged teal				X
Northern pintail		X-B	X-B	X
American wigeon				X
Common eider		X-B		X
King eider				X
Spectacled eider				X-B
Harlequin duck	X			
Oldsquaw		X-B	X-B	X
Black scoter				X
Surf scoter				X
White-winged scoter				X
Red-breasted merganser	X	X	X	X
Northern harrier		X		
Rough-legged hawk	X(F)	X		
Golden eagle	X			
American kestrel				X
Peregrine falcon				X
Willow ptarmigan	X			X
Rock ptarmigan	X-B	X-B		
Sandhill crane		X	X	X
Black-bellied plover		X	X	X
Lesser golden-plover	X-B	X-B	X-B	X-prob B
Semipalmated plover	X-B(F)			X
Lesser yellowlegs				X
Spotted sandpiper	X-B(F)			
Ruddy turnstone	X	X	X	X
Sanderling				X
Semipalmated sandpiper	X	X-prob B	X	X-B
Least sandpiper	X			
White-rumped sandpiper			X	X
Baird's sandpiper	X-B(F)	X	X-B	X
Pectoral sandpiper	X-B	X-prob B	X-B	X-prob B
Dunlin		X	X	X-prob B
Stilt sandpiper		X	X	
Buff-breasted sandpiper		X	X-B	X

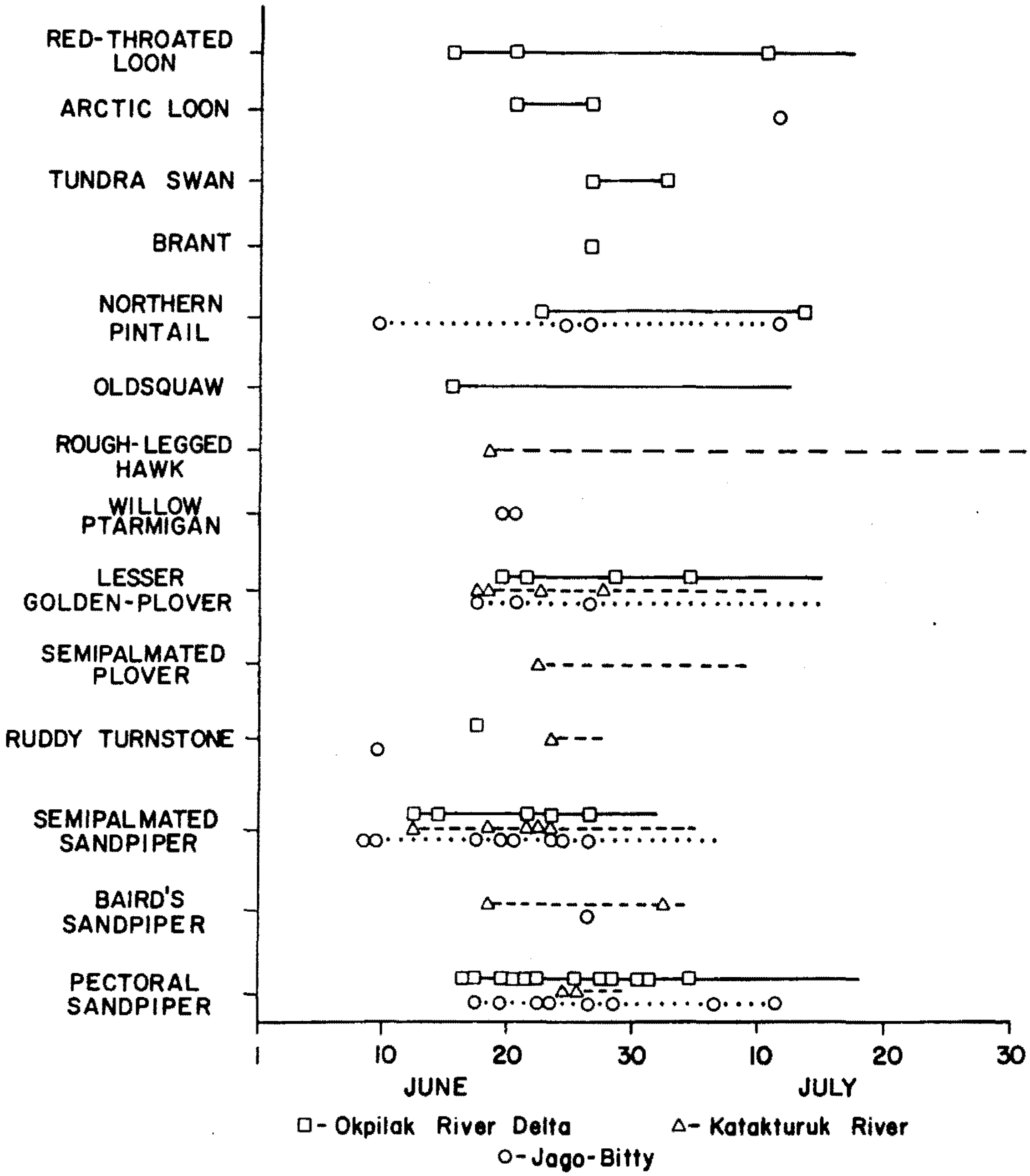
Table 1. Continued.

Species	Aichilik River	Sadlerochit Delta	Jago Delta	Barter Island
Long-billed dowitcher		X-prob B	X	X
Common snipe	X			
Red-necked phalarope		X		X
Red phalarope			X	X
Pomarine jaeger				X
Parasitic jaeger	X	X-B	X	X
Long-tailed jaeger	X	X	X	X
Bonaparte's gull				X
Herring gull		X		X
Thayer's gull				X
Slaty-backed gull				X
Glaucous gull	X	X-prob B	X	X
Black-legged kittiwake				X
Ross' gull				X
Sabine's gull				X
Ivory gull				X
Arctic tern	X	X-prob B	X	X
Black guillemot		X		X
Snowy owl			X	X
Short-eared owl	X(F)			X
Common nighthawk				X
Say's phoebe	X(F)			
Horned lark				X
Cliff swallow	X-B(F)			X
Northern raven	X	X	X	X-prob B
American robin	X(F)			
Varied thrush		X		
Yellow wagtail	X		X	
Water pipit	X(F)			
Northern shrike	X-B(F)			
Wilson's warbler				X
American tree sparrow	X(F)			X
Savannah sparrow	X-B	X	X	
White-crowned sparrow	X(F)			
Dark-eyed junco				X
Lapland longspur	X-B	X-B	X-B	X-B
Snow bunting	X-B(F)	X-prob B		X-B
Redpoll	X-B	X	X	X

RED-THROATED LOON - Common breeder. Red-throated loons were present in Pond/Sedge Tundra Complex and Aquatic Tundra throughout the period of field work from 12 June to 18 August. Courtship calling was common throughout this time with diminished frequency between 30 June and 10 July. Five nests were found in Pond/Sedge Tundra: the first on 16 June (Fig. 1) contained 1 egg, not incubated; 3 nests were being incubated at Camp Pond on 21 June; 1 nest was found 12 July, status unknown. First hatching was observed on 18 July with 1 downy young and 1 egg pipped in 1 nest; three other nests were still incubated on this date. More nests were found in 1983 than in 1982, when only 2 were found (Fig. 2). From 6 to 11 August, 9 family groups with a total of 13 young were observed within a 5.6 km radius of camp, with not all suitable habitat searched within this area. Five groups had 1 young each and in 4 instances 2 young were seen. Usually only 1 adult was attending the young at a time (6 of 9 observations). Red-throated loons were more commonly seen or heard in August than during other months as they vocalized in flight between Pond/Sedge Tundra breeding areas and coastal lagoon or ocean feeding areas.

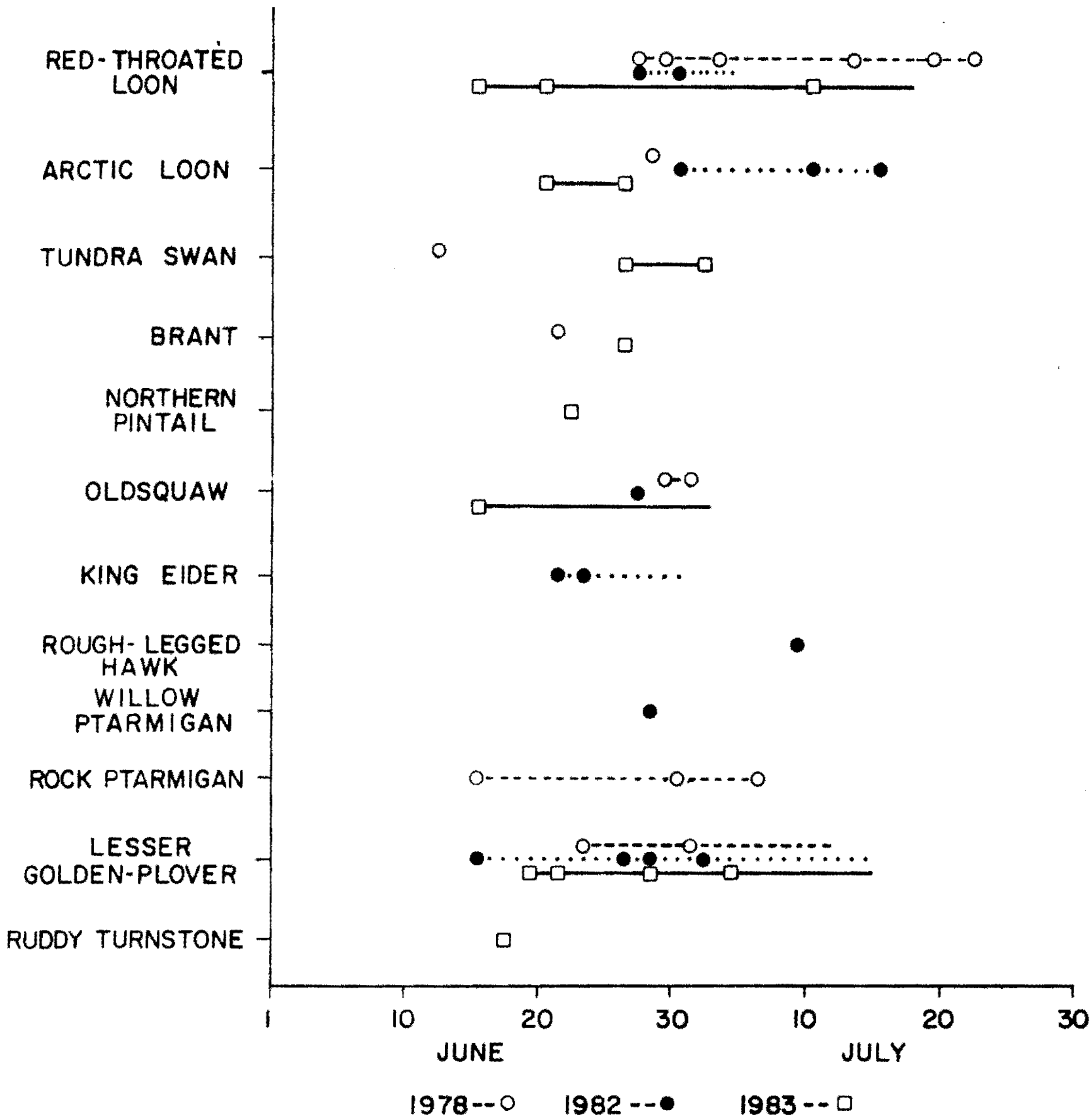
ARCTIC LOON - Common breeder. Arctic loons were present throughout the duration of field work from 12 June to 18 August. Several were observed flying and courtship-calling between 12 and 15 June; many were present in Aquatic Tundra on 17 June. First nest building was observed at the edge of Aquatic Tundra in Camp Pond 21 June (Fig. 1). A second nest was found being incubated 27 June, still earlier than incubation dates recorded in 1978 or 1982 (Fig. 2). Although only 2 nests were found, 7 family groups were observed on 6 to 18 August within 4.8 km of camp. The majority of family groups consisted of a pair of adults with 1 young, but 2 or 3 young per group were also observed. Vocalization was common throughout the breeding season, with increased levels of this and courtship "dancing" displays noted from 6 to 18 August after the conclusion of incubation and hatching of young. Flocks of arctic loons, numbering as many as 17, were observed in Camp Lake on 17 and 18 August.

TUNDRA SWAN - Uncommon breeder. Singles and pairs were seen almost daily from 12 June to 18 August, usually in Aquatic Tundra and lakes. They were less frequently observed in Riparian habitat along the Okpilak River: a pair was seen resting on gravel bar on 18 June, 3 were seen swimming in the river on 25 June; and 2 pairs foraged in a Riparian area and adjacent ridge on 16 July. One nest was found on 27 June, which consisted of a high mound of moss on a small island in Aquatic Tundra (east of plot 122). On 12 July the nest was checked and contained 3 eggs; a photographer remained in vicinity for about 1.5 h, during which time adults did not resume incubation. On subsequent days the adult was not observed incubating, though a pair remained in vicinity. The nest again was checked on 10 August, and observed to have failed with 1 cold egg still in the nest and 1 dead downy chick out of nest. The human disturbance may have occurred at a critical time and was suspected as a factor in this failure. A second nest was found 3 July at 3 Drum Marsh at a nest site which had been used in 1978 and probably was occupied in 1982. The nest was observed to have hatched by 15 July when 5 cygnets were seen swimming with a pair of adults in Aquatic Tundra and also were seen feeding on forbs on an adjacent pingo. Four young in this group had survived as of 8 August. A third nest site was observed near a pond north of 3 Drum Marsh on 23 June during an aerial swan



1983 CHRONOLOGY OF NESTING AT THREE ARCTIC NATIONAL WILDLIFE REFUGE STUDY SITES

Fig. 1.



1978, 1982, 1983 CHRONOLOGY OF NESTING AT THE OKPILAK RIVER DELTA SITE

Fig. 2.

survey (Bartels et al. 1984), and 1 adult with 3 young were observed in adjacent Aquatic Tundra on 8 August. Two additional nests were found during the aerial swan survey for which other field observations were not collected; these were first found along ponds to the southeast of Riparian plots on 23 June, and on later survey, 3 young were observed in the company of paired adults in the area on 21 August (Bartels et al. 1984). Swans were observed more commonly in 1983 than 1982, and greater numbers of breeding pairs were found (Fig. 2). This corresponds with general findings of tundra swan populations for these years on the entire ANWR coastal plain (Bartels et al. 1984). A flightless, probably molting, swan was seen in Moist/Wet Sedge Tundra adjacent to a beaded stream 3 km northeast of camp on 8 August. The largest groups seen all summer consisted of 7 and 8 swans in ponds between the Okpilak River and Camp Lake on 16 August.

GREATER WHITE-FRONTED GOOSE - Uncommon spring migrant. Several flocks flew over the study area in June: a few on 14 June, 2 on 15,16,18 June, 6 on 20 June, 5 on 21 June, 8 on 22 June, 2 on 29 June.

SNOW GOOSE - Uncommon spring migrant. A flock of 26 snow geese foraged on sedges in Wet Sedge Tundra (northwest of plot 143) on 13 June. A flock of 6 was seen flying to the west 0.8 km northwest of camp on 19 June.

BRANT - Uncommon spring and fall migrant and rare breeder. It is likely that the major part of the brant spring migration was not observed in 1983 due to the late start of field work at Okpilak, 12 June. Small flocks were infrequently observed flying east (34 on 13 June, a few on 14 June, 5 on 16 June, 10 on 17 June, 6 on 19 June, 2 on 21 June, 16 on 22 June, 6 on 24 June, 1 on 25 June). Brant uncommonly used tundra wetland habitats: a flock of 10 foraged in Aquatic Tundra at 3 Drum Marsh 17 June and a flock of 7 foraged in Aquatic Tundra (east of plot 122) on 22 June. A nest being incubated on a small island in Aquatic Tundra was found 27 June, with the other member of the pair in the vicinity (Figs. 1 and 2). The nest was empty on 13 July with no evidence of its success or failure, but brant were not present in the area. The last observation of brant on the tundra was on 3 July when a flock of 4 was seen feeding in *Arctophila fulva* at 3 Drum Marsh. Brant were observed flying west on later dates (1 on 28 June, 10 on 8 July) and flying east (flocks of 40 and 10 on 17 August and 30 on 18 August).

CANADA GOOSE - Uncommon summer visitant. First observation was on 18 June of a flock of 3 seen swimming in the Okpilak River. A flock of 6 was seen standing on a Riparian area along the Okpilak River on 2 July. Other observations were of a pair flying to the south, west, and north over the study area on 21, 28 June, and 11 July respectively.

GREEN-WINGED TEAL - Rare summer visitant. Two sightings were made in 1983: 2 males were seen swimming in the Okpilak River on 24 June; a single male swam with a flock consisting of 1 female northern pintail and 2 female oldsquaw in a small creek about 4 km south of camp (adjacent to plot 144) on 9 July. The species was not observed in 1982 and a single male was observed in 1978.

NORTHERN PINTAIL- Fairly common breeder and fall migrant. Small groups, pairs, and singles were seen almost daily in all habitats from 13 June to 18

August. Two active nests were found, the first on 23 June (Fig. 1) with a female incubating 9 eggs in the nest located in Moist Sedge-Shrub (plot 152). This nest was still being incubated on 29 June but appeared to have been predated when checked on 9 July. An earlier nest was suspected on 19 June with "nesty" female behavior observed in Moist/Wet Sedge Tundra (plot 143). On 5 July, an empty nest was found in this area unattended. On this same date a nest with 9 eggs incubated by a female was found on an adjacent plot, likely a second nesting effort. The nest apparently hatched by 18 July. First young were seen on 8 August. Five family groups consisting of 1 to 2 females with 1 to 10 young were observed between 8 to 10 August and were probably the results of reproductive effort in addition to the nests found. In 1983 breeding appeared to be more common than in 1982, when no nests were found although a few young of the year were seen, and 1978 when no evidence of breeding was found (Fig. 2). This was suspected to correspond to drought conditions on North American prairie pothole breeding areas as described for previous years by Derkson and Eldridge (1980). The latest observation was of a flock of 20 pintails resting on a partially vegetated mudflat in Arey Lagoon 17 August.

AMERICAN WIGEON - Rare spring migrant. In 1982 a single wigeon was seen flying east over camp on 9 June. None were observed in 1978 or 1983.

EUROPEAN WIGEON - Casual spring migrant. In 1978 a pair was observed at Three-Drum Marsh on 12 June. None were seen in 1982 or 1983.

GREATER SCAUP - Rare summer visitant. A single sighting was made on 2 July in 1983 of a flock of 10 greater scaup swimming with 14 surf scoters in Camp Lake. Greater scaup were not observed in 1982 but flocks of 3 to 4 birds were seen in 1978.

COMMON EIDER - Uncommon spring migrant. Only a single sighting was made of a pair of common eiders circling over Aquatic Tundra at 3 Drum Marsh on 17 June.

KING EIDER - Uncommon spring migrant. The only sighting was of 2 birds flying over Arey Lagoon 0.8 km from camp on 27 June. In 1983, king eiders were not found breeding. In contrast to 1978, when 2 breeding pairs were observed and 1982 when 2 nests were found.

SPECTACLED EIDER - Rare spring migrant. A single sighting in 1983 was of 1 male flying south over Wet Sedge Tundra 2.4 km west of camp on 24 June. Spectacled eiders were more commonly observed in 1982 with 1 to 3 pairs sighted from 12 to 17 June, but were not observed during 1978.

OLDSQUAW - Common spring and fall migrant and breeder. Oldsquaw were seen almost daily during the entire field season from 13 June to 18 August. Pairs were observed in courtship display on 14 and 15 June in Pond/Sedge Tundra Complex and thermokarst pits in Moist/Wet Sedge. One nest found 16 June with 4 eggs, contained 9 eggs as of 7 July (Figs. 1 and 2). The female was last observed incubating the nest on 13 July; the nest was empty and apparently hatched on 17 July. During incubation the female remained on the nest during approaches by observers within 1 m; therefore it is probable that other oldsquaw nests were overlooked. The first young were observed on 6 August in Aquatic Tundra. A total of 6 family groups with 35 young (5-7 per group) were observed between 8 and 18 August in Pond/Sedge Tundra and in lakes within 3.2 km of camp. A flock of 10 males roosted on shoreline bluffs and swam near the shore of Arey Lagoon 4 July. Larger flocks of males and/or females were seen on lakes starting in midsummer: 17 adults in a flock on 17 July; 35 juveniles with adults on 13 August; and 7 juveniles with 6 adults in Camp Lake on 18 August.

SURF SCOTER - Rare summer visitant. A flock of 14 was seen swimming with a flock of greater scaup at Camp Lake on 2 July. Surf scoters were not observed during 1978 or 1982.

WHITE-WINGED SCOTER - Rare spring and summer migrant. A pair was observed flying south on 15 June 1982 and 4 were seen flying west on 1 July 1978. None were observed in 1983.

RED-BREASTED MERGANSER - Rare summer visitant. Two females were seen swimming in the Okpilak River on 2 July 1983. Red-breasted mergansers were not observed during 1978 or 1982.

NORTHERN HARRIER - Rare summer visitant. A single sighting occurred in 1983; 1 female or immature individual was seen hunting over Riparian habitat along the Okpilak River on 2 July. This species was more frequently observed in 1982 but in 1978 no sightings were made.

ROUGH-LEGGED HAWK - Rare breeder. Rough-legged hawks were not observed in 1983 and only 1 sighting of 2 birds was made on 4 June 1978. This contrasts with 1982 when numerous sightings were made and 1 nest was found on flat Moist Sedge-Shrub Tundra (Fig. 2).

GOLDEN EAGLE - Uncommon summer visitant. The first observation was of an immature eagle which hunted over Moist Sedge Shrub Tundra, 4 km south of camp on 15 June. Single eagles were seen flying over Riparian habitat near the Okpilak River 5 km southwest of camp; flying over Wet Sedge 5.5 km southeast of camp on 26 June; an immature standing on 3 Drum pingo 3 July; an immature was present along Okpilak River on 16 July. Eagles were more commonly observed in 1983 than in 1978 or 1982.

WILLOW PTARMIGAN - Uncommon breeder. Willow ptarmigan were not observed in 1983, but in 1978 and 1982 nests were found in Moist Sedge-Shrub Tundra (Fig. 2).

ROCK PTARMIGAN - Uncommon summer resident. Single rock ptarmigan were seen in Moist Sedge-Shrub habitat on 15 June and 8 July, and in Moist/Wet Sedge 3-5 km south of camp 18 and 26 June. In 1983 rock ptarmigan were less commonly observed and breeding was not noted as compared to nests found in 1978 (Fig. 2) and subadults seen in 1982.

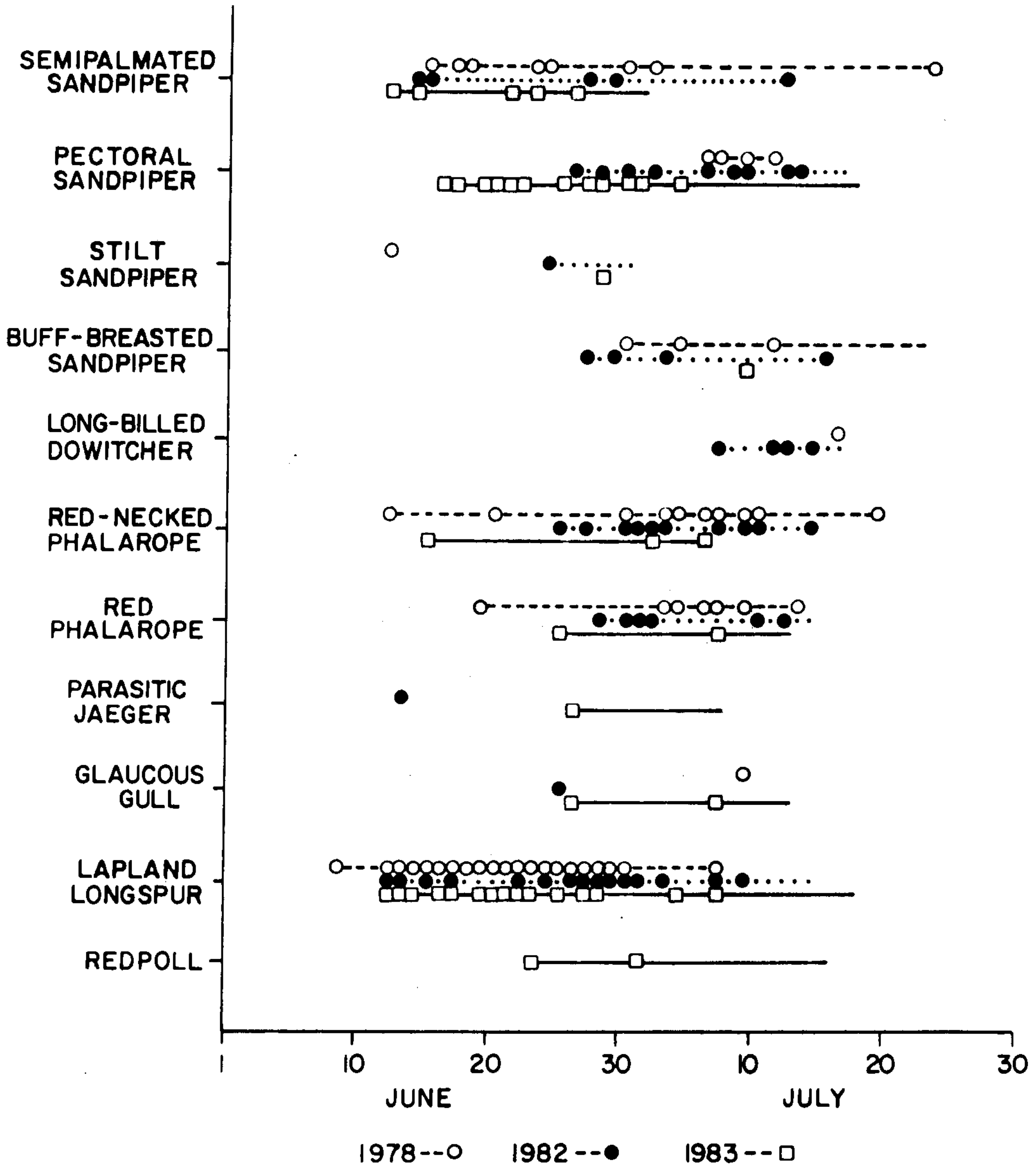
SANDHILL CRANE - Uncommon summer visitant. Sandhill cranes were most frequently observed in June. Single individuals were seen flying west over the study area on 13, 14, 16 and 19 June. One crane foraged in Moist/Wet Sedge Tundra on 21 and 22 June, and at Camp Pond on 23 June. A pair of cranes was seen flying east 23 June. Crane pairs were observed calling on 25 June 1.6 km northwest of camp; flying south near the Okpilak River 2 July; calling in Wet Sedge and feeding in Moist/Wet Sedge habitat on 16 and 17 August.

BLACK-BELLIED PLOVER - Uncommon fall migrant. Black-bellied plovers were only observed during fall migration in 1983, whereas in 1982 and 1978 sightings were also made in the spring. First observation was of 2 birds on polygon ridges of Wet Sedge Tundra on 6 August. Small flocks were observed in Wet Sedge and Pond/Sedge (4 on 7 August, 1 or 2 on 10-13 August, 3 on 17 August), and a flock of 5 seen with 4 lesser golden-plovers on an Okpilak River gravel bar on 16 August. Larger flocks of 17-25 black-bellied plovers were observed on 8 and 9 August in Wet Sedge and Pond/Sedge Tundra.

LESSER GOLDEN-PLOVER - Fairly common breeder, common fall migrant. Lesser golden-plovers were seen daily during field work between 12 June and 18 August, primarily in Moist/Wet Sedge but also less commonly in Moist Sedge-Shrub habitats. Four nests were found, 3 in Moist/Wet Sedge and 1 in Moist Sedge-Shrub on 20, 22, 29 June and 5 July. Three nests contained 4 eggs and 1 had 2 eggs. Presence of the first nest was suspected 14 June in Moist/Wet Sedge when defensive postures were noted but the nest was not found until 20 June. This nest began hatching 9 July with 2 of 4 eggs pipped, and by 10 July 3 young were hatched with the final egg pipped. Eggs were pipped at 2 other nests on 12 and 14 July. Back-dating from these known hatching dates yielded estimated nest initiation dates of 11, 14, and 16 June, based on an incubation period of 28 days (Harrison 1978). Nest initiation was remarkably synchronous among the 3 study areas, however nesting continued longer at Okpilak than at the 2 other inland sites (Fig. 1). Flight-capable juveniles were seen with adults on 6 and 8 August, and independent immatures in flocks of 3 to 8 were observed from 8 to 18 August. An adult with a late brood of downy young, not capable of flying, was observed on 11 August near camp. Nesting chronology appeared later in 1983 than 1982 but earlier than 1978 (Fig. 2).

RUDDY TURNSTONE - Uncommon breeder. First observation was on 16 June, of a flock of 7 flying west over Aquatic Tundra. A nest with 4 eggs was found incubated by an adult in Riparian habitat along Okpilak River (plot 192B) on 18 June (Fig. 1), and was empty and apparently abandoned on 24 June. The last observation was made on 24 June, of 2 birds foraging on the river gravel bar approximately 400 m from the old nest site. In 1982 turnstones were not observed, but little time was spent by observers in appropriate habitats (Fig. 2). In 1978 turnstones were suspected to have nested at the lagoon beach and mudflat and were observed on river delta and river gravel bar habitats.

SEMIPALMATED SANDPIPER - Fairly common breeder. Many semipalmated sandpipers were present in Moist/Wet Sedge Tundra on 12 June, the first day of field observations. Courtship displays were common from 14 June, peaked in frequency 17 and 18 June, and occurred infrequently between 19-26 June. Eight nests were found between 13 and 28 June (Fig. 3), 5 in Moist/Wet Sedge, and 3 in Riparian. Of these nests, 7 contained 4 eggs and 1 had 3 eggs (mean clutch size = 3.99 ± 0.35 S.D.). Based on back-dating from known hatching dates, the majority of nests were initiated 6-9 June, considering a 17-19 day incubation period (Harrison 1978) and commencement of incubation with laying of third egg (Norton 1972). First hatching was observed on 27 June with peak hatching from 27 to 30 June, however, hatching was observed as late as 10 July at 1 nest (Fig. 4). First hatching of semipalmated sandpipers was observed synchronously (within a 24 hour period) at Okpilak, Jago-Bitty and Katakturuk study areas (Fig. 4). From 27 June - 10 July defensive adults called in the vicinity of their nests or chicks in Moist/Wet Sedge, Riparian or Wet Sedge habitats. Adults flocked with long-billed dowitchers, pectoral sandpipers, red phalaropes, red-necked



1978, 1982, 1983 CHRONOLOGY OF NESTING AT THE OKPILAK RIVER DELTA SITE

Fig. 3.

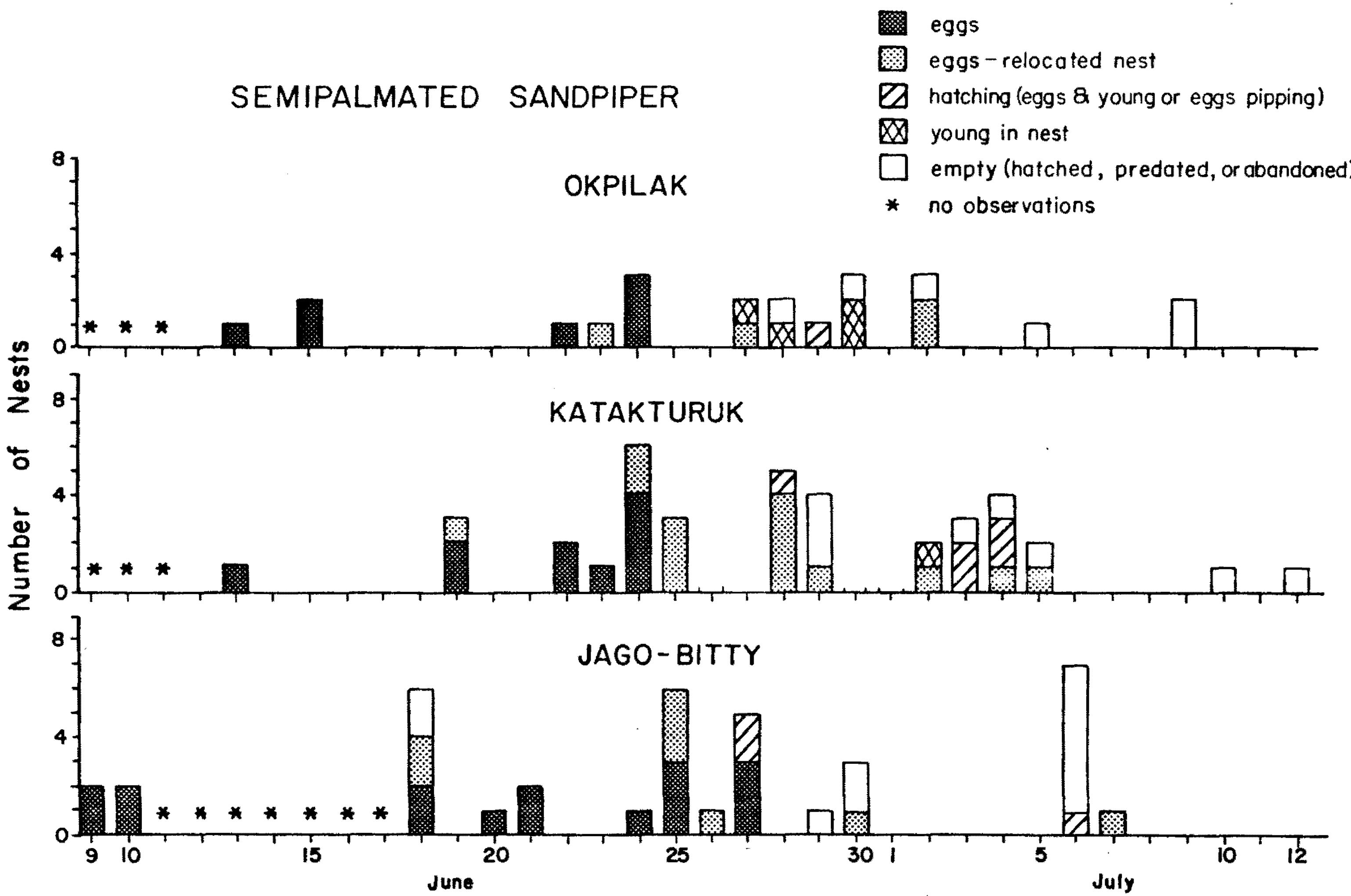


Fig. 4. Nesting chronology of the semipalmated sandpiper at the Okpilak River delta, Katakturuk River, and Jago River-Bitty study areas, Arctic National Wildlife Refuge, Alaska, 1983.

phalaropes and stilt sandpipers in defense of chicks of the various species, primarily in Pond/Sedge habitat from 3 to 12 July. On 3 July a flock of 6 adults behaved defensively in Moist-Wet Sedge habitat. After 13 July semipalmated sandpipers were infrequently observed on tundra habitats, except for Riparian where they were still common on 16 July. On 15 to 18 July, semipalmated sandpipers were usually seen in habitats adjacent to water, including 1 seen foraging along creek, 1 by Camp Pond and 1 by Camp Lake. Flocking was also observed on 17 July when about 10 semipalmated sandpipers were seen flying and foraging with about 90 pectoral sandpipers at 3 Drum Marsh. Semipalmated sandpipers were numerous in Moist/Wet Sedge Tundra adjacent to camp on 6 August, but were only subsequently observed once in tundra habitats; 2 fed in exposed mud areas (on plot 121) on 10 August. The latest observation of semipalmateds in the study area was on 16 August, of a flock of 3 on a mudflat along the Arey Lagoon shoreline.

Mean total population densities at Okpilak in 1983 were lower for 2 of 3 Flooded plots (2.5 birds/km^2) and Moist-Wet Sedge plots (0-5.0 birds/km^2), than in 1978 or 1982. Breeding populations in the Moist/Wet Sedge Tundra were significantly different between 1978, 1982, and 1983. Densities for Riparian plots (55.0-80.0 birds/km^2) were substantially higher than in all other habitats sampled at Okpilak, and were higher than levels recorded for Riparian habitat at Jago Bitty and Katakturuk in 1983.

LEAST SANDPIPER - Rare spring migrant. One to 3 least sandpipers were observed in 1978 foraging on Wet Sedge and Moist/Wet Sedge between 19 and 23 June. The species was not observed in 1982 or 1983.

WHITE-RUMPED SANDPIPER - Rare spring migrant and probable breeder. In 1978 a single bird was observed in Wet Sedge Tundra near the coast in June and a defensive adult was seen in coastal vegetated mudflats south of Barter Island twice in July. White-rumped sandpipers were not seen in 1982 or 1983.

BAIRD'S SANDPIPER - Uncommon summer visitant and fall migrant. A pair of Baird's sandpipers, 1 acting "nesty", was observed in Moist/Wet Sedge 1.6 km southeast of camp on 17 June. All other sightings of this species were made near the Okpilak River 3-5 km southwest of camp: 1 called from Riparian habitat on 25 June; a flock of 3 chased in flight over Riparian Willows on 2 July; 1 foraged on a gravel bar on 16 July; 2 roosted on a gravel bar near the river channel and then flew east on 16 August.

PECTORAL SANDPIPER - Common breeder and abundant fall migrant. Pectoral sandpipers were common during the entire period of field observations from 13 June to 18 August, and were present in all habitats.

Male courtship displays were common from 13 to 22 June and were infrequent during 25 June to 8 July, when only 1-3 males were observed per day in most habitats. In contrast to other habitats in the study area, primarily male pectorals were seen on Flooded plots on 27 June, actively courting and chasing in flocks of 2-5. Flocks of 5 and 6 males were also seen flying over Moist/Wet Sedge on 2 July. The last male was observed 9 July.

On 13 June, the first day afield, a female was observed in "rodent run" defense posture at a probable nest. The first nest was found 17 June in Moist/Wet Sedge, an earlier date than 1982 (27 June) or 1978 (7 July, Fig. 3). Based on back-dating from known hatching dates, assuming a 21-23 day incubation period (Harrison 1978), first clutch completion date was estimated to be between 7 and 9 June 1983. This was earlier compared to estimated dates in previous years: 17 to 19 June 1982, and 19 June 1978. Overall, this period of nesting was earlier in 1983 than in 1982 or 1978 (Fig. 3). Latest clutch completion date in 1983 was estimated to be 27 June. A total of 25 nests was found between 17 June-5 July in 4 habitats: 12 in Wet Sedge; 9 in Moist/Wet Sedge; 2 in Pond/Sedge; 2 in Moist Sedge-Shrub. Pectoral sandpipers sometimes had clumped distribution of nests. At 3 sites, 2 or 3 pectoral nests were located within 30-50 m of each other. A total of 23 nests had a clutch size of 4, and 2 had clutch size of 2, with a mean clutch size of 3.9 $\pm$ 0.4 (S.D.). First hatching probably occurred by 26-27 June when nests were found empty but first actual hatching was observed 2 July with a nest containing 2 eggs and 2 chicks (Fig. 5). By 5 July the majority of nests were empty, however eggs were found incubated as late as 18 July. Females displayed defensive behavior with their chicks from 5 to 18 July in all habitats, including Riparian where nests were not found. Overall, the Pectoral Sandpiper nesting period was very similar between Okpilak delta and Jago-Bitty (Figs. 1,5), but the period when nests had eggs was much longer at Okpilak than at the other 2 areas (Fig. 5). At Okpilak females flocked with long-billed dowitchers, semipalmated sandpipers, red-necked phalaropes, red phalaropes and stilt sandpipers in defense of their chicks as well as those of other species in Wet Sedge and Pond/Sedge habitats between 7 and 17 July. Flocks observed were: 4-6 females flying over Moist Sedge-Shrub on 9 July; 9 on Wet Sedge and 13 flying east on 12 July; and 4-6 at Camp Pond on 18 July. A flock of 90 pectorals of unknown sex flocked with 10 semipalmated sandpipers 17 July at 3 Drum Marsh. Breeding densities of pectorals in all habitats were similar to those found in 1982 but greater than those observed in 1978. Mean summer populations of pectorals were greater than found in either 1982 or 1978 in all habitats.

Pectoral sandpipers were abundant in the fall. Individuals and flocks of 2 to 10 were commonly seen in all habitats from 6 to 18 August. A single pectoral was seen on a sandy beach of Arey Lagoon 8 August; 3 were observed feeding in a spring-formed Wet Sedge area of Riparian habitat (plot 191) on 16 August. Primarily immature pectorals were abundant on Flooded plots on 10 August, in flocks usually ranging from 4-10, with larger flocks containing 14-30 birds also present on plot 123 which was wetter than other plots. On 16 to 18 August, numerous flocks of 2 to 5 pectorals were observed in eastward migration. Highest fall densities of pectorals were found in Flooded plots (300-650 birds/km^2) with this species making up 65-73% of total bird populations. On Flooded, Moist/Wet Sedge and Moist Sedge-Shrub plots, fall densities increased over mean summer populations, and pectorals comprised a greater proportion of total bird population than they did during summer. In 1983 pectorals comprised a larger proportion of fall bird populations than they did in 1982. Breeding populations, however, were not significantly different among the 3 years studied for the 4 habitat types censused in all years; Flooded, Wet Sedge, Wet/Moist Sedge, and Moist Sedge-Shrub.

DUNLIN - Uncommon spring migrant and summer visitant. In 1983 a single sighting was made of 1 dunlin, in breeding plumage, on the pingo VABM Mars on 21 July (C. Babcock and J. McCarthy, pers. comm.). One observation was made in 1982 of 4 dunlin feeding in Pond/Sedge Tundra on 7 June. In 1978 4 observations were made of 1-30 dunlin in habitats along the Arey Lagoon coast.

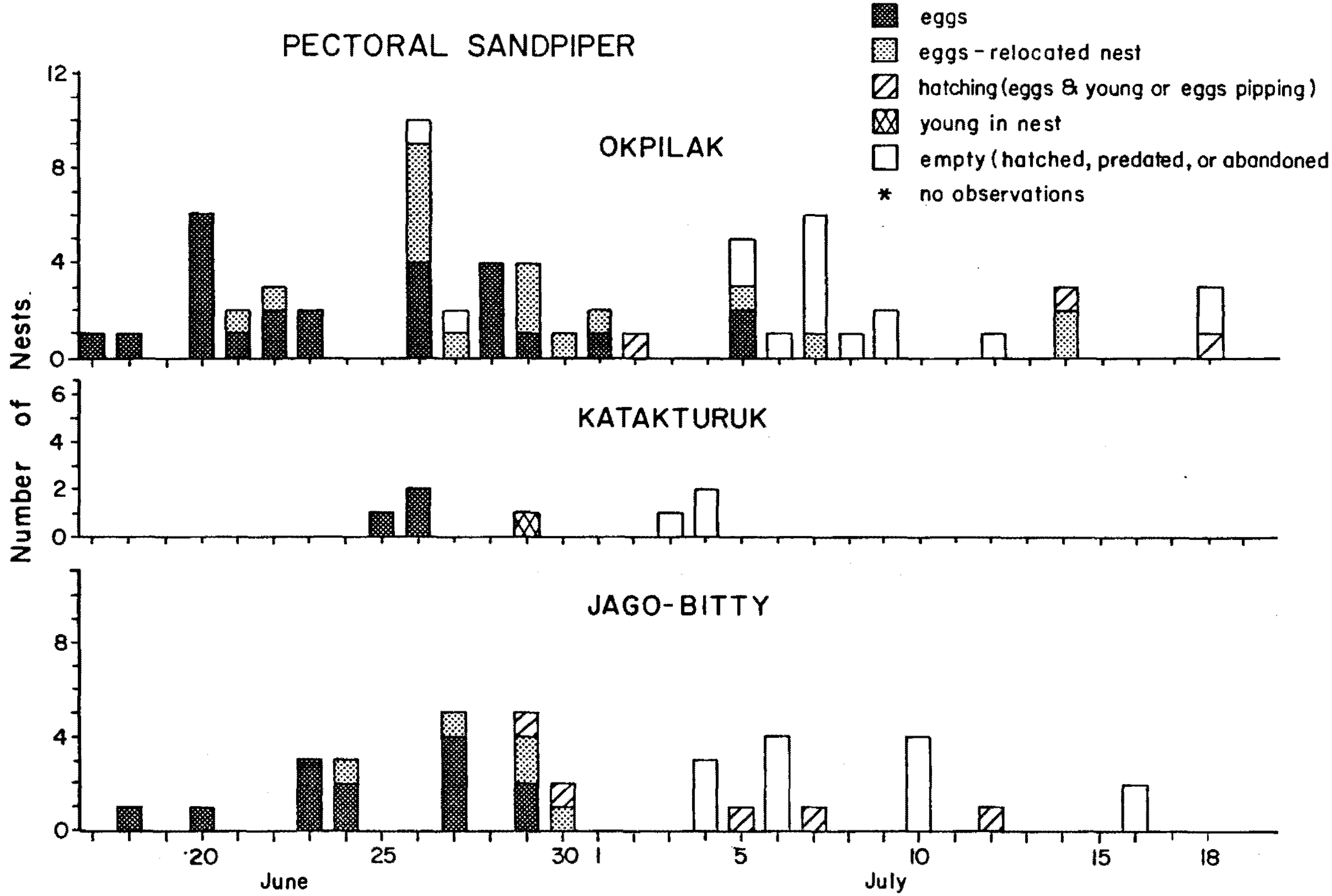
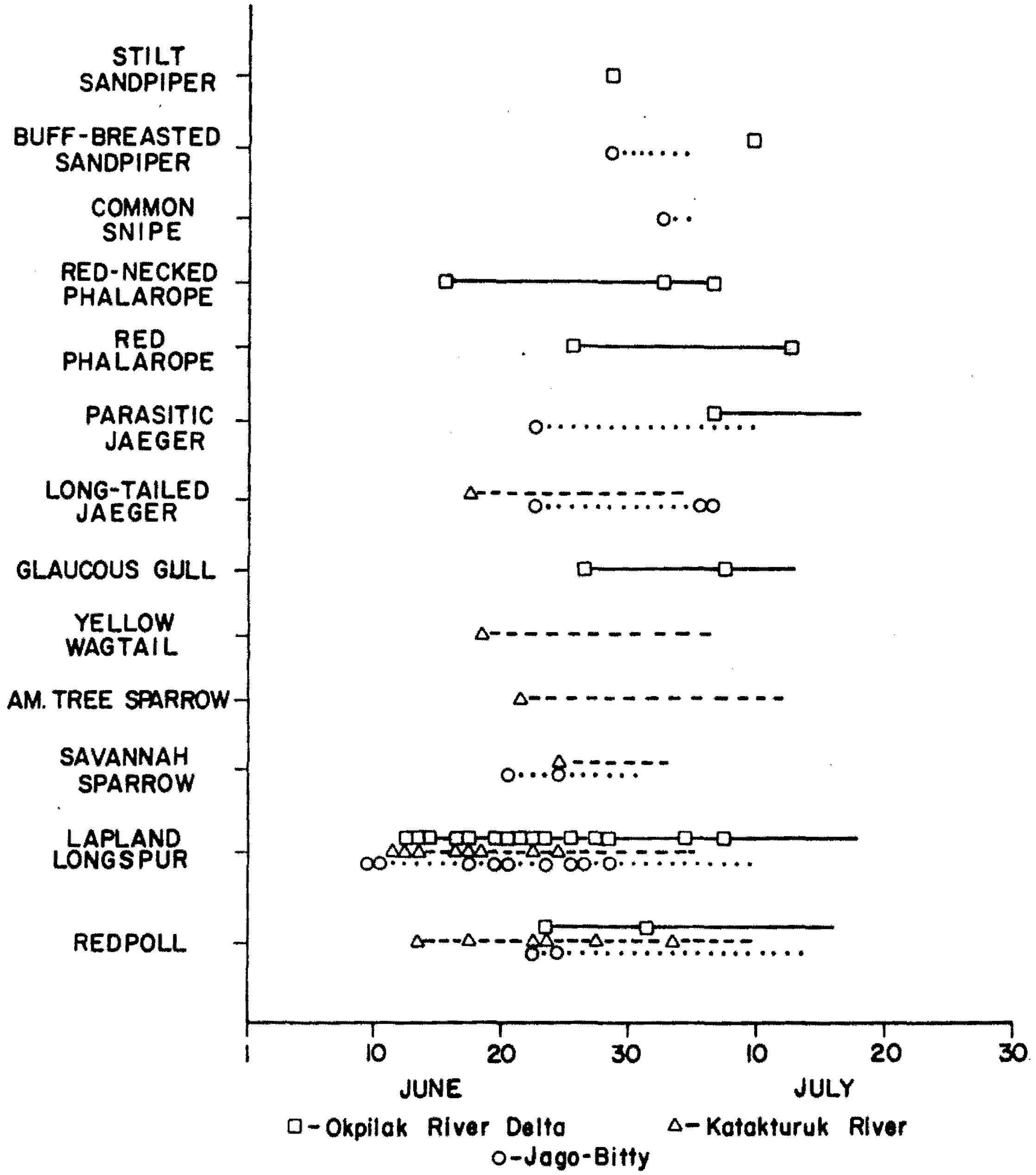


Fig. 5. Nesting chronology of the pectoral sandpiper at the Okpilak River delta, Katakturuk River, and Jago River-Bitty study areas, Arctic National Wildlife Refuge, Alaska, 1983.

STILT SANDPIPER - Uncommon breeder and rare fall migrant. First observation was made on 14 June, of a pair in aerial courtship display in Wet Sedge Tundra. Courtship displays were subsequently observed on 20, 23, 25, 29 June and 8, 9 July in Wet Sedge, Moist Sedge-Shrub and Moist/Wet Sedge Tundra. As in 1982, (Fig. 3) only 1 nest was found in 1983 on 29 June in Wet Sedge Tundra 1.6 km south of camp (Fig. 6). The nest was located on small a tussock in the middle of a low center polygon, and was in the process of hatching, with 1 egg, 1 chick in nest and 1 newly hatched chick out of the nest. The nest was empty on 30 June, with the pair of adults brooding 2 young at the edge of a small pond approximately 30 m from the nest site. Defensive adults were also observed in 2 other areas, in Moist-Wet Sedge and Wet Sedge Tundra at the edge of Camp Pond, on 3, 6, 7 June and on 15 July in Moist Sedge-Shrub Tundra approximately 3 km south of camp. Last observation was on 11 August, of a single stilt sandpiper in Moist/Wet Sedge Tundra 0.8 km northeast of camp.

BUFF-BREASTED SANDPIPER - Uncommon breeder. All sightings were in habitats adjacent to the Okpilak River approximately 4.5 km southwest of camp. A single individual standing on a river gravel bar was first observed 18 June. On 24 June a single buff-breasted flushed from *Dryas*-Prostrate Shrub, Forb tundra on a bluff above the river. The only nest seen in 1983 was found in the same vicinity with 4 incubated eggs on 10 July (Fig. 6). There were no other observations of this species in 1983. Not a single courtship display was seen in 1983, in contrast to previous years when the species was more common and nests were found in tundra habitats near camp (Fig. 3).

LONG-BILLED DOWITCHER - Fairly common breeder, common fall migrant. Long-billed dowitchers were regularly present in the Okpilak area by 12 June, an earlier date than previously recorded. Courtship display flights and calls occurred between 12 and 29 June in all habitats. The latest display was observed by a single bird on 8 July. Defensive behavior was first observed 4 July in Wet Sedge habitat adjacent to Camp lake. On 7 July, 5 very defensive pairs were observed in Pond/Sedge and Wet Sedge habitats south of Camp Pond and the first chicks of the season were suspected. Defensive behavior continued to be observed in Pond/Sedge and Wet Sedge habitats until 17 July when the first chicks were seen in Pond/Sedge habitat at the edge of Camp Pond. Patient watching and careful searching was necessary to locate the 3 downy, probably 3-4 day old chicks that were concealed at the bases of sedge clumps. The defensive adult, calling, flew in large circles around the observer, but repeatedly landed in vicinity of the chicks. No nests were found this year, possibly due to censuses being conducted by fewer people than in 1982, with therefore a greater chance of nests being overlooked since in 1982 all nests were found within 1-3 m of biologists. Defensive adults were still seen from 6 to 10 August in Pond/Sedge and Wet Sedge habitats. A juvenile dowitcher found on 10 August in Pond/Sedge Tundra was barely flight-capable, partially downy and had apparently hatched later than the chicks found on 17 July. A flock of immature birds foraged in the mud of a low center polygon near the coast on 8 August. Small flocks of migrating dowitchers were common on 12 July in Wet Sedge and Pond/Sedge habitats, in addition to defensive pairs of birds observed in these areas. Migrating flocks numbering 4 and 20 flew east, low over the tundra on 16 August. Mean population densities were highest on Flooded plots (15-37.5/birds/km^2). Mean dowitcher population densities in 1983 exceeded those recorded in previous years, in all habitats except Moist Sedge-Shrub in 1978. Fall populations of dowitchers had considerbly higher densities in 1982 than 1983.



1983 CHRONOLOGY OF NESTING AT THREE ARCTIC NATIONAL WILDLIFE REFUGE STUDY SITES

Fig. 6.

RED-NECKED PHALAROPE - Uncommon breeder. First observed on 13 June, a flock of 3 flying over Pond/Sedge Tundra near camp. On 14 June 2 pairs displayed courtship behavior in Wet Sedge. By 13 July very few females were observed. The first nest, with 4 eggs, was found in Pond/Sedge Tundra on 16 June (Fig. 6); it still contained eggs as of 27 June but was empty on 8 July. Two other nests with eggs were found: 1 in Wet Sedge on 3 July; 1 in Pond/Sedge 7 July, but neither was relocated. First chicks were found on 5 July, apparently just hatched and brooded by the male, swimming among sedges at the edge of a thaw pit in Moist-Wet Sedge. Other chicks were found with a pair of adults in Wet Sedge adjacent to Pond/Sedge on 12 July. The nesting period of red-necked phalaropes was shorter than previous years of census, and was earlier than 1982 but later than 1978 (Fig. 3). Downy, barely flight-capable, but independent young were seen in Pond/Sedge and Aquatic Tundra as late as 10 August. From 3 to 18 July flocks of 2-10 were observed with red phalaropes, semipalmated sandpipers, pectoral sandpipers, stilt sandpipers and long-billed dowitchers defending their chicks or those of the other species in Pond/Sedge habitat at Camp Pond. In the fall, red-necked phalaropes in winter plumage were occasionally seen in flocks of 5-20 mixed with red phalaropes feeding and swimming in lakes and Aquatic Tundra.

Red-necked phalarope summer, fall and breeding population densities were greater on Flooded Tundra than in other habitats. Red-necked phalaropes were much less abundant in 1983 than in 1982 but 1983 levels were similar to those of 1978. This was most evident in comparison of mean populations on the Flooded plots: 17.5 - 37.5 birds/km^2 in 1983 versus 58.5 - 67.5 birds/km^{2}in 1982 and 38.4 birds/km^2 in 1978. Breeding populations in the Flooded Tundra habitat differed significantly among the 3 years of study. Breeding populations in all habitats were greater in 1982 and 1978. Total numbers of nests found in the entire study area were also strikingly different between years: 3 in 1983, 14 in 1982 and 13 in 1978 (Fig. 3).

RED PHALAROPE - Uncommon breeder. First observed on 16 June, with 8 seen swimming in Pond/Sedge and Aquatic Tundra. Some pairs were seen on 17 and 18 July, with copulation observed on 27 June. The first nest, with 4 eggs incubated by a male, was found 26 June in Wet Sedge Tundra (Fig. 6). One other nest was found on 8 July, with 4 eggs incubated by the male, in Pond/Sedge Tundra. The first nest probably hatched by 7 July when it was found empty, but another nest was still incubated on 13 July. The first chicks were found swimming with a male in Pond/Sedge at Camp Pond on 3 July. Two mostly downy juveniles were seen in Aquatic Tundra as late as 10 August. Small numbers of phalaropes flocked in defense of their chicks or those of other species including semipalmated sandpiper, pectoral sandpiper, stilt sandpiper, long-billed dowitcher, and red-necked phalarope in Camp Pond and other Pond/Sedge habitats between 7 and 18 July. In August red phalaropes were observed in flocks with red-necked phalaropes, both in winter plumage, in lakes and Aquatic Tundra from 6 to 13 August.

Red phalaropes were substantially less common in 1983 than in 1982 or 1978. Mean population densities were greatest in Flooded Tundra over other habitats during each year studied, but densities were much higher in 1978 and 1982 than in 1983. Breeding densities were also lower in 1983 as shown by plot data as well as indicated by the fact that only 2 nests were found on entire study area in contrast with 8 in 1982 and 9 in 1978 (Fig. 3). Breeding populations were significantly different in the Flooded Tundra habitat among the 3 years of study.

POMARINE JAEGER - Fairly common spring migrant. Pomarine jaegers were observed during spring migration and in early summer from 14 to 27 June 1983. Single jaegers hunted in Wet Sedge, Moist Sedge-Shrub and Pond/Sedge Tundra on 14, 23, 26, and 27 June. A flock of 4 was seen flying west on 16 June and 5 flew over Pond/Sedge and Moist/Sedge habitats on 17 to 19 June. Unlike in 1982 and 1978, pomarine jaegers were not observed during July or August in 1983.

PARASITIC JAEGER - Rare breeder, common summer visitant, common fall migrant. Parasitic jaegers were seen nearly daily from 14 June to 16 August, primarily singly but also in flocks of 2 or 3, hunting in all habitats. The largest flock seen contained 6 jaegers which called persistently as they hunted Moist/Wet Sedge habitat on 28 June. A jaeger attacked and ate a Lapland longspur fledgling on Pond/Sedge Tundra on 7 July. A pair dive-bombed and chased an arctic fox in Moist Sedge-Shrub Tundra on 9 July. The majority of jaegers were dark phase individuals. A single nest was found on 7 July which contained 2 eggs in a depression on a strangmoor ridge in Flooded Tundra (plot 121). A pair of adults performed much distraction display from the time observers were 250 m from the nest. This nest produced at least 1 downy chick which was defended by 2 adults in Pond-Sedge Tundra on 10 August. A parasitic jaeger nest was found considerably earlier in 1982, on 14 June (Fig. 3) in similar habitat, but it was unsuccessful. Nesting was noted later at Okpilak than at the Jago-Bitty study area in 1983 (Fig. 6).

LONG-TAILED JAEGER - Common spring, summer and fall visitant. Long-tailed jaegers were observed nearly daily from 13 June to 18 August. Primarily singles or flocks of 2 to 3 were seen. They hunted in all habitats, but were most frequently seen in Moist/Wet Sedge, Moist Sedge-Shrub and Riparian. A flock of 5 on 14 June included 2 pairs and copulation was observed. A flock of 6 was seen hunting over Moist Sedge-Shrub on 29 June. Long-tailed jaegers were less common in August than during June or July because only single birds were observed in August. Greatest mean population densities were achieved on Moist/Wet Sedge and Moist Sedge-Shrub plots (2.5 - 15.5 birds/km^2).

HERRING GULL - Rare summer visitant. Not observed in 1978 or 1983, represented by a single sighting in 1982 of 1 herring gull with glaucous gulls in Flooded Tundra on 26 June.

THAYER'S GULL - Rare summer visitant. Not observed in 1983 or 1978, represented by a sighting of a single Thayer's gull flying over Aquatic Tundra on 14 June.

GLAUCOUS GULL - Common spring, summer and fall visitant and uncommon breeder. Glaucous gulls were observed daily from 12 June to 18 August, flying over all habitats and most commonly resting in Aquatic and Pond/Sedge Tundra. A nest was suspected in Aquatic Tundra (on plot 123) on 22 June and confirmed containing 2 eggs on 8 July and another nest was found on 27 June in Flooded Tundra (adjacent to plot 122) similar dates as active nests found in 1978 and 1982 (Fig. 3). Juveniles, approximately half-adult size, were observed on 8 August in 2 groups of 2 young swimming in the vicinity of each nest and an additional group of 3 in another Aquatic Tundra area. The largest flock of gulls consisted of 28 birds that mobbed a biologist visiting a nest on 8 July.

SABINE'S GULL - Rare spring migrant and summer visitant. Sabine's gulls were infrequently observed flying over Flooded and Moist/Wet Sedge Tundra near the coast in June and July of 1978 and 1982. None were observed in 1983.

ARCTIC TERN - Uncommon summer and fall visitant. Most frequently observed in June, with first sighting on 13 June, a flock of 5 terns flying over Camp Lake. Terns were seen flying over Camp Lake on 29 and 30 June, 10 July, and 17 August; over Aquatic Tundra on 16 June; Moist Sedge-Shrub on 23 June; Arey Lagoon shoreline on 27 June; Okpilak River Riparian areas on 18, 24, 25 June and on 2 and 16 July.

SNOWY OWL - Rare summer visitant. Only one observation was made in 1983 of a single owl standing on VABM Mars pingo on 22 June. This is in contrast to 1982 when owls were commonly observed between 6 June and 23 August.

SHORT-EARED OWL - Uncommon summer visitant. Three observations were made of single short-eared owls hunting within 1.5 km of camp: on 13 June over Wet Sedge; on 25 June over Moist/Wet Sedge; and on 8 July over Pond/Sedge Tundra. Short-eared owls were less frequently seen in 1983 than in 1982.

SAY'S PHOEBE - Accidental fall migrant. The first reported sighting of Say's phoebe on the outer coastal plain of ANWR was made 17 August. A single phoebe flew along the coastal bluff of Arey Lagoon, 0.8 km north of camp, landing and taking off frequently while observers were 5-10 m from the bird.

BARN SWALLOW - Accidental spring migrant. Only 2 sightings have been recorded, both in 1982, of a single barn swallow (9 and 17 June).

NORTHERN RAVEN - Uncommon summer visitant. One to 3 northern ravens were observed flying over Moist/Wet Sedge Tundra on 18,21,23,24,27,28 June, 1,2,3,5,16 July and 8,18 August. Ravens were observed throughout a longer time span than in 1982 and were more common than in 1978.

SAVANNAH SPARROW - Fairly common breeder. Savannah Sparrows were observed from 18 June to 16 August, primarily only in Riparian habitat during 1983. The species could have been present earlier in the season before researchers visited Riparian habitats. The majority of sightings were within the more specific types Moist Low Willow (willows greater than 20 cm) and *Dryas* river terrace, usually on higher ground above the river channel elevation. Savannah Sparrows were also heard in Moist Sedge-Shrub Tundra near the edge of river bluffs. Singing birds were observed throughout this period. Based on consistency of presence and territorial behavior, breeding was assumed to have occurred in the Riparian habitat, though at low densities (average of 2.5 territories/km^2). Savannah Sparrows were not observed in 1982 but in 1978 one sighting was made of a single bird by camp, and 1 was observed 5 km inland along the Okpilak River (corresponding to the Riparian habitats studied more intensely in 1983), and several were observed a greater distance inland (20-26 km).

FOX SPARROW - Casual summer visitant. Only one observation of this species has been recorded. One fox sparrow was seen in Moist Sedge-Shrub on 28 June 1982.

LAPLAND LONGSPUR - Abundant breeder. Lapland longspurs were present in all habitats during the entire period of observation from 12 June to 18 August. Male courtship displays were common from 12 to 16 June, were infrequent between 17 and 29 June, and only 1 display per day was heard from 30 June to 4 July. Forty-two nests were found from 13 June to 8 July in all habitats studied: 17 in Moist/Wet Sedge, 8 in Moist Sedge-Shrub, 8 in Wet Sedge, 4 in Pond/Sedge, 4 in Riparian. The earliest clutch completion date was 8 June based on back-dating from known hatching dates and incubation period of 10-14 days (Harrison 1978). Twenty-five of the nests were first found with eggs, 17 with young, and 1 empty (Fig. 7). Clutch sizes ranged from 3-6, with modal size of 5 and mean of 4.73 ± 0.74 (S.D). First hatching was observed 21 June. A majority of nests observed after 22 June had hatched. One nest with incubated eggs was found as late as 5 July and was perhaps a second nesting effort. Nesting success was 87.9% of 33 nests and hatching success was 93.4% for 29 nests with sufficient data. Despite the large annual differences in length and initiation of nesting period for other species, these characteristics were similar among the 3 census years at Okpilak delta (Fig. 3). In 1983 longspur nesting activity extended later into the season, past mid-July, at Okpilak as compared to the 2 inland study areas (Fig. 6). First fledglings, some flight-capable, were seen 2 July. At most nests observed after this date young had fledged (Fig. 7). In July juveniles were commonly seen with adults, which were usually observed foraging, often in groups of 2 to 3 males with females. In August, primarily immatures were observed. In Riparian habitat longspurs foraged primarily on seral-herb and gravel bars in fall, in contrast to earlier in the summer when they were more abundant in willows.

While longspurs utilized all habitats in all seasons and were found breeding there, densities were greatest in the drier habitats: Moist/Wet Sedge, Moist Sedge-Shrub and Riparian. Highest mean populations were found in Riparian, possibly due to extensive use of the area for foraging by birds which bred in adjacent habitats on the river bluff and inland beyond. Highest breeding populations were found on Moist Sedge-Shrub, closely followed by Moist/Wet Sedge and Riparian. Fall densities were lower than mean summer densities in all habitats except Moist Sedge-Shrub. Greatest fall densities were found in Moist Sedge-Shrub but were closely followed by densities in Riparian. Breeding densities did not differ significantly among the years 1978, 1982, and 1983 in Flooded, Wet Sedge, Moist/Wet Sedge, and Moist Sedge-Shrub habitats, although maximum variation was less than 10% in the latter 3 habitats, but exceeded 50% for the Flooded tundra.

SNOW BUNTING - Uncommon spring and fall visitant. A single snow bunting was seen flying over VABM Mars pingo on 13 June and in vicinity of camp on 27 June. Three immatures were observed on a coastal bluff 5 km northeast of camp on 8 August. These were possibly from nests in driftwood logs along the mainland shoreline, or flew from nearly Barter Island where snow buntings are known to nest.

REDPOLL sp. - Fairly common breeder. Redpolls were commonly observed 18 June to 16 August in Riparian habitats including willows on gravel bars and *Dryas*-Forb, and on river bluffs along Okpilak River. A single sighting was made in habitats distant from the river, of a redpoll flying over Moist/Wet Sedge Tundra 0.8 km north of camp. Three nests were found 24 June to 2 July in Riparian willow thickets. The first 2 nests were found 24 June, both recently initiated and both over 10 days later than the first date they were

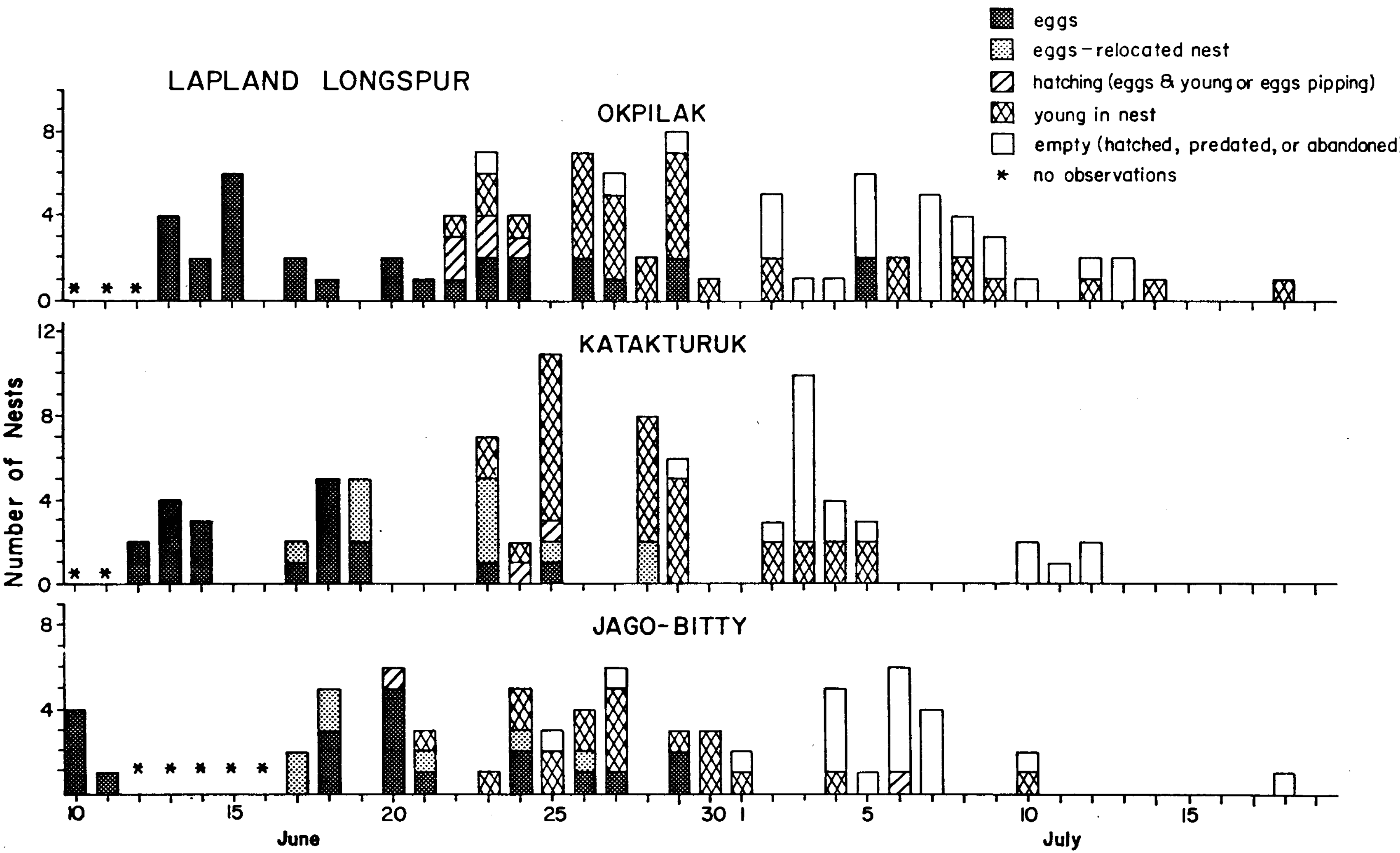


Fig. 7. Nesting chronology of the Lapland longspur at the Okpilak River delta, Katakturuk River, and Jago River-Bitty study areas, Arctic National Wildlife Refuge, Alaska, 1983.

noted for the inland Katakturuk study area (Fig. 6). One nest was on a willow clump on an island in the Okpilak River channel and contained 1 egg, with the full clutch of 4 eggs completed by 2 July. The second nest was located in willows on a bluff and was empty with the female sitting on it 24 June; it contained a full clutch of 5 eggs by 2 July. A third nest also found on 2 July in the center of a willow clump on a gravel bar contained 2 eggs. First hatching occurred by 10 July when 3 young of a 4 egg clutch were found; by 16 July young still in the nest were nearly ready to fledge. The other 2 nests were empty and probably successfully hatched by 10 and 16 July, respectively. Many redpolls were seen in flocks of 2-8 in Riparian habitats 24 June and 16 August. Redpolls were noted in greater numbers and found to be breeding in contrast to previous years probably because of increased field effort in Riparian habitats along the Okpilak River in 1983 (Fig. 3). Redpolls had similar breeding densities in Okpilak Riparian habitat (15 nests/km^2) compared to average densities at Katakturuk (20 nests/km^2) and were higher than breeding densities recorded at Jago-Bitty (average of 3.3 nests/km^2).

RED-THROATED LOON - Fairly common probable breeder on coast, rare fall migrant inland. Two pairs were observed in 2 small ponds near the mouth of the Katakturuk River on 30 June; adults were also observed feeding in Simpson Cove. Single adults were seen and heard flying over camp in mid-August.

TUNDRA SWAN - Uncommon breeder on coast, rare summer visitant inland. Three adults flew north-northwest on 20 June. A pair with nest containing 3 eggs was observed in a saline meadow-pond area at the mouth of the Katakturuk River 30 June.

GREATER WHITE-FRONTED GOOSE - Rare spring migrant. Two adults flew over camp 12 June.

GREEN-WINGED TEAL - Uncommon breeder in foothills. One adult was observed in an overflow channel of the Katakturuk River 6 km south of camp 24 June. At least 10 adults, including at least 3 pairs with broods of up to 8 young were observed in a wet and mossy Riparian area 24 km upriver from camp, at the base of the Sadlerochit Mountains, 20 July.

NORTHERN PINTAIL - Uncommon breeder and spring migrant. Single pairs were observed in Tussock Dwarf Shrub habitat 13 June and in Riparian habitat 14 June. On 16 June a flock of 9 flew upriver and 4 adults were observed on a small lake 8 km northeast of camp. Single adults flew over Riparian habitat on 18 and 23 June. One nest was found in Riparian and 1 brood in Tussock Dwarf Shrub habitat in 1982; no nests or broods were observed in 1983. At least 15 adults were observed in saline meadows, ponds, and inlets near the mouth of the Katakturuk River 30 June.

AMERICAN WIGEON - Status unknown. Three adults were observed on a small lake 8 km northeast of camp 16 June.

GREATER SCAUP - Status unknown. Three males and a female were observed on a small lake 8 km northeast of camp 16 June.

COMMON EIDER - Status unknown. One female was observed in a saline meadow-pond area at the mouth of the Katakturuk River 30 June.

HARLEQUIN DUCK - Uncommon summer visitant. A pair was observed on the river near camp 12 June. A single female flew downriver 13 June. A pair was observed on the river 8 km north of camp 29 June. A female, 2 pairs, and 2 females were seen at 18, 24, and 30 km south of camp on the Katakturuk River on 20 and 21 July.

OLDSQUAW - Status unknown. Three pairs were observed on a small lake 8 km northeast of camp 16 June. Many adults were observed on ponds at the mouth of the Katakturuk River and in Simpson Cove, including 1 male and 2 females courting, on 30 June.

SURF SCOTER - Status unknown. About 200 adults, mostly males, were observed feeding and resting in Simpson Cove 30 June.

WHITE-WINGED SCOTER - Status unknown. Fourteen adults, mostly males, were observed in Simpson Cove 30 June.

RED-BREASTED MERGANSER - Status unknown. Three pairs and 8 other adults were observed at Simpson Cove 30 June. None were seen inland in 1983, but a pair was seen flying upriver in 1982.

NORTHERN HARRIER - Rare summer and fall visitant. One adult hunted over Riparian Willow and *Dryas* river terrace 8 km north of camp 1 July. There were 3 observations in 1982 in June and late August.

ROUGH-LEGGED HAWK - Uncommon breeder. One pair nested near the top of the river bluff 2 km north of camp. Two adults were frequently seen flying and hunting in the area throughout June and July. The nest contained 3 eggs on 19 June (Fig. 1). On 8 July, 3 recently hatched downy young were observed in the nest. On 19 July, 3 adults were observed attending the nest. On 9 August only 2 young were observed in the nest. A second nest was found on a river bluff 18 km south of camp on 20 July containing 1 young bird, with 2 adults in the vicinity.

GOLDEN EAGLE - Uncommon summer and fall visitant. One was observed 19 June in 1983; there were 4 observations in 1982 in June and late August.

PEREGRINE FALCON - Rare summer visitant. Not observed in 1983; there were 2 sightings but no positive identification in 1982.

WILLOW PTARMIGAN - Uncommon spring and fall visitant. Two males were observed 13 June and 1 female was observed 19 June, 1 km northwest of camp in Tussock Dwarf Shrub habitat. One pair was observed 12 July, 1 km south of camp in Riparian habitat. In 1982 there were 2 observations in late August in Tussock Dwarf Shrub and bluff habitats.

ROCK PTARMIGAN - Common breeder. In 1982, 2 nests were found, 1 on Moist Sedge and 1 on Tussock Dwarf Shrub, and a nest was suspected on Moist Sedge-Shrub habitat. In 1983 no nests were found. A pair copulated in Riparian habitat near camp 12 June. Males displayed through 28 June in Riparian habitat. There were 11 observations of single males in Moist Sedge-Shrub, Tussock Dwarf Shrub, and Riparian habitats 19 June to 15 July. One male was observed along Simpson Cove shoreline 30 June. Two pairs were observed, with 10 and 7 flight capable young, 14 km south of camp in Riparian habitat 25 July. Two pairs were observed with 9 and 6 flight capable young in Moist Sedge and Riparian habitats near camp 9 August; also single males and 1 female were observed in Riparian and Tussock Dwarf Shrub habitat 9-11 August.

SANDHILL CRANE - Rare summer visitant. One flew north downriver 26 June.

LESSER GOLDEN-PLOVER - Common breeder and fall migrant. Adults were observed every day from 12 June to 16 August. They were more numerous in Tussock Dwarf Shrub and Riparian habitats (12-16 birds/km^2) than in Moist Sedge or Moist Sedge-Shrub habitats (7 birds/km^2) during June and July. During fall census (9-11 August) they were seen only in Moist Sedge and Riparian habitats.

Six nests were found between 18 and 28 June, (Fig. 1) all with 4 eggs. Four nests were in Riparian or *Dryas* terrace, 1 in Tussock Dwarf Shrub, and 1 in Moist Sedge habitat. Hatching dates for the Riparian nests (4-8 July first egg hatched) were earlier than for the 2 nests in other habitats (estimated

12 July in Tussock Dwarf Shrub and 20 July in Moist Sedge), suggesting that the Riparian habitat was preferred for nesting. Hatching success was 14 out of 16 for 4 nests in which it was observed. Flight capable young were first observed 9 August.

Small flocks of about 5 birds were first seen about 25 July; many flocks of 10-15 were seen flying east and northeast around 12 August. In 1982 1 flock of 12 was observed 26 August. Lesser golden-plovers were observed all along the Katakturuk River, from its mouth to 34 km south of camp, in all habitats, except not in Katakturuk gorge.

SEMIPALMATED PLOVER - Fairly common breeder inland. One nest was found 22 June (Fig. 1) on a gravel bar across the river from camp; 4 eggs hatched 8 July. There were 2 more nests along the bluff northwest of camp. Birds were seen in Riparian habitat near camp from 12 June through 14 July. Many pairs were observed, including 2 with large but flightless chicks, from camp upriver to the valley 34 km south, 19 to 25 July. None were observed from 2 km north of camp to the coast. The last sighting was 1 bird observed near camp 13 August.

WANDERING TATTLER - Fairly common suspected breeder inland (foothills and mountains) and spring migrant. Single birds were observed along the river in Riparian or *Dryas* terrace habitats 14 and 15 June, near camp. At least 15 single birds were observed along the Katakturuk River from 24 to 34 km upriver from camp on 21-24 July (in the foothills, gorge, and valley beyond); some birds were extremely defensive.

SPOTTED SANDPIPER - Fairly common breeder inland (foothills and mountains) and spring migrant. A single bird was observed 18 June, and a pair was observed 21 and 23 June, along a river channel in Riparian habitat 1 km south of camp. At least 15 single birds were observed along the Katakturuk River from 16 to 34 km upriver from camp on 20-24 July (in the foothills, gorge, and valley beyond). An adult with 1 large flightless chick was observed 24 July near the end of the Katakturuk gorge, 34 km upriver from camp.

WHIMBREL - Rare probable breeder inland. Four adults were observed on 1 July 5 km south of camp, feeding in Moist Willow/Sedge habitat; they flew north. One adult was observed 24 July 18 km south of camp in Low Willow habitat near the river, vocalizing and very defensive, with a nest or chicks suspected.

RUDDY TURNSTONE - Fairly common breeder (more common towards coast, less common further inland). Singles and pairs were observed in Riparian habitats (Low Willow, *Dryas* terrace, gravel bars) from 12 June through the end of July near camp. The last observation was 9 August in 1983, but 1 bird was seen feeding on a gravel bar 26 August 1982. One nest was found 24 June (Fig. 1) with 2 eggs on a gravel bar near camp; the first egg hatched 28 June. One nest was found 29 June with 4 eggs on gravel bar 8 km downriver from camp. Many pairs were observed along the Katakturuk River from camp to the river mouth 29 June to 1 July. A few pairs were observed along the Katakturuk River from camp to 24 km upriver 19-25 July.

SANDERLING - Rare breeder. There were 2 observations in 1982, including a defensive adult with 2 chicks in Riparian habitat 14 July. None were observed in 1983.

SEMIPALMATED SANDPIPER - Abundant breeder. Birds were observed daily from 11 June to mid-July in Tussock Dwarf Shrub and Riparian habitats; a few were observed 17-23 June in Moist Sedge and Moist Sedge-Shrub habitats. Display flights were observed 18-24 June in Riparian, Tussock Dwarf Shrub, and Moist Sedge habitats. Densities were 20-30 birds/km^2 on Tussock Dwarf Shrub plots and 55 birds/km^2 on Riparian plots in June and early July; 3 birds/km^2 on Tussock Dwarf Shrub and 20 birds/km^2 on Riparian in mid-July. The only August sighting was 2 birds in Riparian habitat on 13 August.

Three nests were found in Tussock Dwarf Shrub habitat 13-19 June with 4 eggs each; 7 nests were found in Riparian 22-24 June with clutch size 2-4 (mean 3.1) eggs (Fig. 1). In Tussock Dwarf Shrub habitat 2 nests hatched between 25 and 29 June, and 1 between 29 June and 3 July (Fig. 4). In Riparian habitat known hatching dates were 28 June, 2 July, 3 July, and 4 July (2 nests), and 1 nest hatched between 5 and 12 July. Although fewer nests were found in Tussock Dwarf Shrub habitat, they averaged larger clutch sizes and earlier hatching dates than in Riparian habitat. Nests were on the ground, generally concealed by sedge or willow. Flightless chicks were observed on Riparian plots on 5 and 12 July and on Tussock Dwarf Shrub plots on 6 and 13 July, accompanied by adults.

Many semipalmated sandpipers were observed along the Katakturuk River from camp to the river mouth 29 June - 1 July, including defensive pairs and small flocks of 5-6 birds. Many were also observed from camp to 24 km upriver on 19,20,and 24 July, but were less numerous farther inland, and none were observed beyond 24 km south of camp (3 km from the Sadlerochit Mountains).

BAIRD'S SANDPIPER - Fairly common breeder. The first observation was 13 June. A nest was found on the bluff near camp 19 June, with 4 eggs, of which 3 hatched by 29 June (Fig. 1). A nest was found on 3 July, with 4 eggs that hatched on 4 July, on a gravel bar by the river. An adult with chicks was seen 5 July and 12 July on a Riparian plot. Many were seen on Simpson Cove shoreline 30 June; several were seen in Riparian and bluff habitat along the Katakturuk River up to 27 km south of camp (gorge entrance) 19 to 24 July. The last observation was 9 August: 2 adults on the river terrace near camp.

PECTORAL SANDPIPER - Fairly common breeder and fall migrant. The first observation was 11 June. Males made display flights over Wet Sedge 12-14 June. A nest was found in Tussock Dwarf Shrub with 4 eggs which hatched 29 June (Fig. 5). Two nests were found (each with 4 eggs) and a third suspected in Moist Sedge-Shrub habitat 26 June. They were empty by 4 July, but defensive adults were seen in the area on 7 July. A nest was suspected on the Wet Sedge plot, and an adult with 1 chick was observed there 14 July. Duration of nesting activity was shorter and numbers of nests found were less at Katakturuk than at the Okpilak and Jago-Bitty study areas (Fig. 1).

Pectorals were observed on the Wet Sedge plots and Moist Sedge-Shrub plots on all censuses. They were observed on Tussock Dwarf Shrub at the top of the bluff only until 3 July, but were on the Tussock Dwarf Shrub plot adjacent to Moist Sedge-Shrub habitat throughout all censuses. One was observed in Riparian habitat 11 August. Several were observed in Wet Sedge habitat near the mouth of the Katakturuk River 30 June, but none were observed upriver from camp 19-25 July. Pectorals were observed at Katakturuk camp through 16 August 1983, but no large flocks were seen. In 1982 flocks of 5-25 were observed 26 August traveling west and feeding in wet areas.

DUNLIN - Rare possible breeder. One bird was observed feeding near the abandoned Distant Early Warning Line site on Simpson Cove shoreline 30 June. A pair in breeding plumage with nest suspected was observed 2 km inland from the mouth of the Katakturuk River 30 June.

BUFF-BREASTED SANDPIPER - Rare summer visitant. There were 3 observations on Riparian and Tussock Dwarf Shrub habitat 19 and 21 June, and 5 July, 1982. None were observed in 1983.

RED-NECKED PHALAROPE - Rare breeder inland. Two adults were observed in a small lake 8 km northeast of camp 16 June. Ten adults were observed in a small pond near the Katakturuk River mouth (2 km inland) 30 June. None were observed near camp in 1983, but in 1982 a male defended 3 chicks on a Moist Sedge-Shrub plot 15 July.

POMARINE JAEGER - Rare spring migrant. One bird was observed hunting over Riparian habitat Willow 12 June. One bird was observed flying 15 and 18 June.

PARASITIC JAEGER - Uncommon possible breeder. They were present throughout the summer 11 June to 10 August with 1-4 birds observed regularly, over all habitats. A pair was observed at Simpson Cove shoreline 30 June. Five were observed 10-16 km upriver from camp, 19-20 July. In 1982 a nest was suspected in Moist Sedge-Shrub habitat.

LONG-TAILED JAEGER - Fairly common breeder. One to 4 birds were observed daily in the study area 11 June to 16 August, flying and hunting over all habitats. One nest was found on a Dryas terrace 1 km south of camp with 2 eggs that hatched 3-4 July (Fig. 6). One adult with 2 flight-capable young was observed 11 August hunting over Tussock Dwarf Shrub habitat. A few pairs were observed near the mouth of the Katakturuk River 30 June, in Tussock Dwarf Shrub and Moist Sedge habitats. A few pairs were observed from camp to 34 km upriver along the Katakturuk 19-25 July. In 1982, 5 nests were found within a 9.5 km radius of camp.

HERRING GULL - Rare spring migrant. One was observed flying over the river 21 June 1982. None were observed in 1983.

GLAUCOUS GULL - Rare spring and fall migrant inland, probable coastal breeder. One was observed 24 June flying south along the river, and 1 was observed 14 August flying over the river. Many were observed at the mouth of the Katakturuk River and at Simpson Cove 30 June, including one pair with probable nest in a saline meadow-pond area at the mouth of the Katakturuk.

ARCTIC TERN - Status unknown. Three adults were observed flying over a saline meadow-pond area at the mouth of the Katakturuk River 30 June.

SNOWY OWL - Rare summer visitant. One was observed flying and resting at the base of Katakturuk River bluffs 6 July 1982. None were observed in 1983.

SHORT-EARED OWL - Uncommon summer visitant. One was observed hunting over Tussock Dwarf Shrub habitat 19 June, 6 July, and 15 August. One was chasing and being chased by a rough-legged hawk and long-tailed jaeger over Moist Sedge habitat 16 August.

HORNED LARK - Rare summer visitant; possible breeder in foothills. Four adults and 1 juvenile were observed feeding and vocalizing on hillsides above the Katakturuk River 34 km upriver from camp (in the valley between the Sadlerochit and Shublik Mountains) 22 July. In 1982, 2-4 adults were seen feeding and displaying 21-23 June in Riparian and ridgetop habitat near camp.

NORTHERN RAVEN - Rare summer visitant. A single bird was observed flying north 11,12,25,and 28 June, and flying south 16 and 17 June. A pair was observed 5 km south of camp in Riparian habitat 30 June, and 1 bird was observed 5 km inland from the Katakturuk River mouth 30 June. A single bird was observed flying over camp 3,4,6, and 14 July, and being chased by long-tailed jaegers 26 July. A pair dive-bombed a dome tent 10 August, and single birds were observed 15 and 16 August.

AMERICAN ROBIN - Rare summer visitant. One was observed 24 June in Low Willow habitat near camp. One was observed 22 July in Riparian Willow habitat along a tributary of the Katakturuk River 35 km upriver from camp (in the valley between the Sadlerochit and Shublik Mountains). One was observed 24 July in Riparian habitat in the Katakturuk River gorge 32 km upriver from camp.

YELLOW LOW WAGTAIL - Fairly common breeder. The first observation was 12 June in Willow. A nest was found 19 June in Tussock Dwarf Shrub habitat at the edge of Katakturuk River bluff, with 5 eggs; 4 eggs hatched 29-30 June; the young fledged by 13 July. Wagtails were most commonly seen in low to medium willow thickets within Riparian habitat and willow-filled gullies of the bluff. At least one nest was suspected on or near each Riparian plot. Six to 8 adults were observed on censuses of Riparian plots in June-July, and 13 on 9-11 August. The last observation was 15 August. Adults were observed feeding fledged juveniles on all Riparian plots 10-12 July.

WATER PIPIT - Rare probable breeder, more common in foothills; fairly common fall migrant. Single birds were observed 13,16, and 19 June on the river bluff near camp and on a bluff 6 km northeast of camp. Many were observed from 14 to 40 km upriver from camp, along the river and on hillsides and in Tussock Dwarf Shrub habitat. Two were observed 15 August feeding on a gravel bar near camp. In 1982 a nest was suspected on the river bluff west of camp. Up to 12 birds were observed in Riparian and Tussock-Dwarf Shrub plots on 25 and 26 August 1982.

NORTHERN SHRIKE - Rare summer visitant and breeder in foothills. One adult was observed hunting 29 June in Riparian habitat 1 km south of camp. One juvenile was observed in Riparian habitat on 21 July 27 km south of camp at the entrance to Katakturuk gorge. An adult pair with 4 flight-capable young was observed near a nest in Riparian Willow habitat 30 km upriver from camp in Katakturuk gorge on 21 and 24 July. Two juveniles were observed hunting in Riparian Willow habitat 18 km upriver from camp 24 July.

YELLOW WARBLER - Casual spring migrant. One adult was observed feeding in low willow 16 June.

AMERICAN TREE SPARROW - Fairly common breeder inland. Males sang 12-24 June. Tree sparrows were observed on all 3 Riparian plots, approximately 40 birds/km^2 in June, 17 birds/km^2 in July, and 180 birds/km^2 in August. One nest was found in Low willow on 22 June with 5 eggs (Fig. 6). The first eggs hatched 5 July, but only 4 chicks remained 12 July. A few adults were observed downriver from camp on 29 July but not beyond 5 km north. Many were observed from camp to 35 km upriver 19-25 July. In 1982 adults and juveniles were still present in Low willow near camp 25 August.

CHIPPING SPARROW - Casual summer visitant. A single singing bird was observed in Low willow 23 June 1982. None were observed in 1983.

SAVANNAH SPARROW - Uncommon Breeder. The first observation was 13 June in Tussock Dwarf Shrub habitat. Up to 9 birds were observed on Tussock Dwarf Shrub and Moist Sedge-Shrub plots in June and July. One nest was found in Moist Sedge-Shrub habitat on 25 June with 6 small nestlings (Fig. 6); on 3 July 1 large nestling was in the nest and 1 dead one was nearby. Two nests were suspected on Tussock Dwarf Shrub plots. A fledged juvenile was observed feeding with adults on 13 July. Single birds were seen in Low willow habitat on 12 July and 9,10,15 August. Six were seen on 11 August on Tussock Dwarf Shrub plots. In 1982 a single bird was singing in low riparian willow 25 August. A few were observed along the Katakturuk River from camp to the river mouth 29 June, and several at Simpson Cove 30 June. A few were also observed along the Katakturuk upriver to 14 km south of camp, 19 and 20 July.

WHITE-CROWNED SPARROW - Fairly common probable breeder inland and in foothills. A single male displayed and sang in low willow 1 km north of camp on 12,18,24 June and 1 July. Four birds fed and vocalized 6 km south of camp in low willow 2 July. Many were observed in Riparian Willow from 11 to 35 km upriver from camp, along the Katakturuk River, 20-24 July.

LAPLAND LONGSPUR - Abundant breeder. Lapland longspurs were observed every day at Katakturuk Camp from 11 June to 16 August. They were observed in all habitats, but were most dense within low willow sections of Riparian habitat, especially in July and August (250-300 birds/km^2).

Male display flights were observed 11-26 June in all habitats. Four nests were found in Moist Sedge habitat 14-23 June; 7 nests were found in Tussock Dwarf Shrub habitat 13-25 June; and 10 nests were found in Riparian habitat 12-25 June (Fig. 6). Clutch sizes were 3-6 (mean = 4.8) compared to 4-8 (mean = 5.3) in 1982. Estimated[1] nest initiation dates were 1-22 June and estimated[1] hatching dates were 18 June - 5 July. One nest was destroyed by predators before hatching and 1 after hatching in Riparian habitat. Dead chicks were found in 3 nests in Tussock Dwarf Shrub habitat and in 1 nest in Moist Sedge habitat, for a total of 10 dead chicks. Hatching success for nests not predated was 76 out of 83 eggs, or 92%. All young had left nests by 3 July on Tussock Dwarf Shrub habitat, by 11 July on Moist Sedge habitat, and by 12 July on Riparian plots (Fig. 7). Nests were located primarily on the south side of tussocks; some were at the base of willows or on stream banks. Fledged juveniles were observed 5-13 July in all habitats.

[1]Using 10-14 days incubation from last egg (Harrison 1978).

Many Lapland longspurs were observed from Katakturuk Camp to the mouth of the Katakturuk River on 30 June, and upriver to the Sadlerochit Mountains on 19-25 July. None were observed in the Katakturuk gorge 27-34 km south of camp and only a few in the valley between the Sadlerochit and Shublik Mountains.

SMITH'S LONGSPUR - Casual summer visitant, more common in foothills. A single male was observed in Tussock Dwarf Shrub habitat 25 June near camp; in Riparian habitat on 23 July 40 km upstream along the Katakturuk River from camp; and in Riparian habitat near camp 11 August.

SNOW BUNTING - Status unknown. A single bird was observed flying over the river terrace near camp, after strong winds, 22 June. Many were observed when investigators visited the Simpson Cove shoreline 30 June. One bird was observed in Riparian habitat, in Katakturuk River gorge, 30 km upriver from camp, 21 July. Seven were observed in the Sadlerochit Mountains above 600 m elevation 22-23 July, 35 km up the Katakturuk River from camp.

REDPOLL - Common breeder. Nine nests were found, all in portions of low willow Riparian habitat, from 14 June to 4 July (Fig. 6). Known and (estimated)[1] nest initiation dates were (9 June), (11 June), 13 June, 22 June, (25 June), and 4 July. Known and (estimated)[1] hatching dates were (20 June), 22 June, 26 June, and (7 July). Three nests were destroyed by predators either before or soon after hatching. Clutch sizes ranged from 2 to 5 (mean = 4.1). Hatching success was 17 out of 19 for 4 nests which were not destroyed by predators. Most young fledged the first week of July. Fledged juveniles were first observed 5 July. Nests were located in willow bushes, up to 75 cm from the ground.

Redpolls were observed primarily in Riparian Willow habitat, at densities of around 65 birds/km^2 in June, 20 birds/km^2 in July, and 67 birds/km^2 in August. Two were observed in Moist Sedge-Shrub habitat at the top of the bluff west of camp on 13 July. One was observed along the shoreline at Simpson Cove 30 June. Many were observed in low willow porttions of Riparian habitat along the Katakturuk River from camp to 34 km upriver 19-25 July, and 4 were observed on a mountainside in the Sadlerochit Mountains 35 km upriver from camp on 23 July. Large groups including fledged juveniles were seen in Riparian habitat 9 August, and some were still present 16 August. In 1982 small flocks were seen 25-26 August.

[1]Incubation and nestling period seemed to be shorter than those given in Harrison (1978); they were estimated at 10 days and 7 days, respectively. Hatching dates were estimated with 10-day incubation from the third egg. The wide spread in nest initiation dates suggest that double clutches might have been possible.

RED-THROATED LOON - Uncommon summer visitant. Represented by a single observation of a pair flying and calling over a large lake 11 km northeast of camp on 12 July.

ARCTIC LOON - Uncommon breeder. A single nest was found with 2 eggs incubated by 1 adult at edge of the third large lake 11 km northeast of camp on 12 July (Fig. 1). Two other adults were seen in this vicinity on 12 July. One arctic loon was seen swimming in a lake 3 km northeast of Marie Mountain (south of camp approximately 34 km) on 23 July.

TUNDRA SWAN - Uncommon spring migrant and breeder. First observed 5 June when a single swan was seen flying southeast about 8 km north of camp. A pair flew from the southeast and landed in Riparian habitat 1.5 km west of camp on 10 June. A flock of 4 with 1 unidentified goose was seen flying 6.5 km northeast of camp on 11 June. A single swan was seen swimming and calling on a large lake 11 km northeast of camp 12 July. The only breeding effort was recorded on an aerial swan survey on 21 August, with 1 pair and 2 young sighted in a lake 5.5 km north of camp (Bartels et al. 1984).

GREATER WHITE-FRONTED GOOSE - Fairly common spring migrant. This species was only observed during spring migration. Flocks of 3 or 4 were seen flying over Jago-Bitty camp on 2, 3, and 5 June. Single pairs were seen flying east over an area 5 km northeast of camp on 7 June, with a single goose over camp on 9 June, and flying to the north over Moist Sedge-Shrub 3 km north of camp on 20 June.

SNOW GOOSE - Uncommon spring migrant. Two sightings were made of snow geese flying over camp; a flock of 4 on 3 June and a single bird on 4 June.

BRANT - Uncommon spring migrant. Two observations were made of brant flying over camp; a flock of 3 on 2 June and a single bird on 4 June.

GREEN-WINGED TEAL - Rare summer visitant. Only a single observation was made of 1 teal swimming in the lake 1.6 km north of Marie Mountain in the foothills region (approximately 34 km south of camp).

MALLARD - Rare summer visitant and breeder. There were 2 observations at a large lake located 11.5 km southeast of camp: 4 pairs seen on 2 July; 8 adults with 10 ducklings on 25 July. This is the first documented breeding record for this species on the coastal plain of ANWR.

NORTHERN PINTAIL - Common summer resident and fairly common breeder. Pintails were seen flying singly and in small groups daily from 1 to 11 June, and less frequently after this period. Pintails were the most common species of waterfowl breeding in the study area. Five nests were found between 9 June and 12 July: 3 on plots (2 in Riparian, 1 in Moist Sedge-Shrub) and 2 adjacent to lakes 11.5 km north of camp. Clutch sizes were 6, 6, and 8 for 3 nests where eggs were counted. Of 3 nests rechecked, 1 was destroyed by predators probably by jaeger or gull, and 2 had hatched by 30 June and 6 July. A brood of 2 ducklings with 3 adults seen 11 August was the latest observation of the species.

GREATER SCAUP - Rare summer visitant. A single sighting was made of a scaup which flushed from tall willows in Riparian habitat 1.6 km north of camp on 10 June.

LESSER SCAUP - Rare summer visitant and breeder. Two sightings were made: 2 scaup swam in the pond 11.5 km south of camp on 2 July; 1 adult with a brood of 6 swam in a pond 1.6 km east of Marie Mountain (34 km south of camp). These observations represent the first record as well as documented breeding of this species on the coastal plain of ANWR.

HARLEQUIN DUCK - Uncommon summer visitant. A pair of harlequin ducks was seen flying over Okpirourak Creek at its confluence with Jago River 1.5 km north of camp on 10 and 24 June.

OLDSQUAW - Fairly common summer visitant and breeder. Oldsquaw were observed from 2 June to 11 August, as singles, pairs, small flocks (2-6 birds) and rarely larger flocks in river, lakes, Wet Sedge, Moist Sedge and Wet/Moist Sedge habitats. Courtship displays and chasing between males and females were observed on 5 June involving 2 pairs 1.5 km northeast of camp; 6 June among 3 birds in the Jago River and a pair in Moist Sedge 1.5 km north of camp; and 11 June with 3 oldsquaw in Wet Sedge 8 km north of camp. Nests were not found, but 3 broods of 4 ducklings were seen with 9 adults on the pond 11.5 km south of camp on 25 July. The last pair observed was on 12 July on a large lake 11.5 km northeast of camp. Larger flocks were observed in lakes: 15 birds 11.5 km south of camp on 2 July; 13 birds 11.5 km northeast of camp on 12 July; 2 flocks (17, 11 birds) 1.5 km east of Marie Mountain (34 km south of camp) on 23 July; 9 birds 11.5 km south of camp on 25 July. The last observation was on 11 August of a flock of 6 females swimming in Okpirourak Creek 1.6 km north of camp.

RED-BREASTED MERGANSER - Uncommon summer visitant. The species was first observed 6 June, a pair flying west over the Jago River about 1.5 km northeast of camp. One other sighting, on 11 June, was made of a single female flying east over the Jago River about 5 km northeast of camp.

NORTHERN HARRIER - Rare summer visitant. Single sighting of a harrier chased by a long-tailed jaeger was made 14.5 km south of camp on 24 July.

ROUGH-LEGGED HAWK - Uncommon summer visitant. One hawk was seen hunting near camp on 24 June. Two observations were made to the south of camp: 1 flying over an area 14.5 km up-river on 2 July; 1 standing in Moist/Wet Sedge Tundra 3.2 km northwest of Marie Mt. (34 km from camp) on 22 July. In 1982 an active rough-legged hawk nest was found on the river bluffs of Bitty (10.5 km south of camp) with 2 downy young and 2 eggs in a stick nest attended by a pair of hawks on 23 July. No nest was present in 1983.

GOLDEN EAGLE - Fairly common summer visitant. Single golden eagles, including 1 immature, were observed soaring and hunting over areas 1.5 to 5 km from camp on 9, 10, 21, 25 June, and over Marie Mt. on 21 July. Pairs were seen soaring 3 km southeast of camp on 24 June, over Bitty (7 km south of camp) 1-3 July, and 2 immatures flew over Okpirourak Creek near Marie Mt. (33 km from camp) on 22 July.

WILLOW PTARMIGAN - Common resident, fairly common breeder. Willow ptarmigan were most commonly observed in Moist Sedge-Shrub (1.1 birds/km^2) and Tussock Dwarf Shrub Tundra (0.2 birds km^2), but also less frequently in Moist/Sedge and Wet Sedge from 2 June - 12 August. Courtship behavior by 3 males in winter and breeding plumage was observed 9 June in Tussock Dwarf Shrub Tundra. Two nests were found: on 20 June in Moist Sedge-Shrub with 10 eggs incubated by female (found abandoned with cold eggs 27 June); on 21 June in Tussock Dwarf Shrub Tundra with 12 eggs incubated by female (11 eggs hatched by 7 July) (Fig. 1). At the latter nest the female did not flush on 26 June until researchers approached within 2 m and in a later test of rope dragging technique she did not flush at all (thus demonstrating the ineffectiveness of rope dragging). The majority of broods were seen in the Moist Sedge-Shrub type. First young of the season, a brood of 4 with female, were observed on 6 July. Other broods seen included: 9 young with defensive male 12 July; male defending brood on 25 July; pair with brood of 10 on 26 July. Groups of older chicks were found in additional habitats: a brood of 8 chicks, 2/3 grown, with a pair of adults in Moist/Wet Sedge on 8 August; brood of 9 full-grown young with 1 adult in Wet Sedge on 11 and 12 August.

ROCK PTARMIGAN - Common resident, uncommon breeder. While rock ptarmigan were observed as frequently as willow ptarmigan, breeding was less common and was seen in an additional habitat - Riparian. Rock ptarmigan were not as abundant, however, as willow ptarmigan, with 0.3 birds/km^2 in Tussock Dwarf Shrub and 0.2 birds/km^2 in Riparian. Rock ptarmigan were observed between 1 June and 13 August. Male courtship behavior was observed 1 June and 3 June near camp and on 9 June in Tussock Dwarf Shrub Tundra. A male was observed displaying to a #10 tin can lid on 5 June near camp! Females were seen molting to summer plumage on 9 June. First flocking by males was observed 12 July with a group of 5 in Moist Sedge-Shrub 11 km north of camp. No nests were found, although breeding occurred in the study area. The first young found were on 26 July: chicks were flight-capable in the presence of a pair of adults in Moist/Wet Sedge. Another brood consisting of 10, 2/3-grown chicks was found 13 August, in Riparian habitat (plot 391).

SANDHILL CRANE - Rare spring migrant. Single observation of a pair flying over the Jago River 1.5 km east of camp was made on 5 June.

BLACK-BELLIED PLOVER - Rare summer visitant and migrant. A single sighting of a flock of 4 birds flying west over low willow 3 km northeast of camp was made 7 July.

LESSER GOLDEN-PLOVER - Common summer visitant, fairly common breeder. Lesser golden-plovers were seen daily in all habitats during the period biologists were in the study area, 1 June to 13 August. This species was observed as far inland as 1.5 km south of Marie Mtn., with 2 seen there on 20 July. Pairs were noted in courtship display, chasing and calling on 1 and 6 June. Three nests containing 4 eggs were found on 18, 21 and 27 June in Moist Sedge, Tussock and Moist Sedge-Shrub Tundra, respectively (Fig. 1). The earliest nest presumably hatched by 4 July. Hatching in process was observed at one nest on 7 July with 3 eggs pipped and on 15 July at another in which 2 chicks and 2 pipped eggs were found. Backdating of these nests indicates nest initiation dates of 9 and 13 June, respectively. First chick out of nests was found 12 July in Wet Sedge Tundra. First flight capable young, in a flock of 3, were seen in Riparian Willow on 20 July. Other groups of young chicks were subsequently seen in Riparian 1.5 km east of camp on 23 and 26 June. First flocking was seen on 28 July, with a group of 15 in Moist Sedge Tundra near camp. The first eastward migration was seen as a flock of 27 flew over Tussock Dwarf Shrub Tundra on 9 August.

SEMIPALMATED PLOVER - Uncommon summer visitant. All sightings were of pairs in July, mostly in habitats adjacent to the Jago River. Two observations were of birds in mud 11 km south of camp (1 and 26 July), and one sighting was made on a gravel bar 3.2 km south of camp on 3 July. The only observation of this species on tundra habitat was on 12 July in Tussock Shrub Tundra 3.2 km north of camp.

SPOTTED SANDPIPER - Rare summer visitant. One sighting of a single bird was made in the foothills region 1.6 km north of Marie Mountain in Moist Sedge-Shrub Tundra on 20 July. The species may remain inland into September, based on observations at 8 km inland along the Aichlik River on 11 September.

WHIMBREL - Rare summer visitant. One observation was made: 2 whimbrels calling and chasing each other over Riparian near camp on 26 June.

RUDDY TURNSTONE - Fairly common breeder. Most sightings were of a pair which nested near camp on a gravel bar of the Jago River. First observation was of a pair feeding on 2 June. Copulation was observed on 5 June and fighting between 2 males was also noted. A nest with 4 incubated eggs was found 6 June and its 2 eggs hatched 29 June (Fig. 1). Backdating gave an estimated clutch completion date of 3 June. A pair was observed defending chicks on 26 July. The last observation was made on 8 August of a pair in winter plumage. Only 1 observation was made of a turnstone in a habitat other than Riparian habitat: a single bird was seen in Moist/Wet Sedge 1.6 km north of Marie Mountain (33 km from camp) on 20 July.

SEMIPALMATED SANDPIPER - Common breeder. Semipalmated sandpipers were present in the study area upon the researchers' arrival 1 June. Semipalmated sandpipers were most commonly seen in Moist Sedge, particularly areas with low willow vegetation, Riparian, and Moist Sedge-Shrub. They were seen less frequently in Tussock Dwarf Shrub and Wet Sedge Tundra. Courtship displays were noted from 1 to 9 June. A total of 17 nests was found between 9 and 27 June, (Fig. 1) all with a clutch size of 4 eggs. The majority of nests were found in Riparian habitat (9 nests), with remainder in Moist Sedge-Shrub (5 nests) and one each in Moist Sedge, Wet Sedge and Tussock Dwarf Shrub Tundra. Nest success rate was 92.3% (13 nests) and hatching success rate was 92.3% (12 nests) based on nests with sufficient data. At one of the first nests found the adult removed a cracked egg by carrying it in its feet. Subsequently, the nest was found abandoned. The first nest with pipped eggs was seen on 25 June and first hatching was observed on 27 June. After this date, the majority of nests had hatched, but hatching was witnessed as late as 6 July and one nest still contained incubated eggs on 7 July (Fig. 4). Back-dating of known hatches yielded nest initiation dates of 6,8, and 17 June. An adult was observed defending chicks in Moist Sedge on 27 July. The last observation was of a single bird in Riparian habitat 8 August.

BAIRD'S SANDPIPER - Uncommon breeder. First observed on 3 June, a single bird in Wet Sedge habitat 800 m south of camp. The majority of other sightings were of single birds in Riparian habitats. One Baird's was seen on a gravel bar 4.8 km northeast of camp on 7 June. The only nest found contained 4 incubated eggs on 27 June in Riparian habitat. Other sightings were made in this general vicinity on 29 June and 12 July. One Baird's sandpiper was found calling in Alpine Tundra 11 km west of Marie Mountain on 21 July.

PECTORAL SANDPIPER - Common breeder and fall migrant. First seen on our arrival to the study area on 1 June when 3 birds were seen courting in Moist Sedge Tundra near camp. Observed in all habitat types on study area but nested commonly only in Wet Sedge and Moist Sedge-Shrub and sparsely in Moist Sedge types. Male courtship display was observed only during the first week of June. Perhaps courting activities were limited in early June 1983 because of extremely high winds (averaging 16 km/h) during the courting period. The first nesting probably began 11 June because on that date a fresh eggshell and defensive female were seen on a Wet Sedge plot. The first nest was found 17 June (when researchers returned after a 6-day lapse) on a Moist Sedge tundra plot near camp. Based on back-dating from known hatching dates using a 21-23 day incubation period (Harrison 1978) the earliest clutch completion date was 8 June while the latest clutch completion date was 21 June. A total of 15 nests were found in the following habitats: Moist Sedge-Shrub(6), Wet Sedge (5), and Moist Sedge (4). First hatching was observed 29 June, with other nests in the process of hatching 30 June, 5,7, and 12 July (Fig. 5). By the first week of July the majority of nests were empty. Mean clutch size was 3.8 $\pm$ 0.4 (S.D.), nest success for 13 followed nests was 100%, while hatching success was 96%. Females exhibited defensive behavior near nests and young on the Moist Sedge-Shrub and Wet Sedge plots throughout the month of July. The peak of flocking by denfensive females with flocks of up to 10 other individuals flocking around the defensive birds occurred 10 July. Flocking occurred later into July and August but was not nearly as prevalent as along the coast. The first flocking away from defensive birds was noted on 27 July as 9 birds were seen flying over a Riparian area. Pectoral sandpipers became less common in August as flocks of 7,5,14,3 and 3 were seen on 9,10,11,12, and 13 August, respectively.

DUNLIN - Uncommon spring and fall migrant. Only 2 observations, 1 spring and 1 fall, have been made of Dunlins near Jago-Bitty: on 10 June 1 bird flying over Riparian 1 km northeast of camps and on 11 August 1 bird sitting in willows 4 km northeast of camp.

STILT SANDPIPER - Uncommon breeder. First observed on 4 June when 2 birds were seen: 1 feeding and flying in a Wet Sedge area near camp; and 1 sitting in low willows 2 km south of camp. A pair in courthship flight was observed 7 and 11 June over Wet Sedge Tundra 3 km northeast of camp. A pair defending 3 chicks was found in Moist/Wet Sedge (Mosaic) just north of plot 333 on 29 June. Three flight-capable young were observed 12 July in the company of 2 adults 11 km NE of camp in Wet Sedge Tundra.

BUFF-BREASTED SANDPIPER - Uncommon breeder. The first observation was on 11 June when 1 bird was seen sitting on a gravel bar 2 km south of camp. A subsequent observation of the species, not apparently related to nesting, was made of 1 bird in Tussock Dwarf Shrub Tundra 3 km south of camp. The first and only nest was found on 29 June in Moist Sedge Tundra 0.2 km south of camp (Fig. 6). The 4 eggs in this nest pipped on 5 July and were hatched by 6 July. Using an incubation period of 23 days (Martin and Moitoret 1981) back-dating yielded a nest initiation date of 12 June.

LONG-BILLED DOWITCHER - Fairly common summer resident, probable rare breeder. The first observation was 2 June when 2 birds were seen standing in low willow 1 km south of camp. Frequent observations of pairs in courtship flights or singles were made throughout June in Wet Sedge or Moist Sedge Tundra. The first flocks occured in Wet Sedge Tundra on 12 July when 30 birds were counted. Three adults in winter plumage were seen in Tussock Dwarf Shrub Tundra on 9 August 2 km south of camp. The only evidence of breeding was the observation of a juvenile bird on a Wet Sedge census plot 5 km northeast of camp on 11 August. The species may remain inland into September, based on observations of several small (5-10) flocks 8 km inland on the Aichilik River 10-12 September.

COMMON SNIPE - Fairly common breeder. Snipe were limited to a specific combination of habitat types defined by Wet Sedge or Wet/Moist Sedge (Mosaic) tundra in proximity to willows of low or medium height. A nesting/display area was found 1 km west of camp along a small tributary to Okpirourak Creek. In that area displaying males were observed almost daily from 1 June until 2 July, the last recorded display flight. Snipe were also found displaying in a similar combination of habitats 11 km south of camp along the southern base of Bitty ridge. The first and only nest found was on 29 June in 1.5 m tall willows along Okpirourak Creek, 1.5 km north of camp (Fig. 6). On 16 July the same nest was abandoned precluding determination of nest-initiation date.

RED-NECKED PHALAROPE - Uncommon breeder, fairly common summer resident. The first observation was 4 June when a pair was seen flying near camp. Pairs and singles were seen in small ponds, sections of river and creek, Moist Sedge, Wet Sedge, and Riparian habitats throughout June and early July. The only evidence of breeding was 1 chick with 2 defensive adults in Wet Sedge Tundra 11 km north of camp on 12 July. The latest observation was of 2 birds near camp on 23 July. The paucity of red-necked phalaropes in this inland study area was not expected, and may be related to annual variability as well as inland/coastal differences.

RED PHALAROPE - Rare spring migrant. Only 1 individual was observed on 5 June at a small pond 1 km southwest of camp.

POMARINE JAEGER - Common spring migrant. The species was seen as single birds or in groups of up to 8 birds hunting locally and/or traveling eastward every day observers were in the field from 1 to 18 June. Numbers of pomarines seen declined towards the last few days they were present. The decline in pomarine jaegers corresponded to a decline in numbers of caribou cows and calves in the immediate area, suggesting an association. On 11 June a total of 5 pomarine jaegers were seen scavenging on a caribou calf carcass that was killed by a bear the day before, 1.6 km south of camp on Tussock Dwarf Shrub Tundra. The latest date a large group of caribou cows with calves was seen on the study area was 21 June, 3 days later than the last pomarine jaeger observation.

PARASITIC JAEGER - Rare breeder, common summer resident. Parasitic jaegers were seen most days observers were in the field in June and July. Mostly groups in migration were observed 2-11 June with pairs and singles predominating thereafter. A majority of observations were over Moist Sedge, Moist Sedge-Shrub, Wet Sedge, and Riparian habitats. The only nest was of a dark phased pair found 23 June in Wet Sedge tundra 4 km northeast of camp; it contained 2 eggs (Fig. 6). Hatching occurred about 30 June, based on 1 pipped egg. Nest initiation was probably 2-6 June, based on an incubation period of 24-28 days (Harrison 1978). Two chicks were in the nest when it was checked 10 July, and by 18 July the chicks had left, but were still in the areas as indicated by 2 defensive adults nearby. The 2 nearly grown and fledged young were seen in the vicinity of the nest accompanied by 2 defensive adults on 11 August, which represented the latest observation of the species on the study area.

LONG-TAILED JAEGER - Fairly common breeder, common summer resident. First observation was on 2 June when a flock of 3 was seen hunting over Riparian habitat near camp. Groups of 3 to 5 were seen regularly throughout June and early July, but no real migratory movement was detected as with pomarine and parasitic jaegers. Observations were made mostly on or over Riparian and Dryas terrace habitats, with lesser numbers in Moist Sedge, Wet Sedge, and Tussock-Dwarf Shrub habitats. The first nest was found on 18 June, containing 1 egg on open Dryas terrace 0.5 km northeast of camp (Fig. 6). A second nest was found 23 June which consisted of 2 eggs in Wet Sedge Tundra 3 km northeast of camp. The third nest was not found until 7 July and it contained 1 pipped egg and 1 chick. Back-dating the latter nest of known hatching date yielded an estimated nest initiation date of 14 June. The first nest to be found contained an incubated egg on 6 July but was empty by 14 July. The latest observation was of 3 birds hunting over Tussock Dwarf Shrub Tundra 8 August.

MEW GULL - Rare visitor to middle coastal plain, probable rare breeder in foothill region. One defensive adult was seen at Jago Lake near Marie Mt. in the foothills.

GLAUCOUS GULL - Uncommon summer resident. The species was present on the study area when the field crew arrived 1 June. Single birds were observed flying and hunting on 1 and 23 June, and 20 July; a groups of 5 was observed standing on a gravel bar on 12 July.

BLACK-LEGGED KITTIWAKE - Casual late summer visitant. One immature was seen flying near camp on 10 August.

ARCTIC TERN - Rare breeder and summer resident. The first observation was of a single bird flying over the Jago River on 29 June. A brood of 2 chicks defended by 3 adults was found on the shore of a large lake 11 km northeast of camp on 12 July.

SHORT-EARED OWL - Uncommon summer visitant. All observations were of single birds hunting over Wet Sedge or low willows within a 5 km radius of camp on 1,10,24 and 29 June and 4 July. Although not observed at the Jago-Bitty camp because of its lateness in the season, a pronounced migration of short-eared owls was observed on the coastal plain in early September: 3-5 birds per day at 6 km inland along the Aichilik River on 10 to 12 September and about the same or more birds per day at Barter Island the first 2 weeks of September.

HORNED LARK - Uncommon summer visitant and probable breeder. Both observations are from the medium to tall willow stands near the south-facing slope of VABM Bitty, the first a pair seen on 2 July; the other a single individual seen on 26 July. Larks were more numerous in the foothills around Mt. Marie and Old Man Creek.

NORTHERN RAVEN - Uncommon resident. Singles or a pair were seen flying overhead from camp or nearby plots on 2,4,5,6,7,20,23,29,30 June. One bird was seen south of VABM Bitty 2 July; 1 was seen farther inland near Marie Mt. 20 July. The latest observation was on 9 August 2 km south of camp.

YELLOW WAGTAIL - Uncommon summer resident and probable breeder. Wagtails were present on the study area when researchers arrived 1 June. A majority of observations were in association with low to medium height willows; they were also observed in Tussock Dwarf Shrub and Moist Sedge Tundra. Singles were observed 1,6, and 9 June near camp. Pairs (2, 3, and 2 respectively) were observed on 10,21, and 23 June in Riparian habitat 2 km north of camp. Several birds from adjacent territories flocked together in common defense of suspected nests 2 July on the south side of VABM Bitty, 10 km south of camp. The latest observation was 20 July near Marie Mt., 35 km south of camp.

WATER PIPIT - Uncommon summer resident and probable breeder. Pipits were most often seen in association with the Jago River bluff which extended from 2 km south of camp to VABM Bitty, 11 km south of camp. This bluff included Tussock Dwarf Shrub, Low Willow, Wet and Moist Sedge, and rock outcrops, all of which were used by pipits vocalizing and defending suspected nests. Singles were seen on 2 and 21 June; many were seen on a walk from camp along the river bluff 2, 3 and 25 July; and 2 pairs were seen near Mt. Marie, 35 km south of camp.

CEDAR WAXWING - Accidental. Two birds were observed in the medium high shrub thickets on the south side of VABM Bitty 11 km south of camp on 2 July.

NORTHERN SHRIKE - Rare summer visitant, possible breeder. A group of 4 birds, probably juveniles, was seen in medium height willow 14 km south of camp and 3 km south of VABM Bitty on 24 July.

TREE SPARROW - Uncommon summer resident and probable breeder. Males perched and singing on 1-1.5 m tall willows were seen on 10, 21, and 29 June at the confluence of Okpirourak Creek and Jago River. Many individuals were seen in medium-height willows on the south facing slopes of VABM Bitty on 1 and 25 July, as well as in Riparian habitats 2 km south of Marie Mt. along the Jago River.

SAVANNAH SPARROW - Fairly common breeder. The species was seen or heard most days observers were afield. Savannah sparrows were present on the study area 1 June when researchers arrived. The species was most frequently associated with Riparian habitats and Wet, Moist, or Tussock Dwarf Shrub Tundra which had substantial prostrate shrub cover interspersed with dense sedge or grass cover. The first nest was found 21 June (Fig. 6) in Tussock Dwarf Shrub habitat; it had 4 eggs which subsequently hatched by 26 June; on 7 July the young had fledged. Two nests were found on 25 June, both in Riparian Willow, and both with 4 chicks. Both nests subsequently checked 1 July still had 4 chicks which were then banded; by 5 July both nests had fledged. The latest observations on the study area were 21-23

July when many savannah sparrows were seen in the Marie Mt. area, and on 24 July when many were seen in the shrub communities south of VABM Bitty, along the Jago River.

FOX SPARROW - Rare summer resident and possible breeder. The species was represented by a single observation of a pair flying over medium-height willows on the south-facing slopes of VABM Bitty 10 km south of camp.

WHITE-CROWNED SPARROW - Rare summer resident. A pair was seen on 1 and 3 July and a single bird was seen on 2 July in medium-height willows on the south-facing slope of VABM Bitty 11 km south of camp.

LAPLAND LONGSPUR - Abundant breeder. The species was seen every day researchers were afield, and was present on the study area when camp was set up 1 June. Breeding was noted in all 5 habitat types censused, but at varying densities: most abundant in Riparian (mean 7.8 nests and/or territories/km^2); intermediately abundant in Moist Sedge, Moist Sedge-Shrub, and Tussock Dwarf Shrub (3.5, 3.7, and 4.0 nests/territories/km^2), and least abundant in Wet Sedge (2.5 nests/territories/km^2).

Intensive courtship displays were noted 1 June until 11 June (when observers departed the study area for a week). Display flights were again noted 17 June but of decreasing intensity until 24 June, when the latest flight song was observed. The first nests were found 10 June, both on Moist Sedge Tundra 1 km west of camp (Fig. 6). During the period 10-21 June, most nests contained eggs (Fig. 7). The most frequent clutch size was 5 (54%) out of a range of 4-7. The nest success rate was 91% and hatching success was 81% out of 20 nests followed. The first hatching was noted 20 June, and the latest hatching noted 6 July (Fig. 7.). The resultant range in nest initiation dates, based on back-dating using an incubation period of 10-14 days (Harrison 1978) was 6-10 June to 22-26 June. During the period 23 June to 4 July, most nests had chicks. The earliest date that chicks of nearly fledgling size were found, hence allowing banding, was on 29 June. By the period 5 to 12 July, fledgling longspurs had become abundant on the censuses. Shortly thereafter, a discernible vacation of Moist Sedge, Moist Sedge-Shrub and Tussock Dwarf Shrub habitats by longspurs was coincident with a marked increase in longspurs in Riparian plots (see Results and Discussion of variability due to season). By 9 August adult and juvenile longspurs flocked in premigratory staging, and represented the latest observation on the study area.

SMITH'S LONGSPUR - Rare summer visitant. Only one observation was made, a single bird calling in Moist Sedge Tundra near camp on 25 July.

SNOW BUNTING - Rare summer visitant. The species was represented by a single observation of 1 bird in a rocky area on the Jago River 2 km north of Marie Mt., 35 km south of camp in the foothills region.

REDPOLL - Fairly common breeder. Redpolls were seen most days researchers were in Riparian habitats, where a majority of observations occurred. The first observation was made on 2 June in low willows 2 km south of camp. The first nest was found on 23 June located 0.3 m high in a 1 m tall willow shrub in Riparian habitat 4 km northeast of camp (Fig. 6). A female "hoary" type was incubating on 23 and 29 June. On 23 June the nest contained 2 eggs and 3 young; on 29 June it contained 5 young; by 10 July the young had apparently fledged. A second nest containing 14 eggs was found in a Riparian plot on 25 June; on 1 July it contained 5 eggs; by 5 July 3 eggs were hatched, 2 were unhatched; and on 14 July 4 live and 1 dead chicks were present. Incubation of the first nest probably began about 8 June, based on back-dating the known hatch date using an incubation period of 15 days (Harrison 1978). The latest observation was on 11 August.

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Fairbanks Fishery Resources Progress Report Number FY84-1

FISHERIES STUDIES ON THE NORTH SLOPE OF THE ARCTIC NATIONAL WILDLIFE REFUGE, 1983

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ABSTRACT

During 1983, the Fairbanks Fishery Resource Station conducted fisheries studies on the coastal plain of the Arctic National Wildlife Refuge. The major emphasis in 1983 was fall and winter movement and spawning areas of arctic char and general species distribution and life history in the Hulahula River. Fish distribution and life history in the Okpilak and Jago River drainages, and several smaller rivers were also studied. Char movement and overwintering was again studied on the Canning River. Physical characteristics of these drainages were examined and related to potential overwintering habitat. During the study period, char movement into the Lower Hulahula River ranged from the beginning of August through the beginning of September. The peak movement in numbers of fish appeared to occur around the last week of August.

Fall concentrations of char on the Hulahula River were located by aerial survey in mid-September. The fish appeared to be concentrated in three sites which are consistent with the three fish holes used historically for subsistence fishing. Major spawning areas were located at the upper two fish holes. Overwintering pools appear to be limited. Hulahula River radio-tagged char showed little movement during late fall and early winter. A few tagged fish remained at the original site and the remaining fish had moved no further than 5 km downstream into a large aufeis field.

Fairbanks Fishery Resources Progress Report No. FY84-1
FISHERIES STUDIES ON THE NORTH SLOPE OF THE ARCTIC NATIONAL WILDLIFE REFUGE, 1983

INTRODUCTION

Section 1002c of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980 included provisions for a 5 year assessment of the fish and wildlife resources of the coastal plain of the Arctic National Wildlife Refuge (ANWR). This assessment was to include the following: an assessment of the size range, and distribution of fish and wildlife populations; a determination of the extent, location and carrying capacity of fish and wildlife habitat; an assessment of the impacts of human activities and natural processes on fish and wildlife and their habitat; and an analysis of potential impacts from oil and gas exploration, development, and production. During 1983 the Fairbanks Fishery Resources Station conducted aquatic studies in accordance with the fishery portion of this mandate.

The study area established by ANILCA includes most of the coastal plain of the ANWR from the Aichilik River on the east to the Canning River on the west. It covers an area of approximately 630,000 hectares (2520 sq. miles) and includes 135 km of coastline, barrier islands and lagoons along the Beaufort Sea. Eight major drainages and several smaller coastal streams either flow or are contained within the study area. Relatively few lakes, compared to the western Alaska coastal plain, are found in the study area and the majority of these are shallow thaw lakes supporting only a seasonal summer fishery at best.

Very little is known about fish populations and their habitats on the coastal plain of the ANWR. Craig (1977a; 1977b) conducted studies on arctic char life history on the Canning River and Sadlerochit Springs during 1972 and 1973. Previous fish distribution studies have reported only two species, grayling and char, in fresh water on the coastal plain east of the Canning River (Ward and Craig, 1974).

This study reports the results of the aquatic surveys on the coastal plain during 1983. Specific objectives were to: 1) Assess general distribution and life histories of major fish species on Okpilak, Jago and Hulahula Rivers and smaller drainages between the Katakturuk River and the Aichilik River; 2) Identify and describe char overwintering movements and habitat requirements on the Canning and Hulahula Rivers; 3) Monitor anadromous char migration patterns on the Hulahula River; 4) Identify and describe char spawning grounds and habitat requirements for the Hulahula River.

METHODS

Access into the survey areas consisted of a variety of fixed wing and rotor wing aircraft including: Cessna 185, Super Cub, and Bell 206 and Hughes 500D helicopters. Aircraft type depended on availability and site accessibility. Surveys at the sites were conducted on foot or by inflatable Zodiac rafts.

Fish capture techniques depended on the location and included the following: 125 X 6ft. monofilament experimental gill nets with five 25 ft. panels of 1/2 in. to 2 1/2 in. bar mesh; 30 X 6ft. monofilament experimental gill nets with five 6ft. panels of 1/2 in. to 2 1/2 in. bar mesh; baited minnow traps; Type XI Smith-Root backpack electrofisher; beach seines from 30 X 4ft. to 100 X 8ft.; and hook and line.

Fork length of fish was measured to the nearest millimeter from the tip of the snout to the fork in the caudal fin. Weights of fish were determined using Pesola spring scales with ranges of 0 to 250 g, 0 to 500 g and 0 to 2500 g. Coefficient of condition (K) was determined for char and grayling according to the following equation:

$$K = \frac{\text{Weight} \times 10^5}{\text{Length}^3}$$

Ages were determined from otolith samples taken from grayling and char. Otoliths were cleaned and soaked in liquid detergent, ground on 400 grit wet sanding paper and read under a Bausch and Lomb binocular microscope, using reflected light, at 30-40X magnification. The first year of growth was defined as 0 age class using Nordeng's (1961) explanation that a hyaline zone between the center and the first annulus is formed during the first summer after hatching.

Numbered Floy FD-67 anchor tags were implanted in fish in the Hulahula to gain information on movement patterns. The adipose fin was clipped on fish too small to tag. Water chemistry measurements for total alkalinity, total hardness, and pH were made with Hach AL-36B kits. Conductivity was determined with Hach Mini Conductivity Meters. Water and air temperatures were also taken at each sampling site.

USGS, 1:63,350 and 1:250,000 scale maps were used to determine stream order, extent of channel braiding and gradient characteristics of the Hulahula, Jago and Okpilak Rivers and small tributaries of these rivers. Strahler's method (1957) was used to determine stream order. Stream orders ranged from 1 to 5. After all streams that were surveyed were ordered, they were broken down into reaches.

A radio telemetry study was conducted on arctic char in the Canning River during the winter of 1982-1983 to locate and describe overwintering habitat and to monitor winter movements. Another telemetry project was initiated on char in the Hulahula River in September 1983 to compare results to a different area. Radio transmitters were implanted in fifteen arctic char on the Canning River in September 1982.

In addition, 29 arctic char in the upper Hulahula River were implanted with radio tags during September 1983. Relocations of the Canning River fish was accomplished periodically through the winter. Aerial relocation for the

Hulahula River fish will be attempted on a bi-monthly basis throughout the winter and early spring of 1983-1984.

Telonics equipment was utilized for the telemetry studies and included: 1) RB-5 transmitters, weight 27g, diameter 1.7 cm, length 5.6 cm; 2) TR-2 Receiver with the TS-1 Scanner/Programmer; and 3) RA-2AK Antennaes. The frequency range selected for the above equipment was 151.000 MHz to 153.999 MHz. Pulse rate for the transmitters was selected at 55 per minute to extend the operational life of the lithium batteries to 8 months. Antennaes were mounted during aerial tracking on the wing struts of a Cessna 185.

In the Canning River study, 12 fish of the 15 collected for tagging were caught by seine and three were caught by angling. Twenty-seven fish, collected for tagging in the Hulahula River were captured by angling. One fish was collected by electrofishing and one char was collected by experimental gill net. Fish were anesthetized in MS-222, weighed and measured, tagged and returned to a holding pen for a 24 hour period for observation. Tagging was accomplished by sliding the tag through the mouth into the stomach cavity. The 10.5 in. external antennae on the radio tag was attached to the upper maxillary with a wing band and left trailing along the fishes body.

The minimum size of fish in which tags were implanted was determined, in part, from the 1982 implants and from necropsy analysis on eight fish of different sizes implanted with the tags and then held for 1 to 2 days in a holding pen. The stomach was ruptured on three fish, 514 mm and 1250 g and smaller. Fish over 500 and 1400 g appeared healthy with no apparent damage to stomach cavity. Attempts were made to limit the minimum size to 500 mm and 1400 g. During both studies, the size range was 507 mm and 1200g to 664 mm and 2900g. The smallest fish tagged, 507mm and 1200g, was one being held for necropsy analysis that escape from the holding pen.

Aerial tracking is accomplished by parallel flights along the river at altitudes of 500-1000 feet above ground level. Specific locations are determined by monitoring pulse volume.

OKPILAK RIVER

Physical - Chemical Characteristics

The Okpilak River, at its mouth is a fifth order stream with a 0.95 percent gradient. Braided channel area is primarily found throughout the river with irregular channel configurations in the upper reaches. There are two springs feeding into the Okpilak River, one of which is thermal. Neither spring is within the 1002c study area. The upper watershed contains landlocked lakes. Okpilak Lake was sampled during July, 1983. Seven sites were sampled; three in the main channel, one unnamed tributary in the lower portion, and three sites on the Akutoktak River (Figure 1).

Discharge was determined for three of the sample areas from July 2-6, 1983 (Table 2). Discharge ranged from 0.16 cms, in the lower portion, to 0.28 cms in the upper Akutoktak River. The channel width averaged 10.7 m with an average depth of 0.35 m. Discharge and depth were not taken for the main channel due to water levels too high to wade through.

Water chemistry sampling for all seven sites can be found in Table 1. Water temperature averaged 9.5°C, pH ranged from 6.8 to 7.5 and conductivity ranged from 30 umhos/cm in the lower main channel to 120 umhos/cm in Akutoktak River. Total alkalinity was lowest on the Upper Akutoktak River and highest in a tributary to the lower Okpilak River (35 mg/l and 87 mg/l respectively). Total hardness ranged from 70.4 mg/l in Upper Akutoktak River to 154 mg/l in the middle section of the main channel.

Table 1. Chemical characteristics of sample areas on the Okpilak River, July 1983.

	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Conductivity (umhos/cm)	H_2O Temp. (°C)	Air Temp. (°C)	pH
Lower River						
A	68.4	119.7	80	7.0	9.0	7.5
B	86.5	102.6	44	6.5	13.0	7.0
Akutoktak River						
C	85.5	153.9	30	8.0	10.0	7.5
D	68.5	136.8	120	14.0	11.0	7.5
E	35.2	70.4	115	10.0	16.0	6.8
Upper River						
F	68.4	68.4	94	11.5	17.0	7.3
G	34.2	51.3	120	-	-	6.9

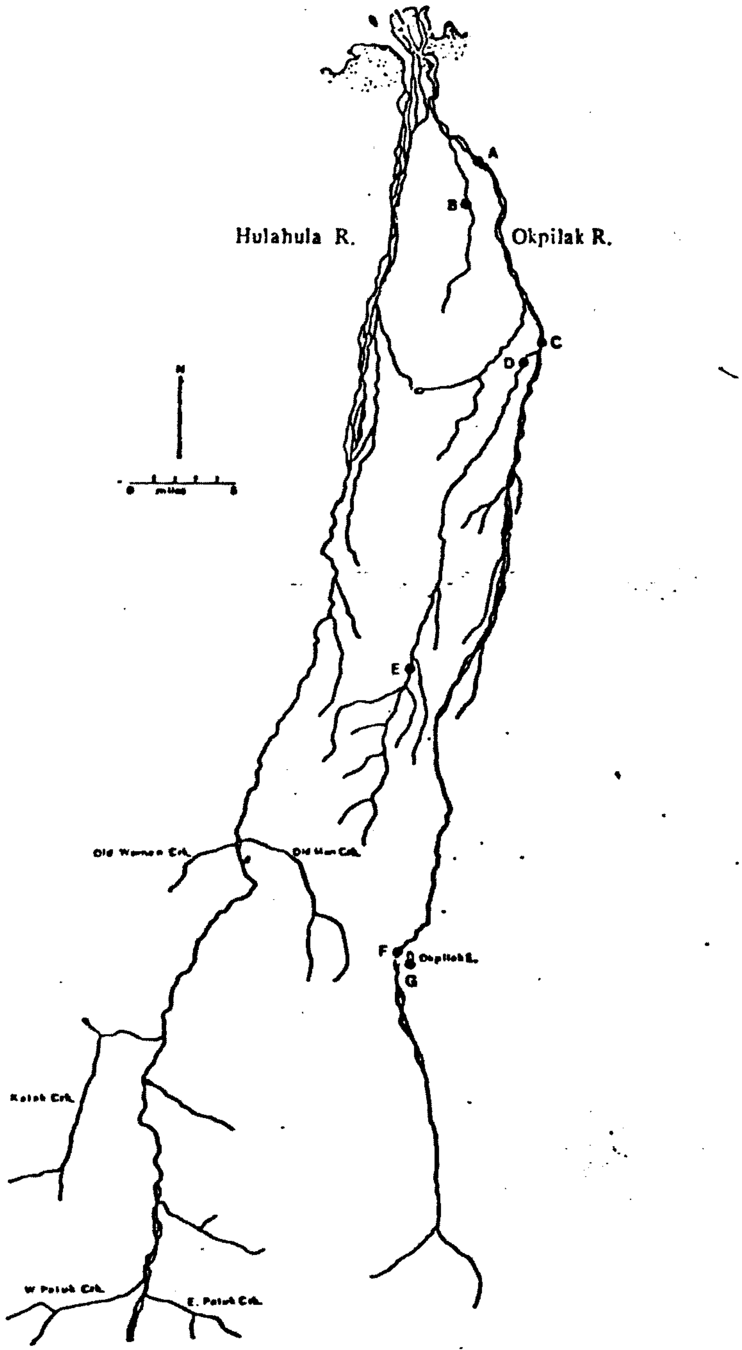

Figure 1. Chemical and physical sampling locations in the Okpilak River, July 1983.

Table 2. Physical characteristics of sample areas on the Okpilak River, July 1983.

	Stream Order	% Gradient	Channel Configuration	Wetted Perimeter (m)	Average Depth (m)	Discharges (cms)	Average Velocity (m/s)	% Pool Area	% Riffle Area	Predominant Substrate
Lower River										
A	5	.95	Braided	3.05 - 61.0	-	-	-	90	10	Small and Large Gravel
B	3	.69	Irregular	7.3	.26	.16	.09	80	20	Small and Large Gravel
Akutoktak River										
C	5	.92	Braided	3.05 - 30.5	-	-	-	10	90	Small and Large Gravel
D	4	.61	Irregular	15.4	.52	.23	.03	60	40	Small and Large Gravel
E	3	.64	Irregular	9.4	.26	.28	.12	40	60	Boulder and Rubble
Upper River										
F	4	.36	Braided	3.05 - 61.0	-	-	-	20	80	Small and Large Gravel

Fish Distribution and Abundance

Figure 2 presents fish sampling locations and spring areas for the Okpilak River drainage. Distribution of fish species collected from various sample areas is found in Table 3.

Grayling were not found in the Okpilak River above the confluence of the Akutoktak River during the 1983 summer sampling period. Grayling were well distributed throughout the clear water tributaries studied. The lower tributary and main channel (sites H & J) had small numbers of adult grayling present. Middle reaches of the Okpilak were not sampled during this study (between sites B & J). Ward and Craig (1974) seined site E on July 23, 1974 with no fish captured. Future investigations in this portion of the river should reveal a better understanding of fish species occurance. The Akutoktak River (sites C, D, F & G) has a wide distribution of grayling throughout. Adults and juveniles were found mostly in pool areas at sites C and G. Fry were observed on August 6, 1982 at site F.

Okpilak Lake (site A), which is landlocked, has populations of grayling and lake trout. Juveniles and adults were captured for both species.

Aerial surveys were flown for the Okpilak River in September 1982 and 1983 by USFWS personnel. Survey boundaries are shown in Figure 2. No fish were spotted during these flights.

Relative abundance and mean length of fish collected in the Okpilak River drainage during July 1983 are shown in Table 4. Grayling were found in greatest numbers near the mouth of the Akutoktak River (site G) and in Okpilak Lake (site A). Gill net catch rates were 0.30 and 0.42 fish per hour respectively, while angling catch rates were higher at 6.0 and 2.67 fish per angling hour. Elsewhere in the sample area, adult and juvenile grayling were found in relatively low numbers. Minnow traps were least effective with a catch rate of 0.007 fish per hour for the Okpilak River. Grayling fry were found in large numbers at site F on August 6, 1982. Grayling fry were probably just beginning to emerge during the 1983 sampling period (July 2-6) therefore not found. Craig and Poulin (1974) and USFWS (1983) predicted fry emergence for nearby rivers as occuring between the last 2 weeks of June and 1st week of July.

Lake trout were found in low numbers at Okpilak Lake with a gill net catch rate of 0.08 fish per hour.

Length Frequency

Length frequency histograms for grayling collected from the Okpilak River and Okpilak Lake are presented in Figures 3 and 4. Both sampling areas consisted predominantly of similar length groups when comparing gillnet catch results. The mean fork lengths of grayling caught in Okpilak Lake and the Okpilak River system are similar, 235 mm and 264 mm respectively.

Age and Growth

Age and growth of grayling collected in the Okpilak River area are presented in Table 5 and 6. A comparison of length-age relationships for grayling from

Okpilak Lake with the Okpilak River system stock are similar. These figures fall within the ranges given by Craig and Poulin (1974) for Weir Creek and the Kavik River, which are both in close proximity to the study area.

Table 3. Fish distribution in the Okpilak River drainage.*

Sample Area	Sample Date(s)	Fish Species	Life Stage(s)	Comments
A	July 5-6, 1983	Gr Lt	J,A J,A	USFWS, Fishery Resources, Fairbanks
B	July 6, 1983	No fish collected		USFWS, Fishery Resources, Fairbanks
C	July 4-5, 1983	Gr	J,A	USFWS, Fishery Resources, Fairbanks
D	July 23, 1974	No fish collected		Ward & Craig (1974)
E	July 23, 1974	No fish collected		Ward & Craig (1974)
F	August 6, 1982	Gr	F	USFWS, Fishery Resources, Fairbanks
G	July 2-4, 1983	Gr	J,A	USFWS, Fishery Resources, Fairbanks
H	July 2, 1983	Gr	A	USFWS, Fishery Resources, Fairbanks
I	July 2, 1983	Gr	A	USFWS, Fishery Resources, Fairbanks

Gr - Grayling
Lt - Lake trout
A - Adult, J - Juvenile, F - Fry

*See figure 2 for sample site locations.

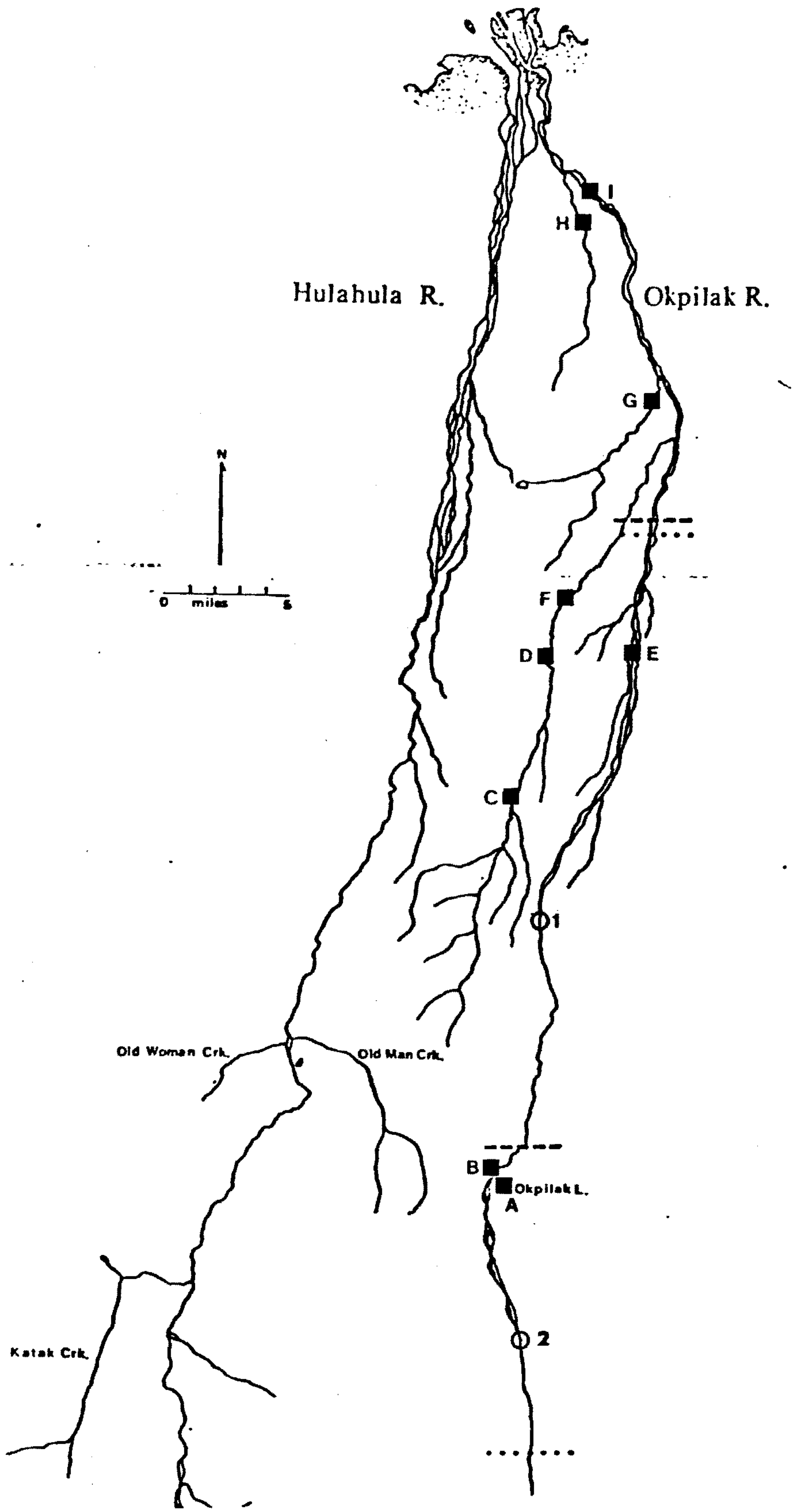

Figure 2. Fish sampling locations (■), spring areas(O), and aerial survey boundaries (----1982)(....1983) in the Okpilak River system. 1974-1983.

Table 4. Catch-per-unit-effort and mean fork length of grayling and lake trout collected in the Okpilak River drainage, July 2 - July 6, 1983.

Sample Location	Fish Species	# of Fish Collected	Total Effort	Mean Fork Length (mm)	Length Range (mm)	Catch per-unit Effort
			30' Experimental Gill Net			
A	Gr	15	36.0 hrs.	234	126-328	0.42/hr.
A	Lt	3	36.0 hrs.	265	123-395	0.08/hr.
B	-	0	36.0 hrs.	-	-	-
C	Gr	4	42.0 hrs.	255	235-274	0.09/hr.
G	Gr	24	79.5 hrs.	254	135-375	0.30/hr.
H	Gr	2	34.0 hrs.	306	306-307	0.06/hr.
I	Gr	2	32.0 hrs.	360	335-385	0.06/hr.
All (without A)	Gr	32	187.5 hrs.	264	135-385	0.17/hr.
			Angling			
A	Gr	4	1.5 hrs.	360	281-405	2.67/hr.
C	Gr	1	0.5 hrs.	334	-	2.00/hr.
G	Gr	18	3.0 hrs.	323	260-286	6.00/hr.
All (without A)	Gr	19	3.5 hrs.	324	260-386	5.43/hr.
			30' Seine			
G	Gr	8	8 hauls	195	119-327	1.0/haul
			Minnow Trap			
A	-	0	51	-	-	-
G	Gr	2	198.0 hrs.	108	95-122	0.01/hr.
B	-	0	36	-	-	-
H	-	0	51	-	-	-
All (without A)	Gr	2	285	108	95-122	0.007/hr.

The oldest fish caught was from Okpilak Lake, a grayling, with a fork length of 354 mm and aged over 15 years. The majority of fish fell between the 2 and 7 year age classes. Grayling matured sooner in Okpilak Lake than from the Okpilak River. By age 4 all the lake population sampled had matured, while the river fish were not all mature until age 5. Small sample sizes for Okpilak Lake make these comparisons less conclusive but still provide a general relation- ship. Grayling from the Tamayariak River (USFWS 1983) were all mature by the seventh year of growth.

Sex ratios for Okpilak River and lake resident grayling show some differences. Compositions are presented in the following table.

Area	Total Number of Fish	Percent Immature	Percent Male	Percent Female
Okpilak Lake	19	15.8	36.8	47.4
Okpilak River	51	25.5	47.0	27.5

Table 5. Age specific length (otolith) of grayling collected from the Okpilak River, July 2 - July 5, 1983.

Age	Sample Number	Mean Fork Length (mm)	Standard Deviation	Length Range (mm)	% Mature
2	6	131.2	5.2	122 - 135	0
3	1	235.0	-	-	100
4	11	235.5	17.5	195 - 260	30
5	5	278.2	12.9	263 - 295	100
6	7	291.7	42.8	242 - 365	100
7	9	310.7	31.0	254 - 358	100
8	2	341.0	48.1	307 - 375	100
9	1	359.0	-	-	100
10	1	344.0	-	-	100

Three lake trout were captured from Okpilak Lake. The age specific lengths are presented in Table 6. The youngest fish was an immature in its 6th year and the oldest was over 13 years old with a fork length of 394 mm.

Table 6. Age specific length (otolith) of fish collected from Okpilak Lake, July 5 - July 6, 1983.

Age	Sample Number	Mean Fork Length (mm)	Standard Deviation	Length Range (mm)	% Mature
			Arctic Grayling		
2	3	131.3	6.8	126 - 139	0
3	0	-	-	-	-
4	4	230.2	5.3	223 - 235	100
5	1	252.0	-	-	100
6	3	270.0	14.2	254 - 281	100
7	0	-	-	-	-
8	0	-	-	-	-
9	1	220.0	-	-	100
10	1	369.0	-	-	100
11	0	-	-	-	-
12	1	405.0	-	-	100
13	1	385.0	-	-	100
15	1	354	-	-	100
			Lake Trout		
6	1	123	-	-	0
10	1	277	-		100
13	1	394	-		100

Weight and Condition

The following length-weight relationship was calculated for grayling collected from Okpilak Lake, July 5 - July 6, 1983.

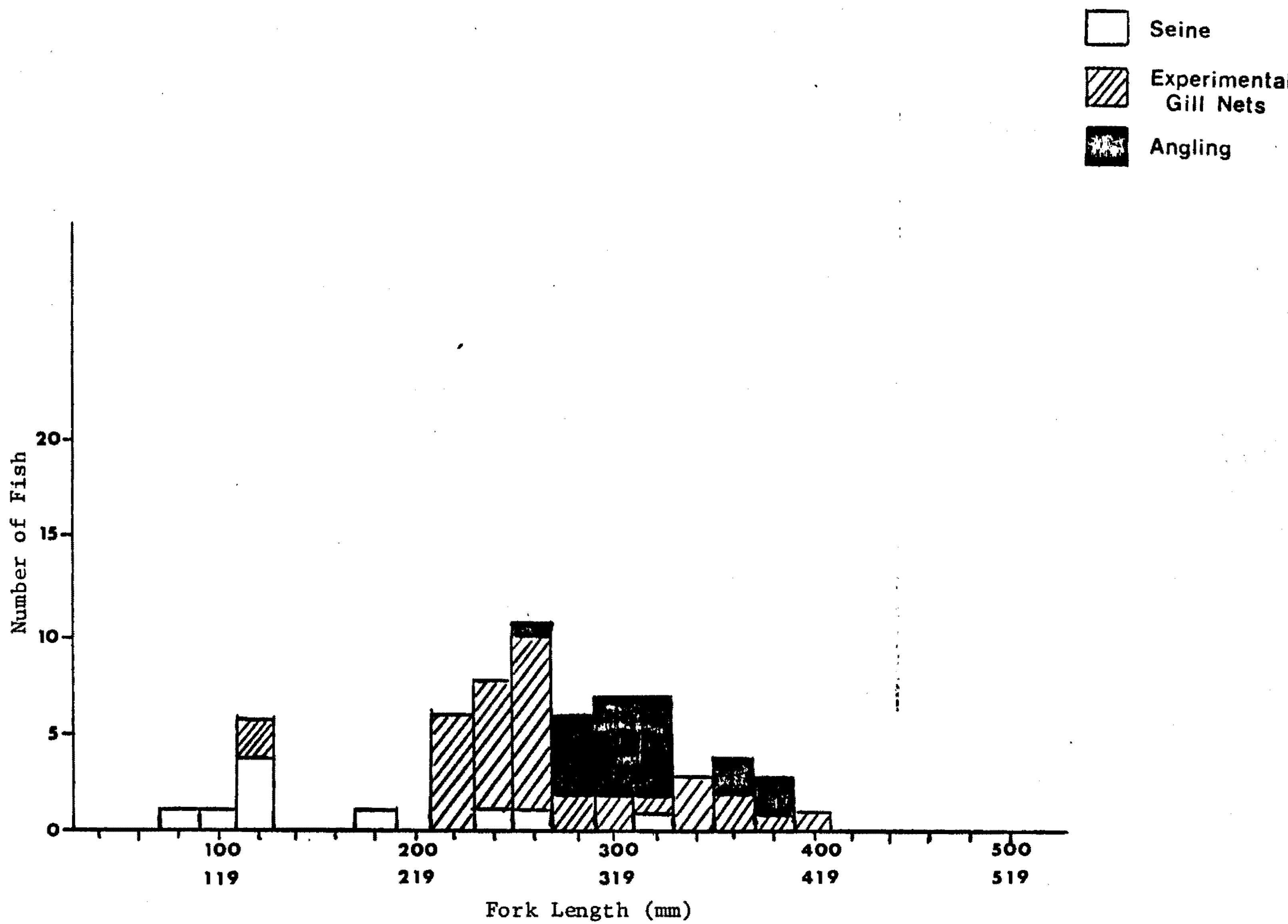

Figure 3. Length frequency of 65 arctic grayling collected by seine, experimental gill net, and angling in the Okpilak River system, July 1983.

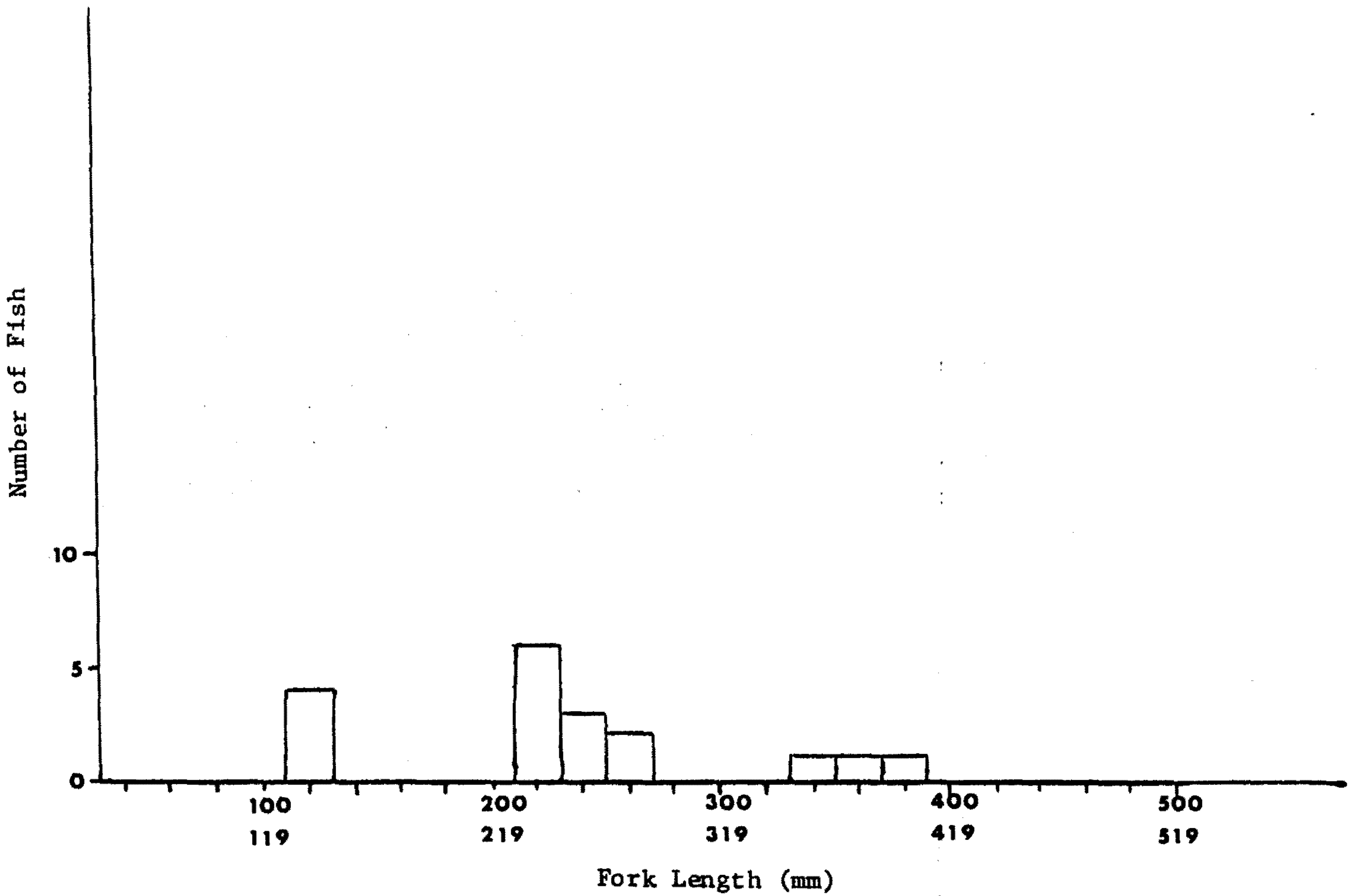

Figure 4. Length frequency of 18 arctic grayling collected by experimental gill net in Okpilak Lake, July 1983.

Grayling ($n = 19$, $r = 0.993$, fork length range = 123-405 mm, weight range = 14-645 gms):

$$\text{Log}_{10} W_{(g)} = 3.180 \text{ Log}_{10} L_{(mm)} - 5.422.$$

The following length-weight relationship was calculated for grayling collected from the Okpilak River, July 2 - July 5, 1983.

Grayling ($n = 60$, $r = 0.986$, Fork length range = 95-386 mm, weight range = 3-505 gms):

$$\text{Log}_{10} W_{(g)} = 3.174 \text{ Log}_{10}(L) - 5.46$$

Condition factors (K) for grayling collected from the Okpilak River drainage during July, 1983 are reported in Tables 7 and 8. The mean K values for length groups above 200 mm are greater for Okpilak River. K values for grayling collected from the Tamayariak and Sadlerochit Rivers (USFWS 1983) are similar to the results from the Okpilak Lake population. The significance of these differences has not been determined.

Spawning and Overwintering

Little is known about the spawning and overwintering of grayling in the Okpilak River. The large concentrations of grayling fry observed on August 6, 1982 in the middle sampling area F of the Akutoktak River indicates that this portion of the river is being heavily used for spawning. By comparing movement patterns of grayling from Weir Creek (Craig & Poulin, 1974) and Tamayariak River (USFWS, 1983), the adults captured in early July at the mouths of Okpilak River tributaries (site G, H, J) probably were moving downstream from spawning areas located up these tributaries.

Overwintering habitat for the Okpilak River system is most likely very limited. No suitable habitat has been described for the drainage. Since the Okpilak River is highly braided through most of its lower reaches and shallow water depths occur in the upper areas, grayling probably overwinter in the small isolated pools that are available.

Table 7. Coefficient of condition (K) for grayling from Okpilak Lake, July 5 - July 6, 1983.

Length Group (mm)	Number in Sample	Mean K	Standard Deviation
100 - 149	3	0.83	0.11
150 - 199	0	-	-
200 - 249	6	1.12	0.11
250 - 299	5	1.05	0.10
300 - 349	-	-	-
350 - 399	4	1.05	0.15
400 - 449	1	0.97	-

Table 8. Coefficient of condition (K) for grayling from the Okpilak River, July 2 - July 5, 1983.

Length Group (mm)	Number in Sample	Mean K	Standard Deviation
50 - 99	1	0.35	-
100 - 149	7	0.96	0.31
150 - 199	1	0.74	-
200 - 249	12	0.96	0.08
250 - 299	18	0.90	0.07
300 - 349	15	0.93	0.05
350 - 399	6	0.91	0.10

JAGO RIVER

Physical - Chemical Characteristics

The Jago River, at its lower reaches, is a fourth order stream with a 0.56 percent gradient. A braided channel is primarily found throughout the river. The main channel of the Jago River was sampled August 8, 1975 and found to have a discharge of 7.6 cms (Childers et.al., 1977). There are several lakes in the upper watershed. Three of these lakes were sampled during the summer period. Five sites were sampled for physical and chemical characteristics throughout the Jago drainage during July 1983 (Figure 5).

Table 9. Chemical characteristics of sample areas on the Jago River, July 1983.

	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Conductivity (umhos/cm)	H_2O Temp. (°C)	Air Temp. (°C)	pH
Lower River						
A	51.3	51.3	68	13.0	19.0	6.8
Okpirourak Creek						
B	70.4	70.4	130	15.0	20.0	7.5
C	17.1	34.2	37	20.0	22.0	6.5
Okerokovik Springs						
D	136.8	205.3	380	8.0	21.0	8.0
Jago Lake						
E	34.2	85.5	78	19.0	22.0	7.5

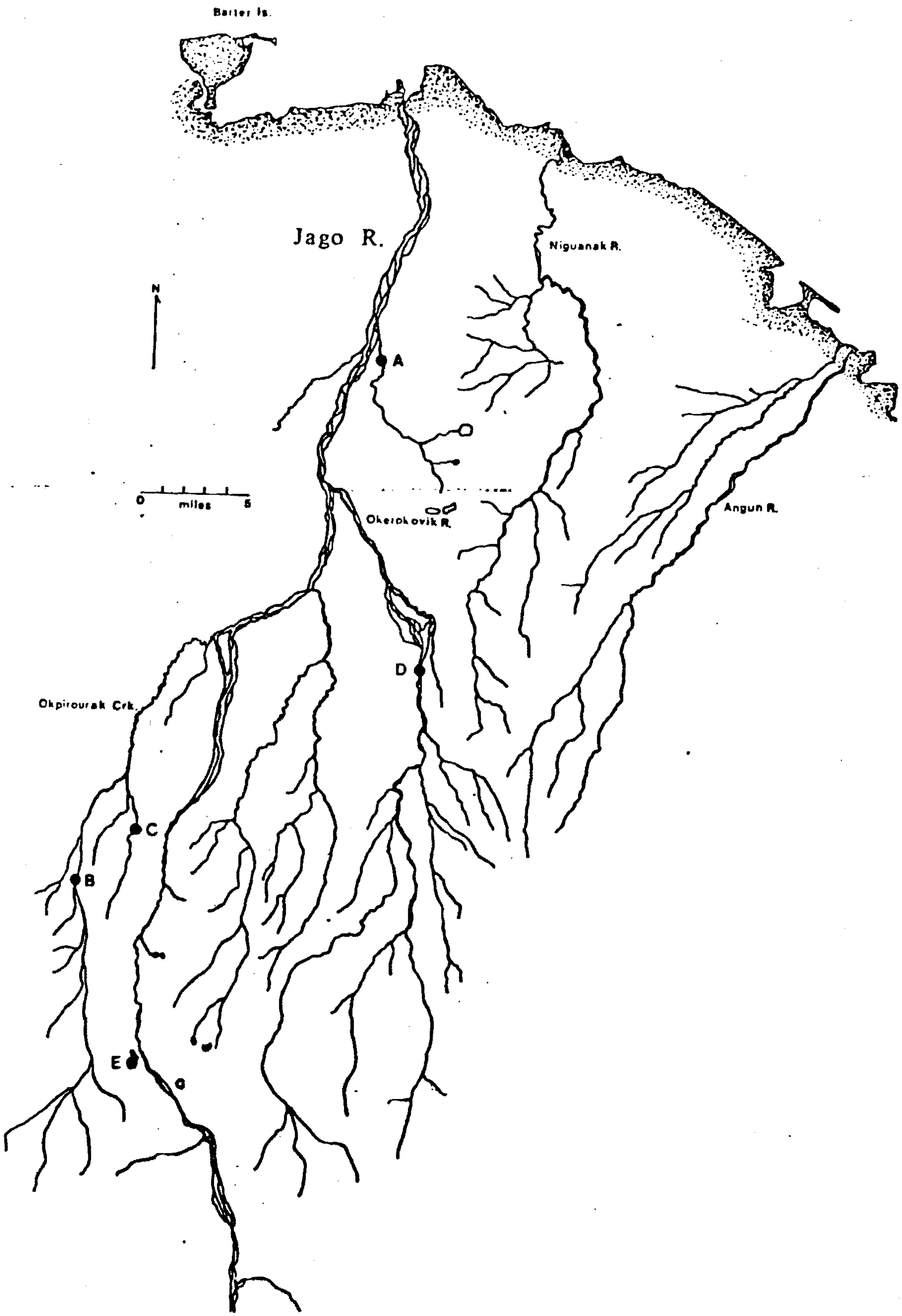

Figure 5. Chemical and physical sampling locations in Jago River, July 1983.

Table 10. Physical characteristics of sample areas on the Jago River, July 1983.

	Stream Order	% Gradient	Channel Configuration	Wetted Perimeter (m)	Average Depth (m)	Discharges (cms)	Average Velocity (m/s)	% Pool Area	% Riffle Area	Predominant Substrate
Lower River										
A	4	.56	Irregular	1.5	.55	.14	.18	-	-	-
Okpirourak Creek										
B	3	.23	Irregular	16.8	.21	1.14	.34	-	-	-
C	3	.47	Straight	-	-	-	.03 cms	-	-	-
Okerokovik Springs										
D	3	.30	Braided	10.1	.12	.14	.12	-	-	-

Discharge was determined for four of the 1983 field sites (Table 10). Discharge ranged from less than .03 cms in an upper reach of Okpirourak Creek to 1.14 cms in the lower Okpirourak. One spring is located on the Okerokovik River. Discharge was measured during the July sampling period showing discharge at 0.14 cms. Discharge was also measured during a earlier study on August 8, 1975 with results of 2.4 cms (Childers et.al., 1977). The average width and depth were 9.5 m and 0.29 m respectively. Water chemistry sampling was conducted for all sites and is shown in Table 9. The pH range was from 6.5 to 8.0 and conductivity fell to a low of 37 umhos/cm in Okpirourak Creek. Total alkalinity and total hardness were lowest in the Okpirourak Creek (17 mg/l and 34 mg/l, respectively) and highest in the Okerokovik River (137 mg/l and 222 mg/l).

Fish Distribution and Abundance

Fish sampling locations and spring area for the Jago River drainage are found in Figure 6. Table 11 shows fish distribution for the various sample locations.

Table 11. Fish distribution in the Jago River drainage.*

Sample Area	Sample Date(s)	Fish Species	Life Stage(s)	Comments
A	7/8/83	No fish collected		USFWS, Fishery Resources, Fairbanks
B	7/9/83	AC-LR	A,J	USFWS, Fishery Resources, Fairbanks
C	7/8/83	AC-LR	A	USFWS, Fishery Resources, Fairbanks
D	7/7/83	No fish collected		USFWS, Fishery Resources, Fairbanks
E	7/7/83	No fish collected		USFWS, Fishery Resources, Fairbanks
F	7/23/74	No fish collected		Ward & Craig (1974)
G	7/1/82, 7/6/83	NSB	A	USFWS, Fishery Resources, Fairbanks
H	7/23/74	No fish collected		Ward & Craig (1974)
I	7/23/74, 7/8/83	No fish collected No fish collected		Ward & Craig (1974) USFWS, Fishery Resources, Fairbanks
J	7/2/82	No fish collected		USFWS, Fishery Resources, Fairbanks
K	7/3/82	No fish collected		USFWS, Fishery Resources, Fairbanks
L	7/3/82	No fish collected		USFWS, Fishery Resources, Fairbanks
M	7/8/83	No fish collected		USFWS, Fishery Resources, Fairbanks

AC - Arctic char LR - Lake resident
NSB - Ninespine Stickleback
A - Adult J - Juvenile

*See figure 5 for sample site locations.

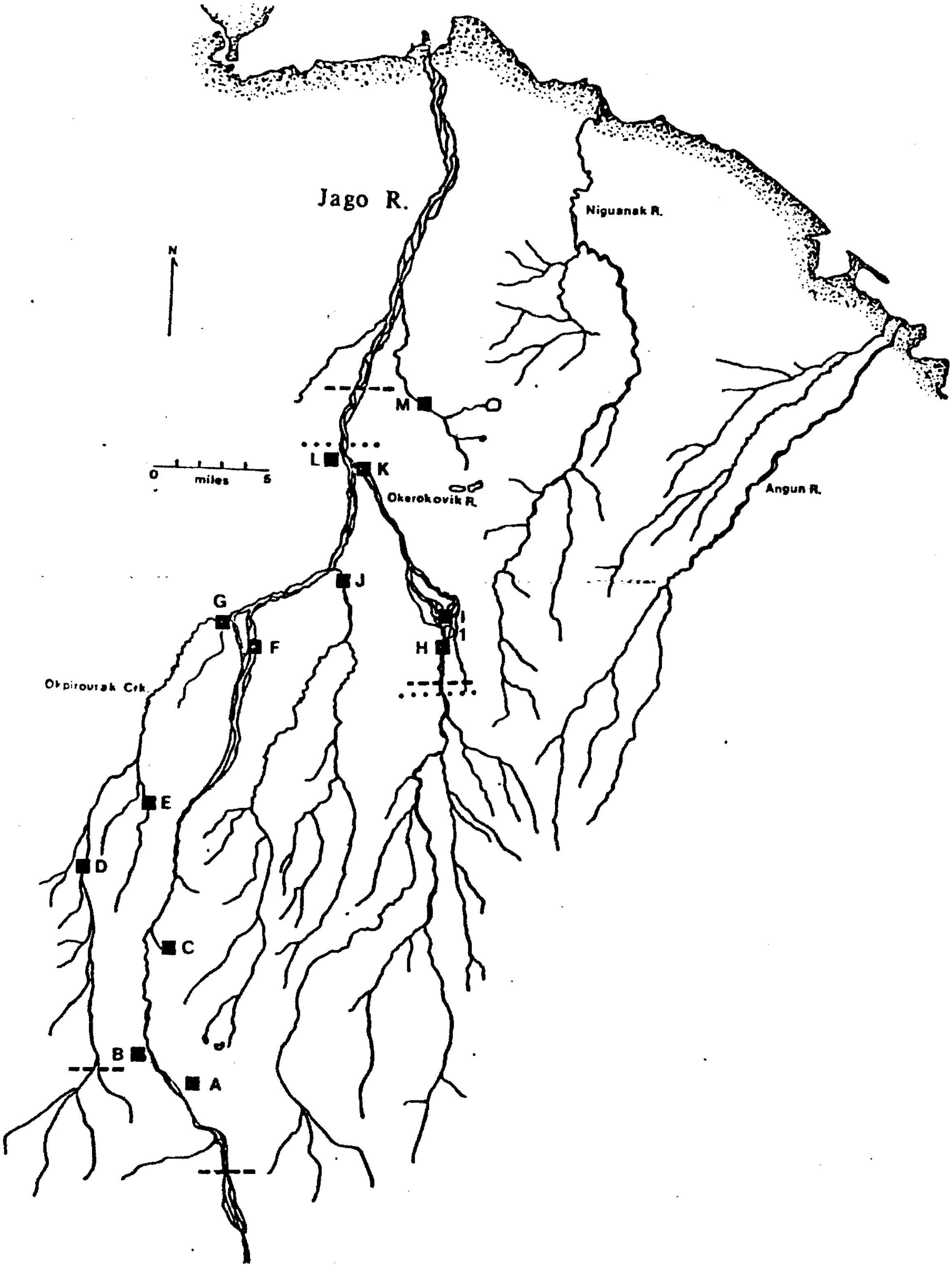

Figure 6. Fish sampling locations (■), spring area (O), and aerial survey boundaries (---- 1982)(.... 1983) in the Jago River drainage, 1974-1983.

The Jago River and tributaries were sampled by USFWS personnel on June 30 to July 6, 1982 and July 7-8, 1983. A total of 20 hours of E-125 gill net effort, 93 hours of E-30 gill net effort and 34.6 minutes of electrofishing effort resulted in no fish collected. Two ninespine sticklebacks were captured after 102 hours of minnow trap effort at the mouth of Okpirourak Ck. (site G). Ward and Craig (1974) seined sites F, H, and I with no fish caught.

Three lakes (site A, B, C), isolated from the Jago River system, were investigated July 7-9, 1983 by USFWS personnel. Resident populations of arctic char were found in Lakes B and C. No fish were collected in Lake A after 46 hours of E-30 gill net effort. One resident char was caught in Lake C after 48 hours of E-30 gill net effort. Forty-eight resident char were captured in Jago Lake (Lake B); 22 from 23 hours of E-125 gill net effort, 18 from 69 hours of E-30 gill net effort, and 8 from 9.3 minutes of electrofishing effort.

Aerial surveys of the Jago River system were flown on September 25, 1982 and September 13, 1983. Survey boundaries are depicted in Figure 6. No fish were spotted during these flights.

Length Frequency

A length frequency histogram for lake resident arctic char from Jago Lake (site B) is presented in Figure 7. Sixty-five percent of the sample had fork lengths between 280 and 379 mm. The largest char caught was 525 mm.

Age and Growth

Age specific lengths (determined by otoliths) for Jago Lake resident arctic char collected July 9, 1983 are found in Table 12. The youngest fish collected were in their 5th season of growth (4+ years old). The oldest char was aged at greater than 16+ years old with a fork length of 370 mm. Growth rates were similar to populations of lake resident arctic char in Northern Alaska summarized by McCart (1980).

Table 12. Age specific length (otolith) of arctic char collected from Jago Lake, July 9, 1983.

Age	Sample Number	Mean Fork Length (mm)	Standard Deviation	Length Range (mm)	Percent Mature
4+	4	139.5	5.4	135 - 147	0
5+	1	260.0	-	-	100
6+	4	274.7	16.0	253 - 289	100
7+	3	280.7	24.9	252 - 297	100
8+	7	327.7	29.0	284 - 366	100
9+	1	337.0	-	-	100
10+	3	364.3	17.2	349 - 383	100
11+	1	395.0	-	-	100
12+	1	398.0	-	-	100
13+	2	417.0	18.4	404 - 430	100
17 - 18+	1	370.0	-	-	100

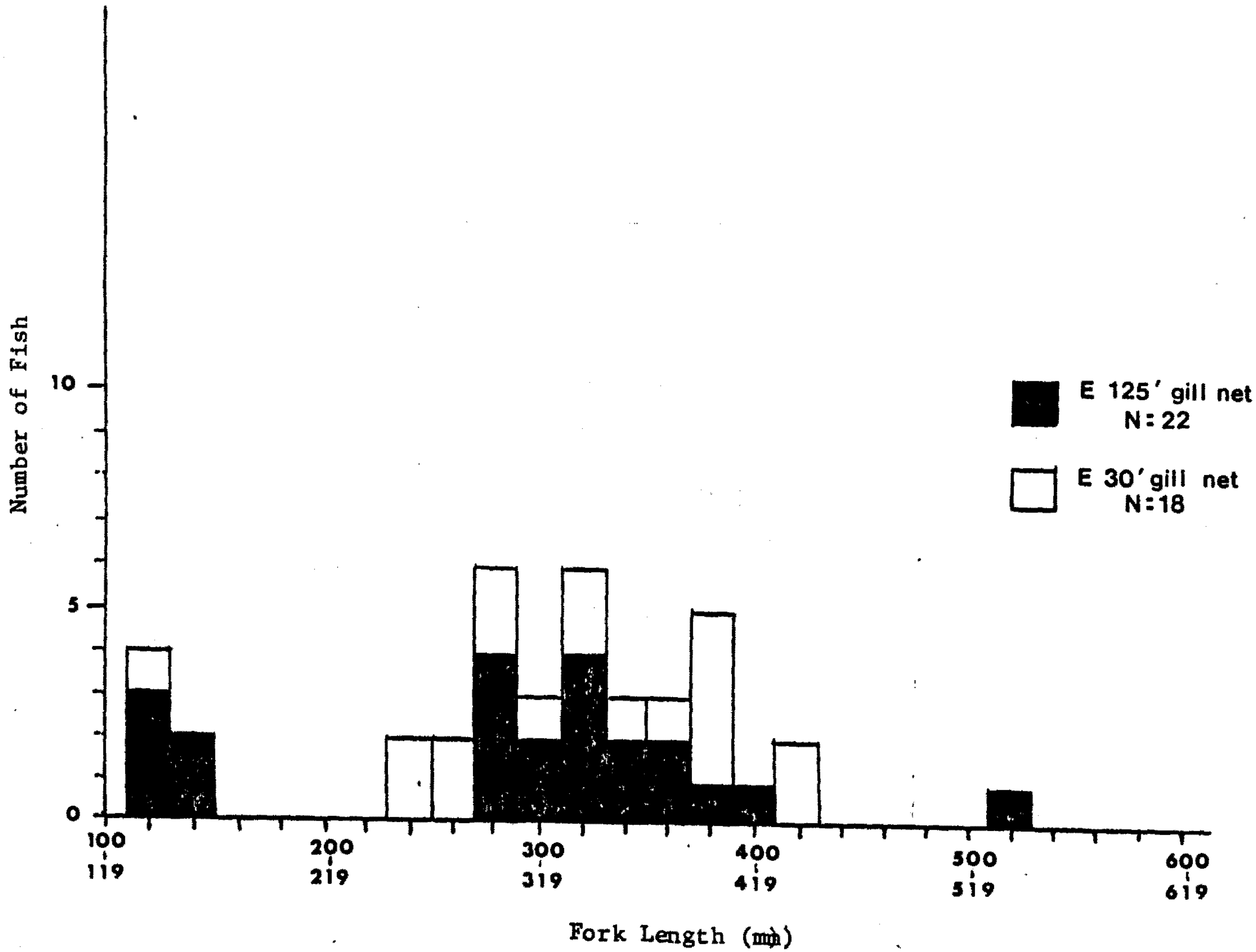

Figure 7. Length frequency of 40 arctic char collected by experimental gill net in Jago Lake, July 9, 1983.

The Jago Lake residents collected reached sexually maturity after the age of 4 years old. From Table 12, all 4+ aged fish were immatures with older age classes consisting of 100% sexually mature individuals. These results are similar to data collected from Canning Lake CT-28, Alaska (Craig, 1977). McCart and Bain (1972) described a north slope population of lake resident char at Campsite Lake, Alaska which did not begin to spawn till 9 years of age.

From the total sample of 40 char, 15% were immature, 42.5% mature males, and 42.5% mature females.

Since sample size for the Jago Lake population is small, comparisons with other studies should be examined in general terms.

The following length-weight relationship was calculated for arctic char collected from Jago Lake, July 9, 1983.

Lake resident arctic char (n = 40, r = 0.992, fork length range = 126-528 mm, weight range = 10-875 gms) =

$$\log_{10} W_{(g)} = 3.278 \log_{10} L_{(mm)} - 5.768.$$

Table 13. Coefficient of condition (K) for arctic char collected from Jago Lake, July 9, 1983.

Length Group (mm)	Number in Sample	Mean K	Standard Deviation
100 - 149	6	0.60	0.06
150 - 199	0	-	-
200 - 249	0	-	-
250 - 299	10	0.90	0.04
300 - 349	11	0.93	0.09
350 - 399	9	0.87	0.06
400 - 449	3	0.78	0.16
450 - 499	0	-	-
500 - 549	1	0.59	-

HULAHULA RIVER

Physical - Chemical Characteristics

The Hulahula River is a third order stream. In the lower reaches the stream is braided with over a 0.38 percent gradient. The upper tributaries consist of straight channel configurations and steeper gradients increasing to 9.5 %. Three springs were found in the Hulahula River. Only one of these springs is within the study area. Five sites on the Hulahula River main channel were sampled during July and September 1983 and four tributaries in the upper Hulahula and one in the lower river were sampled in July 1983 (Figure 8).

Discharge was determined for the upper Hulahula River site and the five tributaries (Table 14). Discharge ranged from 0.03 cms in the lower tributary to 8.87 cms in the upper Hulahula River. Discharge of the main river approximately 40 km from the mouth was also measured at 20.9 cms on August 7,

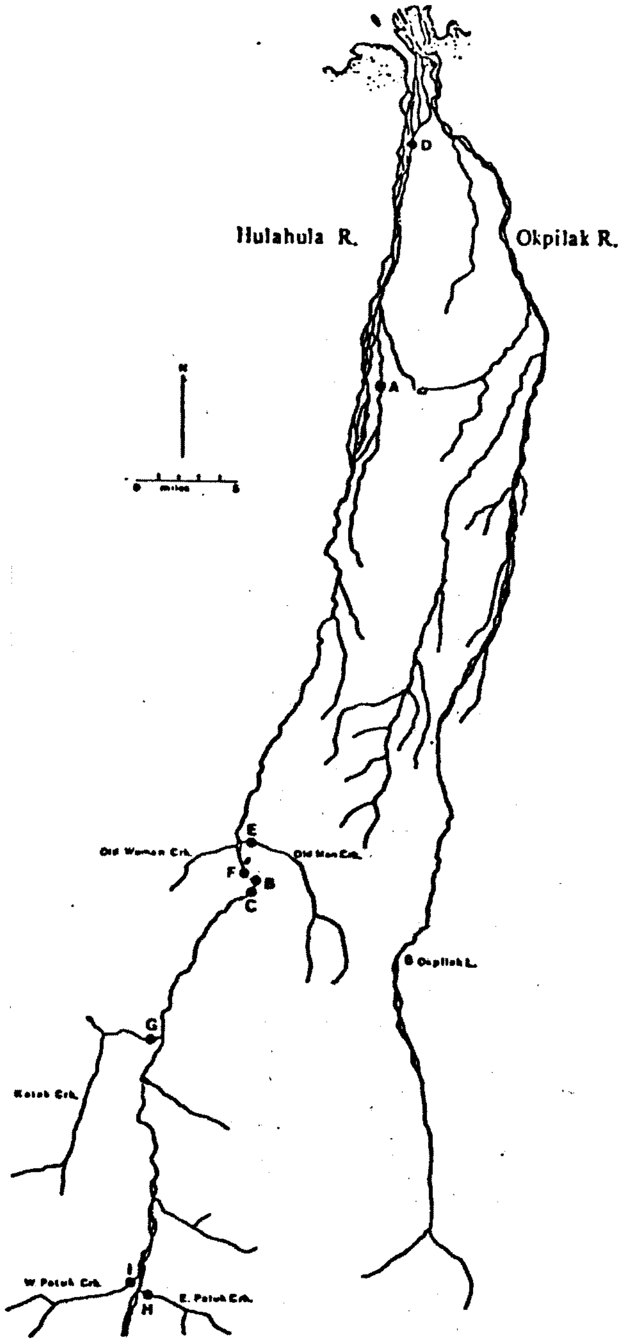

Figure 8. Chemical and physical sampling locations in the Hulahula River, July and August 1983.

Table 14. Physical characteristics of sample areas on the Hulahula River, July and August 1983.

	Stream Order	% Gradient	Channel Configuration	Wetted Perimeter (m)	Average Depth (m)	Discharge (cms)	Average Velocity (m/s)	% Pool Area	% Riffle Area	Predominant Substrate
Hulahula River										
A	3	0.38	Irregular	2.7	.21	.03	.06	-	-	-
F	3	0.53	Irregular	49.4	.45	8.87	.42	40	60	Cobble and Boulder
Patuk Creek										
H	3	3.8	Straight	13.4	.34	3.4	.79	5	95	Small and Large Gravel
I	2	9.5	Straight	14.6	.15	1.02	.49	10	90	Small and Large Gravel
Katak Creek										
G	3	3.25	Straight	16.5	.18	1.47	.52	-	-	-
Old Man Creek										
E	2	2.84	Straight	10.2	.27	.78	.30	-	-	-

1975 (Childers, et.al., 1977). The main channel width, at the upper river site was 49.4 m with an average depth of 0.45 m. The tributaries ranged from a width of 2.7 m in the lower tributary to 16.5 in Katak Creek. The average depth for the tributaries was 0.23 m.

Water chemistry sampling for all sites is shown in Table 15. The pH ranged from 7.5 to 8.5 and conductivity fell to a low of 140 umhos/cm in Katak Creek and a high of 440 umhos/cm in the Springs in the upper Hulahula River. Total alkalinity ranged from 68.4 mg/l in Katak Creek to 153.9 mg/l in the springs. Total hardness ranged from 68.4 mg/l in West Patuk Creek to 273.6 mg/l in East Patuk Creek.

Table 15. Chemical characteristics of sample areas on the Hulahula River, July and August 1983.

	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Conductivity (umhos/cm)	H_2O Temp. (°C)	Air Temp. (°C)	pH
Hulahula River (July)						
A	119.7	153.9	270	6.0	6.0	8.0
B	153.9	222.3	440	7.0	9.0	7.8
C	85.5	102.6	180	8.0	-	7.5
Lower Hulahula River (August)						
D	102.6	173.9	320	9.5	9.0	8.5
Old Man Creek (July)						
D	102.6	119.7	155	10.0	14.0	8.0
Upper Hulahula River (August)						
F (Aug. 14)	102.6	136.8	-	7.0	10.0	7.8
F (Aug. 31)	119.7	222.3	360	4.0	2.0	8.0
Katak Creek (July)						
G	68.4	85.5	140	7.0	16.0	7.5
Patuk Creek (July)						
H	102.6	273.6	340	5.0	6.0	8.0
I	68.4	68.4	150	5.5	5.0	7.5

Fish Distribution and Abundance

Figure 9 presents fish sampling locations and spring areas for the Hulahula River drainage. Distribution of fish species collected from various sample areas is found below in Table 16.

Table 16 Fish distribution in the Hulahula River drainage.*

Sample Areas	Sample Date(s)	Fish Species	Life Stage(s)	Comments
A	July 14, 1983	No fish collected.		USFWS, Fishery Resources, Fbks.
B	Aug. 3- Sept. 1, 1983	AC	J,A	USFWS, Fishery Resources, Fbks.
		GR	J,A	
	July 16, 1983	No fish collected.		
C	July 11, 1983	AC	J	USFWS, Fishery Resources, Fbks.
D	July 11-16, 1983	No fish collected.		USFWS, Fishery Resources, Fbks.
E	Aug. 12- Sept. 21, 1983	AC	J,A	USFWS, Fishery Resources, Fbks.
		Gr	A	
F	July 11, 1983	Gr	J,A	USFWS, Fishery Resources, Fbks.
G	July 16, 1983	AC	J	USFWS, Fishery Resources, Fbks.
H	July 15, 1983	AC	J	USFWS, Fishery Resources, Fbks.
I	July 15, 1983	AC	J	USFWS, Fishery Resources, Fbks.

Gr - Grayling AC - Arctic Char A - Adult J - Juvenile

*See figure 9 for sample site locations.

Sixty fish, 57 arctic char and 3 grayling, were collected during the sampling period of July 1-16, 1983. Electrofishing was used to collect the majority of the fish, with two grayling caught in a 30 ft. experimental gill net, in the main channel of the upper Hulahula. Arctic char were widely distributed throughout the drainage. They were collected in almost all of the areas sampled. Grayling were not found in the tributaries of the upper Hulahula. Of the 60 fish collected, 59 were juvenile char and grayling and one was an adult grayling from the main channel of the upper Hulahula.

During the August-September survey of the main channel Hulahula, 2788 fish were collected. 1046 fish were caught in the lower river. Of those fish, only one grayling was collected. The majority of the char were collected from pool areas and calm side waters. 1742 fish were collected from the main channel of the upper river; 47 grayling and 1695 char. Arctic char distribution was consistent throughout the reach sampled with larger concentrations in deep pools.

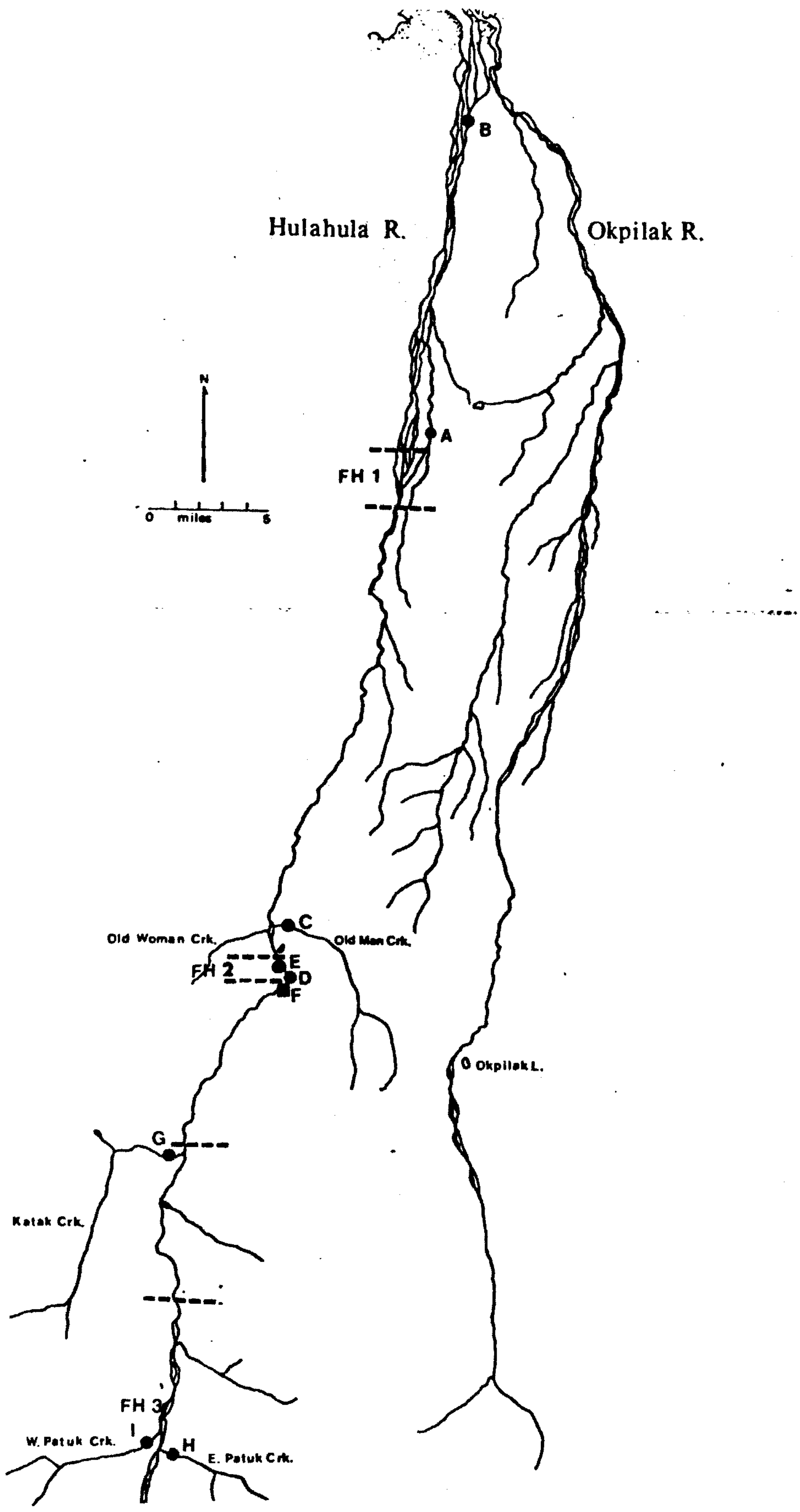

Figure 9. Fish sampling locations (●), spring area (■), and aerial survey boudaries (----1983) in the Hulahula River system, 1983.

Relative abundance and length ranges of fish collected in the Hulahula River during August and September, 1983 is shown in Table 17. Graphs depicting the various catch-per-unit-effort rates are found in Figure 10 through 15. Arctic char were abundant throughout the sampling areas. Electrofishing was the main sampling technique during the July sampling. Catch rates on the lower river tributary, Katak Creek, East and West Patuk Creeks were 0.26/min., 1.3/min., 0.8/min. and 0.8/min., respectively. A 30' experimental gill net was set on Katak Lake for four hours with no fish caught.

Several sampling techniques were used during the August and September, 1983 sampling. Gillnets were used only in the lower river with catch rates of 0.41/hr. for 30' nets and 0.37/hr. for the 125' net. Angling catch rates were 0.49/hr. and 4.5/hr. for the lower and upper river, respectively. One hundred foot seine haul catch rates for the lower river was 2.6/haul and 3.8/haul for the upper river. Electrofishing was used on the upper river, with a catch rate of 0.26/min. Minnow trap sampling in the lower Hulahula resulted in a catch rate of 0.3/hr.

Table 17. Catch-per-unit-effort and fork length range of grayling and arctic char collected in the Hulahula River drainage, July 1-16 and August 1 - September 21, 1983.

*Sample Location	Fish Species	# of Fish Collected	Total Effort	Length Range(mm)	Catch per Unit Effort
		30' Experimental Gill Net			
B	AC	164	404.3 hrs.	123-658	.41/hr.
G	-	0	4.0 hrs.	-	-
		125' Experimental Gill Net			
B	AC,Gr	229	617.9 hrs.	114-568	.37/hr.
		Angling			
B	AC	11	22.3 hrs.	70-576	.49/hr.
E	AC,Gr	1029	263.6 hrs.	209-701	4.5 /hr.
		100' Seine			
B	AC	582	225 hauls	54-623	2.6 /haul
E	AC,Gr	34	9 hauls	172-303	3.8 /haul
		Electrofishing			
A	-	0	10 min.	-	-
C	AC	2	7.8 min.	-	.26/min.
E	AC,Gr	679	12.7 hrs.	197-727	.97/min.
G	AC	13	10.2 min.	-	1.3 /min.
H	AC	7	8.6 min.	-	.8 /min.
I	AC	23	28.6 min.	-	.8 /min.
		Minnow Trap			
B	AC	60	189 hrs.	63-162	.3 / hr.

AC - Arctic Char Gr - Grayling

*See Figure 9 for sample locations.

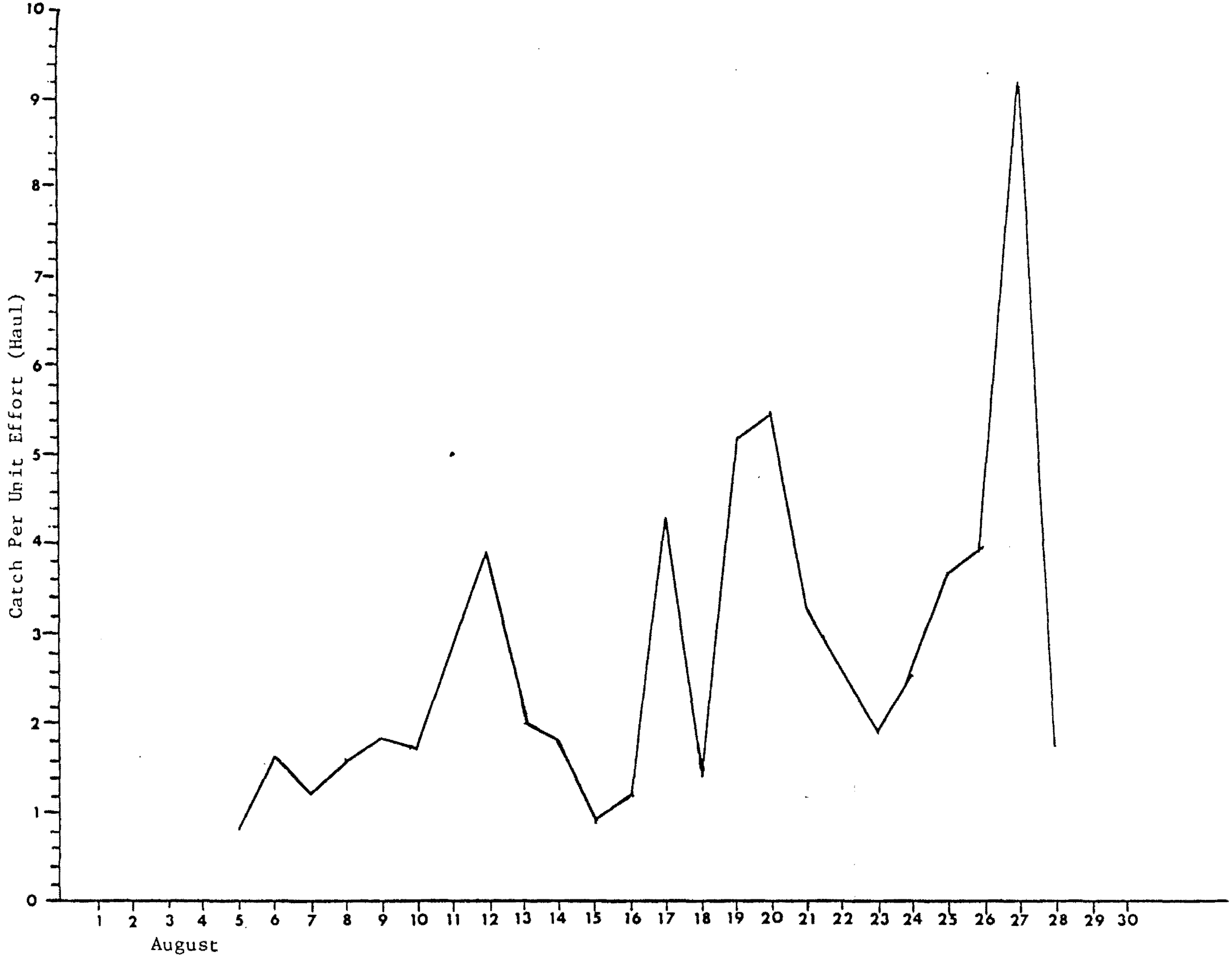

Figure 10. Daily catch rates of 582 arctic char collected by seine in the Lower Hulahula River, August 1 - 28, 1983.

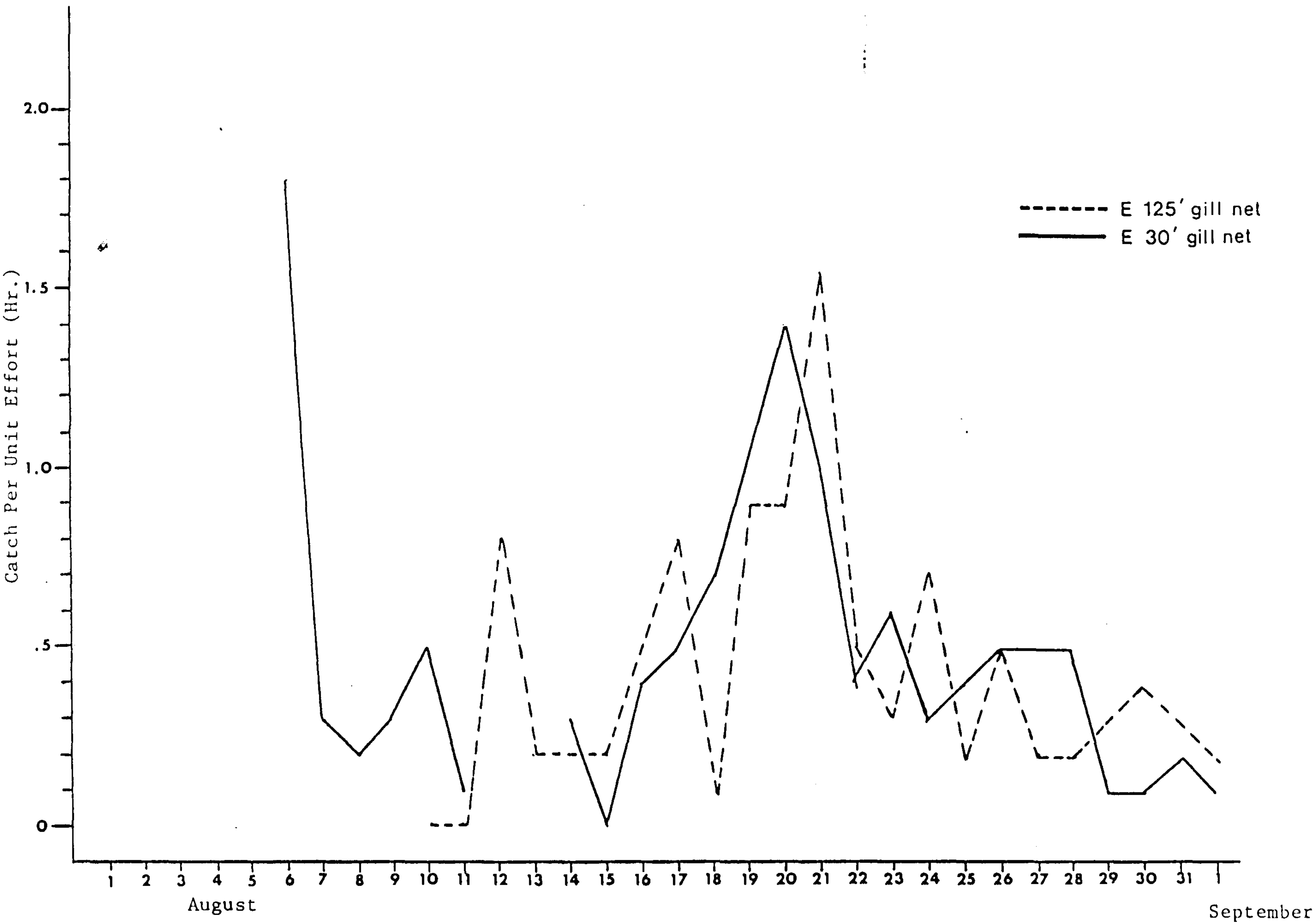

Figure 11. Daily catch rates of 393 arctic char collected by experimental gill nets in the Lower Hulahula River, August 1 - September 1, 1983.

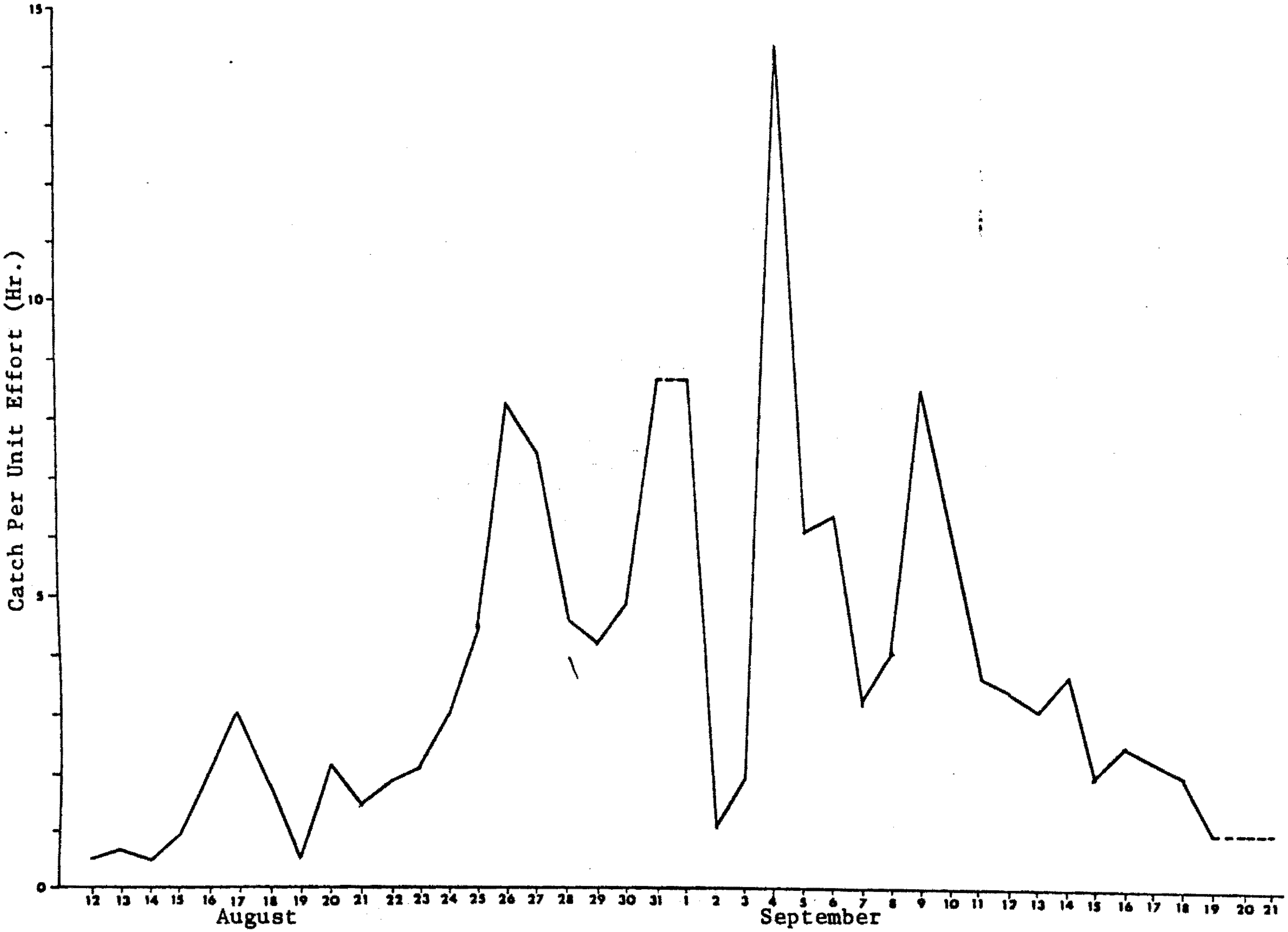

Figure 12. Daily catch rates of 1003 arctic char by angling in the Upper Hulahula River, August 12 - September 21, 1983.

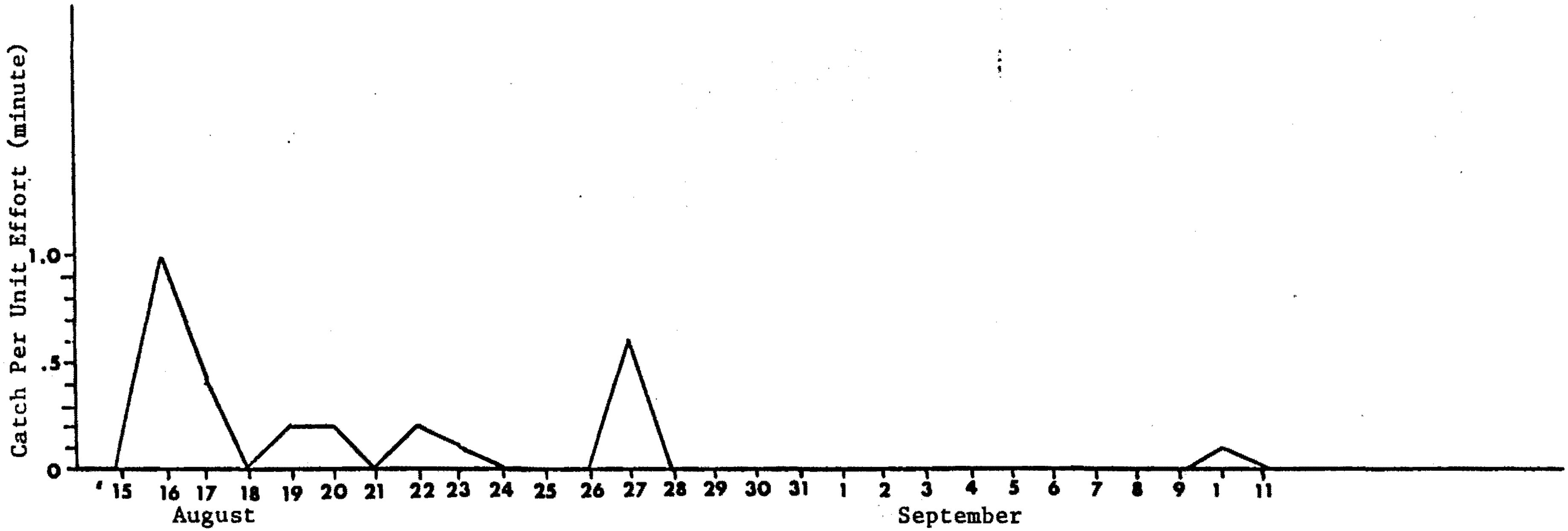

Figure 13. Daily catch rates of 16 arctic grayling by electrofishing in the Upper Hulahula River, August 15 - September 11, 1983.

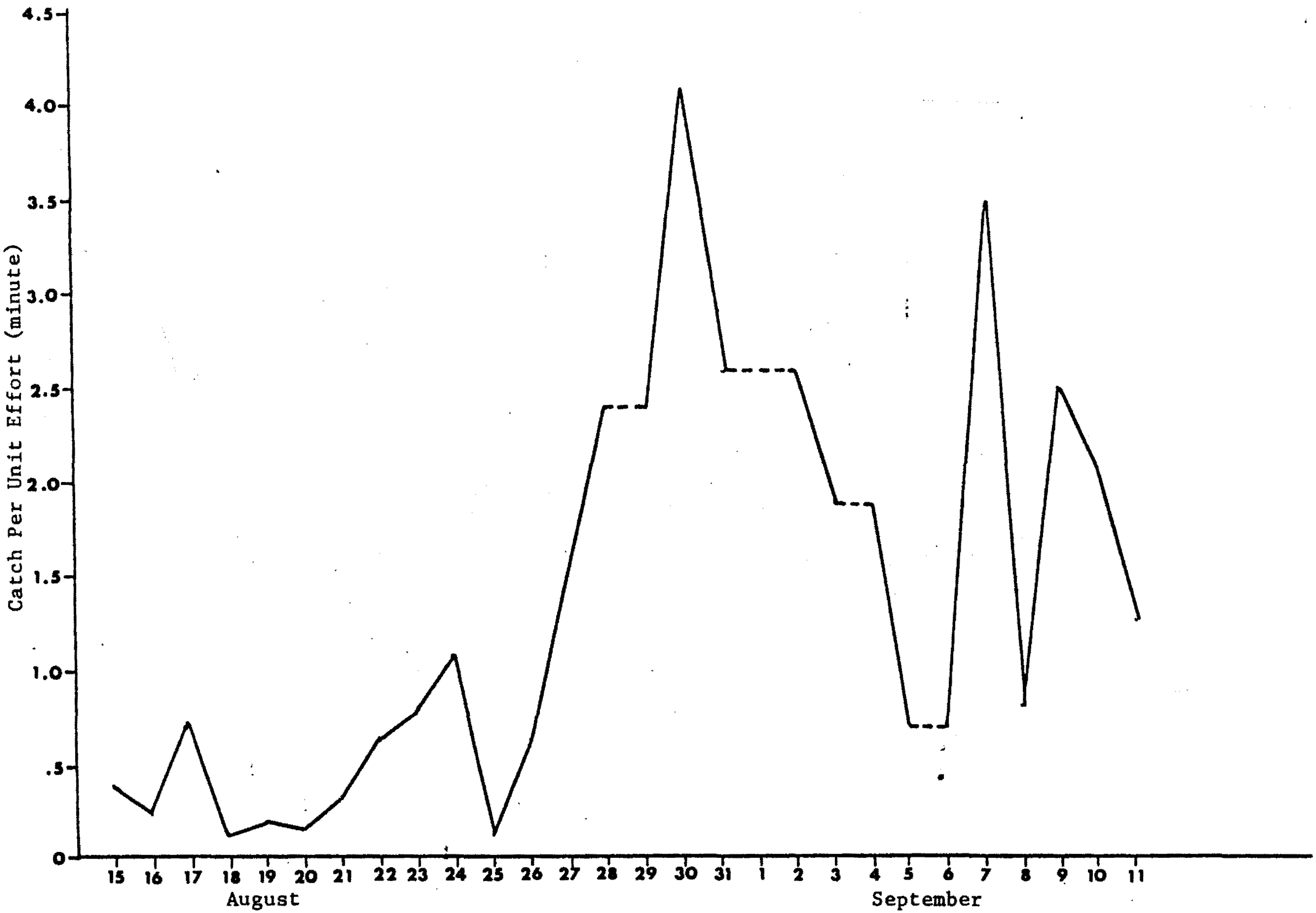

Figure 14. Daily catch rates of 663 arctic char by electrofishing in the Upper Hulahula River, August 15 - September 11, 1983.

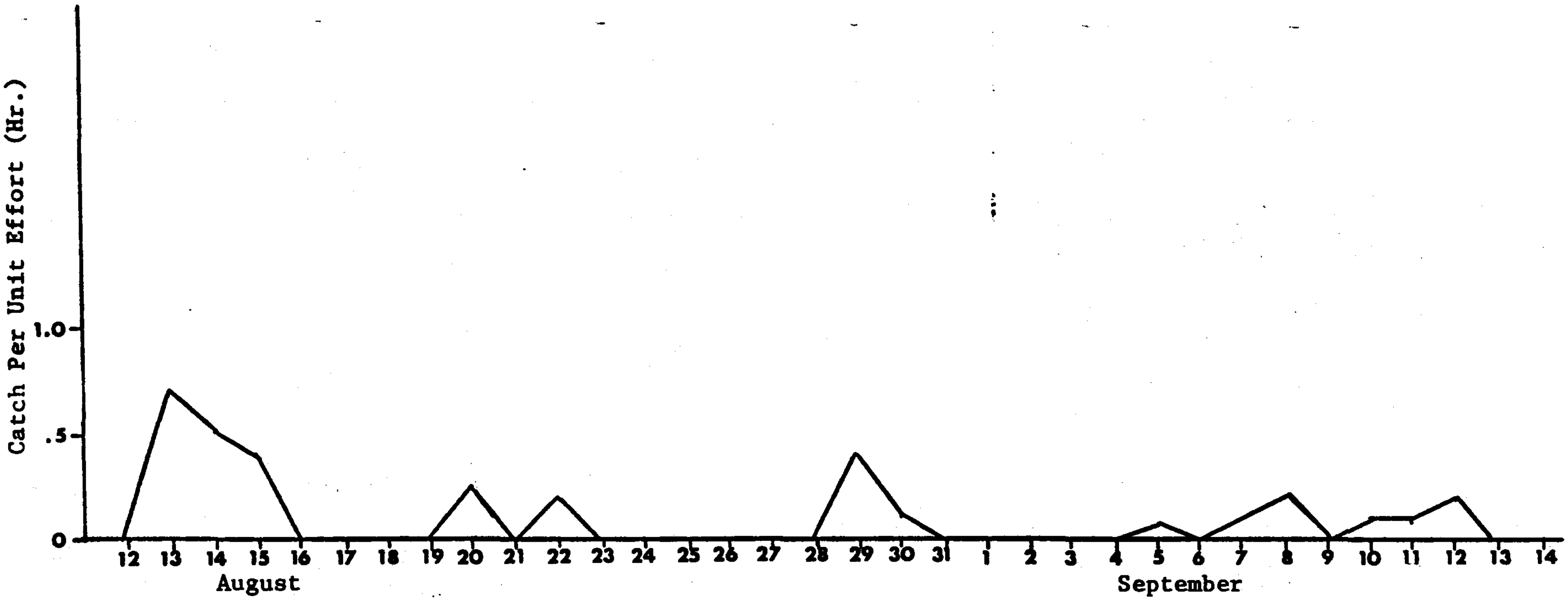

Figure 15. Daily catch rates of 26 arctic grayling collected by angling in the Upper Hulahula River, August 12 - September 20, 1983.

Length Frequency

Length frequency histograms for char and grayling collected from the Hulahula River are presented in Figures 16 through 19. In the lower site the char were predominantly within the 280 to 320 mm length group. The length increased in the upper river to where the majority fell between 420 and 460 mm.

Age and Growth

Age and growth information for char is shown in Table 18 and Figure 20. In a comparison of length-age relationships for char from the Hulahula River and the Sadlerochit and Itkilyariak Rivers (USFWS, 1983) the stocks are similar. These figures are higher than most of the Canning River (USFWS, 1983) figures. Only the main channel of the Canning, near Shublik Springs had length-age ranges larger than the Hulahula River. Char were aged from two sampling locations; lower and upper Hulahula (map location B and E). Age classes 0 to 12+ were represented in the sampled group. Otoliths were used to age all char sampled. The oldest fish caught was from the upper Hulahula with a fork length of 494 mm and in age class 12. The majority of the fish in the Hulahula River fell between age classes 3 and 8. By age class 5 100% of the char sampled had matured.

Table 18. Age specific length (otolith) of arctic char collected from the Hulahula River, August 6 - September 21, 1983.

Age	Sample Number	Mean Fork Length (mm)	Standard Deviation	Length Range (mm)
0+	2	67.0	2.83	65 - 69
1+	3	100.7	3.79	98 - 105
2+	5	133.0	8.09	115 - 150
3+	17	242.71	20.07	200 - 269
4+	14	269.71	20.33	237 - 319
5+	22	334.59	40.06	265 - 388
6+	26	415.04	56.79	290 - 511
7+	14	458.67	60.38	362 - 518
8+	14	533.00	42.50	451 - 577
9+	2	519.00	48.08	485 - 553
10+	2	517.00	16.97	505 - 529
11+	1	343.00	-	-
12+	1	494.00	-	-

Weight and Condition

The following length-weight relationships were calculated for char from the lower and upper Hulahula River sampling sites, collected during August 6-September 21, 1983.

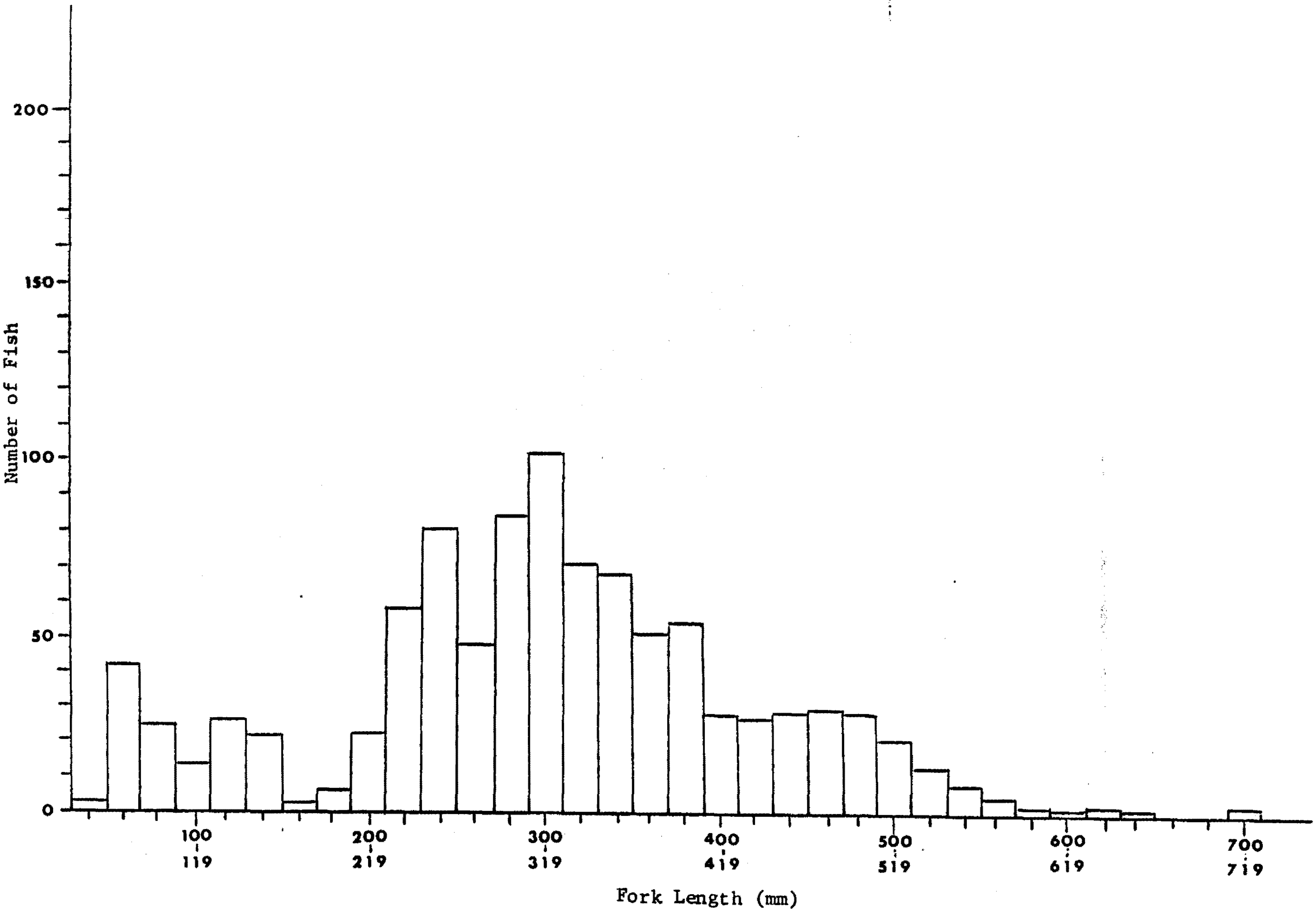

Figure 16. Length frequency of 989 arctic char collected by minnow trap, experimental gill net, seine and angling in the Lower Hulahula River, August 1 - September 1, 1983.

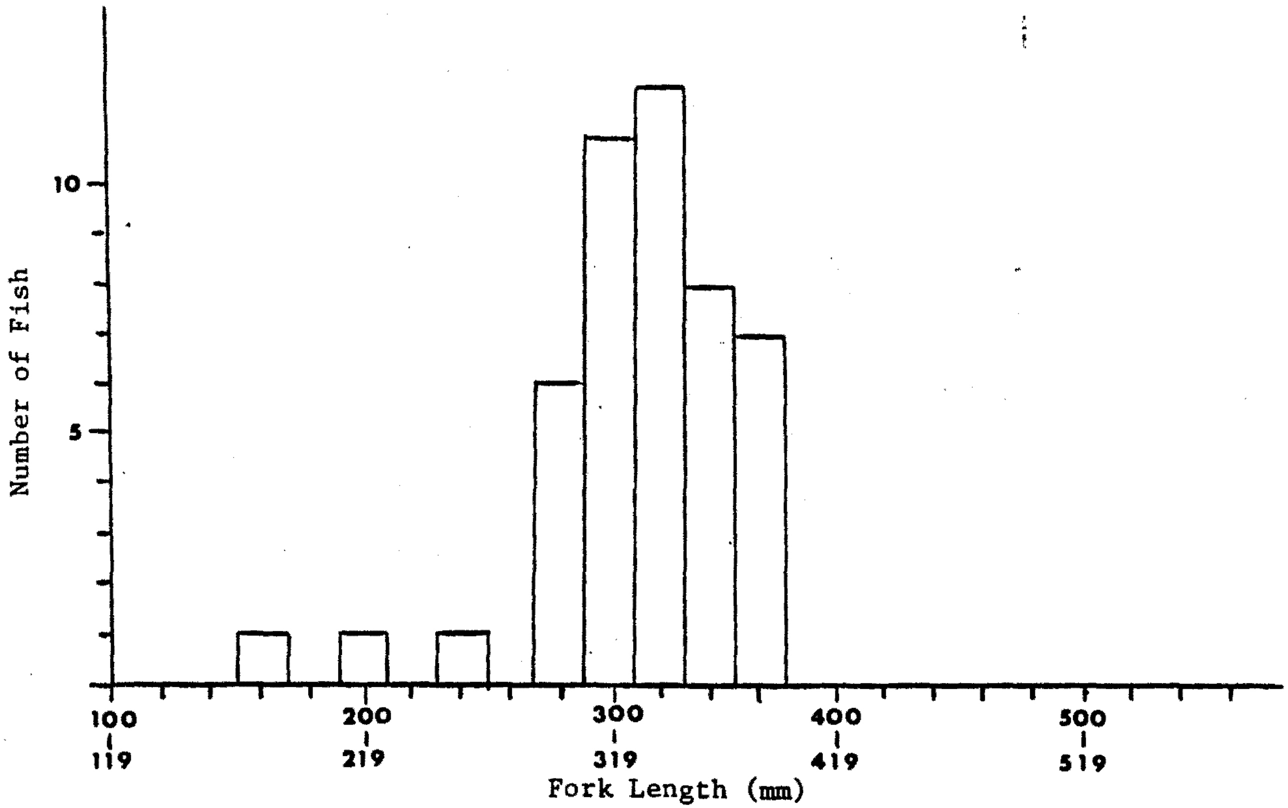

Figure 17. Length frequency for 47 arctic grayling collected by angling and electrofishing in the Upper Hulahula River, August 12 - September 20, 1983.

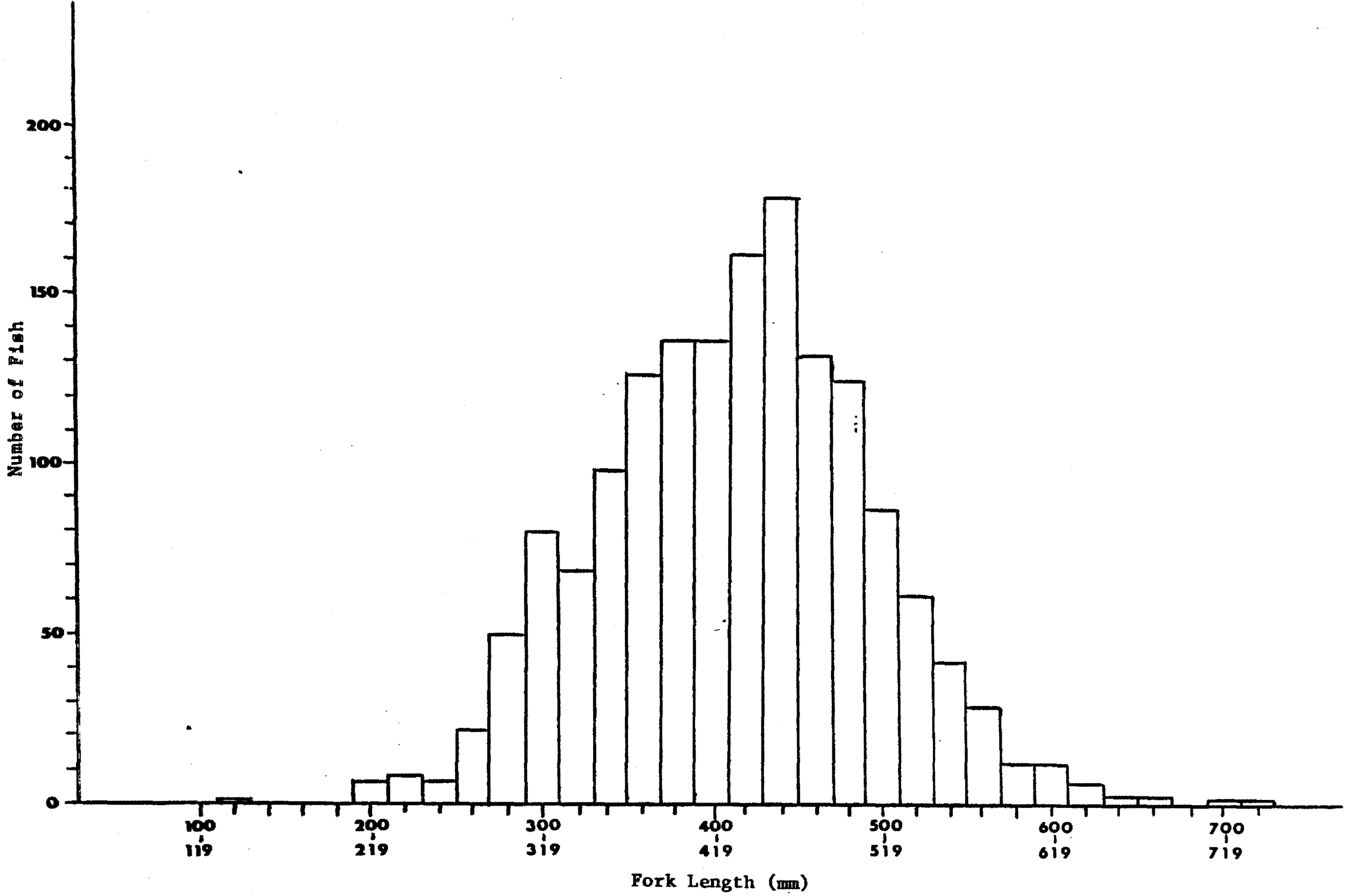

Figure 18. Length frequency of 1590 arctic char collected by electrofishing and angling in the Upper Hulahula River, August 11 - September 20, 1983.

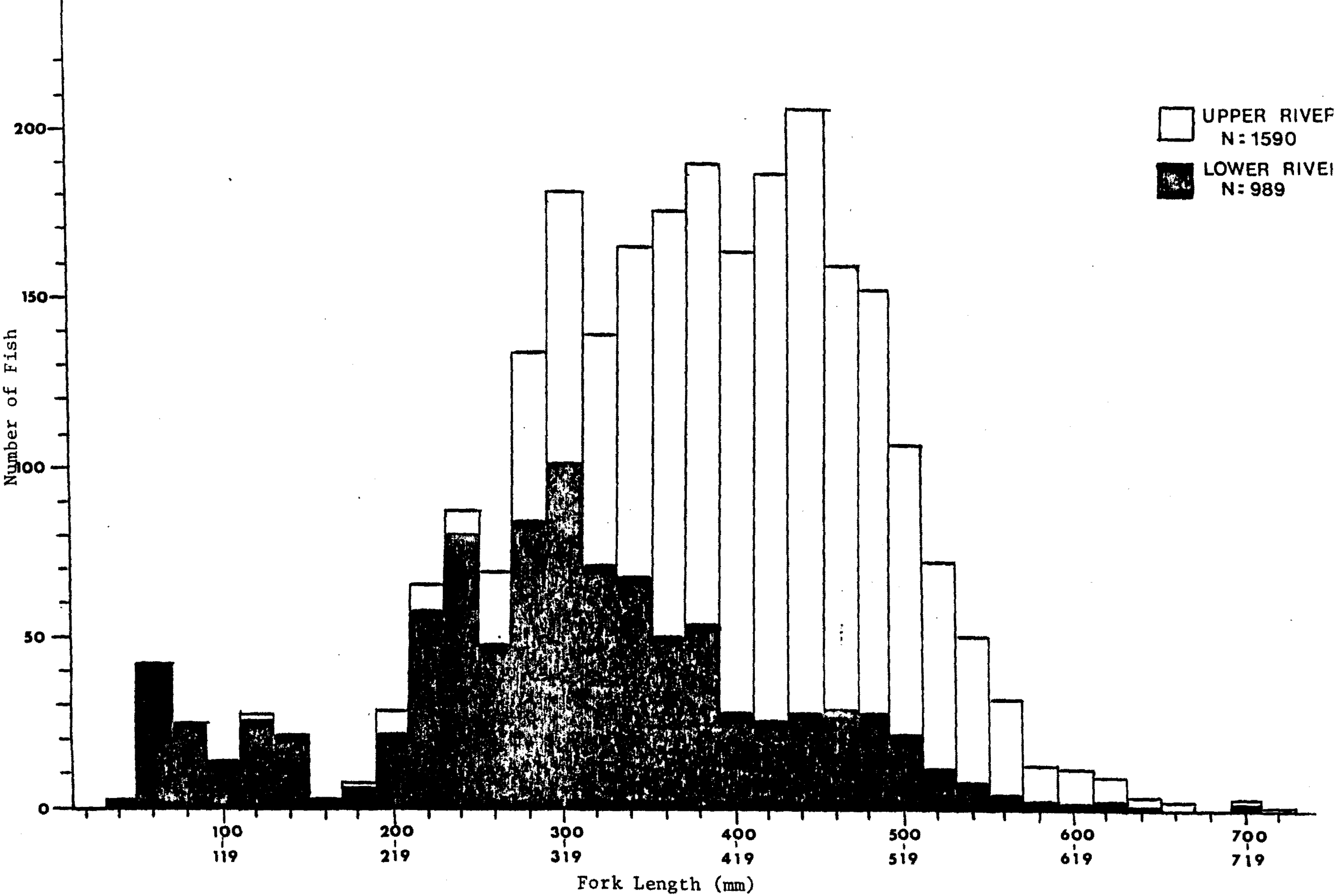

Figure 19. Length frequency of 2579 arctic char collected by minnow trap, experimental gill net, seine, electrofishing and angling in the Lower and Upper Hulahula River, August 1 - September 20, 1983.

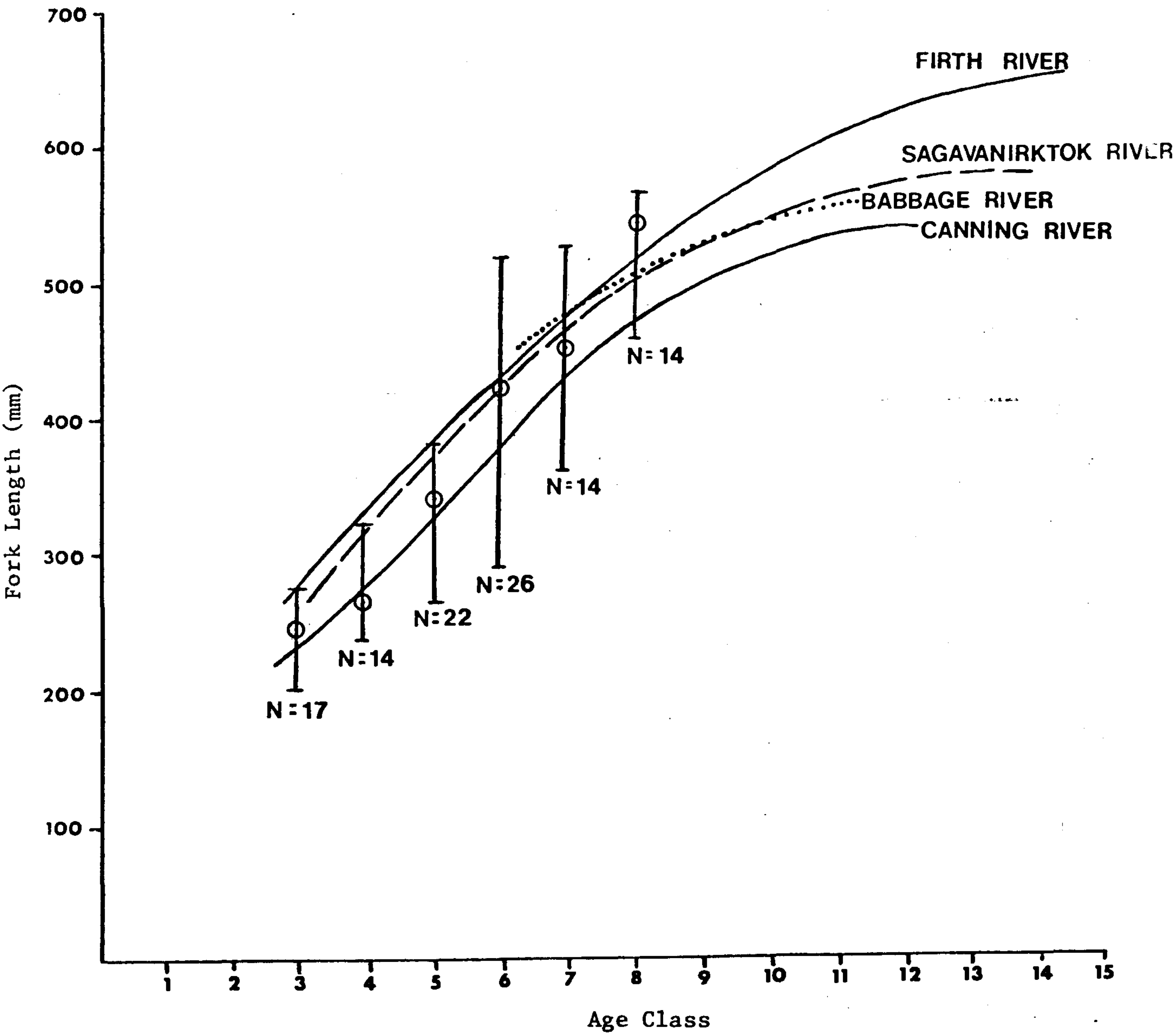

Figure 20. Comparison of growth rates of sea-run char from the Hulahula River (O = mean, I = range) with those of other char populations in Beaufort Sea drainages.

The following length-weight relationship was calculated for arctic char collected from the Hulahula River during August 6 - September 21, 1983.

Anadromous non-spawners (n = 106, r = 0.975, fork length range = 351 to 638 mm, weight range = 340 - 2700 gms):

$Log_{10}\ W_{(g)} = 3.345\ Log_{10}\ L_{(mm)} - 5.947$

Anadromous spawners (n = 99, r = 0.986, fork length range = 351 to 727 mm, weight range = 440 - 3400 gms):

$Log_{10}\ W_{(g)} = 2.959\ Log_{10}\ L_{(mm)} - 4.917$

Anadromous male spawners (n = 53, r = 0.987, fork length range = 369 - 727 mm, weight range = 475 - 3400 gms):

$Log_{10}\ W_{(g)} = 2.923\ Log_{10}\ L_{(mm)} - 4.822$

Anadromous female spawners (n = 32, r = 0.979, fork length range = 417 - 604 mm, weight range = 660 - 1990 gms):

$Log_{10}\ W_{(g)} = 3.067\ Log_{10}\ L_{(mm)} - 5.197$

Total anadromous char (n = 205, r = 0.978, fork length range = 351 - 727 mm, weight range = 340 - 3400 gms):

$Log_{10}\ W_{(g)} = 3.157\ Log_{10}\ L_{(mm)} - 5.446$

Resident arctic char (n = 73, r = 0.992, fork length range = 60 - 375 mm, weight range = 3 - 450 gms):

$Log_{10}\ W_{(g)} = 2.884\ Log_{10}\ L_{(mm)} - 4.776$

Coefficient of condition (K) was determined for char and grayling from the lower and upper sampling locations (Tables 19 and 20). The mean K values for grayling collected from the Hulahula are similar to those collected in the Canning River (USFWS, 1983) and slightly higher than grayling found in the Tamayariak River (USFWS, 1983). The mean K values for char length groups over 250 mm are similar to those collected in the Canning River (USFWS, 1983).

Table 19. Coefficient of condition (K) for grayling from Upper Hulahula River, August 15 - September 21, 1983.

Length Group (mm)	Number in Sample	Mean K	Standard Deviation
150 - 199	1	0.81	-
200 - 249	2	1.04	0.18
250 - 299	7	0.97	0.06
300 - 349	23	0.97	0.09
350 - 399	11	0.93	0.06
400 - 449	1	0.57	-

The following length-weight relationship was calculated for grayling collected from the Upper Hulahula River during August 15 - September 21, 1983.

Grayling (n = 49, r = 0.963, fork length range = 172-410 mm, weight range = 41-500 gms):

$Log_{10}\ W_{(g)} = 2.884\ Log_{10}\ L_{(mm)} - 4.733$

Table 20. Coefficient of condition (K) for arctic char from the Hulahula River, August 6 - September 21, 1983.

Length Group (mm)	RESIDENT						ANADROMOUS														
	Presmolt & Residuals			Residuals			Nonspawner & Immature			Spawner Total			Male Spawner			Female Spawner			Spawner Out		
	n	$\overline{K}$	S.D.	n	$\overline{K}$	S.D.	n	$\overline{K}$	S.D.	n	$\overline{K}$	S.D.	n	$\overline{K}$	S.D.	n	$\overline{K}$	S.D.	n	$\overline{K}$	S.D.
50 - 99	20	1.08	0.23																		
100 - 149	24	0.87	0.18																		
150 - 199	4	0.87	0.10																		
200 - 249				10	0.96	0.14	21	0,96	0.08												
250 - 299				7	0.94	0.21	44	0,97	0.11												
300 - 349				8	0.90	0.16	34	0,91	0.12	1	0.84	-	1	0.84	-						
350 - 399				2	0.81	0.06	37	0,87	0.09	7	0.93	0.11	5	0.94	0.12						
400 - 449							40	0,90	0.13	26	0.99	0.17	8	0.94	0.08	15	1.04	0.21			
450 - 499							37	0,98	0.12	56	0.95	0.06	8	0.94	0.09	40	0.95	0.06			
500 - 549							37	0,98	0.10	70	0.95	0.08	14	0.93	0.05	48	0.97	0.07	2	0.66	0.02
550 - 599							31	1,01	0.10	16	0.96	0.05	8	0.93	0.05	6	1.00	0.04	1	0.64	-
600 - 649							6	0,98	0.06	9	0.88	0.07	8	0.89	0.07	1	0.82	-			
650 - 699										3	0.91	0.09	3	0.91	0.09						
700 - 749										2	0.92	0.06	2	0.92	0.06						

Spawning and Overwintering

Little is known about the spawning and overwintering of grayling in the Hulahula River. Grayling juveniles were not captured at any of this year's sample sites and adult grayling were relatively rare in fall sampling at the lower river. Several adult grayling were observed at Fish Hole 2 during August and September. Grayling were also reported in the winter subsistence catch at this site (Furniss, 1975).

Char overwintering areas are based on observations of fall concentrations during aerial surveys. Char appeared to be concentrating at Fish Holes 1, 2 and 3. (FH1, FH2, FH3 on site location map). Kaktovik villagers historically fish these three holes. The upper hole (3) is at the confluence of the Hulahula and East and West Patuk Creeks. The second hole is located one mile above Old Man Creek and receives the majority of subsistence use. The first fish hole is about 25 miles downstream of Fish Hole 2. Furniss (ADF&G, 1975) measured 34 char from the subsistence fishery at Fish Hole 2 in April 1974. Char lengths in this sample ranged from 12 to 570 mm with most fish between 200-300 mm.

Twenty-nine char were implanted with radio tags in September in an attempt to monitor fall and winter movements and to locate overwintering areas. These radio-tagged fish that were located in large concentrations at Fish Hole 2 in the fall were dispersed downstream over a 5 km section of river by November. The final results from this study will be reported in January 1985.

Anadromous char spawning habitat on the north slope is associated with springs and ground water sources that insure an adequate winter water supply for egg and fry survival. Char spawning habitat is limited on the Hulahula River. Aerial surveys in September revealed three main areas of char concentrations. These areas were associated with the subsistence Fish Holes mentioned above. Spawning was observed at Fish Hole 2. The fish observed around Fish Hole 3 were spread along a 5 km reach between Katak and East and West Patuk Creeks and are most likely spawning in this area. Although fish were observed at Fish Hole 1 during the aerial surveys, it is not known whether this area is used for spawning.

Fish Movement

Char migration was observed on the Hulahula River during August and September 1983. Timing of movement into the river was recorded by catch-per-unit-effort and is reported on Figures 10 and 11. Timing of arrival at Fish Hole 2 in the upper river was also recorded by catch-per-unit-effort and is depicted on Figures 12 through 15. Based on these results, it appears the peak movement of char into the river occurred in late August. These fish consisted primarily of non-spawning and immature char. Relatively few adult spawners were captured in the lower river. Only 8.3% of a sample of 120 fish were determined to be spawners. This may be because these fish had already moved past the area by August 5 when sampling was started or because the adults remained in fresh water during the year in which they spawn. Further work is planned next year to determine if these spawning adults do remain in the river through summer.

Char were tagged with numbered floy tags in the lower sample area during August 1983. Twelve of these fish were recaptured at the upper sample area in late August and September (Table 21). The average time between tagging and recapture for these fish was 26 days, with the shortest time 15 days and the longest, 35 days. Distance traveled was approximately 75 kilometers.

Table 21. Char migration over a 75 kilometer section of the Hulahula River, August and September 1983.

Tag #	Fork Length	Date Tagged	Recaptured Date	Total Days	Average Distance Per Day (km)
3504	444	8-7	9-11	35	2.1
2743	357	8-8	9-8	31	2.4
2696	434	8-10	8-30	20	3.8
2691	447	8-10	9-6	27	2.8
2629	300	8-11	9-3	23	3.3
2647	323	8-11	9-8	28	2.7
2640	363	8-11	9-11	31	2.4
2538	362	8-12	8-27	15	5.0
2553	377	8-17	9-13	27	2.8
2842	363	8-20	9-6	17	4.4
2832	378	8-20	9-11	22	3.4
2807	308	8-20	9-16	26	2.9

OTHER SITES

Physical - Chemical Characteristics

Physical and chemical characteristics were taken on several small drainages on the arctic coastal plain. The Niguanak and Angun Rivers are second order streams with gradients of 0.25 percent in the Niguanak to 0.54 percent in the Angun. Carter Creek and Upper-Lower Marsh Creek are third order streams with gradients of 0.38%, 0.63% and 0.21%, respectively. Irregular channel area was primarily found throughout these systems. A map of these sites can be found in Figures 21 and 22.

Discharge was determined for all sites during the study period (Table 23). Discharge was estimated at 0.42 during a previous study by Childers (1977) on August 10, 1975. Discharge ranged from a low of 0.10 cms in the Carter Creek and a high of 0.89 cms in the Niguanak River. The average channel width in these areas was 10.6 m with an average depth of 0.15 m.

Water chemistry sampling for these sites is found below in Table 22. Water temperature averaged 8°C with a low of 3°C in Angun River and a high of 10.0°C in Niguanak River. The pH averaged 8.0 and conductivity ranged from 74 umhos/cm in Angun River to 400 umhos/cm in upper Marsh Creek. Total alkalinity was lowest in Angun River at 34.2 mg/l, and highest in upper Marsh Creek (119.7 mg/l). Total hardness ranged from 51.3 mg/l in Niguanak River to 289 mg/l in Upper Marsh Creek.

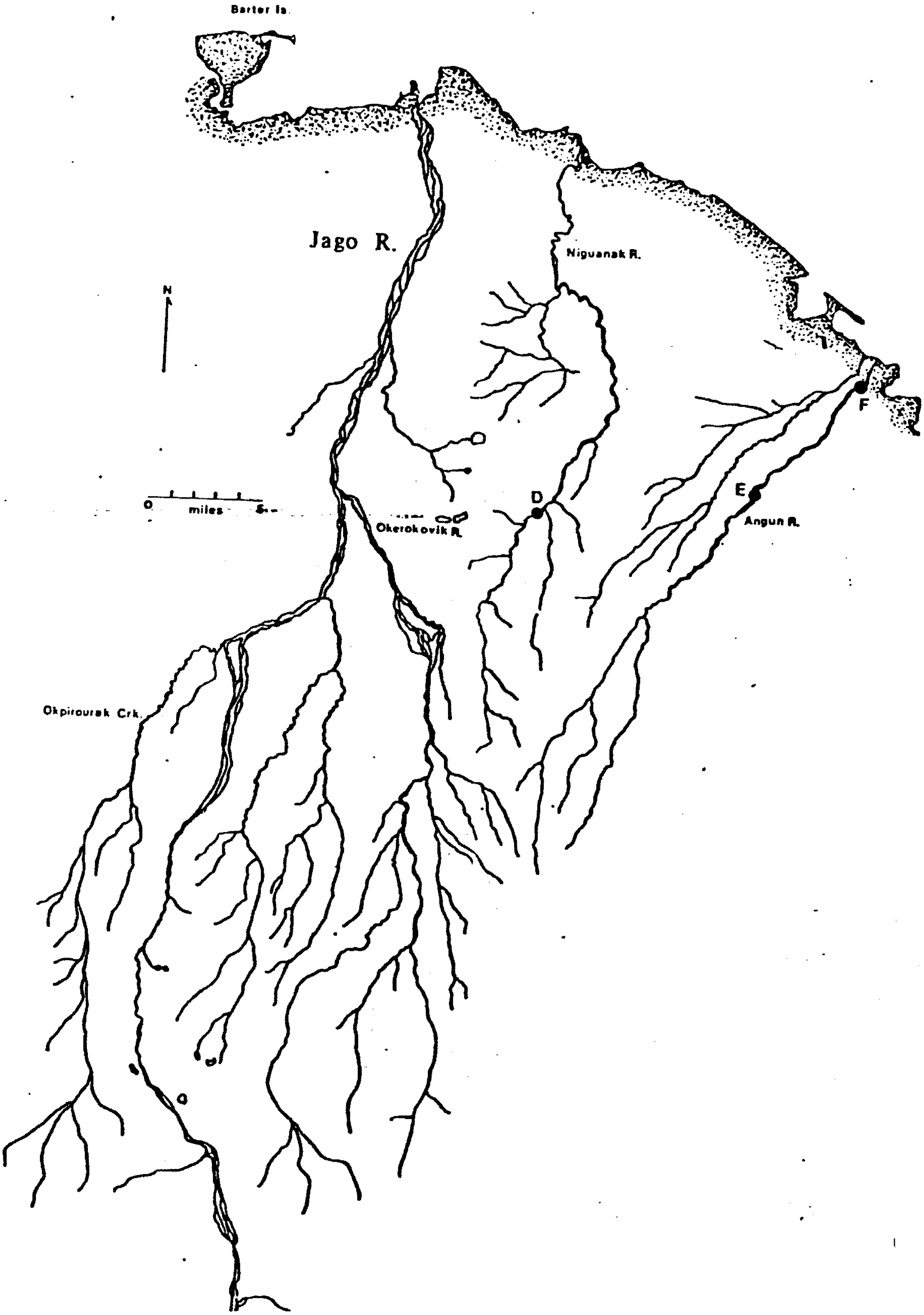

Figure 21. Chemical and physical sampling locations in the Niguanak and Angun Rivers, July 1983.

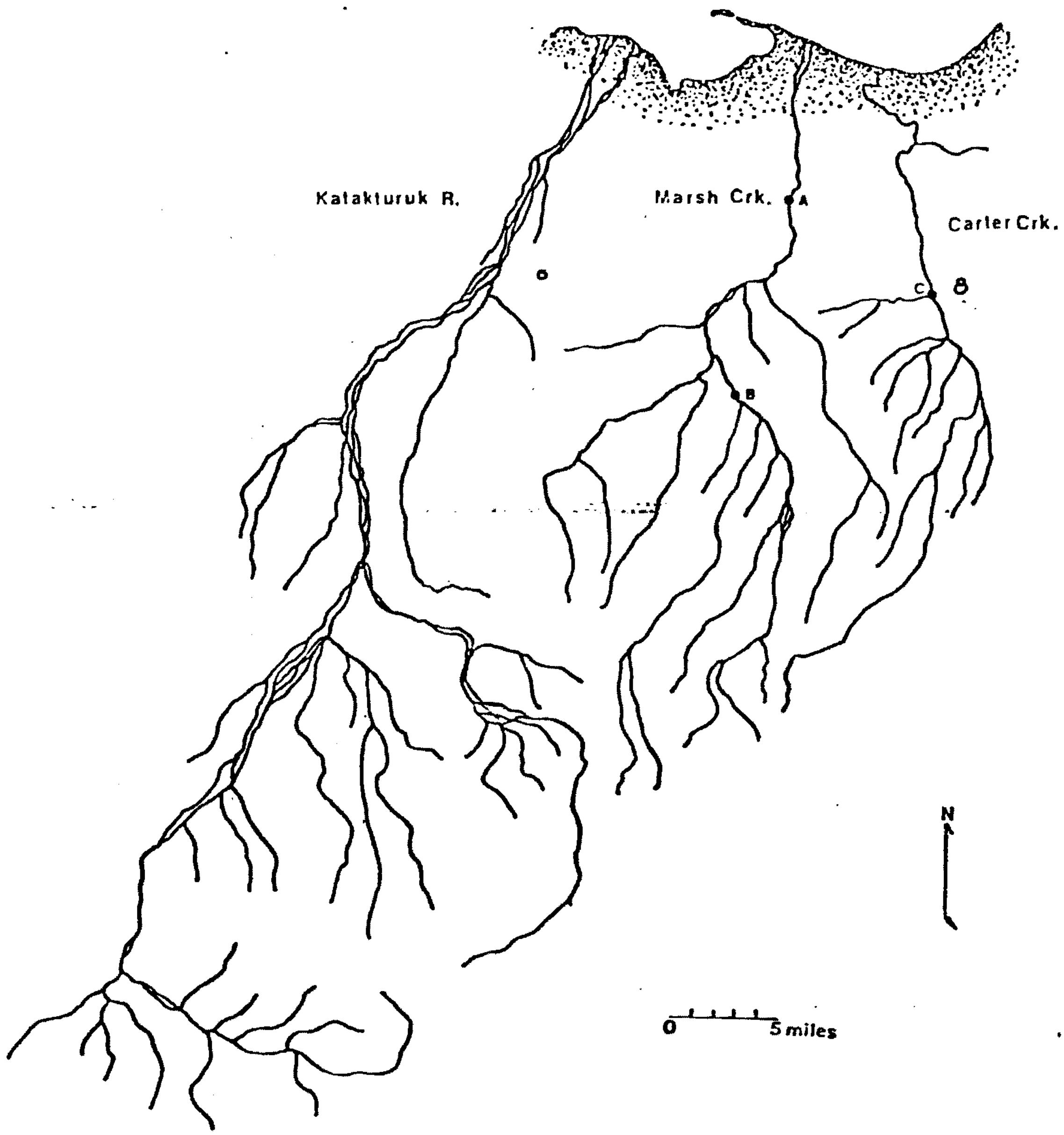

Figure 22. Chemical and physical sampling locations in Marsh and Carter Creek, July 1983.

Table 22. Chemical characteristics of sample areas on arctic coastal plain rivers, July 1983.

	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Conductivity (umhos/cm)	H_2O Temp. (°C)	Air Temp. (°C)	pH
Upper Marsh Creek (A)	119.7	289	400	8	-	8.5
Lower Marsh Creek (B)	119.7	273	340	8	-	8.5
Carter Creek (C)	102.6	85.5	170	7.0	5.0	7.5
Niguanak River (D)	68.4	51.3	95	10.0	9.0	8.0
Angun River Site 1 (E)	51.3	68.4	74	3.0	5.0	8.0

Fish Distribution

Fish sampling locations for the Niguanak River, Angun River, Marsh Creek and Carter Creek are presented in Figures 23 and 24. All sites were surveyed by USFWS personnel in either 1982 or 1983.

The Niguanak River was sampled on July 1-2, 1983 at two locations with no fish captured. A total of 10 hours of E-125 gillnet effort, 10 hours of E-30 gillnet effort and 11.3 minutes of electrofishing effort were used.

Two locations on the Angun River were electrofished on July 2-3, 1983 with a total of 10.2 minutes of effort. No fish were found.

Carter Creek was investigated at two sites on July 14, 1983 and site G on August 6, 1982. No fish were discovered after 17.5 minutes of electrofishing effort and 50 hours of E-30 gillnet effort.

One male anadromous char (275 mm fork length) was captured by an E-30 gillnet on July 14, 1983 in Marsh Creek (site F). Total sampling effort for both sites was 9.1 minutes of electrofishing and 74 hours of gillnet effort.

Aerial investigations of small rivers in the study areas were conducted in July of 1982 and 1983.

No fish were spotted during these flights. Many of the small streams on the coastal plain dry up by August and offer very limited seasonal fish habitat. It is unlikely that these areas support yearly populations of fish other than an occasional or accidental excursion.

Only one fish was found in these rivers. This is probably related to the lack of suitable overwintering habitats. All of these streams flow directly into the Beaufort Sea with long distances between major river drainages making migration into larger and suitable overwintering rivers difficult.

Table 23. Physical characteristics of sample areas on the Arctic coastal plains river systems, July, 1983.

	Stream Order	% Gradient	Channel Configuration	Wetted Perimeter (m)	Average Depth (m)	Discharges (cms)	Average Velocity (m/s)	% Pool Area	% Riffle Area	Predominant Substrate
Upper Marsh Creek										
(A)	3	.63	Irregular	11.3	.18	.46	.24	10	90	Small and Large Gravel
Lower Marsh Creek										
(B)	3	.21	Irregular	22.6	.21	.68	.15	20	80	Small and Large Gravel
Carter Creek										
(C)	3	.38	Irregular	4.3	.12	.10	.21	-	-	-
Niguanak River										
(D)	2	.25	Irregular	14.0	.18	.89	.37	-	-	-
Angun River										
(E)	2	.54	Irregular	12.2	.15	.21	.12	-	-	-
(F)	2	.38	Irregular	14.5	.15	.56	.27	-	-	-

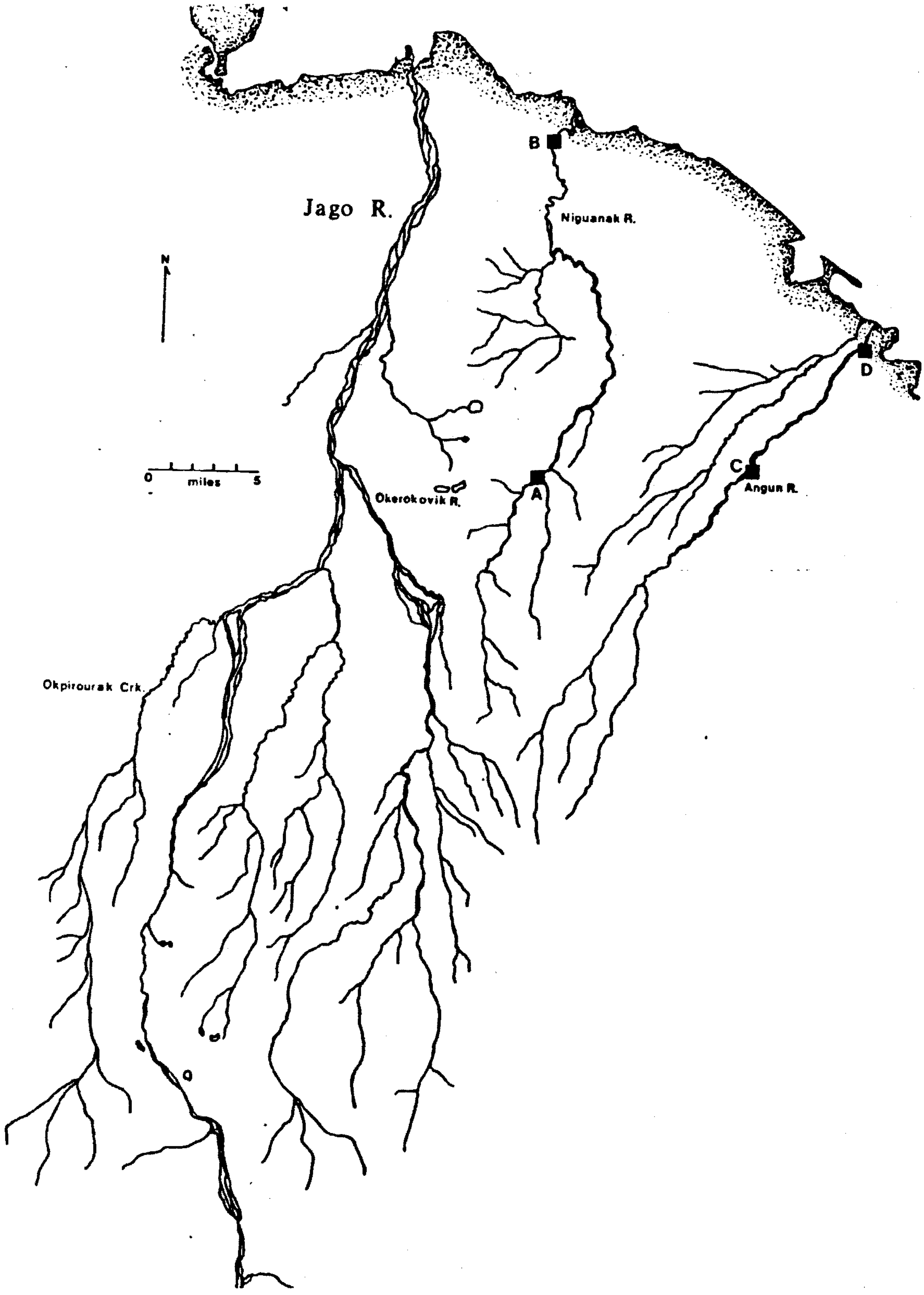

Figure 23. Fish sampling location for Niguanak and Angun Rivers, 1983.

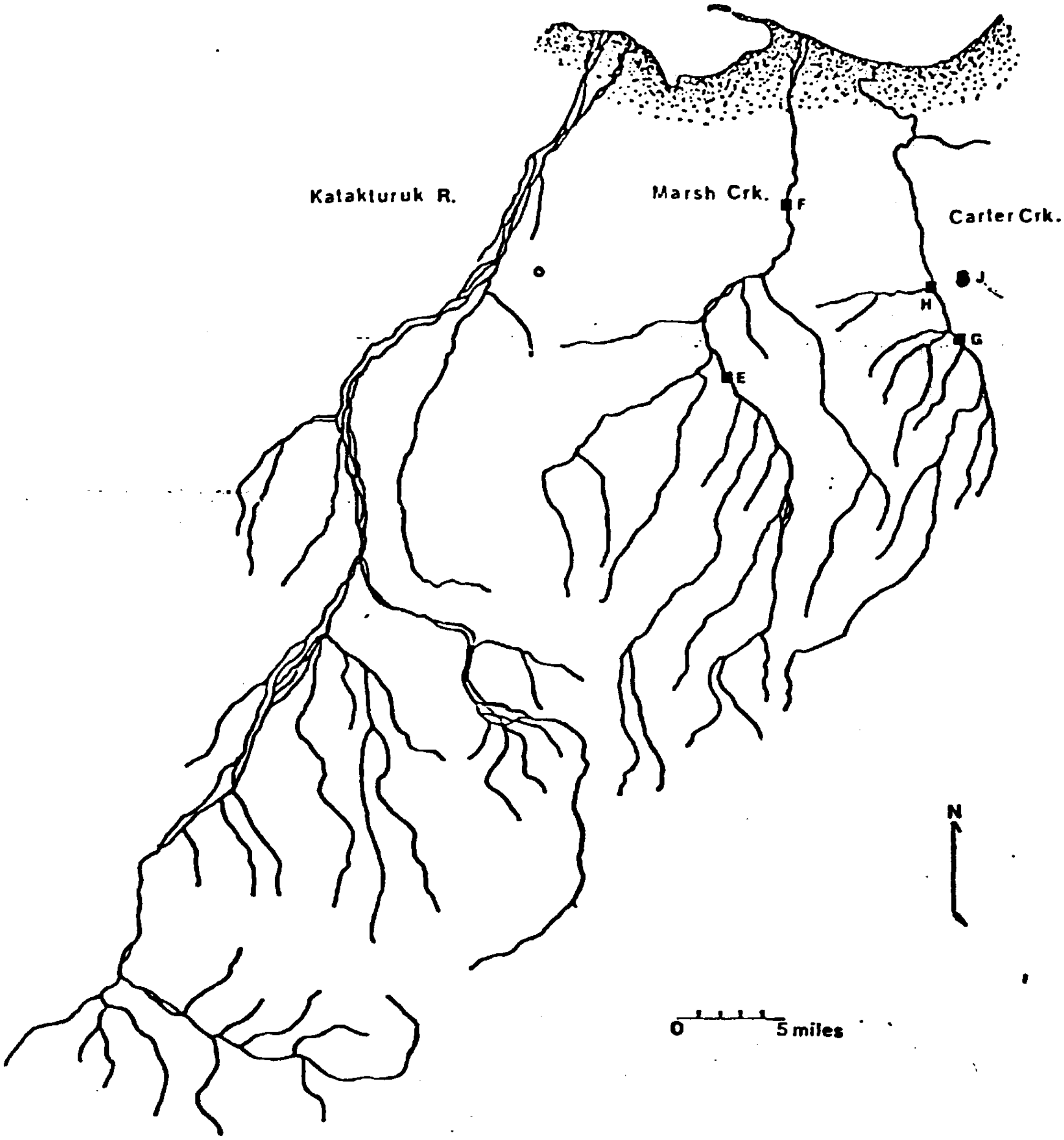

Figure 24. Fish sampling locations for Marsh and Carter Creeks, 1982-1983.

From an oil and gas development aspect, it is significant to point out that the following rivers lacked fish populations: Katakturuk River, Marsh Creek, Carter Creek, Jago River, Angun River, Sikrelurak River, and Kogotpak River. The fisheries will not be affected by mining or other floodplain development.

CANNING RIVER

Overwintering

In September 1982, a radio telemetry study was initiated on the Canning River to monitor fall and winter movements and to locate and describe winter habitat of arctic char. This was the second year of telemetry studies on char overwintering in the Canning River. In 1981, nine char were implanted with tags and relocated periodically during the winter of 1981-1982 (USFWS, 1983).

In the 1982 study, radio transmitters were implanted in char at two sites on the main river within two kilometers downstream from the confluence of Shublik Springs. The Shublik Springs area on the Canning River was chosen as the study site because of the large fall concentration of char in the main river. These fish are one of the northern most fall concentrations on the Canning River and are closest to the 1002c study area. Most anadromous char in the Shublik area are non-spawners and immatures.

Shublik is one of the largest springs on the north slope of the Arctic National Wildlife Refuge with a continuous annual discharge of 0.72 m^3/sec. at a temperature of 5.5°C. It maintains a large open water section throughout the winter for approximately 1 km downstream where it empties into the main river. Aufeis is extensive in this section of river. By late winter the aufeis field below Shublik Springs covers the entire floodplain and is over 2 km in width in some areas. It is continuous for over 25 km of river below the spring confluence. Depth of the ice is uncertain but is in excess of three meters in several areas.

Summer channel configuration is extremely braided and shallow with few pools. During a depth survey of the Canning River in August 1981 using a recording fathometer, only two pools were observed over 2 meters in depth in a 25 km reach of river below the Shublik Springs confluence.

Although adult char are concentrated in a two kilometer section of river below the spring during fall, none have been captured from the open water in this area during late winter. Their movements and distribution from freeze-up through the winter has been largely unknown.

Fifteen char were implanted with radio tags between September 23 to 25, 1982 and were relocated periodically during the winter. All fish tagged were adult non-spawners and ranged in fork length from 515 mm up to 667 mm (Table 24). Locations observed during aerial tracking were recorded and are reported on Figure 25. All identified sites are estimations because of the difficulties in correlating exact locations in winter ice conditions to maps depicting braided channel configurations and because of the imprecision of aerial relocation under these conditions. These sites should be considered general areas of fish overwintering and not specific pool or point locations.

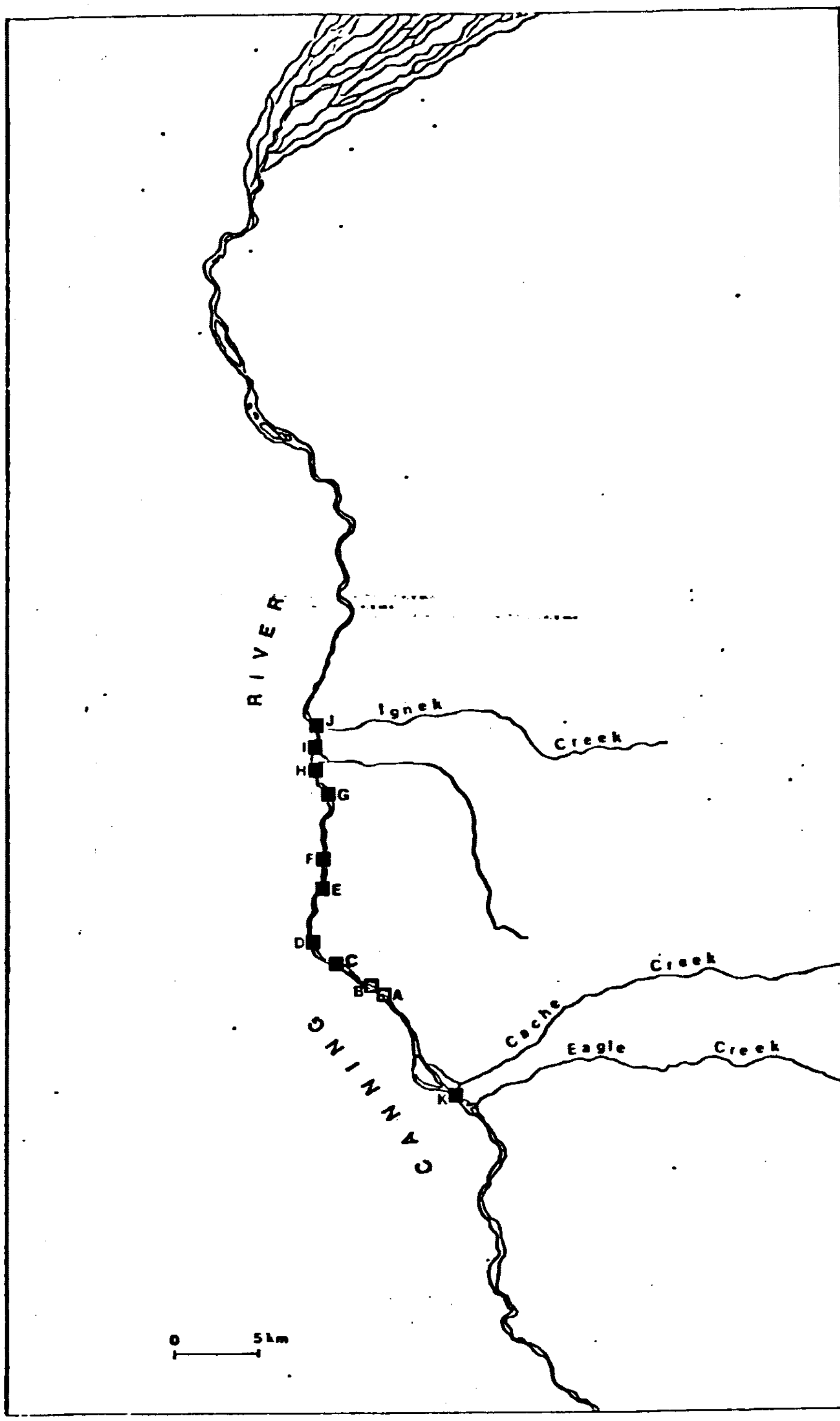

Figure 25. Overwintering locations (■) of 15 radio tagged char in the Canning River, 1982-1983. Locations A and B (□) are tagging and release sites for all fish.

Table 24. Length and weight of char radio-tagged in the Canning River, September 1982.

No.	Date Released	Frequency (MHz)	Fork Length (mm)	Weight (gm)	FWS Floy Tag No.	Release Site*
1	9/22/82	151.730	557	1550	002985	A
2	9/23/82	151.630	530	1425	002996	A
3	9/23/82	151.750	537	1475	002999	A
4	9/24/82	151.690	595	1950	-	B
5	9/24/82	151.910	549	1550	-	B
6	9/24/82	151.840	537	1475	-	B
7	9/25/82	151.720	559	1900	003067	B
8	9/25/82	151.870	667	2800	003068	B
9	9/25/82	151.740	555	1925	003069	B
10	9/25/82	151.770	600	1975	003070	B
11	9/25/82	151.790	582	1950	003071	B
12	9/25/82	151.880	525	1550	-	B
13	9/25/82	151.900	519	1450	-	B
14	9/25/82	151.850	515	1375	-	B
15	9/25/82	151.890	532	1400	-	B

*Relocation sites depicted on Figure 25.

All radio-tagged fish overwintered within the aufeis area below the spring. By November 17, 1982 all fish had moved at least 3 km away from the original tagging site. The longest movement was downstream 23.5 km by one fish and five out of the 15 tagged had moved 18 km or more by this date. As mentioned earlier, this entire area is overlain by an extensive aufeis field. The reasons for preference of this aufies area over the open water near the spring or the ice covered river immediately below is unknown. Location C (Figure 25) was the most heavily utilized by the tagged sample of fish. Nine fish were in this location in November and four of these remained at this site through February 1983. Location E had the second highest number of fish at any one observation with four recorded on February 25. Two or more fish were recorded at each location at some time during the winter with the exception of locations F, I, J, and K where only 1 fish was recorded at the locations during the winter.

There appeared to be some consistency from the two years of study. Of the five overwintering sites identified in this area in the 1981-1982 study, four were again utilized in 1982-1983. These locations were C, D, E, and G on Figure 25. A total of 12 locations have been recorded from radio-tagged fish during the two year study.

During the period April 12 to 17, 1983, attempts were made to locate and describe the overwintering habitat characteristics of several of the radio-tagged fish below Shublik Springs. By this time only 5 tags were still functioning probably as a result of battery failure. The remaining tags were located from ground tracking and holes were drilled into the aufeis in close proximity to the tag signals. At all locations, the ice thickness was more than 2.7 meters, the limit of our ice auger. One 30 foot gill net was set in an ice covered section of river just below the open water of the spring for approximately five hours but no fish were caught. Grayling and small char were observed in the open water.

There was considerable movement recorded from the radio-tagged fish through most of the winter (Table 25). Although most movement was early in the winter, 5 out of 15 fish were still moving during February. Of the early movement from October to November 17, 14 fish moved downstream away from the tagging site while one fish moved upstream 9 km where it remained throughout the winter. Movement decreased after the November 17 relocation and became varied in direction up or downstream. Only six fish had moved between November 17 and February 3. Four of these six were recorded moving downstream from 7 to 17 km while the other two moved upstream 2 and 4 km. Movement in February further decreased but became primarily upstream in direction. Five fish were recorded moving, four of which were upstream from 3.5 to 10 km. One fish moved downstream 3 km from location C to D.

Movement in February is significant in that the aufeis field is extensive by this time. Movement through this area indicates that overwintering locations within this aufeis field are not as isolated as previously thought. Evidently channels are maintained throughout the aufies permitting access over large distances. During February, movement was recorded from 5 different fish from location C to H over a total distance of 17 km. Any disturbances to such areas from water withdrawals or other developmental activities would not be restricted to an isolated pool but could affect overwintering fish for considerable distances.

One radio-tagged char from the 1981-1982 study was recaptured in 1983. This fish was recaptured by angling near Bullen Point on July 22, 1983. The fish, which was originally radio-tagged near Shublik Spring on October 1, 1982, had moved 56 km west along the coast from the mouth of the Canning River. The fish was reported in apparently healthy condition with the radio tag still well seated in its stomach.

Table 25. Winter movement of radio-tagged char[1] in the Canning River, 1982-83.

Tag Frequency MHz	Fork Length (mm)	Weight (gms)	Date Tagged	Tagging Location	Locations[2] Nov. 17	Feb. 3	Feb. 25	Apr. 14[3]
151.630	530	1425	9/23	A	C(-4)	E(-7)	E(0)	E(0)
151.690	595	1950	9/24	B	H(-20)	H(0)	E(+0)	-
151.720	559	1900	9/25	B	J(-23.5)	J(0)	H(+3.5)	-
151.730	557	1550	9/22	A	C(-4)	E(-7)	E(0)	E(0)
151.740	555	1925	9/25	B	C(-3)	C(0)	C(0)	C(0)
151.750	537	1475	9/23	A	C(-4)	F(-9.5)	D(+6.5)	-
151.770	600	1975	9/25	B	K(+9)	K(0)	K(0)	K(0)
151.790	582	1950	9/25	B	C(-3)	C(0)	D(-3)	-
151.840	537	1475	9/24	B	C(-3)	C(0)	C(0)	-
151.850	515	1375	9/25	B	C(-3)	C(0)	C(0)	-
151.870	667	2800	9/25	B	G(-18)	G(0)	G(0)	-
151.880	535	1550	9/25	B	C(-3)	C(0)	C(0)	C(0)
151.890	532	1400	9/25	B	H(-20)	G(+2)	E(+8)	-
151.900	519	1450	9/25	B	I(-22)	G(+4)	G(0)	-
151.910	549	1550	9/24	B	C(-3)	H(-17)	H(0)	-

1 All char tagged were adult non spawners.
2 Locations are depicted on Figure 8. Number in parenthesis indicates movements in km from previous relocation. Upstream movement is indicated by (+) and downstream by (-).
3 Unable to locate several fish, probably due to tag battery failure.

Acknowledgements

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ABUNDANCE, DISTRIBUTION AND DIVERSITY OF AQUATIC MACROINVERTEBRATES ON THE NORTH SLOPE OF THE ARCTIC NATIONAL WILDLIFE REFUGE, 1982 AND 1983

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2 February 1984

ABSTRACT

Quantitative aquatic macroinvertebrate samples were collected from 46 sites in the vicinity of 1002c Study Area, Arctic National Wildlife Refuge, during the summers of 1982 and 1983. Density, biomass, number of taxa, diversity (H') and evenness (J') values were determined for macroinvertebrate communities from all stations. Mean values were compared for tundra, spring, and mountain stream types. Density of invertebrates ranged from 11 organisms/m^2 to 15,555 organisms/m^2. Mean density increased by nearly an order of magnitude between mountain and tundra streams and between tundra and spring streams. Species composition was dominated by taxa of Orthocladiinae, Simuliidae, Oligochaeta, and Baetidae. The majority of the taxa collected were representative of the collector - gatherer functional group. The scarcity of other functional groups was reflected in the generally low diversity (H') values found in the study area. Highest diversity values were found in tundra streams. Low diversity values were found at spring stream sites, and were attributed to the high redundancy of chironomids in the invertebrate samples at these sites. Significant positive correlations ($P < 0.01$, $r \neq 0$) were found between density and biomass of organisms with alkalinity and conductivity values.

INTRODUCTION

Section 1002c of the Alaska National Interest Lands Conservation Act (ANILCA) made provisions for an assessment of fish and wildlife habitat of the coastal plain of the Arctic National Wildlife Refuge. During 1981 - 1983, the Fairbanks Fishery Resources Station has conducted studies in accordance with the fishery portion of the mandate. Aquatic macroinvertebrates were sampled, in addition to collection of fish distribution, abundance and life history data.

There is very little information published pertaining to aquatic macroinvertebrate communities in Alaskan arctic streams. Slack et. al. (1979) compared differences in macroinvertebrate communities between a north and south-flowing stream in the Brooks Range of Alaska. Craig and McCart (1975) sampled invertebrate populations in stream drainages between Prudhoe Bay and the Mackenzie Delta. They reported standing crop information, and taxonomic information primarily to order for most taxa and to family for Dipterans.

Aquatic macroinvertebrates are important in the food chains for most fish species found in streams draining the North Slope. Their abundance and distribution can be useful in biological classification of arctic waters and aid in understanding the distribution of fishes in these waters. They are also useful in monitoring environmental perturbations, and are generally more sensitive to environmental changes than fish. Benthic invertebrate communities exhibit a diverse fauna, inhabiting many different microhabitats, are not capable of much avoidance to sampling techniques and exhibit varying levels of tolerance to pollution and other perturbations.

This report provides baseline data on aquatic macroinvertebrate populations for streams draining the 1002c Study Area, and may serve as a basis of comparison in the event of resource development within the study area.

METHODS AND MATERIALS

USGS, 1:63,360 quadrangle maps were used to determine stream order, channel character, and gradient of stream study area reaches. Stream order was determined following the method of Strahler (1957). Gradients were calculated from 50 and 100 foot contour lines on the maps. Stream reaches were assigned to one of the four categories: straight, irregular, braided, or meandering (Smith and Glesne, 1982). Percent pool, riffle, shallows and substrate particle size were estimated by observation of a 100 meter section of the stream at each study site.

Water chemistry parameters; pH, total hardness, total alkalinity, and dissolved oxygen, were measured using a Model FF-1 Hach water chemistry kit. Conductivity was measured in micromhos per centimeter using a Hach Model 17250 Mini Conductivity meter.

Discharge was calculated using the following formula:

$$Q = W D V$$

Q = Discharge
W = Width of Wetted Perimeter
D = Mean Depth
V = Mean Velocity

Depth was measured to the nearest tenth of a foot using a standard wading rod. Velocity was measured at approximately 0.6 the water depth using a Marsh - McBirney Model 201 current meter.

Benthic samples were collected between June and September 1982 and between July and September 1983. Most of the samples were collected during July and early August of both years. Three replicate samples were collected at each station using a 1024 micron Surber sampler. All samples were collected in stream riffles. Samples were placed in Whirl Pak bags and preserved with a 5 to 10% formalin solution.

In the lab, a sample was first washed through a Tyler Standard 0.147 mm screen to remove the formalin and silt, then transfered to a large tray. Small subsamples were then transfered to a smaller white tray with grid lines drawn on the bottom to assist in processing the sample. The organisms were then placed in small, labeled vials and preserved with 70% isopropyl alcohol. Samples with large amounts of moss were washed and dissected thoroughly to dislodge clinging organisms.

Organisms were identified to genera where possible, using a Bausch and Lomb 1-7x dissecting microscope. Chironomid larvae were first sorted into look alike groups under the dissecting scope. Then representatives from each group were mounted on 1 X 3 inch slides, using CMCP-10 mounting media, and then identified to subfamily at 100X and 400X on a Nikon microscope. Blotted wet weights for all taxonomic groups were obtained using a Sartorius analytical balance. Wet weights and counts, for each taxa were then recorded. Taxonomic references used for invertebrate identification included Merrit and Cummins (1978), Usinger (1973), Pennak (1978), Wiggins (1978), Edmunds et. al. (1976), Johannsen (1969), Beck (1976), and Stewart (in press).

Aquatic macroinvertebrate diversity (H') was calculated according to the following equation:

$$H' = - \quad (p_i \log_2 p_i)$$

where p_i was the proportion by number of the community belonging to the $_i$th species (Pielou, 1975).

This index was originally proposed (Shannon and Weaver, 1949) as a measure of the information content of a code. Diversity values depend on both species richness (the number of species) and evennness of representation of species within the community. Evenness (J') was calculated as:

$$J' = \frac{H'}{\log_2 S}$$

where s equals the species richness and H' equals diversity (Pielou, 1975).

Evenness values range from) to 1 with 1 representing the greatest evenness of representation of species within a community. A predominance of one species or a few species in a community would be represented by J' close to 0.

The mean, standard deviation, standard error, and sampling precision were calculated for biomass, density, diversity and eveness, from each set of samples, from each station. Density (number of organisms/sample) exhibited a negative binominal distribution therefore, the log (x + 1) transformation was used before performing statistical analysis (Elliot, 1971). Least square regressions and scatter diagrams were generated to determine relationships between physical parameters and macroinvertebrate densities, biomass, diversity and evenness values. Significance levels based on the correlation coefficient were determined using the tables found in Zar (1974).

STUDY AREA

The study area, is approximately 630,000 hectares, and was bounded on the west by the Canning River, on the east by the Aichilik River, on the south by the Brooks Range, and on the north by the Beaufort Sea (Figure 1).

The area may be conveniently classified into zones or provinces after Wahrhoftig (1965) who recognizes an Arctic Coastal Plain, Arctic Foothills, and Arctic Mountain Province.

Within the study area the coastal plain is fairly narrow (15-25 km) and less distinct to the extreme east. The area is mostly poorly drained, with relatively few lakes compared to more westerly areas of the coastal plain. The shore is generally only 1-10 ft. above the ocean. The permafrost table was reported to be only 1/2-4 feet below the surface and quaternary marine sediments, as well as tertiary sedimentary deposits, underlie the area (Wahrhoftig 1965). The soil is neutral to slightly alkaline and commonly has a 8-12 cm layer of organic material overlying loam. The 600 foot contour line is often used to separate the coastal plain from the foothills.

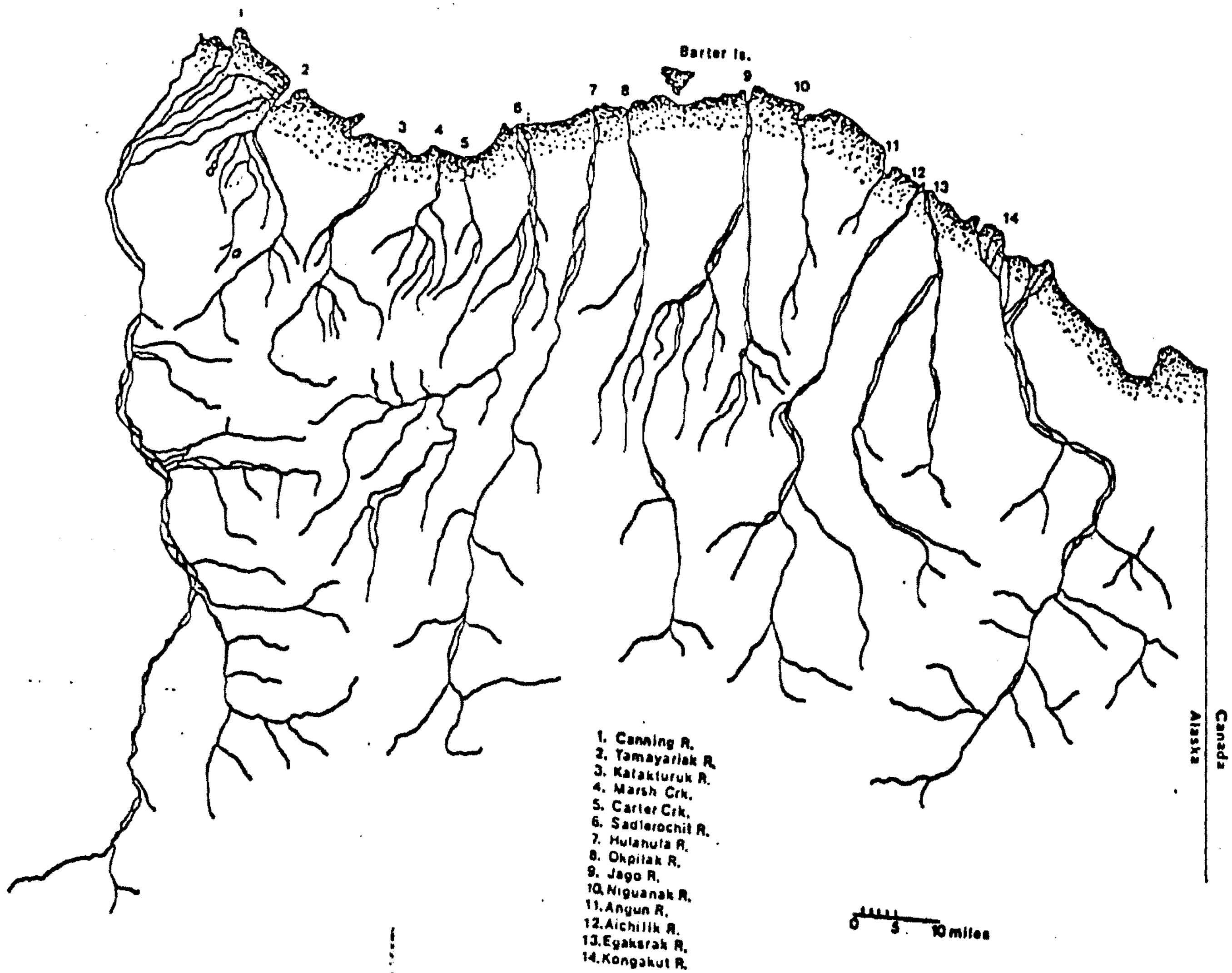

Figure 1. Major drainages within the 1002c Study Area.

The foothills comprise the largest zone within the study area (44%). Rolling plateaus and low linear mountains (to 1200 feet), with east-trending mountains characterize the area. The dominant vegetation consists of a Moist Tussock, Sedge-Dwarf Shrub, Tundra complex. Dark colored mineral soils (mollisols) which are neutral to slightly alkaline in reaction tend to predominate. Devonian to Cretaceous age sedimentary rocks underlie most of the foothills. When exposed these are tightly folded and overthrust to the north (Warhoftig 1965). The southern margin was glaciated during the Pleistocene, and glacial debris covers portions near the mountains (Craig and McCart 1974).

The Arctic mountain province makes up a smaller portion of the study area. This area includes the Shublik and Sadlerochit Mountains in the southwest part of the study area to the Romanzoff Mountains in the extreme east. The extreme southern edge of the study area is dominated by weather resistant metasedimentary quartzites, phyllites, schists, and argillites. Immediately north is a narrow east-west belt of the Lisbourne formation which consists of Mississippian limestone and dolomites (Hobbie 1962). The Shublik and Sadlerochit Mountains are underlain by sandstone, siltstone, and shales. The vegetation ranges from alpine tundra and barren ground, in the Sadlerochit and Shublik Mountains, to vegetation similar to the foothill province. Valley and piedmont glaciers advanced throughout the area during the early Pleistocene to the Quaternary ages.

The climate tends to parallel the zones described above. Foggy, often windy and rainy weather with cooler temperatures dominate the coastal areas, while clearer, warmer, and drier weather is generally found in the foothills during the summer. Rainfall in the area is slight (less than 8 inches). Snowcover is scanty in the winter and is drifted into hard banks by prevailing easterly or westerly winds. Photoperiods are extreme. Depending on the location and latitude, darkness may persist for as long as 83 days during winter and continuous daylight may last for 61 days during the summer (Hobbie 1962).

The principle drainages within the study area include: the Canning River, Tamayariak River, Katakturuk River, Marsh Creek, Carter Creek, Sadlerochit River, Hulahula River, Okpilak River, Jago River, Niguanak River, Angun River, and Aichilik River (Figures 1-7).

The dynamic character of streams defies any absolute classification of them, but in general they tend to follow the physiographic provinces just described above. This is based on the premise that streams reflect the geology, soils, and vegetation they originated from. Craig and McCart (1974), and more recently Harper (1981) have classified arctic streams according to this principle. They identified mountain streams, spring-fed streams, glacier-fed streams, and tundra (lowland) streams. Streams of these types are found throughout the study area. Unless otherwise noted the following is a summary of these two reports.

Mountain streams often exhibit low stream order and high gradient. The water originates as surface runoff or from springs. Flow regimes for these types of streams are highly variable compared to spring or tundra stream. Eighty percent or more of the annual flow may issue during the spring thaw. These streams often dry up during the summer. Riparian (bank-side)

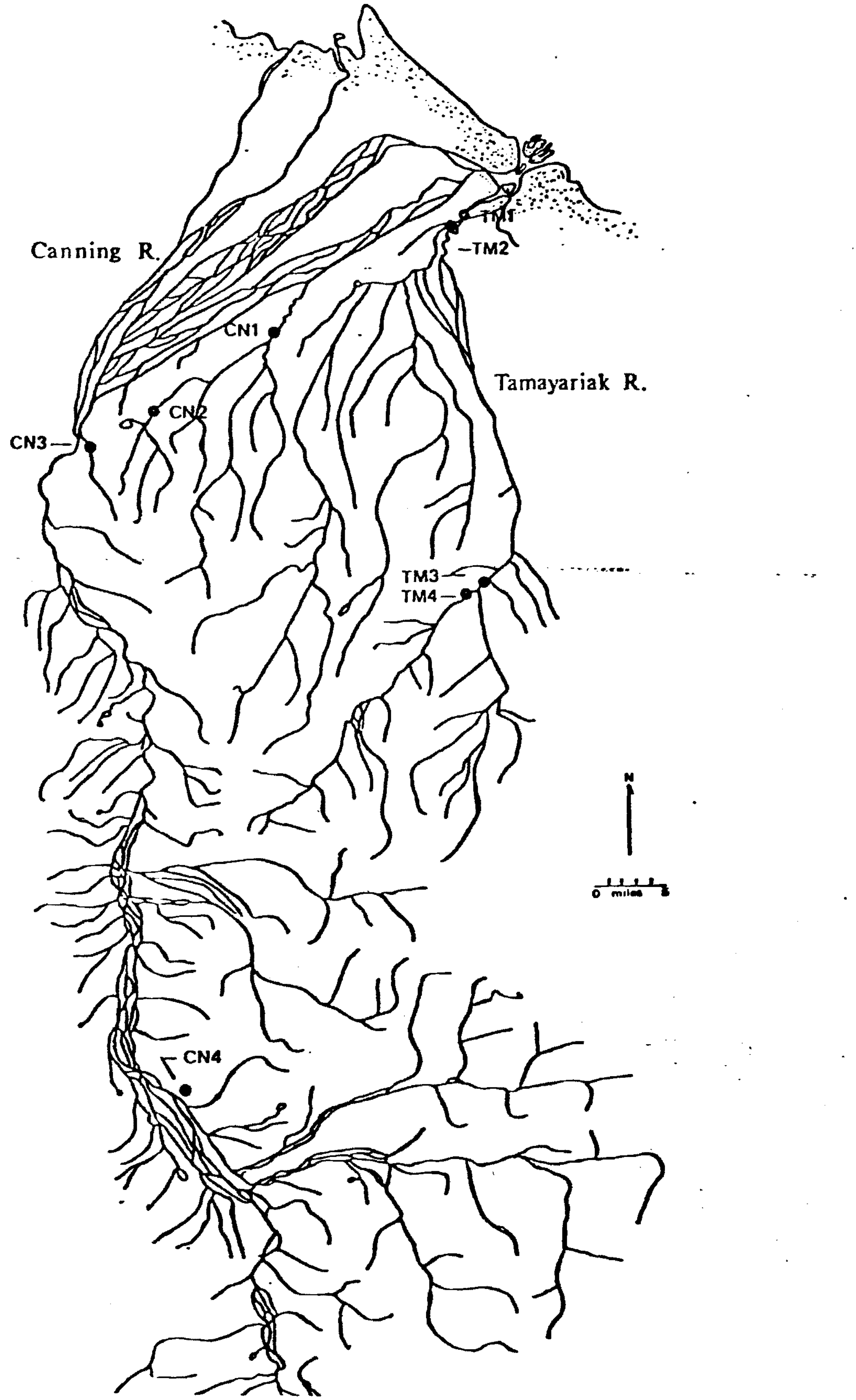

Figure 2. Macroinvertebrate sample locations on the Canning and Tamayariak Rivers for 1982-1983. (Not all of the Canning River drainage is shown.)

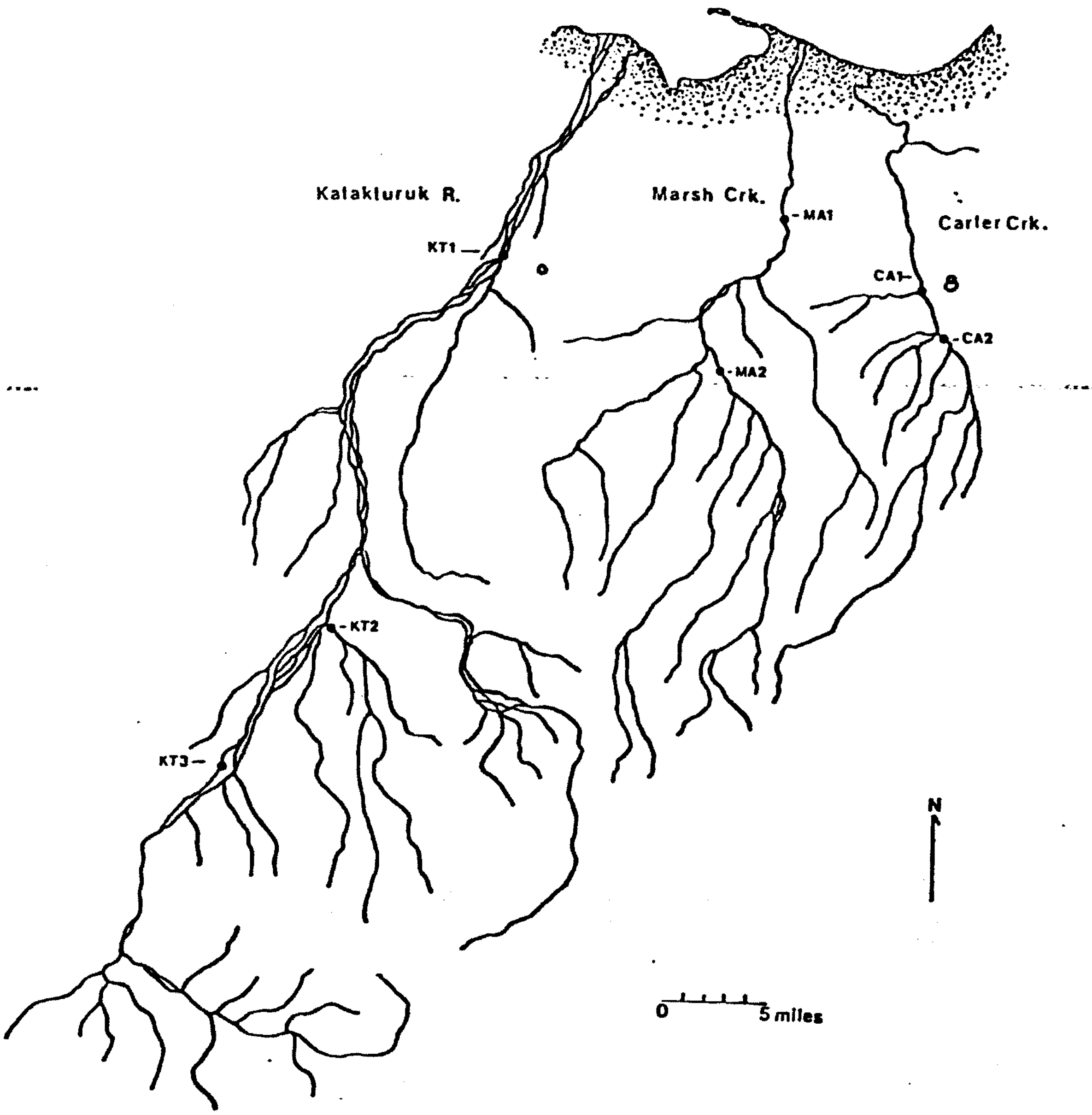

Figure 3. Macroinvertebrate sample locations on the Katakturuk River, Marsh Creek, and Carter Creek for 1982-1983.

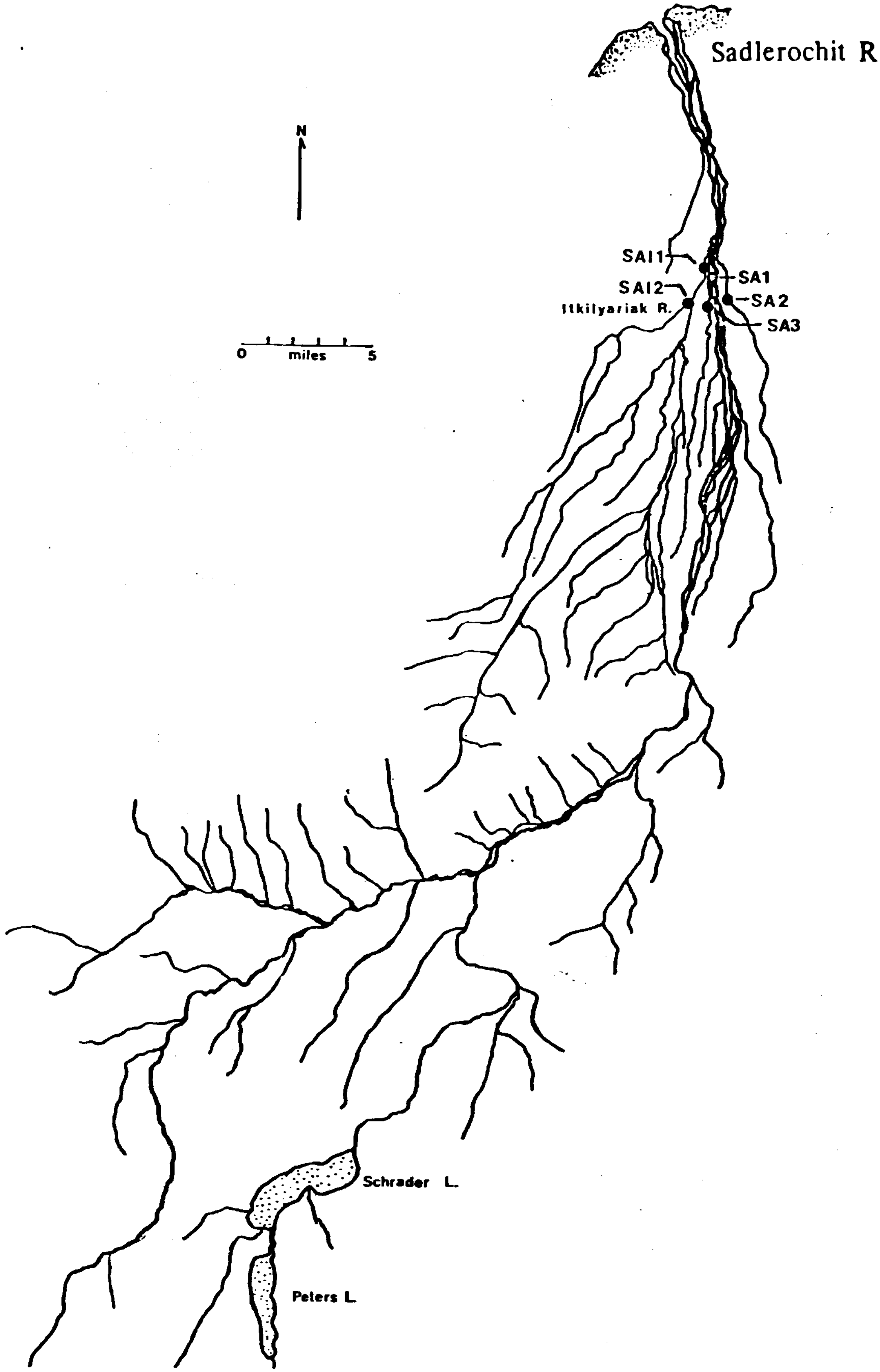

Figure 4. Macroinvertebrate sample locations on the Itkilyariak and Sadlerochit Rivers for 1982-1983. (Not all of the Sadlerochit River drainage is shown.)

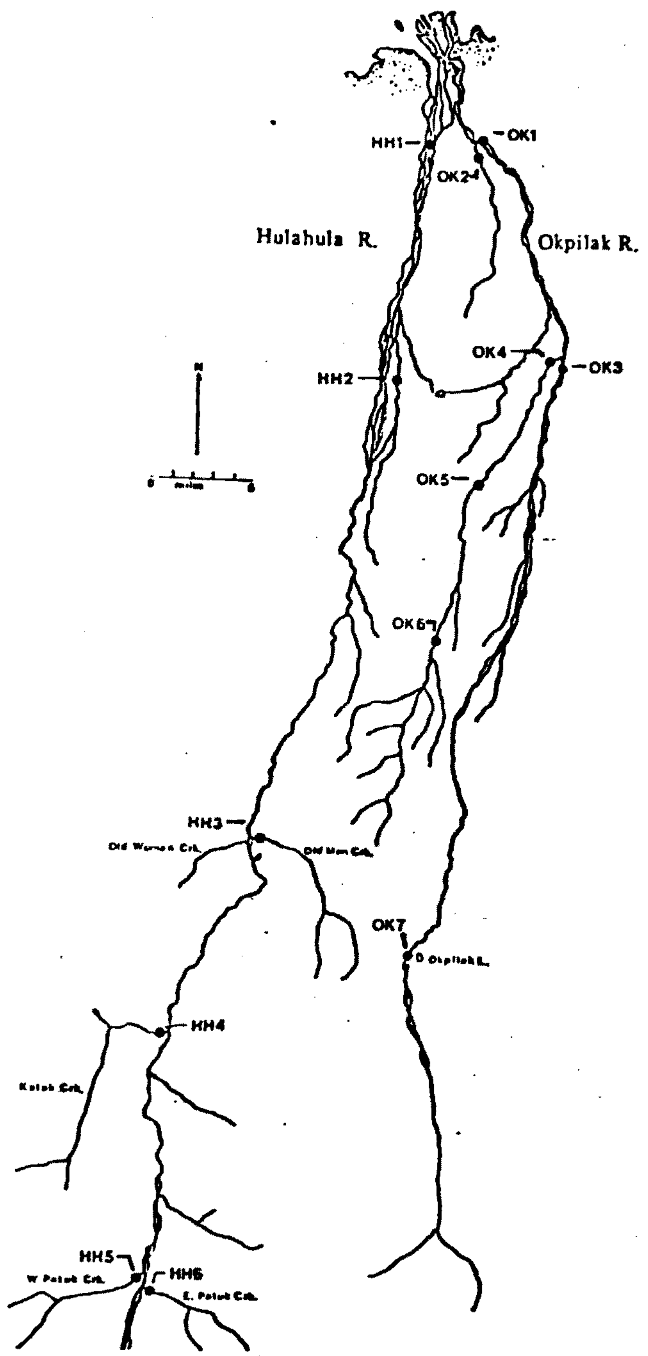

Figure 5. Macroinvertebrate sample locations on the Hulahula and Okpilak Rivers for 1982-1983. (Not all of the Hulahula River drainage is shown.)

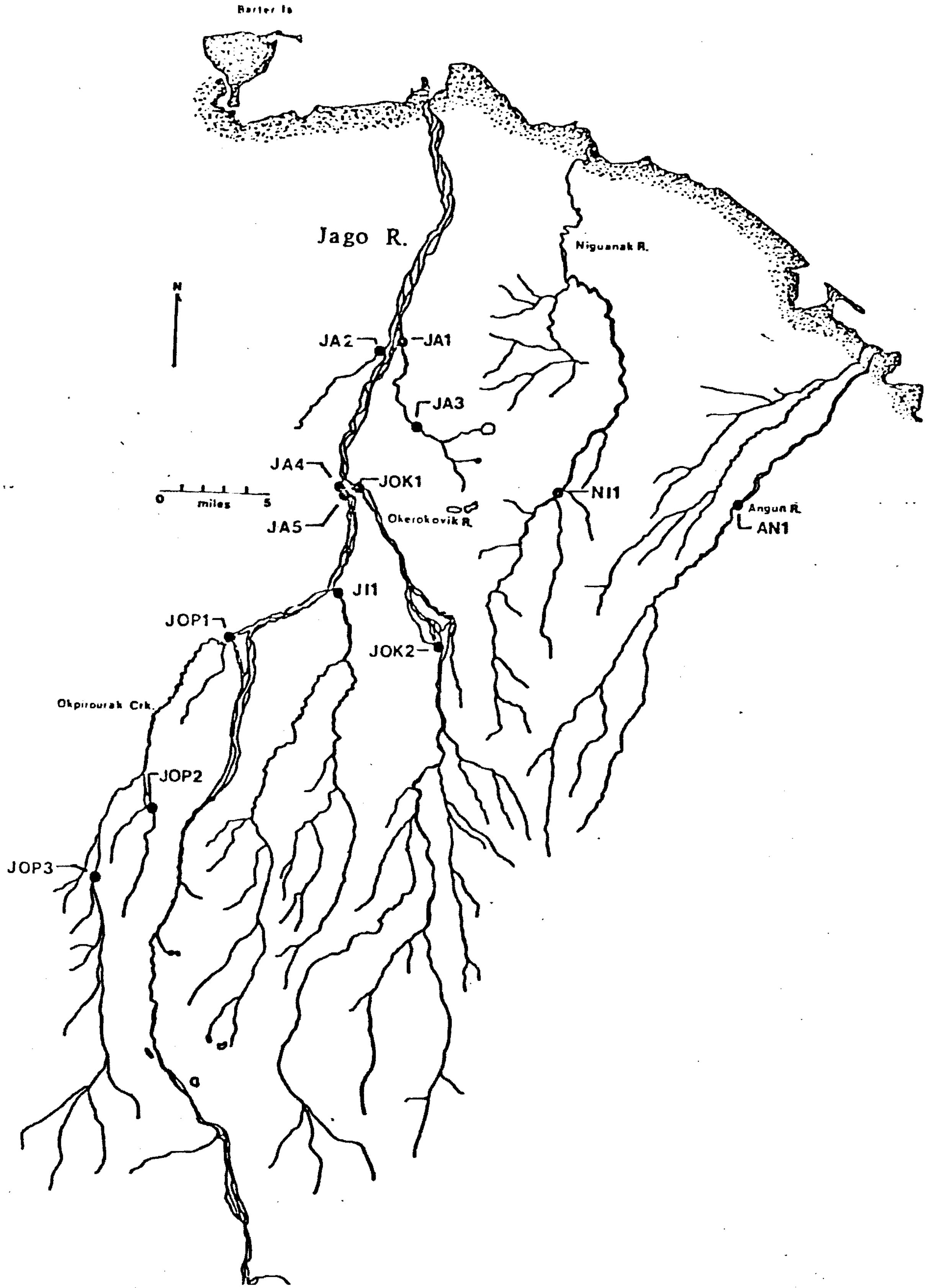

Figure 6. Macroinvertebrate sample locations on the Jago, Niguanak and Angun Rivers for 1982-1983. (Not all of the Jago River drainage is shown.)

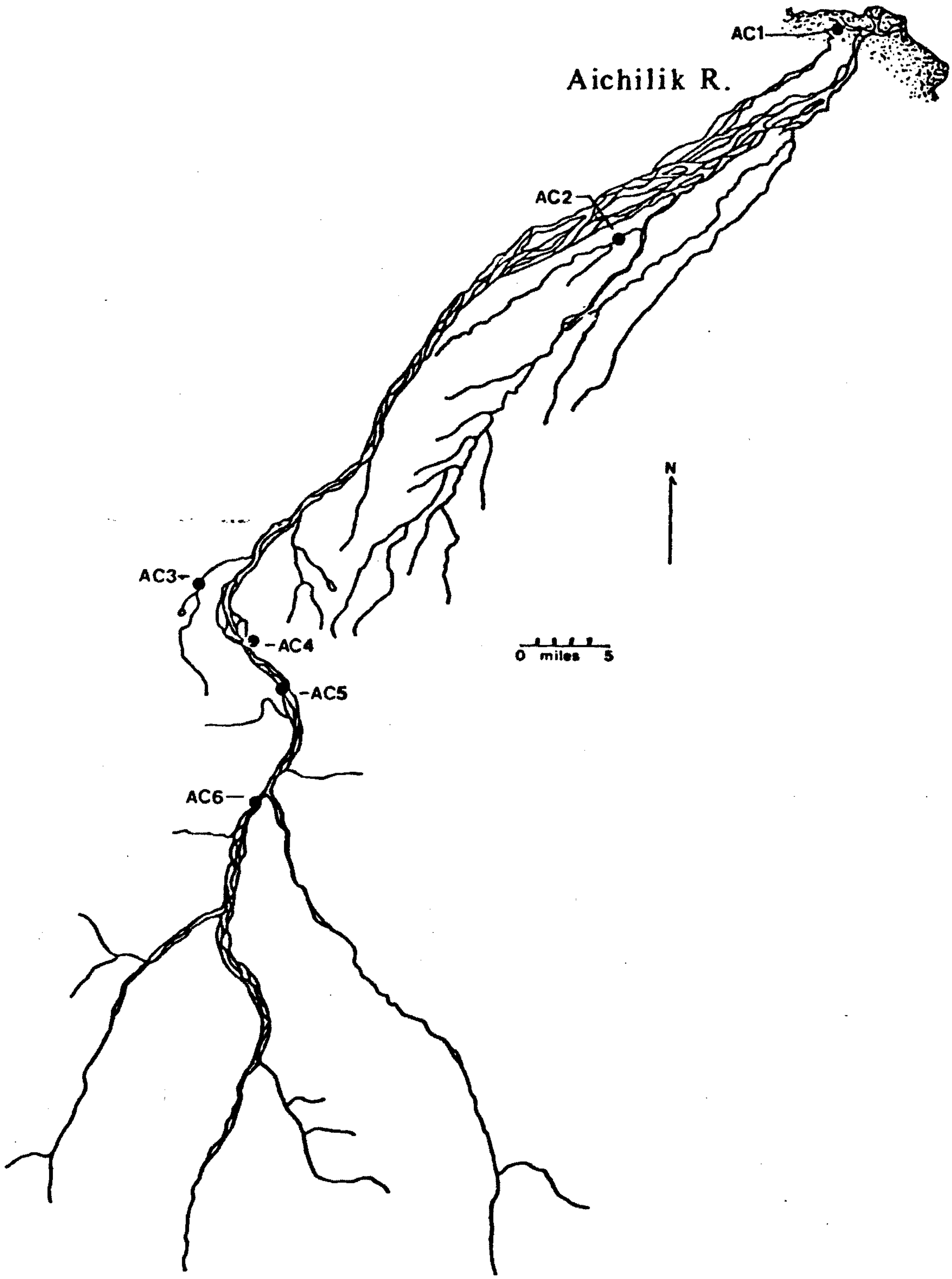

Figure 7. Macroinvertebrate sample locations on the Aichilik River for 1982-1983. (Not all of the drainage is shown)

vegetation is usually sparse. Turbidity and suspended sediments are higher than either spring or tundra stream types. Braided areas may occur in wider valleys, and alluvial fans are sometimes present. Except for deep pools, these streams freeze to the bottom during the winter. The water is essentially poor in minerals and has low conductivity, especially during the spring.

Spring-fed streams within the study area arise near, or within, the streambed of mountain stream channels. Virtually all springs are confined to the foothill or mountain provinces. Some are associated with the Lisbourne limestone group, and others arise from suprapermafrost sources. During the summer, a characteristic feature is the presence of abundant riparian vegetation. Willow (Salix spp.) and alder (Alnus spp.) are the most conspicuous species. The flora is reported to be similar to vegetation found in more temperate climates. Flow and water temperature are more constant than other stream types. Most springs within the study area have a cold water source with temperatures in the vicinity of 5 degrees centigrade at the spring orifice. Thermal springs are also present, and a temperature of 13 degrees centigrade was recorded at Sadlerochit Spring (Kalff and Hobbie 1973). The streambed of springs is almost always covered by a dense mat of moss or algae. Some spring-fed streams maintain open water channels during the winter. As a result, large ice fields (aufeis) form below the spring source. These sheets may attain thicknesses of 4.6 to 6.0 m and some persist through the summer.

Glacier-fed streams comprise a smaller portion of the rivers within the study area, because comparatively few glaciers are present. Where present these streams are immediately noticeable because other portions of a river drainage are affected by them. These types are characterized by low temperatures and low nutrients. Suspended sediment load is highest when the effects of the long photoperiod ablate glaciers the most. A distinct fluctuation in daily flow is observed in these streams with maximum flow in the evening and lowest during the early morning hours. Braided stream channels are a distinctive feature of most of these streams. Craig and McCart (1974) included this category under the mountain stream type. For the purpose of this report, this category will also be included as a mountain stream.

Tundra or lowland streams are characteristic of the coastal or foothill provinces. Flow is restricted to the summer months. Suspended solids concentrations, carried during the spring thaw, tends to be intermediate between spring and mountain streams. The primary source of water is from surface runoff. Because of the water-impermeable permafrost layer, run-off is rapid. Low stream order and low gradient are highly characteristic of these streams. Braided channels may occur in more extensive drainages. Riparian vegetation is primarily comprised of grasses and sedges. The water is generally low to moderate in calcium, nutrients, pH, and conductivity. The water color is often stained yellow or brown. Thaw or beaded streams are sometimes present. These are formed by successional freezing and thawning of the underlying permafrost. These streams tend to be deeper than other types, with slower flow and higher summer temperatures. Substrates range from cobbles to sand and silt.

RESULTS

Chemical Characteristics

Water chemistry for all sites sampled is shown in the Appendix (Table 8). A summary of chemical characteristics by stream type (ie. tundra, mountain, spring) for each major drainage in the study area is presented in Table 1.

Mean total alkalinity values for tundra streams ranged from 51 mg/l in the Angun River Drainage to 146 mg/l in the Sadlerochit Drainage. The mean total alkalinity value for 37 tundra stream sites sampled, was 89 mg/l. Mean alkalinity for mountain streams exhibited similar values, with eleven sites sampled showing a mean of 83 mg/l. Mean alkalinity was highest for the spring stream type (134 mg/l).

Total hardness values showed a similar pattern, with springs having the highest mean concentration (199 mg/l) and tundra and mountain stream types exhibiting lower concentrations (123 mg/l and 129 mg/l, respectively). Marsh creek, a tundra stream had the highest total hardness (281 mg/l). The lowest total hardness concentrations were found at the Niguanak and Angun River sites (51 mg/l and 68 mg/l, respectively).

Conductivity values were very high at spring stream sites, with a mean of 357 umhos/cm. Tundra and mountain streams exhibited moderately high mean values of 176 umhos/cm and 164 umhos/cm, respectively. The lowest conductivity values were found at mountain and tundra stream sites on the Okpilak, Niguanak, and Angun Rivers (less than 100 umhos/cm).

Mean pH values at all locations ranged from 7.1 to 8.0. There was very little difference between the mean pH values of the three stream types.

Physical Characteristics

Physical characteristics for each stream site sampled are found in the Appendix, Table 9. Mean values for physical parameters, by stream order, are presented in Table 2.

Percent gradient ranged from 0.53 to 1.48. First, second, and third order streams exhibited the highest gradients and fourth and fifth order streams exhibited the lowest gradients. Mean values for wetted perimeter increased with stream order and ranged from 2.0 meters, for first order streams, to 34.6 meters, for fifth order streams. Average depth, discharge and average water velocity also increased with stream order. Average depth ranged from 0.24 meters to 0.63 meters. Summer discharge values ranged from 0.08 cms, at first order streams, to 7.23 cms for fifth order streams. Average water velocities ranged from 0.24 m/sec to 0.63 m/sec. Shallow water habitat (less than 0.3 m deep) was predominant at most stream sites and varied little with stream order.

Aquatic Macroinvertebrates

A list of taxa collected, from the 46 locations sampled, is shown in Table 3. A total of 29 taxa were identified, of which, the largest number of taxa were found in the Diptera group.

Table 1. Chemical parameters, for tundra, mountain and spring stream types, from major drainages in the 1002c Study Area, ANWR, Summers of 1982 and 1983.

	No. of sites	Total Alkalinity (mg/l)		Total Hardness (mg/l)		Conductivity (umhos/cm)		pH	
		x̄	range	x̄	range	x̄	range	x̄	range
CANNING R.									
Tundra	3	103	(103)	103	(103)	171	(138-200)	7.8	(7.5-8.0)
Spring	1	137	-	170	-	-	-	8.0	-
TAMAYARIAK R.									
Tundra	4	125	(120-137)	171	(154-205)	243	(225-260)	8.0	(7.7-8.3)
KATAKTURUK R.									
Tundra	2	116	(111-120)	193	(188-198)	275	(270-280)	7.8	(7.8)
Spring	1	116	-	198	-	300	-	7.8	-
CARTER CK.									
Tundra	2	86	(68-103)	77	(68-85)	148	(125-170)	7.8	(7.5-8.0)
MARSH CK.									
Tundra	2	120	(120)	281	(273-289)	370	340-400)	8.5	(8.5)
SADLEROCHIT R.									
Mountain	1	85	-	137	-	240	-	7.8	-
Tundra	4	146	(120-171)	180	(138-221)	303	(250-395)	7.9	(7.8-8.0)
HULAHULA R.									
Mountain	5	92	(68-120)	140	(68-154)	211	(140-340)	7.8	(7.5-8.0)
Tundra	1	86	-	103	-	180	-	7.5	-
OKPILAK R.									
Mountain	3	74	(68-87)	114	(68-154)	68	(30-94)	7.4	(7.3-7.5)
Tundra	4	60	(35-87)	90	(51-137)	97	(44-120)	7.1	(6.8-7.5)
JAGO R.									
Spring	1	137	-	205	-	380	-	8.0	-
Tundra	10	54	(17-107)	86	(34-222)	100	(37-280)	7.1	(6.5-7.7)
NIGUANAK R.									
Tundra	1	68	-	51	-	95	-	8.0	-
ANGUN R.									
Tundra	1	51	-	68	-	74	-	8.0	-
AICHILIK R.									
Mountain	2	73	(60-86)	120	(103-137)	150	(100-200)	7.8	(7.5-8.0)
Tundra	3	91	(34-120)	91	(34-120)	163	(50-230)	7.8	(7.0-8.5)
Spring	1	145	-	222	-	390	-	7.5	-
COMBINED									
Tundra	37	89	(17-171)	123	(34-289)	176	(37-400)	7.6	(6.5-8.5)
Spring	4	134	(116-145)	199	(170-222)	357	(300-390)	7.8	(7.5-8.0)
Mountain	11	83	(60-120)	129	(68-274)	164	(30-340)	7.7	(7.3-8.0)

Table 2. Mean values for physical characteristics of streams sampled in the vicinity of the 1002c Study Area, ANWR, summers of 1982 and 1983.

	STREAM ORDER				
	1	2	3	4	5
Gradient (%)					
$\bar{x}$	0.93	1.48	1.01	0.52	0.54
S.D.	0.85	2.50	1.11	0.19	0.32
N	8	13	14	9	7
Wetted Perimeter (m)					
$\bar{x}$	2.0	5.7	8.6	13.2	34.6
S.D.	2.0	4.7	5.3	8.3	35.2
N	4	11	10	7	3
Average Depth (m)					
$\bar{x}$	0.20	0.22	0.28	0.36	0.32
S.D.	0.06	0.13	0.14	0.11	0.10
N	8	12	12	7	3
Discharge (cms)					
$\bar{x}$	0.08	0.22	0.94	2.80	7.23
S.D.	0.14	0.25	1.13	2.69	5.55
N	5	10	10	7	3
Average Velocity (m/sec)					
$\bar{x}$	0.24	0.25	0.31	0.49	0.63
S.D.	0.25	0.12	0.22	0.35	0.28
N	7	11	12	7	3
% Shallow ($<$ 0.3m)					
$\bar{x}$	90.0	80.0	72.0	63.0	73.0
S.D.	7.1	14.0	24.2	23.8	3.5
N	4	2	8	5	2
Predominant Substrate	Large gravel to small gravel	Large gravel to small gravel	Large gravel	Large gravel	Large gravel to small rubble

Table 3. Aquatic macroinvertebrate taxa collected at forty-six stream locations in the vicinity of the 1002c Study Area, ANWR, Summers of 1982 and 1983.

Platyhelminthes
 Turbellaria
  Tricladia
   Planariidae
    Dugesia sp.

Nematomorpha

Annelida
 Oligochaeta

Arthropoda
 Crustacea
  Amphipoda
   Gammaridae
    Synurella sp.
 Arachinoidea
 Hydracarina
Insecta
 Ephemeroptera
  Baetidae
   Baetis sp.
  Heptageniidae
   Cinygmula sp.
  Metretopodidae
   Metretopus sp.
 Plecoptera
  Nemouridae
   Nemoura sp.
   Zapada sp.
  Chloroperlidae
   Alloperla sp.
   Utaperla sp.
  Perlodidae
   Isoperla sp.
  Capniidae
  Leuctridae
 Trichoptera
  Limnephilidae
   Dicosomoecus sp.
   Ecclisomyia sp.

Coleoptera
 Dytiscidae
  Agabus sp.
Diptera
 Empididae
 Psychodidae
  Pericoma sp.
 Rhagionidae
  Atherix sp.
 Tipulidae
  Pedicia sp.
  Tipula sp.
 Simuliidae
  Prosimulium sp.
 Chirnomidae
  Chironominae
  Diamesinae
  Orthocladiinae
  Tanypodinae
Mollusca
 Gastropoda
  Physidae
   Physa

Distribution

A list of taxa and their relative abundance, by sampling location, is presented in the Appendix, Table 10. Frequency of occurrence of taxonomic groups by stream type is shown in Table 4. A total of 10 taxa were collected in mountain streams and 22 taxa were collected in tundra and in spring streams (Table 4). Oligochaetes, *Baetis* sp., *Cinygmula* sp., *Nemoura* sp., Capniidae, *Prosimulium* sp., Diamesinae and Orthocladiinae were found in all stream types. Mountain streams had few taxa, with those taxa being represented by low to moderate frequency among the sampling sites. Tundra sites had a large number of taxa, however, many of the taxa exhibited a low frequency of occurence. Spring stream sites also had a high number of taxa, but with most of the taxa occuring in greater frequency than that found for tundra streams. More taxa of Plecoptera and Diptera were represented at spring stream sites than at tundra and mountain stream types.

Species Composition

Percent composition of major taxanomic groups of aquatic macroinvertebrates collected in the study area is shown in Table 5 and Figure 8.

Mountain and tundra streams exhibited similar species compositions. Orthocladiinae, Simuliidae, and Ephemeroptera were the predominant taxa collected at these sites, with these taxa representing 84 percent of the composition in both tundra and mountain stream types. Tundra streams were represented by many more taxa than found in mountain streams, however they only accounted for a small part of the population.

Orthocladiinae was the predominant taxa found in spring streams, which accounted for 76 percent of the species composition. Spring streams were similar to tundra streams in numbers of taxa, only. Percent composition of Diamesinae was similar in both mountain and spring streams. Composition of Oligochaetes was greater in spring streams than in mountain and tundra streams.

Macroinvertebrate Abundance and Diversity

Statistical analysis of data and mean values for density, biomass, diversity and evenness are shown in Tables 11 - 13, in the appendix. Mean values for density, biomass, diversity, evenness, and number of taxa are shown in Table 6 and in Figures 9 - 11.

Density of organisms was greatest in spring stream samples (13,263 organisms/m^2. Mean density of organisms in tundra streams (1068 organisms/m^2 was nearly an order of magnitude greater than in mountain streams (208 organisms/m^2). Biomass of organisms showed a similar trend, with much less variation between mean values for the three stream types.

Mean diversity (H') and evenness (J') was much greater for the tundra stream type (H' = 1.689, J' = 0.670). Diversity was lowest in mountain stream samples (0.676) and can be attributed primarily to the low number of taxa found at these sites ($\bar{x}$ = 3.5 taxa/site). Spring streams exhibited the highest mean number of taxa (9.25 taxa/site), however, the extreme redundancy of, primarily, chironomid larvae, contributed to the low evenness value (0.284) and consequently, the low diversity value (0.855).

Table 4. Frequency of occurrence of aquatic macroinvertebrate taxa collected in the vicinity of the 1002c Study Area, ANWR, Summers of 1982 and 1983.

	STREAM TYPE		
	Tundra	Mountain	Spring
No. of Sites	(32)	(10)	(4)
Platyhelminthes			
Turbellaria			
Tricladia			
Planariidae			
Dugesia sp.	9.4	0.0	50.0
Nematomorpha	3.1	0.0	0.0
Annelida			
Oligochaeta	87.5	20.0	75.0
Arthropoda			
Crustacea			
Amphipoda			
Gammaridae			
Synurella sp.	9.4	0.0	25.0
Arachnoidea			
Hydracarina	53.1	0.0	25.0
Insecta			
Ephemeroptera			
Baetidae			
Baetis sp.	78.1	40.0	50.0
Heptageniidae			
Cinygmula sp.	65.5	20.0	50.0
Metretopodidae			
Metretopus sp.	6.3	0.0	0.0
Plecoptera			
Nemouridae			
Nemoura sp.	93.7	40.0	50.0
Zapada sp.	0.0	0.0	25.0
Chloroperlidae			
Alloperla sp.	0.0	0.0	25.0
Utaperla sp.	0.0	0.0	25.0
Perlodidae			
Isoperla sp.	0.0	10.0	25.0
Capniidae	46.9	30.0	50.0
Leuctridae	9.4	0.0	0.0
Trichoptera			
Limnephilidae			
Dicosomoecus sp.	6.3	0.0	0.0
Ecclisomyia sp.	6.3	0.0	25.0
Coleoptera			
Dytiscidae			
Agabus sp.	6.3	0.0	0.0
Diptera			
Empididae	0.0	0.0	25.0
Psychodidae			
Pericoma sp.	0.0	0.0	25.0
Rhagionidae			
Atherix sp.	0.0	0.0	50.0
Tipulidae			
Pedicia sp.	9.4	0.0	50.0
Tipula sp.	53.1	0.0	25.0
Simuliidae			
Prosimulium sp.	87.5	30.0	75.0
Chirnomidae			
Chironominae	40.6	0.0	25.0
Diamesinae	34.4	50.0	75.0
Orthocladiinae	100.0	100.0	100.0
Tanypodinae	21.9	10.0	0.0
Mollusca			
Gastropoda			
Physidae			
Physa sp.	9.4	0.0	0.0
No. of taxa	22	10	22

Table 5. Percent composition for major taxonomic groups of aquatic macroinvertebrates, 1002c, Study Area, ANWR.

Taxa		Stream Type		
		Tundra	Mountain	Spring
Platyhelminthes				
	Planariidae	0.02	-	0.64
Nematomorpha		0.01	-	-
Annelida				
	Oligochaeta	3.02	1.30	8.60
Arthropoda				
	Gammaridae	0.30	-	0.11
Arachnoidea				
	Hydracarina	1.80	-	0.03
Insecta				
	Ephemeroptera	(23.46)	(22.03)	(0.38)
	Baetidae	13.98	13.61	0.27
	Heptageniidae	9.43	8.42	0.11
	Metretopodiae	0.05	-	-
	Plecoptera	(7.4)	(5.4	(1.24)
	Nemouridae	6.15	3.24	0.42
	Chloroperlidae	-	-	0.79
	Perlodidae	-	0.22	0.01
	Capniidae	1.17	1.94	0.02
	Leuctridae	0.08	-	-
	Trichoptera	(0.07)	-	(1.56)
	Limnephilidae	0.07	-	-
	Coleoptera	(0.04)	-	-
	Dytiscidae	0.04	-	-
	Diptera	(63.84)	(71.27)	(87.42)
	Empididae	-	-	0.11
	Psychodidae	-	-	0.24
	Rhagionidae	-	-	0.70
	Tipulidae	0.51	-	0.11
	Simuliidae	35.81	46.00	0.86
	Chironomidae	(27.52)	(25.27)	(85.40)
	Chironominae	1.18	-	0.01
	Diamesinae	0.96	8.64	9.32
	Orthocladiinae	25.10	16.41	76.07
	Tanypodinae	0.28	0.22	-
Mollusca				
	Physidae	0.04	-	-

Percent composition represents combined samples for all stations under each stream type.

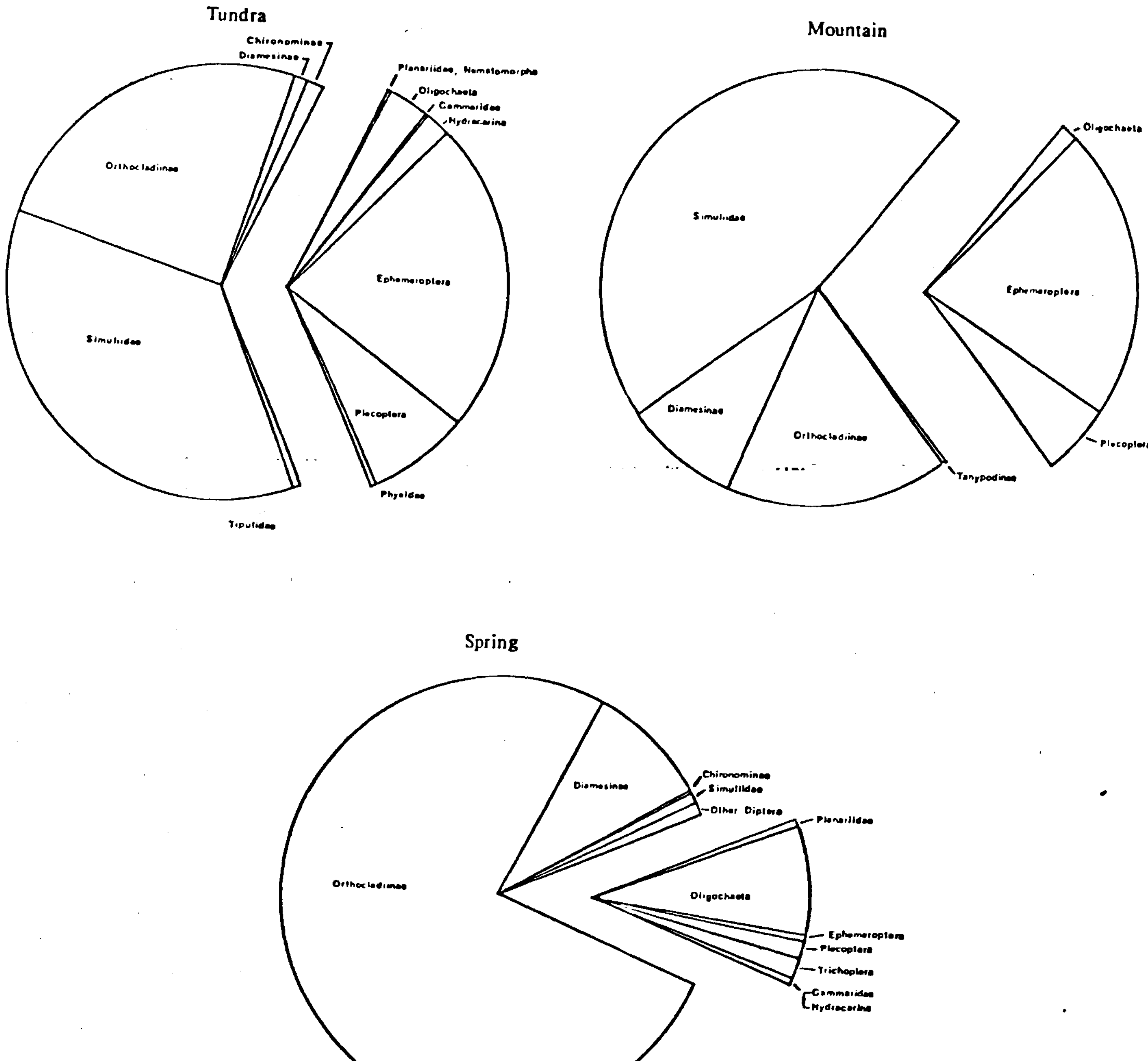

Figure 8. Percent composition for major taxonomic groups of aquatic macroinvertebrates, 1002c Study Area, ANWR.

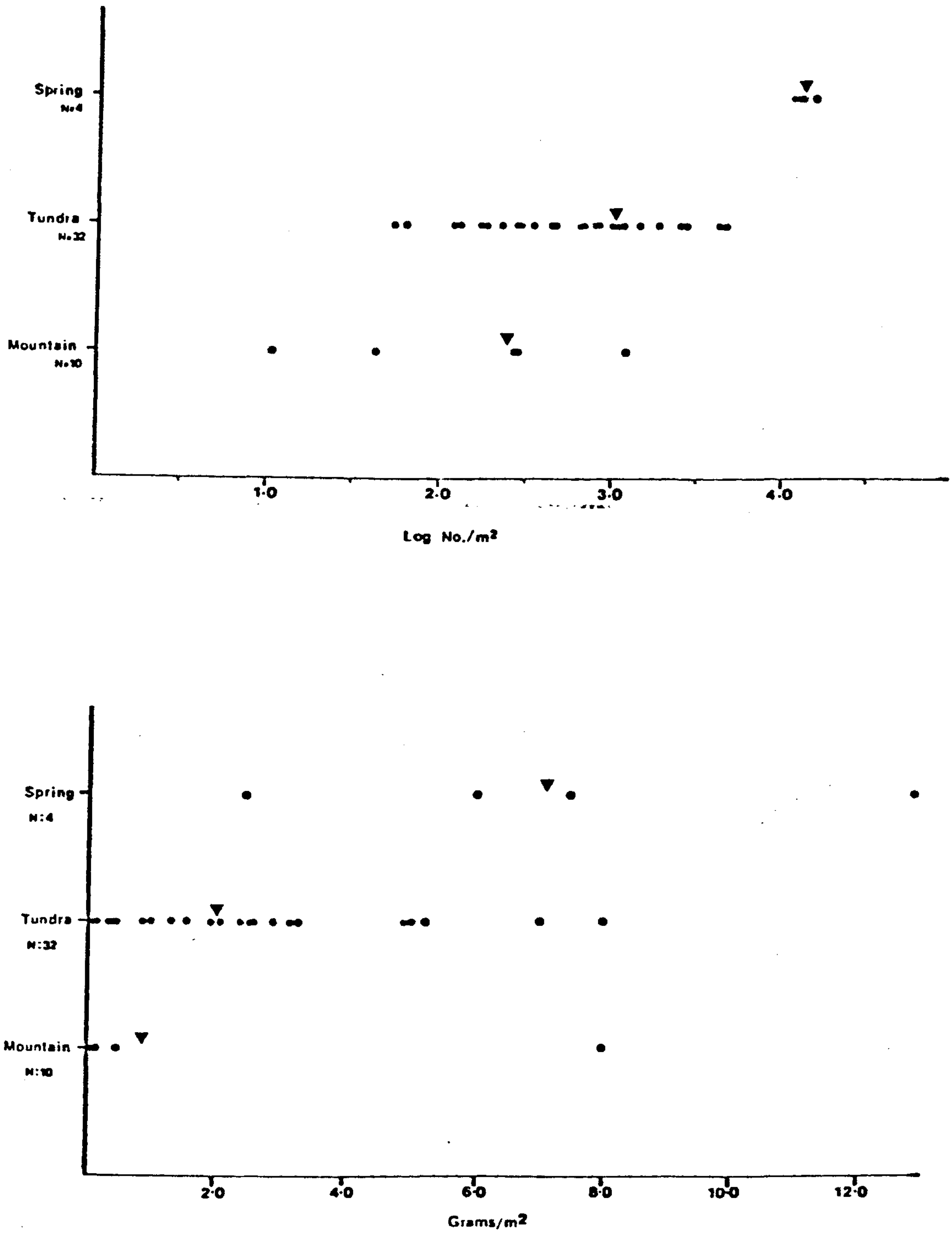

Figure 9. Log number/m^2 and grams/m^2 ($\bar{x}$ = ▼) for aquatic macroinvertebrates collected in the vicinity of the 1002c Study Area, ANWR.

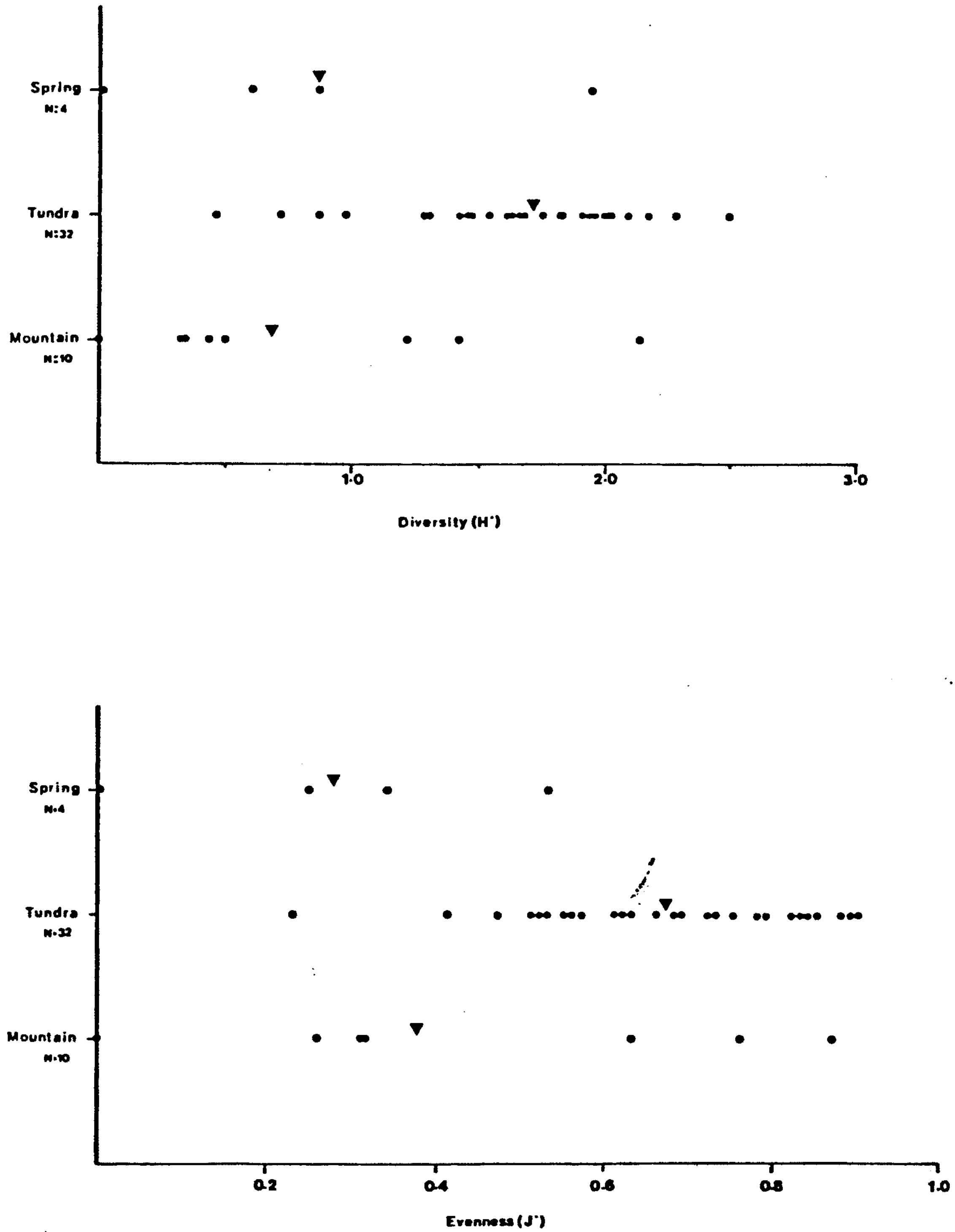

Figure 10. Diversity (H') and Evenness (J') for aquatic macroinvertebrates ($\bar{x}$ =▼) collected in the vicinity of the 1002c Study Area, ANWR.

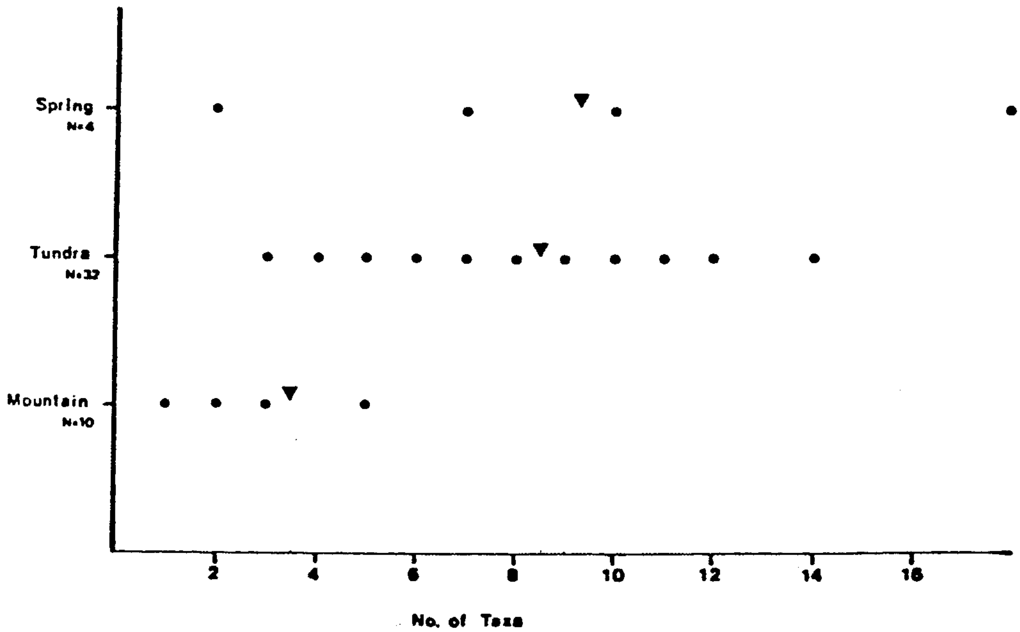

Figure 11. Number of taxa ($\overline{x}$ = ▼) for aquatic macroinvertebrate samples collected in the vicinity of the 1002c Study Area, ANWR.

Table 6. Mean density (no./m^2), biomass (gms/m^2), diversity (H'), evenness (J'), and number of taxa ($\pm$ standard error), by stream type, 1002c Study Area, ANWR.

	Stream Type		
	Tundra	Mountain	Spring
No. of Samples	32	10	4
Density			
no./m^2	1068.0 $\pm$ 207.7	207.8 $\pm$ 118.4	13,263.0 $\pm$ 816
Biomass			
gms/m^2	2.023 $\pm$ 0.359	0.897 $\pm$ 0.796	7.152 $\pm$ 2.179
Diversity			
H'	1.689 $\pm$ 0.084	0.676 $\pm$ 0.216	0.855 $\pm$ 0.402
Evenness			
J'	0.670 $\pm$ 0.027	0.377 $\pm$ 0.092	0.284 $\pm$ 0.106
No. of Taxa			
No.	8.46 $\pm$ 0.45	3.50 $\pm$ 0.60	9.25 $\pm$ 3.35

Regression analysis of selected physical parameters with macroinvertebrate density, biomass, diversity, and eveness values are shown in Table 7. Scatterplots, of the significant regressions ($P \quad 0.05$, $r = 0$), are shown in Figures 12 - 14, in the appendix.

There were no significant correlations with discharge. There was a significant positive correlation ($P = 0.05$) between biomass and average velocity. Diversity and evenness values did not show any significant correlations with any of the physical parameters. Strong positive correlations ($P < 0.01$) were found between density and biomass of macroinvertebrates with both conductivity and alkalinity values. The highest correlation ($r = +0.541$, $P = 0.001$) was between density of invertebrates and water conductivity.

Table 7. Regression analysis of physical parameters with density, biomass, diversity and evenness of aquatic macroinvertebrates from the 1002c, Study Area, ANWR.

INDEPENDENT VARIABLES	DEPENDENT VARIABLES Density(log_{10})	Biomass	Diversity	Evenness
Discharge				
n	40	40	40	40
r	-0.106	+0.202	-0.157	-0.92
Significance Level	N.S.	N.S.	N.S.	N.S.
Average Velocity				
n	37	37	37	37
r	+0.063	+0.338	-0.073	-0.167
Significance Level	N.S.	0.05	N.S.	N.S.
Conductivity				
n	45	45	45	45
r	+0.541	+0.464	+0.042	-0.074
Significance Level	0.001	0.005	N.S.	N.S.
Alkalinity				
n	46	46	46	46
r	+0.462	+0.398	+0.109	+0.027
Significance Level	0.005	0.01	N.S.	N.S.

n = Sample Size
r = Correlation Coefficient
Significance Level = P(r = 0)

DISCUSSION

Invertebrate densities for this study ranged from 11 organisms/m^2 to 15,555 organisms/m^2. These values may be close to seasonal minimum densities due to the midsummer sampling scheme. Cowan and Oswood (unpublished) and Hynes (1970) stated that benthic invertebrate populations generally exhibited lowest densities during midsummer. Craig and McCart (1974) reported a range in densities from 22 organisms/m^2 to 84,000 organisms/m^2, for samples collected in the general vicinity of the study area. They concluded that tundra and spring streams had densities much the same as southern latitude streams, however, mountain streams exhibited much lower densities. Platts et.al. (1983) reported that densities of benthic invertebrates, in Rocky Mountain streams in Utah, Idaho, Colorado and Wyoming, ranged from 1000 organisms/m^2 to 10,000 organisms/m^2.

This study supports the stream classification system developed by Craig and McCart (1974). Invertebrate density and biomass values were very similar to their findings. Macroinvertebrate density was generally an order of magnitude greater from mountain to tundra streams and from tundra to spring streams. The classification scheme generally reflects the stream stability. Mountain streams, exhibiting the lowest densities, have greater fluctuations in discharge, turbidity (particularly those with glacial water sources) and greater instability of substrate. Tundra streams exhibit intermediate stability while spring streams are very stable.

The amount and type of organic matter in the streams may greatly influence the density biomass and distribution of stream invertebrates (Anderson and Sedell, 1975; Egglishaw, 1964; and, Cowan and Oswood, unpublished). From observations of riparian vegetation it appears that allochthonous organic input decreases from spring streams to tundra streams and from tundra to mountain streams. The autochthonous organic components of these stream types appear to follow the same pattern. Dense growths of algae have been observed at all of the spring stream sites. Increased turbidity at many of the mountain stream sites may severely limit autotrophic production. Using conductivity and alkalinity as an index of production, results indicated very little difference between mountain and tundra streams. Spring streams had much higher values for conductivity and alkalinity. Density and biomass of aquatic invertebrates showed strong correlation with alkalinity and conductivity values.

Merrit and Cummins (1978) classified aquatic invertebrate taxa by functional group (i.e. collector - gatherer, scrapers, shredder etc). Species composition of all three stream types was dominated by the collector - gatherer and scraper functional groups (ie. Simuliidae, Orthocladinae, Diamesinae, Baetidae, and Oligochaeta), which generally feed on fine particulate organic matter. Shredder species, which primarilly feed on leaf litter, exhibited very low densities. The scarcity of allochthonous organic matter is reflected by the sparse distribution of species in the shredder functional group. At higher altitudes and latitudes, riparian vegetation is restricted and streams are primarily autotrophic with the collector functional group dominating the macroinvertebrate community (Vannote et. al., 1980). The low diversity of functional groups is reflected in the low values found for species diversity (H'), throughout the study area. Diversity values ranged from 0.001 to 2.479, with the majority being less than 1.5. Brunskill et. al. (1973) noted a decline in diversity of benthic invertebrates with increasing latitude.

Mean diversity (H') and evenness (J') values for mountain and spring streams were very low. low values for mountain streams reflect the instability of these waters. Spring streams exhibit highly stable conditions. Low diversity values in these waters results from the uneven distribution of taxa within the benthic community structure. At these sites, chironomids accounted for 85% of the species composition. Vannote et. al. (1980) stated that systems with highly stable physical structure may have low biotic diversity yet maintain ecosystem stability. Tundra streams exhibited the highest diversity and evenness values. This may be partially explained by the wide range of temperatures found in these waters. Under these conditions, optimum temperatures will occur for a larger number of species than if the thermal regime displayed minimum variance (Vannote et. al., 1980).

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APPENDIX

Table 8. Chemical characteristics for all stream locations sampled in the vicinity of 1002c Study Area, ANWR, Summers of 1982 and 1983.

Location	Dissolved Oxygen (mg/l)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Conductivity umhos/cm	pH
CANNING R.					
CN-1	10	103	103	200	8.0
CN-2	10	103	103	175	7.9
CN-3	10	103	103	138	8.0
CN-4 Spring	10	137	170	-	8.0
TAMAYARIAK R.					
TM-1	10	124	205	260	7.7
TM-2	10	120	154	225	8.3
TM-3	10	137		260	7.8
TM-4	11	120	154	225	8.3
KATAKTURUK R.					
KT-1	8	120	188	270	7.8
KT-2	11	111	198	280	7.8
KT-3 Spring	7	116	198	300	7.8
CARTER CK.					
CA-1		103	85	170	7.5
CA-2	10	68	68	125	8.0
MARSH CK.					
MA-1		120	273	340	8.5
MA-2		120	289	400	8.5
SADLEROCHIT R.					
SA-1	7	85	137	240	7.8
SA-2	10	154	154	255	8.0
SA-3	8	171	221	310	8.0
SAI-1	7	120	205	395	7.8
SAI-2	10	137	138	250	7.8
HULAHULA R.					
HH-1		120	154	270	8.0
HH-2		86	103	180	7.5
HH-3		103	120	155	8.0
HH-4		68	86	140	7.5
HH-5		68	68	150	7.5
HH-6		103	274	340	8.0

Table 8. Continued.

Location	Dissolved Oxygen (mg/l)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Conductivity umhos/cm	pH
OKPILAK R.					
OK-1		68	120	80	7.5
OK-2		87	103	44	7.0
OK-3		86	154	30	7.5
OK-4		68	137	120	7.5
OK-5	9	51	51	110	7.0
OK-6		35	70	115	6.8
OK-7		68	68	94	7.3
JAGO R.					
JA-1	10	43	103	72	6.9
JA-2	9	43	120	92	6.9
JA-3		51	51	68	6.8
JA-4	7	67	51	88	6.9
JA-5	9	47	86	80	6.7
JOK-1	9	107	222	280	7.7
JOK-2 Spring		137	205	380	8.0
JI-1	9	56	51	72	7.5
JOP-1	10	43	68	80	7.2
JOP-2		17	34	37	6.5
JOP-3		70	70	130	7.5
NIGUANAK R.					
NI-1		68	51	95	8.0
ANGUN R.					
AN-1		51	68	74	8.0
AICHILIK R.					
AC-1	10	120	120	230	8.0
AC-2		34	34	50	7.0
AC-3		120	120	210	8.5
AC-4 Spring	13	145	222	390	7.5
AC-5	11	86	137	200	8.0
AC-6	9	60	103	100	7.5

Table 9. Physical characteristics for all stream locations sampled, 1002c Study Area, Summer of 1982 and 1983.

Location	Stream Type	Stream Order	Gradient %	Channel Type	Wetted Perimeter (m)	Ave. Depth (m)	Discharge (cms)	Ave. Velocity (m/sec)	% Pool (> 0.3m)	% Shallow (< 0.3m)	Predominant Substrate
CANNING											
CN-1	Tundra	4	0.45	Irregular	4.0	0.20	0.20	0.52	40	60	Large and small gravel
CN-2	Tundra	2	0.65	Straight	1.2	0.15	0.06		30	70	Large and small gravel
CN-3	Tundra	1	0.60	Straight	1.0	0.30	0.03		10	95	Cobble and large gravel
CN-4	Spring	1	3.00	Straight	1.2	0.20	0.57	0.77	10	90	Rubble-cobble
TAMAYARIAK											
TM-1	Tundra	5	0.28	Irregular	10.0	0.30	2.65	0.34	25	75	Large and small gravel
TM-2	Tundra	4	0.90	Irregular	4.0	0.50	0.79	0.12	60	40	Large and small gravel
TM-3	Tundra	4	0.79	Irregular	6.5	0.30	4.26	0.62	15	85	Rubble-cobble
TM-4	Tundra	3	0.75	Irregular	7.0	0.40	3.20	0.62	10	90	Rubble-cobble
KATAKTURUK											
KT-1	Tundra	5	0.30	Braided	18.8	0.43	5.64	0.89			
KT-2	Tundra	3	1.40	Straight							
KT-3	Spring	1	0.85	Braided	3.5	0.15	0.08	0.15			
CARTER CK.											
CA-1	Tundra	3	0.38	Irregular	4.3	0.12	0.10	0.21			
CA-2	Tundra	3	0.75	Straight	2.5	0.20	0.20	0.22	30	70	Large and small gravel
MARSH CK.											
MA-1	Tundra	3	0.21	Irregular	7.0	0.21	0.68	0.15	20	80	Large and small gravel
MA-2	Tundra	3	0.63	Irregular	5.0	0.18	0.46	0.24	10	90	Large and small gravel
SADELROCHIT R.											
SA-1	Mountain	5	0.30	Braided	75.0	0.23	13.40	0.68	30	70	Rubble-cobble
SA-2	Tundra	1	0.50	Meandering	1.0	0.18	0.01	0.09	20	80	Small gravel - silt
SA-3	Tundra	1	0.70	Meandering	5.0	0.28	0.01	0.02	5	95	Small gravel - silt
ITKILYARIAK											
SAI-1	Tundra	4	0.40	Irregular	20.0	0.30	1.85	0.40	10	90	Rubble - large gravel
SAI-2	Tundra	4	0.40	Irregular							
HULAHULA R.											
HH-1	Glacial Mount.	5	0.30	Braided							
HH-2	Tundra	2	0.38	Irregular	2.7	0.21	0.01	0.06			
Old Man Ck.											
HH-3	Mountain	2	2.84	Straight	10.2	0.27	0.78	0.30			
Katak Ck.											
HH-4	Mountain	3	3.25	Straight	16.5	0.18	1.47	0.52			
W. Patuk											
HH-5	Mountain	2	9.50	Straight	14.6	0.15	1.02	0.49	10	90	Small and large gravel
E. Patuk											
HH-6	Mountain	3	3.80	Straight	13.4	0.34	3.40	0.79	5	95	Small and large gravel

Table 9. Continued.

Location	Stream Type	Stream Order	Gradient %	Channel Type	Wetted Perimeter (m)	Ave. Depth (m)	Discharge (cms)	Ave. Velocity (m/sec)	% Pool (> 0.3m)	% Shallow (< 0.3m)	Predominant Substrate
OKPILAK R.											
OK-1	Glacial Mount.	5	0.95	Braided							
OK-2	Tundra	3	0.69	Irregular	7.3	0.26	0.16	0.09	80	20	Large and small gravel
OK-3	Glacial Mount.	5									
OK-4	Tundra	4	0.61	Irregular	15.4	0.52	0.23	0.03	60	40	Large and small gravel
OK-5	Tundra	3	0.66	Irregular	7.7	0.30	0.40	0.19	30	70	Large and small gravel
OK-6	Tundra	3	0.64	Irregular	9.4	0.26	0.28	0.12	40	60	Boulder-rubble
OK-7	Glacial Mount.	4	0.36	Braided							
JAGO R.											
JA-1	Tundra	2	0.28	Straight	6.0	0.35	0.39	0.20			
JA-2	Tundra	1	0.70	Irregular	4.6	0.23	0.34	0.35			
JA-3	Tundra	2	0.56	Irregular	1.5	0.55	0.14	0.18			
JA-4	Tundra	1	0.75	Irregular	0.8	0.17	0.02	0.16			
JA-5	Tundra	2	0.45	Irregular	2.2	0.27	0.11	0.19			
OKEROKOVIK											
JOK-1	Tundra	4	0.35	Braided	23.7	0.32	6.64	0.95			
JOK-2	Spring	1	0.30	Straight	3.0	0.12	0.14	0.12			
IGILATAVIK											
JI-1	Tundra	4	0.45	Irregular	19.1	0.38	5.66	0.85			
OKPIROURAK											
JOP-1	Tundra	3	0.28	Meandering	19.1	0.65	2.81	0.25			
JOP-2	Tundra	3	0.47	Straight			0.03				
JOP-3	Tundra	3	0.23	Irregular	16.8	0.21	1.14	0.34			
NIGUANAK R.											
NI-1	Tundra	2	0.25	Irregular	14.0	0.18	0.89	0.37			
ANGUN R.											
AN-1	Tundra	2	0.54	Irregular	12.2	0.15	0.21	0.12			
AICHILIK R.											
AC-1	Tundra	2	0.20	Irregular							
AC-2	Tundra	2	0.94	Irregular	3.7	0.12	0.12	0.27			
AC-3	Tundra	2	1.50	Straight	1.8	0.09	0.03	0.21			
AC-4	Spring	2	1.13	Straight	3.0	0.13	0.14	0.33			
AC-5	Glacial Mount.	5	0.95	Braided							
AC-6	Glacial Mount.	5	0.70	Irregular							

Table 10. Relative abundance and distribution of aquatic macroinvertebrates collected in the vicinity of the 1002c Study Area, ANWR, Summers of 1982 and 1983.

TAXA	CANNING R.				TAMAYARIAK R.				KATAKTURUK R.			CARTER CK.		MARSH CK.	
	CN-1	CN-2	CN-3	CN-4**	TM-1	TM-2	TM-3	TM-4	KT-1	KT-2	KT-3	CA-1	CA-2	MA-1	MA-2
Platyhelminthes															
Turbellaria															
Tricladia															
Planariidae															
<u>Dugesia</u> sp.		R		A				R					R		
Nematomorpha															
Annelida															
Oligochaeta	R	R	C	A	R	C	R	R	R		C	R	C	C	C
Arthropoda															
Crustacea															
Amphipoda															
Gammaridae															
<u>Synurella</u> sp.															
Arachinoidea															
Hydracarina		C	C	R			R					A	R	C	R
Insecta															
Ephemeroptera															
Baetidae															
<u>Baetis</u> sp.	C	C	A	C	C	A	C	R	A	C	C	A	C	A	A
Heptageniidae															
<u>Cinygmula</u> sp.	A	C		R	C	A	A	C	C	R	C	C	A	A	C
Metretopodidae															
<u>Metretopus</u> sp.															
Plecoptera															
Nemouridae															
<u>Nemoura</u> sp.	C	A	C		R	C	C	C	A	C	C	A	A	C	C
<u>Zapada</u> sp.				A											
Chloroperlidae															
<u>Alloperla</u> sp.				A											
<u>Utaperla</u> sp.				A											
Perlodidae															
<u>Isoperla</u> sp.				A											
Capniidae	C			R	C	C	C	R	C			C		R	R
Leuctridae															
Trichoptera															
Limnephilidae															
<u>Dicosomoecus</u> sp.															
<u>Ecclisomyia</u> sp.				A								R			
Coleoptera															
Cytiscidae															
<u>Agabus</u> sp.															
Diptera															
Empididae				C											
Psychodidae															
<u>Pericoma</u> sp.				C											
Rhagionidae															
<u>Atherix</u> sp.				A											
Tipulidae															
<u>Pedicia</u> sp.		R		C											
<u>Tipula</u> sp.	R		R			R	R					R		R	R
Simuliidae															
<u>Prosimulium</u> sp.	R		C	R	A	A	A	C	A	C	A	A	R	A	A
Chirnomidae															
Chironominae		A		R								C			R
Diamesinae		R		A							A				
Orthocladiinae	C	A	A	A	R	A	C	R	C	R	A	A	C	A	A
Tanypodinae	R					R	R					C	R		
Mollusca															
Gastropoda															
Physidae															
<u>Physa</u> sp.		R	R												
No. of Taxa	9	11	8	19	7	9	10	7	7	5	7	12	9	9	10

*Relative abundance: R-< $5/ft^2$, C- 6-$25/ft^2$, A-> $25/ft^2$.
**Spring Locations.

Table 10. Continued.

TAXA	ANGUN R. AN-1	NIGUANAK R. NI-1	JAGO R. JA-3	JA-4	JA-5	JOP-1	JOP-2	JOP-3	JOK-2**	AICHILIK R. AC-2	AC-3	AC-4**	AC-6
Platyhelminthes													
Turbellaria													
Tricladia													
Planariidae													
Dugesia sp.									R				
Nematomorpha													
Annelida													
Oligochaeta	C		A		R	R	R	C	R	C	R		
Arthropoda													
Crustacea													
Amphipoda													
Gammaridae													
Synurella sp.	C		A		R	R	R	C	R	C	R		
Arachinoidea													
Hydracarina			R				R	R			C		
Insecta													
Ephemeroptera													
Baetidae													
Baetis sp.		R					R	C		C	A		
Heptageniidae													
Cinygmula sp.		R						R		R	R		
Metretopodidae													
Metretopus sp.							R						
Plecoptera													
Nemouridae													
Nemoura sp.	R	R	R		R		C	R	R	C	A		
Zapada sp.													
Chloroperlidae													
Alloperla sp.													
Utaperla sp.													
Perlodidae													
Isoperla sp.												R	
Capniidae		C	R					R			R		R
Leuctridae	R	R											
Trichoptera													
Limnephilidae													
Dicosmoecus sp.				R			R						
Ecclisomyia sp.								R					
Coleoptera													
Cytiscidae													
Agabus sp.				R			R						
Diptera													
Empididae													
Psychodidae													
Pericoma sp.													
Rhagionidae													
Atherix sp.									R				
Tipulidae													
Pedicia sp.								R	R				
Tipula sp.	C		R					R	R		R		
Simuliidae													
Prosimulium sp.	R	C	R	C	R	R	A	A	A	A	A		
Chironomidae													
Chironominae		R	R				C	R		C	R		
Diamesinae	C	R	R					R	A		C		A
Orthocladiinae	A	A	C	C	R	C	C	A	A	A	A	A	A
Tanypodinae								R					
Mollusca													
Gastropoda													
Physidae													
Physa sp.													
No. of Taxa	8	9	9	4	4	3	10	14	10	8	12	2	3

*Relative abundance: R= < 5/ft^2, C= 6-25/ft^2, A= > 25/ft^2.
**Spring Locations.

Table 10. Continued.

TAXA	SA-1	SA-2	SA-3	SAI-1	SAI-2	HH-1	HH-2	HH-3	HH-4	HH-5	HH-6	OK-1	OK-2	OK-3	OK-4	OK-5	OK-6	OK-7
	SADELROCHIT R.					HULAHULA R.						OKPILAK R.						
Platyhelminthes																		
Turbellaria																		
Tricladia																		
Planariidae																		
Dugesia sp.																		
Nematomorpha																	R	
Annelida																		
Oligochaeta		A	R	R	R		R	R	R				C		C	R	R	
Arthropoda																		
Crustacea																		
Amphipoda																		
Gammaridae																		
Synurella sp.																		
Arachinoidea																		
Hydracarina		A		R	C		R									R	R	
Insecta																		
Ephemeroptera																		
Baetidae																		
Baetis sp.	A	A		A	A	R	A	C		R				R	R	A		
Heptageniidae																		
Cinygmula sp.	A		R	A	R		R	C						R	A			
Metretopodidae																		
Metretopus sp.															R			
Plecoptera																		
Nemouridae																		
Nemoura sp.	R	C	C	C	A	R	C	R			C		C		A	R	R	
Zapada sp.																		
Chloroperlidae																		
Alloperla sp.																		
Utaperla sp.																		
Perlodidae																		
Isoperla sp.						R												
Capniidae				R											R		R	R
Leuctridae													R					
Trichoptera																		
Limnephilidae																		
Dicosmoecus sp.																		
Ecclisomyia sp.																		
Coleoptera																		
Cytiscidae																		
Agabus sp.																		
Diptera																		
Empididae																		
Psychodidae																		
Pericoma sp.																		
Rhagionidae																		
Atherix sp.																		
Tipulidae																		
Pedicia sp.																R		
Tipula sp.				R	R		R						R		C		R	
Simuliidae																		
Prosimulium sp.	A	A		A	A		A	C						R	A		C	
Chirnomidae																		
Chironominae			R				C								R		R	
Diamesinae		A		R	C	R		R		R	R		R		R			
Orthocladiinae	C	A	C	R	A	R	A	C	R	R	R	R	C	R	A	C	A	R
Tanypodinae				R						R							R	
Mollusca																		
Gastropoda																		
Physidae																		
Physa sp.							R											
No. of Taxa	5	7	5	11	9	5	10	7	2	5	3	1	6	2	10	8	11	2

*Relative abundance: R= < $5/ft^2$, C= $6-25/ft^2$, A= > $25/ft^2$.
**Spring Locations.

Table 11. Statistical analysis of raw and transformed data for number of organisms/sample, from all stations, 1002c Study Area, ANWR.

Station	RAW DATA Sample Size	Mean No.	Standard Deviation	Standard Error	% Precision	TRANSFORMED DATA LOG (x+1) Mean	Derived Mean	Standard Deviation	Standard Error	% Precision
CANNING R.										
CN-1	3	78	13.05	7.53	9.7	1.89	78	0.07	0.04	2.0
CN-2	3	62	12.53	7.23	11.7	1.79	62	0.09	0.05	2.8
CN-3	2	259	7.78	5.50	2.1	2.41	256	0.01	0.01	0.4
*CN-4	3	950	964.12	556.63	58.5	2.83	1102	0.43	0.25	8.7
TAMAYARIAK R.										
TM-1	3	30	11.59	6.69	22.3	1.47	32	0.18	0.10	6.9
TM-2	3	162	99.14	57.23	35.3	2.14	184	0.33	0.19	9.0
TM-3	3	82	100.46	58.00	70.7	1.70	103	0.52	0.30	17.7
TM-4	3	11	4.04	2.33	21.2	1.08	12	0.13	0.08	7.1
KATAKTURUK R.										
KT-1	3	332	337.44	194.82	58.7	2.37	400	0.45	0.26	11.0
KT-2	3	16	4.93	2.84	17.8	1.23	17	0.12	0.07	5.5
*KT-3	3	920	613.83	354.39	38.5	2.85	1157	0.43	0.25	8.8
CARTER CK.										
CA-1	3	230	64.06	36.99	16.1	2.35	232	0.12	0.07	3.0
CA-2	3	111	4.36	2.52	2.3	2.04	109	0.02	0.01	0.5
MARSH CK.										
MA-1	3	76	39.20	22.63	29.8	1.84	79	0.23	0.14	7.4
MA-2	3	92	32.00	18.47	20.1	1.95	94	0.14	0.08	4.1
SADLEROCHIT R.										
SA-1	3	100	62.98	36.36	36.4	1.92	114	0.35	0.20	10.5
SA-2	3	229	53.36	30.75	13.4	2.35	230	0.11	0.06	2.6
SA-3	3	11	0.58	0.33	3.0	1.07	11	0.02	0.01	1.2
SAI-1	2	376	453.96	320.99	85.4	2.29	433	0.77	0.55	23.9
SAI-2	3	185	237.15	136.91	74.0	1.98	135	0.62	0.36	18.1

*Indicates spring areas.

Table 11. (Continued.)

		RAW DATA				TRANSFORMED DATA LOG (x+1)				
Station	Sample Size	Mean No.	Standard Deviation	Standard Error	% Precision	Mean	Derived Mean	Standard Deviation	Standard Error	% Precision
HULAHULA R.										
HH-1	3	3	2.51	1.45	48.5	0.58	4	0.27	0.16	27.1
HH-2	3	152	110.64	63.88	42.0	2.09	172	0.36	0.21	9.8
HH-3	2	25	1.41	0.99	4.0	1.41	25	0.02	0.01	1.0
HH-4	3	1	1.00	0.58	58.0	0.26	1	0.24	0.02	7.5
HH-5	3	2	1.73	0.99	49.9	0.43	2	0.23	0.13	30.2
HH-6	3	5	8.38	4.84	96.7	0.50	8	0.63	0.36	72.4
OKPILAK R.										
OK-1	3	1	1.00	0.58	58.0	0.20	1	0.35	0.20	100.0
OK-2	3	16	5.29	3.05	19.1	1.22	16	0.13	0.07	6.1
OK-3	3	2	1.15	0.66	33.2	0.20	1	0.35	0.20	100.0
OK-4	3	48	26.66	15.39	32.1	1.63	45	0.31	0.18	10.9
OK-5	3	43	9.71	5.60	13.0	1.64	44	0.09	0.05	3.3
OK-6	3	27	7.21	4.16	15.4	1.44	27	0.11	0.06	4.4
OK-7	3	1	1.73	0.99	99.0	0.20	1	0.35	0.20	100.0
JAGO R.										
JA-3	3	28	7.54	4.35	15.5	1.45	28	0.11	0.07	4.5
JA-4	3	10	15.88	9.16	91.7	0.59	6	0.77	0.45	75.6
JA-5	3	4	3.78	2.18	54.5	0.58	6	0.51	0.29	50.3
JOP-1	3	4	2.52	1.45	36.4	0.62	5	0.28	0.16	26.2
JOP-2	3	27	18.23	10.52	39.0	1.39	32	0.30	0.17	12.5
JOP-3	3	71	50.46	29.13	38.3	1.78	76	0.30	0.17	9.7
*JOK-2	3	1043	823.22	475.28	45.6	2.90	1232	0.40	0.23	8.0
ANGUN R.										
AN-1	3	40	19.30	11.14	27.9	1.56	42	0.25	0.14	9.3
NIGUANAK R.										
NI-1	3	21	2.00	1.15	5.5	1.34	21	0.04	0.02	1.7
AICHILIK R.										
AC-2	3	60	13.11	7.56	12.6	1.78	61	0.09	0.05	3.0
AC-3	3	135	36.61	21.13	15.7	2.12	131	0.13	0.07	3.4
*AC-4	2	903	922.77	652.49	72.3	2.80	1447	0.56	0.40	14.1
AC-6	3	22	13.43	7.75	35.2	1.27	26	0.37	0.21	16.8

*Indicates spring areas.

Table 12. Statistical analysis of raw data for weight of organisms/sample from all stations, 1002c Study Area, ANWR.

Station	Sample Size	Mean Wt.(gms)	Standard Deviation	Standard Error	% Precision
CANNING R.					
CN-1	3	0.233	0.128	0.074	31.7
CN-2	3	0.053	0.013	0.008	14.2
CN-3	2	0.444	0.298	0.172	38.8
*CN-4	3	1.197	0.772	0.445	37.2
TAMAYARIAK R.					
TM-1	3	0.047	0.024	0.014	29.8
TM-2	3	0.450	0.326	0.188	41.8
TM-3	3	0.197	0.242	0.140	70.9
TM-4	3	0.024	0.007	0.004	16.8
KATAKTURUK R.					
KT-1	3	0.655	0.725	0.420	63.9
KT-2	3	0.034	0.004	0.002	6.8
*KT-3	3	0.687	0.526	0.303	44.1
CARTER CK.					
CA-1	3	0.211	0.082	0.047	22.4
CA-2	3	0.262	0.110	0.006	2.4
MARSH CK.					
MA-1	3	0.089	0.054	0.031	35.0
MA-2	3	0.220	0.184	0.106	48.3
SADLEROCHIT R.					
SA-1	3	0.153	0.098	0.056	37.0
SA-2	3	0.300	0.282	0.163	54.2
SA-3	3	0.025	0.013	0.007	30.0
SAI-1	2	0.749	0.899	0.635	84.8
SAI-2	3	0.482	0.390	0.225	46.7
HULAHULA R.					
HH-1	3	0.009	0.010	0.006	64.2
HH-2	3	0.237	0.149	0.086	36.3
HH-3	2	0.048	0.006	0.004	8.8
HH-4	3	0.001	0.001	0.0005	57.7
HH-5	3	0.002	0.001	0.0006	28.9
HH-6	3	0.005	0.007	0.004	80.8

*Indicates spring areas.

Table 12. (Continued.)

Station	Sample Size	Mean Wt.(gms)	Standard Deviation	Standard Error	% Precision
OKPILAK R.					
OK-1	3	0.001	0.001	0.0005	57.7
OK-2	3	0.050	0.046		
OK-3	3	0.002	0.003	0.002	100.0
OK-4	3	0.092	0.072	0.042	45.2
OK-5	3	0.099	0.020	0.012	11.7
OK-6	3	0.058	0.047	0.027	46.8
OK-7	3	0.002	0.003	0.002	86.6
JAGO R.					
JA-3	3	0.146	0.182	0.105	71.9
JA-4	3	0.100	0.173	0.099	99.8
JA-5	3	0.003	0.002	0.001	33.3
JOP-1	3	0.005	0.003	0.002	34.6
JOP-2	3	0.054	0.045	0.026	48.1
JOP-3	3	0.127	0.138	0.079	62.2
*JOK-2	3	0.557	0.383	0.221	39.7
ANGUN R.					
AN-1	3	0.310	0.261	0.151	48.6
NIGUANAK R.					
NI-1	3	0.022	0.002	0.001	5.2
AICHILIK R.					
AC-2	3	0.079	0.014	0.008	10.2
AC-3	3	0.179	0.148	0.085	47.7
AC-4	2	0.220	0.028	0.016	7.3
AC-6	3	0.016	0.010	0.006	36.1

*Indicates spring areas.

Table 13. Mean density (no/m^2), biomass (gm/m^2), diversity (H'), evenness (J'), and number of taxa of aquatic macroinvertebrates from all stations, 1002c Study Area, ANWR.

Station	Sample Size	no./m^2	gm/m^2	Diversity (H')	Evenness (J')	No. of taxa
CANNING R.						
CN-1	3	839	2.50	1.685	0.613	9
CN-2	3	667	0.57	2.479	0.853	11
CN-3	2	2752	4.77	1.301	0.470	8
*CN-4	3	11847	12.87	1.940	0.531	18
TAMAYARIAK R.						
TM-1	3	344	0.51	1.631	0.685	7
TM-2	3	1978	4.84	2.082	0.753	9
TM-3	3	1107	2.11	2.033	0.718	10
TM-4	3	129	0.26	2.001	0.902	7
KATAKTURUK R.						
KT-1	3	4300	7.04	1.423	0.522	7
KT-2	3	183	0.37	1.661	0.791	5
*KT-3	3	12406	7.39	0.863	0.339	7
CARTER CK.						
CA-1	3	2494	2.27	1.814	0.561	12
CA-2	3	1172	2.82	1.529	0.572	9
MARSH CK.						
MA-1	3	849	0.96	2.494	0.837	9
MA-2	3	1010	2.37	1.947	0.683	10
SADLEROCHIT R.						
SA-1	3	1226	8.05	1.402	0.632	5
SA-2	3	2472	3.23	1.450	0.547	7
SA-3	3	118	0.27	1.279	0.891	5
SAI-1	2	4655	8.05	1.599	0.505	11
SAI-2	3	1451	5.18	1.902	0.727	9
HULAHULA R.						
HH-1	3	43	0.10	0.417	0.263	5
HH-2	3	1849	2.55	1.765	0.619	10
HH-3	2	269	0.52	2.117	0.866	7
HH-4	3	11	0.01	0.001	0.001	2
HH-5	3	22	0.02	0.500	0.316	5
HH-6	3	194	0.05	0.501	0.317	3

*Indicates spring areas.

Table 13. (Continued.)

Station	Sample Size	no./m^2	gm/m^2	Diversity (H')	Evenness (J')	No. of taxa
OKPILAK R.						
OK-1	3	11	0.01	0.001	0.001	1
OK-2	3	172	0.54	1.769	0.884	6
OK-3	3	11	0.02	0.306	0.306	2
OK-4	3	484	0.99	2.085	0.783	10
OK-5	3	473	0.99	0.971	0.414	8
OK-6	3	290	0.62	2.031	0.755	11
OK-7	3	11	0.02	0.306	0.306	2
JAGO R.						
JA-3	3	301	1.57	1.608	0.664	9
JA-4	3	65	1.08	0.466	0.233	4
JA-5	3	65	0.03	0.877	0.553	4
JOP-1	3	54	0.05	0.717	0.532	3
JOP-2	3	344	0.58	2.179	0.826	10
JOP-3	3	814	1.37	1.965	0.632	14
*JOK-2	3	13244	5.98	0.600	0.247	10
ANGUN R.						
AN-1	3	452	3.33	1.611	0.734	8
NIGUANAK R.						
NI-1	3	226	0.23	0.943	0.827	9
AICHILIK R.						
AC-2	3	656	0.85	1.451	0.608	8
AC-3	3	1408	1.92	2.290	0.749	12
*AC-4	2	15555	2.37	0.019	0.019	2
AC-6	3	280	0.17	1.208	0.762	3

*Indicates spring areas.

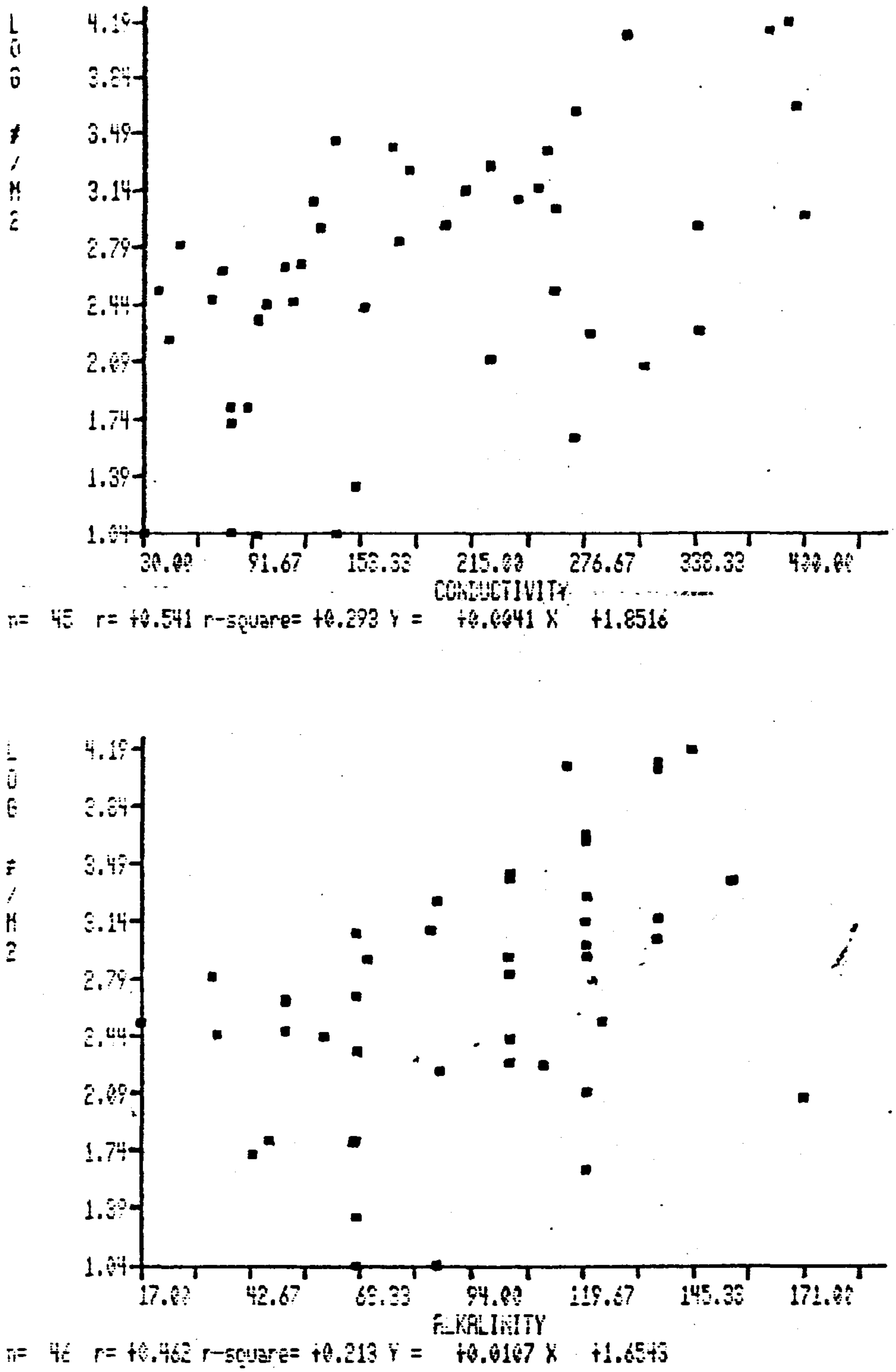
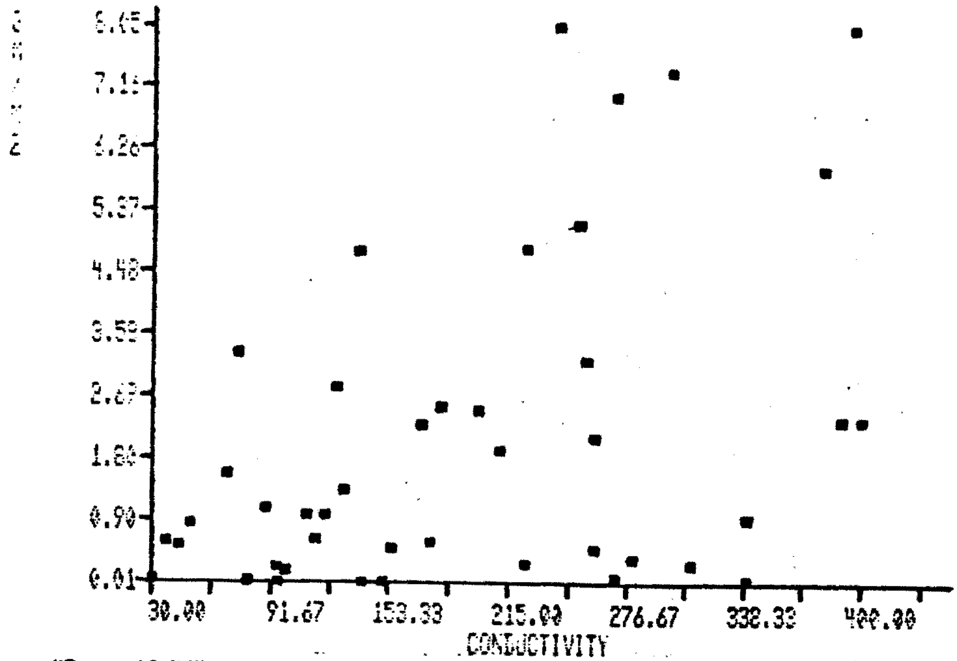
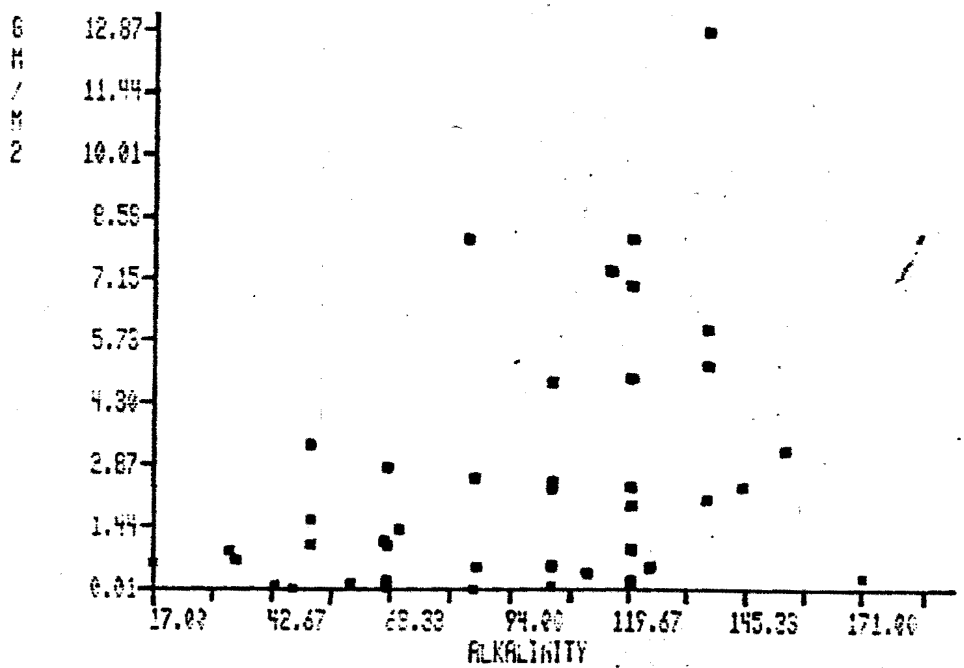


Figure 12. Regression of alkalinity and conductivity with density (log no/m^2) of aquatic macroinvertebrates from samples collected in the vicinity of the 1002c Study Area, ANWR.



n= 45 r= +0.464 r-square= +0.215 Y = +0.0102 X +0.0314



n= 46 r= +0.398 r-square= +0.158 Y = +0.0313 X -0.6953

Figure 13. Regressions of alkalinity and conductivity with aquatic macro-invertebrate biomass (gms/m^2) from samples collected in the vicinity of the 1002c Study Area, ANWR.

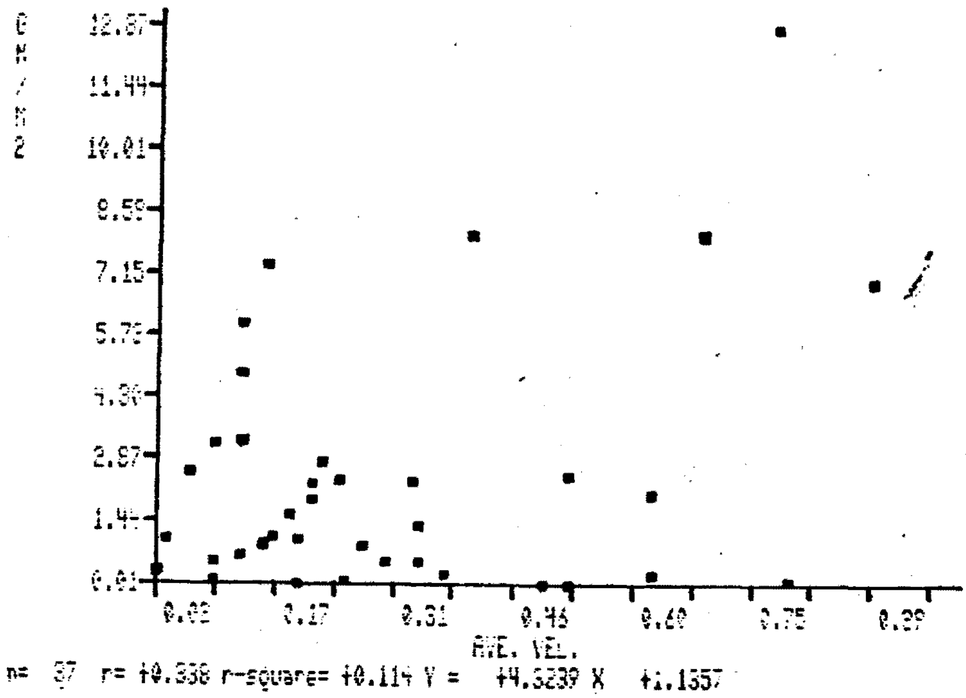


Figure 14. Regression of biomass (gms/m^2) of aquatic macroinvertebrates with average water velocity from samples collected in the vicinity of the 1002c Study Area, ANWR.

DWRC Progress Report: Sub-work Unit 5
PROBE: SPATIAL AND TEMPORAL DISTRIBUTION OF BITING AND PARASITIC INSECTS ON THE COASTAL PLAIN AND ADJOINING FOOTHILLS OF THE ANWR

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Key Words: Porcupine caribou herd, summer range, insects, insect relief habitat, traps, model

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PROGRESS REPORT
Denver Wildlife Research Center
Caribou Project
Sub workunit 5

Title: Probe: Spatial and temporal distributions of biting and parasitic insects on the coastal plain and adjoining foothills of the ANWR.

Introduction: The temporal and spatial distributions of biting and parasitic Dipterans are central to the ecology of the Porcupine Caribou Herd (PCH). Insect harassment and infestation are primary modifiers of caribou behavior, condition and habitat during periods of critical energy balance. Mosquitoes (Culicidae), gad flies (Tabanidae), black flies (Simuliidae), midges (Ceratopogonidae), warbles and bots (Oestridae) are the principal families involved.

Post-calving aggregations and mid-August dispersals of caribou were attributed to mosquito and Oestrid harassment respectively by Pruitt (1960), Kelsal (1968), Curatolo (1975), Roby (1978). Reindeer exhibit similar patterns of aggregation in response to harassment (Baskin 1970). Helle and Aspi (1983) trapped significantly fewer biting insects in the center than periphery of reindeer herds and concluded that aggregation reduced harassment. Oestrid harassment and the associated aberrant running by caribou resulted in dispersal and contributed to a decrease in grazing and lying during August (Curatolo 1975, Roby 1978). Insect harassment significantly altered the activity budget of West Greenland cows and calves. Feeding time was decreased by 45% and 55% and lying by 90% and 80% respectively. Moderate to severe insect harassment was observed 40% of the days during July. Foraging and rumination were reduced to an absolute minimum and concomittant avoidance behavior put the animals in a marked negative energy balance (Thing and Thing 1983). Reimers (1980) hypothesized that growth and fattening in reindeer are less correlated to summer range characteristics than to activity patterns. Insect harassment reduced the time spent eating as well as increased the speed of walking during both grazing and walking periods (Thompson 1973, White et al. 1975). Calf condition and survival may be a function of decreased nursing time, increased nursing interval and abandonment during periods of high harassment (Calef and Lortie 1973, White et al. 1975). Blood loss to mosquitoes has been estimated at 125g/day/reindeer during periods of severe harassment (Nikolaevskii, 1968). Heavy infestation of Oestrid larvae was a suspected cause of poor survival in the Western Artic Herd (Davis and Valkenberg, 1978). Reindeer herders consider Oestrid infestations of sufficient economic importance to warrant massive control programs (Nordkuist 1967, 1975, Saveljev 1968, Kelsall 1978, Dietrich 1980, Helle 1980, Kummenejii 1980).

Wright (1980) concluded that the midsummer spatial distribution of semi-domestic reindeer was more closely allied with insects than forage availability. Pronounced oscillatory movements between inland and coastal habitats were attributed to insect harassment (Cameron and Whitten 1979, 1980, Cameron et al. 1979, 1981, 1983). Movements were to coastal insect relief sites during harassment and to inland sites for forage when harassment declined. Movement patterns, energetics and condition all suggest that unrestricted access to insect relief habitat is potentially critical to the health of the PCH.

Insect relief habitats have been identified as barren ground, aufeis, snow patches, glaciers, open water, off shore islands, ridges, gravel bars and coastal areas (Banfield 1954, Kelsal 1968, Skoog 1968, Curatolo 1975, Roby 1978, White et al. 1981). The identification was based on the extrapolation of subjective measures of insect harassment to humans and caribou (Banfield 1954, Harper 1955, Pruitt 1960, Kelsall 1968, Epsmark 1968, Curatolo 1975, Roby 1978, Thompson 1973, White et al. 1975, White et al. 1981). Harassment and therefore utilization of relief habitat by caribou was a function of ambient air temperature and wind in the presence of insects (White et al. 1975). The relationship was incorporated into a model to estimate the energetic costs of increased activity and decreased grazing associated with harassment (Bunnell et al. in prep). Basal metabolic rate nearly doubled during periods of harassment. Escape to insect relief habitat was assumed to be energetically efficient even though available forage was generally less.

Human activity and resource development may alter caribou access to insect relief habitat. The probability of successfully crossing roads and/or pipelines was decreased during mosquito season and increased under Oestrid harassment (Curatolo et al. 1982). Cows and calves also avoid intensively developed areas (Cameron et al. 1983). Either reduced access to or displacement from insect relief habitat can be expected to prolong the negative effects of insect harassment and ultimately reduce production and populations (Klein 1980). Caribou aggregations during the mosquito season are also susceptible to human induced stampedes that contribute to herd disruption, crippling and separation of cows from calves (Calef and Lortie 1973, Roseneau and Curatolo 1976).

The adverse effects of insects on caribou, the importance and potential loss of insect relief habitat with development, and the potential for development and increased human activity on the summer range of the PCH, combine to emphasize the need to 1) identify and locate the insect relief habitats on the Arctic coastal plain 2) confirm the importance of insect/PCH interactions and 3) develop guidelines that prevent or mitigate the loss of insect relief habitat if development occurs. This study was designed to evaluate the techniques required to address the following objectives.

Long range objectives include:

1. Define the spatial and temporal distribution of biting and parasitic Dipterans on the summer range of the Porcupine Caribou Herd (PCH).

2. Correlate the spatial and temporal distributions of insects and caribou at multiple scales of measure (i.e., site specific to summer range).

3. Define and map the relief habitat on the summer range of the PCH.

4. Define the correlations between weather variables, insect activity and harassment levels (caribou, human).

5. Develop a predictive model for the potential spatial and temporal distribution of the PCH on the summer range based on insect and weather variables.

6. Determine if the caribou models that define behavioral responses of caribou to insect harassment are applicable to the PCH.

Probe objectives include:

1. Determine the feasibility of:

   a. delineating general spatial and temporal distributions and relative activity of mosquitoes, gad flies, black flies, biting midges and parasitic diptera (Oestridae) over the coastal plain using sticky traps, Manitoba traps and subjective measures of harassment.

   b. detecting differences in insect activity and possibly relative abundance in perceived insect and insect relief habitat.

   c. correlating trap results with 1) land cover classes 2) topography 3) subjective human and caribou harassment levels 4) weather variables and 5) existing insect harassment models.

2. Define limitations, logistics, variances and assumptions associated with the protocols employed.

Methods:

I. Spatial and temporal distribution of insects.

The coastal plain and adjoining foothills of the ANWR were partitioned latitudinally into coast, plain and foothills, and longitudinally into east, central and west for a total of nine cells. Permanent sampling points in perceived insect and insect relief habitats were established in each cell (Fig. 1). Specific sites were dependant on access by single engine fixed wing aircraft having short takeoff and landing capabilities. Landing strips, although randomly chosen in each cell, were limited and associated with riparian habitats. Sampling points were centered in insect and insect relief habitats greater than 0.5 ha in size. All sites were located within 0.5 km of the strip. Elevation, slope, distance north to coast and land cover class (Walker et al. 1982) were recorded for each site.

Sticky traps were placed at all 18 sites. The cylindrical traps (12.7 cm diameter x 30.5 cm height) were staked vertically at approximately 40 cm above ground level. Traps were constructed from a section of stove pipe bolted to a 0.9 m length of 2.5 cm square tubing beveled at one end. A welded bracket and bolt atop the tube supported a hexagonal rain cap (30 cm diameter). A rain gauge and a minimum-maximum thermometer were secured to a shelf bracket attached to the top of the trap. The sticky adhesive (stickem special(R)) was heated to reduce viscosity and applied in a thin layer with a wide putty knife to a 40.0 cm x 30.5 cm sheet of white plastic shelf covering. White was selected for its passivity to mosquitoes (Taylor 1962). Sticky sheets were clipped to the cylinders when deployed and covered with clear plastic wrap (0.10 m) when collected. Site, trap number, date and the four cardinal aspects were recorded on each wrap. The covered papers functioned as a permanent record of the catch for each collection period.

(R) reference to trade names does not imply endorsement by USFWS.

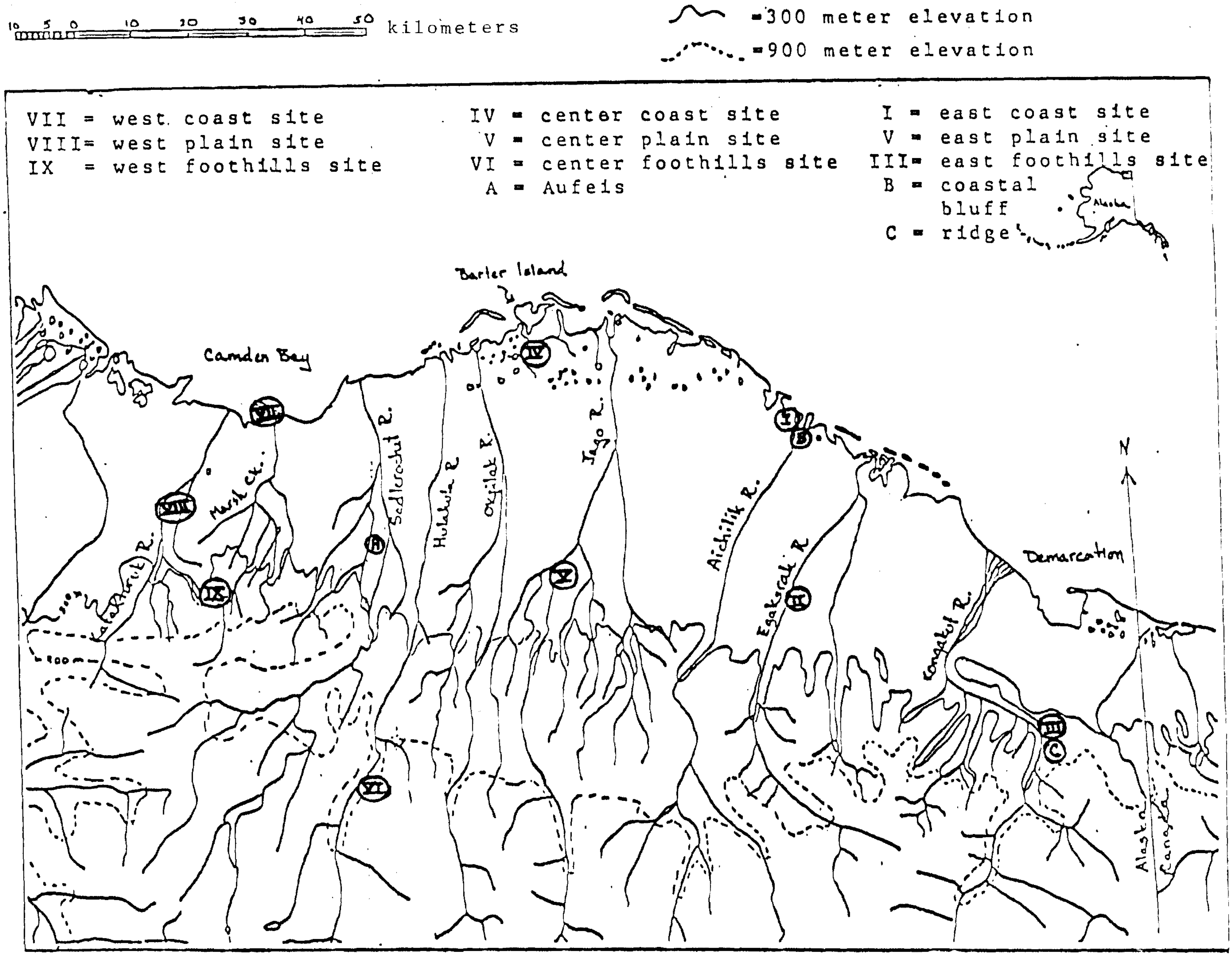

Fig. 1. General locations of insect and insect relief trapsites

Manitoba or canopy traps were set at each of the nine insect habitat sites. The traps were modeled after a figure (Southwood 1980) of a design used successfully by Bracken et al. (1962) and Bracken and Thorsteinson (1965) to capture gad flies. The trap incorporated a black sphere (20 cm diameter), hung from the center of a tripod, as the attractant. The top half of the tripod was covered with an opaque vinyl canopy. The sphere was partially exposed below the canopy and allowed to swing in the wind. Insects attracted beneath the canopy escaped upward through a funnel and were collected in a mason jar. A plaster block impregnated with a killing agent (Dexachlor(R)) was placed in each jar. Insects were emptied into ziploc bags and saved for later identification.

Specimens on the sticky sheets were identified and counted in situ using a large, illuminated magnifying lens mounted on a movable arm. Identification to family was based on recognition of a few key taxonomic characteristics. The families of interest were identified by the listed characteristics: 1) Culicidae by the long proboscis which if not visible would result in confusion with Chaoboridae and Chironomidae 2) Tabanidae by the divergence of R4 and R5 veins at the wing tip, the pulvilliform empodia, and the robust body 3) Oestridae by the bending of the M1+2 which ends before the wing tip, the R5 cell narrowing or closing distally and the stout body 4) Ceratopogonidae by spotted wings or weak posterior wing veination with a strong radial sector that is approximately one-half the length of the wing 5) Simuliidae by their stout bodies, humpbacks and broad wings with weak posterior veination and 6) Syrphidae by the M3+Cu1 and the M1+2 running parallel to the wing edge. A large number of specimens of the same taxa were examined to confirm their identity. Identification of Oestridae to genus was based on the spacing of facial grooves; with the warble fly (Oedemagena) being broadly separated and the bot fly (Cephenomyia) narrowly separated.

The traps were initially set on 17 June 1983 and pulled 20 August 1983. Collection intervals varied from 5-14 days and averaged 7 days between deployment and June 10 when caribou were present and 14 days thereafter. All traps were tended the same day when weather and aircraft availability allowed. A complete circuit took 9-12 hours. Order of attendance was varied from period to period.

Relative humidity, ambient air temperature (shaded), minimum-maximum and current temperatures (unshaded), soil temperature, soil pH, windspeed and direction, cloud cover, fog cover, cumulative precipitation and depth to permafrost were recorded during each site visit throughout the study. Weather measurements were taken at approximately 0.9 m above ground level. Soil temperature and pH were measured at a depth of 5 cm and 7.5 cm respectively. Thermometers were standardized across the temperature ranges encountered with individual regressions over a single mercury thermometer.

The level of insect (almost exclusively mosquitoes) harassment to humans was recorded during each site visit. The levels matched those used for ongoing insect research on the Central Arctic Herd (Curatolo-personal communication). Categories were 0=no insects, 1=insects present but not biting, 2=insects bothersome and biting and 3=insects intolerable, biting, vision and breathing affected. Insect harassment of caribou when present was also recorded at the trap sites. The level (0-3) of harassment was based on the behavioral responses defined by Thompson (1973). A predicted level (0-2) of harassment of caribou was calculated from wind and temperature measurements taken at each site. Calculations were based on the model published in White et al. (1975).

Preliminary analyses of the results were limited to comparisons of summary statistics and one ANOVA run on mosquito captures with procedure General Linear Model for unbalanced designs (SAS,1980).

II. Ancillary trials.

Insect activity and cumulative winds were measured on additional insect relief sites (aufeis, ridgetop and coastal bluff) and paired moist-wet sedge insect sites (Fig. 1). Three sticky traps were placed in line at 50m intervals at each site. Trap lines in the paired sites were parallel and separated by approximately 100 m, 400 m and 700 m from the aufeis, ridge and coastal bluff locations respectively. A portable wind spectrum analyzer (model 2700(R)-Downeaster Manufacturing Co. Inc. Dennis, Cape Cod, Mass.) was set near the central trap on each line. Anemometer cups were staked approximately 30 cm above ground level. Trials on the ridge top, aufeis and coastal bluff were conducted from 20-31 July, 31 July-6 August and 6-20 August respectively. Sites were tended only when the traps were set and pulled.

Preliminary Results and Discussion:

Manitoba traps failed to provide any information on the distribution of the biting and parasitic Dipterans. Only four mosquitoes and one gad fly were trapped during the entire summer.

Sticky traps proved to be a simple, transportable and inexpensive method for quantifying families of insects with highly visible taxonomic characteristics. Greater taxonomic resolution was impractical for all but those families represented by a limited number of species in the arctic (i.e. two species of Oestridae). Removal of specimens from the sheets for identification was successful for only the large, robust species. Except for tilting as the permafrost melted, no deficiencies in trap design were encountered. Driving a metal stake into the permafrost first and placing the trap over the stake resolved the problem. Retention of mosquito sized insects trapped in the adhesive was high based on repeated observations of individual sheets over 11 days. However, entrapment was not ensured when contact was limited (i.e. one leg). Warbles bound in adhesive and found at the base of the trap indicated escape may be a function of insect size.

The sensitivity of sticky traps was sufficient to provide both spatial and temporal measures of mosquito (table 1), warble (table 2) and gad fly (table 3) activity. In situ identification and enumeration of black flies and biting midges were difficult because the adhesive engulfed key taxonomic features. Gross estimates indicated biting midges were rare if present on the sheets. Black flies were uncommon until the fifth period when the number of identifiable specimens increased on both the insect and insect relief sheets from the west-plain cell. Other Diptera on the sheets included representatives of Tipulidae, Chironomidae, Tachinidae, Sarcophagidae, Calliphoridae, Muscidae and Syrphidae. The Syrphids, potentially confused with Oestrides in the field, were most common in the August samples.

Table 1. Number of mosquitoes (culicidae) caught per trap day at each site by period

			location									
			coast			plain			foothills			
period	date	Insect hab.[1]	east	center	west	east	center	west	east	center	west	Mean
0	17-19 June	IR										
		I	(traps	established)		(traps	established)		(traps	established)		
1	25-26 June	IR	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	
		I	0.00	0.00	0.00	0.00	0.37	0.00		0.00	0.00	0.05
2	30 June	IR	0.00	0.00	0.00	0.00	0.40	0.40	0.40	0.20	0.20	0.18
		I	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.80	0.00	0.15
3	9-10 July	IR	0.00	0.00	0.10	0.00	22.00	3.30	0.00	0.00	0.10	2.83
		I	0.33	0.50	0.00	0.33	9.44	1.90	0.67	0.00	0.20	1.49
4	23 July	IR	0.93	3.08	1.54	0.93	14.29	5.61	0.29	0.46	2.08	3.24
		I	1.57	12.46	0.61	0.71	20.29	3.77	0.86	0.54	1.69	4.72
5	6-7 Aug	IR	0.21	2.86	1.07	3.21	7.64	1.64	0.50	0.0	0.29	1.94
		I	1.00	4.50	0.57	3.64	8.71	2.57	2.64	0.43	0.43	2.72
6	19-20 Aug	IR	0.07	0.00	0.00	0.21	1.92	1.23	0.00	0.08		0.44
		I	0.07	0.08	0.0	0.07	0.15	2.46	0.07	0.08		0.37
	TOTAL	IR	0.32	1.27	0.57	1.00	8.44	2.33	0.20	0.13	0.66	1.66
		I	0.63	3.67	0.25	1.08	7.92	2.16	1.05	0.29	0.60	1.96
	COMBINED		0.48	2.50	0.41	1.02	8.18	2.25	0.60	0.21	0.63	1.81

[1]IR=insect relief habitat, I=insect habitat

Table 2. Number of adult warbles (Oestridae) caught per trap day at each N-S, E-W location by period.

		location								
		coast			plain			foothills		
period	date	east	center	west	east	center	west	east	center	west
0	17-19 June	(traps	established)		(traps	established)		(traps	established)	
1	25-26 June	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	30 June	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	9-10 July	0.06	0.00	0.00	0.22	0.06	0.05	0.00	0.00	0.00
4	23 July	0.21	0.19	0.04	0.00	0.00	0.00	0.00	0.00	0.00
5	6-7 Aug.	0.11	0.29	0.04	0.00	0.14	0.00	0.00	0.00	0.00
6	19-20 Aug.	0.07	0.08	0.00	0.32	0.08	0.04	0.04	0.00	
TOTAL		0.10	0.12	0.02	0.10	0.06	0.02	0.01	0.00	0.00

Table 3. Number of gadflies (Tabanidae) caught per trap day at each N-S, E-W location by period.

		location								
		coast			plain			foothills		
period	date	east	center	west	east	center	west	east	center	west
0	17-19 June	Traps	Established		Traps	Established		Traps	Established	
1	25-26 June	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	30 June	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	9-10 July	0.00	0.00	0.00	0.00	0.17	0.05	0.67	0.20	0.20
4	23 July	0.00	0.00	0.00	0.04	0.00	0.07	0.25	0.00	0.08
5	6-7 Aug.	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04
6	19-20 Aug	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	TOTAL	0.00	0.00	0.00	0.01	0.02	0.02	0.17	0.03	0.07

Warble flies first appeared on the sheets from the third trapping period (table 2). The fewest captures were recorded from the western and foothills cells. The majority of the captures occurred after nearly all of the PCH had left the study area. Except for the foothills, captures coincided with the general distribution of the PCH earlier in the season. Gad flies were first caught and peaked during the third period (table 3). None were captured in the coastal cells and most were caught in the foothills. None were caught after 7 August. Sample sizes for warbles and gad flies were inadequate to detect any differences in catch between insect and insect relief sites.

The first appearance of mosquitoes on the traps progressed from the central-plain cell to the foothills cells to the coastal cells during the first, second and third periods respectively (table 1). The mosquito season was shorter in the coastal cells than in either the foothills or two of the three plains cells. The results from the ANOVA of captures per trap day are summarized in table 4. All of the main effects and interactions associated exclusively with the spatial and temporal distribution of mosquitoes were significant. The difference in catch per day between the insect and insect relief sites was not significant. Similarly, none of the interaction terms containing the insect habitat effect was significant. Duncan's multiple range test was performed on the highest level interaction (E-W cells X N-S cells X period) to identify and interpret the source of significance (table 5). The tabular values represent the mean number of mosquitoes caught per trap day in both the insect and insect relief sites. Traps in the central-plain cell caught more mosquitoes per day and caught them earlier than all other locations. The high capture rate at the central-coast cell and the absence of significantly higher capture rates in the foothills cells stand out. Site descriptions (table 6) failed to provide a simple explanation for either the absence of differences between insect and insect relief sites or the significant differences that occurred between cells.

Soils at the insect relief sites were consistently drier and, except for the east-coast cell, more acidic than the adjacent insect relief sites. Mean soil temperatures at the insect relief sites averaged 4.4° C warmer than the insect sites (Table 7). Minimum and maximum temperatures also averaged 0.5°C and 2.0°C warmer on the insect relief sites (Table 8). The distribution of precipitation (Table 9) and point estimates of relative humidity (Table 10), ambient air temperature (Table 11) and wind speed (Table 12) did not account for the significant differences in mosquito catch between the east-west, north-south cells. Simple relationships between trap results and individual site or weather variables appear to have little value for predicting insect relief habitat. The predictive value of complex relationships will be assessed when the multivariate analyses are completed.

The level of insect harassment experienced during each site visit, the observed level of harassment of caribou when present at the sites, and the predicted harassment level of caribou are summarized by site and period in Table 13. The number of caribou observations acquired at the trap site was inadequate to contrast harassment levels in insect and insect relief sites. Future studies will require an independent and specific protocol to achieve adequate sample sizes for habitat contrasts. A cost-effective alternative would be to correlate human and caribou harassment levels, sample human harassment levels across habitats and project the level of harassment to caribou. Limited observations from the probe indicate caribou do not

Table 4. ANOVA of the spatial and temporal distribution of mosquitoes on the coastal plain and contiguous foothills of the Arctic National Wildlife Refuge.

Source	DF	F value	Pr > F
E-W cells (east, center, west)	2	11.81	0.0006
N-S cells (coast, plain, f.hill)	2	17.80	0.0001
Insect habitat (I, IR)	1	0.03	0.8713
Period (1-6)	5	11.43	0.0001
E-W X N-S	4	9.67	0.0003
E-W X Inst-hab	2	0.06	0.9444
E-W X Period	10	6.22	0.0005
N-S X Inst-hab	2	1.14	0.3425
N-S X Period	10	3.88	0.0069
Inst. hab X Period	5	1.52	0.2354
E-W X N-S X Inst-hab	4	1.21	0.3414
E-W X N-S X Period	19	2.33	0.0429
N-S X Inst-hab X Period	10	1.02	0,4653
E-W X Inst-hab X Period	10	1.72	0.1562
error	17		
model(r^2=0.949)	86	3.60	0.0021

Table 5. Mean number of mosquitoes (culicidae) caught per trap day at each N-S, E-W location by period.

		coast			plain			foothills		
period	date	east	center	west	west	center	west	east	center	west
0	17-19 June	(traps established)			(traps established)			(traps established)		
1	25-26 June	0.000(E)[1]	0.000(E)	0.000(E)	0.000(E)	0.188(E)[1]	0.000(E)	0.000(E)	0.000(E)	0.000(E)
2	30 June	0.000(E)	0.000(E)	0.000(E)	0.000(E)	0.200(E)	0.200(E)	0.500(E)	0.500(E)	0.100(E)
3	9-10 July	0.167(E)	0.250(E)	0.050(E)	0.167(E)	15.722(B)	2.600(E)	0.333(E)	0.000(E)	0.150(E)
4	23 July	1.250(E)	7.769(C,D)	1.077(E)	0.821(E)	17.286(A)	4.692(C,D,E)	0.571(E)	0.500(E)	1.885(E)
5	6-7 August	0.607(E)	3.679(C,D,E)	0.821(E)	3.429(D,E,)	8.179(C)	2.107(E)	1.571(E)	0.214(E)	0.357(E)
6	17-20 August	0.071(E)	0.038(E)	0.000(E)	0.143(E)	1.038(E)	1.846(E)	0.036(E)	0.077(E)	

[1]Numbers followed by the same letters are not significantly different at the 0.05 level (Duncan's multiple range test).

Table 6. Site characteristics associated with the location of each trap.

Location N-S	Location E-W	Insect Hab.[1]	Landcover[2] (A)	Landcover[2] (B)	Landcover[2] (C)	Soil pH	Elev. (m)	Distance to coast(km[3])	Moisture regime[2]
coast									
	East	IR	C	V	e	5.4	4	0.2	moist well drained
		I	B	III	b	6.0	3	0.2	wet, lowland
	Cntr	IR	E	X	a	7.0	6	7.5	dry
		I	B	III	a	6.4	6	7.5	wet, lowland
	West	IR	E	X	a	7.0	4	0.1	dry
		I	B	III	c	6.0	4	0.1	wet lowland
plain									
	East	IR	C	V	d	6.3	43	14.5	dry
		I	B	III	a	6.0	44	14.5	wet, lowland
	Cntr	IR	C	V	c	6.8	149	46.5	moist, well drained
		I	C	IV	a	6.5	149	46.5	wet, lowland
	West	IR	C	V	c	6.6	143	19.3	dry
		I	C	IV	a	6.4	144	19.3	wet, lowland
foothills									
	East	IR	E	IX	b	6.9	249	27.0	dry
		I	C	IV	a	6.3	267	27.0	wet, lowland
	Cntr	IR	E	X	a	7.0	450	68.6	dry
		I	E	IX	b	6.5	451	68.6	moist well drained
	West	IR	C	V	d	6.5	374	32.2	dry
		I	C	IV	a	6.4	374	32.2	wet, lowland

1. I = insect habitat, IR = insect relief habitat.
2. Land cover classification based on Walker et al. (1982).
3. Measured due north.

Table 7. Soil temperature (C) recorded at a depth of 5 cm at each trap site during each visit.

			location								
		insect[1]	coast			plain			foothills		
period	date	hab.	east	center	west	east	center	west	east	center	west
1	17-19 June	IR	1.7	7.2	15.5	7.2	6.7	4.4	12.2	15.0	11.1
		I	1.7	5.0	11.1	1.1	4.4	5.5	5.5	10.0	6.7
2	25-26 June	IR	8.9	10.0	16.7	13.9	13.9	11.1	15.0	29.4	14.4
		I	6.7	4.4	6.1	1.7	5.5	7.2	7.2	14.4	6.7
3	30 June	IR	1.7	4.4	3.3	8.3	6.1	6.1	15.5	12.8	8.3
		I	3.9	2.2	2.8	1.1	3.9	5.5	5.5	10.0	2.8
5	9-10 July	IR	7.8	17.2	14.4	15.0	12.3	10.5	28.3	22.2	15.5
		I	3.9	5.0	8.3	7.8	4.4	10.5	10.0	13.9	9.4
6	6-7 Aug.	IR	4.4	4.4	4.4	10.0	6.1	4.4	10.0	5.0	6.1
		I	4.4	3.3	4.4	8.9	4.4	7.2	5.0	5.0	5.0
7	19-20 Aug.	IR	10.0	5.0	4.4	14.4	4.4	4.4	8.9	8.3	5.5
		I	5.5	2.8	4.4	3.3	4.4	3.3	6.7	6.1	4.4
	MEAN	IR	5.7	8.0	9.8	11.5	8.2	6.8	15.0	15.4	10.1
		I	4.3	3.8	6.2	4.0	4.5	6.1	7.0	9.9	5.8
	Combined		5.0	5.9	8.0	7.8	4.5	6.5	11.0	12.7	8.0

[1]IR = Insect relief habitat, I = Insect habitat

Table 8. Maximum and minimum temperatures recorded in an opaque white plastic case at each trap site during each period.

			maximum/minimum Temp.[2] (C°)								
		Insect	coast			plain			foothills		
Period	Date	Hab.[1]	east	center	west	east	center	west	east	center	west
0	17-19 June	IR I		(traps established)			(traps established)			(traps established)	
1	25-26 June	IR									
		I		18.0/-9.8	27.5/ 0.2	26.0/-0.3	32.5/-5.2	33.2/-18.1	27.8/-4.6	33.7/-15.9	31.4/-1.
2	30 June	IR	17.1/ 1.1	15.1/-1.3	17.2/ 0.4	26.0/-0.5	31.0/ 0.0	31.1/ 0.3	34.8/ 1.1	28.4/ 2.5	31.8/ 0.
		I		16.1/-2.7	19.3/ 2.1	24.3/-0.7	30.3/ 1.5	26.9/ 1.8	31.4/-3.7	30.1/ 2.0	27.0/ 2.
3	9-10 July	IR	20.1/-1.9	19.6/-0.3	18.2/ 0.9	28.9/-0.5	35.9/ 0.0	30.7/ 0.3	36.7/ 1.5	28.2/ 0.6	31.8/-1.
		I		19.1/-0.6	18.9/-3.2	28.1/-0.7	33.9/ 2.4	25.3/ -0.3	32.3/-2.8	33.2/-1.0	28.0/ 2.
4	26 July	IR	21.1/ 0.1	23.5/-1.3		27.9/ 0.5	33.9/ 0.0	29.8/ 0.3	33.8/ 1.5	30.3/-0.4	29.9/ 0.
		I		22.7/-1.0		26.7/ 0.2	33.3/ 2.5	24.0/ 1.5	26.4/-3.6	30.8/-0.5	31.7/-1.
5	6-7 Aug.	IR	24.1/ 1.1	26.4/-1.3	22.0/-1.0	25.5/ 1.0	35.9/ 1.0	33.4/ 2.2	33.8/ 1.5	28.4/-0.4	31.8/-1.
		I	22.3/-0.9	25.4/-2.8	23.5/ 1.1	23.7/-0.7	27.6/-2.4	26.9/-11.7	28.0/-5.2	28.1/ 0.5	22.9/ 6.
6	19-20 Aug.	IR	22.1/-3.4	25.5/-3.7	23.0/-2.0	26.0/-1.5	26.2/-1.9	27.0/ 0.3	30.0/-0.4	35.1/-5.7	
		I	22.3/-4.8	20.0/-8.2	21.8/-6.6	25.7/-2.7	27.6/-6.4	22.2/-12.6		28.1/-13.3	

[1]IR = Insect relief habitat, I = Insect habitat
[2]Temperatures are a function of ambient air temperature and insolation.

Table 9. Distribution of precipitation over E-W, N-S locations by period.

		precipitation (mm)/per day/period								
		coast			plain			foothills		
period	date	east	center	west	east	center	west	east	center	west
0	17-19 June	(traps	established)		(traps	established)		(traps	established)	
1	25-26 June	0.4	0.7	0.1	0.9	0.5	0.2	0.0	0.1	0.1
2	30 June	0.1	0.0	0.0	0.0	0.1	0.0	0.0	1.0	0.2
3	9-10 July	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
4	23 July	1.0	1.1	0.8	1.2	1.2	1.7	0.9	1.4	1.8
5	6-7 Aug.	1.2	0.5	0.9	1.4	1.7	0.8	1.1	0.5	1.2
6	19-20 Aug.	0.2	0.2	1.5	0.3	0.5	0.6	2.1		
	Total	0.61	0.39	0.43	0.68	0.86	0.67	1.02	0.71	0.89

Data were normalized to correct for unequal periods.
Evaporation during disparate period intervals biases the data, therefore period contrasts should be interpreted with caution.

Table 10. Relative humidity (%) recorded during visits to each N-S, E-W location.

		coast			plain			foothills		
period	date	east	center	west	east	center	west	east	center	west
0	17-19 June		52	78	86	87	92		63	82
1	25-26 June	71	78	78	90	93		59	37	34
2	30 June	91	91	92	83	92	74	78	86	67
3	9-10 July	78	67	67	52	44	52	36	33	44
4	23 July	100	87	86	68	55	51	86	55	44
5	6-7 Aug	81	93	92	86	93	93	93	93	93
6	19-20 Aug	65	75	64	31	71	78	54	45	61
	MEAN	81	78	80	69	76	73	68	59	61

Table 11. Ambient air temperature at each N-S, E-W location during each visit.

		Temperature (C°)								
		coast			plain			foothills		
Period	Date	east	center	west	east	center	west	east	center	west
0	17-19 June		18.0	7.0	5.0	10.0	5.5		14.0	10.5
1	25-26 June	7.2	6.1	6.7	11.1	8.3		12.2	22.7	23.8
2	30 June	2.2	6.1	3.3	3.3	5.0	9.4	7.2	8.3	10.6
3	9-10 July	7.2	8.0	8.0	17.2	20.6	18.8	22.2	22.7	21.1
4	23 July	7.2	10.6	7.2	15.0	19.4	20.0	20.6	19.4	20.6
5	6-7 Aug	2.7	7.7	5.0	8.3	6.7	7.2	7.7	6.7	7.2
6	19-20 Aug	12.2	3.9	7.2	17.8	6.7	6.7	12.8	8.3	6.1
	MEAN	6.5	8.5	6.5	11.1	11.0	11.3	12.1	14.6	14.3

Table 12. Mean wind speed and direction at E-W, N-S locations during each visit.

		Windspeed-km/hr-(direction°)								
		coast			plain			foothills		
period	date	east	center	west	east	center	west	east	center	west
0	17-19 June	17(270)	16(45)	2(335)	6(270)	14(45)	7(270)	(270)	15(350)	0( )
1	25-26 June	7(45)	16(360)	14(25)	5(45)	0( )	16(360)	0( )	16(360)	16(360)
2	30 June	8(340)	16(30)	8(360)	6(20)	16(270)	14(360)	3(260)	14(360)	11(270)
3	9-10 July	15(350)	11(270)	10(260)	10(20)	10(40)	12(340)	10(360)	0( )	14(280)
4	23 July	8(50)	3(360)	3(40)	10(5)	3(360)	8(20)	4(350)	18(360)	6(360)
5	6-7 Aug.	6(360)	10(30)	6(30)	6(350)	11(315)	0( )	11(290)	6(360)	0( )
6	19-20 Aug.	14(50)	26(220)	24(230)	2(5)	12(50)	32(220)	22(165)	12(350)	32(230)
	MEAN	10.6	14.0	9.7	6.3	8.8	12.8	8.1	11.5	11.0

Table 13. Comparison of observed human, observed caribou and predicted caribou levels of harassment by insects.

			location																										
		insect	coast									plain									foothills								
period	date	hab.[1]	east			center			west			east			center			west			east			center			west		
			obs.		pred.	obs.		pred.	obs.		pred.	obs.		pred.	obs.		pred.	obs.		pred.	obs.		pred.	obs.		pred.	obs.		pred.
			H[2]	C[3]	C[4]	H	C	C	H	C	C	H	C	C	H	C	C	H	C	C	H	C	C	H	C	C	H	C	C
0	17-19	IR	0			0		2	0	0	1	0	0	0	0	0	0	0		0	0			0		1	0		1
	June	I	0			0		2	0	0	1	0	0	0	0	0	0	0		0	0			0		1	0	1	1
1	25-26	IR	0	0	0	0		0	0	0	0	0		1	0	0	1	0			1	0	1	0		2	0		2
	June	I	0	0	0	0		0	0	2	0	0		1	0	0	1	0			2	1	1	2		2	0	0	2
2	30	IR	0		0	0		0	0		0	0		0	0		0	0		0	1-2		1	0		0	1		1
	June	I	0		0	0		0	0		0	0		0	0		0	0		0	1-2		1	0		0	1		1
3	9-10	IR	0		0	1		0	1		1	1		2	2		2	1		2	1		2	2		2	1		2
	July	I	0		0	1		0	1		1	1		2	2		2	2		2	1		2	2-3		2	1		2
4	26	IR	0		0	2		1	0		1	1		2	2		2	1		2	2		2	0		2	2		2
	July	I	0		0	2		1	0		1	1-2		2	2-3		2	1		2	3		2	1	0-1	2	2		2
5	6-7	IR	0		0	0		0	0		0	1		1	0		0	1		1	0		0	0		1	0-1		1
	August	I	0		0	0	0	0	0		0	1		1	1		0	2		1	1		0	0		1	1		1
6	19-20	IR	0		1	0		0	0		0	0		2	0		0	0		0	0		0	0		0	0		0
	August	I	0		1	0		0	0		0	0		2	0		0	0		0	0		0	0		0	0		0
	MEAN	IR	0		0.2	0.4		0.4	0.1		0.5	0.4		0.9	0.6		0.7	0.4		0.7	0.8		0.9	0.3		1.1	0.7		1.1
		I	0		0.2	0.4		0.4	0.1		0.5	0.5		0.9	0.8		0.7	0.7		0.7	1.2		0.9	0.8		1.1	0.7		1.1
		combined	0		0.2	0.4		0.4	0.1		0.5	0.5		0.9	0.7		0.7	0.6		0.7	1.0		0.9	0.6		1.1	0.7		1.1

1. I = insect habitat, IR = insect relief habitat
2. human harassment levels 0-3 (Curatolo and Murphy 1983)
3. caribou harassment levels 0-3 (Thompson 1973)
4. predicted caribou harassment level (0-2) based on model (White et al. 1975)

respond to harassment until harassment of humans reached a level 2. A quantitative measure of harassment to humans (i.e. sweep net counts) would remove the existing subjectivity.

The levels of harassment experienced during the site visits did not correlate well with the trap results. The highest levels occurred at the foothill sites followed by the plain sites and coastal sites. Harassment levels were lower at insect relief sites than at the insect sites. The disparity between trap and harassment results appears to be related to temperature (Taylor 1963) and the passive (no attractant) versus the active (human attractant) nature of the two methods. For example, the warmer soils at the insect relief sites (Table 7) may create thermals that alter dissemination of the attractant and the harassment level without altering the trap catch (Helle, personal communication).

The predicted harassment level of caribou, based on the wind and temperature measurements from each site visit, failed to agree with trap results or human harassment levels during the initial trap periods. The failure was expected because the model assumes insects are present and that harassment is independent of insect abundance. The model was also insensitive to differences between insect and insect relief sites for the same reasons. The PCH generally departs the summer range of the ANWR by the fourth trapping period, therefore the utility of the model for estimating the energetic costs of insect harassment to the PCH will be dependent on incorporating a measure of insect abundance.

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CALVING DISTRIBUTION AND INITIAL PRODUCTIVITY IN THE PORCUPINE CARIBOU HERD, 1982

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An interim report to the Arctic National Wildlife Refuge
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BACKGROUND

The main calving grounds of the Porcupine Caribou Herd (PH) lie between the Arctic Ocean and the north slopes of the Romanzof and British Mountains in the eastern Brooks Range (Fig. 1). Calving generally occurs in relatively snow-free foothills, but the coastal plain is also used extensively. Pregnant cows reach the calving grounds by traveling through mountain passes along the international border or in Canada. Movement then proceeds westward, and during years of early snowmelt and easy traveling conditions, most calves are born in Alaska in the Arctic National Wildlife Refuge (ANWR). Cows at the vanguard of this movement tend to calve earlier, resulting in a time and location disparity in peak of calving and in calf:cow ratios from west to east across the calving grounds. This later peak of calving in the east may be caused by a preponderance of young and/or barren cows at the rear of the movement, but in some years the differences disappear after a week or 10 days, suggesting that cows at the rear of the movement calve later but do not necessarily have lower calving success than cows at the front of the movement.

Since 1977, most PH calving has occurred east of the Hulahula River and west of the Kongakut River. The highest densities of calving caribou have been in the foothills between the Jago and Kongakut Rivers in the ANWR (Fig. 1). During years of deep snow and/or late snowmelt, spring migrations may be delayed and considerable calving occurs on the North Slope in the Yukon Territory or in the mountains, the upper Firth River drainage, or the northern part of Old Crow Flats.

In May 1982, United States Fish and Wildlife Service personnel using fixed-wing aircraft searched for caribou approaching the traditional high density calving areas in ANWR. Very few caribou were observed. Unusually late snowmelt throughout northern Alaska and Yukon Territory slowed or delayed the PH spring migration and diverted caribou to the east of the international border. It appeared that calving would occur mainly in Canada. Plans to map and describe high density calving areas in ANWR could not be implemented. Alternatives were examined and efforts were shifted to describe calving distribution during an abnormal year.

METHODS

Daily fixed-wing reconnaissance surveys were flown, as weather permitted, over the known PH calving areas and also over the northern part of PH winter range beginning 1 June. Two aircraft searched different areas simultaneously. Flight altitudes were generally 1,000-2,000 m AGL to facilitate tracking of radio-collared caribou. When caribou were observed, we descended to 30-50 m AGL and recorded location and numbers of caribou, number of newborn calves, caribou trails in snow, and extent and amount of snow cover on the ground. Chronology of calving was determined by estimating relative number of calves and antlerless cows on successive surveys.

The reconnaissance flights indicated a calving concentration between the Firth River and Spring River. Density of cow caribou in this area was estimated by flying 2 low-level transects (10-50 m AGL) in a helicopter. Flight lines were oriented roughly southeast-northwest across the area, one about 6 km inland from the coast and another along the northern edge of the British Mountains. Beginning and end points of the transects were tentatively determined from the fixed-wing reconnaissance. The boundaries used in density calculations were marked on the map when all observers agreed the number of caribou being sighted changed suddenly. We flew well past these points to make sure they marked the limits of high density calving. Observations were terminated while crossing the flooded Firth River delta, and portions of flight lines to the east and west of the flooded Delta area were treated separately (Fig. 2). Three observers recorded all caribou seen within 0.8 km of each flight line. The helicopter pilot diverted course, as necessary, to obtain an accurate count and composition of each caribou group encountered. Topographic maps were used to keep within the 1.6 km wide survey transect corridors; caribou outside the transects were ignored.

Composition data from the transect surveys and from observations of collared cows were used to estimate initial productivity in the PH.

RESULTS AND DISCUSSION

Snow Conditions and General Calving Distribution

Few PH caribou calved in the ANWR during 1982. Steep slopes along major river valleys in the eastern Brooks Range were mostly snow-free during early June, but the foothill and coastal plain portions of ANWR that are normally used for calving had nearly 100% snow cover. Based on trails in snow and on the movements of radio-collared caribou, most cows that wintered in the Chandalar area in Alaska turned east at the crest of the Brooks Range and calved in Canada. Some caribou moved north along the Aichillik River and possibly along the Egaksrak River, and dispersed along the northern edge of the mountains. A few widely scattered cows with calves were found on the snow-covered coastal plain between the Clarence and Kongakut Rivers.

Caribou from the Ogilvie Basin-Tanana Hills wintering area traveled to the calving grounds along the international border and through the Firth River valley and British Mountains. As late as 1 June, several thousand caribou were moving north between the Coleen River and Muskeg Creek, and a few were still crossing the Porcupine River near Old Crow.

Snow remained in the northern Richardson Mountains and the North Slope east of the Babbage River until at least 7 June. No sign of caribou was observed in this area during calving surveys. Some widely scattered groups comprised mostly of adult bulls, but containing a few hard-antlered cows, were traveling northwest on the eastern edges of Old Crow Flats on 1 June, but most cows from the Richardson wintering area had already crossed the snow-free flats toward the British Mountains.

The only high density calving area found during the reconnaissance flights was between the Firth River and Spring River. Numerous groups of cows with newborn calves were observed in this low, rolling, lake-dotted terrain south of Herschel Island on 4 June. Confirmed or suspected migration routes from all 3 PH wintering areas led toward this region, which was the only snow-free area anywhere within the traditional calving grounds. Low cloud cover and turbulent flying conditions prevented more detailed survey coverage, but observations of numerous cow caribou sighted as far south as Muskeg Creek suggested that the entire British Mountains region might have supported high density calving. Eight of the 9 radio-collared cow caribou in the PH were located in the high density calving area or on migration routes leading to this area.

Chronology of Calving

Calving appeared to occur 4-5 days earlier on the high density calving area north of the British Mountains than it did in areas to the south. On the high density area, calving began about 1 June and peaked on 4-6 June. Only 1 newborn calf was observed south of the British Mountains on 1 June, and none were noted there on 4 June, even though several thousand adult cows with hard antlers were still in the area. Many young calves were observed north of the British Mountains on 4 June. During transect surveys of the northern part of the calving concentration area on 8 June, over 80% of the cows had calves. South of the British Mountains far fewer calves were present on 8 June, but many hard-antlered cows were without calves, suggesting delayed calving south of the northern calving concentration area.

The chronology of calving among collared cows was consistent with the above pattern (Table 1). Collared cows on the northern portion of the concentrated calving area had all calved by 8 June. Farther to the south and to the west, at least 3 out of 4 collared cows had not calved by 7 June.

Density of Caribou in the Concentrated Calving Area

Within the high density calving area south of Herschel Island, more cows were found near the foothills than near the coast (Table 2, Fig. 2). The data collected on density transects indicated about 5,900 cows calved in the survey area. If similar densities applied to most of the British Mountains, a total of about 23,400 cows may have calved in the high density area (Fig. 2).

Density of cows between Komakuk Beach DEW Site and the Firth River was low and accounted for only 300 cows in that area north of the mountains. Several areas of similar density were noted during fixed-wing surveys along the northern edge of the Brooks Range in ANWR. However, locations of collared cows and the extensive aerial reconnaissance indicated that few cows calved in the peripheral areas.

Initial Productivity

Transect surveys of the high density calving area revealed 81 calves/100 cows in the northern part of the concentration area; 58 calves/100 cows were found in the low density calving area immediately to the west. Because of probable delayed calving outside the northern high density area, and because no composition counts were made in the British Mountains, no overall estimate of initial productivity in the PH could be made. However, the high productivity noted in the areas that were surveyed, and the fact that at least 6 of 8 collared PH cows for which presence or absence of calves was recorded gave birth to viable calves, suggests that overall productivity was good, in spite of unusually extensive snow cover, delayed migration, and displacement of calving to mountain and south slope areas.

Table 1. Chronology of calving among radio-collared cows in the Porcupine Caribou Herd in 1982.

Area	Number with calves/number observed			
	4 June	6 June	7 June	8 June
Northern part of calving concentration	2/4	3/4	--	4/4
Southern part of calving concentration	0/3	--	1/3[a]	--
Aichillik R., ANWR	--	0/1[b]	--	--

[a] Cows without calves still showed signs of pregnancy, i.e., hard antlers.

[b] This cow gave birth sometime after 6 June.

Table 2. Numbers and composition of Porcupine Herd caribou observed on calving ground transects in June 1982.

Transect	Area (km^2)[a]	Cows	Calves	Yearlings	Bulls	Total
1	35.9	15	9	1	0	25
2	43.6	185	151	23	0	359
3	41.1	574	466	68	0	1108
4	38.5	77	44	16	0	137

[a] 1.6 km x length of transect.

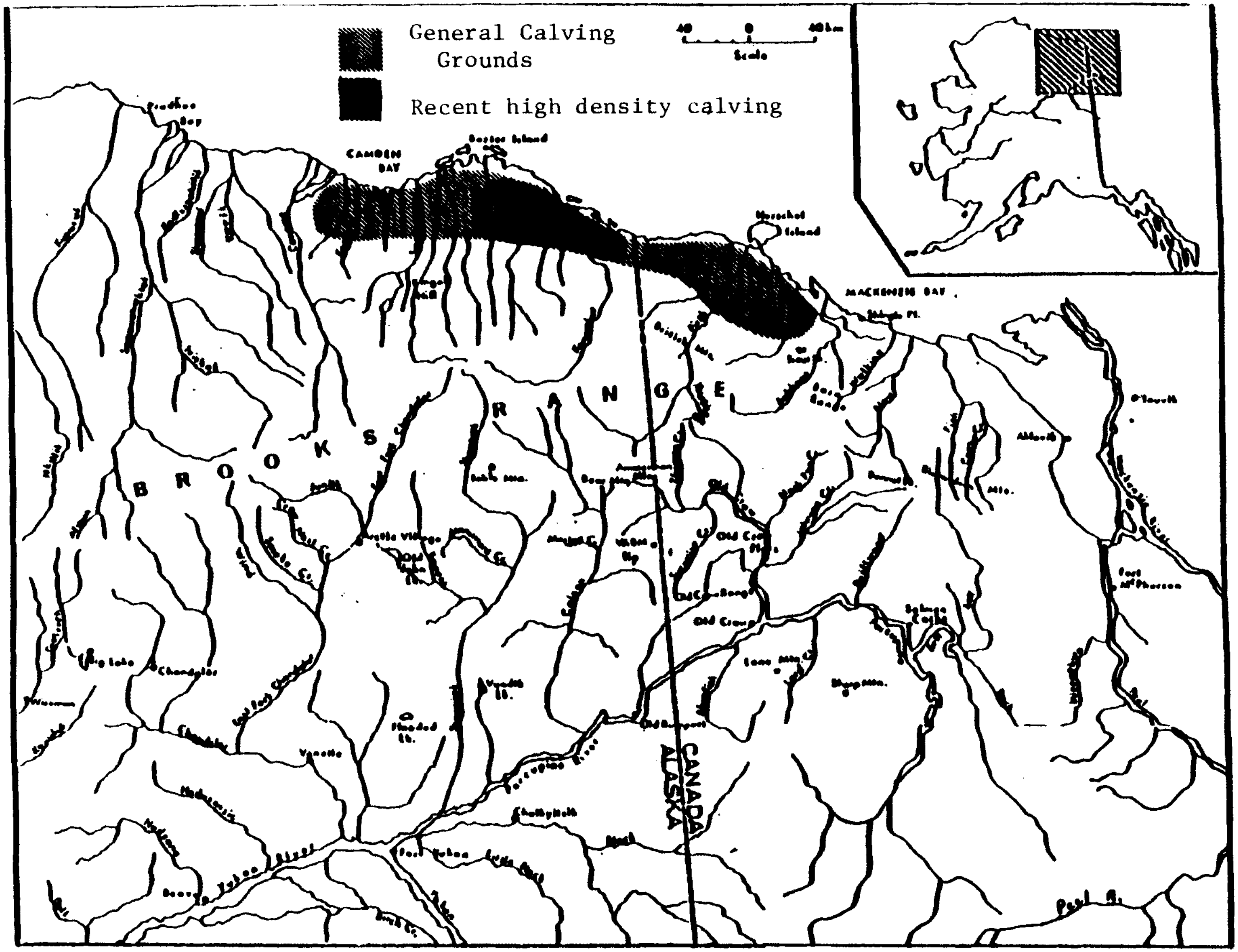

Fig. 1. Calving grounds of the Porcupine Caribou Herd.

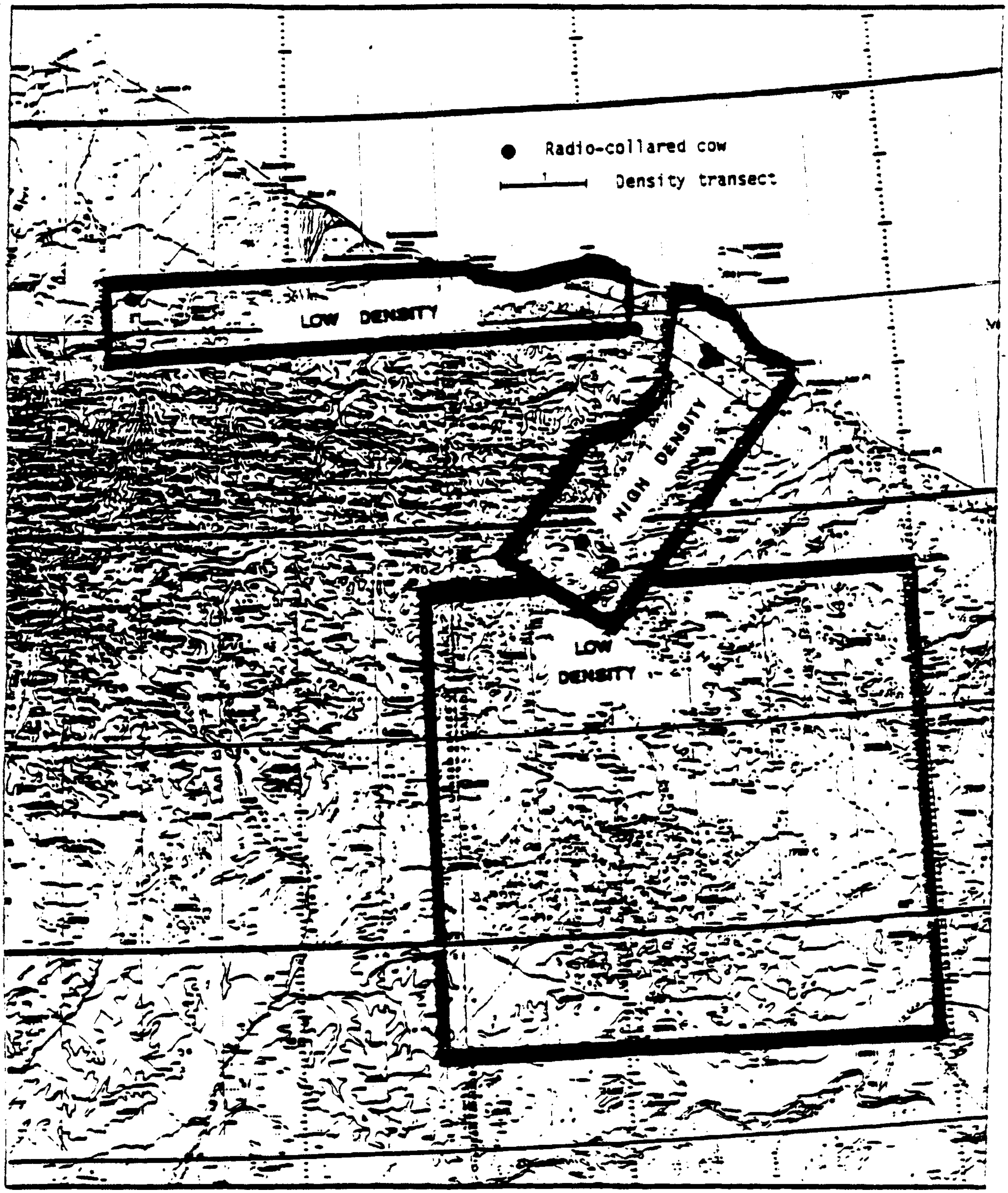

Fig. 2. Distribution of Porcupine Herd calving, 1982.

SIZE AND COMPOSITION OF THE PORCUPINE CARIBOU HERD, 1982

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Introduction

A census of the Porcupine Caribou Herd (PH) was conducted in July 1982 to determine the current status of the population. The PH numbered about 100,000 in 1972, and biologists speculated that it had maintained that size since the early 1950's (LeResche 1975). In 1977 the population was estimated at 105,000 caribou (Bente and Roseneau 1978, Davis 1978). In 1979, a modified aerial photo-direct count-extrapolation census technique (APDCE, Davis et al. 1979) was used for the 1st time on the PH; 105,693 caribou were counted from photos, and the herd was estimated to number 110,000 caribou (Whitten and Cameron 1980). Estimates of productivity, recruitment, and hunting mortality since 1979 suggest that the PH may now be increasing (Whitten and Cameron 1981, 1983a). Recent movements of the PH into winter ranges not occupied for many decades may also indicate an increasing population (Whitten and Cameron 1982). The current census was undertaken to determine if the herd had increased, and if so, by how much.

The 1982 census of the PH was a joint effort of the Alaska Department of Fish and Game (ADF&G), U.S. Fish and Wildlife Service, and Yukon Department of Renewable Resources (YDRR).

Procedures

The PH was censused in early July 1982 using the modified APDCE technique (Davis et al. 1979). Aerial reconnaissance and frequent relocations of 29 radio-collared caribou were used to monitor the size and distribution of aggregations of caribou. Caribou in the mountains were photographed with 35-mm cameras on 6-7 July when they aggregated between the Egaksrak and Clarence Rivers. Caribou on the coastal plain were photographed on 13 July with a 9 in x 9-in aerial camera.

Saturation coverage of 5,000 km^2 surrounding the aggregations ensured that all groups of caribou in the immediate area were counted. Caribou outside the aggregation area were estimated by searching 14 township-size (92.4 km^2) blocks that were randomly selected from within a 100 km distance to the east, south, and west.

Composition counts of caribou on the coastal plain and in the mountains were conducted on 6 and 8 July and on 7 July, respectively. Observers were transported to caribou groups by helicopter and positioned near the groups. Binoculars or spotting scopes were used as necessary. Caribou were classified as large bulls, small bulls, cows, calves, or yearlings.

Results

PH caribou aggregated in early July in 2 separate areas with different types of insect relief habitat. About 30% of the caribou occupied ridges, mountain tops, and snow patches in the northern Brooks Range between the Egaksrak and Clarence Rivers. The remainder of the herd was on the coastal plain, occupying gravel bars, deltas, and beaches for insect relief.

Photo Counts of the Mountain Aggregations

The total photographic count for the mountain aggregations was 46,107 distributed in 11 distinct groups. Five groups east of the Kongakut River contained 16,964 caribou on 6 July, while 6 groups between the Egaksrak and Kongakut Rivers contained 29,143 caribou on 7 July. Monitoring of the 10 radio-collared caribou in these groups revealed no mixing of caribou between areas photographed on different days.

Photo Counts of the Coastal Aggregations

Photographs of 8 coastal aggregations taken on 13 July revealed 81,473 caribou. This total includes some caribou that were photographed in the mountains. Daily monitoring of radio-collared caribou indicated that about half of one of the mountain groups (2,287 caribou) later mixed with the coastal aggregations. This was the only mixing incident that resulted in double counting. Only 46 caribou were observed during 10 hours of aerial surveys within the 5,000 km^2 area surrounding the main aggregations.

Estimates of Caribou Numbers Outside of the Aggregation Areas

Peripheral area surveys in the 14 random count areas (each 92.4 km^2) revealed no additional caribou. All radio-collared caribou were within the various aggregations. Thus, it is unlikely that many caribou were missed in the photographic coverage.

Composition Counts

Composition counts of the mountain aggregations were based on samples from most groups; overall, about 20% of the caribou were classified. Thus, composition results for the mountain groups are thought to be reasonably accurate. It is noteworthy that in past years, mountain habitats have been used almost exclusively by bulls during the post-calving period, however, in 1983 the mountain groups contained nearly 30% cows and calves (Table 1).

Separate composition counts of the coastal aggregations were made on 6 and 8 July, and sex-age ratios differed greatly between days (Table 1). Both samples represented only a small portion (numerically and geographically) of the aggregation, and considerable movement was occurring among the coastal groups during the counting periods. Obviously, neither count was representative of the aggregation, and there is no reason to believe that averaging the 2 counts would give a more accurate estimate of composition.

Adjustments to the Photo Counts

YDRR biologists tallied calves when counting caribou on the mountain aggregation photographs. They identified only 2.1% calves, while the composition counts indicated 8.2% (Table 1). Thus, nearly 3 calves were apparently missed for each calf counted. This indicates that an additional 3,090 calves may have been in the mountain aggregation. The discrepancy was likely due to eclipsing of calves by adults in the oblique photographs.

Because a vertical photo angle was used for the coastal groups, eclipsing should not have presented a serious counting problem. However, in some of the higher resolution photographs, calves could be seen next to or touching cows. In lower quality prints, some calves appeared only as blips on the cow images, and in the poorest photographs, many cow/calf pairs appeared as a single image. Thus, calves were also likely undercounted in the coastal aggregations. Since the composition count was unreliable for the coastal aggregations, no attempt was made to segregate calves during the photo-counts. The amount of undercount of calves was estimated using the following: Post-calving aggregations in years of good calf production in the arctic caribou herds in Alaska usually include 20-30% calves (Whitten and Cameron 1980, 1981, 1983a). We estimated conservatively that there were 20% calves in the 1982 coastal aggregations (this is coincidentally the mean calculated from Table 1) and that half of these were missed in the photo-counts. This indicates that about 9,000 additional calves should have been present on the coastal plain.

The final estimate of PH population size in July 1982 was 137,264 caribou (Table 2). The minimum population, based on unadjusted photo counts, was 125,174. These results confirm that the PH is increasing. Apparent growth rate from 1979 to 1982 was 5.8-7.7% per year (Table 3). This rate of increase is lower than that of the Central Arctic or Western Arctic Herds (Whitten and Cameron 1983a, Davis et. al 1980). Factors influencing the recent change in population trend in the PH are not yet understood, but ongoing studies of calf mortality and yearling survival may provide some insight.

Recommendations

Peripheral area searches during modified APDCE censuses have proven to be unnecessary and are not cost-effective--at least in the Porcupine and Western Arctic Herds (Whitten and Cameron 1980, J. Davis and P. Valkenburg, pers. commun.). When large numbers of caribou are seen during reconnaissance of peripheral areas, the post-calving aggregations tend to be less intense, with smaller and more scattered groups. Under these circumstances, sources of error, such as missing aggregations or extreme variability among peripheral area estimates, become much more serious. Conversely, when conditions are favorable for large aggregations, few if any caribou are found in peripheral areas. As the degree of aggregation is obvious from precensus reconnaissances, biologists should either wait for ideal conditions or postpone the census for a year.

A major source of error in photo censuses of caribou is the inability to identify calves on photographs. The problem can be addressed by counting calves on photos and comparing results to composition data; however, difficulties in obtaining accurate composition data limit the usefulness of that approach. Another possible method is to run low-level transects with belly-mounted, high-speed, high-resolution 35 mm cameras over the same groups previously photographed using standard vertical or oblique methods. Only calves and adults need be classified, and the results might yield standard conversion factors for photo interpretation.

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Table 1. Composition counts of the Porcupine Caribou Herd, July 1982.

Date	Area	Cows	Calves	Small bulls	Large bulls	Yearlings	Total
6 Jul	Coastal Plain	2,883	1,606	673	410	718	6,290
8 Jul	Coastal Plain	2,594	734	512	383	1,123	5,346
7 Jul	Mountains	1,563	665	2,413	2,329	1,112	8,082

Table 2. Estimated Population Size of the Porcupine Caribou Herd, July 1982.

Photo Counts	Number of Caribou
Mountain aggregations	46,107
Coastal aggregations	81,473
Caribou photographed twice	-2,287
Direct count from photos	125,174
Adjustments to Photo Counts	
Calves missed in mountain aggregation photos	3,090
Calves missed in coastal aggregation photos	9,000
Calves missed in group photographed twice	-119
Estimated Porcupine Herd total	137,264

Table 3. Apparent growth rate of the Porcupine Caribou Herd, 1979-82.

	1979	1982	Growth rate (percent/year)
Count from photos	105,683	125,174	5.8
Estimated total	110,000	137,264	7.7

STUDIES OF THE PORCUPINE CARIBOU HERD, 1982-1983

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Alaska Department of Fish and Game

A Preliminary Report to the Arctic National Wildlife Refuge
U.S. Fish and Wildlife Service

January 1984

Note: The following 2 reports are preliminary and partial analyses of data collected between mid-July 1982 and mid-July 1983. Major findings are summarized in narrative form. Conclusions are subject to change as data analysis becomes more complete. Final reports will include tables, figures, and a more detailed presentation of results.

I. Fall, Winter, and Spring Distribution of the Porcupine Herd in Alaska, 1982-83

Methods

Radio-collared caribou were monitored on an infrequent and irregular basis from mid-July 1982 through mid-May 1983. All flights were by fixed-wing aircraft, and flight altitudes were 1000-2500 m AGL to facilitate radio reception. Observers also looked for sign of caribou (tracks or craters in snow, fresh trails on gravel bars and lake margins, etc.) and recorded location and direction of movement of any large groups of caribou observed.

Sixteen female caribou were captured and radio-collared on winter range near Arctic Village on 20-21 March 1983. While these caribou were collared primarily to increase the number of marked animals for calving grounds studies and herd censusing, they also facilitated the monitoring of spring migration.

Results and Discussion

During late July and early August 1982, most of the Porcupine Herd moved east along the Arctic Coastal Plain into the Babbage/Blow River valleys and the British Mountains in the Yukon Territory. However, several large aggregations moved southward across the Brooks Range through the Okpilak, Hulahula, and Jago valleys into the Sheenjek and Coleen drainages. The caribou on the south side of the Brooks Range later moved northeast into the Firth River valley and the British Mountains, and most apparently joined the rest of the herd near the Blow and Babbage Rivers.

Porcupine Herd caribou probably moved back into Alaska during October, but no monitoring flights were conducted that month for confirmation. By mid-November, an estimated 10,000 Porcupine caribou were distributed throughout the mountains between the lower Middle Fork of the Chandalar River and Arctic Village. No fresh caribou sign and no radio-collared caribou were located between Arctic Village and the Sheenjek River. Thus, it appeared that no other PH caribou were present in northeastern Alaska.

By March 1983, most of the caribou in the Chandalar valley had moved back north and east past Arctic Village. Based on amount of cratering in the upper East Fork Chandalar Valley, it appeared that more than 10,000 caribou had used the area. Arctic Village residents reported that more caribou had entered their area from the east during January. Scattered groups of caribou were found all across the southern foothills of the Brooks Range east to the Coleen River during March; 2 radio-collared caribou not sighted in Alaska in November were located on the Coleen river. Thus, it seemed that a second major movement of Porcupine caribou from the Yukon Territory into Alaska occurred during mid-winter 1982-1983.

Sixteen caribou were radio-collared near Arctic Village in late March, after most of the caribou wintering in the area had begun to move toward the calving grounds. In fact, these caribou themselves were moving northeast at the time of collaring; 10 days after capture they were in the upper Koness River drainage, 30-80 km northeast of the capture site.

Spring migration proceeded northeastward across the Sheenjek and Coleen valleys, thence through Joe Creek and Mancha Creek into the Firth River valley in the Yukon Territory. There, caribou from the Chandalar wintering area joined caribou from wintering areas in Canada. Movement onto the calving grounds in Alaska was from the lower Firth River westward across the northern foothills of the Brooks Range and the Arctic Coastal Plain into ANWR.

II. Size of the Porcupine Caribou Herd, 1983

Methods

The Porcupine Herd was censused in July 1983 using an aerial photo-direct count technique. Daily monitoring of 140 active radio-collared PH caribou enabled us to keep track of the size and distribution of large, postcalving aggregations of caribou. Aggregations were photographed on 6 July, using a 9" x 9" aerial camera mounted in a Dehavilland Beaver aircraft. This census differed from previous techniques principally in that no effort was made to estimate additional caribou in areas peripheral to the photo-count/saturation search areas.

Composition counts were conducted opportunistically by landing a fixed-wing aircraft near moving aggregations of caribou and classifying as many caribou as possible as they walked by. Relatively little effort was put into composition counts in 1983, however, and the sample size was correspondingly small.

Results and Discussion

The PH moved *en masse* into the hills south of Komakuk Beach on 1 and 2 July. It appeared that dispersal was imminent and no census would be possible. Then on 3 July caribou moved rapidly back to the Demarcation Bay area in Alaska. On 4 and 5 July the herd split, with some moving southwest into the Brooks Range and others going west on the coastal plain. These separate groups remained tightly aggregated, and the presence of 140 active radio collars enabled us to keep close track of their movement. Conditions were ideal for photography on 6 July. All active radio collars were accounted for, and intensive peripheral searches for caribou using 3 fixed-wing aircraft did not detect any more groups of caribou outside the main aggregation areas.

Caribou on the coastal plain were distributed between the Aichillik and Niguanak Rivers in 13 groups. Of those in the mountains, 10 groups were found in the Egaksrak Valley and 1 was in the Kongakut valley.

A few caribou were missed in instances when photo coverage did not quite reach the outer edge of a group, but such errors were thought to be insignificant. However, a serious problem arose when cross-transect movement of a very large, dense group occurred. Caribou moved from one photo-transect line into one already covered before they could be photographed. This could have resulted in several thousand caribou not appearing on the photos.

Due to lack of ground count composition data, it will be difficult to estimate the proportion of calves missed on photos, such as was done in 1982. As yet, no attempt has been made to do so.

Two or more individuals often counted the same photograph, and individual counts differed by up to 20%. However, much of this variability was eliminated through further training and improved optical equipment.

The direct photo-count was 135,284 caribou, based on the mean total for photographs tallied by 2 or more counters, and not otherwise adjusted in any way. Compared to previous such unadjusted counts, this is consistent with the 6 to 8% annual increase estimated between 1979 and 1982.

There were 93,645 caribou counted in the coastal plain aggregations, including 80,651 in a single group. In the mountains, there were 41,639 caribou, with 12,396 in the largest group.

Ground composition counts were conducted on the coastal aggregations only. A sample of 1918 caribou on 5 July yeilded 72 calves, 12 yearlings, and 10 bulls per 100 cows. Another count of 666 on 9 July yielded 76 calves, 6 yearlings, and 7 bulls per 100 cows. Past experience suggests that the mountain aggregations likely had much higher bull and yearling/cow ratios and probably lower calf/cow ratios. These few data, nevertheless, indicate very high early survival of calves, considering that initial productivity in the highest density calving area was 74 calves/100 cows.

In past years of intense post-calving aggregation, peripheral area counts have yielded insignificant numbers of additional caribou. Extensive reconnaissance and active searching for caribou during radio-tracking flights did not reveal any additional groups of caribou not associated with the 2 major aggregations or with an active radio collar. Hence, we feel that the 1983 census was essentially a direct count of the entire herd.