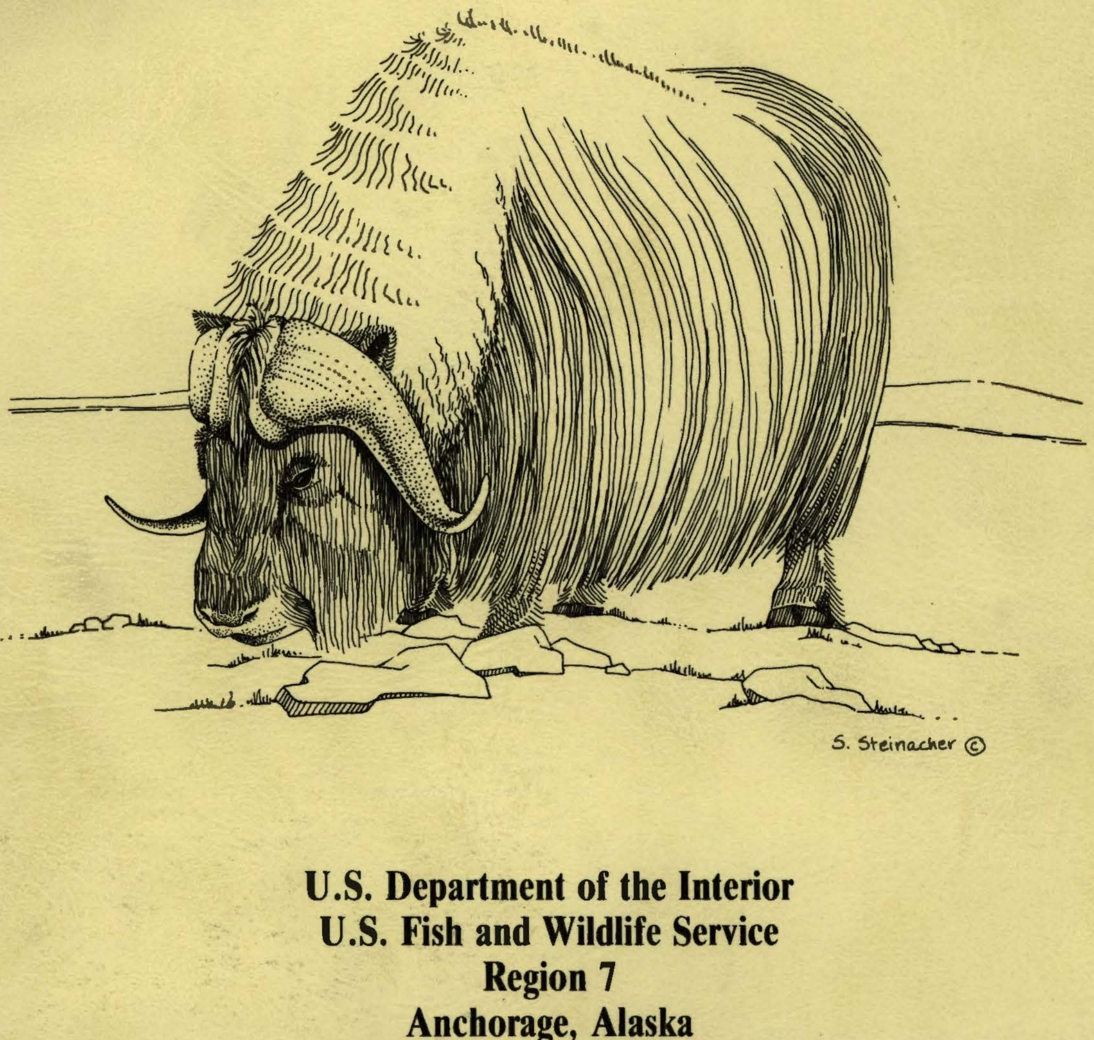
ARCTIC NATIONAL WILDLIFE REFUGE COASTAL PLAIN RESOURCE ASSESSMENT

# 1984 UPDATE REPORT BASELINE STUDY OF THE FISH, WILDLIFE, AND THEIR HABITATS

**Volume I**

**Section 1002C**

**Alaska National Interest Lands Conservation Act**




**U.S. Department of the Interior**

**U.S. Fish and Wildlife Service**

**Region 7**

**Anchorage, Alaska**

**March 1985**

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Section 1002C
Alaska National Interest Lands Conservation Act

Edited by
Gerald W. Garner and Patricia E. Reynolds

U.S. Department of the Interior
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## Conversion Table

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

| Multiply Metric (S1) 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 third 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 1984 with emphasis on studies designed to obtain new information about ANWR coastal plain resources which are being conducted by U.S. Fish and Wildlife Service (USFWS) personnel. For readers interested in quantified results, progress reports of these studies are included as appendices of this report. Other studies being conducted on or near the ANWR coastal plain are also briefly summarized in this update report. Publications or unpublished reports of these other studies may be available from the investigating agencies or individuals. The report follows the format of the initial baseline report (USFWS 1982) and the 1982 and the 1983 update reports (Garner and Reynolds 1983, Garner and Reynolds 1984). 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 by principle investigators and report status. Many of the results reported are part of on-going studies whose findings should be viewed as preliminary.

## Literature Cited


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

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

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

| Initial Baseline Report Ch. No. Title status | Work conducted in 1984 | Principal investigators/Affilitation | | Project/report |
|---|---|---|---|---|
| 2. DESCRIPTION OF THE STUDY AREA | The ecology of tundra ponds of the Arctic coastal plain: a community profile | J. Hobbie | Ecosystems Center Marine Biological Laboratory, Woods Hole, MA | Final Report FWS/OBS-83/25 USFWS, Washington, D.C. |
| 3. SOILS AND VEGETATION | Cooperative land cover/terrain mapping of the ANWR | C. Marcon<br>S. Talbot<br>M. Shasby<br>L. Strong<br>L. Pank | USFWS, Anchorage<br>USFWS, Anchorage<br>USGS, Anchorage<br>USGS, Anchorage<br>USFWS, Research, | Data analysis in progress |
| | Mapping vegetation, land-forms and soils for resource inventory and geographic information system | K. von Schleider | Environmental Systems Research Institute Redlands, CA | Status unknown |
| | Soil evolution and biogeo-chemical dynamics in arctic Alaska | F. Ugolini | Univ. Washington, Seattle, WA | Status unknown |
| 4. BIRDS | Terrestrial bird populations and habitat use on coastal plain tundra | C. Moitoret<br>P. Miller<br>R. Oates<br>M. Masteller | USFWS-ANWR,Fairbanks<br>USFWS-ANWR,Fairbanks<br>USFWS-ANWR,Fairbanks<br>USFWS-ANWR,Fairbanks | Fieldwork continuing ANWR Progress Report No. FY85-13 (See Appendix) |
| | Species accounts of migratory birds observed at study sites | P. Miller<br>C. Moitoret<br>M. Masteller | USFWS-ANWR,Fairbanks<br>USFWS-ANWR,Fairbanks<br>USFWS-ANWR,Fairbanks | Field work continuing ANWR Progress Report No. FY85-14 (See Appendix) |
| | Migratory bird use of coastal lagoons | A. Brackney<br>J. Morton<br>J. Noll | USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing, ANWR Progress Report No. FY85-11 (See Appendix) |
| | Movements of molting oldsquaw | A. Brackney<br>J. Morton<br>J. Noll<br>M. Masteller | USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing, ANWR Progress Report No. FY85-12 (See Appendix) |
| | Distribution, and abundance and productivity of fall staging lesser snow geese in northeast Alaska and northwest Canada | R. Oates<br>A. Brackney<br>M. Masteller | USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing, ANWR Progress Report No. FY85-7 (See Appendix) |
| | Ecology of staging snow geese | A. Brackney<br>M. Masteller<br>J. Morton | USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing ANWR Progress Report No. FY85-8 (See Appendix) |
| | Tundra swan surveys | A. Brackney<br>J. Morton<br>J. Noll<br>M. Masteller | USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing, ANWR Progress Report No. FY85-10 (See Appendix) |
| | Distribution and relative abundance of golden eagles in relation to the Porcupine Caribou herd during calving and post-calving periods | F. Mauer | USFWS-ANWR, Fairbanks | Field work continuing ANWR Progress Report No FY85-3 (See Appendix) |
| | Birds and mammals along the Hulahula River, Alaska 5-10 June 1984 | R. Gill<br>M. Amaral | USFWS-Region 7,Anchorage<br>USFWS-Region 7,Anchorage | Trip report on file, USFWS-ANWR, Fairbanks |
| 5. MAMMALS | Fall and winter movements and distribution and annual mortality patterns of the Porcupine Caribou herd, 1983-1984 | K. Whitten<br>F. Mauer<br>G. Garner | ADF&G, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing ANWR Progress Report No FY-85-17(See Appendix) |
| | Calving distribution, initial productivity, and neonatal mortality of the Porcupine caribou herd, 1984 | K. Whitten<br>F. Mauer<br>G. Garner | ADF&G, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing, ANWR Progress Report No. FY85-18(See Appendix) |
| | Distribution of biting and parasitic insects on the coastal plain and adjoining foothills | L. Pank<br>C. Curby<br>B. Nankivell<br>C. Simon<br>R. Wright | USFWS, DWRC, Fairbanks<br>USFWS, DWRC, Fairbanks<br>SCA<br>SCA<br>SCA | Denver Wildlife Research Center Prog. Rept. (See Appendix) |
| | Yearling mortality study of the Porcupine caribou herd | D. Russell | Yukon Dept. of Renewable Resources Whitehorse, YT | Field work and data analysis continuing |

Table 1. (Continued).

| Initial Baseline Report Ch. No. Title | Work conducted in 1984 | Principal investigators/Affiliations | | Project/report status |
|---|---|---|---|---|
| | Spring migration and staging of male caribou in the Porcupine caribou herd | A. Martel<br>D. Russell | Canadian Wildlife Service Whitehorse, YT | Field work and data analysis continuing |
| | Movement patterns in the Central Arctic Herd caribou in the Arctic National Wildlife Refuge in spring and summer | R. Cameron<br>K. Whitten<br>W. Smith | ADF&G, Fairbanks<br>ADF&G, Fairbanks<br>ADF&G, Fairbanks | ADF&G preliminary report (see Appendix) |
| | Population and herd dynamics, distribution, movements and habitat use of muskoxen | P. Reynolds<br>L. Martin<br>G. Weiler<br>J. Noll<br>J. Morton | USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing, ANWR Progress Report No. FY85-1(See Appendix |
| | Muskox habitat use | C. O'Brian | Univ. AK., Fairbanks | M.S. thesis in preparation |
| | Moose surveys | L. Martin<br>G. Garner | USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing, ANWR Progress Report No. FY85-6 (See Appendi |
| | Bowhead whale surveys | B. Morris | National Marine Fisheries Service | Status unknown |
| | Brown bear ecology | G. Garner<br>H. Reynolds<br>L. Martin<br>G. Weiler<br>J. Morton<br>J. Noll | USFWS-ANWR, Fairbanks<br>ADF&G, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing, ANWR Progress Report No.FY84-9 (See Appendix) |
| | Habitat use and behavior of brown bears | M. Philips | Univ. Ak., Fairbanks | M.S. thesis in preparation |
| | Seasonal movements and prey relationship of wolves | G. Weiler<br>G. Garner<br>L. Martin | USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing ANWR Progress Report FY85-5 (See Appendix) |
| | Wolf prey utilization and denning behavior | H. Haugen | Univ. Ak., Fairbanks | Field work completed, ANWR Progress Report No. FY85-4 (See Appendix) |
| | Distribution and abundance of wolverines | F. Mauer | USFWS-ANWR, Fairbanks | Field work continuing, ANWR Progress Report No. FY85-16(See Appendix |
| | Distribution, densities and general ecology of microtine rodents and arctic ground squirrels | C. Babcock | Univ. Ak., Fairbanks | Field work completed, ANWR Progress Report No. FY85-15(See Appendix |
| | Small mammal speciman collecting | S. McDonald | Univ. Ak, Fairbanks | Results on file, USFWS ANWR, Fairbanks |
| 6. FISH | Fisheries investigations on the in the Arctic National Wildlife Refuge, 1984 | R. West<br>D. Wiswar | USFWS, Fishery Resource Station, Fairbanks | Field work continuing, Fishery Res. Progress Report No. FY85-1 (See Appendix) |
| | Aquatic survey of the Kaktovik dredging operation, 1983 and 1984 | 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 | Caribou hunting: land use dimensions and recent harvest patterns in Kaktovik, north east Alaska | S. Pederson<br>M. Coffing | ADF&G Susbsistence Division, Fairbanks | Final report: Technical paper No. 92, ADF&G Division of Subsistence, (Fairbanks) |
| 8. IMPACTS OF GEOPHYSICAL EXPLORATION | Effects of winter seismic exploration on the coastal plain | N. Felix<br>T. Jorgenson | USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing, ANWR Progress Report No. FY85-1 (Impact Studies) |
| | Effects of winter seismic exploration activities on muskox | P. Reynolds<br>D. LaPlant | USFWS-ANWR, Fairbanks<br>USFWS-ANWR, Fairbanks | Field work continuing ANWR Progress Report No. FY85-2 |
| 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

In 1984, community profile of tundra pond ecology was published (Hobbie 1984). One of a series prepared for the National Coastal Ecosystems Team of the Division of Biological Services, USFWS, this report was designed to provide comprehensive reviews and syntheses of current research results and scientific literature which could be used in making sound management decisions about natural resources. Unique aspects of the arctic coastal plain were described and classification schemes and distribution of tundra as well as research on arctic Alaska wetlands were discussed. Physical and chemical conditions of the coastal plain were presented. Mean temperature given for three stations along the coast from lows of -28.2 to -31.8°C in February to highs of 3.7 - 6.4° C in July, and average snow accumulation on the coastal plain was reported as 80 cm. Hobbie (1984) found that solar radiation and depth of water bodies influenced water temperature of ponds more than air temperature. Temperatures of large lakes were also effected by ice cover thickness and duration. Reported results showed that chemistry of ponds and lakes were controlled by soils and that phosphorus was the most important nutrient limiting algae and plant growth. The thaw-lake cycle and the biological components of coastal plain ponds were described. Small planktonic algae had very low annual rates of productivity due to the short ice-free season and production by small benthic algae was limited by light and nutrient (phosphorus) availability. Production in such areas exceeded that of the adjoining tundra. Crustations dominated the zooplankton of ponds and lakes, and species composition may be controlled by size - selective predation by other zooplankton. Benthic animals, primarily detritivores and deposit feeders, with a large biomass and productivity and feeding and burrowing habitats which change the structure of the sediments were important components of the pond ecosystem. No fish existed in ponds or lakes less than 1.7 m deep. Hobbie (1984) also described production and carbon flux in a coastal pond near Barrow. All primary plant production, dominated by vascular plants such as <u>Carex aquatilus</u>, entered the detrial food web, as no plant-grazing herbivores were present in this pond. Low plant productivity was affected by sediment control of phosphate in the waters. Discussions of wetlands and birds, and the effects of humans on wetlands in Hobbie's (1984) report are summarized in Chapter 4 and Chapter 9 of this interim report.

### Literature Cited

Hobbie, J.E. 1984. The ecology of tundra ponds of the Arctic Coastal Plain: a community profile. U.S. Fish Wildl. Serv. FWS/OBS-83/25. 52pp.

## Chapter 3

## SOILS AND VEGETATION

### Land Cover Mapping

The cooperative land cover/terrain mapping effort of the entire Arctic National Wildlife Refuge (ANWR), begun in 1983, was continued in 1984 by C. Marcon, S. Talbot, and B. Kirk (USFWS planning staff), M. Shasby and L. Strong (USGS Anchorage field office), and L. Pank (USFWS research division). Although most of this mapping effort was outside the ANWR study area, much of it covered the U.S. range of the Porcupine caribou herd. Photo interpretation and classification of the multi-spectral scanner data were completed in 1984. The first draft of the land cover maps was finished in October 1984 and reviewed by ANWR and Research Division staff in Fairbanks. Problems were encountered with indentifying a uniform classification system across this large diverse area. Modifications were made to the existing Walker and Webber (1982) classification scheme and 22 classes of land cover were eventually identified. A final map will be completed in 1985. This map will be ground-truthed and a detailed accuracy assessment will be completed in summer 1985.

### Other Studies

In 1984, two projects were issued permits for conducting work on ANWR. A study of soil evolution and biogeochemical dynamics in arctic Alaska was to begin in July and August 1984 near the Okpilak River about 13 km south of the study area. The project's principle investigator, F.C. Ugolini (University of Washington) conducted studies of soil-forming near the Okpilak River in 1980, 1981, and 1982. Field work, to be carried out in July and August 1984 by D.J. Marrett and N. Gulke, involved topographic surveys of microrelief, plant community analysis, detailed soil survey, and instrumentation of selected soil profiles using tenseometers for soil moisture, thermocouples for temperature and tension lysemeters for collecting soil solutions. A number of soils were to be sampled for chemical analysis and voucher specimens of vegetation were to be collected. Current status of this project is unknown.

Also in 1984, a resource inventory and geographic information system development project to be conducted by Environmental Systems Research Institute (K. von Schlieder, project manager) for the North Slope Borough was also issued a permit. In July and August 1984, areas south of the Brooks Range divide were to be surveyed by fixed-wing aircraft. Areas requiring further inspection on the ground were to be examined by helicopter. Current status of the project is also unknown.

## Chapter 4

# BIRDS

In 1984, new studies which examined the ecology of fall staging snow geese, and determined distribution and abundance of golden eagles in relation to the calving ground of the Porcupine caribou herd were begun. Studies of bird populations and habitat use on coastal plain tundra, and migratory bird use of the coastal lagoon systems continued as did annual surveys for staging snow geese and tundra swans on the Arctic National Wildlife Refuge (ANWR) coastal plain.

## Bird Use of Tundra Habitats

### Populations and Habitat Use

In 1984, studies documenting tundra bird populations and habitat use continued by US Fish and Wildlife Service -Arctic National Wildlife Refuge biologists C.S. Moitoret, P.A. Miller, R.M. Oates, and M.A. Masteller. Methods and results are described in ANWR Progress Report No. FY85-13 (see Appendix). Primary study objectives were to determine and compare habitat occupancy levels of breeding, resident, and transient birds, to determine breeding, resident and transient population density estimates of a quality sufficient to extrapolate to total populations of the ANWR and to determine baseline levels of annual and seasonal variations for abundant and conspicuous species. During breeding and post-breeding periods in June-August 1984, 45 10-ha plots representing seven habitat types at two coastal (Sadlerochit, Jago Delta) and one inland (Aichilik) study sites were each censused seven times and compared to data collected from three different coastal (Okpilak) and inland (Katakturuk, Jago Bitty) sites in 1983. Three replicate census plots were established within each habitat type at each study site. Habitat types were identified using a modified Landsat classification scheme (Appendix, ANWR Progress No. FY85-13 Table 1). Bird and nest densities were analyzed with a nested analysis of variance (MANOVA). Habitat differences based on bird use were clarified using breeding season plot census data from 1983 and 1984 in a multivariate analysis (TWINSPAN).

Snow melt, plant flowering and bird nesting phenology occurred earlier in 1984, than in 1983 and 1982. Habitat use varied between study sites, and these variations were different in 1983 and 1984. Some locational differences may have been due to coastal versus inland influences or differences in habitat quality at different sites. Yearly variation in bird populations and habitat may have also occurred. In Wet Sedge habitat, total bird densities were higher at coastal sites than at inland sites throughout the summer in 1983 and 1984. Post-breeding shorebird densities were also higher on Wet Sedge coastal sites in 1984. In Moist Sedge-Shrub habitat, higher densities of most birds species were observed at the Aichilik study site in 1984. In Riparian habitat, highest densities of many bird species were found at one coastal study site (Sadlerochit) in 1984 and one inland study site (Katakturuk) in 1983, suggesting that differences in habitat quality affected bird densities. Three habitats tended to rank significantly higher than others in bird use at all three study sites in 1984: Moist Sedge-Shrub (most important at the Aichilik inland study site), Riparian (most important at the coastal Sadlerochit study site) and Mosaic (most important at the coastal Jago-Delta study site). Wet Sedge habitat, also found at all three study sites was important for birds at the Sadlerochit study site and for post-breeding birds at the Jago-Deta study site. Tussock habitat was important at the inland Aichilik study site, but not at the coastal Sadlerochit study site, were it was also found. Flooded habitat, found only at one coastal (Jago-Delta) site in 1984, was important habitat for shorebirds but not for passerines. Site-specific densities of individual species did not necessarily follow these trends.

Between-year differences observed included the use of Flooded habitat which had the highest total bird density in 1983, but ranked lower than the three habitats in 1984. The highest total nest densities were observed in Riparian habitat in 1983, and in Mosiac habitat in 1984.

In 1984, total bird densities increased significantly between the breeding and post-breeding seasons in three habitats: Moist-sedge at the inland Aichilik site, Riparian at the two coastal sites, and Wet Sedge th the Jago Delta site. This increase was primarily due to flocking and migrating shore birds. During the last post-breeding census in 1984, bird density in Tussock habitat also increased, due to higher densities of ptarmigan. Migratory flocks also resulted in special and temporal variation in bird densities. Seasonal use patterns between habitats and between coastal and inland sites were different in 1984 than in previous years.

A TWINSPAN analysis of breeding census data from 1983-1984 showed Flooded and Riparian habitats distinct from other habitat types with higher and more diverse bird use. The five other habitat types fell into one of two categories: Mosaic habitat-wet habitats or habitats with high interspersion; uniform habitats - less diverse and drier. Mosaic types had higher bird use and more bird diversity than did uniform types. This analysis suggests defining tundra bird habitats by factors such as micro-relief, interspersion of ponds and shrub cover rather than by broad land cover classes.

Species Accounts of Migratory Birds

In 1984, species accounts of birds observed during studies of terrestrial bird populations and habitat were prepared by USFWS-ANWR biologists P.A. Miller, C.S. Moitoret, and M.A. Masteller. Methods and results are described in ANWR Progress Report Number FY85-14 (see Appendix). Species accounts describe status, breeding chronology, migration, and habitat use of 46 bird species observed at the Aichilik River study area, 60 species at the Sadlerochit River Delta study area, and 54 species at the Jago River Delta study area in 1984, as well as information collected at these sites in late July and early August 1983. Bird breeding chronology, behavior, status, and distribution data were recorded daily between 2 June and 20 August, except for a period in late July-early August when new study areas were being surveyed. Bird species observed at these new sites are also summarized in this report.

## Bird Use of Lagoons and Offshore Habitats

### Lagoon Surveys

Standardized surveys of the ANWR lagoon system were completed by USFWS-ANWR biologists A.W. Brackney, J.M. Morton and J.M. Noll in 1984. Methods and results are reported in ANWR Progress Report Number FY85-11 (see Appendix). The major objective of these 1984 surveys was to obtain an index of relative numbers of migratory birds using coastal lagoons, with emphasis on oldsquaw molting in selected lagoons. Four additional lagoons were surveyed in 1984 in addition to the 10 lagoons and an offshore transect flown in 1981-1983. Three aerial surveys were flown on 22 July, 5 August, and 18 August along predetermined routes at an altitude of 30 m.

A total of 26 species of birds were observed during the three surveys (Appendix, ANWR Report No. FY85-11, Table 1). By comparison 25-32 species have been observed in previous years. Total numbers of birds counted ranged from 24,021 to 35,081 with oldsquaw comprising 83.3% to 92.6% for the birds observed. Numbers of oldsquaw observed in the four new lagoons surveyed in 1984 comprised 11.6%-12.7% of the total number seen (Appendix, ANWR Report No. FY85-11 Table 2). Oldsquaw counts recorded in 1984 were similar to those made in 1981, but higher than 1982 and lower than 1983 (Appendix, ANWR Report No. FY85-11 Table 3). Timing of the molt may be related to peak numbers of oldsquaw observed in the second week of August (Appendix, ANWR Report No. FY85-11, Fig. 1). Most birds were completing their wing molt by 10 August in 1983 and 1984.

Oldsquaw movements and distribution showed no set pattern from year to year (Table 3). In 1984, distribution was more even than 1983 and movemenbs appeared to be local rather than the general shift to the west seen in 1983. Consistently higher densities of oldsquaw were observed in Oruktalik Lagoon in 1984 as well as during the other three years. The small size of this lagoon may have influenced the relatively higher densities. Numbers of oldsquaw apparently moved offshore between late July and mid-August in 1982, 1983, and 1984. The opposite trend occurred 1981. Offshore movements may be a dispersal in response to crowding or an attempt to exploit offshore food resources.

Three species of scoters, and female and juvenile eiders were also observed during 1984 lagoon surveys, but numbers varied from survey to survey (Appendix, ANWR Report No. FY85-11, Table 1) and between lagoons. Numbers of loons and gulls were consistent from survey to survey. Numbers of glaucous gulls counted in each lagoon varied, most likely because this species is transient and opportunistic. Adult loons probably used lagoons to forage for fish. Numbers of geese, primarily black brant, rose sharply by 18 August, probably at the beginning of the staging period. Geese observed on 22 July and 5 August were in molt and flightless.

### Oldsquaw (*Clangula hyemalis*) Movements

In 1984, USFWS-ANWR biologists, A.W. Brackney, J.M. Morton, J.M. Noll and M. A. Masteller continued a study to monitor movements of oldsquaw within ANWR coastal lagoons. Methods and results are reported in ANWR Progress Report No. FY85-12 (see Appendix). Forty-four oldsquaw were captured on 7-11 August 1984, and 28 birds were fitted with radio-transmitters. Seven flights were made to relocate radio-collared birds between 12 August and 13 September 1984. Nine movements of surviving radio-collared oldsquaw ranged from 0.01 to 3.85 km/day with a mean of 0.69 km/day ± 1.29 SD. All movements were local and within or adjacent to the lagoon in which the birds were captured.

Habitat selection, based on radio-relocations from 1983 and 1984 within seven aquatic habitats, showed that radio-fitted oldsquaw avoided open water in the lagoons to a high degree and selected habitats in the following order of preference: lagoon barrier island, ocean barrier island, lagoon mainland shoreline, pass, and ocean mainland shoreline. Similar results were obtained when lagoon survey data (ANWR Progress Report No. FY85-11) were correlated with transects classified as one of three habitat types: barrier island, open water, or mainline shoreline. Oldsquaw habitat use shown by this analysis differed from studies which demonstrated that a higher abundance of prey items favored by oldsquaw occurs in the open water of the lagoons. Shelter may be as important as food availability, but more information is needed to define habitat requirements of post-breeding oldsquaw.

## Snow Goose Studies

### Snow Goose (Anser caerulescens) surveys

In 1984, USFWS ANWR biologists, R. Oates, A. Brackney and M. Masteller completed surveys to document the distribution, abundance, and productivity of snow geese staging on the ANWR coastal plain and adjacent areas in northwest Canada. Methods and results are reported in ANWR Progress Report No. FY85-7 (see Appendix). Surveys of snow geese staging in ANWR were initiated in 1978 and have been flown by refuge staff for the past seven years. Objectives of the surveys were to determine chronology of migration and staging, to estimate the distribution and numbers by snow geese present during the peak of staging, to estimate the percent young present during staging, and to identify areas used consistently by staging snow geese.

An area between the Bathurst Peninsula in Northwest Territories, Canada and the Hulahula River in ANWR was over flown along a pre-determined grid of north-south transects at 150 m above ground level. Two ANWR biologists flew the Alaskan portion of the survey on 13 and 21 September, after a reconnaissance flight on 28 August. Canadian Wildlife Service biologists (CWS) flew the Canadian portion during the same time period. This report only covered data from the Alaskan portion of the survey. Estimated flock sizes, direction of movement, type of flight, and behavior were recorded and flocks were photographed. Numbers of geese in the enlarged photographs were counted independently by two counters to obtain estimates of counter variability. Estimates of snow geese numbers in all flocks were corrected for errors when counts from photographs showed significant differences from estimated counts and also differed between counters. Composition counts of family groups were made from the ground.

Snow geese were first seen in ANWR on 17 August 1984 and by 28 August an estimated total of 1290 snow geese in small flocks were present. The main influx of geese probably occurred between 30 August and 7 September 1984. On 13 September a corrected estimate of 94,528 birds were seen in 149 flocks between the Hulahula River and Clarence River. Mean flock size was 634. On 21 September a corrected estimate of 48,405 geese with a mean flock size of 440 was made in the same area. Number of geese apparently declined between 13-21 September with most birds departing by 25 September. No snow geese were observed in the eastern half of the coastal plain on 26 September. Peak numbers of geese observed in 1984 were 4.8 times the peak numbers observed in 1983, but only 87% of a nine year average (Appendix, ANWR Progress Report No. FY85-7, Table 3). The percent of the western arctic breeding population using ANWR for staging is apparently highly variable. In 1984, the highest concentration of snow geese were observed along the upper Jago River and between the Jago and Okpilak Rivers. These areas were the last to be occupied and the first to be vacated. Other areas of concentration occurred along the Clarence, Niguanak, Aichilik, and Kongakut Rivers. Although reliable age-ratios could not be determined from photographs, 95 family groups observed from the ground had a mean of 2.56 (± 1.03 SD) young per successful breeding pair.

Ecology of Staging Snow Geese

In 1984, USFWS-ANWR biologists A.W. Brackney, M.A. Masteller and J.M. Morton initiated a study of feeding ecology and energetics of snow geese staging on the ANWR. Methods and results are summarized in ANWR-Progress Report No. FY85-8 (see Appendix). Study objectives were to quantify the normal daily activity patterns of staging snow geese, to determine the types of foods consumed, and to quantify changes in body weight during the staging period. Future analyses will determine average daily food intake, quantify changes in body protein and body lipid levels, and determine the caloric and protein quality of foods ingested in order to develop a model of energy expenditure and intake by staging snow geese. Fourteen geese were collected during the arrival phase of the staging period, 20 geese were collected during the departure phase, and two geese were collected between arrival and departure phases (Appendix, ANWR Progress Report No. FY85-8, Table 1). Food items from esophageal and proventricular samples were identified, counted, and weighed. Time budgets were collected from 8-20 September 1984.

Birds in all age/sex classes showed a consistent weight gain over the staging period (Appendix, ANWR Progress Report No. FY85-8, Table 2). Mean weight gain ranged from 14.5 g/day (juvenile males) to 23.4 g/day for adult males. The increase in mean body weight was 21% for adult males, 17% for adult females and 15% for juvenile males. No juvenile females were collected during the beginning of the staging period.

Food items analyzed from collected birds consisted exclusively of shoots and roots (Appendix, ANWR Progress Report No. FY85-8, Table 4). Twelve of 36 geese (33%) contained no food items. The major food was the large stems and fleshy rootstocks of Eriophorium angustifolium which was found in 91.7% of the aggregate wet weight of all food samples. E. scheuchzeri and Equisetum variegatum comprised 5.0% and 2.0% of the aggregate wet weight, respectively. Carex aquatilus and Dupontia fisheri were the most abundant plant species in graminoid tundra habitat sampled at Demarcation Bay (Burgess 1984) and Point Barrow (Webber 1978), but were conspicuously absent from these goose food samples. At Demarcation Bay, E. angustifolium comprised only 0.3-2.8% of the plant cover, suggesting that geese were highly selective in the foods they consumed. Geese grazing on roots and stems remove the entire plant, and may be creating favorable feeding areas for future use, as E. angustifolium tends to be pioneer species. Large numbers of geese could deplete food resources in a specific area for several years, however, dispersal of birds over wide areas and yearly shifts in distribution could be mechanisms for maximizing food resources.

Observations for collection of time budget data were made by recording individual behavior at 15 second intervals during daylight hours, and were collected from a total of 129 adults and 137 juveniles on the ground. Preliminary data analysis indicates that adults spent more time on alert (12.2%) and sleeping (6.0%) and less time feeding (60.6%) than did juveniles. Juvenile feeding behavior comprised 78.7% of their time while alert behavior comprised only 1.5% and sleeping behavior was negligible. Feeding behavior occupied majority of daytime activity for both adults and juveniles. Juveniles spent more time walking (40.7%) than did adults (29.9%), suggesting that juveniles feed less efficiently. Higher feeding rates by juveniles may be a function of this inefficient feeding as well as an apparent need to obtain more food. Diurnal variation in percentage of time snow geese juveniles and adults spent feeding was observed (Appendix, ANWR Report No. FY85-8, Fig. 1). Less feeding occurred in the late morning and early afternoon when sleeping behavior and other resting behaviors occurred.

The mean daily percentage of flying time was 5.8%, based on 141 instantaneous counts of flying and total geese in flocks. Most flying occurred in early morning when geese moved to feeding areas. Late morning and early afternoon peaks were also observed. Additional time budget data are needed to define variations in behavior affected by weather and the progression of the staging period.

Tundra Swans (Cygnus columbianus) Surveys

Two aerial surveys to estimate the number of tundra swans using ANWR coastal wetlands were completed by USFWS-ANWR biologists A.W. Brackney, J.M. Morton, J.M. Noll, and M.A. Masteller in 1984. Methods and results are reported in ANWR Progress Report No. FY85-10 (see Appendix). The 1984 surveys covered areas identical to those flown in 1981, 1982, and 1983. During the 26-27 June 1984 nesting survey number of pairs (149), nests (100), and non-breeding adults (120) exceeded the number seen in June 1983 (Appendix, ANWR Progress Report No. FY85-10, Table 1). Total adults counted in June 1984 was 402, 52% higher than 1983. The Canning-Tamayariak and Aichilik-Egaksrak-Kongakut River deltas had the highest number of nests in 1983 and 1984. The latter area also had the highest density of nests (0.12 nests/km$^2$, 0.18 pairs/km$^2$; Appendix, ANWR Progress Report No. FY85-10, Table 1). In spite of increased nesting attempts in 1984, the total number of adults counted during the post-breeding productivity survey on 23, 27 and 29 August 1984 were less (280) than in any year since standardized surveys were begun (Appendix, ANWR Report No. FY85-10, Table 2). As the number of pairs seen in August (106) was less than the number of pairs seen in June (149), some unsuccessful pairs may have left the study area by late August 1984. By contrast, non-breeding swans or unsuccessful breeders from other areas apparently entered the study area between the June and August 1983 surveys. Fewer single birds and swans in flocks were seen in August 1984 (68) than in August 1983 (113). In August 1984, 165 cygnets in 62 broods were seen compared with 176 cygnets in 64 broods seen in 1983. Mean brood sizes were not significantly different in the two years (2.7-2.8 cygnets), but nest success was apparently lower in 1984 (broods/pair = 0.42; broods/nest = 0.62) compared with 1983 (brood /pair=0.61, broods/nest = 0.82).

In spite of higher nesting densities, breeding success was lowest (brood/nest = 0.44) on the Canning-Tamayariak River delta. Overall breeding success may have been reduced by additional nesters utilizing suboptimal habitat. A comparison of nest locations on the Canning delta in 1983 and 1984 showed that birds were nesting in two new locations and nest densities had increased in one area in 1984.

## Other Birds Studies

### Distribution of Golden Eagles (Aquila chrysaetos)

In 1984, USFWS-ANWR biologist F. J. Mauer initiated surveys to document distribution and relative abundance of golden eagles in relation to the Porcupine caribou (Rangifer tarandus) herd during calving and post-calving periods. Methods and results of these surveys are presented in ANWR Progress Report No. FY85-3 (see Appendix). Objectives of these survey were, to determine relative abundance and distribution of golden eagles associated with calving and post-calving caribou, to determine temporal aspects of golden eagle occurrence on the northern portion of ANWR, and measure productivity of golden eagle nest sites adjacent to caribou calving and post-calving areas. Observations of eagle were collected from biologists associated with field projects in the ANWR. In early June, aerial surveys were flown along 16 north-south transect lines, and over areas of high caribou density and areas not occupied by caribou. New and historical nest site locations in or adjacent to calving and post-calving caribou areas were checked from 4 July-10 August 1984. From 3 May-11 August 1984, 428 golden eagles were sighted on the Porcupine caribou calving grounds, post-calving areas, or adjacent areas. Of 192 birds classified according to age, 89% were sub-adult and 11% were adult birds. Most (88%) observation of golden eagles were in areas currently or recently occupied by caribou (Appendix, ANWR Report No. FY85-3, Fig. 3-7). Few eagle observations were recorded prior to the arrival of caribou calving, then numbers of eagle observations increased and reached a peak during the post-calving period from 20-30 June (Appendix, ANWR Report No. FY85-3, Fig. 8). As aggregations moved east, there was a corresponding shift in location of eagle observations. Golden eagles were feeding or perched on caribou calf carcasses on 23 occasions and on adult carcasses on 13 occasions. Most calf predation or scavenging took place in the post-calving period, as did the incidence of multiple eagle sightings, where 2 to 13 birds were seen at one location. Six of 25 calf carcasses examined were probably killed by eagles. Eagle predation on calves was documented as late as 23 July in Canada. Golden eagles were observed near brown bears (Ursus arctos) on five occasions and wolves (Canis lupus) on four occasions. Two adult bald eagles were seen in the area and one snowy owl was observed on a calf carcass in the study area. Numbers of eagles observed were not different between areas occupied or unoccupied by caribou during systematic aerial transects. During intensive aerial searches over caribou post-calving concentrations, 5.0 eagles/h of flight time were seen versus no eagles seen during similar searches over areas not occupied by caribou.

Nests were found at seven of 12 historical golden eagle sites near the calving area, but only one site produced young in 1984. Golden eagle production on the north flank of the Brooks Range appeared to be relatively low in 1984.

Miscellaneous Bird Observations

On 4-10 June, USFWS biologists R. Gill (Research) and M. Amaral (Endangered Species) established a camp on the Hulahula River in an attempt to verify a report of an Eskimo Curlew (Numernius borealis) made in August 1983 by H. Behmann (University of Kiel, West Germany). No Eskimo Curlew was seen and the biologists concluded that H. Behmann probably confused an upland sandpiper (Bartramia longicauda) for a curlew, as the appearance and behavior of the two birds is similar. During their investigation they observed 39 species of birds at the Hulahula River camp site including 17 species of passerines, 9 species of shorebirds, 6 species of waterfowl, and 4 species of raptors, 3 species of gulls, and 1 species of ptarmigan. Their report included an annotated species list of observations.

Hobbie (1984) included a chapter on bird use of wetlands in his community profile of tundra ponds on the arctic coastal plain. The most abundant birds were wading shore birds, like the pectoral sandpiper and dunlin, which utilized soil insects in the tundra or exposed sediments of temporary wetlands. Red and northern phalarope fed on large plankotnic and sediment animals. Ducks, primarily pintail, oldsquaw, and three species of eider use ponds for food and breeding. Geese were locally abundant, and grazed on vegetation, especially rhizomes and young shoots, as did swans. Arctic loons, which preferred large ponds, used stands of Arctophila for nesting, and used pond invertebrates to feed their young.

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Chapter 5

# MAMMALS

In 1984, ecological studies of ungulate and predator species were continued on the coastal plain of the Arctic National Wildlife Refuge (ANWR). Field work on wolf prey utilization and denning behavior and the ecology of small rodents and ground squirrels were completed by University of Alaska Fairbanks (UAF) graduate students.

## Caribou (Rangifer tarandus)

### Porcupine Caribou Herd

1983-1984 Fall and Winter Movements, Distribution and Mortality: Results of radio-tracking surveys during the the winter of 1983-1984 were summarized by ADF&G biologist K.R. Whitten, USFWS-ANWR biologists F.A. Mauer and G.W. Garner, and Canadian Wildlife Service (CWS) biologist D.E. Russell. Methods and results are presented in ANWR Progress Report No. FY85-17 (see Appendix). In Alaska, surveys were flown once in October, February, and March and twice in November and May. In Canada, surveys were flown once in October, December, February, April, and May. In late July and August 1983, caribou of the Porcupine herd moved south through Brooks Range toward the Chandalar area, near Arctic Village, then moved eastward to the southeast Brooks Range in Alaska, and to the British Mountains and Old Crow Flats in Canada. Animals moved back into the Chandalar area in October, probably just after the rut. Most were between Ackerman Lake and Arctic Village by late October, although some were as far southwest as Chandalar Lake and a few remained scattered throughout the southern foothills. At the same time, 56 of 63 radio-collared caribou located in Canada were in the Ogilvie River basin. During the winter, caribou remained in these traditional wintering areas. In February and March 1984, most Porcupine caribou in Alaska were still in the vicinity of Arctic Village (Appendix, ANWR Report No. FY85-17, Fig. 3), and in Canada a majority of caribou continued to inhabit the Ogilvie basin. A small portion of the Porcupine herd (less than 1000) remained on the north slope of the Brooks Range and wintered in the Schrader Lake/Kikiktat Mountain. In 1984, spring migration was delayed by deep snow in the southern foothills of the Brooks Range. Distribution changed little in March and mid-April 1984. Some movement northeast was observed in early May, but many did not move until snow and travel conditions improved in mid- to late May. Caribou wintering in Alaska moved along the southern flanks of the Brooks Range toward the headwaters of the Firth River where they joined with caribou from Canadian wintering grounds.

All 10 radio-collared bulls wintered in Canada and 19 of 63 radio-collared cows wintered in Alaska. Assuming the percentage of radio-collared animals represented an equal percentage of the total population, roughly 40,000 Porcupine caribou, predominantly cows and calves, wintered in Alaska. Estimates of caribou on winter range have been consistently lower than known herd size. Casual estimates made during radio-relocation flights suggested 20-30,000 caribou wintered in Alaska.

Minimum first year mortality was 39% (20 of 51), assuming that eight calves whose collars failed in winter had survived, and eliminating four shed collars and three unverified mortality signals from the sample. Maximum first year mortality was 57% (31 of 54), assuming the collars with mortality signals and collars failing in winter were on dead animals. If the eight calves, whose collars failed in winter, survived and the three unverified mortalities had died, first year mortality was 43% (23 of 54). Among radio-collared caribou older than calves, 64 of 73 survived through May 1984, six died, and three collars failed. Minimum mortality was 8% (6 of 73) and maximum mortality was 12% (9 of 73).

In 1983, most calf mortality occurred during summer, especially within the first nine days of birth. More calves died during fall migration (September - October) than during the entire mid-winter period (November - March), as did more adults (Appendix, ANWR Report FY85-17, Table 2).

1984 Calving Distribution, Productivity, and Neonatal Mortality: In 1984, ADF&G biologist K. R. Whitten and USFWS ANWR biologists F.J. Mauer and G.W. Garner continued the study of distribution, production and mortality on the calving grounds of the Porcupine caribou herd. Methods and results are presented in ANWR Progress Report No. FY85-18 (See Appendix). Primary objectives of this study were: to delineate distribution of Porcupine caribou herd calving and describe characteristics of areas used, to determine initial calf production, and document the extent, causes and chronology of neonatal mortality, and to measure variation in calf mortality factors between core and peripheral areas and/or between different habitat types or localities.

Caribou calves were captured and radio-collared in areas with high densities of calving females, and relocated every other day from 3 June through 6 July 1984. Relocation surveys were made periodically from July though November 1984. Mortalities were investigated as soon as possible using a helicopter. Mortality of captured calves was compared with mortality of calves born to cows radio-collared in previous years.

In 1984, deep snow south of the Brooks Range delayed the onset of migration, as animals followed traditional routes through the Richardson Mountains, across Old Crow Flats and along the southern flank of the Brooks Range, but light snow cover north of the mountains permitted most cows to reach traditional calving areas in ANWR. At the onset of calving (30 May - 2 June), the highest densities of caribou were just north of the Brooks Range foothills from Demarcation Bay to the Aichilik River, and in the low hilly country on both sides of the Niguanak River. Many caribou were also located in the Buckland hills and the coastal plain south of Stokes Point in northwest Canada, as well as moving along the coastal plain and foothills from the Firth River to Demarcation Bay. Pregnant cows led the migration, yearling and barren cows were at the rear, and bulls remained south of the Brooks Range. Throughout the calving period, cows continued to move northward and westward until the birth of their calves. In 1984, very few animals calved in the Jago River foothills, traditionally a high density area, but high density calving occurred immediately east and north of these foothills. Some calving cows remained in the Buckland Hill/Stokes Point area in Canada. Caribou wintering on the ANWR south and east of the Sadlerochit River calved with the Porcupine herd on the Niguanak River. Caribou wintering in the Sadlerochit Mountains and Canning River moved north or northwest to Central Arctic herd calving areas.

Peak of calving among radio-collared cows was probably 4 June 1984 (Appendix, ANWR Report No. FY85-18, Fig. 5). Twenty-three of 31 (74%) radio-collared cows (3+ years) gave birth. No 2-year old radio-collared cows (N=28) showed signs of pregnancy in 1984. The same observations were noted in 1983, and in Central Arctic herd caribou, compared with interior Alaskan herds where 50% or more of 2-year old cows may be pregnant. Productivity among radio-collared cows (3+) was 67-74% in 1982-1984, suggesting that initial productivity of the entire herd was also probably similar in all three years.

Sixty calves were captured, measured, and radio-collared in two high density calving areas on 3-6 June 1984. After 17 of these calves apparently died from study-induced abandonment, 17 additional calves were captured in two locations on 5-7 June. Average search/capture/processing time was 6.7 min per calf.

Excluding study-induced mortality, the natural mortality rate of radio-collared calves was 26.8% (16 of 60) between 3 June and 12 November 1984. Predation was confirmed or identified as the most probable cause of mortality in 13 of 16 (81.3%) cases (Appendix, ANWR Report No. FY85-18, Table 5). During the intensive study period of 3 June to 6 July 1984, four predator-related mortalities and one accidental death occurred. Between August and October 1984, nine predator-relative mortalities and one mortality due to disease were documented. One calf was killed by a hunter in November 1984 (Appendix, ANWR Report No. FY85-18, Fig. 6). Predators were identified for 4 of 13 mortalities due to predation. Two calves were killed by wolves; one was found on 10 June in the ANWR foothills and one was found on 21 September in Canada. Wolves also were suspected in seven other mortalities occurring between August and October. Golden eagles killed one collared calf in late June 1984, compared with three mortalities by golden eagles in 1983. One calf, unaccompanied by it's dam was killed or scavenged by a brown bear in August 1984, south of the Brooks Range. The sex ratio of dead collared calves was 2.2 males/female compared with the sex ratio of 1.3 males/females of all collared calves. This higher mortality rate for males was not statistically different from female mortality rates, but was similar to results reported for other populations (Kelsall 1968).

Four of 16 (25%) mortalities occurred during calving and early post-calving. Three of four calves died at 7 days old, one died at 21 days old. Only one mortality occurred during post-calving movements in July, but 10 mortalities occurred in August and September, when the Porcupine caribou were widely dispersed south of the mountains.

Higher densities of predators, smaller dispersed groups, and shrubby vegetation may have increased chances for predation in the fall. The same seasonal pattern of calf mortality was also documented in 1983.

Nineteen carcasses of unmarked caribou calves were collected from calving and post-calving areas between 3 June -6 July. Four were killed by golden eagles, and four others were scavenged by birds, with the cause of death unknown; wolves and brown bears each killed two. Two died of starvation/pneumonia complications. One was still-born and one was subject to predation and/or scavenging by unknown species. Mortality of six adult cows, including two radio-collared females, was documented on the calving area. Two died possibly from complications during birth. A brown bear apparently killed one cow.

Most mortalities occurred between the Aichilik River and Canadian border, south and east of "core" calving concentrations. A similar distribution of mortalities was recorded in 1983, suggesting that mortality rates may be greater in "peripheral" calving areas, and may be related to densities of predators.

From 3 June to 6 July 1984, calf survival among collared calves in calving and post/calving areas was 93% (excluding study-related mortalities), compared with a survival rate of 95.6% for control calves of radio-collared cows. Calf survival rates in 1983 were 82.5% for collared calves and 72.2% for control calves.

Radio-collared calves remained in the general area of their birth for two weeks (Appendix, ANWR Report No. FY85-18, Figs. 10 and 11). Group sizes gradually increased and groups from the Niguanak "core" calving areas and Egaksrak-Kongakut "peripheral" calving area merged on about 19-20 June on the coastal plain between the Niguanak and Aichilik Rivers. Herds then spread east/southeast to the foothills and northern flanks of the Brooks Range. Net movement rates per day increased from 2-3 km/day to 5-6 km/day, reaching 18.5 km/day by 26 June 1984. In late June 1984, the post-calving aggregation divided. About 2/3 of the radio-collared caribou moved east into Canada, reaching the Firth River-Spring Creek area by 3 July. The remainder moved south into the mountains between the Kongakut and Aichilik Rivers, crossing the continental divide into the Kongakut River drainages by 1 July. Movements through the mountains were rapid (25-30 km/day).

<u>Distribution of Biting and Parasitic Insects</u>: In 1984 L. Pank, C. Curby (USFWS-Denver Wildlife Research Center), B. Nankivell, C. Simon and R. Wright (Student Conservation Association) continued studies of the spatial and temporal distributions of biting and parasitic insects on the coastal plain and adjoining foothills of the ANWR. Methods and preliminary results are reported in DWRC Progress Report: Subunit 5 (See Appendix). Objectives for the 1984 study season were: to determine if levels of mosquito activity and harassment of humans and caribou differed between coast, plains and foothills sites, and between insect relief and insect sites, to determine if differences in mosquito activity and harassment were associated with topography, distance from riparian habitat (river and coast) and weather, to define and determine if diel patterns of mosquito activity and weather at coast, plains and foothills sites were related, to develop a method and sampling protocol to indirectly assess and predict the level of mosquito harassment of caribou, and to assess the accuracy and define the limitations of the White et al. (1975) model for predicting insect harassment of caribou.

Totals of 28, 12 and 19 trap sites were established on the coast, plains and foothills, respectively. Data were collected daily from each of these three zones between 22 June and 14 July. Mosquito activity was assessed by catch size from sticky traps and sweep nets, and by objectively assigned levels of human and caribou harassment by mosquitoes. Weather data included relative humidity, minimum, maximum and current ambient air temperature, wind speed, soil temperature and cloud cover. Elevation, slope, aspect and landcover class (Walker et al. 1983) were recorded for each site, and all sites were classified as insect or insect relief habitat. Data were recorded hourly for seven 24 hour periods to quantify diel patterns. Trap sites were gridded to determine if mosquito catches were related to distance from the coast (coastal sites) or distance to riparian habitat (plains sites). Traps were deployed across terrain to assess the effect of topography on catch. Caribou activity and response to insect harassment were recorded at trap sites from which caribou were visible.

Preliminary conclusions of the 1984 data indicate that mosquitoes were the dominant insect modifier of caribou behavior on the ANWR, based on trap results and caribou observations. Mosquitoes emerged earlier in the foothills than on the coast. The level of mosquito activity increased from the coast to the foothills and the period of mosquito activity within a day was shorter on the coast than the plains. Of the four measures of insect activity tested, sweep net catch was the best estimator of behavioral response in caribou to mosquitoes. A corridor of low mosquito activity was present along the Aichilik River. Diel patterns of weather and insect activity were pronounced. The coast provided the greater relief habitat. The incorporation of landcover type will improve the predictive accuracy of the White et al. (1975) model.

Central Arctic Caribou Herd

In 1984, ADF&G biologists R.D. Cameron, K.R. Whitten and W.T. Smith monitored radio-collared caribou from the Central Arctic Herd (CAH) using areas near and within ANWR. Methods and results of this investigation are summarized in a preliminary report prepared for the USFWS-ANWR (see ADF&G Interim Report, Appendix). Principle objective of this study was to determine the timing and extent of range use within ANWR by Central Arctic caribou. During the summer of 1984, the study area between Prudhoe Bay and the Katakturuk River was subdivided into three regions of approximately equal size with the eastern most region falling within the boundaries of ANWR. Numbers of radio-collared caribou within each region were tallied for each of four relocation periods.

During calving in early June, 23 of 30 radio-collared caribou including 15 of 19 adult cows, were located in the two eastern regions, within 20 km of the coast primarily between Bullen Point and the western ANWR boundary. On 3 July this distribution had changed little, but by 12 July an eastward movement had occurred and more than half of 33 radio-collared caribou were located within ANWR. By the end of July, animals had generally drifted west again. These and other observations over the past decade suggest that mid-summer movements into and out of the western portion of ANWR occur annually. Extrapolating this sample of radio-collared caribou for the entire population indicates that up to 25% of the Central Arctic caribou herd, excluding calves, may occupy the western edge of ANWR for a brief period each summer. Continued expansion of the CAH population may result in an increased use of this area both in time and space.

Muskox (<u>Ovibos</u> <u>moschatus</u>)

Population and herd dynamics, distribution, movements and habitat use:

In 1984, work continued on the ecology of muskoxen by USFWS-ANWR biologists P.E. Reynolds, L.D. Martin, G.J. Weiler, J.M. Noll, and J.M. Morton. Methods and results from 1982-1984 are described in ANWR Progress Report Number FY85-1 (See Appendix). The objectives of this study were: to determine population size, composition, and herd dynamics; to document seasonal distribution patterns, movements, and habitat use; and to locate and define calving areas.

Between 1982 and 1984, 40 muskoxen were captured, measured and marked in the ANWR. Thirty-eight muskoxen were radio-collared and relocated 19-26 times each year 1982, 1983, and 1984. One cow was collared with an experimental satellite collar in 1984. Population surveys were flown in mid-April 1982 and late March 1983 and 1984, and in late October and early November 1982, 1983, and 1984. Sex and age composition counts were made in mid-June and late August 1983 and late June-early July 1984. Ground observations of behavior, activity patterns, and habitat use were made in early August 1984.

The post-calving muskox population was estimated to be 257 in 1982 311 in 1983 and 384 in 1984. The annual mean rate of increase between 1974 and 1984 was 19% (Appendix, ANWR Report No. FY85-1, Table 7). In 1984, 89% of the estimated population was classified (Appendix, ANWR Report No. FY85-1, Table 8). The 1984 bull:cow ratio was 0.92 for animals older than three years of age. Cow:calf ratios were 0.75 calves/cow in 1984, compared with 0.66 calves /cow in 1983 and 0.63 calves/cow in 1982. An estimated total of 81 calves were produced in 1984. Radio-collared cows produced calves yearly or every other year. A mean reproductive interval of 1.8 years was calculated based on observation of five radio-collared cows for three consecutive years. Cow:calf ratios for radio-collared cows were the same (0.76 calves per cow) as ratios observed for the entire population (0.75 calves per cow) on 1984. Observations of calves estimated to be less than a week old in early July 1984, suggests that some cows may come into a second estrus if they fail to conceive during the peak of the rut in August. Annual mortality , including the harvest of five bulls, was calculated to be about 4% in 1984. Most of this mortality apparently occurred between October 1983 and April 1984.

Most muskoxen were seen in moderately sized mixed-sex herds of 10-30 animals throughout the year, although a herd as large as 105 muskoxen was seen. Herd size reached a maximum in April and October and a minimum in August during the rut in 1982, 1983, and 1984. Bulls were also found in bull groups ranging in size from two to nine animals, or observed as solitary animals. Unlike cows, many adult bull muskoxen did not remain with one herd for long periods of time, but moved from herd to herd. Small groups of cows and single cows were seen much less frequently. Most muskoxen were concentrated in the same geographic areas in 1982, 1983, and 1984, and previous studies suggest some of these areas have been used since the animals were released in 1969 and 1970. Some animals have dispersed east and west of the study area and into at least one new location within the study area. Seasonal use of specific areas was documented in 1982-1984.

Changes in areas used during the peak of caving in mid-May occurred, but most variation was a shift in distribution to adjacent areas or dispersal of some animals into new areas. Bull groups and solitary bulls were often spacially segregated from mixed-sex herds and made relatively long movements between geographic areas, particularly in July and August. Muskoxen were most frequently associated with river creek drainages except in winter and spring when ridges and hillsides blown partly free of snow were used. Use of vegetation types appeared to follow a phenological progression with muskox using tussock and low vegetation in May and June, early blooming forbs on rivers in early June, and riparian willows and associated low vegetation after emergence of leaves in late June. In August and September habitat use appeared to variable as herds spread out during the rut. Willows and low vegetation were used in September and October as animals congregated on major river drainages. Snow covered most of the vegetation between October and May.

Moose (Alces alces)

In 1984, USFWS-ANWR biologists L.D. Martin and G.W. Garner conducted spring and fall surveys for moose along the Canning and Kongakut drainages. Methods and results are described in ANWR-Progress Report Number FY85-6 (see Appendix). Objectives of aerial moose surveys were to determine the population size, composition, and distribution of moose; to determine productivity; and to determine over-winter calf survival. Moose surveys were conducted along both drainages as early as 1974, but standardized survey routes were not established until 1980. These routes were followed during moose surveys in October 1983, and in April and October 1984.

In the Canning River drainage, 149 moose were seen during the 20 April 1984 survey, compared to 147 moose seen in the area in April 1980. The percentage of short yearlings in the population were similar in April 1980 (9.5%) and April 1984 (11.4%). On 2 November 1984, 158 moose were observed compared to 149 moose seen on 30 October 1983 (Appendix, ANWR Report No. FY 85-6 Table 1). Most (87.3% - 92.4%) moose were in the Cache/Eagle Creek portion of the drainage in 1983 and 1984, respectively. Number of calves within the Canning River drainage declined from 25 in October 1983 to 17 in April 1984, or surrounding drainages. The Canning River moose population has been relatively stable since 1980.

In the Kongakut River drainage, 134 moose were observed on 19 April 1984, compared with 123 moose seen in April 1980. Total numbers of moose declined from 158 in October 1983 to 134 in April 1984. Numbers of short yearlings (19) were less in April 1984 compared with April 1980 (25), probably because calf production (13.3%) was low in 1983. On 30 Oct-1 November 1984, 239 moose were seen in the Kongakut drainage, an increase of 51.3% over the October 1983 survey (Appendix, ANWR Report Table 1) and the highest number of moose recorded during any historical survey. Distribution of moose within the drainage was similar in 1983 and 1984.

A higher percentage of bulls (including yearlings) was seen in the Kongakut drainage than in the Canning drainage in both 1983 and 1984 surveys. Adjusted sex ratios showed that in 1983 the bull/cow ratio in the Kongakut drainage was double that observed in the Canning River drainage. By October

1984, 64 moose including 40 cows apparently had moved into the Kongakut drainage. Sex-ratios observed on the Canning River were relatively stable in 1983 (0.67 bulls/cow) and 1984 (0.70 bulls/cow). Productivity was similar in both years within a drainage, but the Kongakut had higher productivity (0.44-0.46 calves) per cow compared with 0.36-0.38 calves per cow seen in the Canning River drainages. Apparent calf survival between fall 1983 to spring 1984 was at least 89.5% in the Kongakut River drainages and 68.0% in the Canning River drainages.

A survey was conducted of all major drainages between the Kavik River and the Kongakut River in the spring of 1984 as part of a cooperative effort with the ADF&G to determine moose populations on the north slope of Alaska. Most (368 of 399) of the moose seen were located in three drainages: the Kavik River, the Canning River and the Kongakut River. The Aichilik and Egaksrak Rivers may also have small over-wintering populations. Percentages of short yearlings ranged from 12.7% in the Canning Marsh Fork drainage to 23.7% in the Kavik drainage, and averaged 15.5% for the entire survey (Appendix, ANWR Reports No. FY 85-6 Table 4). Miscellaneous observations of moose made in 1984 documented summer dispersal of animals along several rivers crossing the ANWR coastal plain.

## Marine Mammals

### Bowhead Whale (*Balaena mysticetus*)

In 1984, B. Morris and other biologists with the National Marine Fisheries Service requested permission to observe and acoustically monitor bowhead whale occurrence in near shore waters of the eastern Beaufort Sea from 10-24 September 1984. The status of this work is unknown.

## Predators

### Brown Bear (*Ursus arctos*)

In 1984, work continued on a study of brown bears utilizing the ANWR coastal plain and adjacent foothills by USFWS-ANWR biologists G.W. Garner, L. D. Martin, G. J. Weiler, J. M. Morton, and J. M. Noll, in cooperation with ADF&G biologist H. V. Reynolds. Methods and results are discussed in ANWR Progress Report No. FY85-9 (see Appendix). Objectives of this study are to determine the location of dens and described the ecology of denning for brown bears using the ANWR coastal plain, to determine the seasonal habitat use patterns of brown bears using the ANWR coastal plain, to determine seasonal interrelationships between brown bears and other wildlife species, especially caribou, and to determine the structure, size, status, and reproductive biology of brown bear populations on the northern slope of the eastern Brooks Range.

Between 1982-84, 103 brown bears were captured on the ANWR coastal plain or in adjacent foothills and mountains, 45 of these bears have been recaptured. Radio-collars were put on 74 different bears between 1982 and 1984. Of 57 bears captured in 1984, 27 were found in coastal plain habitats, 16 were in foothill habitats, and 14 were in mountainous habitats. Sex ratios of captured bears in each habitat were equal except for the foothills when more females were caught (Appendix, ANWR Progress Report No. FY 85-9 Table 1).

Sex and age structure of 124 captured bears and their associated offspring alive at denning in 1983 and new bears captured in 1984 indicate a population of relatively young age structure. Of 86 bears older than 2.5 years, 62 (72%) were between the ages of 3.5 and 11.5 years. Twenty four bears (28%) were 12.5 years and older. Ratios of males to females were approximately equal in both young and old age classes. This structure suggests an apparently stable population. In 1982, relatively good survival of young bears through the first four years of life was documented. In 1983 and 1984, high rates of apparent mortality (58.9% and 54.2% respectively) were observed in cubs and yearling cohorts. Two study-related mortalities and three other mortalities of adult females were documented. The breeding season of bears extended from May through early July with pairs often seen during this period. Eight of 26 females, accompanied by young bred at 5.5 years, the earliest age at which breeding was observed to occur (Appendix ANWR Progress Report No. FY 85-9 Table 4). Females losing cubs or yearling by early summer apparently bred the same year.

Brown bears were observed in the vicinity of caribou through June. Bears were observed chasing caribou 3 times, feeding on adult caribou 6 times, and feeding on calf carcasses 10 times in June and early July 1984. One male bear was seen on a caribou carcass in October 1984.

Dens of 58 bears were located in the fall of 1983 and observed in April and May 1984 to document dates of emergence (Appendix ANWR Report No. 9 Table 5). One bear emerged by 19 April and 7 others emerged between 23-27 April, 25 bears emerged on 6-7 May. In 1983, 18 of 28 radio-collared bears were out of the den by 1 May. In 1984, all bears emerged by 16 May. In 1983, emergence extended from 24 April through 30 May 1983. Males and non-parturient females emerged first, followed by females with young. In 1984, sows with cubs emerged from 6 May-16 May.

Physical characteristics of 49 bear dens were measured in late May, and late July - early August 1984 (Table 6). One den was located in coastal plain tundra habitat, others were in the foothills and mountains. Den site elevations ranged from 347-1649 m ($\bar{X}$ = 966 ± 45 m). One den was dug into 2 m of snow, 3 were rock cave dens, and 45 were dug dens, 2 of which had partly or completely collapsed by late May 1984. By late July-early August 42 of 45 dug dens were partly or completely collapsed, indicating that soil texture and moisture content are important factors in den site selection. Aspects of dens were concentrated in a southeast direction with mean aspect of 150° (Appendix ANWR Report No. 9 Fig. 4), indicating that dens are located on slopes which are warmer and normally snow-free earlier than north facing slopes. Edaphic factors may also be important in site selection.

Den sites of 43 bears were located in mountainous habitats, 6 were in foothill habitats, and 2 were in coastal plain habitat. In 1984, 3 bears denned by 15 October and 21 bears denned by the end of October (Table 7), in contrast to 1983 when 9 of 46 bears did not enter dens until 9 November.

Wolf (Canis lupus)

Seasonal Movements and Prey Relationships: In 1984 USFWS-ANWR biologists G.J. Weiler, G.W. Garner, and L.D. Martin and ADF&G biologist W. Reglin initiated a study to document seasonal movements and prey relationships of wolves in the northern portion of the Arctic National Wildlife Refuge. Methods and results are discussed in ANWR Progress Report No. FY85-5 (see Appendix). This report summarizes current literature with an emphasis on information known about northern wolves. In 1984, a major objectives of the study was to define seasonal ranges of individual wolves and associated packs that use the north slope of the Brooks Range and the coastal plain in ANWR.

Eleven wolves were captured and radio-collared between 19 May-5 July 1984. Members of three different packs denned in 1984 and three den sites were located. A fifth pack consisting of two wolves were killed by local hunters prior to denning. All but two of the captured wolves were non-breeding animals less than three years of age. One lactating female, and one possibly breeding-age male were also captured.

The Sadlerochit pack was comprised of eight wolves in March 1984, before three pack members were killed by a hunter. Two wolves, including one lactating female and one 2-year old female, were radio-collared in late June and July (Appendix ANWR Progress Report No. FY 85-5 Fig. 1). A third adult male was observed, but never captured. The pack used the area along and near the Sadlerochit River until late July, but expanded their range to include the Canning River, Cache Creek, and Eagle Creek in late July and early August. One pup was produced, but the den was never located. A black wolf joined the pack in mid-October, but the young radio-collared female left the pack and moved to the Okpilak River, where she was seen in October and November 1984.

The Aichilik pack was comprised of seven wolves. Four pups were raised at a den site located on 12 June (Appendix ANWR Progress Report No. FY 85-5 Fig. 2). Two young radio-collared females used the coastal plain extensively during June. One moved east into Canada between 4-17 July, and the other moved to the Kongakut River on 23 July, possibly in search of caribou. Both returned to the Aichilik River area, but were usually seen alone. Limited information from August-November suggests the wolves moved south of the Brooks Range as far as Double Mountain on the Sheenjek River, then moved north to the upper Aichilik area.

The Canning River pack, which consisted of five wolves in March 1984, probably denned on the Canning River. The den site was located and pup scats were found but pups were never seen. A solitary wolf found north of the den site on 26 June was not captured, but a male was radio-collared near the same location of 5 July. This wolf was relocated three times on the Marsh Fork and was always alone.

The Kongakut River pack, comprised of six wolves, denned at a historical location and reared two pups in 1984. Two wolves, a male and a female were captured as solitary animals on the Kongakut River in late June 1984. Between 27 June - 28 July, the male was relocated alone five times on the Kongakut River, but never associated with the den after its capture. When relocated in late September, it had moved 193 km to near Bell River in Canada and by early December it was still in Canada near Aklavik (Appendix ANWR Report No. FY 85-5 Fig. 7). The female captured on the Kongakut River, was alone on the Kongakut during six relocations between 30 June and 13 August, but visited the den on five occasions. Between 19 September and 28 October, it moved to Aspen Creek in Canada and returned to the Kongakut River (Appendix ANWR Report No. FY 85-5 Fig. 7) Two pups from the den were seen without adults 6 km from the den on 19 July. On 31 October three adult wolves and two pups were seen near the Kongakut River.

The Old Man Creek Pack was comprised of a pair of wolves, seen on 19 April and 28 April between the Hulahula and Okpilak Rivers. Both wolves were killed on 2 May by local hunters. Examination of the carcasses showed the female was carrying a litter of four pups.

One 3-year old female, radio-collared on 3 June, was observed alone and with a 3-4 year old male, which was also radio-collared on 25 June. These two wolves remained together until early July. After which the female traveled south of the Brooks Range, but returned to the Kongakut River by mid-September. On 30 October it was associated with a black wolf, both of which were seen in Canada on 7 November. The male left the area on 9 July and was found on 8 November with four other wolves 217 km southwest on the Ivishak River. A solitary 1 to 2-year old male was captured on 5 June and remained between the Canadian border and the Aichilik River. A solitary male radio-collared on 25 June, which moved between the Clarance River and Ammerman Mountain in Canada, was seen with a grey wolf twice in late September 1984.

Distribution showed that wolves used the ANWR coastal plain east of the Aichilik River extensively, and this use coincided with the presence of caribou. Information is lacking on the use of the coastal plain by wolves in late May to June. Minimum population estimate for the study area were 27 adults and seven pups in late summer 1984, not including five known and three suspected mortalities.

Wolf Prey Utilization and Denning Behavior: H.V. Haugen, graduate student at UAF completed field work for a master's project on prey utilization and behavior of wolf packs near dens in 1984. Methods and results of his 1984 field work are summarized in ANWR Progress Report Number FY85-4 (see Appendix). Wolf packs were observed at two different den sites on the Canning River and Kongakut River in 1984. Scats were collected in each drainage, and at each den site after the wolves left. Relative prey utilization was expressed as a ratio of kg item eaten to kg of caribou eaten, as well as percentage composition calculated from an estimate of total kg eaten. Behavior of six adults and two pups was recorded at the Kongakut den from 28 May-20 July. Few wolf observations were made at the Canning den.

In 1984, 75 of 151 scats collected along the Kongakut drainage were analyzed for prey remains. More than one prey items was found in 31.6% of adults scats and 23.5% of pup scats, an increase over the 4.1% found with more than one prey species in 1983. Calculated kg of young caribou eaten, expressed as a percentage of total kg eaten, declined from 15.2% in 1983 to 4.8% in 1984 (Appendix ANWR Report No. 85-5 Fig. 2). During the same time, percentages of adult and young sheep increased from 7.1% to 12.8% and non-ungulates species increased from 0.5% to 1.9%, suggesting an increased utilization of non-caribou species in 1984.

In 1984, 46 of 190 scats collected from the Canning were analyzed. More than one prey item, was found in 15.2% of adult scats, compared with 5.9% in 1983. In 1984, moose was apparently the principle prey item, in contrast to 1983 when no moose remains were found in scats collected in the Canning drainage (Appendix ANWR Report No. 85-4 Fig. 4). Caribou utilization apparently declined between 1983 and 1984. Caribou and moose comprised 75-90% of the wolves' diet in 1983 and 1984. In 1983, caribou may have been more available to wolves along the Canning drainage, when the Porcupine caribou herd moved as far west as the Hulahula River. In 1984, the herd was not found further west than the Jago River. Prey was apparently scarce in the Canning River drainage in 1984, compared with 1983, and may have contributed to the apparent denning failure that year. Movements of Porcupine caribou may have been more favorable for Kongakut wolves, but when the herd moved out of the herd's range earlier than usual, wolves may have utilized other prey species.

During a period of 54 days, behavior of wolves was recorded at the Kongakut den. Six wolves older than pups, including one adult male, two yearling males, and two adult females and one 2-year old female were observed at the den. Two of these wolves were radio-collared in the Kongakut drainage on 27-30 June, but one, a yearling male, was never at the den following its capture. Two pups were first observed out of the den on 15 June 1984, when they were moved to an auxiliary den. The first observations of pups receiving and eating meat were on 27 June. The dominant wolves showed similar daily activity patterns.

The two dominant wolves were seen most often in the evening prior to the departure of the male at 2100-2300 h, and the morning when the male returned about 0700-1000 h. They were rarely seen at mid-day, when the male was sleeping in the willows and the female presumably was with the pups in the den. After emergence of the pups, the female was often visible during mid-day. Both adults were less visible at the den after mid-July. Non-dominant wolves were seen less frequently. No successful hunting was seen, but on three occasions, solitary wolves were observed chasing caribou, and five wolves were seen once hunting in a herd of caribou. Three wolf dens were examined during this study and physical characteristics were described.

Wolverine (*Gulo gulo*)

In 1984, USFWS-ANWR biologist F.J. Mauer initiated a study of wolverines in the northern portion of the ANWR. Methods and results are included ANWR Progress Report No. FY85-16 (see Appendix). One major objective of the 1984 study was to determine the feasibility of aerial survey techniques to measure wolverine distribution and abundance. The report summarized current knowledge about wolverines, with an emphasis on studies conducted in arctic Alaska. In 1984, observations of wolverines reported by biologists and others working in the ANWR study area were summarized. In late April 1984 aerial reconnaissance surveys were conducted to identify techniques suitable for systematic inventory of wolverine tracks and trails. Eleven observations of wolverines were reported in 1984, and 4 of 10 seen north of the continental divide were within the ANWR study area (Appendix ANWR Report No. 85-16 Fig. 3). Distribution of observations in 1984 and earlier years suggests that wolverines range throughout the coastal plain, foothills and mountain portions, but wolverine densities in the area may be low, compared to that documented in northwestern Alaska. One wolverine was observed catching and killing a ground squirrel. Single wolverines were observed feeding on a caribou carcass and a brown bear carcass.

During wolverine survey flights on 19-20 April 1984, favorable condition for aerial tracking existed only in the southeastern portion of the study area. Tracks of one wolverine were followed for about 12.8 km, tracks of two additional wolverines also were seen during the reconnaissance; an extensive track system was found on 3 May. A majority of the study area was covered with wind-packed snow, not suitable for seeing tracks. Results of this survey suggest that suitable weather and snow conditions rarely occur over a large area, but substantial data from certain areas may be collected during short time intervals.

## Small Mammals

Arctic Ground Squirrels (Spermophilus parryi) and Microtines.

In 1984, C.A. Babcock, a UAF graduate student completed field work for a master's degree study on microtine rodents and arctic ground squirrels on the ANWR coastal plain and foothills. Methods and results are presented in ANWR Progress Report Number FY85-15 (see Appendix). Objectives of this study were to: estimate the distributions and densities of ground squirrels and microtine rodent species occurring within the ANWR coastal plain; to determine habitat use and population dynamics of ground squirrels and microtine species; and to note predator use of microtines and ground squirrels. In 1984, the study was carried out from 31 May - 25 August at three study sites located on a latitude/altitude transect across the coastal plain. Microtines were sampled three times at each with a 130 x 130 m (2 ha) grid line of traps for five days at monthly intervals in both 1983 and 1984. Specimens were also obtained with snap traps and from raptor pellets. Ground squirrels were collected.

Fewer microtines were caught in 1984 than in 1983. The largest decrease was observed at the Kongakut site where a high of about 15 trappable animals per ha in 1983 declined to 1.5 trappable animals per ha in 1984. At the Katakturuk site, microtine densities appeared to decrease between early and late summer 1984. At the Okpilak Site, densities remained fairly uniform throughout the summer and between years, (Table 1).

Singing voles (Microtus miurus) were captured only at the Kongakut study area, at higher elevations in moist areas vegetated with shrub willows and forbs. Food storage piles collected by singing voles consisted primarily of Lupinus arcticus with Hedysarum spp. and Salix spp. also also present.

Densities were lower in 1984, than in 1983 and sex ratios were skewed toward females. Tundra voles (Microtus oeconomus) were trapped at all three sites in both live trap-grids and in snap traps. Although this species tends to use a wide variety of habitats, in 1984 the highest densities were found in stands of Eriophorium_ angustifolium. In 1984, a total of 24 individuals were live trapped, compared with 83 live trapped in 1983, and the sex-ratio was skewed; 28 males per four females. High over-winter mortality due to light and patchy snow probably caused the change in diversity and demography. Animals trapped at the Kongakut site had significantly smaller litter sizes than those found at the Okpilak site, suggesting they were subjected to nutritional stress. Collared lemmings (Dicrostonyx torquatus) were caught at all three sites but densities were low, (less than two per ha) and appeared to have declined between 1983 and 1984. Brown lemmings (Lemmus sibericus) were captured primarily at the coastal site at Okpilak in 1984, where 20 individuals were snap-trapped in the stand of Eriophorium in which the highest densities of M. oeconomus were found. Relatively few brown lemmings were captured at Okpilak in 1983, only five individuals were captured at the Katakturuk site in both years combined, and none were caught at the Kongakut site.

An analysis of micro-habitat use of microtine species at all three study sites observed mixed results. At the Kongakut site where only M. oeconomus was captured, the species showed a strong selection for wet micro-habitat in 1983 and both years combined (Appendix ANWR Report No. FY 85-15 Table 2). No selection was detectable in 1984 when only nine individuals were trapped.

At the Katakturuk site, M. oeconomus selected wet micro-habitat in 1984, but no significant difference in microsite selection was detected in 1983 when more animals were captured (Appendix ANWR Report No. FY 85-15 Table 3). At the Okpilak site, all species combined showed significant selection for dry (xeric and subxeric) micro-habitats in 1983 and for both years combined, but no significant selection was observed in 1984 (Appendix ANWR Report No FY 85-15 Table 4). Comparison of micro-habitat selection by species at the Okpilak site showed significant selection of dry micro-habitats by Dicrostonyx and wetter micro-habitats by M. oeconomus, suggesting that strong interspecific competition was avoided at this site.

Mircotine rodents are primary prey for short-tailed weasels (Mustela erminea) and least weasels (Mustela nivalis). One short-tailed weasel was captured in 1983 at Okpilak site where the highest incidence of microtine nest predation (24.3%) was observed. Two least weasels were caught at the Kongakut site in 1984 where 13.5% of nests examined had been disrupted by predation. Microtines are important prey species for avian predators in ANWR, primarily snow owls (Nyctea scandica) and jaegers (Stercorarius spp.). Only one snowy owl was seen at the Okpilak site in 1984, although they were commonly seen in 1982. Jaegers nested at both Okpilak and Katakturuk sites in both 1983 and 1984. Rough legged hawks, which nested at Katakturuk both years, had two surviving chicks in August 1984. Raptor pellets collected at the Katakturuk site (1983 and 1984) and Okpilak site in (1983) showed a higher percentage M. oeconomus at Katakturuk. Proportions of Lemmus and Dicrostonyx were not significantly different in the two areas. Only 2% of the skulls from Okpilak pellets and 18% of the skulls from Katakturuk pellets were M. oeconomus, although trapping data indicated that this species out numbered lemmings at both sites. These data suggest that avian predation takes place when lemming populations are high and that lemming populations fluctuate widely in density.

In 1984, arctic ground squirrels (Spermophilus parryi) were collected from all three study areas. Squirrels lived in extensive colonies at the Kongakut area on river bluffs and rock outcrops, but were limited to river bluffs and dunes at Katakturuk and Okpilak sites. Sex ratios were equal at all sites and mean weights ranged from 500g - 725 g. Dispersal of young from natal dens occurred in July and August. Squirrels were observed feeding on forbs and herbaceous plants or plant parts. Grizzly bears preyed on squirrels at all three sites, and rough legged hawks hunted colonies at Kongakut and Katakturuk sites in 1984, as did golden eagles at the Kongakut site.

Other Studies

From 15-21 August 1984, during an a field trip to the Hulahula River to look for pika (Ochotona collar is), mammals were collected by S. MacDonald and G. Jarrell (Table 1). All specimens were deposited in the University of Alaska Museum. No pika were found during the trip.

Table 1. Mammals collected at the Upper Hulahula River valley (69° 05'N, 144° 37'W), 15-21 August 1984 (data source: letter from S.O. MacDonald, letter to G.W. Elison, 30 August 1984, ANWR-USFWS, Fairbanks files).

| Scientific name | Common name |
|---|---|
| Spermophilus parryi | arctic ground squirrel |
| Sorex cinereus | shrew |
| Sorex monticolus | shrew |
| Clethrionomys rutilus | red-backed vole |
| Microtus oeconomus | tundra vole |
| Microtus miurus | singing vole |
| Mustela nivalis | short tailed weasel |

From 5-10 June 1984, during a field trip to confirm a sighting of an Eskimo Curlew, R. Gill and M. Amaral saw several mammals near their campsite on the Hulahula Rivers (Gill and Amaral 1984). Mammals observations were summarized from the annotated species list in their trip report (Table 2).

Table 2. Mammals observed near the Hulahula River southeast of Kikiktat Mountains, 5-10 June 1984 (data source: Gill and Amaral 1984).

| Scientific name | Common name | Number seen |
|---|---|---|
| *Spermophilus parryi* | arctic ground squirrel | numerous |
| *Erethizon dorsatum* | porcupine | 1 |
| *Canis lupus* | wolf | tracks |
| *Vulpes vulpes* | red fox | 2 |
| *Ursus arctos* | grizzly bear | 4 |
| *Gulo gulo* | wolverine | 1 |
| *Alces alces* | moose | 2 |
| *Rangifer tarandus* | caribou | numerous antlers |
| *Ovis dalli* | Dall sheep | numerous |

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Chapter 6

# FISH

## Fairbanks Fishery Resources Station Studies

Four separate fisheries investigations were undertaken in the 1002c study area within the Arctic National Wildlife Refuge (ANWR) in 1984: 1) fisheries investigations in Beaufort Lagoon; 2) distribution of Arctic char in the Hulahula River; 3) fall movements of Arctic char in the Aichilik River; and 4) movements and overwintering of Arctic grayling. These investigations were accomplished during June, July, and August, except for the telemetry studies where relocation efforts were made periodically throughout the fall and winter. All of the work was accomplished by the U.S. Fish and Wildlife Service (USFWS) Fairbanks Fishery Resources Station (FFRS) personnel with assistance from ANWR and University of Alaska staff. Methods and results are presented in Fishery Resources Progress Report No. FY85-1 (see Appendix).

### Fisheries Investigations in Beaufort Lagoon

Baseline sampling was undertaken during three separate periods (June 22-28, July 24-30, August 20-26) at Beaufort Lagoon in 1984. Large directional fyke nets and experimental gill nets were used to capture 1401 fish of ten species. Primary species were Arctic char (517), four horn sculpin (306), least cisco (201), Arctic cisco (187), and saffron cod (111). Other species were Arctic flounder (46), boreal smelt (26), eelpout (3), ninespine stickleback (3), and Arctic cod (1).

Objectives of the sampling were to determine seasonal movements, age and growth parameters, and food habits. Samples from four species were also collected for baseline contaminant and histopathological analysis; however, results from this work will not be available until 1985.

Seventy Arctic cisco and 108 Arctic char were tagged with numbered floy tags. Water chemistry parameters were measured periodically at each of the five fish sampling stations as well as at five other stations in the general area. Otoliths collected for age determination, and preserved stomach samples have been analyzed from the major fish species.

### Distribution of Arctic Char in the Hulahula River

Twenty-nine radio-tagged Arctic char, originally fitted with transmitters in the fall of 1983, were relocated throughout the winter and spring in the Hulahula River. All of the tagged fish except one remained in a spring-fed area near Old Man Creek. This site, known as Fish Hole 2, is one of the primary winter subsistence fishing areas used by Kaktovik residents and has been identified as a spawning and rearing site in previous studies.

A float trip on the Hulahula River from the headwaters in the Brooks Range to the coast was made in July 1984 in an attempt to determine summer char distribution in the drainage. No adult char were captured or observed at any site indicating that at least most of the fish had already migrated to coastal lagoons. Juvenile char were captured and observed throughout the system but appeared to be primarily associated with the spring areas. Water chemistry parameters were measured at various locations along the river.

Recoveries from char tagged on the Hulahula River with numbered floy tags in the fall of 1983 were recorded. Twenty-four of the 2,228 tags (1.08%) were recovered either by subsistence or sport fishermen or USFWS biologists. Recoveries were made at the tagging site and elsewhere in the river as well as in saltwater areas. One fish recovered from Beaufort Lagoon had moved approximately 130 km from its tagging site.

Fall Movements of Arctic Char in the Aichilik River

Arctic char were captured near the mouth of the Aichilik River between August 8 and August 18, 1984 in an effort to determine timing of the spawning run and implant fish with radio transmitters. Unusually high and turbid water hampered sampling efforts and only 110 char were captured. Of these, 32 were tagged with numbered floy tags and 5 implanted with transmitters. Subsequent aerial tracking of the radio-tagged fish lead to the identification of a spawning/overwintering site approximately 65 km upriver.

Movements and Overwintering of Arctic Grayling

Arctic grayling were surgically implanted with radio transmitters on three different river systems during August 1984. Four brands of transmitters, varying in size, signal strength, and battery life, were used. Fifteen transmitters were implanted in fish near the confluence of Itkilyariak Creek and the Sadlerochit River, three transmitters were put in grayling near the confluence of Akutoktak Creek and the Okpilak River, and eleven were implanted in fish in the lower Tamayariak River.

During the last tracking effort (October 30 to November 1, 1984) 11 of the 29 (38%) tagged grayling were relocated. Representatives of all four brands were still functioning and major migrations from the tagging sites were noted for each of the three river systems.

One of the fish tagged at the mouth of Itkilyariak Creek was found in Lake Schrader, approximately 71 km upstream from the release site. Two other tagged grayling were found in an aufeis area about 6 km below the lake outlet. Three of the fish were found in the Sadlerochit River near the tagging site but their condition is in question due to the apparent lack of overwintering habitat in that area.

Two of the three grayling tagged in the Okpilak River system were relocated in the Hulahula River. One was found at Fish Hole 1 and the other at Fish Hole 2, both of which are known char overwintering sites. For the tagged fish to reach these locations, they had to move down the Okpilak River to the mouth, travel a short distance to the Hulahula River through a brackish delta, and then travel up the Hulahula to Fish Hole 1 and 2, requiring a total migration of 64 km and 98 km respectively from their release site.

The three Tamayariak system grayling that were relocated were all found in the lower Canning River approximately 42 river km from their tagging site. The Tamayariak and Canning Rivers share a common mouth in a large delta and would require little travel in brackish water from one system to the next.

Overall the grayling telemetry project has been highly successful in testing available transmitters of a size suitable for implantation in grayling, in procedures for handling and surgical implantation of transmitters of these fish, and in identifying previously unknown movement patterns and overwintering areas of grayling on the refuge.

## Other Studies

In addition to studies conducted by the USFWS FFRS, an aquatic survey of the Kaktovik dredging operation was conducted in 1983 and 1984 by L.G.L. Alaska Research Associate, Inc. for the North Slope Borough (Craig 1985). Methods included collecting fish samples with seines and gill nets and measuring turbidity and suspended sediments of surface water samples. In 1983 and 1984, this study found levels of water turbidity and suspended sediments were very high at the stockpile overflow, ( 999 NTU and 12,370-14,340 mg/L, respectively). Average turbidities decreased to 38 NTU at a distance of 25 m from the stockpile overflow, and 9-16 NTU in the remainder of the embayment within which the dredging operation was located. Turbidity at these sites was higher than the 3-9 NTU observed in Kaktovik Lagoon but were within the range of naturally occurring turbities in coastal waters. Suspended sediments likewise were less in the drege embayment and similar to averages observed in Kaktovik lagoon. Fourhorn sculpin were the most abundant species of the 203 and 215 fish caught in 1983 and 1984. Arctic chart and arctic cisco were also important species. Composition and abundance of fish caught in this study were similar to these observed in 1975 by Griffiths et al. (1977), when catch per limit effort data were compared. More fourhorn sculpin were caught in the very turbid waters within 25 m of the dredge stock pile outflow than in Kaktovik lagoon. Reasons for their attraction to this disturbed area are not known. Arctic char and arctic cisco were uniformly distributed throughout the study area. The average size of Arctic char caught in 1983 and four horn sculpin area than these caught in 1984 and tended to be smaller in the outflow area than those caught elsewhere. No fish mortalities were observed at the gravel stockpile and outflow areas in 1983 and 1984. The study concluded that dredging operations probably did not adversely affect local fish populations. The dredge operation deepened the center of the embayment and hypersaline water may collect in this pit making it uninhabitable for fish.

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# CHAPTER 7

# HUMAN HISTORY AND ARCHEOLOGY

## Subsistence

### Kaktovik

In 1984, one technical paper containing information about subsistence use in the Arctic National Wildlife Refuge (ANWR) was completed by the Alaska Department of Fish and Game (ADF&G) Division of Subsistence (Pedersen and Coffing 1984). This study was begun in 1980 to document caribou hunting patterns and harvest levels in the village of Kaktovik as part of a long term project to examine land and resources in that community. The purpose of this report was to describe the spacial requirements of caribou hunters, define where and when hunting took place document the annual caribou harvest levels including sex and herd affinity of harvested animals, and discuss these results in context of the on-going petroleum exploration and development activities in north eastern Alaska.

Methods included asking caribou-hunting households to delineate on maps the total extent of their caribou hunting activities over time. From 1980-1983 detailed maps were collected for 20 of 37 households and twelve other households contributed to aggregate information. The information obtained was thought to be close to 100% of the total area used by Kaktovik caribou hunters. Households not interviewed were members of extended families which had been interviewed. In 1982 and 1983, hunting households were asked to identify areas of highest caribou harvest over time. Caribou harvest information was collected in 1981-1984 during participant observations of hunts, in-season interviews, and systemic village-wide surveys.

Results of this study included maps delineating the total minimum estimate of the extent of land use associated with caribou hunting from 1923 to 1982. The identified area covered the entire ANWR coastal plain study area as well as other areas to the west and south. Hunting primarily took place along the coast by boat during the ice-free months of summer and inland by snow machine in late fall and early spring. Between July 1981 and June 1982, 43 caribou were harvested by 14 households in seven different location. Of the 37 animals for which sex and harvest location were known, 17 (46%) were taken along the coast in July and August 19, (51%) were taken in March-May and 1 (3%) was killed on the coast in October. Bulls comprised 77% of the known harvest in 1981-1982. Between July 1982 and June 1983, a minimum of 110 caribou including 82 bulls and 28 cows were harvested by 26 households in Kaktovik. Eighty-six caribou (78%) were taken in July and August along the coast while 19 (17%) were harvested in April or May and 5 (5%) were taken in September and October. More than half the harvest was shot on or near Barter Island. In 1982-1983, 75% of the known harvest were bulls. At the beginning of the 1983-1984 harvest year, 29 caribou including 16 bulls and 13 cows were taken by eight Kaktovik households at three coastal locating. This report concluded that coastal sites may receive more repeated use over time than inland sites that harvest levels vary considerably from year to year, and that variability may be due in part to availability of caribou during post-calving movements. A trend for harvesting more bulls than cows was also seen, particularly in summer. This study discussed the general range of the

Porcupine and Central Arctic caribou herds and indicated that animals taken in summer east of the Sadlerochit were from the Porcupine herd and that animals taken in October, April or May on the Canning River were most likely Central Arctic animals. Animals taken in the foothills and mountains south of Barter Island were probably from the Central Arctic herd, but Porcupine caribou also overwinter in this area. The study found that harvest sites documented in 1981-1984 occurred within the "subsistence use area" described as the general caribou hunting area used by Kaktovik residents during the past 50 years , and also fell within areas perceived as being intensively used for caribou hunting.

This report discussed the overlap of caribou harvest areas with the ANWR study area which may be subjected to further petroleum exploration and development in the near future. It was suggested that lack of harvest in the highly industrialized areas west of the Canning River may be due to hunter avoidance of developed areas as well as confusion about harvesting regulations. Although harvests were rather low during this study, caribou were identified as the major local terrestrial resource. This study also stated that adequate conservation measures should be established to insure the viability of caribou herds and continued access to caribou herds by Kaktovik residents.

## Chapter 8

# IMPACTS OF GEOPHYSICAL EXPLORATION

## Impacts on Vegetation and Surface Stability

### USFWS Studies

In 1984, U.S. Fish and Wildlife Service (USFWS) - Arctic National Wildlife Refuge (ANWR) botanists N.A. Felix and M.T. Jorgenson assessed the impacts of the 1984 winter seismic exploration program on the vegetation, thermal regime, and visual resources of the Arctic Coastal Plain of ANWR. Methods and results are reported in ANWR Progress Report No. FY85-1-Impacts (see Appendix). Objectives of this study were to determine the snow cover needed to provide adequate protective cover and minimize surface disturbance, to determine the relative sensitivity of vegetation types on the arctic coastal plain, to determine which traffic patterns minimize surface disturbance, and to determine recovery times needed for different levels of disturbance. In 1984, changes in vegetation and soils associated with various levels of disturbance were assessed on 16 intensive study plots (30m x 4m) and 52 photo trend plots (10 m x 4m).

Vegetation disturbance in wet lowland areas ranged from compression of standing dead and slight surface scuffing to compaction of the moss mat below the water surface. Disturbance in tussock tundra ranged from scuffing of tussocks and less than 25% decrease in vegetative cover, to mound top destruction with ruts starting to form, with over 50% decrease in vegetative cover, and over 15% peat exposed. Disturbance in Dryas river terrace commonly included over 50% vegetation damage and over 15% soil exposed. Generally, soil exposure was limited to the surface of the organic layer. Thaw depth increases (p 0.05), ranging from 2.7 - 7.8cm, occurred in 35% of the disturbed plots within all vegetation types (Table 10). Track depression, due to a combination of compaction and thaw settlement, was evident at 1 plot in moist sedge, prostrate shrub tundra where the average track depression was 8.9cm. A summary of the impacts of vehicle disturbance by vegetation type were summarized (Appendix, ANWR Report No. FY85-7, Appendix Table B-1).

The relationship between disturbance levels, vegetation types, traffic patterns, and snow cover was examined using interpretation of color infrared aerial photographs (1:6000 scale). Higher level disturbances occurred more often in vegetation types with high micro-relief and those dominated by birch (Betula nana), dryas (Dryas integrifolia subsp. integrifolia), and ericaceous shrubs (Vaccinium vitis-idaea, Ledum palustre subsp. decumbens) than in wet lowland habitats. Camp move vehicles (cat-trains) caused higher disturbance levels than seismic vehicles. Narrow, concentrated trails (both camp move and seismic) caused higher levels of disturbance than diffuse trails. Nodwell turns created more disturbance than straight Nodwell trails. A reliable understanding of the relationship between snow cover and disturbance was not achieved (Appendix, ANWR Report No. FY85-7, Tables 16-26). However, routing camp moves and locating campsites in drainages and other areas of high snow accumulation was effective in reducing disturbance. Recommendations to reduce the level of disturbance caused by future winter seismic exploration included avoiding narrow, concentrated vehicle trails; routing vehicle traffic and locating campsites in less sensitive vegetation types and areas of high snow cover; and strict monitoring to prevent leaks and spills of oil, diesel, and gasoline.

Other Studies

Two other studies finalized in 1984 examined the effects of vehicles on tundra vegetation. Envirosphere (1984) conducted a study to compare the effects of dynamite and vibrator seismic exploration on visual quality, soils, and vegetation five years after exploration activities occurred. Vibrator trails were more visible than dynamite trails in Tussock Tundra and Moist-Wet Sedge Tundra, according to analysis of aerial photos (1:18000 scale) and helicopter and ground-level observations. This difference was attributed to different traffic patterns, since dynamite trails were generally wide and diffuse and vibrator trials were narrow. Vegetative cover data and tussock damage assessments indicated the vibrated areas in Tussock Tundra were more damaged than track areas which were travelled but not vibrated. No significant vegetative changes were found on dynamite trails in tussock Tundra, but 64% mineral soil was still present at dynamite shot holes. In Moist Sedge/Frost Barren Tundra, there was a significant increase in exposed mineral soil and peat due to decreased cover of vascular plants and mosses on tracks and vibrated areas in the one vibrator site studied. In Moist Sedge, Prostrate Shrub Tundra, vibrator trails remined visible as green trails five years after disturbance occurred. In some areas, increased flowering of cotton grass (Eriophorium angustifolium), scraped polygon rims and visible cleat marks were present. The three River Terraces and two Tall Riparian Willow Habitats studied showed variations in species response. Moss cover was significantly decreased at two sites, and grass cover was significantly increased at one site. Salix alaxensis was significantly shorter on both the vibrator and dynamite trails. Some low willow species were taller on the trail than in the adjacent control area, while others remained shorter.

Abele, et al. (1984) monitored the recovery of summer vehicle trails in Wet Sedge Tundra at two sites in northern Alaska for periods of up to ten years. Recovery of surface depression was observed on all vehicle trails at various rates. In the most dramatic case, a 15 cm depression caused by multiple passes of a light tracked vehicle (Weasel) near Barrow, Alaska rebounded to within 1 cm in five years and to natural level within ten years. The narrow tracks left by the weasels rebounded more quickly than wide tracks left by rolligons at the Barrow site. The surface depression of vehicle tracks near Lonely, Alaska recovered at a much slower rate during a five year study period. This was attributed to standing water in the tracks which slowed the recovery process. Regrowth of mosses and lichens on trails was slow with a minimum of three years before any regrowth was observed. Thaw depth increased in vehicle tracks for 2-3 years after disturbance, and then began to decrease. Recovery of thaw depth was also slower in Rolligon trails at Barrow, and in trails with standing water at the lonely site. Regrowth of vascular species was faster, and stimulated growth of some vascular plants was observed on vehicle trails. The aesthetic impact of these vehicle trails was more prominent and long-lasting than either surface depression or increased thaw depth.

## Impacts of Wildlife and Fish

Effects on muskoxen

Muskoxen are one of the few terrestrial species which remain on the ANWR coastal plain throughout the winter and may be impacted by winter seismic activities. USFWS-ANWR biologists P.E. Reynolds and D.L. LaPlant summarized movement data and observations of muskoxen made from January - May 1984 when seismic exploration activities were conducted on the coastal plain. Methods and results are described in ANWR Progress Report FY85-2 (see Appendix). The objective of the study in 1984 was to document the effects of winter seismic exploration activities on distribution and movements of muskoxen. Radio-collared animals were relocated 11 times between early January and late May 1984 and May 1984 and sightings of muskoxen obtained from aerial overflights and on the ground observations were plotted with locations of seismic lines and associated trails on 1:63,360 scale maps. Movements of herds were delineated and identified as occurring during seismic exploration, if vehicles were within 5 km of herds.

This preliminary study found that the distribution of muskoxen was the same before, during and after seismic activities in 1984 and did not differ from muskoxen distribution observed in 1982-1984. No long range movements of muskoxen were observed in response to seismic activities. Two herds apparently moved 3.0-4.5 km after seismic vehicles approached then at close range. These movements did not exceed the range of movements observed in undisturbed conditions. Muskoxen apparently were not displaced from areas of traditional use during the 1984 seismic program. Limited observations of muskoxen responding to vehicles were highly variable. Three herds did not run until they were approached within 100-400 m, herd ran when vehicles were 3.2 km away. Productivity of muskoxen was higher in 1984 (0.75 calves per cow) compared with 1983 (0.66 calves per cow) and 1982 (0.63 calves per cow) suggesting that the winter seismic exploration program did not affect overall productivity. Because of the transitory nature of the program seismic vehicles encountered muskoxen relatively infrequently, thus limiting potential effects on daily activity patterns and local movements.

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## Chapter 9

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

In 1984, review of literature continued, but as synthesis of material is incomplete, no summaries except the following were prepared for this interim report. Hobbie (1984) discussed the effects of humans on wetlands including oil spills, off-road vehicles and roads in his community profile of arctic coastal plain tundra ponds which has been summarized in Chapter 3 and 4 of this baseline update. Effects of oil spills were documented by observing for seven years the results of an experimental spill of four barrels (1.6 liter/$m^2$) of crude oil into a tundra pond near Barrow in 1970 (Barsdate et al. 1980). Most of the oil had sunk by the end of the first summer, but at least half the oil was still present after several years. The chemical composition was essentially the same after five years except for the loss of low molecular weight hydrocarbons. Zooplankton was strongly affected by the experimental spill. Fairy shrimp were all killed after one day, Daphnia after three days and Heterocope after five days. The first two organisms did not return to the pond until 1976, six years after the spill. Primary productivity of phytoplankton was reduced by 50% for several weeks after the spill and then apparently recovered completely, although the dominant nanoplankton algae was replaced by another species apparently due to removal of the zooplankton. Numbers and production of chironomids were little affected by the experimental spill but one genus was nearly eliminated, as were beetles, caddisflies, stoneflies and snails. These organisms were still absent from the pond six years later. Carex plants, in wet sites, affected by crude oil at Prudhoe Bay, were less susceptible than those in drier sites, and refined oil caused more effect than did crude oil (Walker et al. 1982). Hobbie (1984) also summarized effects of off-road vehicles as a range depending upon the source of disturbance. Removal of standing dead caused by air cushion vehicles and the depression of vegetation caused by balloon-tired vehicles, may eventually result in increased plant production. The compaction of organic layers and possible destruction of vegetation by vehicles with tires or tracks may cause melting of permafrost and thermokarsting which may result in muddy tracks, days, ponds, and aquatic or emergent communities which may not stabilize for hundreds of thousands of years. Permanent gravel roads may block drainage, and cause flooding which may result in the replacement of numerous shallow ponds with larger and deeper water bodies less valuable to water birds breeding on the coastal plain.

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Appendices

List of Appendices

ANWR Progress Report Number FY85-1

# POPULATION AND HERD DYNAMICS, DISTRIBUTION, MOVEMENTS, AND HABITAT USE OF MUSKOXEN IN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1984

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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 and herd dynamics, distribution, movements, and habitat use of muskoxen in the Arctic National Wildlife Refuge, Alaska, 1982-1984.

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Abstract: Muskoxen (*Ovibos moschatus*), transplanted to the Arctic National Wildlife Refuge in northeast Alaska in 1969 and 1970, have been studied since 1982 with the use of radio-telemetry. Forty animals were captured, measured, and marked and 38 muskoxen were radio-collared. In April 1984, the pre-calving population was estimated to be 301 muskoxen. In November 1984, 384 muskoxen were counted. The size of this transplanted population has been expanding since 1976 and has increased at an annual rate of 14-23% during the past three years. An estimated 81 calves were added to the population between late April and late June 1984. Most calves were born in mid- to late May, but the birth of calves in late June 1983 and 1984 suggests that some cows came into a second estrus. Radio-collared cows calved both annually and in alternate years. A mean reproductive interval of 1.80 years was calculated for five radio-collared muskoxen observed for three consecutive years. In early July 1984 0.75 calves per cow (3+) and 0.51 yearlings per cow (3+) were counted among 333 muskox classified. The bull(3+):cow(3+) ratio was 0.92 in 1984. Annual mortality, including a harvest of five adult bulls, was calculated to be approximately 4% in 1984. Muskoxen were most frequently seen in moderately sized mixed-sex herds of 10 to 30 animals, although herds as large as 105 muskoxen occurred. The largest mixed-sex herds were seen in April and October, and mean herd size decreased in August during the rut. Bulls also occurred in groups of 2-9 and as solitary animals, but small groups of cows or solitary cows were seen only infrequently. Many marked adult bulls did not remain with a herd for long periods of time, but moved from herd to herd. Seasonal use of specific areas was documented and dispersal into new areas, particularly in winter, also occurred in 1982-1984. Muskoxen were most frequently associated with river and creek drainages except in winter and spring when ridges and hillsides blown free of snow were used. Use of vegetation types followed a phenological progression with muskox using tussock and low vegetation uplands in May and June, early blooming forbs on river bars in early June, and riparian willow bars after their emergence in late June.

Population and herd dynamics, distribution, movements, and habitat use of muskoxen in the Arctic National Wildlife Refuge, Alaska, 1982-1984.

Muskoxen, successfully reintroduced to the arctic coast of Alaska 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 dispersing, an understanding of herd dynamics is a necessary element for evaluating the role that dispersal, movement, and distribution play 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 three years of an on-going study. Results should be viewed as preliminary.

The objectives of this study are:

1. Determine population size, 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

In 1984 the study area was located in northeastern Alaska between the Canning River and the Canadian border, 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 prepared by the Fish and Wildlife Service (USFWS 1982). Muskoxen were also seen west of the Canning River along the Kavik River, and in northwestern Canada. For purposes of this study, the study area was subdivided into the Tamayariak area, the Sadlerochit area and the Okerokovik area (Fig. 1).

Forty different muskoxen were captured in the ANWR between April 1982 and August 1984. All muskoxen were darted from a Jet Ranger helicopter using a Cap-Chur rifle, 3-10 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 2-4 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 and a canine tooth was collected from two 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 or metal ear 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).

Between April 1982 and August 1984, 38 muskoxen were radio-collared using transmitters made by Telonics (Mesa, Arizona). An experimental satellite collar provided by Telonics was put on one cow in August 1984. In April 1984, 7 collars were replaced on animals captured in 1982. By November 1984, 25 radio-collars were still functioning. Animals were relocated 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, reaction 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. Information collected in 1984 was also entered into data base computer files. Radio-collared muskoxen were relocated 19 times in 1982, 25 times in 1983, and 26 times in 1984.

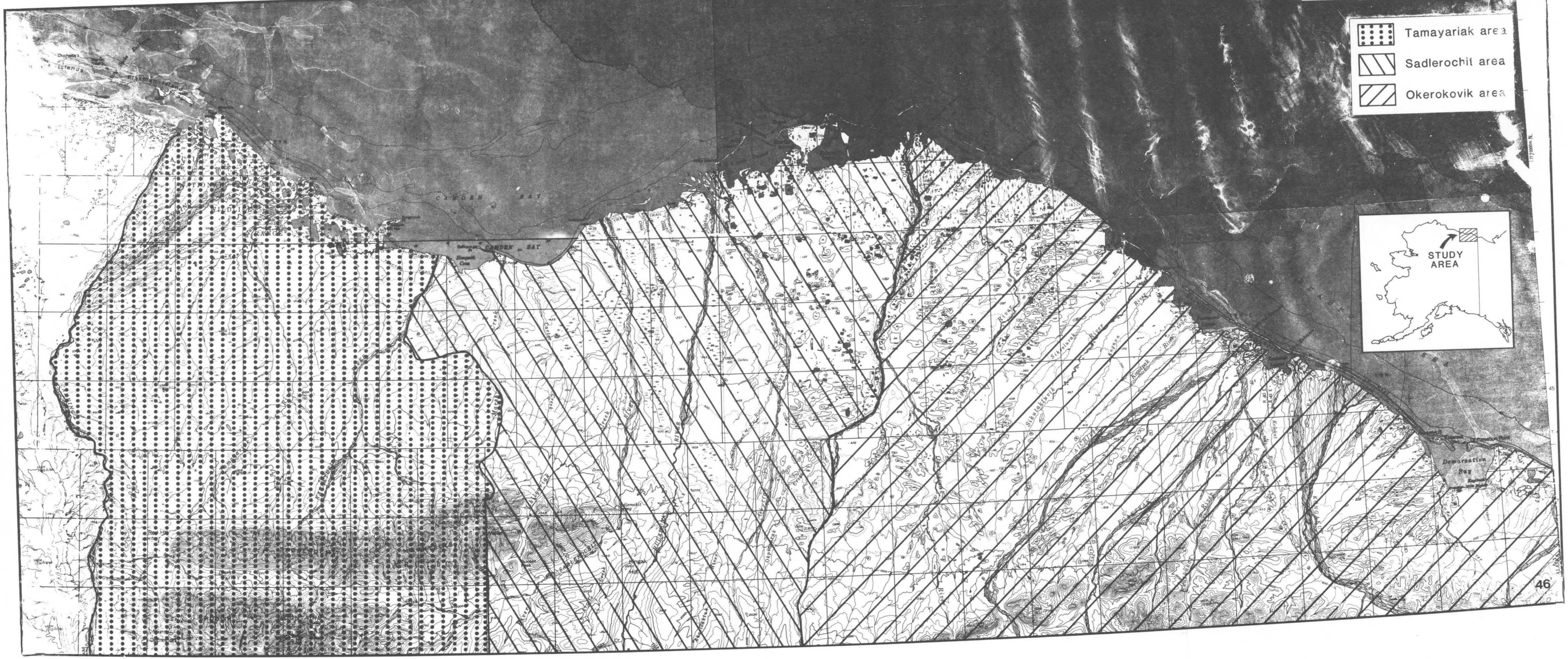
Pre-calving surveys were conducted from fixed-wing aircraft in mid-April 1982 and late March 1983 and 1984. In 1982 muskox herds were located during reconnaissance flights over the study area between the Canning River and Kongakut River. In 1983 and 1984 all major drainages between the Kavik River and the Canadian border (Clarance River) were overflown and all radio-collared muskoxen were located. 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 or 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). Composition counts were made in mid-June and late August 1983, and late June - early July 1984. Animals were classified from the ground with the aid of a Questar telescope. Fall surveys were made in late October and early November in 1982, 1983, and 1984. 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 and 1984 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. Numbers of calves were counted from the air during fall surveys. 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. Ground observations of rutting behavior, activity patterns, and habitat use of two muskox herds were made from 3 to 6 August 1984.

## Results and Discussion

### Capture and Marking Procedures

Between April 1982 and August 1984, a total of 40 muskoxen, including 16 bulls and 24 cows, were captured and marked in the ANWR (Table 1). All animals were

FIG. 1 Muskox study area on the Arctic National Wildlife Refuge



three years of age or older. Body measurements were made on 22 cows and 16 bulls between April 1982 and August 1984 (Tables 2 and 3).

Table 1. Sex and age of muskoxen captured and marked in the Arctic National Wildlife Refuge, 1982 - 1984.

| Year | Date | Adult bull | | 3-year bull | Adult cow | | 3-year cow | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | New | Recap. | New | New | Recap. | New | New | Recap. | Total |
| 1982 | 13-16 Apr | 1 | | 1 | 8 | | 5 | 15 | | 15 |
| 1983 | 2-3 Apr | 3 | | 2 | 4 | 1 | 2 | 11 | 1 | 12 |
| 1983 | 1-2 Nov | 3 | | | | | | 3 | | 3 |
| 1984 | 31 Mar-2 Apr | 4 | 2 | 1 | 3 | 5 | | 8 | 7 | 15 |
| 1984 | 24 Jun | 1 | 1 | | 1 | | | 2 | 1 | 3 |
| 1984 | 16 Jul | | 1 | | | 1 | | | 2 | 2 |
| 1984 | 29 Aug | | | | 1 | | | 1 | | 1 |
| | Totals | 12 | 4 | 4 | 17 | 7 | 7 | 40 | 11 | 51 |

Muskoxen were drugged with M-99 (Etorphine, 1 mg/ml, D-M Pharmaceuticals, Rockville, MD) (Table 4). 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 et al. 1984, Reynolds and Garner 1983). In 1984, more than half the animals handled were immobilized with single injections of M-99: 7cc for cows and 10cc for bulls. However, one adult bull, captured in July 1984 required 26cc before it could be handled. Another adult male captured three weeks earlier was completely immobilized in 10 min with 4cc M-99 or less. Variability in reaction to drugs may be due to variations in drug strength as well as weight, sex, and condition of the animal. In 1984, induction time of 10 animals immobilized with one injection ranged from 2 to 10 min ($\bar{X}$ = 8.2 ± 2.6). Recovery times for 17 animals immobilized in 1984 ranged from 5 to 11 min ($\bar{X}$ = 6.3 ± 2.2 SD). These values were similar to induction and recovery times observed during muskox capture operations conducted in 1982 and 1983 (Reynolds et. al. 1984).

Table 4. Drug dosages used to immobilize muskoxen in the Arctic National Wildlife Refuge, 1982 - 1984.

| Drug dosage used M-99/M-50-50 (cc) | Number of muskoxen drugged 1982$^a$ | | 1983 | | 1984 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F |
| 4.0 - 5.0 | | 2 | | | | | 1 | 2 |
| 7.0 - 8.0 | 2 | 10 | $1^a$ | $3^b$ | 1 | 7 | 2 | 20 |
| 10.0 - 13.0 | | 1 | $4^a$ | $4^b$ | 7 | 4 | 11 | 9 |
| 15.0 - 18.0 | | | 3 | | 1 | | 4 | 1 |
| 26.0 | | | | | 1 | | 1 | |
| Total | 2 | 13 | 8 | 7 | 10 | 11 | 19 | 32 |

[a]All animals drugged with M-99 + 0.2cc Rompun.
[b]All but one animal drugged with M-99 + 0.2cc Rompun.

Radio-collars did not function as well on bull muskoxen as on cow muskoxen (Table 5). At least 6 of 18 radio-collars put on bulls malfunctioned within two to 14 months. Four bulls lost their collars and at least two of these collars were ripped in half. Only two bull collars still functioned after 19 months.

Table 2. Body measurements (cm) of cow muskoxen captured on the Arctic National Wildlife Refuge, 1982 - 1984.

| Capture date | ID# | Est. 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 April 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 |
| 13 April 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 |
| 13 April 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 |
| 13 April 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 |
| 15 April 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 |
| 15 April 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 | - | - | - |
| 15 April 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 |
| 15 April 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 |
| 15 April 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 |
| 16 April 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 |
| 16 April 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 |
| 2 April 83 | 16 | 4+ | F | 209.3 | 202.3 | 7.0 | 11.5 | 91.5 | 71.0 | 107.0 | 39.5 | -- | 20.5 | 47.5 | 53.5 | 40.0 | 7.6 | 12.5 | 16.0 |
| 2 April 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 |
| 3 April 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 |
| 3 April 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 |
| 3 April 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 |
| 3 April 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 |
| 1 April 84 | 32 | 4+ | F | 244.0 | 235.0 | 9.0 | 12.0 | 92.0 | 85.0 | 124.0 | 40.0 | 33.0 | 30.0 | 52.0 | 55.0 | 44.5 | 6.5 | 12.0 | 14.0 |
| 1 April 84 | 33 | 4+ | F | 217.0 | 208.0 | 9.0 | 12.0 | 82.0 | 76.0 | 110.0 | 38.0 | 30.0 | 22.0 | 45.0 | 52.0 | 45.0 | 8.5 | 10.5 | 14.0 |
| 2 April 84 | 36 | 4 | F | 223.0 | 215.0 | 8.0 | 13.0 | 91.0 | 76.0 | 111.0 | 35.0 | 30.0 | 32.0 | 48.0 | 50.0 | 44.0 | 7.0 | 12.5 | 13.0 |
| 30 June 84 | 38 | 4+ | F | 213.0 | 202.0 | 11.0 | 13.0 | -- | 72.0 | 109.0 | 43.0 | 33.0 | 27.0 | 47.0 | 64.0 | 46.0 | 9.0 | 12.5 | 16.0 |
| 29 Aug 84 | 40 | 4+ | F | 215.0 | 207.0 | 8.0 | 14.5 | 94.0 | 84.0 | 105.0 | 42.0 | 32.0 | 26.0 | 48.5 | 48.5 | 40.0 | 7.0 | 10.0 | 13.0 |
| Female $\bar{X}$ | | | | 213.0 | 206.5 | 6.8 | 12.5 | 95.8 | 76.9 | 110.6 | 38.8 | 31.7 | 22.0 | 49.5 | 53.8 | 42.9 | 7.4 | 11.3 | 14.3 |
| S D | | | | 10.0 | 9.2 | 2.2 | 0.9 | 10.3 | 4.5 | 7.0 | 4.6 | 3.5 | 3.8 | 3.64 | 5.4 | 4.5 | 0.9 | 1.1 | 1.2 |

[a]Original transplant animals

Table 3. Body measurements (cm) of bull muskoxen captured on the Arctic National Wildlife Refuge, 1982 - 1984.

| Capture date | ID# | Est. 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 | Boss Width |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 April 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 | -- |
| 14 April 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 | -- |
| 2 April 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 | -- |
| 2 April 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 | -- |
| 2 April 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 | -- |
| 3 April 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 | -- |
| 3 April 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 | -- |
| 1 Nov 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 | -- |
| 1 Nov 83 | 28 | 4+ | M | 244.0 | 239.0 | 5.0 | 18.0 | 112.0 | 87.0 | 104.0 | 36.0 | 32.0 | 32.0 | 57.0 | 74.0 | 62.0 | 9.0 | 17.0 | 22.8 | -- |
| 1 Nov 83 | 29 | 4+ | M | -- | -- | 8.0 | 12.0 | 127.0 | 88.0 | 112.0 | 41.0 | 34.0 | 28.0 | 62.5 | 71.0 | 66.0 | 11.0 | 16.0 | 21.0 | -- |
| 31 Mar 84 | 30 | 5 | M | 248.0 | 239.0 | 9.0 | 12.0 | 106.0 | 84.0 | 122.5 | 44.0 | 31.0 | 25.5 | 61.5 | 67.0 | 62.5 | 8.5 | 19.0 | 24.0 | 29.5 |
| 1 April 84 | 31 | 3 | M | 243.5 | 237.0 | 6.5 | 13.5 | 91.0 | 78.0 | 123.0 | 32.0 | 32.0 | 32.5 | 53.5 | 63.0 | 58.0 | 10.0 | 18.0 | 23.0 | 20.0 |
| 1 April 84 | 34 | 4+ | M | 264.5 | 256.0 | 8.5 | 11.0 | 121.0 | 82.0 | 123.0 | 38.0 | 35.0 | 42.0 | 63.0 | 76.0 | -- | 9.0 | 16.5 | 27.0 | 32.0 |
| 2 April 84 | 35 | 4+ | M | 236.0 | 228.0 | 8.0 | 12.0 | 89.0 | 85.0 | 110.0 | 42.0 | 32.0 | 37.5 | 58.0 | 67.0 | 58.0 | 9.5 | 18.0 | 23.0 | 27.0 |
| 2 April 84 | 37 | 4+ | M | 258.0 | 247.0 | 11.0 | 13.0 | 102.0 | 83.0 | 106.0 | 33.0 | 32.0 | 43.0 | 58.0 | 70.0 | 63.0 | 10.0 | 17.0 | 20.0 | 27.0 |
| 30 June 84 | 39 | 4+ | M | 263.0 | 254.0 | 9.0 | 13.5 | 103.5 | 90.0 | 121.0 | 41.0 | 33.0 | 41.5 | 60.5 | 72.0 | 65.5 | 11.0 | 17.0 | 23.0 | 30.0 |
| Male | $\bar{X}$ | | | 239.5 | 232.0 | 7.4 | 12.9 | 106.0 | 83.9 | 114.22 | 38.6 | 33.6 | 30.9 | 59.1 | 70.0 | 60.1 | 10.2 | 17.5 | 23.5 | 27.6 |
| | S D | | | 17.9 | 17.8 | 1.8 | 1.8 | 15.5 | 4.5 | 9.9 | 5.2 | 2.7 | 7.0 | 5.2 | 5.3 | 4.2 | 1.4 | 1.4 | 2.0 | 4.2 |

Table 5. Longevity of radio-collars on bull and cow muskoxen in the Arctic National Wildlife Refuge, 1982 - 1984.

| | Total collared and/or re-collared | Number of collars | | |
|---|---|---|---|---|
| | | Functioning 19-31 months | Malfunction after 2-14 months | Lost by muskox |
| Bulls | 18 | 2 | 6 | 4 |
| Cows | 29 | 13 | 1 | 2 |

By contrast, only 1 of 29 collars placed on cow muskox malfunctioned after 14 months (Table 5). Two cows lost their collars and 13 collars still functioned after 19 to 31 months. Bull collars probably malfunctioned during antagonistic clashes prior to and during the rut. Most malfunctions and collar losses occurred between July and September.

Some problems occurred by attaching collars too loosely. At least seven collars were loose enough to slip over the boss, in some cases covering part of the face. At least one cow lost her collar in this manner. The two bulls whose collars were ripped off probably became entangled with another bull's horn during dominance fights while rutting.

Population Dynamics

The post-calving population of muskoxen in and adjacent to the ANWR was an estimated 257 animals in 1982 (Reynolds et al. 1983) and 311 animal in 1983 (Reynolds et al. 1984).

1984 Population Estimate. During the pre-calving census in early April 1984, 301 muskoxen were counted between the Kavik River and the Canadian border. In November 1984, 384 muskoxen including an estimated 78 calves were counted during a census of the same area. (Table 6). Observation conditions were excellent during the fall census. Herds were spread out and easy to count from the air.

The ANWR muskox population has increased by a factor of 10 since 1972 and has doubled since 1980 (Table 7). The annual mean rate of increase between 1974 and 1984 was 19%. Jingfors and Klein (1982) calculated an apparent rate of increase of 24% in the ANWR muskox population between 1977 and 1980. This introduced muskox population increased at a relatively slow rate for the first three or 4 years after the transplant when small herds were only producing a few calves each year, but has increased rapidly since 1976 (Fig. 2).

1984 Composition. In early July 1984, 333 muskoxen including 69 calves and 264 animals older than calves were classified between the Tamayariak and Kongakut Rivers. Eight animals including three calves were classified on the Kavik River in early August 1984. Composition data were collected on about 89% of the estimated population in 1984 (Table 6). Most of the animals not classified during the July composition counts were probably small mixed-sex herds in the Tamayariak area.

Composition data collected in July 1984 were compared with composition data obtained in August 1983 (Table 8). The percentage of adults bulls classified was higher in 1984 than in 1983. Adult bulls radio-collared in the fall of 1983 and the spring of 1984 were used to locate bull groups during 1984 composition counts. Some bulls were probably missed during composition counts in 1983 when fewer bulls were radio-collared.

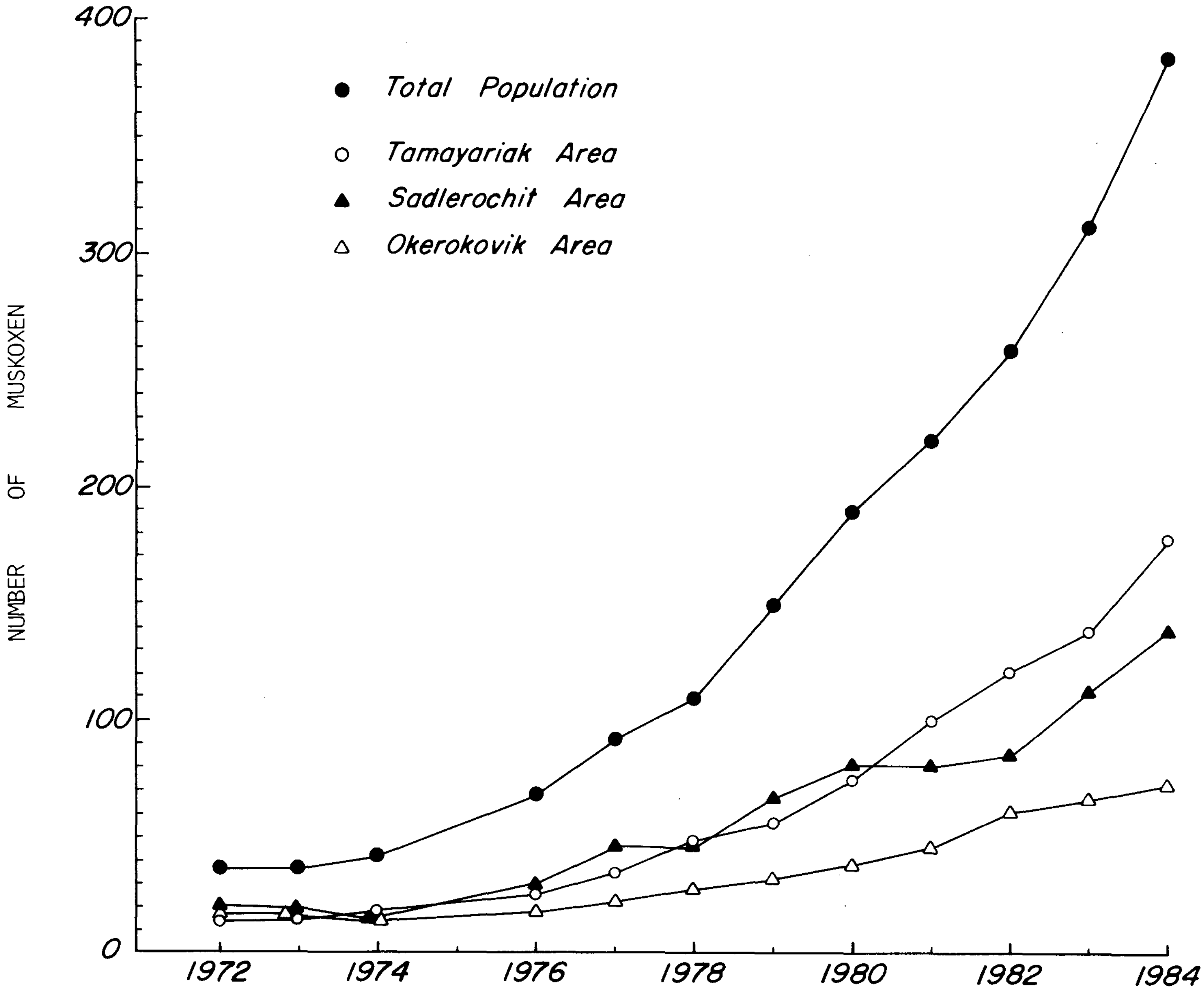



Fig. 2. Estimated numbers of muskoxen in post-calving populations in the Arctic National Wildlife Refuge, 1972 - 1984.

Table 6. Numbers of muskoxen observed in and adjacent to the Arctic National Wildlife Refuge during spring census, summer composition counts, and fall census in 1984.

| | Spring census 2-11 Apr 1984 | Summer composition 3-4 July 1984 | Fall census 30 Oct-1 Nov 1984 |
|---|---|---|---|
| Kavik[a]: | | | |
| Number older than calves | 8 | 5 | 3 |
| Number of calves | | 3 | 3 |
| Totals | 8 | 8 | 6 |
| Tamayariak-Katakturuk: | | | |
| Number older than calves | 133 | 99 | 135 |
| Number of calves | | 30 | 35 |
| Totals | 133 | 129 | 170 |
| Sadlerochit: | | | |
| Number older than calves | 101 | 105 | 110 |
| Number of calves | | 26 | 28 |
| Totals | 101 | 131 | 138 |
| Okerokovik-Kongakut: | | | |
| Number older than calves | 59 | 60 | 58 |
| Number of calves | | 13 | 12 |
| Totals | 59 | 73 | 70 |
| Study area total: | | | |
| Number older than calves | 301 | 269 | 306 |
| Number of calves | | 72 | 78 |
| Totals | 301 | 341 | 384 |
| Calves per ox older than calf | | 0.27 | 0.26 |

[a] Classified in early August

In 1984, the bull:cow ratio was 0.92 for animals three years or older. Gray (1973) found an equal ratio of bulls to cows on Bathurst Island after a stressful winter. In other areas, more cows were seen (Tener 1965, Hubert 1977, Miller et al. 1977, all as cited in Gunn 1982). In areas where conditions were favorable and muskox populations were expanding, more bulls than cows were observed (Tener 1965, Spencer and Lensink 1970).

In 1984, the composition counts were made in early July to insure that all calves had been born. In 1983, differences in numbers of calves observed in early June and late August suggested that some calves were born after the June 1983 composition counts (Reynolds et al. 1984). On 3-4 July 1984, 4 calves were seen in 4 different herds which appeared to be less than one week old. These calves were considerably smaller and darker in color than calves born in late April and May and had difficulty keeping up with the herd when the animals were walking rapidly.

Productivity and Calf Survival. In this study calf:cow ratios were calculated assuming that productive cows were three years of age and older (3+), although some 2-year old cows were observed with calves on the Sadlerochit River in the highly productive year of 1979 (Jingfors and Klein 1982). In 1984, a ratio of 0.75 calves per cow (3+), was calculated for the entire ANWR Study area

Table 7. Estimated numbers of muskoxen in the Arctic National Wildlife Refuge, 1972-1984.

| Date | Tamayariak[a] area | | Sadlerochit area | | Okerokovik[b] area | | Total | | Data source |
|---|---|---|---|---|---|---|---|---|---|
| | no. | i | no. | i | no. | i | no. | i | |
| Summer 1972 | 10 | | 14 | | 12 | | 36 | | Roseneau and Warbelow 1974 |
| Summer 1973 | 11 | 0.09 | 11 | 0.00 | 14 | 0.14 | 36 | 0.00 | Roseneau and Warbelow 1974 |
| Summer 1974 | 14 | 0.21 | 12 | 0.08 | 12 | 0.00 | 38 | 0.05 | USFWS 1982 |
| Summer 1976 | 24 | 0.21 | 27 | 0.28 | 16 | 0.13 | 67 | 0.22 | USFWS 1982 |
| Summer 1977 | 31 | 0.23 | 40 | 0.33 | 19 | 0.16 | 90 | 0.26 | USFWS 1982 |
| Spring 1978 | 32 | | 36 | | 18 | | 86 | | Ross 1978 |
| Summer 1978 | 42 | 0.24 | 46 | 0.13 | 20 | 0.05 | 108 | 0.17 | Ross 1978 |
| Spring 1979 | 44 | 0.27 | 42 | 0.14 | 26 | 0.31 | 112 | 0.23 | Ross 1979 |
| Spring 1980 | 54 | 0.19 | 65 | 0.35 | 29 | 0.10 | 148 | 0.24 | Ross 1980 |
| Spring 1981 | 72 | 0.25 | 78 | 0.17 | 36 | 0.19 | 186 | 0.20 | Ross 1981 |
| Spring 1982 | 97 | 0.26 | 79 | 0.01 | 43 | 0.16 | 219 | 0.15 | Current Study |
| Fall 1982 | 111 | | 80 | | 49 | | 240 | | Current Study |
| Spring 1983 | 119 | 0.18 | 81 | 0.02 | 57 | 0.25 | 257 | 0.15 | Current Study |
| Fall 1983 | 137 | 0.19 | 110 | 0.27 | 64 | 0.23 | 311 | 0.23 | Current Study |
| Spring 1984 | 141 | 0.16 | 101 | 0.20 | 59 | 0.03 | 301 | 0.15 | Current Study |
| Fall 1984 | 176 | 0.22 | 138 | 0.20 | 70 | 0.09 | 384 | 0.19 | Current Study |

i = rate of increase per year.

[a]Includes muskoxen on the Kavik River and Katakturuk River in 1983 and 1984.

[b]Includes muskoxen between the Egaksrak River and the Canadian border in 1983 and 1984.

Table 8. Observed composition of muskox herds on the Arctic National Wildlife Refuge in 1983 and 1984.

| Age-sex class | | Tamayariak area[a] | | Sadlerochit area | | Okerokovik area[b] | | Totals | |
|---|---|---|---|---|---|---|---|---|---|
| | | 26-28 Aug 1983 | 3-4 July 1984 | 26-28 Aug 1983 | 3-4 July 1984 | 26-28 Aug 1983 | 30 Jun-3 Jul 1984 | Aug 1983 | July 1984 |
| Adult bulls | # | 15 | 22 | 8 | 24 | 4 | 20 | 27 | 66 |
| | % | 15 | 16 | 11 | 18 | 12 | 27 | 13 | 19 |
| Adult cows | # | 24 | 27 | 18 | 29 | 6 | 13 | 48 | 69 |
| | % | 24 | 20 | 24 | 22 | 18 | 18 | 23 | 20 |
| 3-yr. bulls | # | 6 | 10 | 2 | 10 | 2 | 2 | 10 | 22 |
| | % | 6 | 7 | 3 | 8 | 6 | 3 | 5 | 7 |
| 3-yr. cows | # | 10 | 13 | 8 | 10 | 4 | 4 | 22 | 27 |
| | % | 10 | 10 | 11 | 8 | 12 | 5 | 10 | 8 |
| 2-yr. bulls | # | 8 | 4 | 7 | 6 | 4 | 5 | 19 | 15 |
| | % | 8 | 3 | 9 | 5 | 11 | 7 | 9 | 5 |
| 2-yr. cows | # | 5 | 9 | 4 | 8 | 2 | 4 | 11 | 21 |
| | % | 5 | 7 | 5 | 3 | 6 | 5 | 5 | 6 |
| Yearlings | # | 12 | 19 | 12 | 18 | 4 | 12 | 28 | 49 |
| | % | 12 | 14 | 16 | 14 | 12 | 16 | 13 | 14 |
| Calves | # | 21 | 33 | 17 | 26 | 8 | 13 | 46 | 72 |
| | % | 21 | 24 | 22 | 20 | 24 | 18 | 22 | 21 |
| Totals | | 101 | 137 | 76 | 131 | 34 | 73 | 211 | 341 |

[a]includes herds on the Kavik and Katakturuk Rivers.

[b]includes bull groups between the Aichilik and Kongakut Rivers.

(Table 9). Productivity was high in all areas, but appeared to be the highest in the Tamayariak area where 0.83 calves per cow (3+) were observed in 1984.

Table 9. Calf:cow ratios observed in muskox herds in the Artic National Wildlife Refuge in 1983 and 1984

| | Tamayariak area | | Sadlerochit area | | Okerokovik area | | Total | |
|---|---|---|---|---|---|---|---|---|
| | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 |
| # calves classified | 34 | 40 | 26 | 39 | 10 | 17 | 70 | 96 |
| # cows(3+) classified | 21 | 33 | 17 | 26 | 8 | 13 | 46 | 72 |
| #calves per cow | 0.62 | 0.83 | 0.65 | 0.67 | 0.80 | 0.76 | 0.66 | 0.75 |

During ground composition counts in July 1984, 0.27 calves per animal older than calf were observed compared with 0.26 calves per animal older than calf seen during aerial fall counts (Table 6). Assuming the percentage of adult and 3-year old cows in the population was 28% (Table 8), the total number of animals in the population was 384 (Table 6), and the total number of cows in the population was 108 (0.28 x 384), the total number of calves produced in 1984 can be estimated as follows:

$$\frac{\text{total \# calves}}{\text{total \# cows}} = \frac{\text{\# calves observed in July}}{\text{\# cows observed in July}}$$

Also, calves comprised 21% of the animals classified in July 1984 (Table 8). Assuming the 72 calves classified represented 89% the total population, the total number of calves produced in 1984 can be estimated as follows:

$$\text{total \# calves} = \frac{\text{\# calves observed}}{\text{\% of population observed}}$$

Using either method to calculate the number of calves, an estimated total of 81 calves was produced in 1984. During the fall census in early November 1984, an estimated 78 calves were observed from the air (Table 6), indicating low mortality rates for calves during the first summer.

Productivity, based on calf:cow ratios, remained high in 1984 and may be increasing. In late June 0.75 calves per cow were seen compared with 0.63 calves per cow recorded in 1982 (Table 10). But ratios calculated for 1982 are probably less accurate than those obtained in 1983 and 1984 due to the smaller sample classified in 1982.

Table 10. Calves, yearlings and 2-year olds per cow (3+) observed in the Arctic National Wildlife Refuge in 1982, 1983 and 1984.

| | Calves/cow(3+) | Yearlings/cow(3+) | 2 year olds/cow(3+) |
|---|---|---|---|
| 1982[a] | 0.63 | 0.61 | --- |
| 1983[a] | 0.66 | 0.47 | 0.49 |
| 1984 | 0.75 | 0.51 | 0.38 |

[a]Data from Reynolds et al. 1983, Table 8.

Calf production was reported as high as 0.89 calves per cow (2 years+) in the ANWR Sadlerochit area in 1979 (Jingfors and Klein 1982). In other areas, muskox calf production has ranged from 0.27 to 0.85 calves per cow (Hubert 1974, Smith 1976, Lent 1978, Lassen 1984).

Yearling:cow (3+) ratios also have been relatively high during the past three years indicating that about 75% of calves survived as yearlings and at least 80% of yearlings survived as 2-year olds in 1982 and 1983 (Table 10). Jingfors and Klein (1982) reported 100% survival in calf and yearling cohorts in the Sadlerochit area between 1979 and 1980. Calf survival on Devon Island ranged from 33% to 75% (Hubert 1977, as cited in Gunn 1982).

Productivity of radio-collared cows was compared in 1982, 1983 and 1984 (Table 11). Cows were considered to have a calf if they were seen alone with a calf or in a herd with equal number of cows and calves, if they were followed closely by a calf, or if maternal behavior such as licking or nursing was observed. Cows in herds without calves were assumed to be barren.

Table 11. Reproductive status of radio-collared muskox cows in the Arctic National Wildlife Refuge, 1982-1984.

| | Est | Year | Accompanied by calf | | | Reproductive |
|---|---|---|---|---|---|---|
| ID | age | collared | 1982 | 1983 | 1984 | interval |
| 1 a | 15 | 1982 | No | Yes | No | 2 years |
| 3 b | 15 | 1982 | Yes | Yes | Yes | 1 year |
| 4 c | 4+ | 1982 | ? | a | | |
| 5 d | 4+ | 1982 | No | a | | |
| 6 e | 4+ | 1982 | ? | Yes | Yes | 1 year |
| 8 f | 4+ | 1982 | ? | Yes | Yes | 1 year |
| 9 g | 4+ | 1982 | Yes(died) | Yes | Yes | 1 year |
| 10 h | 4+ | 1982 | Yes | ? | Yes | 2 years |
| 11 i | 5 | 1982 | No | No | Yes | 3 years[b] |
| 14 j | 18-19 | 1982 | Yes | No | Yes | 2 years |
| 15 k | 5 | 1982 | ? | a | | |
| 16 l | 4+ | 1983 | | ? | Yes | |
| 17 m | 4+ | 1983 | | Yes | Yes | 1 year |
| 21 n | 4 | 1983 | | ? | Yes | |
| 22 o | 4 | 1983 | | ? | ? | |
| 23 p | 4+ | 1983 | | ? | No | |
| 25 q | 4 | 1983 | | ? | Yes | |
| 32 r | 4+ | 1984 | | | No | |
| 33 s | 4+ | 1984 | | | Yes | |
| 36 t | 4+ | 1984 | | | Yes | |
| 38 u | 4+ | 1984 | | | No | |
| 40 v | 4+ | 1984 | | | ? | |

[a] died or lost collar
[b] first calf?

Five radio-collared cows, observed for three consecutive years, produced 10 calves or 0.67 calves per cow per year. Two of five gave birth every year for three years. One of these animals (#3b) was a 15-year old cow. The other (#9g) lost her calf shortly after it's birth in 1982. Two animals produced one calf in three years. One of these cows (#11i) had a calf at age five, perhaps her first reproductive effort. The other animal, (#1a) a 15-year old cow, may be reproducing in alternate years. Another cow, at least 18 years of age (#14j) appears to have reproduced in alternate years as she had a calf in 1982 and 1984, but did not calve in 1983.

Three radio-collared cows (#6e, #8f, #17m) which were observed for two consecutive years also had a calf each year. One cow (#10h) produced a calf during two of the three years she was observed. Miller and Gunn (1979) observed cows breeding in three successive years in the High Arctic. Gunn (1982) states that the age of breeding and the breeding interval may depend on the condition of the animal and possibly on social factors.

Summarized reproductive data (Table 12) were used to calculate estimated mean reproductive intervals using the following formula:

$$\text{Mean reproductive interval} = \frac{\Sigma(n_i \times i_i)}{N}$$

Where $n_i$ = number of cows reproducing at a given interval

$i_i$ = interval in years

$N$ = total number of cows

Using data from all nine radio collared cows the mean reproductive interval was 1.56 years. Using only data from the five radio-collared muskoxen observed for three consecutive years, mean second reproductive interval was 1.80 years. Based upon this limited sample, the mean reproductive interval for ANWR muskox lies between 1.56 and 1.80 years.

Table 12. Reproductive interval of radio-collared muskox cows in the Arctic National Wildlife Refuge, 1982-1983.

| Number of years observed | Number of cows reproducing at known intervals | | | |
|---|---|---|---|---|
| | 1-year interval | 2-year interval | 3-year interval | Total |
| 3 | 2 | 2 | 1 | 5 |
| 2 | 3 | 1 | — | 4 |
| Totals | 5 | 3 | 1 | 9 |

In 1984, the percentage of observed radio-collared cows with calves closely approximated calf:cow ratios calculated for the entire population (Table 13). Numbers of radio-collared cows accompanied by calves increased from 1982 to 1984, following the same trend as calf:cow ratios for the the total population.

Table 13. Productivity of radio-collared cow muskoxen compared with productivity of the total ANWR muskox population, 1982-1983.

| Year | No. of radio-collared cows observed | No. of radio-collared cows with calves | Calves per cow (radio-collared) | Calves per cow (total population) |
|---|---|---|---|---|
| 1982 | 7 | 4 | 0.57 | 0.63 |
| 1983 | 8 | 5 | 0.63 | 0.66 |
| 1984 | 17 | 13 | 0.76 | 0.75 |

In June 1984, the first muskox calf was seen on 26 April, 26 calves were seen on 7 May, and 62 calves were seen 7-9 June. The peak of calving was probably in mid-May as was described by Jingfors (1980). But on 3-4 July 1984, 4 calves estimated to be less than one week old were observed during composition counts indicating that calves were also born 6 to 8 weeks after the peak of calving. Jingfors (1980) reported two calves born on the Sadlerochit between 12-16 June 1979. A new born calf was observed 20 June on Nunivak Island (Smith 1976). Assuming a gestation of 35 to 36 weeks (Palmer and Rouse 1936; Alendal 1971 as cited in Smith 1976), most conceptions probably occur in mid-August. Calves born in late June must be conceived in late September. Some muskox cows may enter a second estrus if they fail to conceive in August. White-tailed deer that do not become pregnant at their first estrus will come into estrus again 28 days later (Marchinton and Hirth 1984).

Behavioral observations in 1984 indicated that the rut had begun by early August. Two herds observed on 3-6 August each contained a single adult bull and no 3-year old bulls. Two adult bulls, including one 5-year old male, remained 50 to 200 m from one of these herds for at least 12 hrs. Although no agnostic behavior was observed between the herd bull and the two peripheral bulls, the latter's activity patterns of eating and resting were not synchronous with the rest of the herd (Fig. 3). Observed courtship patterns were similar to those described by Smith (1976). The bull approached and sniffed the ano-genital region of at least three cows, 3-years of age or older. One of these cows was accompanied by a calf. Two attempted mounts were documented. Flehmening (lip curling) by the herd bull was observed twice in response to fresh urine from females. One cow tolerated the bull leaning against her on two occasions. All other bull-cow encounters resulted in the cows running away from the bull.

<u>Mortality</u>. An estimate of annual mortality (including dispersal) was calculated by subtracting the annual increase of the population from the number of yearlings in the population. This method assumes that immigration of new animals into a transplanted population is unlikely to occur. The ANWR muskox population increased by 44 animals between April 1983 and April 1984 (Table 7). Total numbers of yearlings in 1984 were estimated to be 55, assuming that the total number of cows (3+) in the 1984 population was 108 and that the yearling:cow (3+) ratio was 0.51. If these estimates are correct, 11 animals were lost from the total population of 301 between April 1983 and April 1984, indicating an annual mortality rate of approximately 4%.

In November 1983, 311 muskoxen were counted in and adjacent to the ANWR study area compared with 301 muskoxen counted in April 1984 in the same area. This indicated an over-winter mortality (or dispersal) of about 10 animals or 3%. Most mortality apparently occurs between November and April. Miller et al. (1977, as cited in Gunn 1982) found most winter mortality occurred in late winter to early spring in the High Arctic.

Sources of mortality documented in 1984 included five adult bulls killed by hunters in March (Table 14). All five animals were taken from the Sadlerochit area. One adult male carcass examined in June had died the previous fall and was scavenged by a bear in July 1984. Part of a new born calf leg was found in early June indicating the calf had been killed or scavenged by predators. Two bull muskox skulls found in 1984 were from mortalities probably occurring in 1983 or 1982 (K. Whitten per com, H. Reynolds per com). A muskox hide found in the Canning River in July 1984 (D. LaPlant per com) may have been from a poached animal as no hunters reported kills from this area during the past two years.

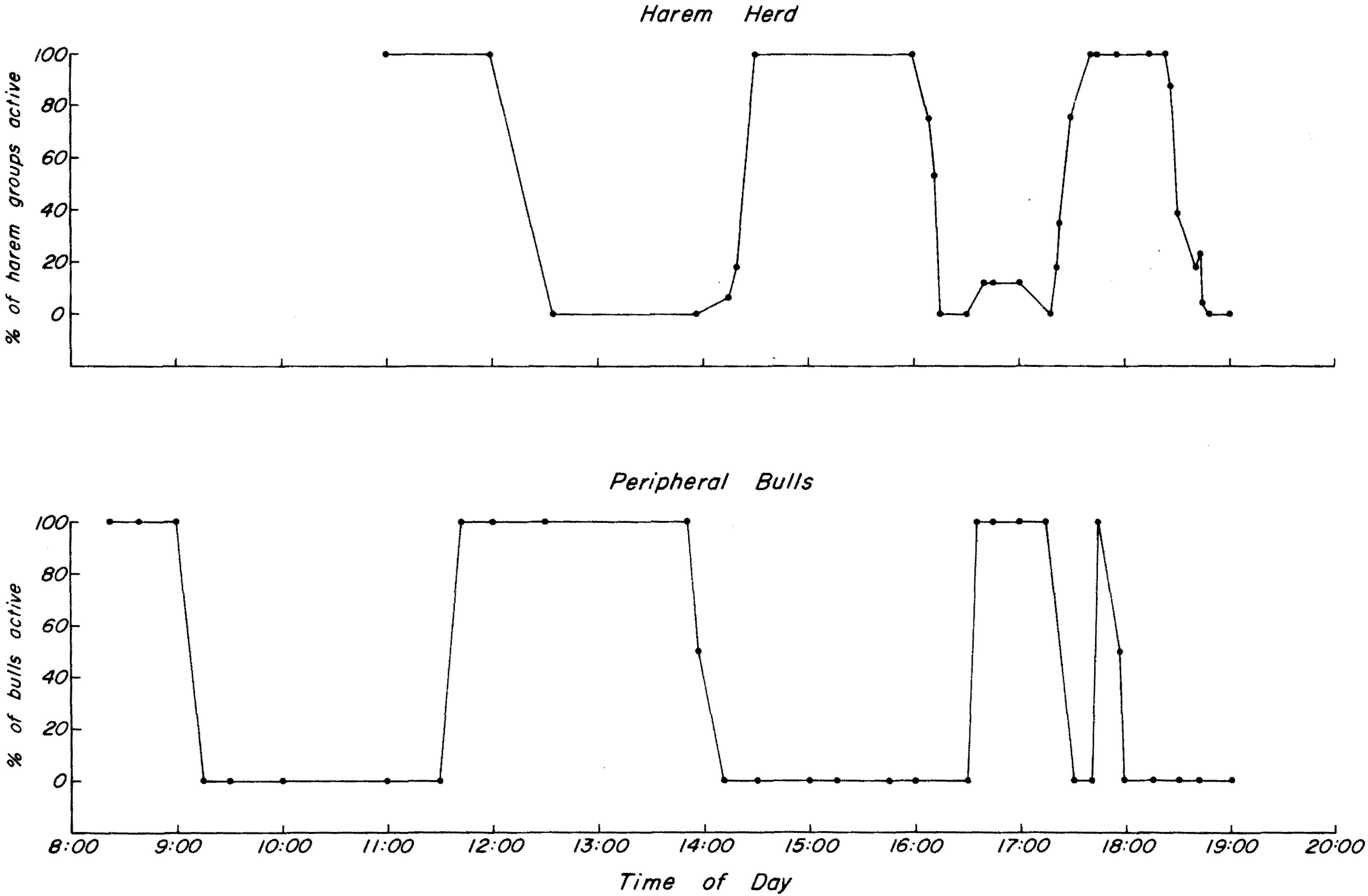



Fig. 3. A comparison of activity patterns of a harem herd of 17 muskoxen and two peripheral bulls on the Okerokovik River, 4 August 1984.

Table 14. Muskox mortalities observed on the Arctic National Wildlife Refuge, 1982 - 1984.

| | | Number | of | muskoxen | |
|---|---|---|---|---|---|
| Year | Month | Bulls(4+) | Cows(3+) | Calves | Cause of mortality |
| 1982 | March | 1 | | | Injuries from fighting |
| | May | | 1 | 1 | Unknown |
| | Oct | | 1 | | Malnutrition |
| 1982? | | 2 | | | Unknown (skulls only) |
| 1983 | March | 4 | | | Hunter kills |
| | Aug | 2 | | | Grizzly predation |
| | Fall | 1 | | | Unknown |
| 1984 | March | 5 | | | Hunter kills |
| | Spring | 1? | | | Poacher? (hide only) |
| | June | | | 1 | Predation/scavenging |
| | Totals | 16 | 2 | 2 | |

## Herd Dynamics

The use of radio-collars on both cows and bulls in 1984 demonstrated that different types of muskox herds occur in the ANWR. Most commonly seen were mixed-sex herds, comprised primarily of cows, subadults and calves, and possibly one or more adult bulls. Bull groups were made up of bulls older than three years of age. Bulls also were observed alone. Small groups of cows and cows with calves as well as single cows were seen less frequently. Gunn (1982) stated that muskoxen spend most of their life in mixed-sex herds, but bulls also occur in single-sex groups of 2-5 and as solitary animals.

Mixed-Sex Herds. Numbers of animals comprising ANWR mixed-sex herds were variable. In 1984, mixed-sex herds ranged in size from two animals (a bull and cow) to 105 animals. Smith (1976) seldom saw mixed-sex herds smaller than five animals on Nunivak Island. Monthly mean herd size, calculated from all observations of mixed-sex herds, ranged from highs of 28-32 muskoxen per herd in February, April and October to a low of 14 muskoxen per herd in August 1984 (Fig. 4). Similar seasonal changes in mean herd size were seen in 1982 and 1983 when the largest herds were seen in mid-April, late October, and early November, and the smallest herds were observed in August (Fig. 5). On Bathurst Island, Gray (1973) found monthly mean herd size changed from highs in February, April, and October to lows in July-August. On Melville Island Miller et al. (1977, as cited in Gunn 1982) also observed a decrease in average herd size from 17.2 in March-April to 10.0 in July-August.

Numbers of large and small mixed-sex herds also varied seasonally (Fig. 6). Most (52-83%) mixed-sex herds observed in ANWR in 1984 were moderately sized, ranging from 10-30 muskoxen throughout the year. The number of mixed-sex herds containing fewer than 10 animals reached a maximum in August as herds fragmented into harems during the rut. Smith (1976) describes a harem as a temporary social unit which exists only during the rut between a single bull and a group of cows, but suggests that a basic social structure independent of bulls may exist. By early October, animals congregated along rivers in large herds and the percentage of herds with more than 30 muskoxen reached a yearly maximum of 55%.

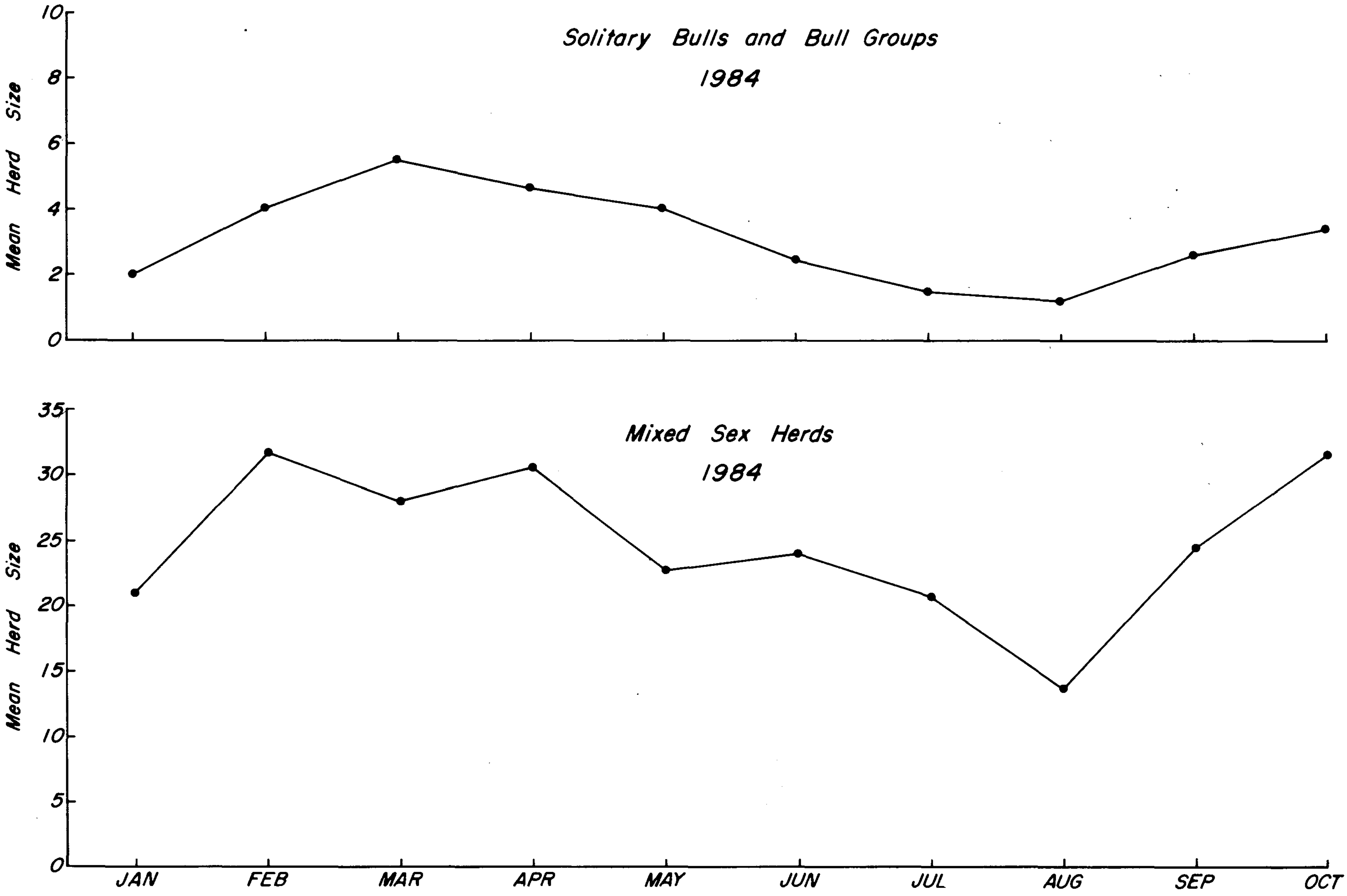



Fig. 4. Seasonal changes in the mean size of muskox herds in the Arctic National Wildlife Refuge, 1984.

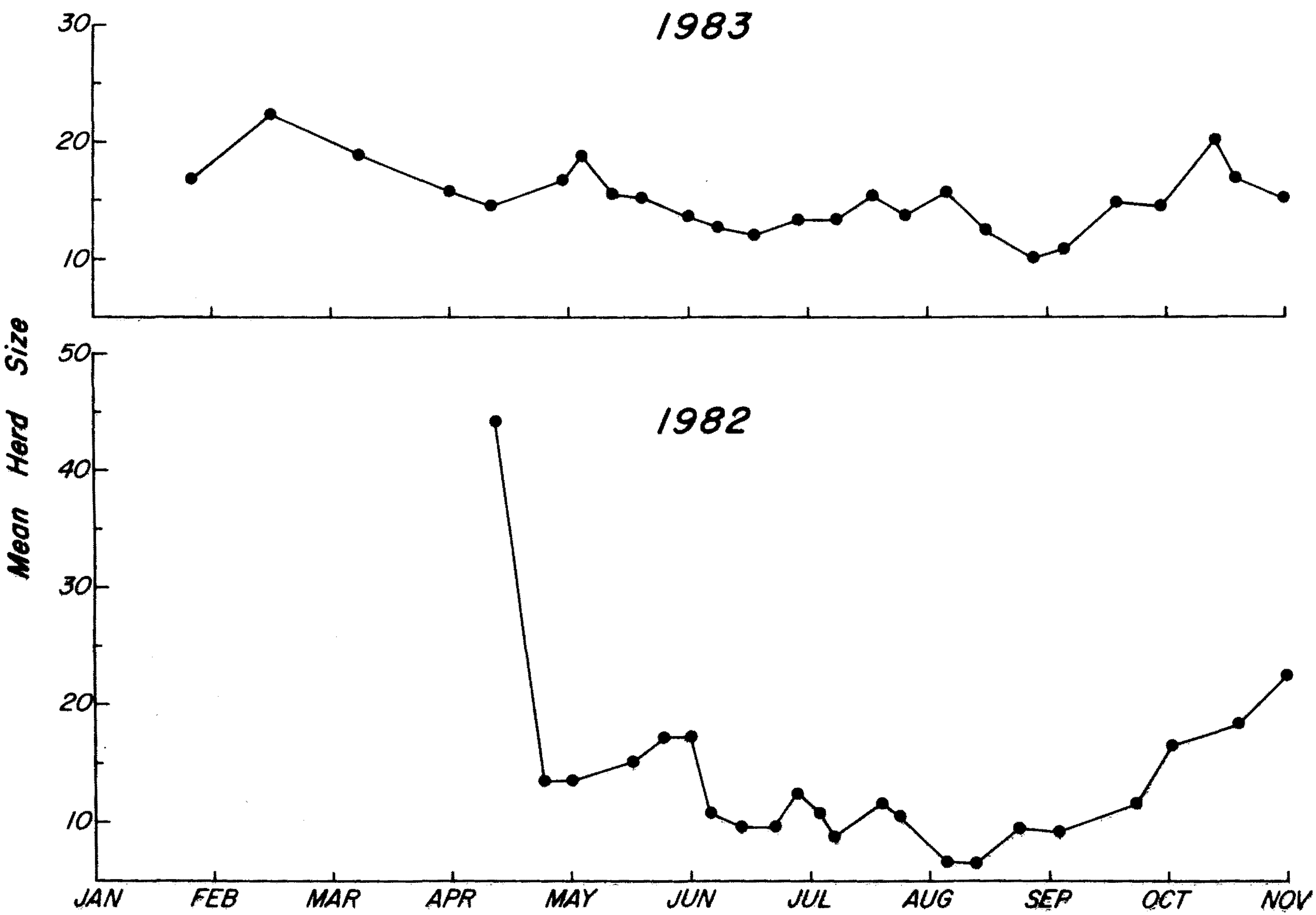



Fig. 5. Seasonal changes in the mean size of muskox herds in the Arctic National Wildlife Refuge, 1982 and 1983.

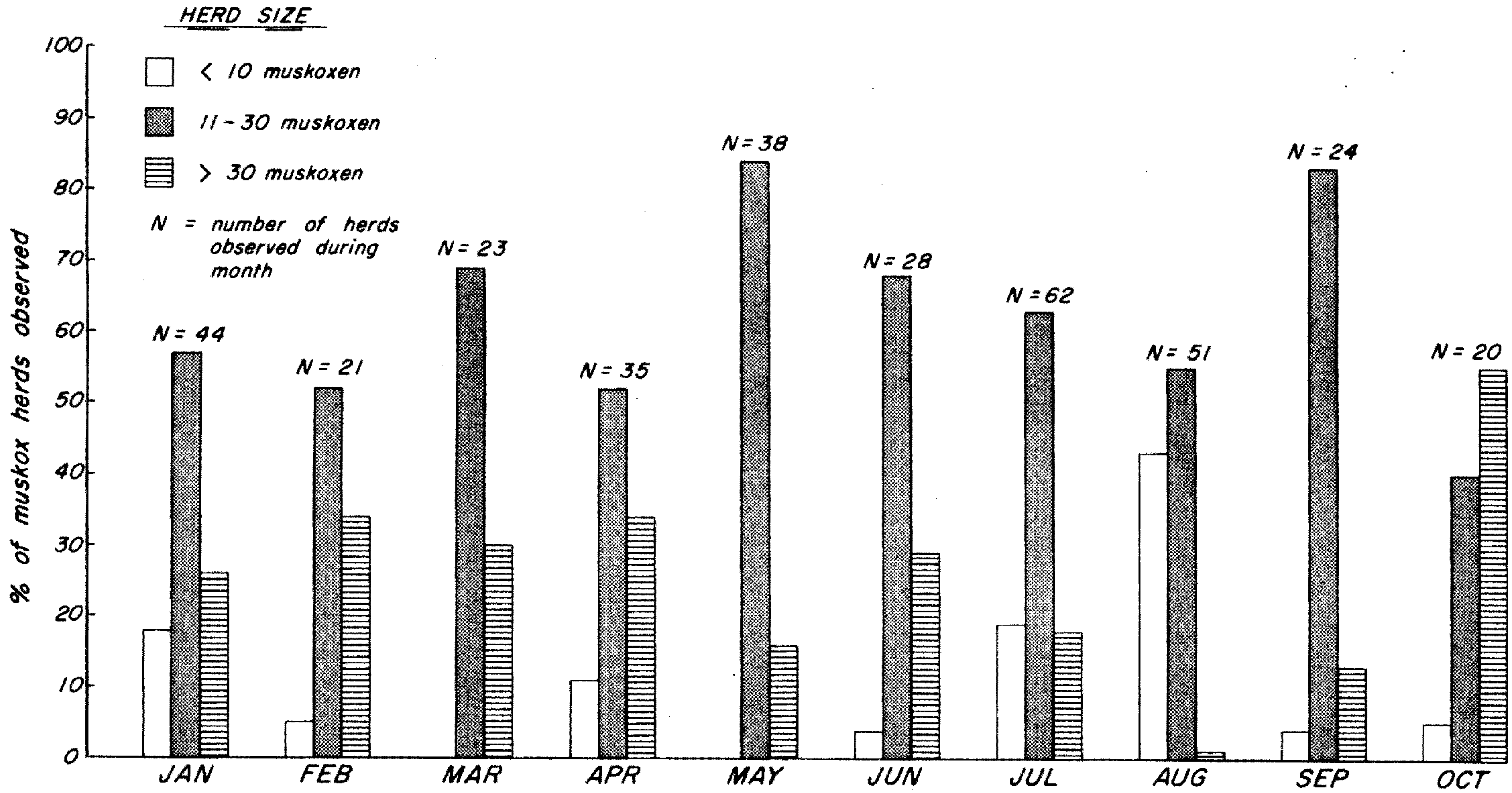



FIG. 6. SEASONAL CHANGES IN THE NUMBER OF LARGE AND SMALL MIXED-SEX HERDS IN THE ARCTIC NATIONAL WILDLIFE REFUGE, 1984.

Herd interactions and movements were derived from herd association of radio-collared muskoxen. Muskox herds observed between April 1982 and November 1984 showed variation in herd stability (Fig. 7). 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 Okerokovik area in 1984, mixed-sex herds were relatively stable in January, February and early March. In late March some herds broke into smaller units. Herds were segregated during calving and did not intermix although at least 1 herd of 24 animals fragmented into smaller groups. In mid-June and July when animals congregated on the Okerokovik River, herds intermixed. Herds fragmented into smaller groups by the onset of the rut in late July and early August. By late September, larger herds formed as animals congregated along major rivers. In October, many of the animals in the area had joined in a single large herd on the Niguanak River. Similar trends in seasonal herd stability were also seen in 1983 (Fig. 8) and 1982 (Fig. 9) in the Okerokovik area (Reynolds et al. 1984).

In the Tamayariak and Sadlerochit areas, in January, February and March 1984, mixed-sex herds were relatively stable (Fig. 10). But as animals congregated prior to and during calving in April and May, herds along the Tamayariak River and Carter Creek split up, reformed, and intermixed. In late July, large herds which had formed in June, fragmented prior to the rut.

One herd on the Katakturuk River remained relatively stable throughout the year (Fig. 10). At least 29 of these animals moved from the Tamayariak River in late October 1982 and remained along the Katakturuk River or adjacent areas throughout 1983 and 1984. Similar trends in seasonal herd stability were observed in 1983 (Fig. 11) and 1982 (Fig. 12) in the Tamayariak and Sadlerochit areas (Reynolds et al. 1984).

Bull Groups. Bull groups in the ANWR ranged in size from two to nine animals. In 1984, the mean bull group size, calculated from all observations of single bulls and bull groups, ranged from a high of 5.7 bulls per group in March to a low of 1.4 bulls per group in August during the rut (Fig. 4).

In contrast to cow muskoxen, many adult bull muskoxen did not remain with one herd for long periods of time, but moved from herd to herd. All male muskoxen marked on the ANWR were associated with bull groups or were observed alone during at least part of the year (Table 15).

In the Okerokovik area, 3-15 adult bulls were segregated from mixed-sex herds on tributaries of the Aichilik River and the Kongakut River during much of the year. One adult bull (N, Fig. 7) captured on the Angun River in April 1984, remained with a mixed-sex herd on the Egaksrak River throughout the spring, but moved east to the Kongakut River in June and remained with two or three other bulls until July. Thereafter it moved further east into Canada where it was observed alone until November 1984, except for a brief period in August when it was associated with a single cow.

A young-aged male (G, Fig. 7), caught as a 3-year old in the Okerokovik area in April 1983, remained with mixed-sex herds from the time of its capture until August 1984, when it moved east to a tributary of the Aichilik River and was observed associated with two to four other bulls until November 1984.

In the Sadlerochit area, at least one bull group over-wintered on the south slopes of the Sadlerochit River in both 1983 and 1984 and moved into mixed-sex

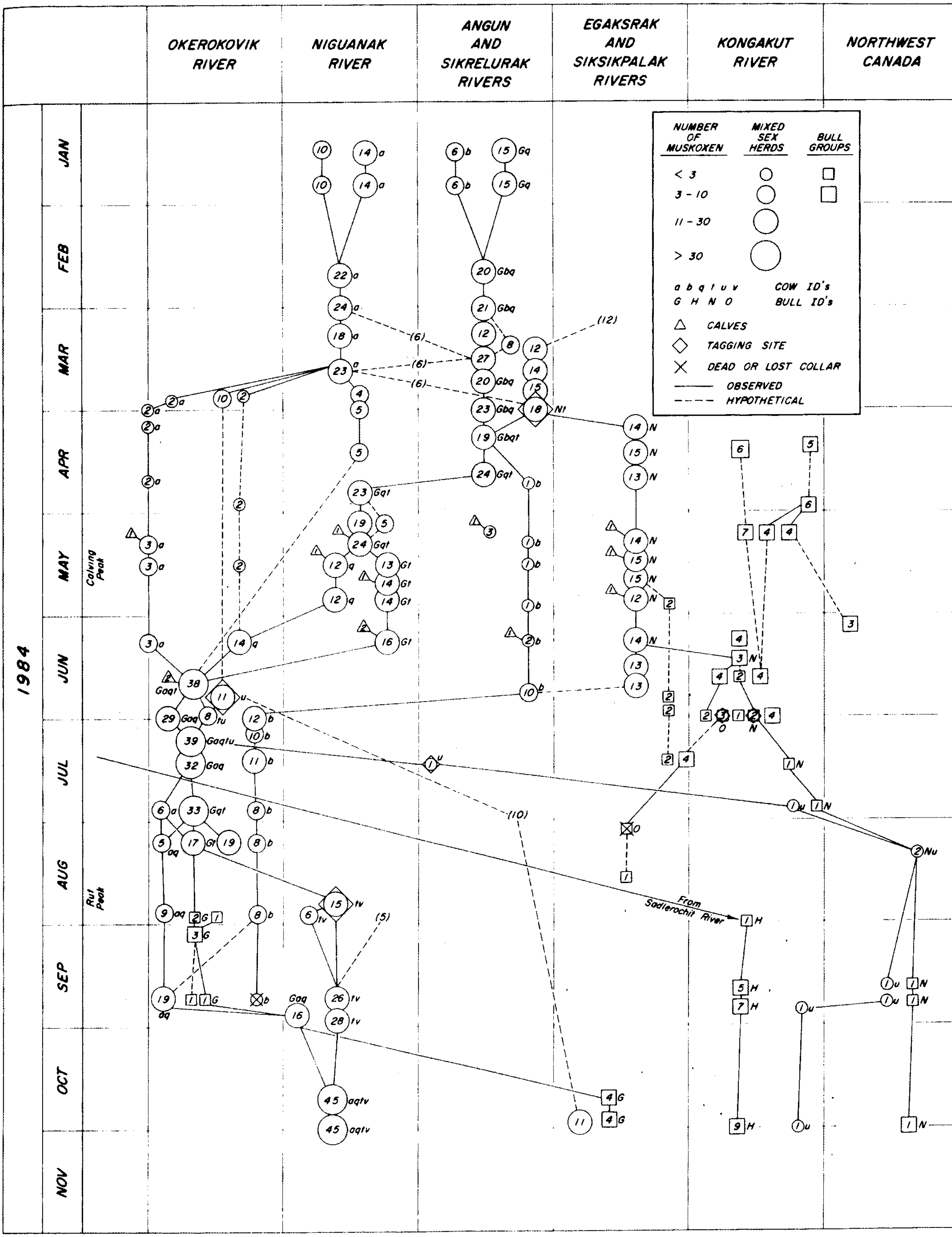



FIG. 7. INTERACTIONS AND MOVEMENTS OF MUSKOX HERDS IN THE OKEROKOVIK AREA, JANUARY - NOVEMBER 1984.

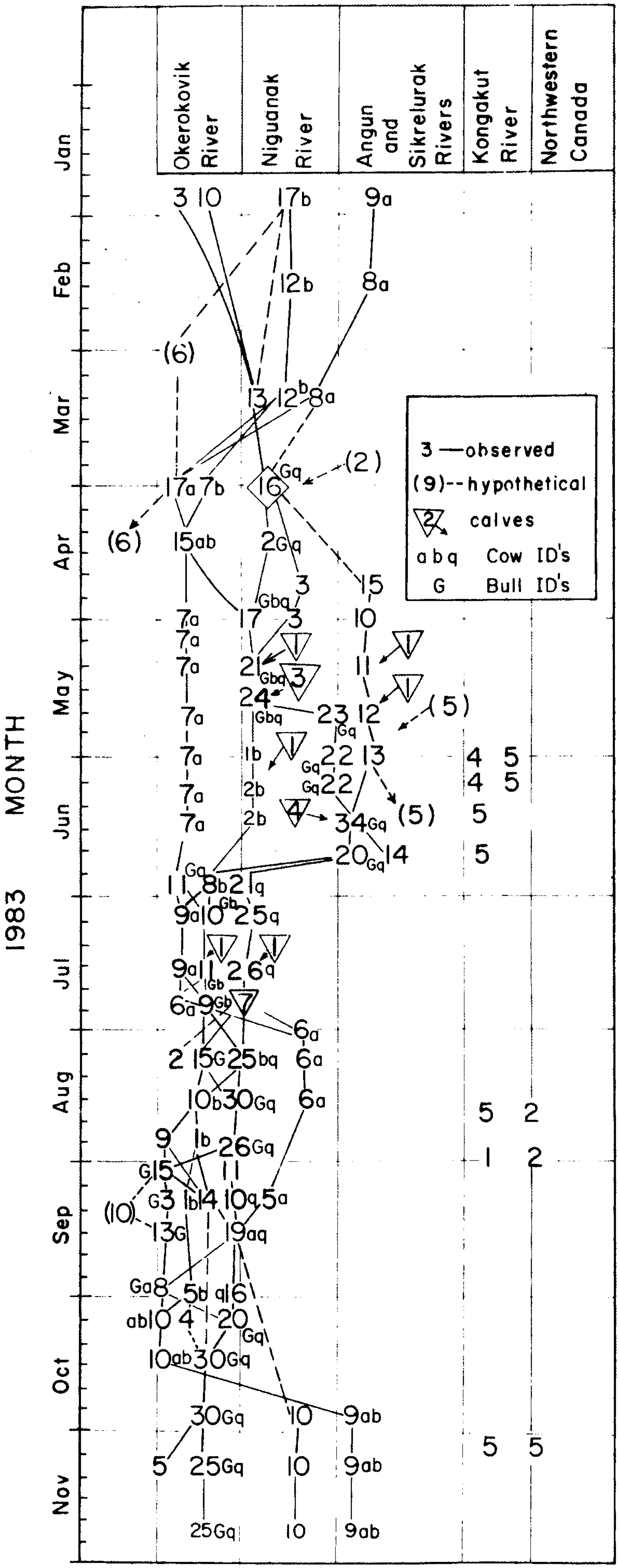



FIG. 8. MOVEMENTS AND INTERACTIONS OF MUSKOX HERDS EAST OF THE JAGO RIVER IN THE OKEROKOVIK AREA, JANUARY-NOVEMBER 1983.

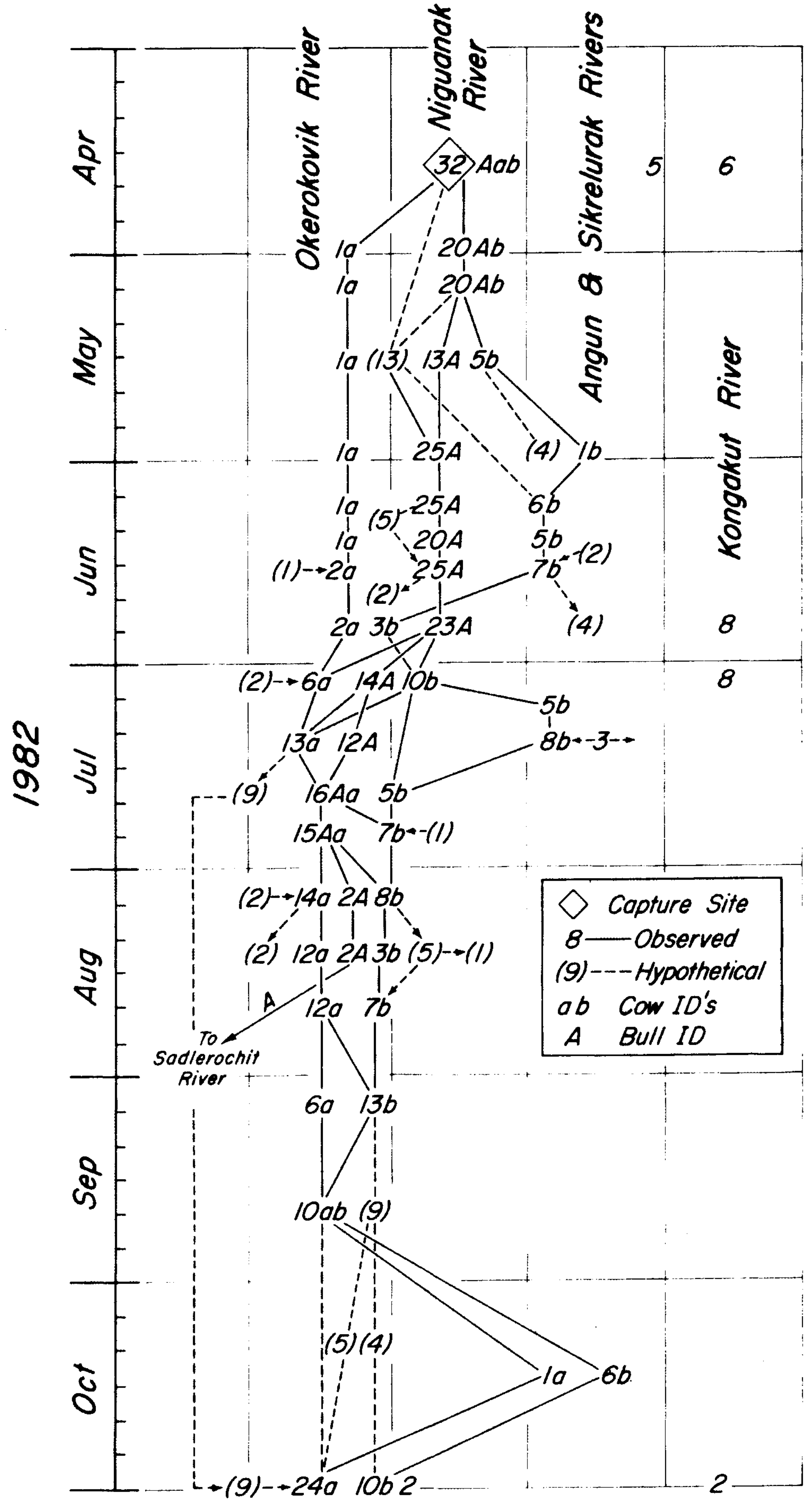



FIG. 9. INTERACTIONS AND MOVEMENTS OF MUSKOX HERDS IN THE OKEROKOVIK AREA, APRIL - OCTOBER, 1982.

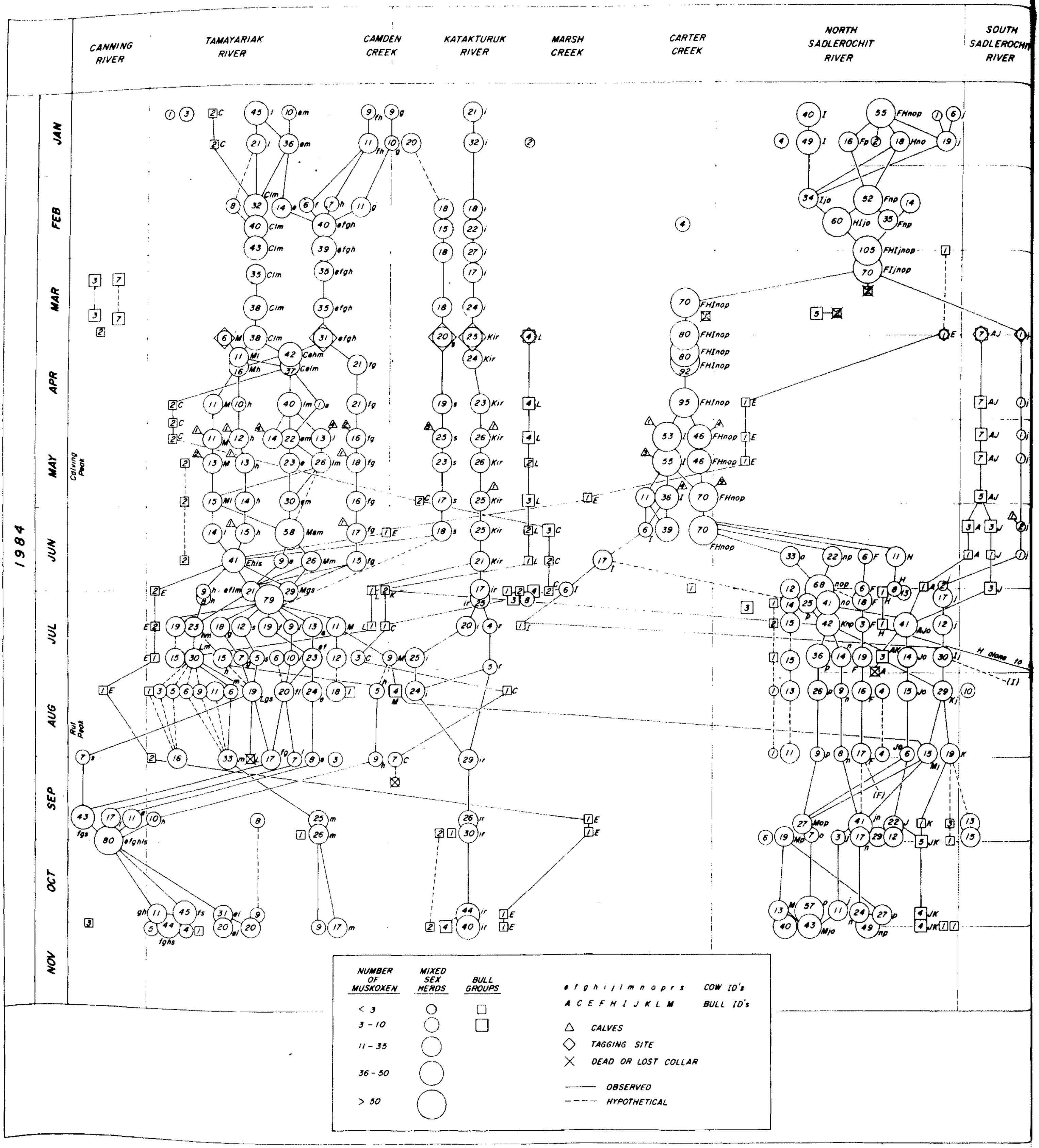



FIG. 10. INTERACTIONS AND MOVEMENTS OF MUSKOXEN HERDS IN THE TAMAYARIAK AND SADLEROCHIT AREAS, JANUARY - NOVEMBER 1984.

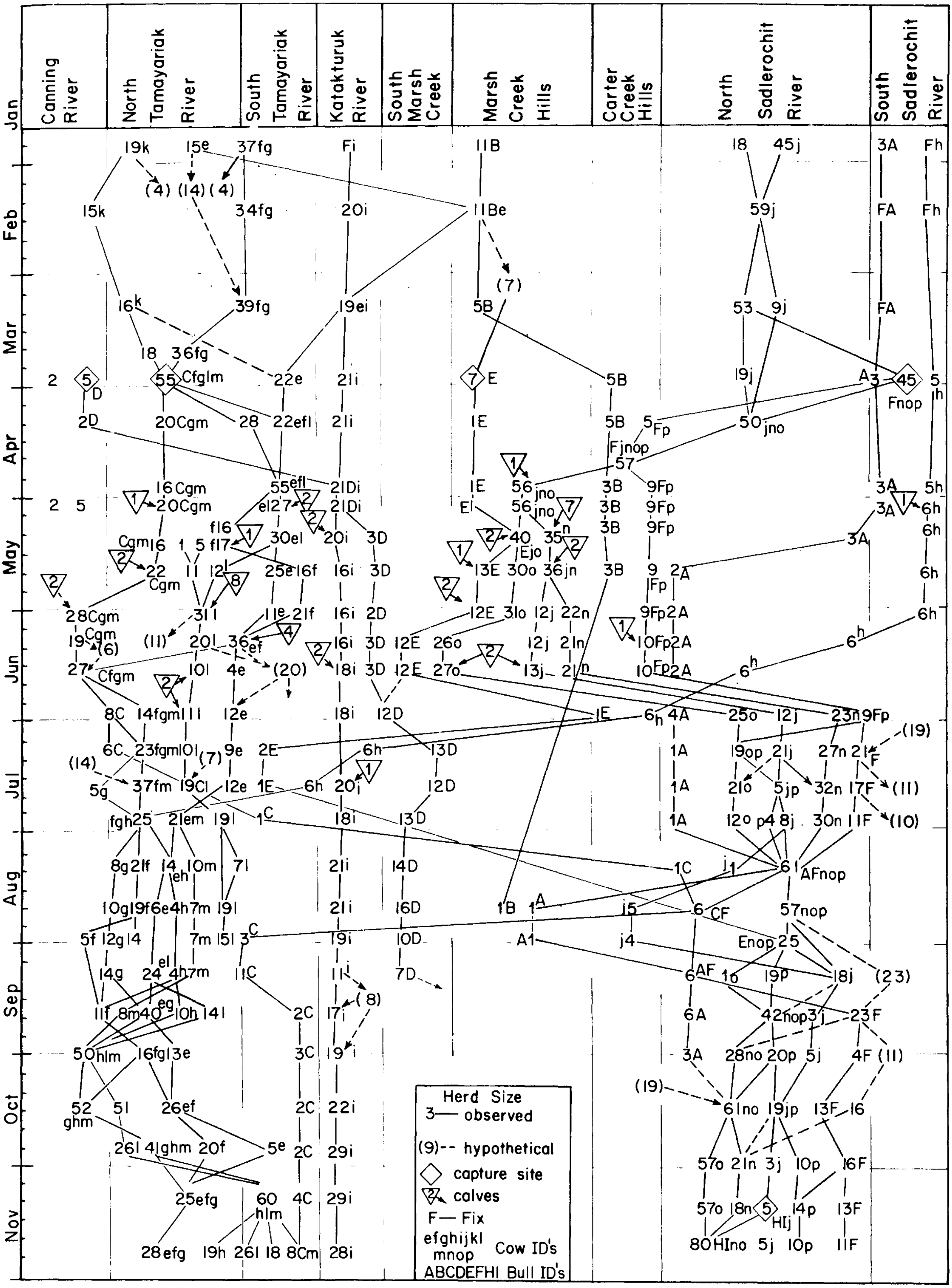



FIG. 11. MOVEMENTS AND INTERACTIONS OF MUSKOX HERDS WEST OF THE HULAHULA RIVER IN THE SADLEROCHIT AND TAMAYARIAK AREAS, JANUARY-NOVEMBER 1983.

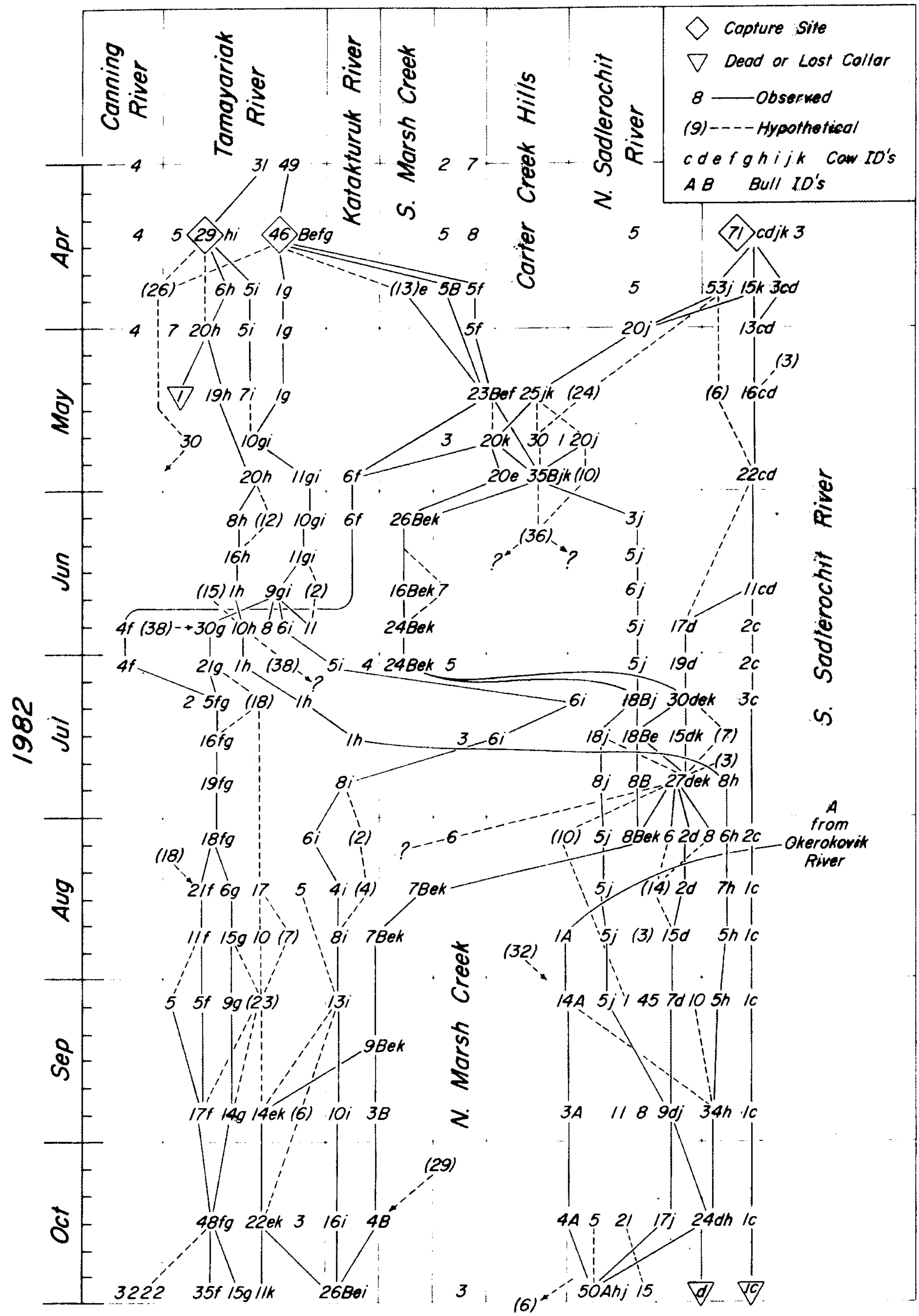
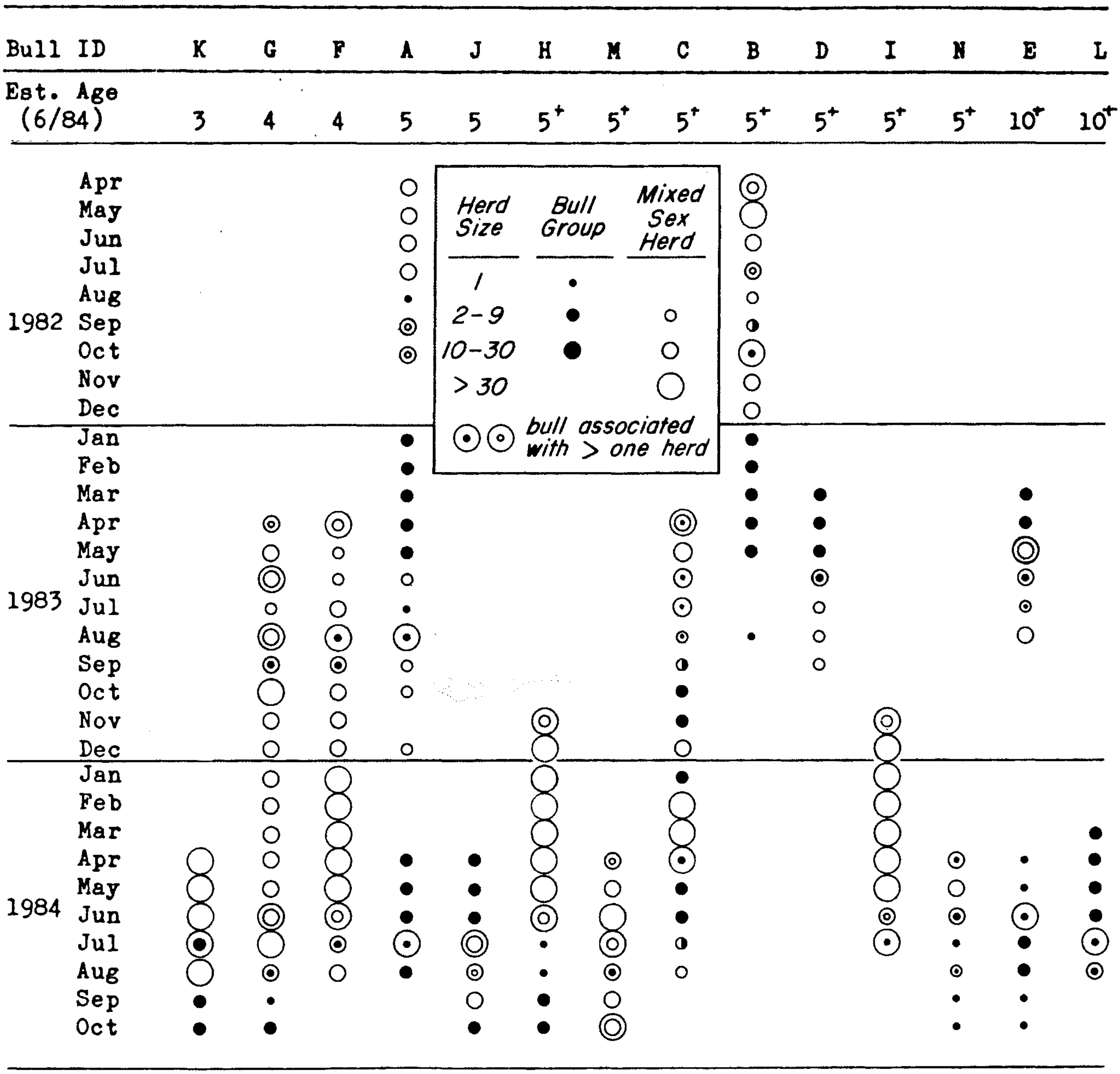



FIG. 12. INTERACTIONS AND MOVEMENTS OF MUSKOX HERDS IN THE TAMAYARIAK AND SADLEROCHIT AREAS, APRIL - OCTOBER 1982.

Table 15. Seasonal association of marked bull muskoxen with mixed-sex herds and bull groups in the Arctic National Wildlife Refuge, 1982-1984.



herds in July (A and J, Fig. 10; A, Fig. 11). In late September 1984, some Sadlerochit bulls were again observed in a bull group of four animals. Radio-collared bulls in this group were 4-and 5-year old males.

Three other radio-collared bulls in the Sadlerochit area remained with mixed-sex herds throughout the winter of 1983-84 (F, H, and I, Fig. 10). One male (H) moved alone east to the Kongakut River in July. The other two animals were observed in mixed-sex herds between July and September after which they dispersed from the area or their collars failed.

A 3-year old bull (K, Fig. 10), radio-collared on the Katakturuk River in April 1984, remained with a mixed-sex herd until July when it moved near mixed-sex herds and bull groups on the Sadlerochit River. By late September, it was associated with another marked bull in a group of 4-5 bulls.

An adult male (C, Fig. 10), captured in April 1983 in the Tamayariak area stayed with mixed-sex herds in spring 1983 and 1984, but was associated with bull groups or alone throughout the remainder of the year.

Cow Groups. Small groups of cows and single cows were seen less frequently during this study. In 1984, a 16-year female (a, Fig. 7), accompanied by a 3-year old female, split away from a herd of 23 muskoxen and moved about 30 km southwest to a bluff area adjacent to the Jago River. They remained in this area until mid-June, after which they returned to the Okerokovik River. A calf was born to the 3-year old cow in early May.

Another 16-year old female (b, Fig. 7) left a herd of 24 muskoxen on the Angun River in late April 1984 and remained alone until after it gave birth to a calf in late May or early June. It joined a herd of 10 animals in late June. This animal also was observed alone in late May and early June during the birth of calves in 1982 and 1983 (b, Fig. 8 and 9).

A mature female muskox (u, Fig. 7), who was in a herd of 39 muskox in late June 1984 on the Okerokovik River, was captured alone on the Angun River two weeks later. The animal was having difficulty walking and may have been left behind when the herd moved from the area. Within two weeks it had moved east into Canada and remained alone for the next three months, except for a short time in early August when it was observed with an adult bull. It returned west and was last seen alone on the Turner River in late October 1984.

A 17-year old female muskox (j, Fig. 10) left a large herd on the Sadlerochit River in late March 1984 and moved approximately 30 km southwest where it remained until early July when it returned to the Sadlerochit River. This animal also had a calf in late May or early June.

In 1983, a herd of five cows spent the winter in the upper Sadlerochit valley, moved to the Sadlerochit River in early June after the birth of 1 calf, and eventually moved to the Tamayariak River in late July 1983 where they joined a herd of 25 muskoxen. The radio-collared cow in this group was observed alone with a calf between late June 1982 and early July 1982, moving from the Tamayariak River to the Sadlerochit River (h, Fig. 11 and 12).

Smith (1976) seldom saw cows alone and suggested that animals which become separated quickly tried to rejoin the herd. Gunn (1982) speculated that parturient cows would be unlikely to leave the protection of the herd to give birth. Observations during this study indicate that at least some cows are alone during birth, possibly because they or the newborn calf are unable to keep up with a moving herd. A small calf observed in late June 1984 could not keep pace with a herd of walking animals and eventually fell behind. The mother ran to the herd, but then returned to the calf.

## Distribution, Movements, and Habitat Use

General Distribution. In 1984, muskoxen observed in the ANWR were concentrated in the same geographic locations in the Tamayariak area, the Sadlerochit area and the Okerokovik area that were used in 1982 and 1983 (Fig. 13). Historical information indicates that these areas have been used by muskoxen since shortly after the animals were released at Barter Island in 1969 (Fig. 14). Lent (1971) reported observations of 5-9 muskoxen along the Sadlerochit River near Sadlerochit Springs between April 1969 and March 1970. In 1972 and 1973, 11-14 animals (including at least 8 adults) were seen along the Sadlerochit River (Roseneau and Warbelow 1974). Between 1978 and 1981, 36-74 muskoxen utilized the Sadlerochit River and adjacent Carter Creek hills (USFWS 1982). Jingfors (1984) described the home range affinity of muskoxen along the Sadlerochit River.

Muskoxen have been observed in the Tamayariak area since at least 1972. Ten to 11 animals, including 8 adults, were seen in 1972 and 1973 between the Katakturuk River and Kavik River (Roseneau and Warbelow 1974). From 1978 to 1981, 32-66 muskoxen were observed along the forks of the Tamayariak River (USFWS 1982).

In the Okerokovik area, 11-13 muskoxen, including 9 adults, were observed in 1972 and 1973 (Roseneau and Warbelow 1974). From 1978 to 1981, 14-33 muskoxen were seen along the Okerokovik, Niguanak, and Angun Rivers (USFWS 1982).

In addition to observations within the study area, muskoxen have been seen to the east of the study area in northwestern Canada (Fig. 15). Some animals moved long distances. In August 1969, within five months of being released after the Barter Island transplant, five muskox were shot in Canada as far east as the Mackenzie delta and another muskox was shot at Arctic Village 240 km south of Barter Island (Lent 1971). Solitary bulls or small groups of animals have been observed in northwestern Yukon Territory almost every year since 1972 (K. Jingfors per com, J. Russell per com, Roseneau and Warbelow 1972). During this study in 1983, as many as five bulls were observed between the Canadian border and the Firth River. These animals may be some of the same bulls observed on the Kongakut River in 1984. Also in 1984, two radio-collared muskoxen (a bull and a cow) moved separately into Canada from the Okerokovik area. The cow returned to the Turner River in late September, but the bull was still on the Babbage River in late November 1984 (Fig. 15). In August 1984, an adult bull was seen in the Romanzof Mountains, near the upper Kongakut River, 50km south of the study area.

West of the study area, single animals have also been seen since 1970 (Fig. 15). Lent (1971) reported that a solitary adult was sighted several times in the Sagavanirktok drainage during the summer and fall of 1970. At least one bull was seen on the Kavik River in 1973 (Roseneau and Warbelow 1974). In 1983 at least one bull was seen near the Kuparuk River west of Prudhoe Bay and one adult bull was reported near Galbraith Lake south of Prudhoe Bay (Reynolds et al. 1984).

At least one mixed-sex herd has also been seen west of the ANWR study area. In the fall of 1981, W. Smith, biologist with the ADF&G, observed 11-19 muskoxen near Franklin Bluffs on the Sagavanirktok River south of Prudhoe Bay. In mid-August 1982, a mixed-sex herd of 9-10 muskoxen was seen near pump station No. 3 by T. Jorgenson, University of Alaska botany graduate student. In August 1983, D. Neel, a hunting guide from Anchorage, saw a mixed-sex herd of about 10 animals on the Toolik River (R. Bortge per com). These animals may have dispersed from the Kavik River where 13 animals were released in June 1970 (Fig. 15).

A mixed-sex herd and bull groups were seen along the Kavik River in 1983 (Fig. 15). In 1983 a mixed-sex herd of 6 animals, including a bull, two cows, two 2-year olds, and one yearling, and bull groups of two and three, were seen in April and November. In 1984 a mixed-sex herd of 6-8 muskoxen was seen April, August, and November. In 1984 this herd had three cows and three calves. Muskoxen seen on the Kavik River in 1983 and 1984 were included in the ANWR population estimates.

In addition to the use of traditional geographic areas, dispersal of mixed-sex herds into new areas within the study area occurred in 1982-1984. In late June 1982, a 3-year old radio-collared cow (i, Fig. 12) moved in a herd of 6 animals from the Tamayariak River to the Sadlerochit River. 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. This herd, which has ranged in size from 16-40 animals, utilized a new area between the upper Katakturuk River and Nularvik River during the winter and spring of 1982-83 and 1983-84 (Fig. 10 and Fig. 11). Calves were seen in this herd in 1983 and 1984. The herd summered on the forks of the Tamayariak River in 1983 and the creeks south of Camden Bay in 1984, as well as the lower Katakturuk River during both summers.

A second herd, ranging in size from 15-23 animals, also moved into the Katakturuk area during the winter of 1983-84 (s, Fig. 10). These animals remained on the upper Katakturuk River throughout the winter and during calving in May, but moved back to the Tamayariak River in June 1984. Small bull groups and solitary bulls have been observed along the Katakturuk River since 1979 (USFWS 1982), but no long term use by mixed-sex herds was observed until this time.

Possible seasonal dispersal of a mixed-sex herd into a new area east of the Okerokovik area also occurred during the spring of 1984 (N, Fig. 7). A herd of 14 animals apparently moved about 30 km southeast from the Angun River to tributaries of the Ekaluakat River and Siksikpalak River in early April 1984. The animals moved shortly after an adult bull (N) in the herd was captured and radio-collared. The herd calved in this area, then apparently returned to the Okerokovik River by early July. The adult bull left the herd in mid-June and moved east to the Kongakut River and further east into Canada.

<u>Winter distribution and movements of mixed herds</u>. In January 1984, mixed-sex muskox herds observed in the Tamayariak area were found along the creeks south of Konganevik Point and the upper Tamayariak River near VABM Yari. In February 1984, some animals had moved to the uplands near VABM Tam. In March 1984, herds were again on the Tamayariak River. Similar areas were used by muskoxen during the winter of 1983 (Fig. 16). Some marked animals utilized the same geographic locations in both 1983 and 1984: cow f and cow g were observed along the creeks south of Konganevik Point in January, February, and March 1983 and January 1984.

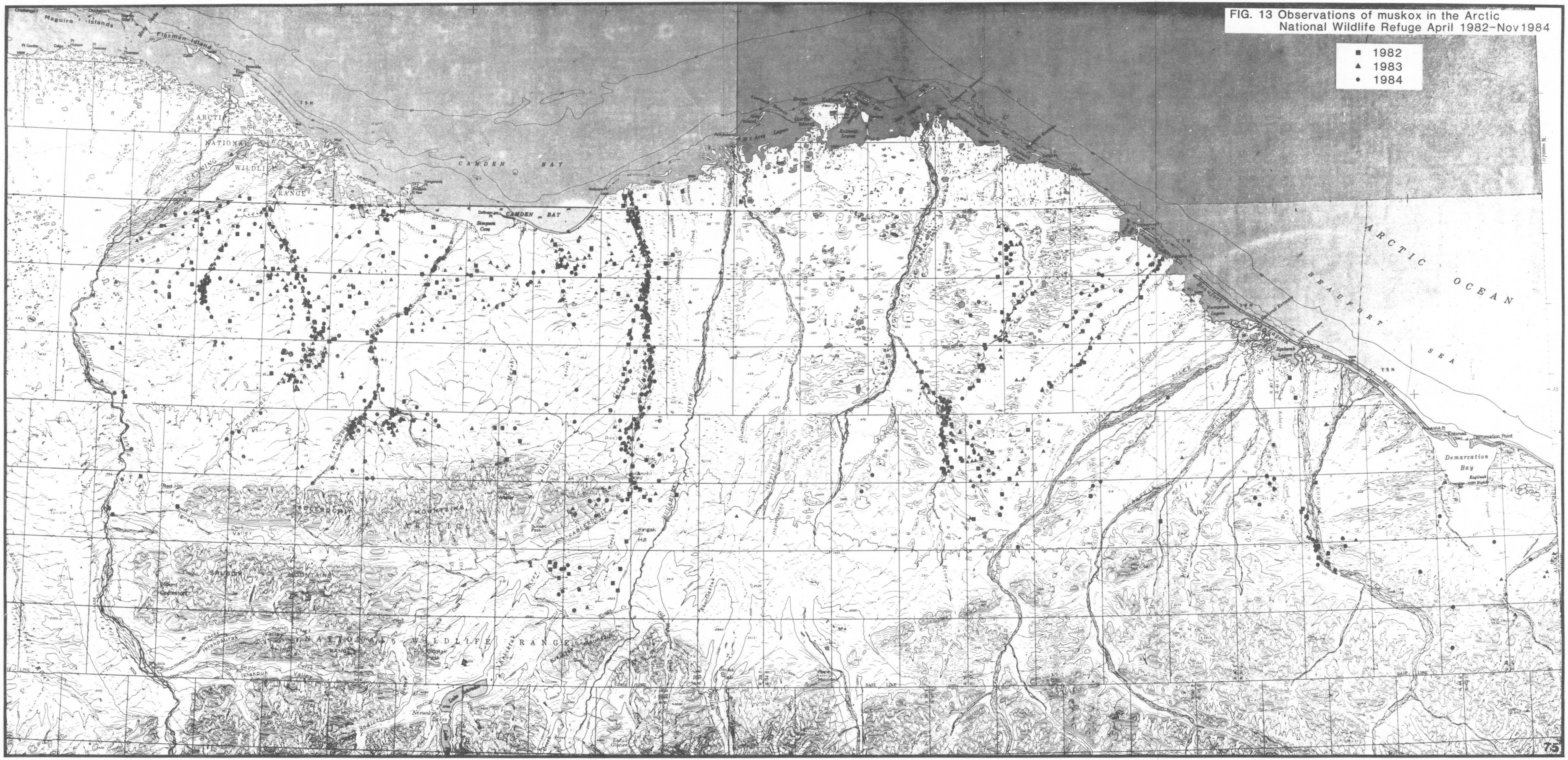



FIG. 13 Observations of muskox in the Arctic National Wildlife Refuge April 1982–Nov 1984

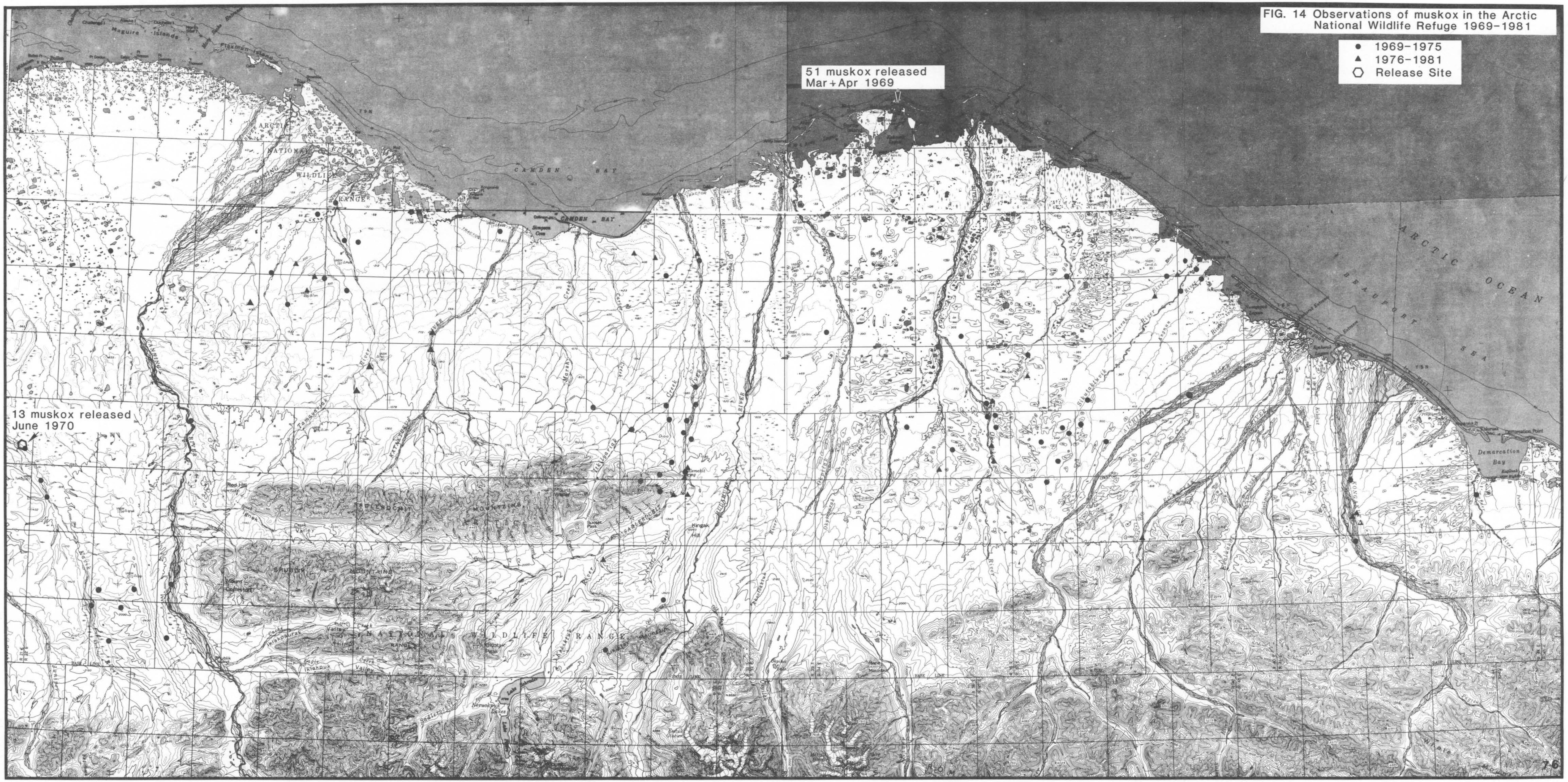



FIG. 14 Observations of muskox in the Arctic National Wildlife Refuge 1969–1981

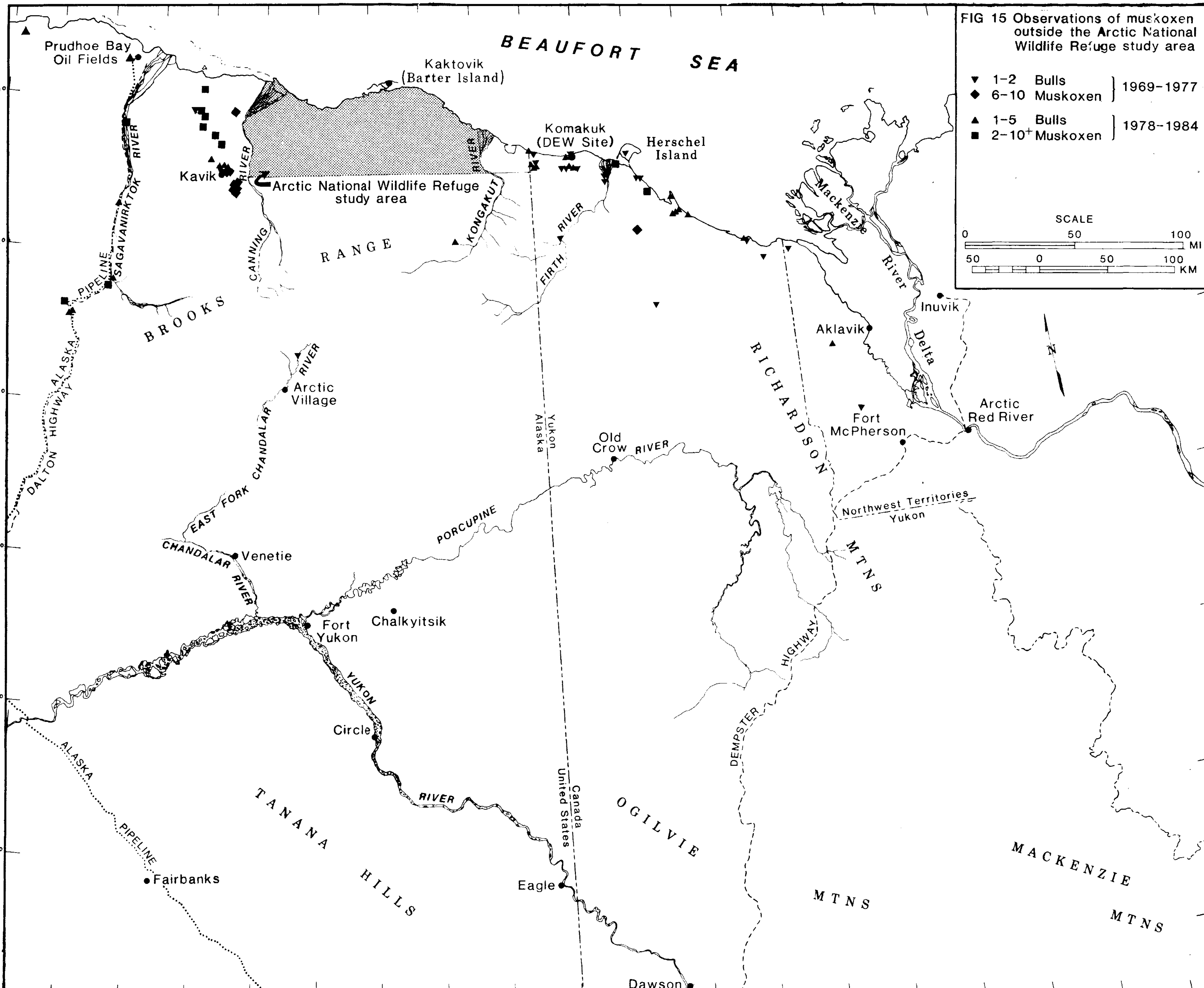


FIG 15 Observations of muskoxen outside the Arctic National Wildlife Refuge study area
1-2 Bulls
6-10 Muskoxen
1969-1977
1-5 Bulls
2-10+ Muskoxen
1978-1984
SCALE
0 50 100 MI
50 0 50 100 KM
BEAUFORT SEA
Prudhoe Bay Oil Fields
Kaktovik (Barter Island)
Komakuk (DEW Site)
Herschel Island
Kavik
Arctic National Wildlife Refuge study area
BROOKS RANGE
RICHARDSON MTNS
OGILVIE MTNS
MACKENZIE MTNS
TANANA HILLS
Inuvik
Aklavik
Arctic Red River
Fort McPherson
Arctic Village
Old Crow
Venetie
Fort Yukon
Chalkyitsik
Circle
Eagle
Dawson
Fairbanks
Yukon
Alaska
Canada
United States
Northwest Territories
Yukon
DALTON HIGHWAY
ALASKA PIPELINE
DEMPSTER HIGHWAY
Mackenzie River Delta
N
70°
69°
68°
67°
66°
65°
148°
146°
144°
142°
140°
138°
136°
134°
132°

At least two mixed-sex muskox herds over-wintered in the upper Katakturuk River area in 1984 (Fig. 16). One herd, which included a radio-collared cow (i), used adjacent areas in 1983 and 1984 when at least some of these animals dispersed from the Tamayariak area (Reynolds et al. 1984). A second herd, containing no marked animals was also seen in the upper Katakturuk River area during late winter 1984. As described previously, these animals had apparently moved here from the Tamayariak area, possibly in late January 1984. An adult cow (s) was radio-collared in this herd in early April 1984.

Most muskoxen in the Sadlerochit area remained in the mid-portion of the river north of Sadlerochit Springs in late winter 1984. Mixed-sex herds utilizing the lower river in January moved south to the same area by February. Large herds also utilized this same area on the lower Sadlerochit River in late winter 1983 (Fig. 16). In mid-March, most animals had congregated into one large herd and moved to the hills east of Carter Creek where in previous years they have calved (Reynolds et al. 1984).

Muskoxen in the Okerokovik area were found along the lower Sikrelurak River and Angun River and along the Niguanak River in January through March 1984 (Fig. 17). Animals also over-wintered along these rivers, as well as the Okerokovik River, in 1983. By late March muskoxen on the Niguanak River moved southwest toward the Okerokovik River.

<u>Pre-calving, calving, and post-calving distribution and movements of mixed-sex herds</u>. During the month of April 1984, most herds in the Tamayariak drainage remained on the main fork of the Tamayariak River in the vicinity of VABM Yari (Fig. 18). But at least one herd of 14, which included marked cows f and g, moved to the west fork of the Tamayariak River in early April and remained there until mid-May. By May, during the peak of calving, animals along the main fork of the Tamayariak River moved downstream toward VABM Mala. By early June, muskox from both areas moved to the Canning River delta. Similar distribution and movement were observed in 1982 and 1983 when animals also calved on the main fork of the Tamayariak River. In 1982 some animals calved in the Carter Creek hills with muskoxen from the Sadlerochit drainage. But in 1983, at least 19 animals, including cow g, spent most of May on the west fork of the Tamayariak River. Movements to the coast and along the lower Canning River also occurred in 1982 and 1983.

The two mixed-sex herds which over-wintered in the upper Katakturuk River in 1984 also calved there (Fig. 18). One herd of about 25 stayed in the hills between the Nularvik River and the upper Katakturuk River where they had over-wintered. The herd of about 20 muskoxen which had moved into the Katakturuk River in late winter calved south of their wintering area.

In 1984, muskoxen over-wintering in large mixed herds on the Sadlerochit River moved to the Carter Creek hills by late March, in contrast to 1982 and 1983 when movements to the Carter Creek hills occurred in late April (Fig. 18). In 1982 and 1983 muskoxen were found on the ridges south of the upper Sadlerochit River in late March and early April. In 1984, an old cow (j) moved to these ridges by late March, gave birth to a calf, and remained there alone until late June when it moved north and rejoined herds on the lower Sadlerochit River. Muskoxen in the Carter Creek hills remained in a large herd of 80-95 in April 1984. But in May, this herd split into two herds and, leaving the hills, moved south along Carter Creek from May until mid-June, when these herds moved back to the Sadlerochit River. In 1982 and 1983, muskoxen also moved back to the Sadlerochit River in late June and early July after emergence of riparian willow leaves.

In 1984, most muskoxen in the Okerokovik area, over-wintering on the Angun River and Sikrelurak River, remained on these rivers until late April when they moved to the Niguanak River to calve (Fig. 19). In late June these animals moved south to the Okerokovik River. Similar patterns were also seen in 1982 and 1983 when muskoxen calved on the Niguanak River, Sikrelurak River, and Angun river and moved to the Okerokovik River in June (Fig. 19). One 16-year old cow (b) calved alone on the Angun River in 1984. The animal remained alone, except for her calf, from late April until early June when she joined a herd on the upper Angun River. This herd moved west to the Okerokovik River and intermixed with other herds in late June 1984.

One mixed-sex herd of 14 muskoxen over-wintering on the Angun River moved east to tributaries of the Ekaluakat River and Siksikpalak River in early April 1984 (Fig. 19). They remained in this area until late June when they moved back to the Okerokovik River and joined other herds. As discussed previously, this may have been a seasonal dispersal.

Two other cows, a 16-year old marked cow a and a 3-year old, left the Okerokoik River in late March 1984 and moved south to bluffs on the Jago River east of VABM Bitty. In late June, after the birth of a calf to the 3-year old, these animals moved northeast to the Okerokovik River where they joined other herds.

Table 16. Calving areas used by muskoxen in the Arctic National Wildlife Refuge, mid-May 1982-1984.

| Location | Estimated numbers of muskoxen 1982 | 1983 | 1984 |
|---|---|---|---|
| Okerokovik Area: | | | |
| Niguanak River | 25 | 21 | 25 |
| Angun River | 6[a] | 10 | 1 |
| Okerokovik River | 1[b] | 7[b] | -- |
| Siksikpalak River | -- | -- | 15 |
| Jago River | -- | -- | 3 |
| Sadlerochit Area: | | | |
| Carter Creek hills | 70[c] | 9 | 101 |
| Marsh Creek hills | -- | 55 | -- |
| Upper Sadlerochit River | 22 | 5 | 1 |
| Tamayariak Area: | | | |
| Tamayariak River, main fork | 26 | 55 | 49 |
| Tamayariak River, west fork | -- | 19 | 18 |
| Upper Katakturuk River | -- | 21 | 49 |
| Totals | 150 | 202 | 262 |

[a]On the Niguanak River until late May.
[b]No calves in herd by late June.
[c]Including muskoxen from both Tamayariak and Sadlerochit areas.

Changes in the use of areas during the peak of calving in mid-May occurred between 1982 and 1984, but most variation was a shift in distribution to adjacent areas or dispersal of some animals into new areas (Table 16). Radio-collared cows showed some yearly variation in the use of calving areas between 1982 and 1984 (Table 17). In all three years, 22-36% of the animals used the same calving location (i.e. moved less than 10 km). In 1983, four of nine cows, and in 1984, two of 14 cows, used totally different areas, located at least 40 km from locations used the previous year. In 1983, three of 9

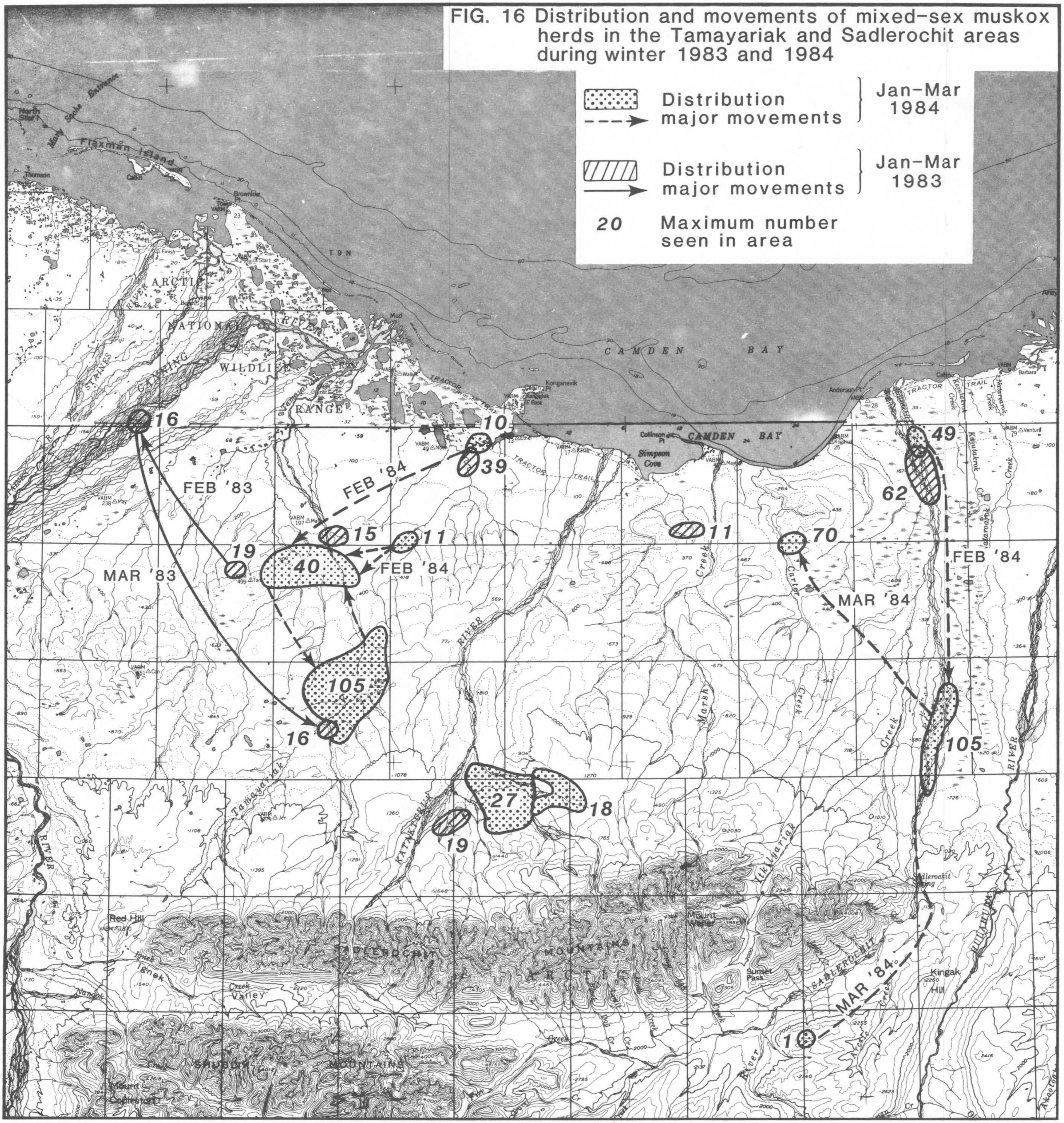



FIG. 16 Distribution and movements of mixed-sex muskox herds in the Tamayariak and Sadlerochit areas during winter 1983 and 1984


FIG. 17 Distribution and movements of mixed-sex muskox herds in the Okerokovik area during winter 1983 and 1984

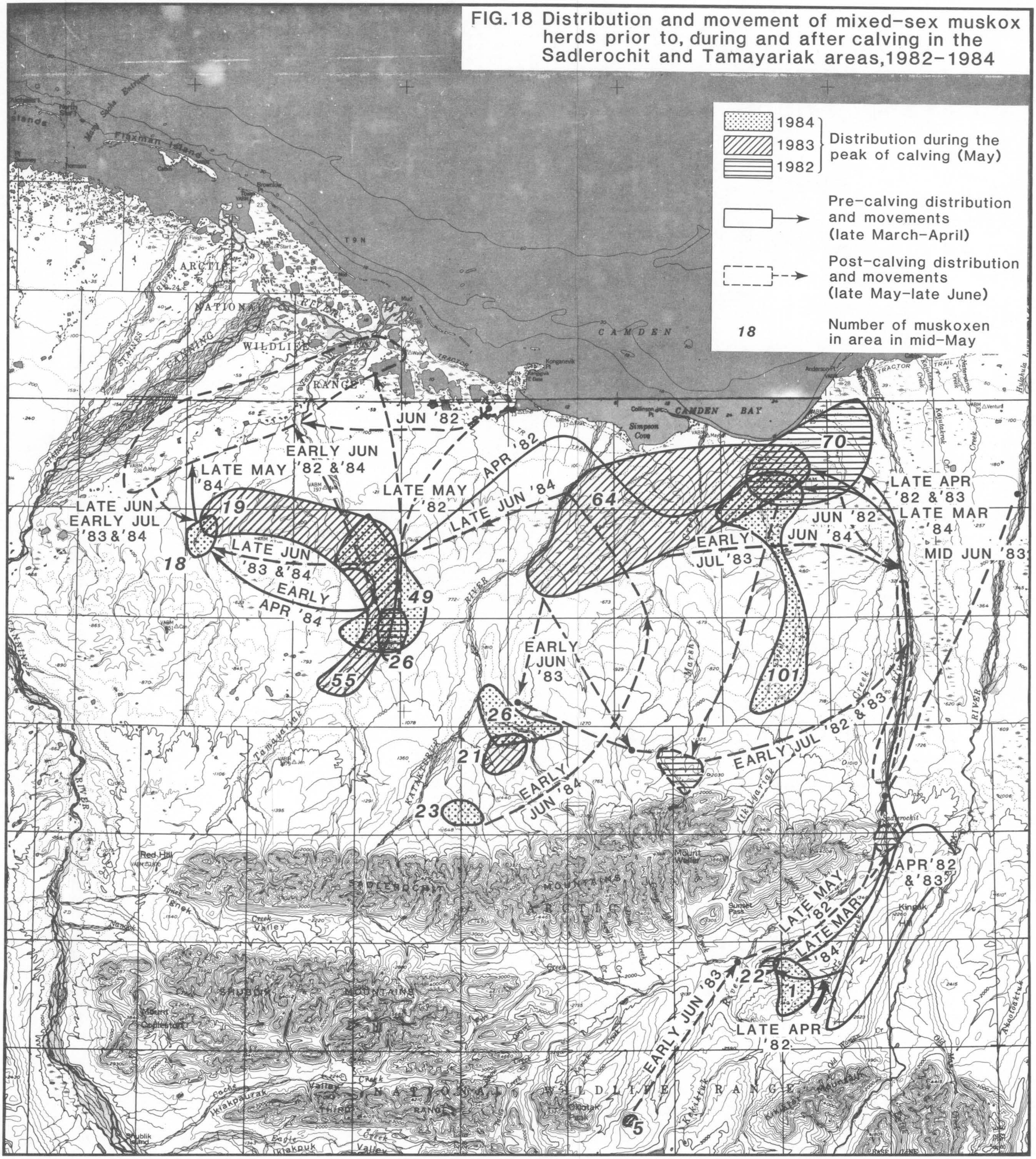



FIG.18 Distribution and movement of mixed-sex muskox herds prior to, during and after calving in the Sadlerochit and Tamayariak areas,1982-1984

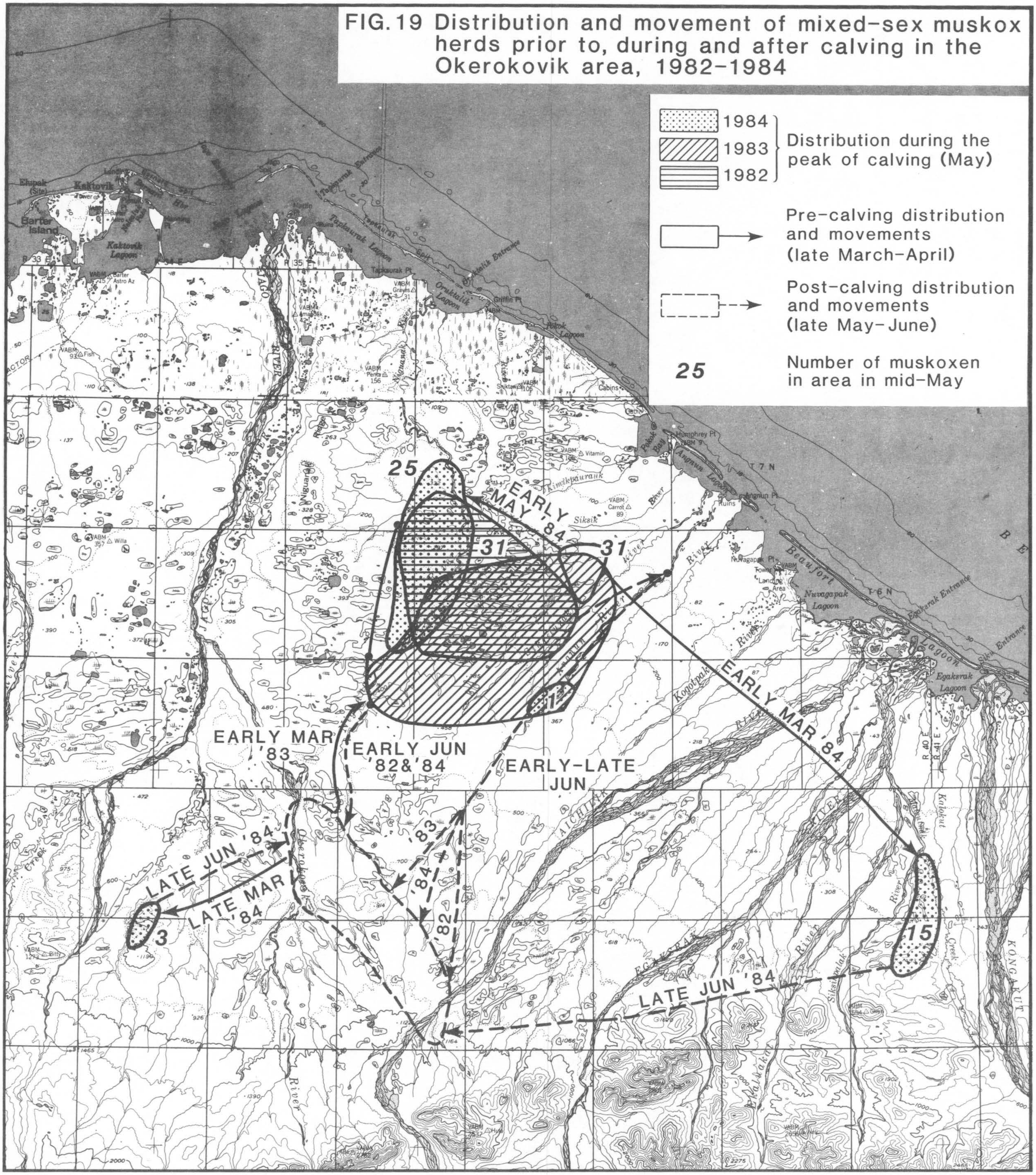



FIG. 19 Distribution and movement of mixed-sex muskox herds prior to, during and after calving in the Okerokovik area, 1982-1984

Table 17. Yearly variation in calving area use by radio-collared muskox cows in the Arctic National Wildlife Refuge, 1982-1984.

| Muskox | Location in mid-May | | | Distance between locations(km) | |
|---|---|---|---|---|---|
| ID | 1982 | 1983 | 1984 | 1982+1983 | 1983+1984 |
| 1a | Okerokovik | Okerokovik | Jago | 7 | 15 |
| 3b | Niguanak | Niguanak | Angun | 8 | 13 |
| 25q | ------ | Niguanak | Niguanak | -- | 4 |
| 14j | Carter Creek hills | Marsh Creek hills | Sadlerochit | 12 | 42 |
| 15k | Carter Creek hills | Tamayariak main fork | Upper | 40 | |
| 23p | ------ | Carter Creek hills | Carter Creek | -- | 10 |
| 21n | ------ | Marsh Creek hills | Carter Creek | -- | 19 |
| 22o | ------ | Marsh Creek hills | Carter Creek | -- | 19 |
| 6e | Carter Creek hills | Tamayariak main fork | Tamayariak main fork | 40 | 5 |
| 8f | Carter Creek hills | Tamayariak main fork | Tamayariak west fork | 40 | 16 |
| 9g | Tamayariak main fork | Tamayariak west fork | Tamayariak west fork | 10 | 4 |
| 10h | Tamayariak main fork | Upper Sadlerochit | Tamayariak main fork | 47 | 47 |
| 16l | ------ | Tamayariak main fork | Tamayariak main fork | -- | 3 |
| 17n | ------ | Tamayariak west fork | Tamayariak main fork | -- | 13 |
| 11i | Tamayariak main fork | Upper Katakturuk | Upper Katakturuk | 13 | 1 |

cows used adjacent drainages 10 to 13 km from areas used in 1982. In 1984, more than half (8 of 14) the cows used areas in adjacent drainages, 10 to 19 km from where they were observed in mid-May 1983. No radio-collared cow observed for three consecutive years calved in the same location during all three years.

Distribution and movements in summer, rut, and fall. In July 1984, muskoxen in the Tamayariak area were concentrated primarily along the west fork of the Tamayariak River, west of VABM Tam (Fig. 20). In August 1984, muskoxen moved east to the main fork of the Tamayariak River near VABM Mala and further east to the uplands south of Konganevik Point. By late September, 80 muskoxen moved west to the Canning River and 26 moved southwest along the Tamayariak River main fork south of VABM Yari, where they stayed until at least early December. Muskoxen on the Canning River moved east to the Tamayariak River west fork in late October. Similar distributions were seen in this area in July-October 1982 and 1983. In July 1982, a small mixed-sex herd containing a marked cow (i), and a solitary cow (h) with her calf moved from the Tamayariak area to the Sadlerochit area.

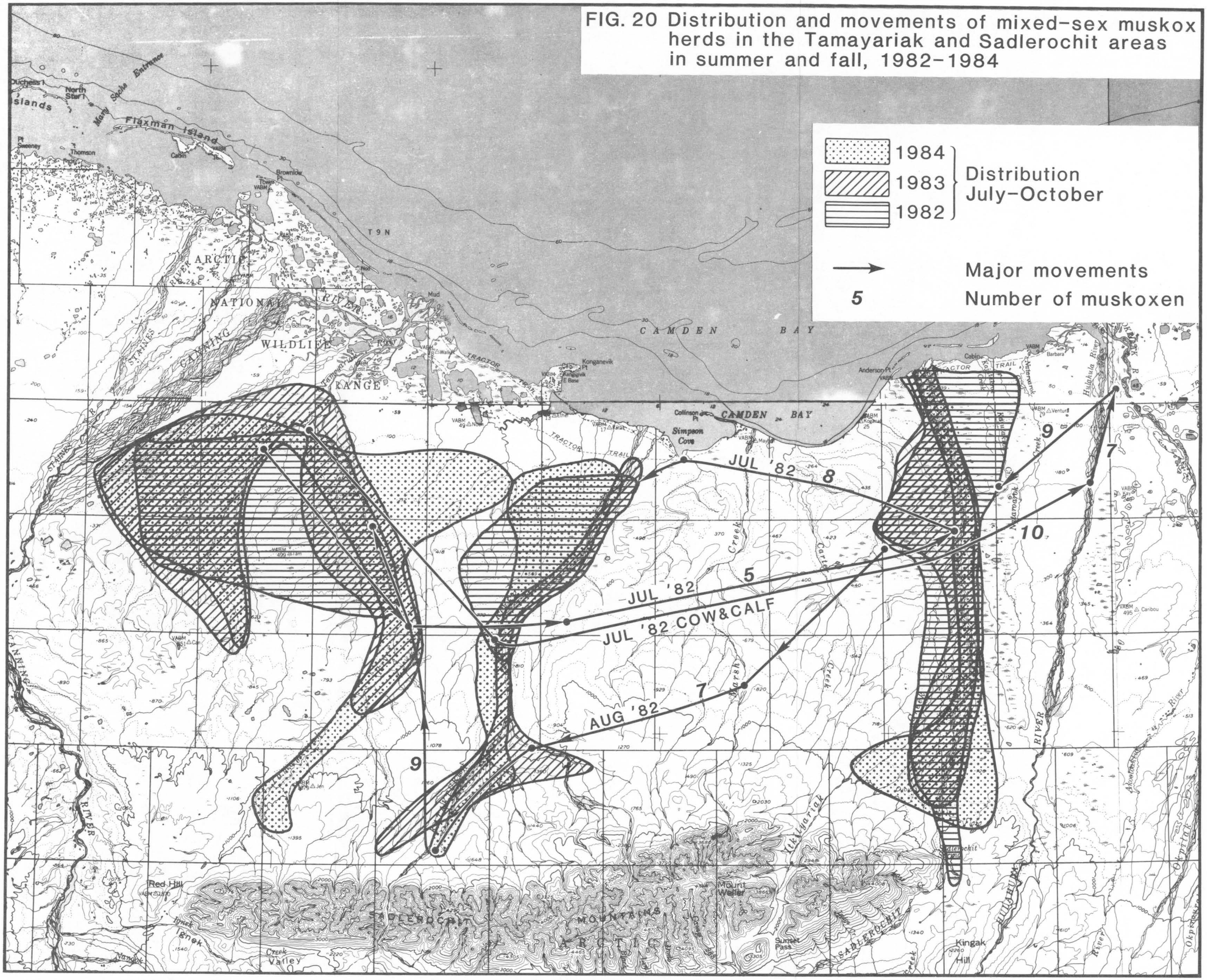
On the Katakturuk River, a mixed-sex herd of about 25 muskoxen, including marked cow i, were found along the lower Katakturuk River and the uplands south of Konganevik Point in July and August 1984. In September-November 1984, this herd returned to the Katakturuk River. In 1982, a herd of 17 to 26 muskoxen, including cow i, were seen along the mid-Katakturuk River in late August after the animals moved into this area from the Tamayariak River. In 1983 this herd utilized the uplands between the upper Katakturuk River and the east fork of the Tamayariak River in July-early September. From late September until late October, this herd was back on the upper Katakturuk River (Fig. 20).

In July and August 1984, mixed-sex herds of muskoxen utilized the Sadlerochit River from Sadlerochit Springs to the delta. This distributional pattern continued into September and October and was similar to summer and fall distributions of muskoxen herds in 1983 and 1982 (Fig. 20). Herd locations were most extended in August and September during the rut when the distribution expanded to include adjacent small drainages. In July 1982, marked cow i accompanied by seven other muskoxen, returned to the Tamayariak area from the Sadlerochit area, and eventually moved to the Katakturuk River in mid-August, where it has remained since that time. Another mixed-sex herd of 7 muskox containing bull B and cows e and k also moved from the Sadlerochit area to the Tamayariak area in August 1982.

In the Okerokovik area in July-August 1984, mixed-sex muskox herds were observed on the Okerokovik River and adjacent hills. This distribution was very similar to that seen in July and August 1982 and 1983 (Fig. 21). One marked cow (u) left the Okerokovik River in mid-July 1984 and moved east into Canada where it was briefly associated with a single bull in August. It was last seen on the Turner River in late September 1984. In late August 1984, one herd moved east to the Niguanak River and then moved to the lower Angun River in late September, where they were joined by other mixed-sex herds from the Okerokovik River by late October 1984. A movement to the lower Angun River from the Okerokovik River also occurred in October 1982 and 1983 (Fig. 21).

Movements of bull groups and single bulls. Bull groups and solitary bulls observed in 1982-1984 were often spacially segregated from mixed-sex herds

FIG. 20 Distribution and movements of mixed-sex muskox herds in the Tamayariak and Sadlerochit areas in summer and fall, 1982-1984



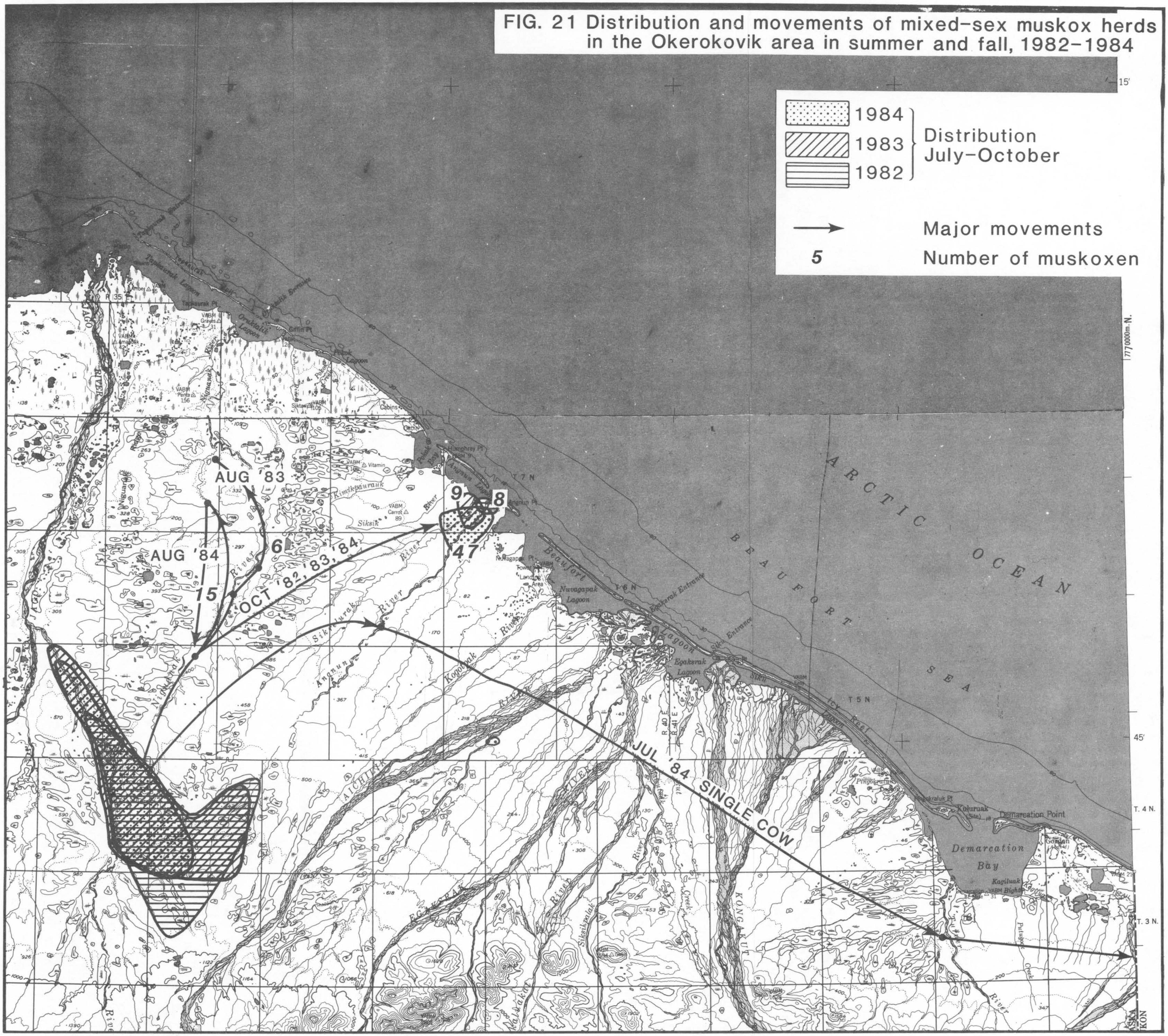



FIG. 21 Distribution and movements of mixed-sex muskox herds in the Okerokovik area in summer and fall, 1982-1984

(Fig. 22). Bulls were seen near the Canning River on the west side of the study area in all three years. Bull use of the upper Katakturuk River has been documented since 1979 (Ross 1979, Ross 1981). Bulls were seen also on the upper Katakturuk River in both 1982 and 1983. In 1984 at least one bull group 2-4 bulls remained along the upper Katakturuk River from mid-March to mid-June. By late June, one radio-collared bull (L) had moved alone to the main fork of the Tamayariak River.

At least one small bull group over-wintered on the south slopes of the eastern end of the Sadlerochit Mountains in 1982, 1983, and 1984. This bull group remained on the mountain slopes until mid-June, when bulls split up and solitary animals moved north to the lower Sadlerochit River where they joined mixed-sex herds.

Bulls have been observed on the Kongakut River on the east side of the Okerokovik area since 1973 (Roseneau and Warbelow 1974). In 1982, 1983, and 1984 bull groups were seen on the Kongakut River throughout the year (Fig. 22). Radio-collared individuals moved into and out of the area in 1984.

Radio-collared bulls associated with bull groups or as solitary animals made long range movements (Fig. 22). Bulls frequently moved between the Sadlerochit area and the Tamayariak area, particularly in July and August. Two bulls also moved between the Okerokovik area and the Sadlerochit area. In August 1982, a 3-year old bull (A), left a mixed-sex herd on the Okerokovik River and moved to the Sadlerochit area where it remained through 1984. In July 1984, a radio-collared bull (H) estimated to be older than 5-years, moved from the Sadlerochit River to the Kongakut River. Two other radio-collared bulls including a 4-year old male, disappeared from the Sadlerochit River in July 1984. Their radio-collars may have failed or they may have made long distance movements into new areas. A solitary bull was seen in the Romanzof mountains near the upper Kongakut River in July 1984. One 4-year old bull (G) left a mixed-sex herd on the Niguanak River in late September 1984 and was observed on a tributary of the Aichilik River in groups of 2-4 bulls in late October and late November.

Many long range movements by bulls were observed prior to an during the rut. Dispersal of young-aged (3-4 year old) males from mixed-sex herds may also occur during this time of year. Such movements may be related to agonistic clashes between bulls during the defense of harem groups.

Habitat use. Seasonal use of different terrain features was apparent in 1982, 1983, and 1984 (Fig. 23). River and creek drainages were most frequently used by muskoxen throughout the year except during the month of April. Major river drainages were used in winter, summer, and fall. But in August 1984, 40% of muskoxen associated with drainages were in creeks rather than along large rivers. Similar trends were seen in August 1983 and 1984 when animals were generally dispersed into relatively small rutting groups.

In winter, ridges, plateaus, and bluffs, often blown partly free of snow, were used by some muskoxen. Lent and Knutson (1971) found that muskoxen tended to congregate where snow was absent or of relatively shallow depth. Gunn (1982) states that muskoxen tend to feed more intensively where snow is absent. Use of this type of terrain reached a maximum in April during all three years. By April on the north slope of Alaska, snow has often abladed in upland areas and inversions may result in temperatures 40°C higher on ridges than in the surrounding drainages. Use of this terrain type corresponded to movements

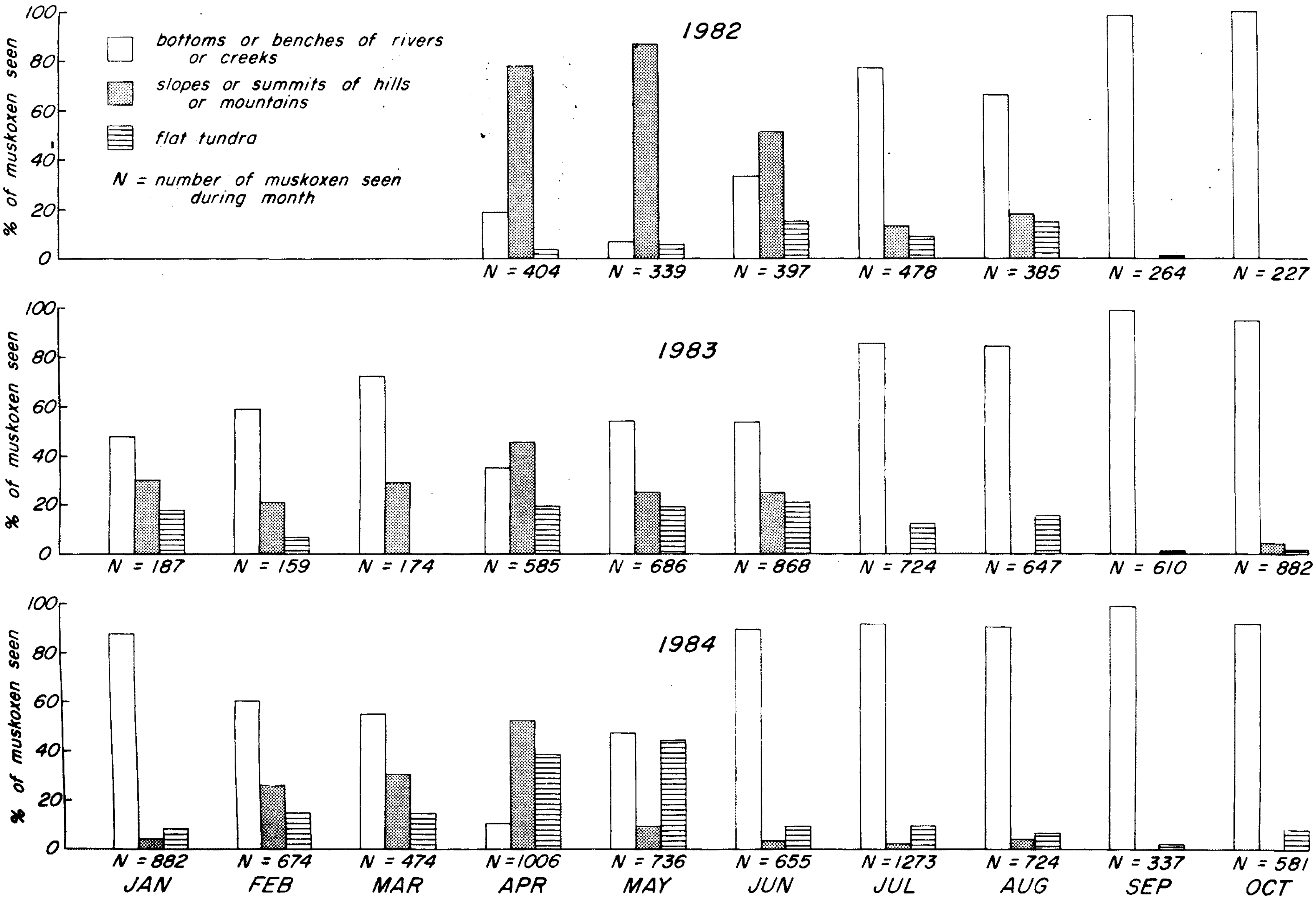



FIG. 23. SEASONAL VARIATION IN MUSKOX USE OF DIFFERENT TERRAIN TYPES IN THE ARCTIC NATIONAL WILDLIFE REFUGE, 1982-1984.

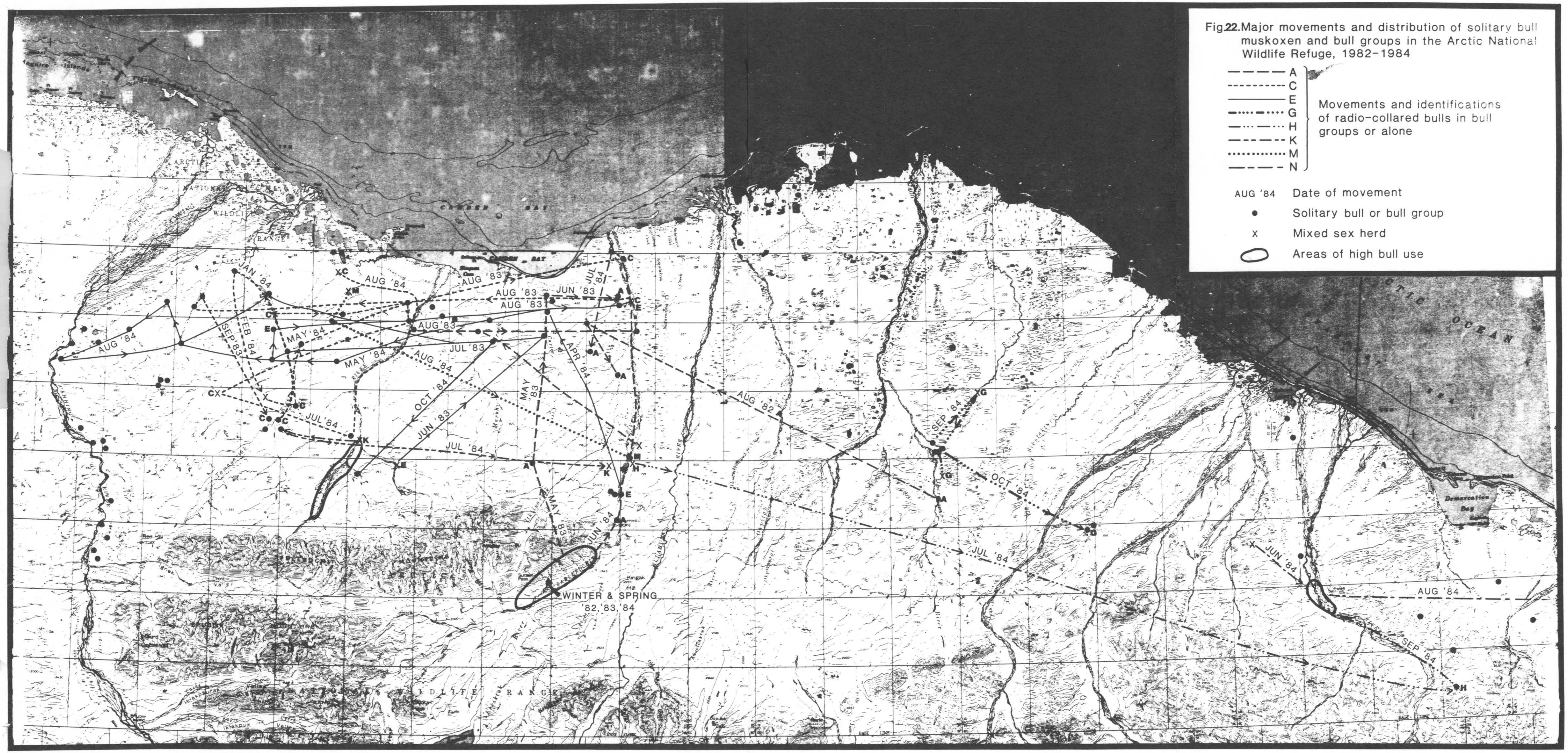



Fig.22. Major movements and distribution of solitary bull muskoxen and bull groups in the Arctic National Wildlife Refuge, 1982-1984

made by Sadlerochit muskoxen to the ridge system southeast of the upper Sadlerochit River in late March 1982 and 1983 and to the Carter Creek hills in late April 1982 and 1983 and late March 1984. Other muskoxen used bluffs above the Tamayariak River and Niguanak River at the onset of calving in late April 1982-1984.

Seasonal differences in muskox use of land cover types, identifiable from the air, also were apparent in 1982, 1983, and 1984 (Fig. 24). Snow covered most of the vegetation from early November through mid-May during all three years. Muskox association with vegetation followed a phenological progression. In late May or early June, as the snow melted first on bluffs and ridges, muskoxen were found in upland areas of low vegetation or tussocks. Robus (1981) found that *Eriorphorum vaginatum* was an important food item for muskoxen in May. In early June animals utilized low vegetation or bare areas along drainages or tussocks on ridges. Movements to the Canning River delta, and the mouth of the Angun River were observed in early June 1982, 1983, and 1984 where muskoxen may have been utilizing early blooming forbs. In late June and early July, as willows emerged, muskoxen moved back into major river drainages during all three years. Robus (1981) found that as riparian willows initiated growth they became important food items. Use of riparian willow stands and adjacent communities of low vegetation continued through July. Habitat use appeared to be variable in August and September as herds dispersed during the rut. In August 1982, muskoxen were again associated with tussock communities. In August 1983, 73% of muskoxen observed were utilizing green wet sedges along small drainages adjacent to major rivers. In August and September 1984, 15-22% of observed animals were in small drainages where green vegetation was present, but most animals were associated with low vegetation on gravel bars. Other muskoxen utilized green vegetation emerging from snow bed or melted aufeis fields in August 1984. Willows and low vegetation were used in September and October as animals congregated on major river drainages. Snow covered the vegetation except for tall riparian willows by early October 1982, early November 1983, and mid-October 1984.

Feeding behavior of muskoxen was observed on the Okerokovik River in early August 1984. Animals were utilizing partially vegetated gravel bars which, from the air, would have been classified as a bare or low vegetation cover type, although scattered willows were present. The muskoxen were observed feeding on seed pods of *Artemesia arctica*, flowers of *Epilobium latifolium*, and terminal buds of *Salix alexensis*. Feeding appeared to be highly selective. Only one or two seed pods were removed from a plant where up to 10 pods were available. Similarly, only a few terminal buds were taken from each willow bush.

## Summary

Transplanted muskox herds in the ANWR are continuing to expand in size and distribution. High productivity and low mortality have resulted in an increasing population which is apparently beginning to exploit new geographic areas, particularly in winter. Until 1981, ANWR muskoxen were associated with large stable herds occupying discrete geographic ranges. In 1982-1984 large herds were also seen particularly in winter and spring, but herds intermixed seasonally as animals congregated during calving, mid-summer, or fall. Most radio-collared cows showed fidelity to specific geographic areas in 1984 compared to long range movements between geographic areas observed in 1982.

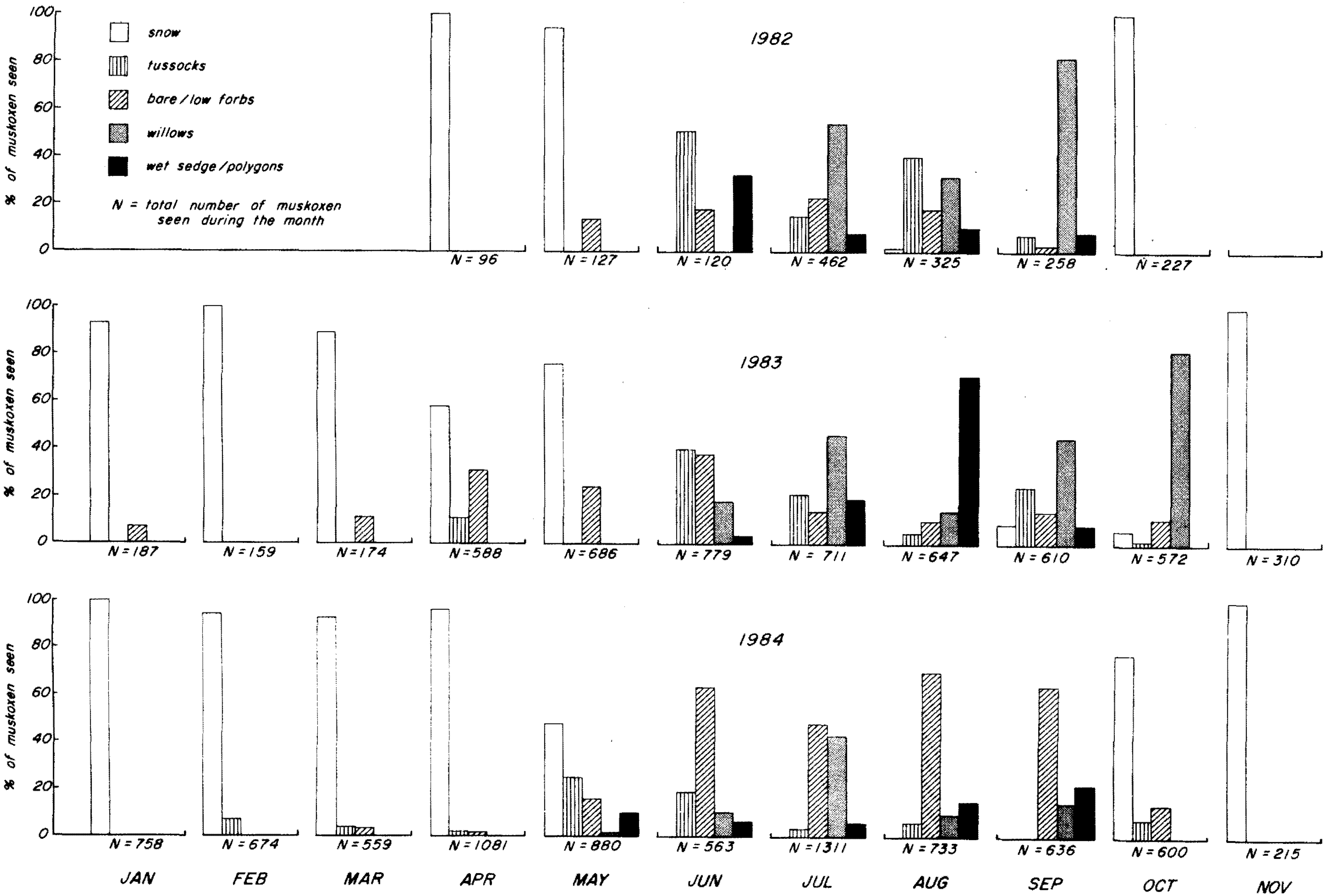



FIG. 24. SEASONAL VARIATION IN MUSKOX USE OF DIFFERENT LAND COVER TYPES IN THE ARCTIC NATIONAL WILDLIFE REFUGE, 1982-1984.

Adult bulls moved across geographic areas and were observed with different mixed-sex herds, in bull groups, or alone. Seasonal movements coincided with seasonal changes in habitat use, which appear to depend upon changing plant phenology.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# EFFECTS OF WINTER SEISMIC EXPLORATION ACTIVITIES ON MUSKOXEN IN THE ARCTIC NATIONAL WILDLIFE REFUGE, JANUARY-MAY 1984

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Key words: Muskoxen, seismic exploration, movements, winter distribution, response to disturbance, Arctic National Wildlife Refuge, Arctic-Beaufort

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Effects of winter seismic exploration activities on muskoxen in the Arctic National Wildlife Refuge, January-May, 1984.

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Abstract: Effects of winter seismic exploration activities on muskoxen (*Ovibos moschatus*) in the Arctic National Wildlife Refuge were documented by relocating radio-collared animals 11 times between early January and late May 1984. Aerial observations of other muskoxen were also obtained during over-flights of the coastal plain. Field monitors traveling with seismic trains provided locations of muskoxen near seismic activities as well as responses of herds to seismic vehicles. Distribution of muskoxen was the same before, during, and after seismic activities and did not differ from muskox distribution observed in 1982-1984. No long range movements of radio-collared muskoxen occurred during seismic activities, although two herds apparently moved 3.0-4.5 km in response to closely approaching seismic vehicles. Muskoxen did not leave areas of traditional use. A limited sample of observations of muskoxen responding to seismic vehicles showed a variety of responses. Three herds did not run into a group until approached within 100 to 400 m. Two herds ran when vehicles were over 3 km away. In 1984, productivity of muskoxen based on number of calves per cow older than three years was greater than in 1983 and 1982.

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Muskoxen are year-round residents of the Arctic National Wildlife Refuge (ANWR) study area and are one of the few species which may be directly affected by the seismic exploration activities conducted during winter. Potential effects include injuries or increased energy expenditures associated with escape responses, disruption of normal activity patterns, and the avoidance of important winter habitat in areas of seismic exploration activity. These factors may cause increased mortality or decreased productivity. Title V, Public Law 96-487 (ANILCA) specifies that one objective of the baseline study of fish and wildlife on the ANWR coastal plain will be to analyze potential impacts of oil and gas exploration, development, and production on muskoxen. Documenting the effects of seismic exploration activities on muskoxen is an important component of this analysis. This report summarizes data collected during the winter and spring of 1984 when a winter seismic exploration program was conducted on the coastal plain of the ANWR. Results should be viewed as preliminary.

The objective of this study is:

1. Document the effects of winter seismic exploration activities on distribution, movements and daily activity patterns of muskoxen.

## Methods and Materials

The study area was located in northeast Alaska between the Canning River and the Canadian Border, 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). For purposes of this study, the principle study area was subdivided into the Tamayariak area, the Sadlerochit area and the Okerokovik area (Fig. 1).

Between late January and early May 1984, a seismic exploration program was conducted on the coastal plain of ANWR. Two crews, using a drilled shothole technique, completed 977 km of seismic line arranged in a 9.7 x 19.3 km grid across the coastal plain (Fig. 2). Large tracked vehicles (primarily Nodwells) were used to carry drills, recording equipment, dynamite, and geophones. Crews also used, smaller, tracked-mounted vehicles (Bombardiers) for surveying and other activities. Strings of ski-mounted trailers pulled by Caterpiller D-7 tractors ("cat-trains") provided logistical support. Fuel and explosives were brought overland in ski-mounted magazines or tanks pulled by tractors. Other supplies and personnel were flown in by turbine Beaver or twin Otter aircraft landing on snow or ice near camps.

Thirty-eight muskoxen were radio-collared between April 1982 and April 1984 as part of a baseline study of muskox ecology on ANWR (Reynolds et al. 1985). Radio-collared muskoxen were relocated 19 times in 1982 and 25 times in 1983. From January to May 1984, when seismic crews were operating on the coastal plain, muskoxen were relocated 11 times, using fixed-wing aircraft outfitted with wing-mount "H" antennas and a scanner-receiver (Telonics, Mesa, Az). Miscellaneous observation of muskoxen were also obtained during other overflights of the coastal plain. U.S. Fish and Wildlife Service (USFWS) field monitors traveling with the seismic crews recorded observations of muskoxen seen near seismic exploration activities. Behavior, responses to activities, and winter habitat use were summarized on field form sheets by monitors. All locations were plotted on USGS quad maps at 63,360 scale.

Following the completion of the winter seismic exploration activities, the location of seismic lines, associated trails and dates of activity were summarized on 63,360 scale maps, using data obtained by seismic crew monitors. Observations of muskoxen between January and May 1984 were also placed on the same maps. Movements by herds containing marked individuals were delineated. Daily movements were calculated by measuring the linear distance (in km) between two consecutive sightings and dividing this distance by the number of days between two sightings. Dates of seismic exploration activity within a given area were estimated by camp location dates and monitor field notes. Movements based on muskox locations within a 5 km radius of a seismic line being shot or surveyed, a camp site location, or an active camp-move trail, were defined as movements which occurred during seismic exploration activities. Other movements were defined as taking place before or after exploration activities were present.

## Results and Discussion

Distribution of muskoxen in the ANWR study area, based on the relocation of radio-collared animals, was similar in April-May 1982, 1983, and 1984, and January-March 1983 and 1984 (Fig. 2). During the seismic exploration program in 1984, all herds observed, with the exception of a herd of two cows near the Jago River, were located within or near areas used by muskoxen during the last three years (Reynolds et al. 1985, Fig. 13).

### Tamayariak Area

In the Tamayariak area portions of five seismic lines traversed areas used by muskoxen in winter (Fig. 2). Several muskox herds were observed in areas concurrently with seismic vehicles and locations and movements of herds were summarized in relation to seismic activities (Fig 3). On 11 January and 25 January, one herd of nine muskoxen was seen in an area about 1 km west of a trail and 4 km north of a seismic line. On 25 January a seismic vehicle traveled within 1 km of the herd,which responded by grouping and running about 1.6 km. Between 25 January and 12 February this herd moved 18 km west, crossing portions of two seismic lines along which vehicles were present on 1-8 and 14-19 February. The herd may have encountered seismic vehicles before or during either one of these movements. By 19 February this herd had joined with a herd of nine other muskoxen. This second group of muskoxen had also moved west across one of the same seismic lines between 25 January and 12 February, before the line was shot on 14-16 February. A third group of 15 muskoxen moved northwest and joined these herds by 19 February. On 28 February, this herd, now containing 39 muskoxen, was located within 1.5 km of a cat train camp near a seismic line. The herd moved 10 km between 28 February and 6 March in approximately the same direction of travel as vehicles moving along the seismic line, but diverging from it by a distance of 1 to 9 km. (Fig. 3).

Muskox herds also utilized areas adjacent to and along the Tamayariak River main fork near VABM Yari from late January through late April 1984 (Fig. 3). These herds remained in the area during times when seismic trains were in the

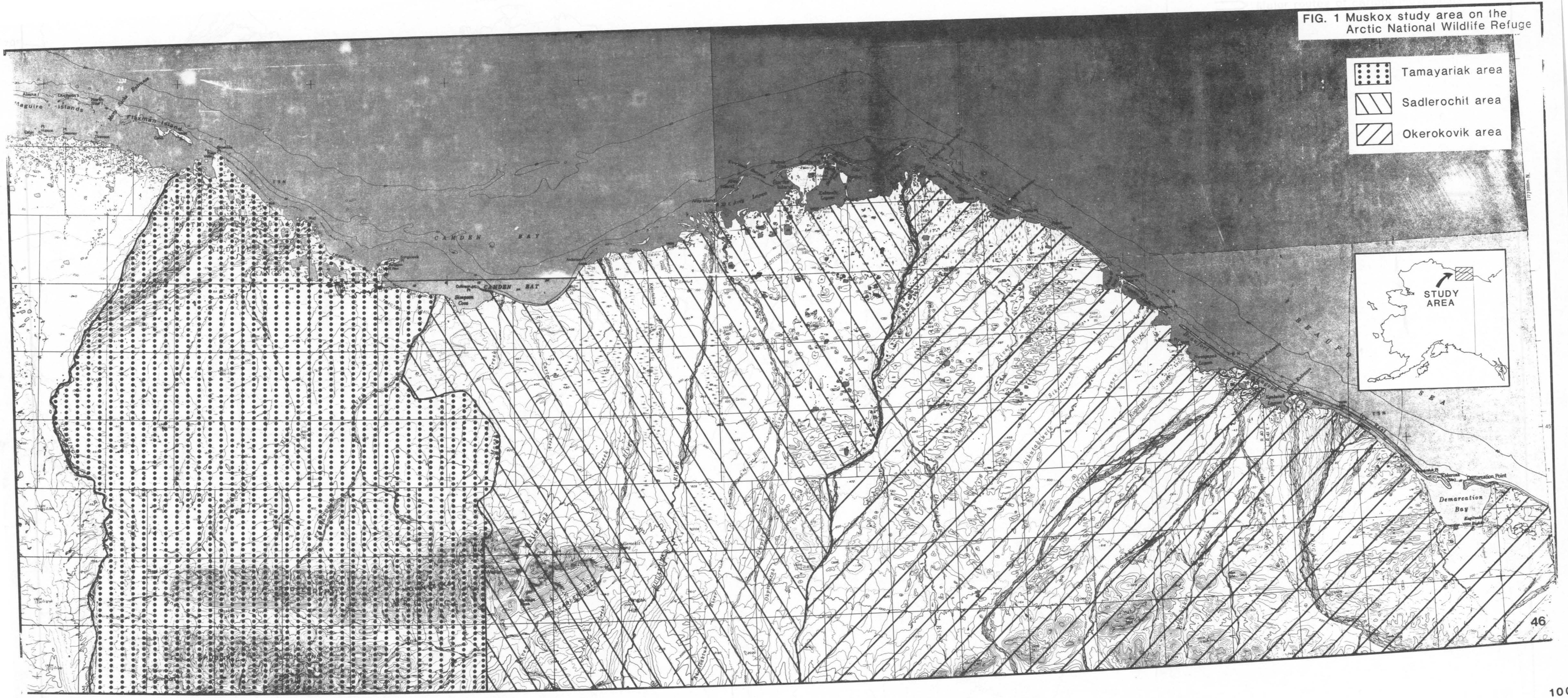

FIG. 1 Muskox study area on the Arctic National Wildlife Refuge


Fig. 2 Distribution of muskoxen (April-May 1982, Jan.-May 1983 & 1984) in relation to the 1984 seismic program in the Arctic National Wildlife Refuge.

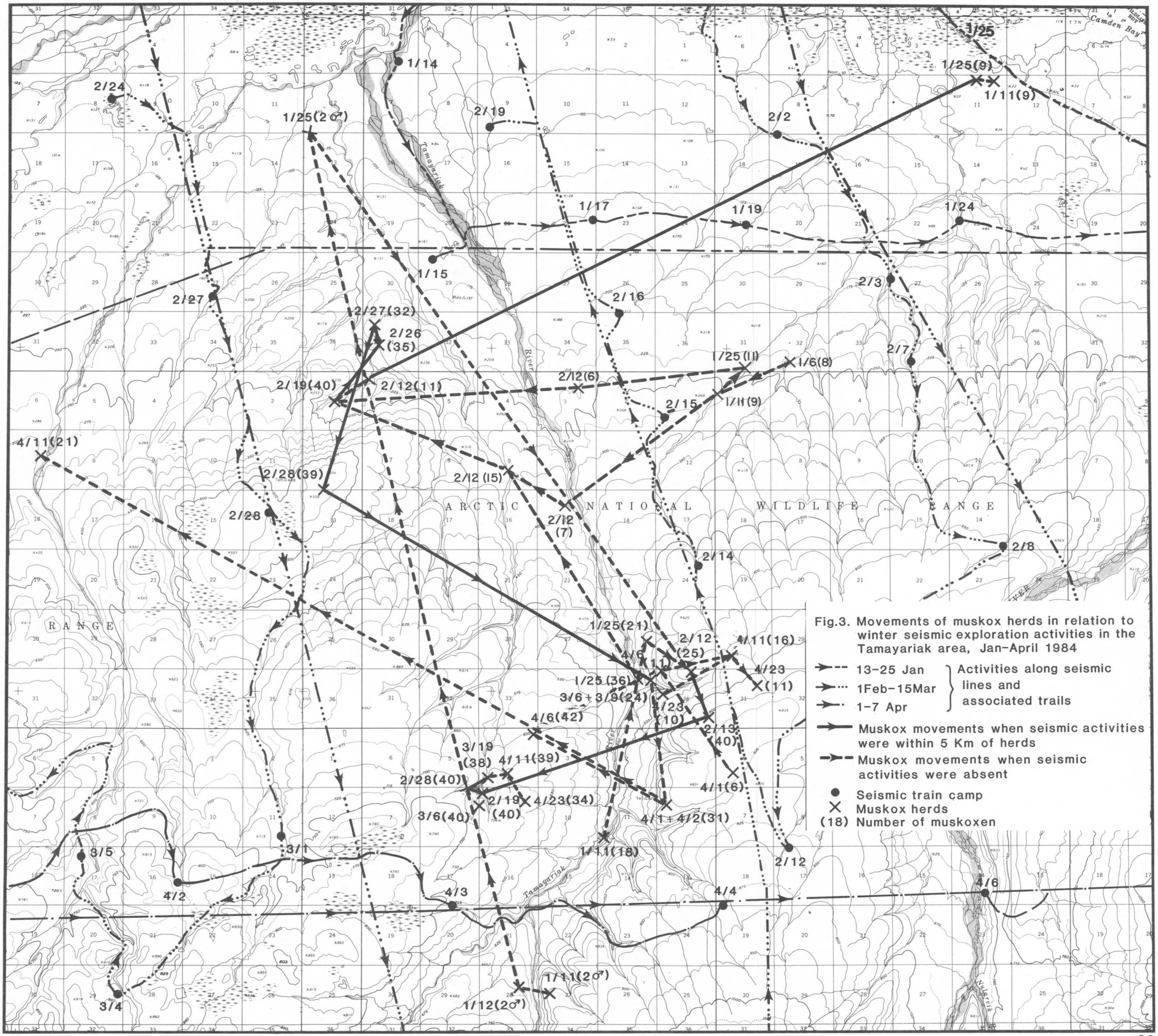


Fig.3. Movements of muskox herds in relation to winter seismic exploration activities in the Tamayariak area, Jan-April 1984

area on 11-15 February and 29 February-2 March. Because of the topography of the area, these muskoxen remained out sight of the seismic crews, with one exception. On 13 February at least 40 muskoxen were observed about 1 km from a seismic line, along which activities were occurring. This herd moved 6 km to the southwest by February 19.

Further east in the Tamayariak area, two mixed-sex herds and several bulls were observed from January through April in the upper Katakturuk drainage between the Nularvik and Katakuruk Rivers (Fig. 4). One seismic line surveyed in early February ended in this area. Bombardiers encountered one herd of 25 muskoxen on 6 February 1984 at a distance of 3.0 km. The animals ran into a group and ran at least 1.0 km out of sight. When relocated on 12 February 1984, they were 2.0 km to the southwest of the same area in which they were observed before and after seismic exploration activities were present.

Behavior of muskoxen in response to seismic vehicles was observed by USFWS seismic field monitors K. Moitoret and D. LaPlant three times in the Tamayariak area in 1984 (Table 1). On 13 February, a herd of 32 animals, which increased to 40 when it was joined by another herd of 8, did not respond to a Bombardier about 800 m away during 3.5 h of observation. A moving Bombardier at the same distance caused the animals to look up from where they were resting. When a Bombardier approached within 200 m the animals ran into a group and faced the disturbance. The animals then ran to the southwest and out of view approximately 1 km away. When radio-collared animals were relocated from the air on 19 February, the herd had moved a total of 6.5 km in the same direction (Fig. 3).

Table 1. Behavioral responses of muskoxen to activities associated with seismic surveys in the Tamayariak area, February-March 1984.

| 1984 Date | Herd ID | No. of muskoxen | Type of activity | Minimum distance (km) | Behavior |
|---|---|---|---|---|---|
| 13 Feb | 16-17-18 | 32 | Bombardier, parked | 0.8 | no response |
| | 16-17-18 | 32 | Beaver aircraft taking off | 4.8 | no response |
| | 16-17-18 | 32 | Bombardier moving | 0.8 | looked up |
| | 16-17-18 | 32 | Beaver aircraft landing | 4.8 | looked up |
| | 16-17-18 | 32[a] | Bombardier, parked | 0.8 | no response |
| | 16-17-18 | 40 | Bombardier approaching herd | 0.2 | run into group run from disturbance |
| 27 Feb | 6-8-9-10 | 28 | Bombardier, parked | 0.3 | no response |
| | 6-8-9-10 | 28 | Bombardier, approaching herd | 0.2 | no response |
| | 6-8-9-10 | 28 | Bombardier, | 0.1 | run into group, |
| 6 Feb | KAT-11 | 25 | Bombardier, moving approaching herd | 3.0 | run into group from disturbance run from disturbance |

[a]herd of 32 joined by a herd of 8

On 27 February, one herd of 28 muskoxen did not respond to the presence of a Bombardier parked 300 m away for 45 min (Table 1). When the vehicle approached within 100m, the herd ran together into a group and ran east from the disturbance. When radio-collared animals were relocated from the air the following day (28 February), the herd had apparently moved 4.5 km southwest (Fig. 3). On 6 February a herd of 25 muskoxen grouped and ran at least 1 km southwest when Bombardiers were operating about 3.0 km northeast of them. (Table 1, Fig. 4).

In the Tamayariak area, distances moved by radio-collared muskoxen during times when seismic activities were within 5 km of herds were similar to distances moved before and after activities were in the area (Table 2). Variability within each time period was high. The range of movements made during times when seismic activities were present was within the range of movements made before and after activities occurred.

Table 2. Movements of radio-collared muskoxen prior to, during, and after seismic survey activities occurred in the Tamayariak area, January-April 1984.

| | Number of observations | Distance moved(km/day)[a] Range | Mean S.D. |
|---|---|---|---|
| Prior to activities (Jan - Feb) | 13 | 0.1 - 1.9 | 0.6 ± 0.5 |
| After activities (March - April) | 19 | 0.0 - 1.9 | 0.5 ± 0.5 |
| During activities (Feb - March) | 7 | 0.0 - 1.4 | 0.6 ± 0.6 |

[a] Excluding single day movements

Sadlerochit Area

In the Sadlerochit area, portions of four seismic lines crossed areas of high muskox use (Fig. 2). One east-west line crossed the Carter Creek hills where muskoxen calved in 1982 and 1983 (Reynolds et al. 1984) and continued across the lower Sadlerochit River. Work along this portion of the line occurred on 19-23 February when muskoxen were located at least 18 km south on the mid-Sadlerochit River. A portion of an east-west line crossing the middle Sadlerochit River was shot on 10-13 April after the animals had moved to Carter Creek hills in early March. A line which paralleled the lower Sadlerochit River within 1.5 km was also shot in late April when the muskoxen were in Carter Creek hills.

Muskox herds moved from the Sadlerochit River to Carter Creek hills prior to calving in 1982, 1983, and 1984 (Reynolds et al. 1985). In 1984, this movement occurred between 6 and 19 March, at least one month before similar movements were seen in 1982 and 1983. During the same time, a single cow left the herd and moved at least 25 km southwest to the ridges above Arctic Creek, in the upper Sadlerochit drainage. No seismic trains were present in the area during the time the animals moved, but this herd was hunted by people on snow machines on 6 March 1984.

Muskoxen may have encountered seismic activities near the Carter Creek hills in late April 1984. On 23 April, the work on the line was within 4.0 km of a

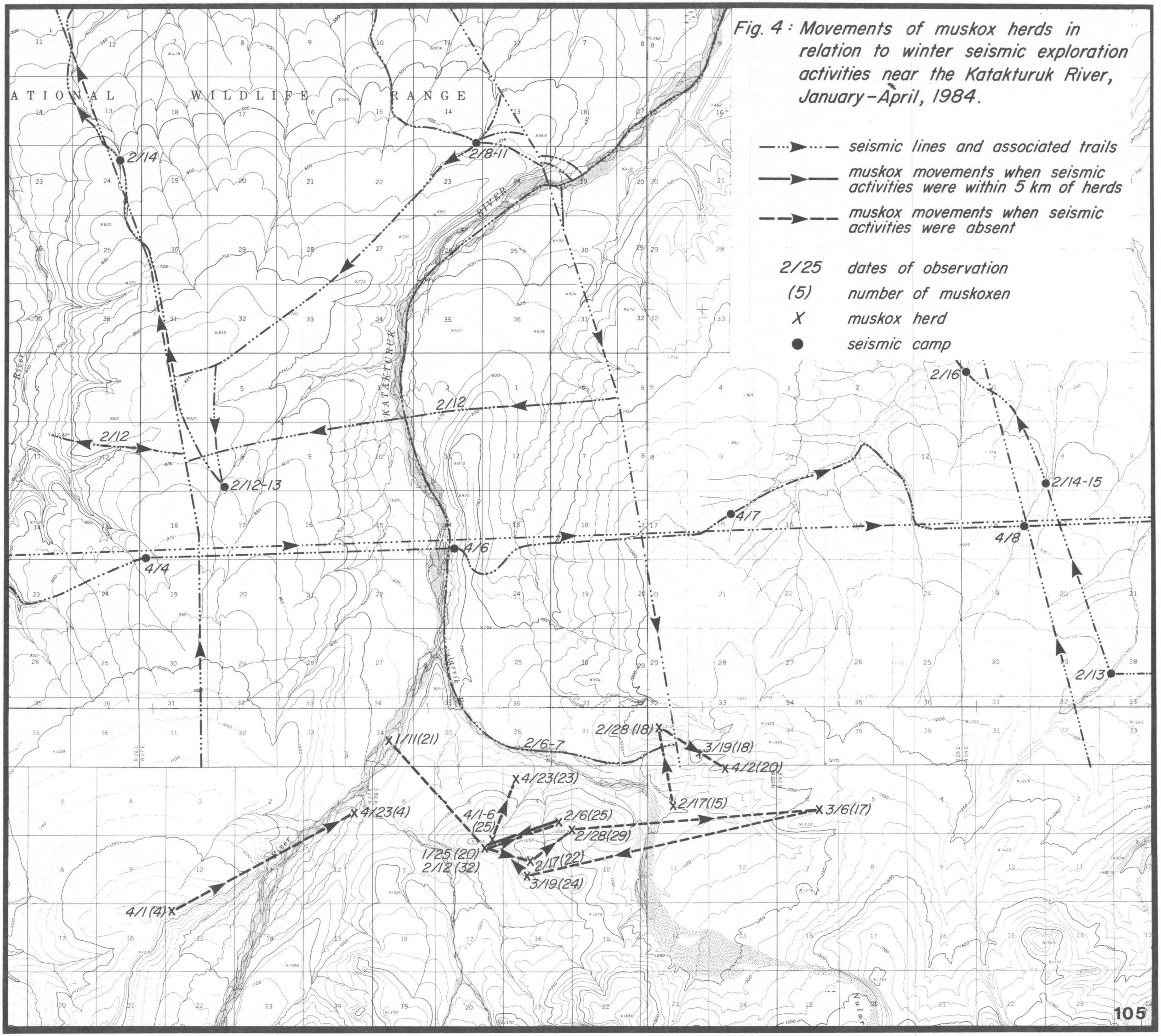


*Fig. 4: Movements of muskox herds in relation to winter seismic exploration activities near the Katakturuk River, January–April, 1984.*

herd of 95 muskoxen. Between 11 and 23 April the animals moved to the creek bottom from the hills where they had been since 19 March. During the following two weeks they continued to travel along Carter Creek after splitting into two different herds (Fig. 5).

In the Sadlerochit area, no observations were made of muskoxen responding to vehicles associated with seismic surveys.

Okerokovik Area

In the Okerokovik area portions of five seismic lines crossed areas of high muskox use (Fig. 2) Seismic lines traversing areas used concurrently by muskoxen were shot in late March. Muskox herds observed in January 1984 on the lower Angun and Sikrelurak Rivers remained in a small area along the Sikrelurak and Angun River from mid-February until late April. These animals were present prior to the arrival of seismic trains in early March and did not leave the area until after the vehicles had left (Fig. 6). No major movements of herds containing radio-collared animals occurred during the time when seismic trains were operating in the area.

The lower Niguanak River was used by herds in January 1984 prior to the arrival of seismic trains. One herd of 14, moved southwest along the river in February and March (Fig. 7). This herd may have encountered seismic vehicles on or near Okerokovik River in late March. On 27-28 March, when a seismic crew was in the area, a herd of 10 muskoxen and 2 animals were seen on hills southwest of the Okerokovik River about 7 km southwest of areas in which they were normally seen. A radio-collared cow and 3-year old cow apparently left the herd and moved 7 km further west (Fig. 7). These movements may have been the result of animals being disturbed by seismic vehicles, but the evidence is only circumstantial.

Observations of muskox herds near seismic vehicles in the Okerokovik area were made by USFWS seismic field monitor P. Miller and GSI personnel (Table 3). Herd No. 3 was observed on three consecutive days. On 16 March the herd ran from three bombardiers which approached within 0.4 km. Within 24 h the herd had moved 3.0 km. On 17 March, 14 of 17 animals in this herd ran into a defense formation once during 40 min of observation. Some individuals in the herd formed loose groups as four Bombardiers traveled along a seismic line 2 to 4 km away. A lone bull (UMB) ran toward this herd when four Bombardiers approached within 0.8 km. More then nine h later this herd was observed in the same location and showed similar behavior when one Bombardier and six drill trucks were witin 2.0 to 3.0 km. On March 18, the herd, which had moved less than 1 km in 24, grouped together in a loose formation as seven drill trucks traveled along the seismic line 3.6 km to the west. On March 19, the herd was relocated from the air and had moved about 2.0 km closer to the seismic line (Fig. 6).

Observations of an unmarked herd of 14 muskoxen in the Okerokovik area showed similar results (Table 3). On 15 and 16 March, part of the herd moved together into a loose group as single vehicles passed within 2.0 to 3.0 km of the herd. Other individuals in the herd showed no change in behavior. Animals were seen again in the same location about three h later while seismic recording was taking place. Although detailed response to the activity was not noted, the animals remained in the area. The muskoxen moved about 1.0 km

Table 3. Behavioral responses of muskox herds to activities associated with seismic surveys in the Okerokovik area, March 1984.

| Date | Herd ID | No. of muskox | Type of activity | Minimum distance (km) | Behavior | % herd responding[a] |
|---|---|---|---|---|---|---|
| 15 Mar | UMA | 14 | 1 tractor, 1 bombardier moving | 0.7 | group in loose formation | 71 |
| | UMA | 14 | 1 Bombardier parked | 0.7 | group in loose formation | 79 |
| | UMA | 14 | 1 Bombardier moving | 1.6 | walk away | |
| | UMA | 14 | 1 truck, 1 bombardier moving | 1.6 | run short distance | 29 |
| | UMA | 14 | 1 Bombardier parked | 1.6 | group in loose formation | |
| | UMA | 14 | 1 truck, 1 bombardier moving | 1.6 | group in loose formation | |
| 16 Mar | 3 | 18 | 3 Bombardiers approaching ox | 0.4 | run long distance | |
| 17 Mar | 3 | 14 | 4 Bombardiers moving | 4.0 | no response | |
| | 3 | 16 | 4 Bombardiers moving | 2.4 | group in loose formation | 86 |
| | 3 | 16 | 4 Bombardiers moving | 2.0 | group in loose formation | |
| | 3 | 17 | 4 Bombardiers moving | 3.2 | run into group | 82 |
| | 3 | 17 | 1 Bombardier moving | 2.4 | group in loose formation | |
| | 3 | 17 | 1 Bombardier moving | 3.2 | group in loose formation | |
| 18 Mar | 3 | 17 | 1 Bombardier, 7 trucks moving | 3.6 | group in loose formation | |
| 17 Mar | UMB | 1 | 4 Bombardiers moving | 0.8 | run toward distant herd | |
| 24 Mar | UMC | 15 | 3 Bombardiers moving | 3.2 | walk away | |
| 24 Mar | UMD | 4 | 1 Bombardier moving | 4.0 | no response | |
| | UMD | 4 | 5 trucks moving | 3.2 | run away | |
| 27 Mar | UME | 2 | 2 Bombardiers moving | 3.2 | no response | |
| 28 Mar | UMF | 10 | 1 Bombardier moving | 2.4 | rise from rest | |
| | UMF | 10 | 1 Bombardier moving | 1.2 | no response | |

[a] if entire herd did not respond; others assumed to show no response.

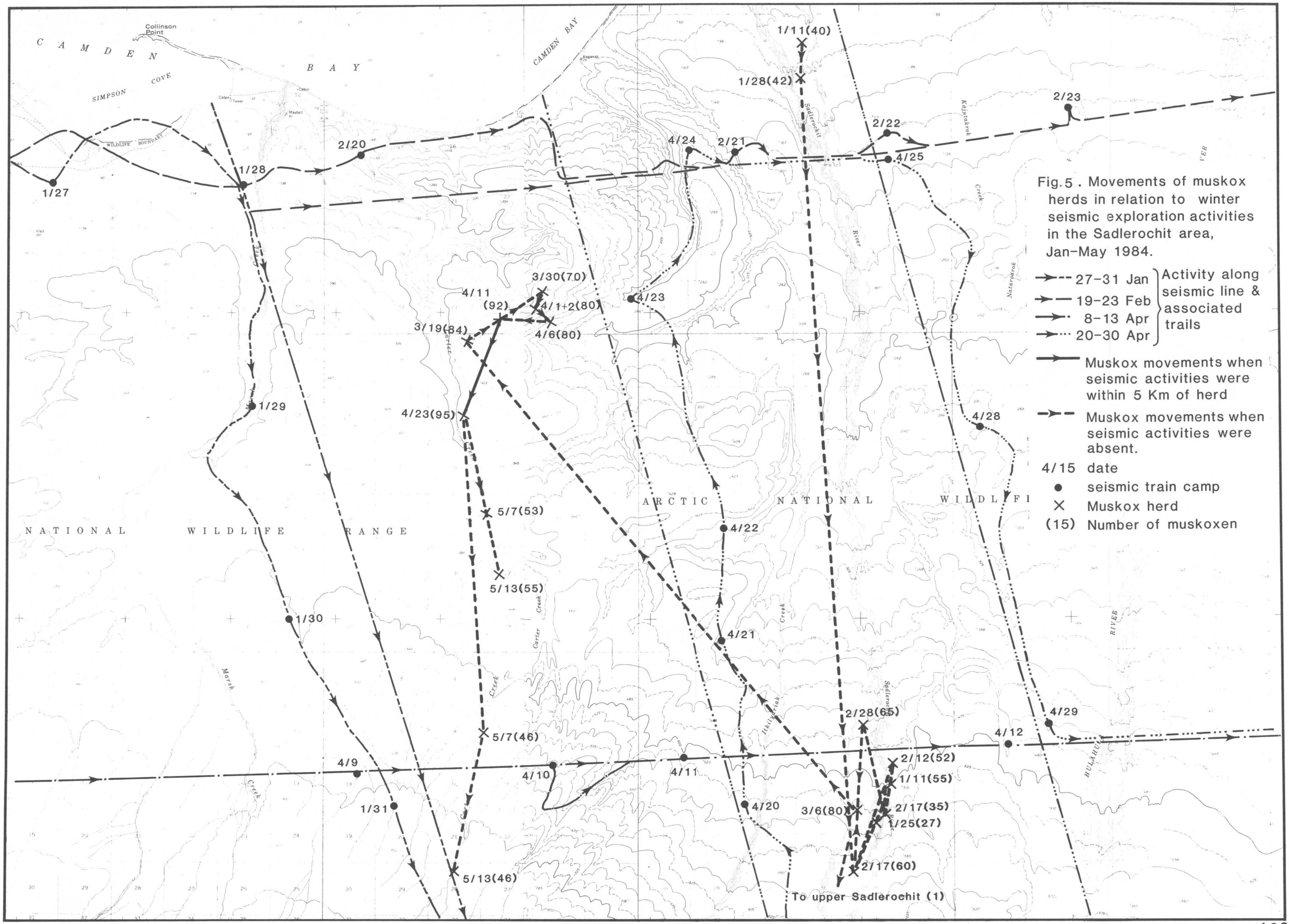
Fig. 5. Movements of muskox herds in relation to winter seismic exploration activities in the Sadlerochit area, Jan-May 1984.
27-31 Jan
19-23 Feb
8-13 Apr
20-30 Apr
Activity along seismic line & associated trails
Muskox movements when seismic activities were within 5 Km of herd
Muskox movements when seismic activities were absent.
4/15 date
seismic train camp
Muskox herd
(15) Number of muskoxen
CAMDEN BAY
Collinson Point
SIMPSON COVE
CAMDEN BAY
WILDLIFE BOUNDARY
NATIONAL WILDLIFE RANGE
ARCTIC NATIONAL WILDLIFE
Sadlerochit River
Carter Creek
Marsh Creek
Katakturuk
Nataroarok Creek
HULAHULA RIVER
Itkilyariak Creek
To upper Sadlerochit (1)
1/11(40)
1/28(42)
2/23
2/22
4/24
2/21
4/25
2/20
1/28
1/27
3/30(70)
4/11
(92)
4/1+2(80)
4/23
3/19(84)
4/6(80)
1/29
4/23(95)
4/28
5/7(53)
4/22
5/13(55)
1/30
4/21
2/28(65)
4/29
5/7(46)
4/12
4/9
4/10
4/11
2/12(52)
1/11(55)
1/31
4/20
3/6(80)
2/17(35)
1/25(27)
2/17(60)
5/13(46)

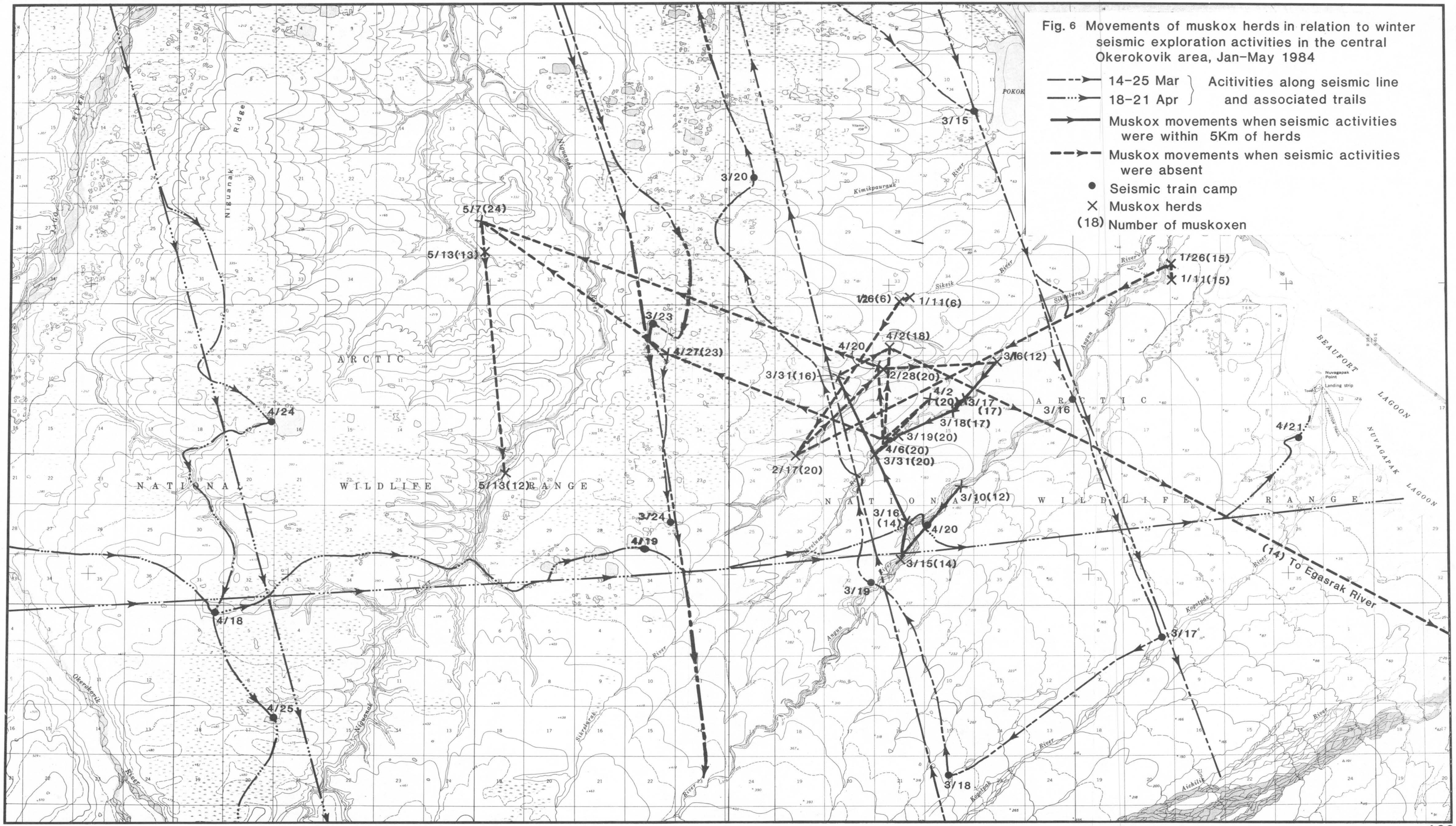

Fig. 6 Movements of muskox herds in relation to winter seismic exploration activities in the central Okerokovik area, Jan-May 1984
14-25 Mar
18-21 Apr
Acitivities along seismic line and associated trails
Muskox movements when seismic activities were within 5Km of herds
Muskox movements when seismic activities were absent
Seismic train camp
Muskox herds
(18) Number of muskoxen
BEAUFORT
LAGOON
NUVAGAPAK
LAGOON
ARCTIC
NATIONAL
WILDLIFE
RANGE
(14) To Egasrak River

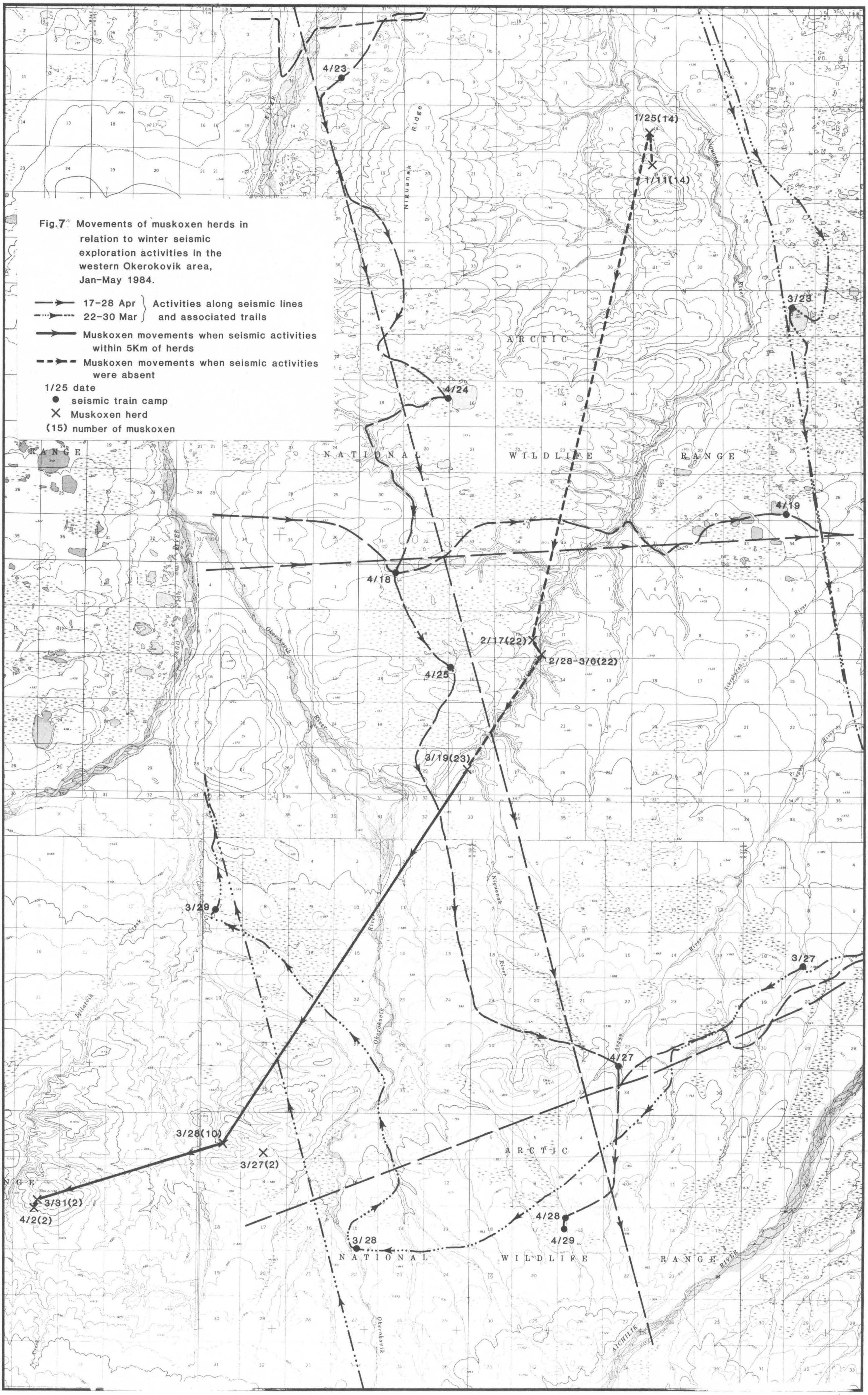


Fig.7 Movements of muskoxen herds in relation to winter seismic exploration activities in the western Okerokovik area, Jan-May 1984.

between 15 and 16 March (Fig. 6). On 24 March, an unmarked herd of four (UMD) did not appear to respond to a Bombardier 4.0 km away, but ran when five trucks were within 3.2 km of them. Two muskoxen (UMG) did not change their behavior as three vehicles were operating 3.0 km from them on 27 March. An unmarked herd of 10 (UMF) showed little response to a Bombardier at 1.2 - 2.4 km (Table 3).

In the Okerokovik area, distances moved by radio-collared muskoxen during times when seismic activities were within 5 km of herds appeared to be greater than distances moved before and after activities were in the area but small sample size preclude statistical comparisons (Table 4). The maximum movement observed occurred when a herd traveled the Niguanak River to hills southwest of the Okerokovik River on 19-27 March. Although seismic vehicles were in the area on 27 March, it is not known if the herd encountered and/or was disturbed by the activity.

Table 4. Movements of radio-collared muskoxen prior to, during, and after seismic survey activities occurred in the Okerokovik area, January- May 1984.

| Relation to seismic activities | No. of observations | Distance moved(km/day)[a] | | |
|---|---|---|---|---|
| | | Range | Mean | S.D. |
| Prior to activities (Jan - Feb) | 9 | 0.0 - 0.8 | 0.3 | ±0.28 |
| After activities (March - May) | 7 | 0.1 - 0.8 | 0.6 | ±0.25 |
| During activities (Feb - March) | 3 | 0.3 - 1.8 | 0.9 | ±0.65 |

[a] excluding single day movements

## General Discussion

In 1984, general distribution of muskoxen was similar before, during and after seismic survey were completed and did not differ from winter-spring distributions in 1982 and 1983. Muskoxen apparently were not displaced from areas of traditional use in 1984. All muskoxen observed were within or near use areas documented in 1982-1984.

Information from movements of radio-collared animals also showed that muskoxen did not move long distances in response to seismic surveys. Observed movements possibly caused by a negative response to the presence of seismic vehicles did not exceed a maximum of 5.0 km. Two herds, observed on two consecutive days before and after animals ran from approaching vehicles, moved 4.5 km and 3.0 km in about 24 h. Preliminary analysis of movement data obtained from radio-collared animals indicates that in undisturbed conditions muskoxen often remain in a small area for several days or a few weeks before moving to a different area. Average daily movements of nine radio-collared muskoxen recorded in 1982 ranged from 0.0 to 6.7 km/day (Reynolds et al. 1983). Jingfors (1982) reported daily group movement rates ranging from 0.66 km/day to 9.9 km/day for a muskox herd on the Sadlerochit River. Any movements caused by the presence of seismic activities probably did not exceed the range of daily movements which occur in undisturbed conditions.

Limited ground observations of muskoxen near seismic vehicles suggest that variability in response to disturbance exists. Two herds did not respond by running into groups and facing the disturbance or fleeing until they were approached within 100 to 200 m. Two different herds ran when surveyors approached at 400 m and 500 m. Two other herds apparently ran when vehicles were over 3 km away.

Muskox herds encountered seismic crews infrequently in 1984. Although the seismic program covered several areas of high muskox use, activities were present within each area for only a few days. Even if disruptions in normal movements and activity patterns occurred, effects on the population were probably not substantial, because of the transitory nature of the program. Productivity, determined by the number of calves born to cows older then three years, was 0.75 calves per cow in 1984 compared with 0.66 calves per cow in 1983 and 0.63 calves per cow in 1982 (Reynolds et al. 1985).

Results of this study were similar to studies documenting the effects of seismic exploration on muskoxen in Canada which found that animals responded to vehicles by forming defensive groups and running, or gradually moving away from the vicinity of a seismic line (Urquahart 1973, Beak Consultants Ltd. 1976, Russell 1977, Jingfors and Lassen 1984). Movements away from lines were apparently of relatively short duration and herd or population size did not appear to be affected.

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# DISTRIBUTION AND RELATIVE ABUNDANCE OF GOLDEN EAGLES IN RELATION TO THE PORCUPINE CARIBOU HERD DURING CALVING AND POST-CALVING PERIODS, 1984.

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Key words: golden eagles, distribution, abundance, predation, caribou, Alaska, north slope, Arctic-Beaufort.

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Distribution and relative abundance of golden eagles in relation to the Porcupine caribou herd during calving and post-calving periods, 1984.

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Abstract: Distribution and abundance of golden eagles (*Aquila chrysaetos*) in realtion to calving and post-calving activities of the Porcupine caribou (*Rangifer tarandus*) herd were investigated by compiling records of incidental observations made by various field personnel, and conducting aerial surveys. The status of golden eagle production at nest sites adjacent to caribou calving and post-calving areas was determined by aerial and ground methods. A total of 323 observations (428 eagles) were recorded between 3 May and 11 August 1984. The ratio of sub-adults to adults was 8:1 for those observations when age was determined (n=192). Eighty-eight percent of recorded observations were made in areas of current or recent caribou occupation. Golden eagles were observed either feeding or perched at caribou calf carcasses on 23 (7.2%) occasions and were at adult caribou carcasses on 13 (4.0%) occasions. Necropsy investigations confirmed that predation by golden eagles was most probable cause of death in 6 of 25 calf carcasses examined. Concentrations of golden eagles in caribou areas occurred during the late calving (13-19 June) and post-calving (20-30 June) periods when 8.1 and 12.4 eagles sightings/24 h occurred. Systematic aerial transect surveys during the calving period did not identify significantly more eagles in areas occupied by caribou versus unoccupied areas. Intensive aerial searches over post-calving concentrations of caribou recorded 5.0 eagles/h of flight time. Similar searches over areas of comparable habitat and terrain which were not occupied by caribou, yielded 0.0 eagles/h. Only 1 out of 12 golden eagle nest sites adjacent to caribou calving and post-calving areas produced young in 1984. Other golden eagle nests remote to caribou areas were also generally unproductive in 1984.

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Predation of caribou (*Rangifer tarandus*) calves by golden eagles (*Aquila chrysaetos*) has been documented in several caribou herds located in Alaska and Canada (Murie 1944, Skoog 1956, Kelsall 1968). An apparent concentration of primarily immature golden eagles in association with calving and post-calving segments of the Porcupine caribou herd has been reported (Calef and Lortie 1973, Roseneau 1974, Schweinsburg 1974, Roseneau and Curatolo 1976, Mauer et al. 1983, Whitten et al. 1984). Cases of golden eagle predation on Porcupine herd calves have also been recorded on a regular basis (Roseneau and Curatolo 1976, Mauer et al. 1983, Whitten et al. 1984). During recent investigations of Porcupine herd calf mortality, golden eagles were found to be involved as a predator or scavenger in 50% of the mortality occurring among radio-collared calves in 1982 (Mauer et al. 1983). In 1983, 27% of study calves dying during 4 June to 3 August was due to golden eagle predation (Whitten et al. 1984). The effect of golden eagle predation on calf survival rates of the Porcupine herd cannot be adequately assessed, however, until more information is obtained regarding eagle abundance and distribution. Further information regarding golden eagle predation and scavenging behavior is also needed.

In 1984 a study plan was developed and field studies carried out with the purpose of obtaining improved information on the ecology of golden eagles on the Porcupine caribou herd's calving grounds. The initial objectives were:

1) Determine relative abundance and distribution of golden eagles associated with calving and post-calving caribou.

2) Determine temporal aspects of golden eagle occurrence on the northern portion of the Arctic National Wildlife Refuge.

3) Measure productivity of golden eagle nest sites adjacent to caribou calving and post-calving areas.

Golden eagle investigations were carried out during May-August 1984 as a part of a comprehensive set of baseline studies of the fish, wildlife and habitats of the coastal plain of the Arctic National Wildlife Refuge.

## Methods and Materials

The study area consisted of the arctic coastal plain, foothills, and northern mountains of the Brooks Range in the Arctic National Wildlife Refuge from the Canning River on the west to the US-Canada international boundary and in to Canada to the Babbage River (Fig 1). The physical environment, climate, geology, vegetation, and other biological resources of this area were described in Wilken et al. (1981) and U.S. Fish and Wildlife Service (1982). Distributions of caribou within the study area were based on information obtained during concurrent caribou investigations (Whitten et el. 1985).

Observation Records. Observations of golden eagles were collected from observers associated with several biological field studies underway in the study area during May-August 1984. Ground crews, engaged in terrestrial bird inventories, recorded golden eagle observations from base camps located near the Sadlerochit River delta, the Jago River delta, and near the foothills of the Aichilik River (Fig 1). Observation records were collected from a ground crew conducting small mammals studies at base camps located at Caribou Pass-Kongakut River, the Okpilak River delta, and near the Katakturuk River (Fig. 1). The small mammal field camps were occupied by observers on a rotational basis of approximately 10 days at each site. Observations of golden eagles were also collected from biologists conducting aerial radio-tracking surveys, and other aerial operations associated with caribou studies (Whitten et al. 1985). During the period of 3 June to 6 July 1984, aerial surveys flown over caribou were conducted on a daily basis and averaged about three h/day over areas associated with caribou. Crews engaged with brown bear and wolf capture operations and radio-telemetry surveys also provided observations of golden eagles. A few additional observations were recorded by fisheries study crews and a raptor/endangered species inventory effort (Gill and Amaral 1984, Amaral and Benfield 1985).

All reported sightings of golden eagles in the study area were compiled in a systematic manner recording: date, location, number of eagles sighted, age classification (adult/immature), activity (flying, perched, feeding), and the presence or absence of caribou. Locations were plotted on 1:63,360 and 1:250,000 scale topographic maps. The presence of white coloration on the under-wings and the base of the primary feathers of the tail was the criteria used to distinguish immature birds.

Aerial Surveys. Systematic and non-systematic aerial surveys were used to collect additional data on golden eagle density and distribution in the study area. The systematic method involved aerial transect surveys similar to that of Boeker and Ray (1971). Sixteen transect lines were located in north-south orientation across the study area from the Beaufort Sea coastline to the northern perimeter of mountainous terrain (Fig. 2). The transects were spaced at 19.4 km intervals and ranged from 74 to 19 km in length. Surveys were conducted by flying the transects in either a Cessna 207 or a Piper PA-18 aircraft at an elevation of approximately 90 m above ground level at speeds of approximately 192 and 144 km/h respectively. Surveys conducted with the Cessna aircraft utilized two observers, one seated on the left and one on the right side of the aircraft. In the Piper aircraft the pilot (seated forward) recorded observations ahead and to the left of the aircraft and an observer (seated in the rear) recorded observations to the right. All eagles observed within 0.4 km of each side of the aircraft were recorded using portable tape recorders. The location of each eagle sighting was plotted on topographic maps. The relative abundance of caribou (high, moderate, low density) was noted. Factors influencing visibility such as time of day, flight direction, sun angle, cloud cover, and snow cover were also noted. Aerial transects were flown on 1-2 June and 8-9 June 1984.

Intensive non-systematic aerial surveys were conducted over areas of current high density of caribou and over areas unoccupied by caribou that were remote ( 30 km) from currently occupied caribou areas and had not been previously occupied by caribou in 1984. A Piper PA-18 Supercub aircraft was used.

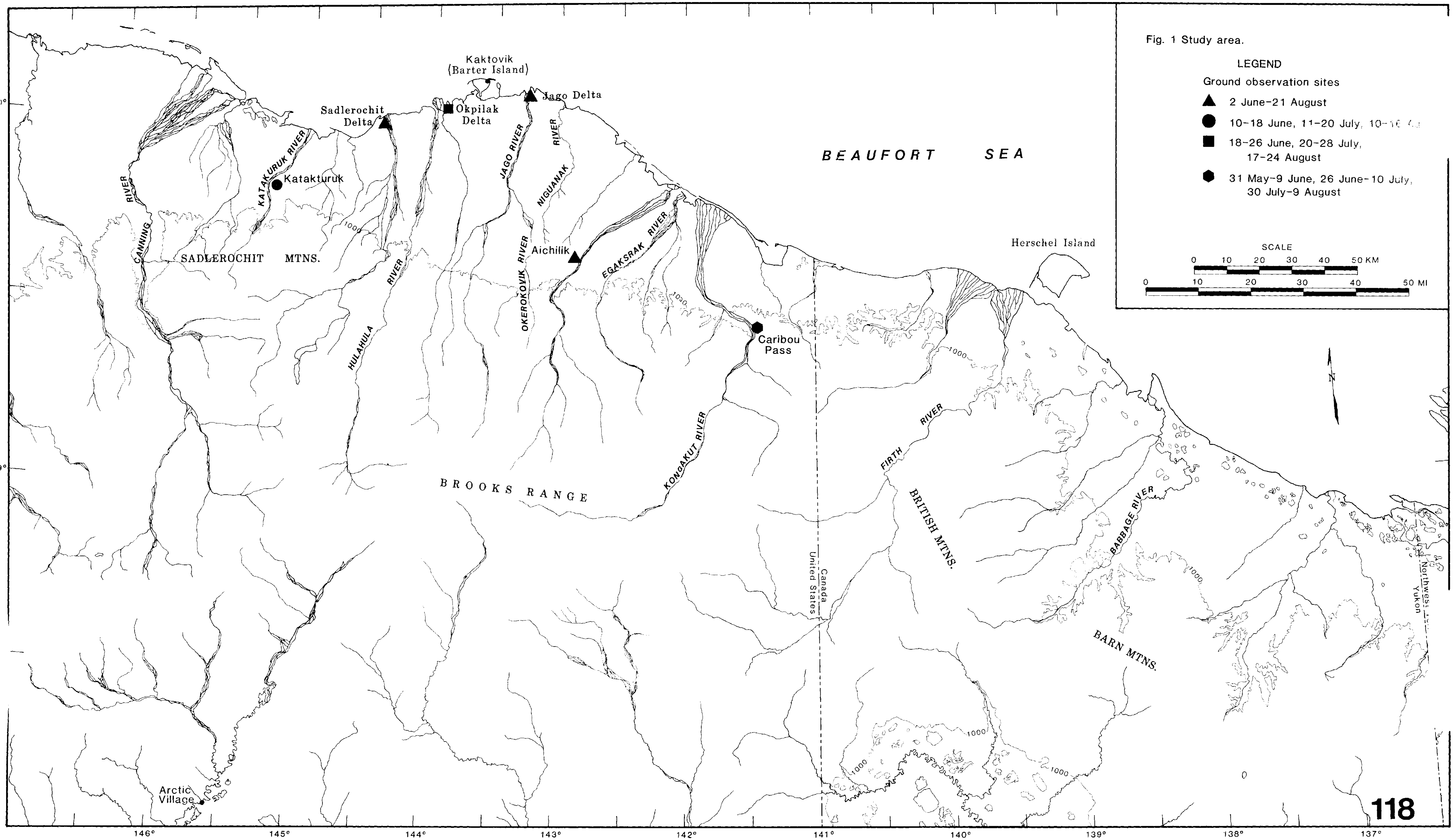


Fig. 1 Study area.

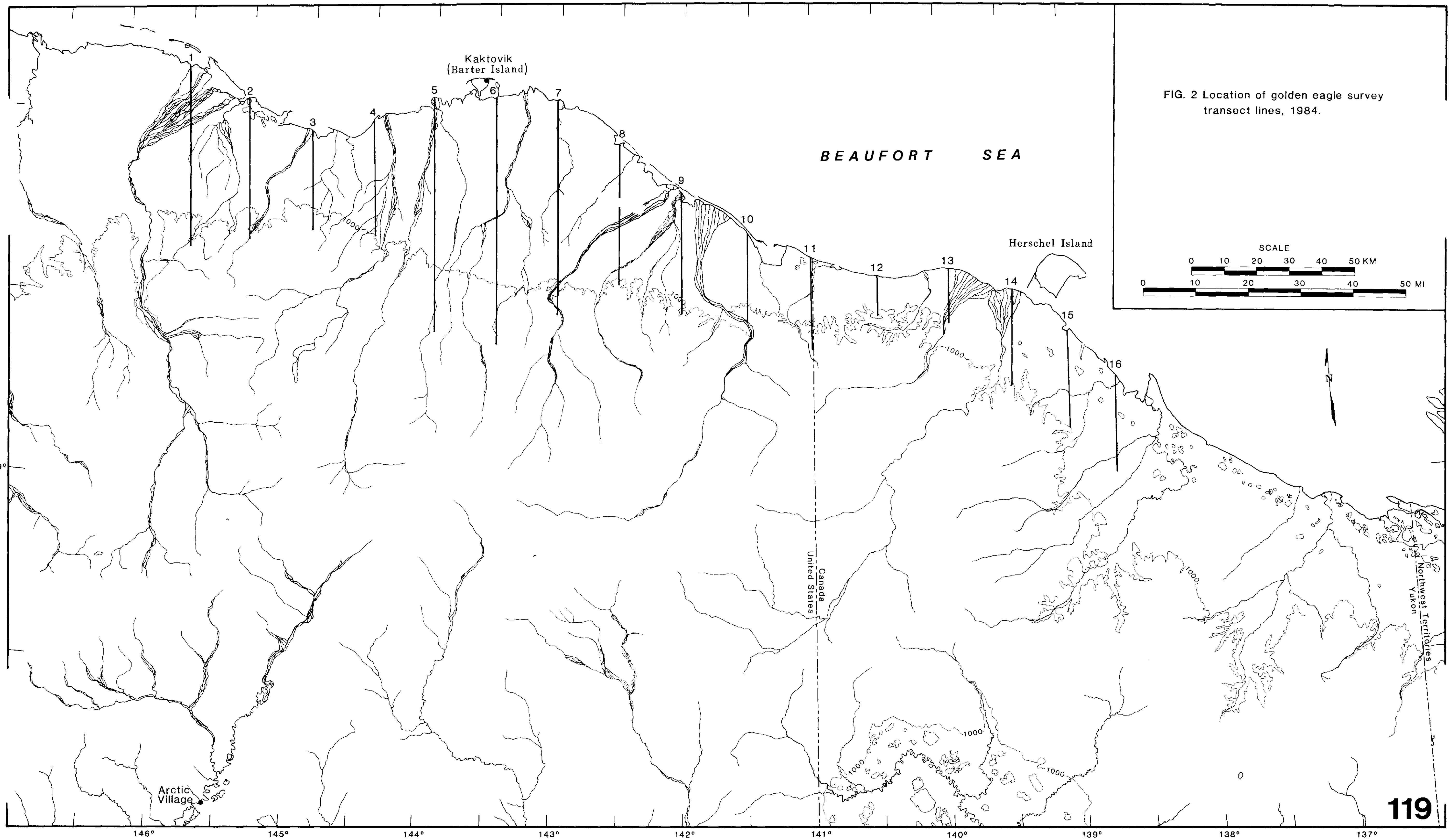


FIG. 2 Location of golden eagle survey transect lines, 1984.

Flight speed was approximately 105 km/h at 90 m above the ground. Flight paths were oriented such that maximum time was devoted to flight over or near to groups of caribou. Aerial surveys in "non-caribou" areas attempted to simulate those conducted over caribou, coinciding in similar habitat and topographic features. All eagle observation were recorded in the same manner as described for the aerial transect surveys. The amount of time for each intensive search was recorded.

Nest Surveys. Previously identified golden eagle nest sites (Roseneau 1973, 1974) that occurred in or adjacent to calving and post-calving areas of the Porcupine herd were surveyed during 4 July to 10 August 1984, from fixed-wing aircraft (Boeker 1970), helicopter (White and Sherrod 1973), or from ground access. New nest sites discovered during the 1984 season were also checked. Nests containing eggs, eaglets, or an adult eagle were classified as active. Locations of new nest sites were plotted on 1:63,360 scale topographic maps and data were recorded in a field notebook.

## Results and Discussion

Observation Records. A total of 428 golden eagles were sighted during 323 observations (1.3 eagles/observation) made from 3 May to 11 August 1984 on the Porcupine caribou herd calving grounds, post-calving areas, and adjacent areas. Due to the high level of observer effort involved, it is likely the some eagles were observed repeatedly during the study period. Of the observed eagles which could be classified according to age (n = 192), 89% (171) were sub-adult and 11% (21) were adult birds. There were 236 unindentifiable eagles recorded. In 1975 a similar ratio of 86% sub-adults and 5% adults were reported (Roseneau and Curatalo 1976). Concentrations of sub-adult golden eagles have also been found in some of the western states in association with domestic sheep and goats during lambing and kidding seasons (Boeker pers. comm.). Most adult golden eagles are restricted to nesting territories in mountainous terrain at the southern periphery of the Porcupine herd calving grounds at calving time. Since the sub-adult eagles are not breeding, they are free to range over great distances and concentrate in favorable forage areas such as the Porcupine herd calving grounds.

Most observations of golden eagles (88%) were recorded in areas currently occupied by caribou or in areas where caribou had recently been (Fig. 3-7). In areas unoccupied by large numbers of caribou, the frequency of reported golden eagle sightings was low and there was no indication of eagle concentrations in these areas (Fig. 3-7). Although aerial supported observer effort was greatest in areas occupied by caribou, the relative frequency of aerial-derived eagle observations was comparable with that recorded by ground crews in caribou and "non-caribou" areas (Table 1). Ground observer effort in "non-caribou" areas was approximately double that of ground observer effort in "caribou" areas. In spite of this difference, 19 eagle sightings were recorded in "caribou" areas and only four sightings for "non-caribou" areas. These data suggest a higher density of eagles occurred within the "caribou" areas.

Prior to arrival of large numbers of caribou into the study area (late May),

Table 1. Comparison of observations of golden eagles recorded by ground observers at field camps remote to caribou concentrations and adjacent to caribou concentrations, Arctic National Wildlife Refuge, Alaska, 1984.

| | Number of golden eagle sightings | | | | |
|---|---|---|---|---|---|
| | Pre-calving (3-27 May) | Calving (27 May-12 June) | Late calving (13-19 June) | Post-calving (20-30 June) | Post-emigration (1-12 July) |
| Camps Remote to Caribou | | | | | |
| Sadlerochit Delta* | | 1 | | | 1 |
| Jago Delta* | | 1 | | | |
| Okpilak Delta[a] | | | | 0 | 0 |
| Katakturk River[b] | | | 1 | | 0 |
| Subtotal | 0 | 2 | 1 | 0 | 1 |
| Camps Adjacent to Caribou | | | | | |
| Aichilik River* | | 2 | 3 | 1 | 0 |
| Caribou Pass[c] | | 4 | | 9 | 0 |
| Subtotal | 0 | 6 | 3 | 10 | 0 |

* Occupied 2 June to 21 August
[a] Occupied 18-26 June, 20-28 July, 17-24 August
[b] Occupied 10-18 June, 11-20 July, 10-16 August
[c] Occupied 31 May-9 June, 26 June-10 July, 30 July-9 August

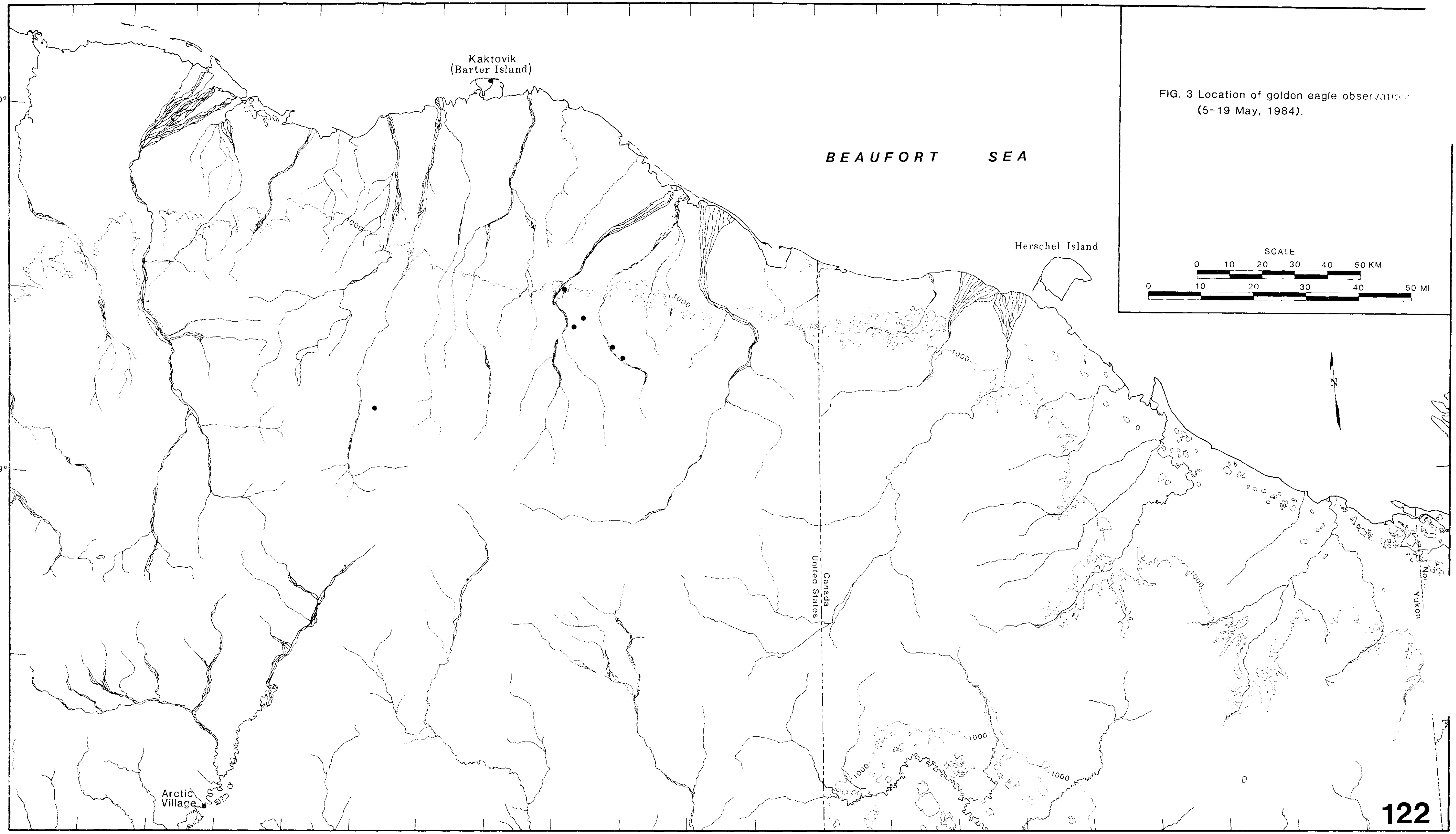


FIG. 3 Location of golden eagle observations
(5-19 May, 1984).

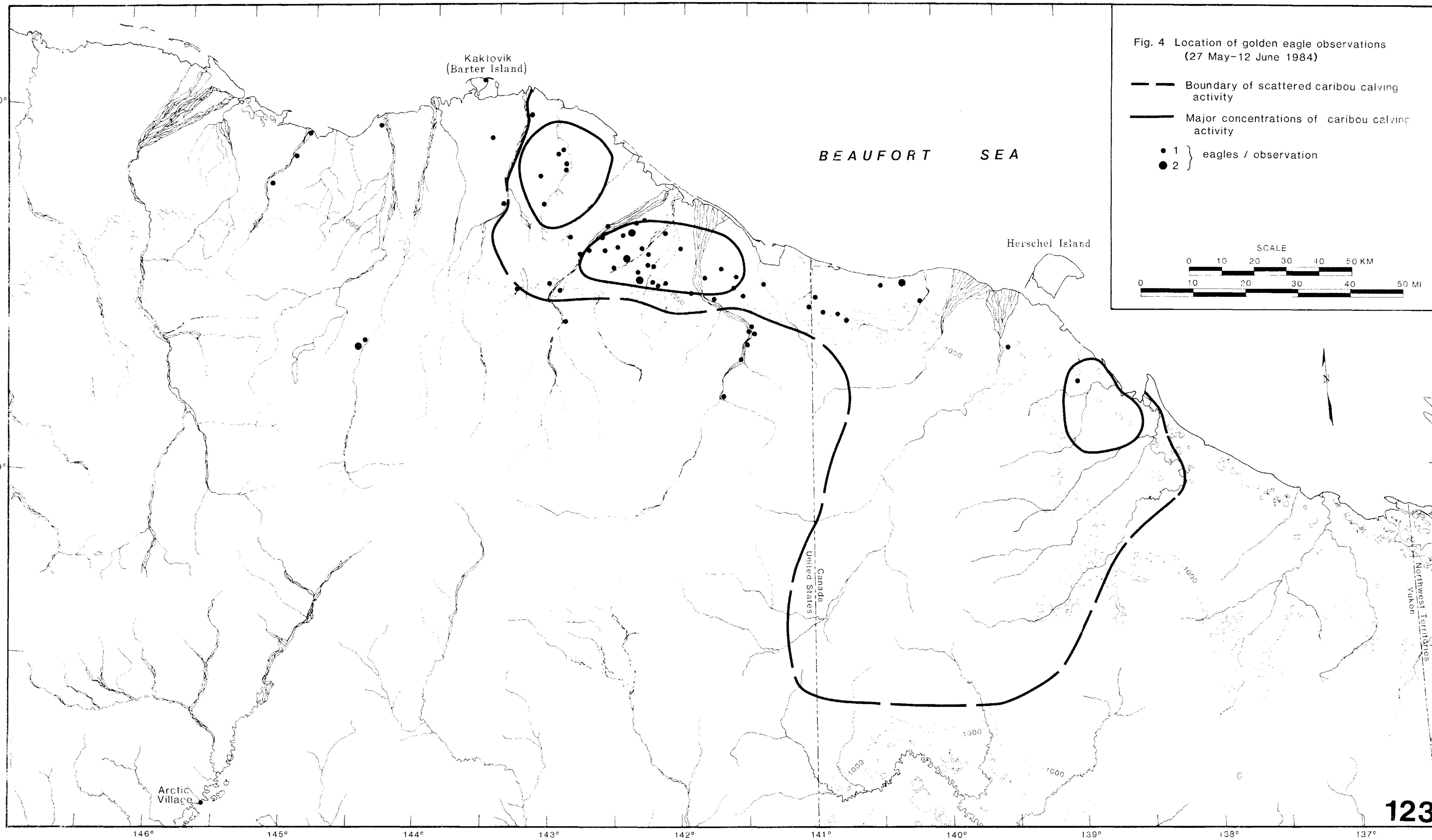

Fig. 4 Location of golden eagle observations (27 May-12 June 1984)
Boundary of scattered caribou calving activity
Major concentrations of caribou calving activity
1 2 eagles / observation
SCALE
0 10 20 30 40 50 KM
0 10 20 30 40 50 MI
BEAUFORT SEA
Kaktovik (Barter Island)
Herschel Island
Arctic Village
Canada
United States
Northwest Territories
Yukon
70°
69°
146°
145°
144°
143°
142°
141°
140°
139°
138°
137°

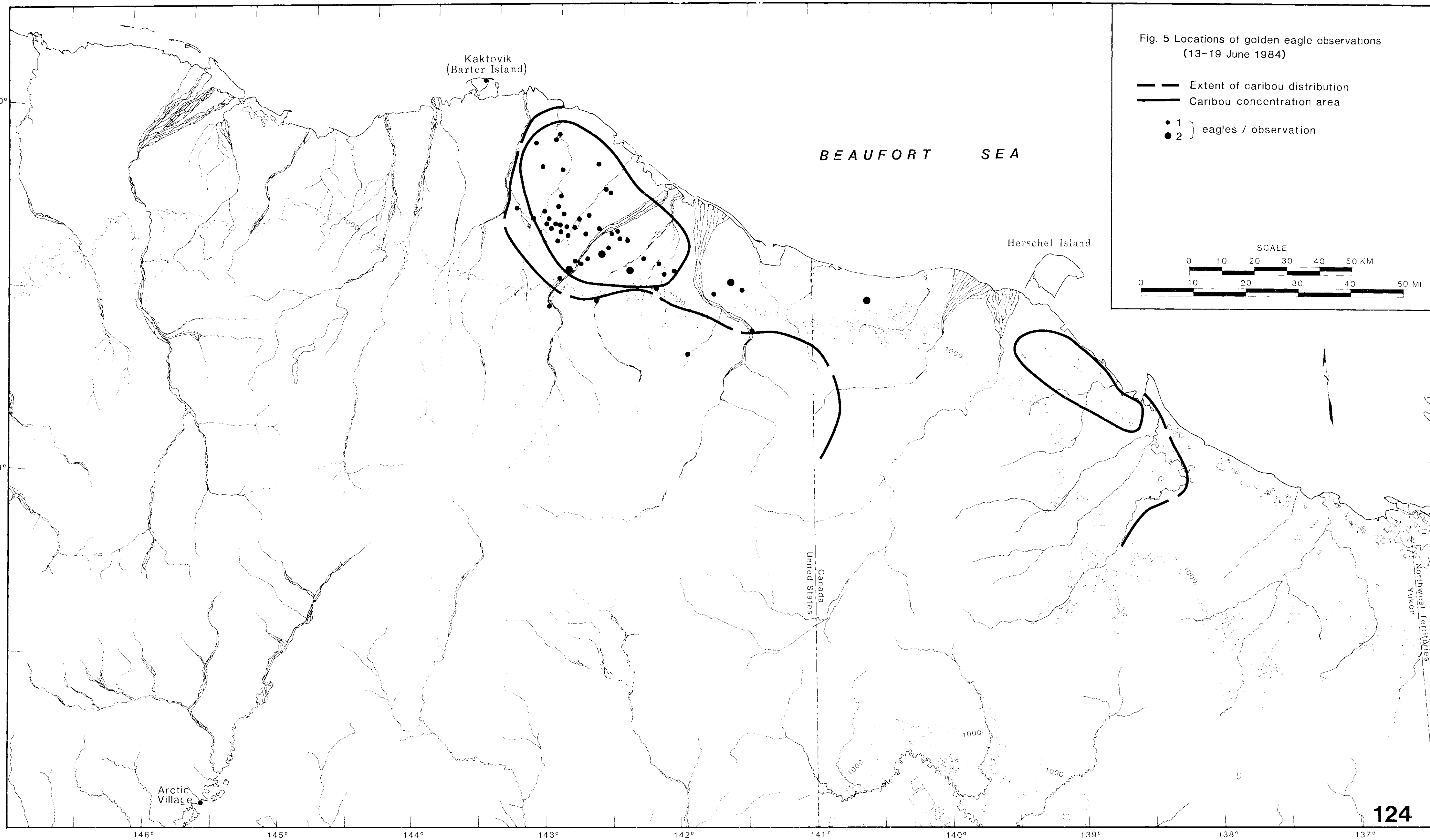
Fig. 5 Locations of golden eagle observations
(13-19 June 1984)
Extent of caribou distribution
Caribou concentration area
1
2
eagles / observation
SCALE
0 10 20 30 40 50 KM
0 10 20 30 40 50 MI
BEAUFORT SEA
Kaktovik
(Barter Island)
Herschel Island
Arctic Village
Canada
United States
Northwest Territories
Yukon
70°
69°
146°
145°
144°
143°
142°
141°
140°
139°
138°
137°
1000

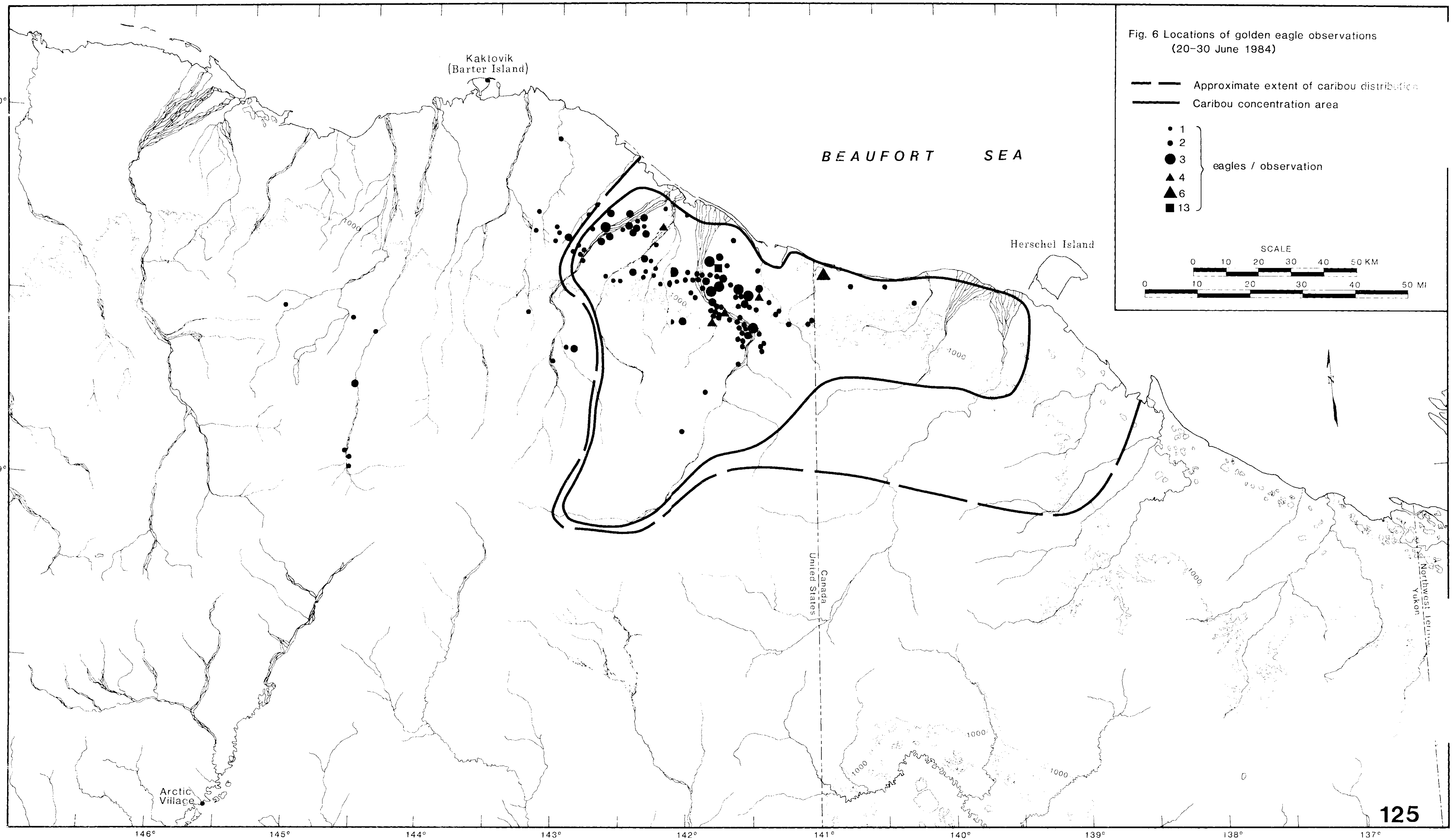


Fig. 6 Locations of golden eagle observations (20-30 June 1984)

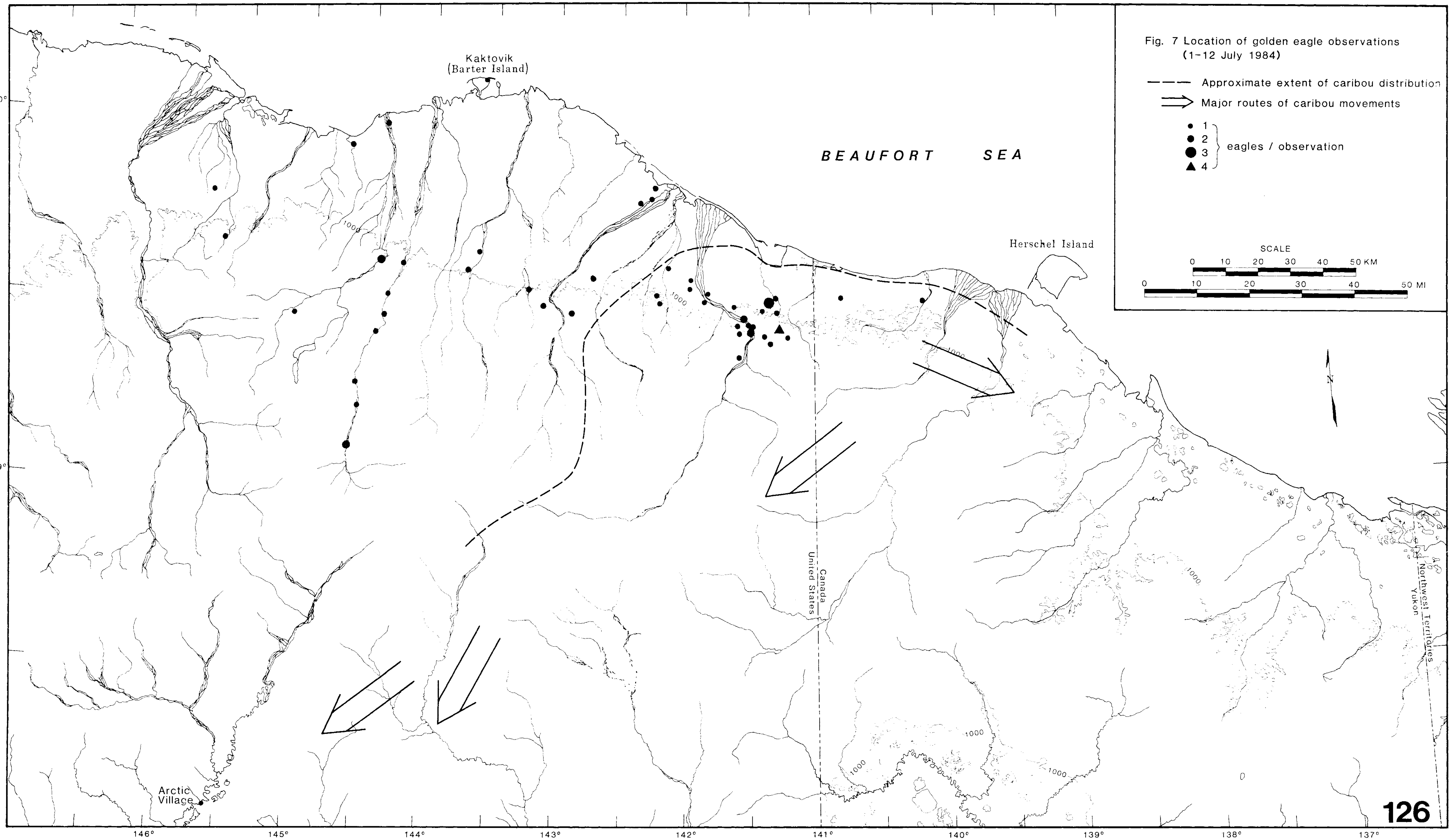


Fig. 7 Location of golden eagle observations (1-12 July 1984)

few eagles were seen. The frequency of eagle observations steadily increased following the peak of caribou calving (4 June) and peaked during the post-calving period (20-30 June, Fig. 8). Golden eagle concentrations were not apparent until about ten days following the caribou calving peak. Caribou are quite widely scattered over a large area at the onset of calving. Following birth of the calves, caribou gradually coalesced into increasingly larger groups. By the post-calving season (20-30 June) groups of caribou numbering in the thousands are common for the Porcupine herd. The frequency of observations of golden eagles coincided with the caribou aggregation process and suggests that the concentration of golden eagles is in part related to caribou behavior. More golden eagles from non-caribou areas may continue to "home" on the abundant food available in caribou aggregations areas. As caribou aggregations began to move rapidly towards the east and south, a corresponding shift in the location of golden eagles observations was noted (Figs. 5 and 6). It is not known if the same individual eagles follow the caribou throughout the summer movement; however, golden eagles were commonly observed in association with caribou herds throughout July in the British and Barn Mountains of Canada (Don Russell pers comm.).

Golden eagles were observed either feeding or perched at caribou calf carcasses on 23 occasions and were at adult carcasses on 13 occasions (Fig. 9). The number of eagle sightings at calf carcasses more than doubled during the post-calving period. This increase corresponds in time with an over-all peak in golden eagle observations and may suggest a higher predation/scavenging rate on calves during the post-calving period. Observations of more than one eagle at a locations were more frequent during the post-caliving season due to the increase in carcass feeding. During 20-30 June there were 23 observations two eagles/site, six observations of three eagles/site, five observations of four eagles/site, one observation of six eagles/site, and one observation of 13 eagles/site. Many of the eagle carcass sighting were made from fixed-wing aircraft in locations lacking suitable landing sites. Consequently most carcasses could not be investigated. For those carcasses that were accessed, necropsy investigations confirmed that predation by golden eagles was the most probable cause of death in 6 out of 25 calf carcasses. One of 16 mortalities among 60 radio-collared calves was the result of golden eagle predation (Whitten et al. 1985). Eagle predation of caribou calves was documented as late as 6 July in Alaska and 23 July in Canada (D. Russell pers. comm.). An unsuccessful eagle attack on caribou calves was observed as late as 26 July (D. Russell pers. comm.). The caribou calf depredated by a golden eagle on 6 July weighed 18 kg.

Golden eagles were observed with other predator/scavenger species on nine occasions. Brown bears (Ursus arctos) were involved in five of these cases and wolves (Canis lupus) were present in the four remaining observations. Eagles usually were perched near to carcasses which were being fed up on by the larger predators. In one case, a wolf flushed an adult willow ptarmigan (Lagopus lagopus) and an immature golden eagle stooped and caught the fleeing ptarmigan. This observation suggests that golden eagles may combine their hunting activities with those of terrestrial predators to take advantage of such events.

There was one observation of a snowy owl (Nyctea scandiaca) at a caribou calf carcass (K. Butters pers comm.). Access to the site was not available, thus

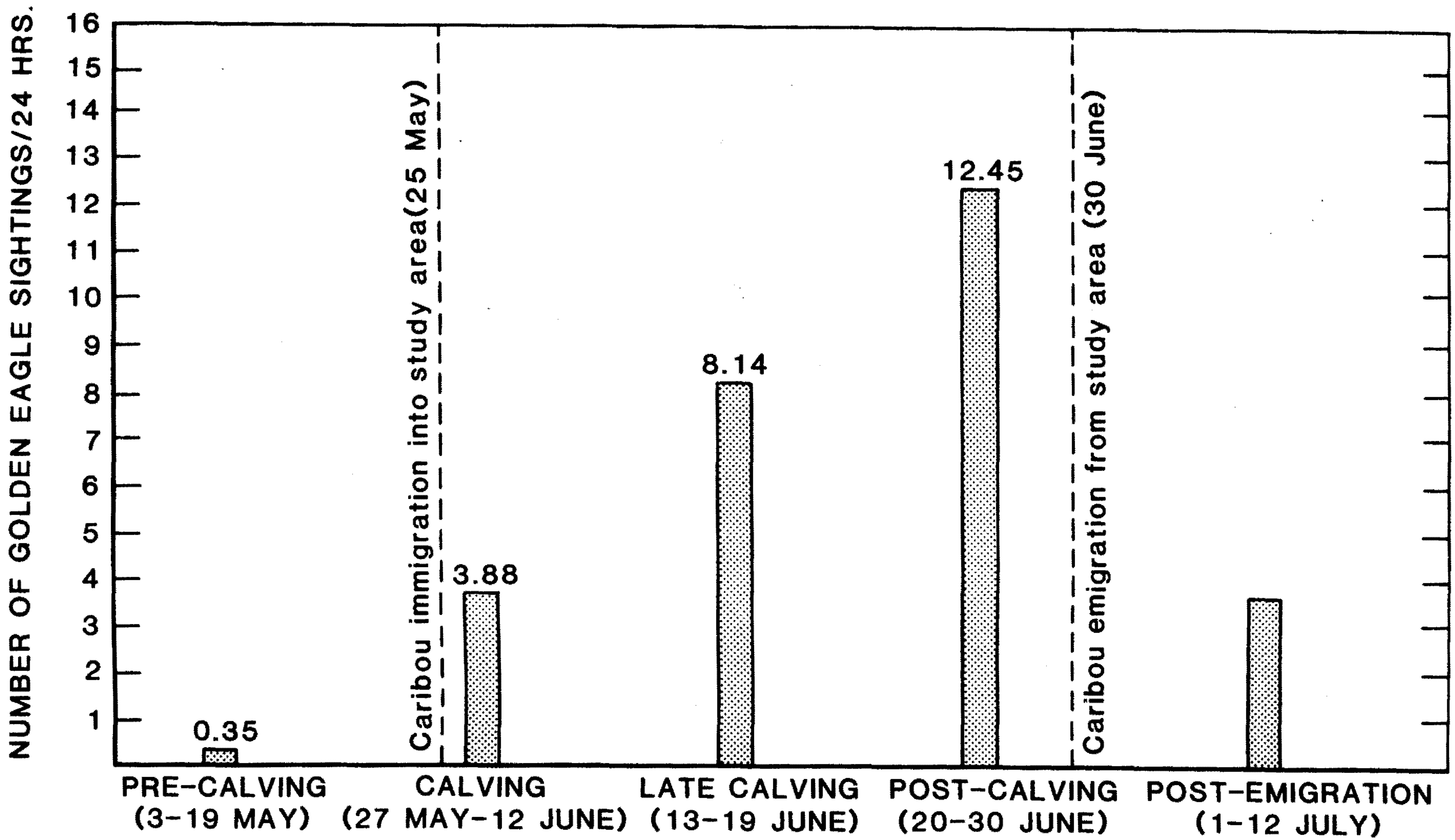


Fig. 8. Frequency of observations of golden eagles during calving and post-calving periods, Porcupine caribou herd, 1984.

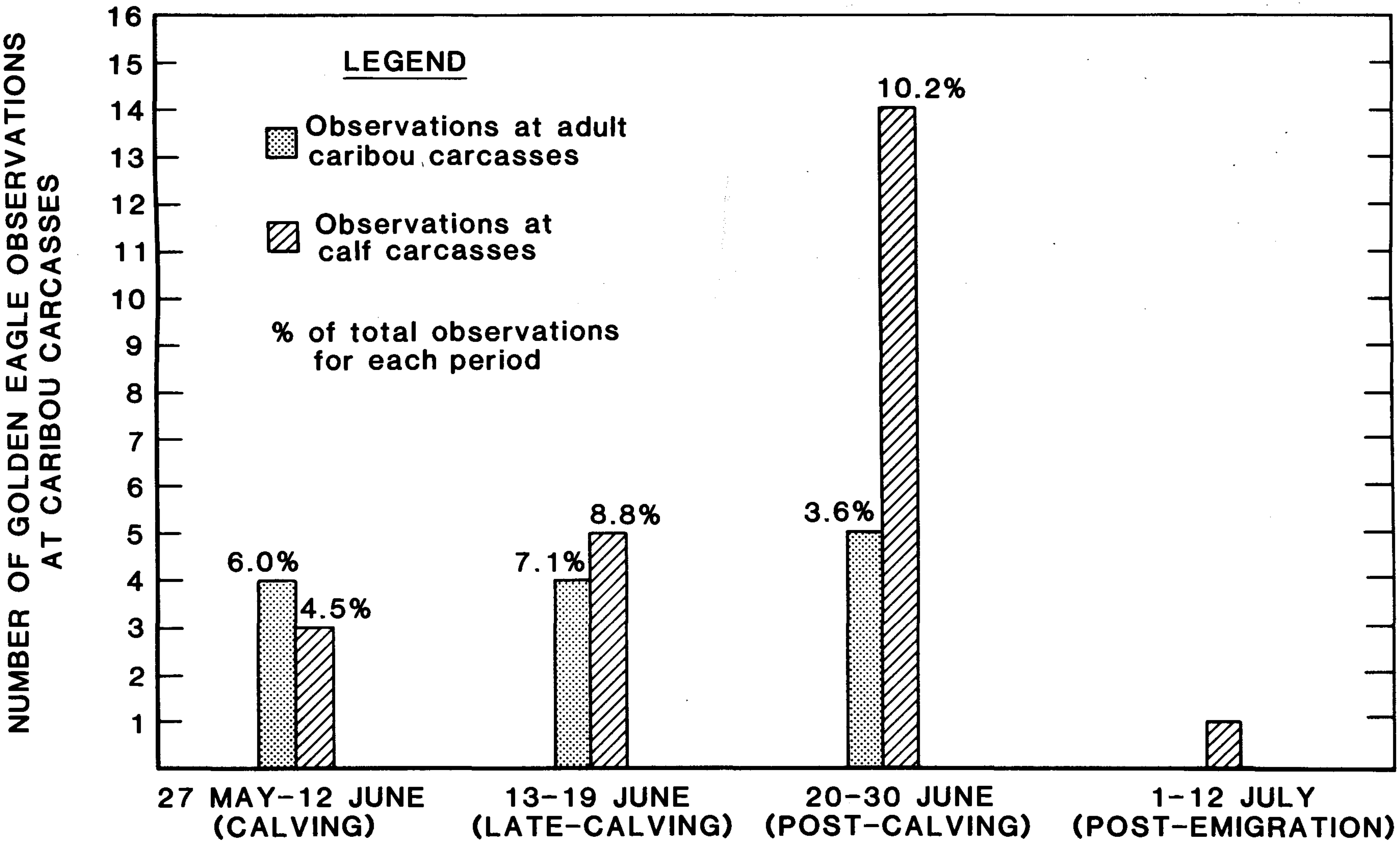


Fig. 9. Frequency of observations of golden eagles at caribou carcasses during calving and post-calving periods, Porcupine caribou herd, 1984.

no data could be collected to discern whether the owl had preyed upon the calf or if it was scavenging. Observations of an adult bald eagle (Haliaeetus leucocephalus) were recorded on the Kongakut River in early July. An adult bald eagle was also observed on the upper Aichilik River.

Aerial Surveys. The first aerial survey was conducted on 1 and 2 June and was intended to measure golden eagle distribution and abundance, at the onset of caribou calving activity. Caribou distribution at that time extended from the Jago River eastward to slightly beyond the Babbage River in Canada. Concentrations of calving females were located between the Jago and Niguanak Rivers, east of the Aichilik River, and east of the Firth River. There were scattered caribou moving west in the foothills from the Kongakut River to the Firth River. Transects 7 through 16 were associated with general caribou distribution (Figs. 2 and 4). Transects 3-6 were in an area generally unoccupied by calving caribou. The June 1-2 survey was conducted with the Cessna 207 aircraft. Only two golden eagles were recorded from transects 7-16 and no eagles were observed on transects 3-6. Approximately 4.4% and 4.2% "caribou" and "non-caribou" areas respectively were sampled. Estimated density of eagles in the caribou area was about 1/124 $km^2$. Applying this density figure to the areas sampled by transects 7-16, and estimated population of 45 eagles is generated. This figure should be considered preliminary and is probably an underestimate of the actual population. Some eagles were probably not seen due to the relative high speed of the survey aircraft (Cessna-207) and to factors influencing visibility (patchy snow/tundra patterns).

Transects 7-16 were surveyed again during June 8-9 using PA-18 Supercub aircraft. Caribou distribution was very similar to that of 1 June. Transects 1-6 were also sampled in the "non-caribou" area. Results were the same as for the first survey: two eagles were observed on transects 7-16 and no eagles for transects 1-6.

On 9 June intensive non-systematic survey was conducted over an area of high concentration of female caribou with young calves which was located between the Aichilik and Egaksrak Rivers. Flying slow and low, a flight path was selected which provided maximum flight time over or adjacent to caribou. A similar search was also conducted on 9 June over an area not occupied by caribou along the Jago River. One golden eagle was recorded during 48 min of survey time over the caribou area. Similar results (one eagle observed) occurred for the survey over a non-caribou area. On 26 June, during the post-calving aggregation period, another trial was made using the non-systematic search method. During 1.6 h flight time over caribou concentration areas near the foothills of the Kongakut River, eight eagles were recorded. A comparable search involving 1.5 h over non-caribou areas between the Okerokovik and Katakturuk Rivers yielded no eagles.

Based on the experience gained during the 1984 field season, the following recommendations can be made:

1) Aerial surveys should be conducted with the PA-18 aircraft or one capable of equivalent slow flight (110km/hr).

2) A stratified sampling scheme should be developed which would place more effort in areas where eagles are believed to be concentrated.

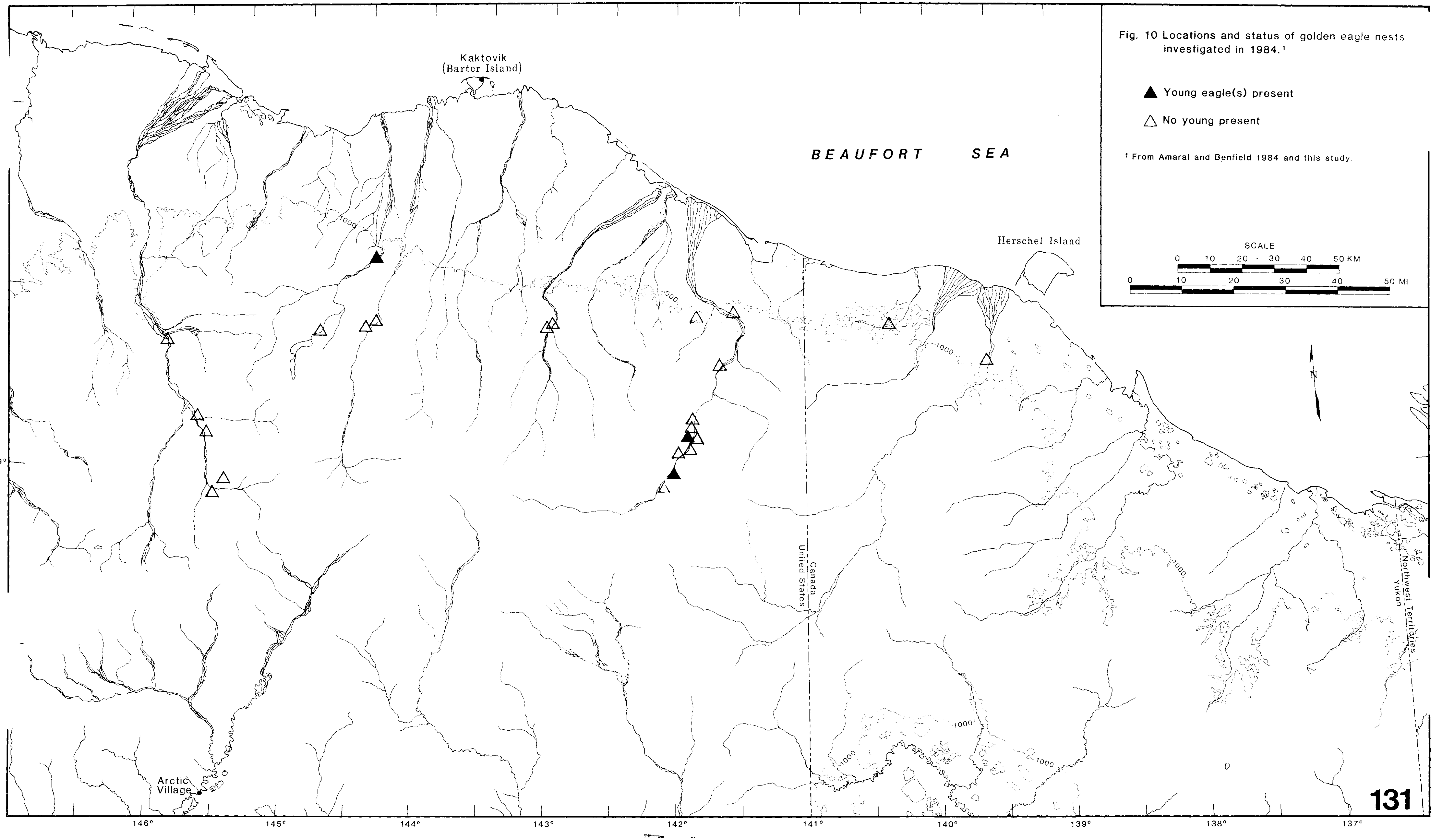


Fig. 10 Locations and status of golden eagle nests investigated in 1984.[1]

▲ Young eagle(s) present

△ No young present

[1] From Amaral and Benfield 1984 and this study.

Nest Surveys. Twelve previously documented golden eagles nest sites (Roseneau 1973 and 1974, Roseneau et al. 1980) located on the northern margin of the Brooks Range in northeastern Alaska were checked for activity (Fig. 10). Nests were found at seven of these sites, no nests were found at the remaining five locations. Only one nest site (located at the eastern margin of the Sadlerochit Mountains) produced young. This nest site was approximately 48 km distant from the perimeter of areas occupied by the Porcupine caribou herd in May-July 1984. None of the nest sites more proximal to caribou calving concentration areas produced young. An adult golden eagle was observed on 10 August in the vicinity of site: AC1 (Roseneau et al. 1980), on the Aichilik River but no evidence of eggs or young were found. A pair of adults were observed in the vicinity of Site 24 (Roseneau 1974), on the Katakturuk river but no nest was found (L. Martin pers. comm.).

Amaral and and Benfield (1985) investigated an additional five golden eagle nests on the Canning River. None of the nests investigated on the Canning River produced young and only one was classified "active". On the Kongakut River two nests containing a total of three young eagles (two and one young per nest) were discovered (Amaral and Benfield 1985). The productive nest sites were 45 and 55 km distant from the nearest concentration of calving caribou. One nest containing one addled egg was also found on the Kongakut River. Three nests were empty but showed signs of attempted nesting and four other sites contained inactive nests. Two previously undocumented golden eagle nests on Katak Creek (Hulahula River drainage) were inactive (Gill and Amaral 1984). Two empty nests were also found in the foothills in Canada (Fig. 10).

By comparison, in 1973, 7 of the 12 documented nest sites were occupied by golden eagles and three occupied nests produced young (Roseneau 1974). Based on available information, it appears that golden eagle production on the northern flank of the Brooks Range may have been relatively low in 1984 as opposed to other years. Golden eagle production at nest sites on the Porcupine River was also lower in 1984 than most previous years in which data were collected (Ritchie 1984).

Summary

Records of observations of golden eagles compiled during 1984 on the calving and post-calving areas of the Porcupine caribou herd are consistent with previous observations reported by caribou biologists. Concentrations of eagles in association with caribou became most apparent during late June when caribou were aggregated into very large groups and had occuppied the general region for three weeks. Most of the eagles were sub-adults. Eagles commonly prey on and scavenge caribou calves. Systematic aerial transects conducted during early June when caribou were relatively dispersed did not detect eagle concentrations in association with caribou. Intensive aerial searches in late June found more eagles in caribou areas than in areas that were unoccuppied by caribou. Golden eagle production in 1984 appeared to be low compared to data from other years and seems to have been low elsewhere in northern Alaska. More work needs to be done in order to determine the numbers of eagles associated with caribou calving areas and to assess the effects of eagle predation on herd dynamics. Further information should also be collected regarding eagle killing rates/behavior on the calving ground; effects of alternative food resources; and golden eagle movements and migration routes from wintering areas to the caribou calving grounds.

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APPENDIX

ANWR Progress Report FY85-3

Appendix Table 1. Observation of golden eagles on the norther portion of the Arctic National Wildlife Refuge and northwestern Canada, Summer 1984.

| Obs. No. | Date | Location[a] | Adult | Sub-adult | U[b] | Activity[c] | Caribou[d] | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | 3 May | Aichilik(M) | | 1 | | F | - | |
| 2 | " | " " | | 1 | | F | - | |
| 3 | 4 May | Egaksrak(M) | | 1 | | F | - | |
| 4 | " | " " | | 2 | | F | - | |
| 5 | 15 May | Hulahula(M) | 1 | | | NA | - | |
| 6 | 19 May | Aichilik(F) | | | 1 | NA | - | |
| 7 | 27 May | Katakturuk(CP) | | | 1 | NA | - | |
| 8 | 30 May | Niguanak(CP) | | 1 | | NA | + | |
| 9 | " | Backhouse(F) | | | 1 | NA | + | |
| 10 | " | W. VABM Dar(CP) | | 1 | | NA | + | |
| 11 | " | E. Firth (CP) | | | 1 | NA | + | |
| 12 | 31 May | Caribou Pass(M) | | | 1 | NA | + | |
| 13 | 1 June | Aichilik (F) | | 1 | | P/F | + | Eating ptarmigan |
| 14 | " | Aichilik (F) | | 1 | | NA | + | |
| 15 | " | Egaksrak (F) | | 1 | | P | + | |
| 16 | 2 June | " " | | | 1 | F | + | |
| 17 | " | Komakuk (CP) | | | 2 | F | + | |
| 18 | " | Kongakut (CP) | | 1 | | P | + | |
| 19 | " | Craig (F) | | 1 | | F | + | |
| 20 | 5 June | Hulahula(M) | 2 | | | F | - | |
| 21 | " | Aichilik(CP) | | 1 | | F | + | |
| 22 | " | Egaksrak (CP) | | 1 | | NA | + | |
| 23 | " | Okerokovik (CP) | 1 | | | P | + | adult carcass/brown bear |
| 24 | " | Caribou Pass (M) | | 1 | | NA | + | |
| 25 | 6 June | Page Creek (F) | | | 1 | F | + | |
| 26 | " | Egaksrak (CP) | | | 1 | NA | + | |
| 27 | " | S. Barter Is. (CP) | | 1 | | F | - | |
| 28 | " | Kongakut (M) | | 1 | | F | + | |
| 29 | " | Caribou Pass (M) | | 1 | | F | + | |
| 30 | 7 June | Hulahula (M) | | 1 | | NA | - | dead |
| 31 | " | Kongakut (CP) | | 1 | | F | + | |
| 32 | " | Ekaluakat (F) | | | 1 | P | + | |
| 33 | " | VABM Gwen (F) | | | 1 | P | + | |
| 34 | " | Kongakut (F) | | | 1 | P | + | |
| 35 | " | Aichilik (M) | | | 1 | F | + | |
| 36 | 8 June | Aichilik (CP) | | | 1 | F | + | |

Appendix Table 1.(Continued).

| Obs. No. | Date | Location[a] | Adult | Sub-adult | U[b] | Activity[c] | Caribou[d] | Remarks |
|---|---|---|---|---|---|---|---|---|
| 37 | 8June | Backhouse (CP) | | 1 | | P | + | adult carcass/brown bear |
| 38 | " | Egaksrak (CP) | | 1 | | P | + | |
| 39 | " | Roland (CP) | | 1 | | F | + | |
| 40 | " | Boundary (F) | | 1 | | F | + | |
| 41 | " | Kongakut (M) | 1 | | | F | - | |
| 42 | " | Kongakut (M) | | 1 | | F | - | |
| 43 | " | Aichilik (CP) | | 1 | | P | + | calf carcass |
| 44 | 9 June | Egaksrak (F) | | 1 | | P | + | |
| 45 | " | Simpson Cove (CP) | | 1 | | F | - | |
| 46 | " | Jago (CP) | | 1 | | F | - | |
| 47 | " | Egaksrak (CP) | | | 1 | F | + | |
| 48 | " | Niguanak (CP) | | 1 | | F | + | |
| 49 | " | Niguanak (CP) | | | 1 | P | + | |
| 50 | " | Aichilik (CP) | | | 1 | P | + | |
| 51 | " | Niguanak (CP) | 1 | | | F | + | |
| 52 | " | Ekaluakat (F) | | 1 | | P | + | calf carcass |
| 53 | " | Niguanak (CP) | | | 1 | NA | + | |
| 54 | " | Turner R. (F) | | | 1 | P | + | |
| 55 | 10 June | VABM Virgin (M) | | 2 | | F | + | |
| 56 | " | Egaksrak (CP) | | 2 | | P | + | calf carcass |
| 57 | " | Katakturuk (CP) | | 1 | | F | + | |
| 58 | " | Egaksrak (CP) | | | 1 | F | + | |
| 59 | " | Egaksrak (CP) | | | 1 | F | + | |
| 60 | " | Egaksrak (CP) | | 2 | | P | + | calf carcass |
| 61 | " | Aichilik (CP) | | | 1 | P | + | |
| 62 | " | Turner (F) | | | 1 | F | + | |
| 63 | " | Ekaluakat(F) | 1 | | | P | + | |
| 64 | " | Craig (F) | | 1 | | F | + | |
| 65 | 11 June | Niguanak (CP) | | | 1 | P | + | adult carcass/brown bear |
| 66 | " | Kongakut (CP) | | 1 | | P | + | |
| 67 | " | Kongakut (F) | 1 | | | F | + | |
| 68 | " | Turner (F) | 1 | | | P | + | |
| 69 | " | Angun (CP) | | 1 | | P | + | |
| 70 | " | Fish (F) | | 1 | | F | + | |
| 71 | 12 June | Niguanak (CP) | | 1 | | P | + | |
| 72 | " | Aichilik (CP) | | | 1 | P | + | |
| 73 | " | Niguanak (CP) | | | 1 | P | + | adult carcass/brown bear |

Appendix Table 1.(Continued).

| Obs. No. | Date | Location[a] | Adult | Sub-adult | U[b] | Activity[c] | Caribou[d] | Remarks |
|---|---|---|---|---|---|---|---|---|
| 74 | 13 June | Aichilik (CP) | | 1 | | F | + | |
| 75 | " | Angun (CP) | | 1 | | F | + | |
| 76 | " | Aichilik (CP) | | 1 | | P | + | calf carcass |
| 77 | " | Ekaluakat (F) | | | 1 | NA | + | |
| 78 | " | Egaksrak (CP) | 1 | 1 | | P | + | |
| 79 | 14 June | VABM Gwen (F) | | | 1 | P | + | adult carcass |
| 80 | " | Aichilik (CP) | | 2 | | P | + | calf carcass |
| 81 | " | Kongakut (F) | | 1 | | F | + | |
| 82 | " | Aichilik (CP) | | 1 | | P | + | |
| 83 | " | Ekaluakat (F) | | 1 | | P | + | |
| 84 | " | Aichilik (CP) | | 2 | | P | + | calf carcass |
| 85 | " | Egaksrak (CP) | | 1 | | P | + | adult carcass |
| 86 | " | Aichilik (CP) | | | 1 | F | + | |
| 87 | " | " " | | | 1 | F | + | |
| 88 | " | " " | | | 1 | F | + | |
| 89 | " | " " | | | 1 | F | + | |
| 90 | " | Angun (CP) | 1 | | | F | + | |
| 91 | " | Niguanak (CP) | | 1 | | P | + | |
| 92 | " | " " | | 1 | | F | + | |
| 93 | 15 June | Niguanak (CP) | | | 1 | F | + | |
| 94 | " | Angun (CP) | | | 1 | P | + | |
| 95 | " | Aichilik (CP) | | | 2 | P | + | |
| 96 | " | " " | | | 1 | F | + | |
| 97 | " | " " | | | 1 | P | + | |
| 98 | " | Egaksrak (CP) | | 1 | | F | + | |
| 99 | " | Caribou Pass (M) | | 1 | | P | + | |
| 100 | " | Angun (CP) | | | 1 | P | + | |
| 101 | " | Niguanak (CP) | | | 1 | F | + | |
| 102 | " | " " | | 1 | | P | + | |
| 103 | " | Kongakut (M) | | | 1 | P | - | |
| 104 | " | Aichilik (CP) | | | 2 | P | + | calf carcass |
| 105 | 16 June | VABM Gwen (F) | 1 | | | P | + | |
| 106 | 16 June | Niguanak (CP) | | | 1 | F | + | |
| 107 | 17 June | Backhouse (F) | | 2 | | F/P | + | |
| 108 | " | Niguanak (CP) | | | 1 | P | + | |

Appendix Table 1.(Continued).

| Obs. No. | Date | Location[a] | Adult | Sub-adult | U[b] | Activity[c] | Caribou[d] | Remarks |
|---|---|---|---|---|---|---|---|---|
| 109 | 17June | " " | | | 1 | F | + | |
| 110 | " | " " | | 1 | | F | + | |
| 111 | " | Angun (CP) | | | 1 | F | + | |
| 112 | " | Aichilik (CP) | | 2 | | F | + | |
| 113 | 18 June | Okerokovik (CP) | | 1 | | F | + | |
| 114 | " | Angun (CP) | | 1 | | P | + | calf carcass |
| 115 | " | Aichilik (CP) | | | 1 | P | + | adult carcass |
| 116 | " | " " | | | 1 | P | + | |
| 117 | " | Niguanak (CP) | | 2 | | F | + | |
| 118 | " | " " | 1 | | | NA | + | |
| 119 | " | Angun (CP) | | | 2 | NA | + | |
| 120 | " | " " | | | 1 | NA | + | |
| 121 | " | Niguanak (CP) | 1 | | | F | + | |
| 122 | 19 June | Angun (CP) | | | 1 | NA | + | |
| 123 | " | " " | | | 1 | P | + | |
| 124 | " | Siksikpalak (F) | | | 1 | NA | + | |
| 125 | " | Turner (F) | | | 1 | F | + | |
| 126 | " | Siksikpalak (CP) | | | 2 | F | + | |
| 127 | " | Aichilik (CP) | | | 1 | F | + | |
| 128 | " | Kogotpak (CP) | | | 1 | F | + | |
| 129 | " | Niguanak (CP) | | | 1 | P | + | |
| 130 | 20 June | Ekaluakat (CP) | | | 1 | NA | + | |
| 131 | " | Aichilik (CP) | | | 1 | F | + | |
| 132 | " | Niguanak (CP) | | | 1 | NA | + | |
| 133 | 21 June | Angun (CP) | | 1 | | P | + | crippled calf |
| 134 | " | Aichilik (CP) | | 1 | | P | + | |
| 135 | " | Egaksrak (CP) | | 2 | | P | + | |
| 136 | " | " " | | | 1 | P | + | |
| 137 | " | " " | | 2 | | P | + | calf carcass |
| 138 | " | " " | | 1 | | P | + | |
| 139 | " | Kongakut (M) | | 2 | | P | + | |
| 140 | " | Kongakut (M) | | | 1 | F | + | |
| 141 | " | Okerokovik (CP) | | 1 | | F | + | |
| 142 | " | Aichilik (CP) | | | 3 | F | + | |
| 143 | 22 June | Kongakut (F) | | | 1 | F | + | |
| 144 | " | " " | | | 1 | P | + | |
| 145 | " | " " | | | 1 | F | + | |

Appendix Table 1.(Continued).

| Obs. No. | Date | Location[a] | Adult | Sub-adult | U[b] | Activity[c] | Caribou[d] | Remarks |
|---|---|---|---|---|---|---|---|---|
| 146 | 22June | Kogotpak (CP) | | 2 | | P | + | |
| 147 | " | Angun | | 1 | | F | + | |
| 148 | " | Aichilik (CP) | | 2 | | P | + | calf carcass |
| 149 | " | " " | | 2 | | P | + | calf carcass |
| 150 | " | " " | | | 2 | F | + | |
| 151 | " | Angun (CP) | | | 1 | F | + | |
| 152 | " | Aichilik (CP) | | | 2 | F | + | |
| 153 | " | " " | 1 | | | F | + | |
| 154 | " | Ekaluakat (F) | | | 1 | P | + | |
| 155 | " | Angun (CP) | | | 1 | F | + | |
| 156 | " | " " | | | 2 | F | + | |
| 157 | " | " " | | 6 | | P | + | |
| 158 | 23 June | Angun (CP) | | | 1 | P | + | |
| 159 | " | Turner (F) | | | 1 | F | + | |
| 160 | " | " " | | 2 | | P | + | |
| 161 | " | " " | | 1 | | F | + | |
| 162 | " | " " | | 1 | | F | + | |
| 163 | " | " " | | | 1 | P | + | |
| 164 | " | " " | | 1 | | P | + | |
| 165 | 24 June | Kongakut (F) | | 1 | | F | + | |
| 166 | " | Turner (F) | | 1 | | F | + | |
| 167 | " | Egaksrak (F) | | 2 | | F | + | |
| 168 | " | Egaksrak (F) | | | 1 | F | + | |
| 169 | " | " " | | | 1 | F | + | |
| 170 | " | Ekaluakat (F) | | | 1 | F | + | |
| 171 | " | Egaksrak (F) | | | 1 | F | + | |
| 172 | " | Okerokovik (F) | | | 1 | F | - | |
| 173 | " | Turner (CP) | | | 1 | P | + | adult carcass |
| 174 | " | Kongakut (F) | | 1 | | F | + | |
| 175 | " | Kongakut (F) | | | 1 | F | + | |
| 176 | " | Ekaluakat (F) | | 1 | | P | + | calf carcass |
| 177 | " | Kongakut (F) | | 1 | | P | + | |
| 178 | 25 June | Demc. Bay (CP) | | 1 | | F | + | |
| 179 | " | Kongakut (CP) | | 1 | | P | + | |
| 180 | " | Aichilik (CP) | | | 1 | p | + | |
| 181 | " | VABM Beets (F) | | 1 | | F | + | |
| 182 | " | Turner (F) | | 1 | | F | + | |

Appendix Table 1.(Continued).

| Obs. No. | Date | Location[a] | Adult | Sub-adult | U[b] | Activity[c] | Caribou[d] | Remarks |
|---|---|---|---|---|---|---|---|---|
| 183 | 25 June | Demc. Bay (CP) | | 1 | | F | + | |
| 184 | " | Clarence (CP) | | 4 | | P | + | adult carcass |
| 185 | " | Aichilik (M) | | | 2 | F | + | |
| 186 | " | Turner (F) | | | 1 | NA | + | |
| 187 | 26 June | Fire (M) | | 1 | | F | - | |
| 188 | " | Ekaluakat (F) | | | 1 | P | + | |
| 189 | " | Kongakut (F) | | 2 | | P | + | |
| 190 | " | Kongakut (F) | | | 1 | P | + | |
| 191 | " | VABM Gwen (F) | | 3 | | P | + | calf carcass |
| 192 | " | Aichilik (M) | 1 | | | F | - | |
| 193 | " | Kongakut (F) | | | 1 | P | + | |
| 194 | 27 June | Aichilik (CP) | | | 2 | P | + | calf carcass |
| 195 | " | " " | | | 1 | P | + | |
| 196 | " | " " | | | 2 | P | + | calf carcass |
| 197 | " | VABM Hula (F) | | | 1 | F | + | |
| 198 | " | Clarence (F) | | | 1 | P | + | |
| 199 | " | Aichilik (CP) | | 4 | | P | + | |
| 200 | " | Aichilik (M) | | | 1 | P | + | |
| 201 | " | Caribou Pass (M) | | 1 | | NA | + | |
| 202 | " | " " | | 1 | | NA | + | |
| 203 | 28 June | Aichilik (CP) | | | 2 | P | + | calf carcass |
| 204 | " | " " | | | 1 | P | + | |
| 205 | " | Kongakut (F) | | | 1 | P | + | |
| 206 | " | Kongakut (F) | | | 4 | NA | + | wolf present |
| 207 | " | Turner (F) | | | 1 | P | + | |
| 208 | " | Kongakut (F) | | | 1 | P | + | |
| 209 | " | " " | | | 1 | P | + | |
| 210 | " | Kikitak (F) | | | 1 | F | - | |
| 211 | " | Hulahula(M) | 1 | | | P | - | |
| 212 | " | " " | | 2 | | P | - | |
| 213 | " | " " | | 1 | | P | - | |
| 214 | 28 June | Hulahula (M) | 1 | | | F | - | |
| 215 | " | VABM Gwen | | 2 | | P | + | |
| 216 | " | Siksikpalak (M) | | | 1 | F | + | |
| 217 | " | VABM Gwen (M) | | 2 | | P | + | |
| 218 | " | Kongakut (F) | | | 3 | P | + | |
| 219 | " | " " | | | 3 | F | + | |
| 220 | " | " " | | | 1 | F | + | |

Appendix Table 1.(Continued).

| Obs. No. | Date | Location[a] | Adult | Sub-adult | U[b] | Activity[c] | Caribou[d] | Remarks |
|---|---|---|---|---|---|---|---|---|
| 221 | 28 June | Kongakut (M) | | | 1 | F | + | |
| 222 | " | Caribou Pass (M) | | 1 | | P | + | |
| 223 | 29 June | Niguanak (CP) | | | 1 | P | - | |
| 224 | " | Aichilik (M) | | 1 | | F | + | |
| 225 | " | Siksikpalak (M) | | 1 | | F | + | |
| 226 | " | Kongakut (F) | | 1 | | P | + | |
| 227 | " | " " | 1 | | | F | + | |
| 228 | " | Kongakut (F) | | 3 | | P | + | calf carcass |
| 229 | " | " " | 1 | | | P | + | adult carcass |
| 230 | " | " " | | 2 | | F | + | |
| 231 | " | Kongakut (M) | | 4 | | P | + | |
| 232 | " | Caribou Pass (M) | | 3 | | F | + | |
| 233 | " | Kongakut (M) | | 1 | | F | + | |
| 234 | " | Caribou Pass (M) | | | 4 | P | + | calf carcass |
| 235 | " | " " | | | 1 | P | + | calf carcass/brown bear |
| 236 | " | Ekaluakat (CP) | | | 5 | NA | + | |
| 237 | " | Kongakut (F) | | | 2 | P | + | calf carcass |
| 238 | " | " " | | | 1 | P | + | adult carcass |
| 239 | 30 June | Kongakut (F) | | | 2 | F | + | |
| 240 | " | Kongakut (M) | | | 1 | P | + | |
| 241 | " | Caribou Pass (M) | | | 1 | P | + | |
| 242 | " | Kongakut (M) | | | 1 | F | + | |
| 243 | " | Caribou Pass (M) | | | 1 | P | + | |
| 244 | " | " " | | | 1 | F | + | |
| 245 | " | Kongakut (F) | | | 1 | P | + | |
| 246 | " | Turner (F) | | | 4 | NA | + | |
| 247 | " | " " | | | 2 | P | + | |
| 248 | " | " " | | | 1 | P | + | |
| 249 | " | " " | | | 1 | P | + | |
| 250 | 30 June | Clarence (F) | | | 1 | P | + | |
| 251 | " | " " | | | 1 | P | + | |
| 252 | " | Backhouse (F) | | | 1 | P | + | |
| 253 | " | " " | | | 1 | P | + | |
| 254 | " | Komakuk (F) | | | 1 | P | + | |
| 255 | " | Angun (CP | | | 1 | P | - | |
| 256 | " | Kogotpak (CP) | | | 1 | NA | - | |
| 257 | " | VABM Gwen (F) | | | 1 | NA | + | |

Appendix Table 1.(Continued).

| Obs. No. | Date | Location[a] | Adult | Sub-adult | U[b] | Activity[c] | Caribou[d] | Remarks |
|---|---|---|---|---|---|---|---|---|
| 258 | 30 June | " " | | | 1 | NA | + | |
| 259 | " | Kongakut (F) | | | 2 | NA | + | |
| 260 | " | " " | | | 1 | NA | + | |
| 261 | " | " " | | | 1 | P | + | |
| 262 | " | Kongakut (F) | | | 1 | NA | + | |
| 263 | " | Caribou Pass (M) | | | 1 | NA | + | |
| 264 | " | Kongakut (CP) | | | 13 | P | + | adult carcass |
| 265 | " | " " | | | 4 | P | + | |
| 266 | " | Caribou Pass (M) | | | 1 | P | + | calf carcass/wolf |
| 267 | 1 July | Hulahula (M) | | | 2 | P | - | |
| 268 | " | Caribou Pass (M) | | | 1 | F | + | |
| 269 | 2 July | Hulahula (M) | | | 1 | F | - | |
| 270 | " | Tamayariak (F) | | | 1 | F | - | |
| 271 | 3 July | Hulahula (M) | | | 1 | F | - | |
| 272 | " | VABM Bitty (F) | | | 1 | F | - | |
| 273 | " | " " | | | 1 | F | - | |
| 274 | " | Okerokovik (CP) | | | 1 | F | - | |
| 275 | " | Beaufort Lagoon (CP) | | | 1 | F | - | |
| 276 | 4 July | Hulahula R. (M) | | | 1 | F | - | |
| 277 | " | Backhouse (F) | | 1 | | P | + | |
| 278 | " | Fish (F) | | 1 | | F | + | |
| 279 | " | Turner (F) | | 1 | | F | + | |
| 280 | 5 July | Kaviak (M) | | 1 | | F | - | killed ptarmigan |
| 281 | " | Sadlerochit (M) | | 1 | | F | - | |
| 282 | " | Hulahula (M) | | | 1 | P | - | |
| 283 | " | " " | | | 1 | F | - | |
| 284 | " | " " | | | 1 | F | - | |
| 285 | " | Caribou Pass (M) | | | 1 | F | + | |
| 286 | 6 July | Caribou Pass (M) | | 1 | | F | + | |
| 287 | " | " " | 1 | | | F | + | |
| 288 | " | Caribou Pass (M) | | | 5 | P | + | |
| 289 | " | Kongakut (F) | | 2 | | F | + | |
| 290 | " | Turner (F) | | 1 | | F | + | |
| 291 | " | " " | | | 1 | F | + | |
| 292 | " | " " | | 1 | | F | + | |
| 293 | " | Kongakut (F) | | 1 | | F | + | |
| 294 | " | " " | | 1 | | F | + | |

Appendix Table 1.(Continued).

| Obs. No. | Date | Location[a] | Adult | Sub-adult | U[b] | Activity[c] | Caribou[d] | Remarks |
|---|---|---|---|---|---|---|---|---|
| 295 | 6 July | Egaksrak (M) | | | 1 | P | + | calf carcass |
| 296 | " | VABM Gwen | | 1 | | F | + | |
| 297 | " | Kongakut (F) | | | 1 | F | + | |
| 298 | " | Aichilik (CP) | | | 1 | P | - | |
| 299 | " | Aichilik (F) | | | 1 | F | - | |
| 300 | " | Caribou Pass (M) | | | 2 | F | + | |
| 301 | 7 July | Turner (F) | | | 3 | P | + | |
| 302 | 8 July | Kongakut (F) | | | 1 | P | - | |
| 303 | " | Aichilik (CP) | | | 1 | F | - | |
| 304 | " | Kongakut (M) | | | 1 | P | - | |
| 305 | " | " " | | 1 | | NA | - | |
| 306 | " | " " | | 1 | | NA | - | |
| 307 | 9 July | Siksikpalak (F) | | | 1 | P | - | |
| 308 | " | Kogotpak (CP) | | | 1 | F | - | |
| 309 | 11 July | Carter (CP) | | | 1 | F | - | |
| 310 | " | Tamayariak (F) | | | 1 | F | - | |
| 311 | 12 July | Aichilik (CP) | | | 1 | F | - | |
| 312 | 17 July | Egasrak (M) | | 1 | | F | - | |
| 313 | 19 July | Sabboth (CP) | | | 3 | NA | | |
| 314 | 22 July | Kongakut (M) | | | 1 | NA | - | |
| 315 | 23 July | Kongakut (F) | | 1 | | NA | - | |
| 316 | " | " " | | 1 | | F | - | |
| 317 | 25 July | Kongakut (M) | | 1 | | F | - | |
| 318 | " | Aichilik (M) | | | 1 | F | - | |
| 319 | 26 July | Kongakut (M) | | | 1 | F | - | |
| 320 | 28 July | Okpirourak (F) | | | 1 | F | - | |
| 321 | 10 August | Kongakut (M) | | 1 | | P | - | |
| 322 | 10 August | Kongakut (M) | | 1 | | P | - | |
| 323 | 11 August | Egaksrak (F) | | 1 | | P | - | |

[a] (M) = mountains
(F) = foothils
(CP) =coastal plain
[b] U = unidentified
[c] F = Flying
P = Perched
NA = Not available
[d] + = caribou present or recently present
- = caribou not present

ANWR Progress Report Number FY85-4

# PREY UTILIZATION BY WOLVES IN TWO DRAINAGES WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE, AND A PRELIMINARY DESCRIPTION OF WOLF PACK BEHAVIOR AROUND THE DEN IN THE KONGAKUT RIVER DRAINAGE

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Key words: Wolf, food habits, behavior, denning, hunting, Arctic National Wildlife Refuge, north slope, Arctic-Beaufort

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# Prey utilization by wolves in two drainages within the Arctic National Wildlife Refuge, and a preliminary description of wolf pack behavior around the den in the Kongakut River drainage

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Abstract: Two wolf (*Canis lupus*) packs were observed for two months at den sites on the Canning and Kongakut Rivers during summer 1984. After abandonment, the dens were inspected and scats were collected. Scat analyses indicated that the Kongakut wolves utilized the available prey species in much the same manner (perhaps with a small shift towards non-ungulate game) during summer 1984 and summer 1983. The wolves in the Canning River drainage showed a marked shift from no detected utilization of moose (*Alces alces*) in summer 1983, towards extensive utilization of moose during summer 1984. Prey utilization is discussed in relation to the Porcupine caribou (*Rangifer tarandus*) herds' movements. It is hypothesized that caribou of the Porcupine herd were unavailable to the Canning wolves while the Kongakut wolves had access to caribou for a certain period when there were many young calves in the herd. The behavior of the Kongakut pack is described, including an episode of prolonged absence by the parent wolves from the den, during which the pups showed a clear reduction in lengths of each behavior bout, and after which little social interaction was observed among members of the den group.

# Prey utilization by wolves in two drainages within the Arctic National Wildlife Refuge, and a preliminary description of wolf pack behavior around the den in the Kongakut River drainage

Preliminary work in summer 1983 concluded that the wolves in the three surveyed drainages (Kongakut, Hulahula, and Canning) apparently have different prey bases and would be of interest for further study (Haugen 1984). No denning pack was found in the Hulahula River drainage in 1984, therefore, the Kongakut and Canning River packs were selected for den site studies. Field camps were set up near each den, and two observers were present at all times in each camp. Blinds were erected and wolves observed according to a predetermined schedule, during which the presence of wolves and their behavior were recorded. (See Appendix for sample data forms).

After assumed abandonment of the den sites, scats were collected and dens were inspected. The wolves in the Canning River drainage abandoned their den in the latter half of June. Few wolf observations were made due to dense willow growth at the site. The Kongakut wolves stayed at the den site throughout the observation period, thus the behavioral descriptions included in this report deal with the Kongakut pack.

The Kongakut wolves were observed over a period of 54 days (28 May-20 July). Six adult wolves were identified in the pack, and two pups were seen. An episode of prolonged absence by the parents was observed during and after which the pack's behavior changed.

## Methods

### Scat Collection and Analysis

Scats were collected around camps and on excursions during the summer. Scats were also collected at each den site after it was abandoned by wolves. Scats were analyzed in the laboratory with the aid of reference collections and manuals. Most scats were assumed to have been dropped during the denning period of April through August, 1984.

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. Each volumetric total was converted to the estimated 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 al. 1978). Average live weights and estimated weight eaten per scat containing each prey item are listed in Table 1. Estimated kilograms 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 proportionally comparing the prey utilized within the two drainages and between the two years. The ratio of 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 corresponding assumed live weights (Table 1) for that prey item. The percentage each prey species contributed was calculated both for kg eaten and for number of individuals eaten.

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 the denning period (153 days-April through August), a total of 260.1 kg was required by each wolf for maintenance purposes. This minimum summer maintenance requirement was divided by the total of all kg eaten as represented in the scat analysis data, and this correction factor was multiplied to the number of individuals eaten to determine the number of each prey item eaten per wolf throughout the denning period.

Behavioral Observations at the Kongakut Den

A blind was gradually moved (over a 3-week period) to within 1 km of the den site, on the opposite and south side of the river. The blind was located on the north side of a long mound. The camp was located behind this mound, and more distant from the den site. The blind was always entered in the same manner, approaching it in a straight line from the edge of the mound, down to the blind and into it from the left side. Observers entered the blind singly and no observers walked in front of the blind.

Behavioral data were collected in three steps. Each hour was divided into an "a" and a "b" bout. During the first 15 min a randomly selected focal wolf was followed and its behavior recorded, while during the next 15 min the locations of all wolves present were recorded, and a scan (an instantaneous description of the behavior of all the wolves present) was recorded. Thus, for each h, two randomly selected wolves were followed and described for 15 min each, and two location squares and two activity scans were recorded.

The behavioral data were recorded on specific data sheets (See Appendix) on which time, location, identity, and behaviors had specific columns under which the data were recorded using codes. Behaviors were divided into several behavioral types, i.e., sleep, play, feed, etc., under which specific codes described each behavior. With this approach complete behavioral histories of the wolves were coded, telling what interactions occurred, where, and when. Also the direction and relative position of movements, and frequencies, durations, and sequences of all behaviors observed were described. Scans were recorded on the same data sheets as the focal animal data. The behavior and location of all wolves present were also recorded. In an attempt to establish locational affinity of individuals and associations between individuals, a location square (See Appendix) was used to develop an index of cohesion, noting where each wolf was located in relation to a described focal point.

Observation periods were chosen using a mixture of random and stratified sampling methods. Several 24-h continuous observations were also performed. Earlier work has generally shown that wolves follow diurnal rhythms, and a stratified sampling method can increase the chance of observing wolves when they were assumed to be most active, i.e., during dusk hours in mornings and evenings. A completely random method was used ensuring that all hours of the day were observed, and to test if the wolves were rhythmic in their behavior.

Table 1. Assumed live weights and calculated weight consumed per volumetric occurrence of each prey item in wolf scats collected along three drainages in the Arctic National Wildlife Refuge, summers 1983 and 1984.

| Prey item occurrence | Assumed live weight (kg) | Estimated weight eaten per volumetric (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 | 0.38 |
| 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 & eggs | 0.1 | 0.38 |
| fish (small) | 0.1 | 0.38 |
| insect | - | - |
| plastic | - | - |
| wolf (probably from licking) | - | - |
| vegetation | - | - |

## Results and Discussion

### Food Habits

A total of 151 scats were collected along the Kongakut River drainage, of which 75 were analyzed. Along the Canning River drainage, 190 scats were collected, and 48 were analyzed. Of the 123 scats analyzed from the two drainages, the content of 1 could not be identified, and 19 were pup scats. The content of the pup scats was not used in the analysis as no estimates exist for determining how much eaten food each volumetric total represents for pups. The remains were identified to species and age, but several could not be aged, and in three scats the remains could not be identified to any specific ungulate. It is assumed that these unknown food remains are from adult prey, and the three scats with unknown ungulate were classified as adult caribou. This assumption decreases the overall accuracy of the estimates; however, caribou appear to be an important food source for wolves in the north (Murie 1944, James 1983) and this lumping of unknown ungulates with adult caribou may minimize the inaccuracy.

Another potential source of error is in the assumption of 1.7 kg 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, and Mech 1977). Therefore, data represented in this report should be regarded as conservative estimates of wolf diets in the two drainages. Since Alaskan wolves range 10-20% heavier than wolves from the contiguous states, a correction factor of 1.2 is also used perhaps improving the estimates of numbers of individual prey types consumed per wolf during the denning period.

Scats collected at the Kongakut den site were generally found in or near trails and/or under or near bushes, tussocks or other protrusions on the ground. More than one prey item was found in 31.6% of the adult scats and in 23.5% of the pup scats. Compared to last year's 4.1% this change is a marked increase in multiple prey item scats. Results of the analysis of 58 adult wolf scats collected at the Kongakut den site are presented in Table 2. When 1984 results are compared with 1983's results (Figs. 1 and 2) there appears to be an increased utilization of non-caribou prey types. In 1983 more evidence of caribou calves was present in scats (Table 2, Fig. 2). The proportion of a wolf's diet consisting of carrion is unknown. Other factors which influence the accuracy of scat analyses include: digestion rates, the time period represented by scats, distance between kill and dens, etc. These factors must be considered when drawing conclusions from scat analysis. What wolves kill, and what they eat may be totally different.

Forty-six adult scats and two pup scats collected from the Canning River drainage were analyzed. None of the pup scats contained more than one prey item, but 15.2% of the adult scats contained more than one prey then. This was a marked increase from 5.9% in 1983. A large increase in utilization of moose was found in 1984 (Table 3), compared to no moose remains in the 18 scats collected in 1983 (Figs. 3 and 4)). The increase in moose utilization coincided with a decline in caribou utilization (Fig. 4). The absence of moose remains in the scats in 1983 may have been due to low sample size, or due to some seasonal specificity.

Comparisons of the relative prey utilization of the total kg eaten (Fig. 5) for the two drainages during the two summers indicate that caribou and adult moose contribute 75-90% of the diet of wolves. The remainder of the diet is a supplementation consisting of young moose, Dall sheep, and non-ungulate species.

The two groups of wolves studied in the ANWR appear to have different food habits which may be influenced by the availability of the prey (Figs. 5,6, and 7). When caribou were accessible, wolves fed heavily on them, as did the Kongakut wolves. When caribou emigrated from an area, wolves shift their attention to other ungulates, i.e., moose and Dall sheep (*Ovis dalli*). The hunting areas of the studied wolves is not well understood. Only further

Table 2. Prey utilization by wolves during the denning period (April through August) in the Kongakut River drainage based upon analysis of 75 scats collected during summer 1984, Arctic National Wildlife Refuge, Alaska.

| Prey item | Frequency Adult[a] | Frequency Pup[b] | Volumetric total Adult | Volumetric total Pup | Kg Eaten | Kg % | Kg Ratio | Individuals # | Individuals % | Individuals Ratio | Individuals/ wolf/ denning period | Multiplied by correction factor of 1.2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Caribou: | | | | | | | | | | | | |
| adult | 5 | | 3.4 | | 5.92 | 5.9 | 0.18 | 0.09 | 0.9 | 0.18 | 0.23 | 0.27 |
| young | 11 | 3 | 10.0 | 2.9 | 4.80 | 4.8 | 0.14 | 0.96 | 10.1 | 1.97 | 2.50 | 3.00 |
| unknown age | 16 | 6 | 14.7 | 5.8 | 25.58 | 25.6 | 0.77 | 0.38 | 3.9 | 0.77 | 0.98 | 1.17 |
| Moose: | | | | | | | | | | | | |
| adult | | | | | | | | | | | | |
| young | 6 | 1 | 5.6 | 1.0 | 5.54 | 5.6 | 0.17 | 0.18 | 1.9 | 0.37 | 0.47 | 0.57 |
| unknown age | 5 | 3 | 4.9 | 3.0 | 41.52 | 41.6 | 1.25 | 0.10 | 1.1 | 0.21 | 0.27 | 0.32 |
| Dall sheep: | | | | | | | | | | | | |
| adult | 2 | 1 | 1.5 | 0.8 | 2.21 | 2.2 | 0.07 | 0.04 | 0.4 | 0.08 | 0.10 | 0.13 |
| young | 6 | 1 | 5.7 | 1.0 | 2.60 | 2.6 | 0.08 | 0.65 | 6.8 | 1.33 | 1.69 | 2.03 |
| unknown age | 6 | 1 | 5.4 | 1.0 | 7.94 | 8.0 | 0.24 | 0.15 | 1.5 | 0.30 | 0.38 | 0.46 |
| Unknown ungulate: | | | | | | | | | | | | |
| young | | | | | | | | | | | | |
| unknown age | 1 | | 1.0 | | 1.74 | 1.7 | 0.05 | 0.03 | 0.3 | 0.05 | 0.07 | 0.08 |
| Rodents: | | | | | | | | | | | | |
| ground squirrel | 12 | 3 | 2.8 | 1.3 | 1.12 | 1.1 | 0.03 | 1.40 | 14.7 | 2.87 | 3.65 | 4.38 |
| microtines | 3 | | 1.2 | | 0.46 | 0.5 | 0.01 | 4.56 | 47.9 | 9.34 | 11.89 | 14.26 |
| Miscellaneous: | | | | | | | | | | | | |
| mustelid | 1 | | 0.5 | | 0.27 | 0.3 | 0.01 | 0.04 | 0.4 | 0.07 | 0.09 | 0.11 |
| bird & egg | 2 | | 0.3 | | 0.10 | 0.1 | t | 0.95 | 10.0 | 1.95 | 2.48 | 2.97 |
| insect | 2 | 1 | 0.1 | 0.1 | | | | | | | | |
| fish | | | | | | | | | | | | |
| plastic | 1 | 1 | 0.1 | 0.1 | | | | | | | | |
| wolf | | 1 | | 0.1 | | | | | | | | |
| undetermined | 1 | | 1.0 | | | | | | | | | |
| Totals | 81 | 22 | 58.0 | 17.0 | 99.78 | 100.0 | | 9.51 | 100.0 | | | |

[a] 31.6% of adult scats contained more than 1 prey item.
[b] 23.5% of pup scats contained more than 1 prey item.

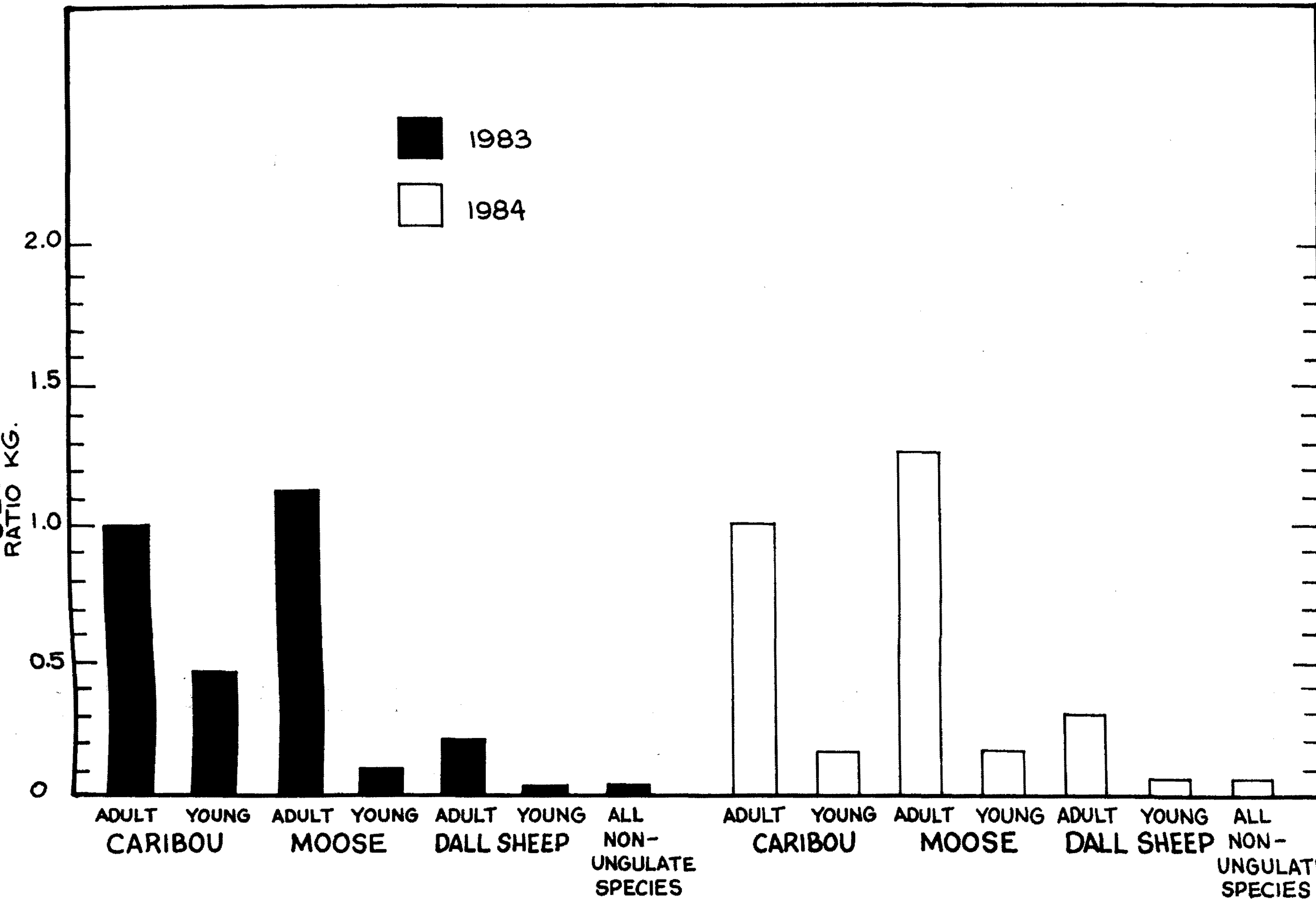


Fig. 1. Relative prey utilization (ratio kg eaten) by wolves in the Kongakut River drainage during the denning period (April through August) of 1983 and 1984. Proportions of prey use are not comparable between years.

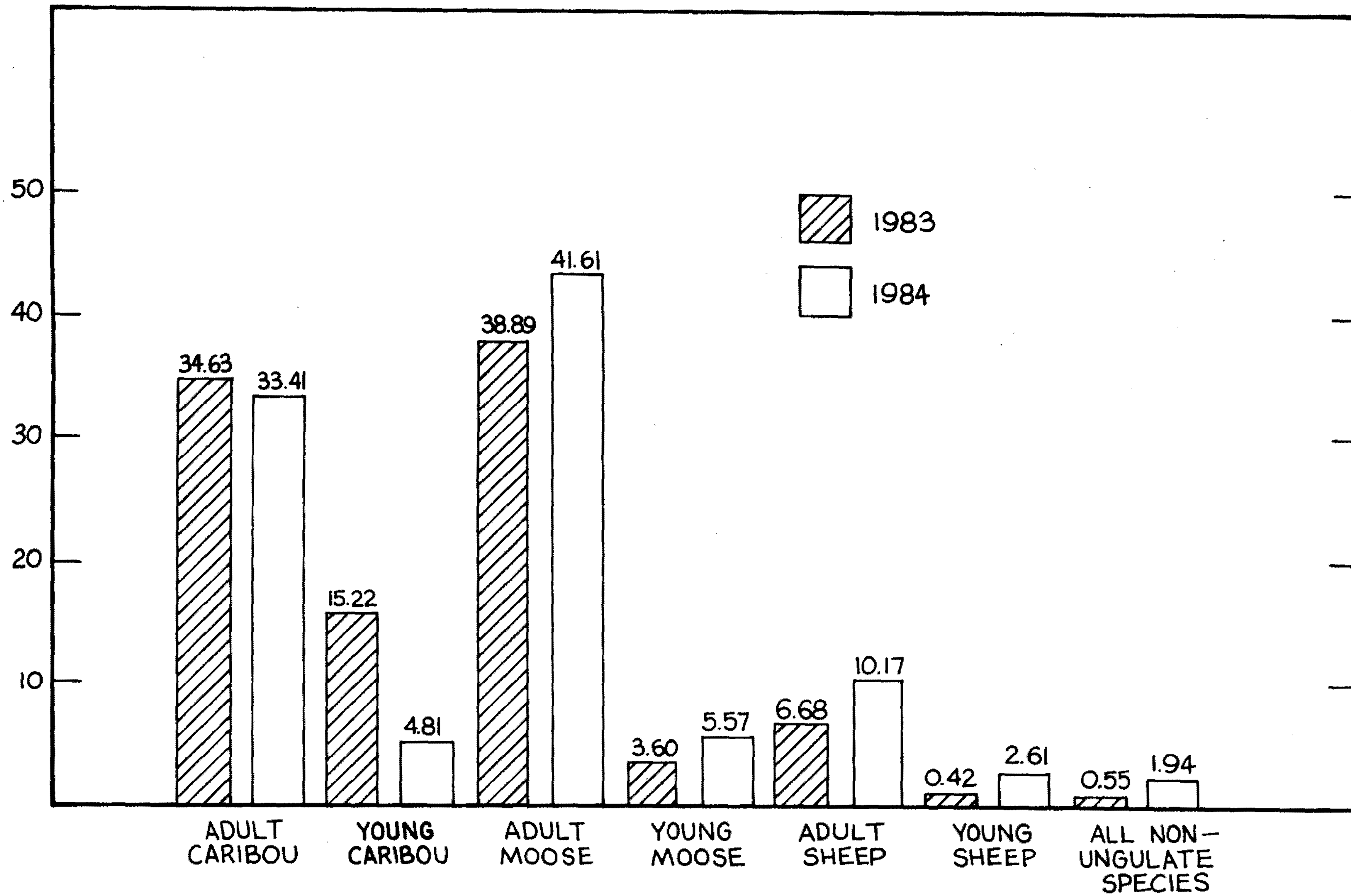


Fig. 2. Food habits (% composition) of wolves in the Kongakut River drainage during the summer denning period (April through August) of 1983 and 1984 within Arctic National Wildlife Refuge, Alaska.

Table 3. Prey utilization by wolves during the denning period (April through August) in the Canning River drainage based upon analysis of 48 scats collected during summer 1984, Arctic National Wildlife Refuge, Alaska.

| Prey item | Frequency Adult[a] | Frequency Pup[b] | Volumetric total Adult | Volumetric total Pup | Kg Eaten | Kg % | Kg Ratio | Individuals # | Individuals % | Individuals Ratio | Individuals/wolf/denning period | Multiplied by correction factor of 1.2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Caribou: | | | | | | | | | | | | |
| adult | 5 | | 5.0 | | 8.70 | 7.5 | 0.46 | 0.13 | 1.8 | 0.46 | 0.29 | 0.34 |
| young | 11 | | 10.8 | | 5.18 | 4.5 | 0.27 | 1.04 | 14.4 | 3.72 | 2.39 | 2.87 |
| unknown age | 5 | | 4.9 | | 8.53 | 7.4 | 0.45 | 0.13 | 1.7 | 0.45 | 0.28 | 0.34 |
| Moose: | | | | | | | | | | | | |
| adult | 1 | | 1.0 | | 8.56 | 7.4 | 0.45 | 0.02 | 0.3 | 0.08 | 0.05 | 0.06 |
| young | 8 | | 7.8 | | 7.72 | 6.7 | 0.41 | 0.25 | 3.5 | 0.91 | 0.57 | 0.68 |
| unknown age | 9 | | 8.2 | | 70.19 | 60.6 | 3.70 | 0.17 | 2.4 | 0.62 | 0.39 | 0.46 |
| Dall sheep: | | | | | | | | | | | | |
| adult | 1 | | 1.0 | | 1.47 | 1 3 | 0.08 | 0.03 | 0.3 | 0.10 | 0.06 | 0.07 |
| young | 2 | | 2.0 | | 0.92 | 0.8 | 0.05 | 0.23 | 3.2 | 0.82 | 0.51 | 0.62 |
| unknown age | 1 | | 1.0 | | 1.47 | 1.3 | 0.08 | 0.03 | 0.4 | 0.10 | 0.06 | 0.07 |
| Unknown ungulate: | | | | | | | | | | | | |
| young | 1 | | 0.6 | | 0.29 | 0.3 | 0.02 | 0.06 | 0.8 | 0.03 | 0.13 | 0.16 |
| unknown age | 1 | | 1.0 | | 1.74 | 1.5 | 0.09 | 0.03 | 0.4 | 0.09 | 0.06 | 0.07 |
| Rodents: | | | | | | | | | | | | |
| ground squirrel | 3 | | 1.0 | | 0.40 | 0.4 | 0.02 | 0.50 | 6.9 | 1.79 | 1.12 | 1.35 |
| microtines | 3 | 2 | 0.9 | 2.0 | 0.34 | 0.2 | 0.02 | 3.42 | 47.4 | 12.26 | 7.68 | 9.22 |
| Miscellaneous: | | | | | | | | | | | | |
| mustelid | 1 | | 0.4 | | 0.22 | 0.2 | 0.01 | 0.03 | 0.4 | 0.10 | 0.06 | 0.08 |
| bird & egg | 1 | | 0.1 | | 0.04 | t | t | 0.38 | 5.3 | 1.36 | 0.85 | 1.02 |
| insect | 1 | | t | | | | | | | | | |
| fish | 2 | | 0.2 | | 0.08 | 0.1 | t | 0.78 | 10.8 | 2.80 | 1.75 | 2.10 |
| plastic | 1 | | 0.1 | | | | | | | | | |
| wolf | | | | | | | | | | | | |
| undetermined | | | | | | | | | | | | |
| Totals | 57 | 2 | 46.0 | 2.0 | 115.83 | 100.0 | | 7.21 | 100.0 | | | |

a 15.2% of adult scats contained more than 1 prey item.
b 0% of pup scats contained more than 1 prey item.

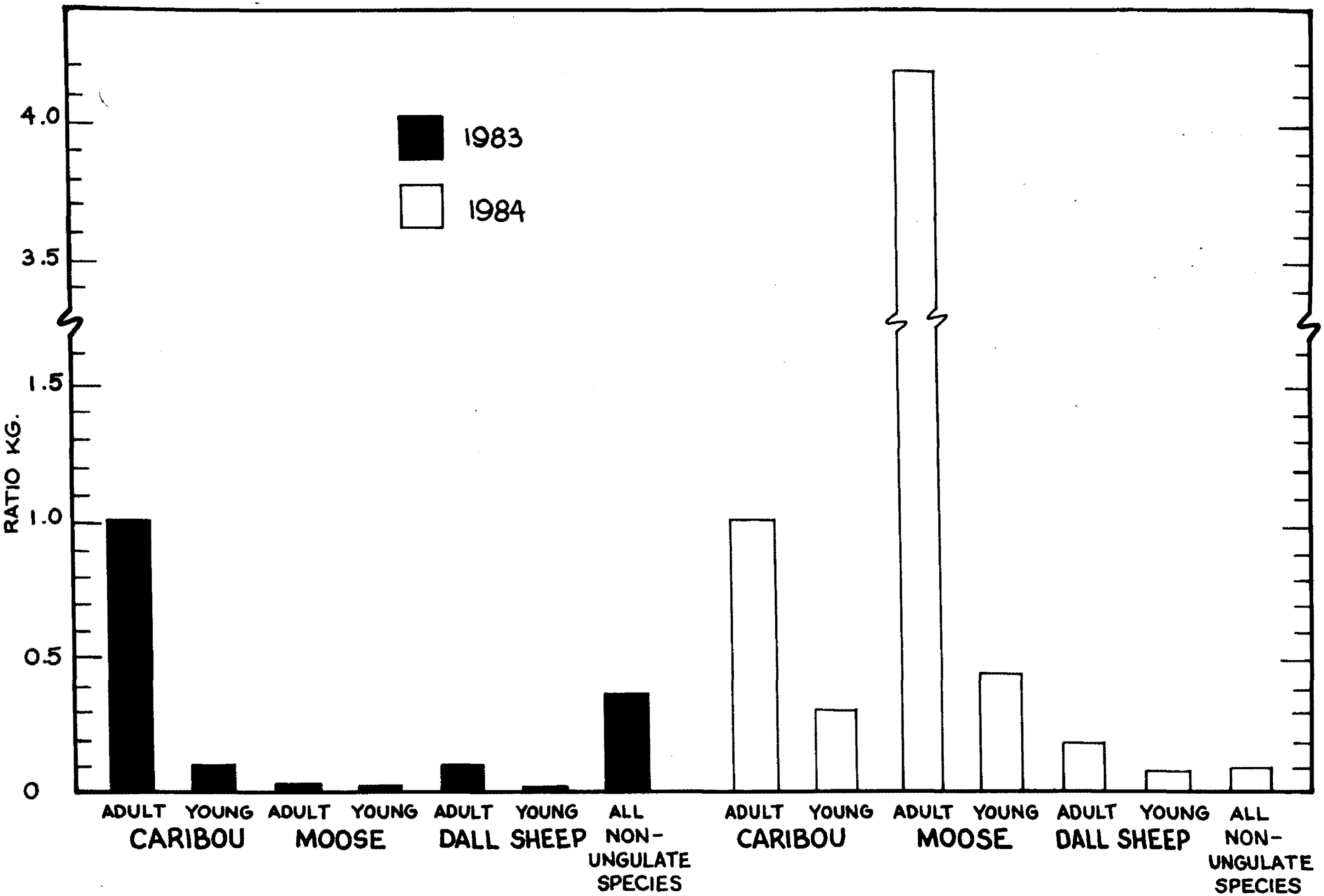


Fig. 3. Relative prey utilization (ratio kg eaten) by wolves in the Canning River drainage during the denning period (April through August) of 1983 and 1984. Proportion of prey use are not comparable between years.

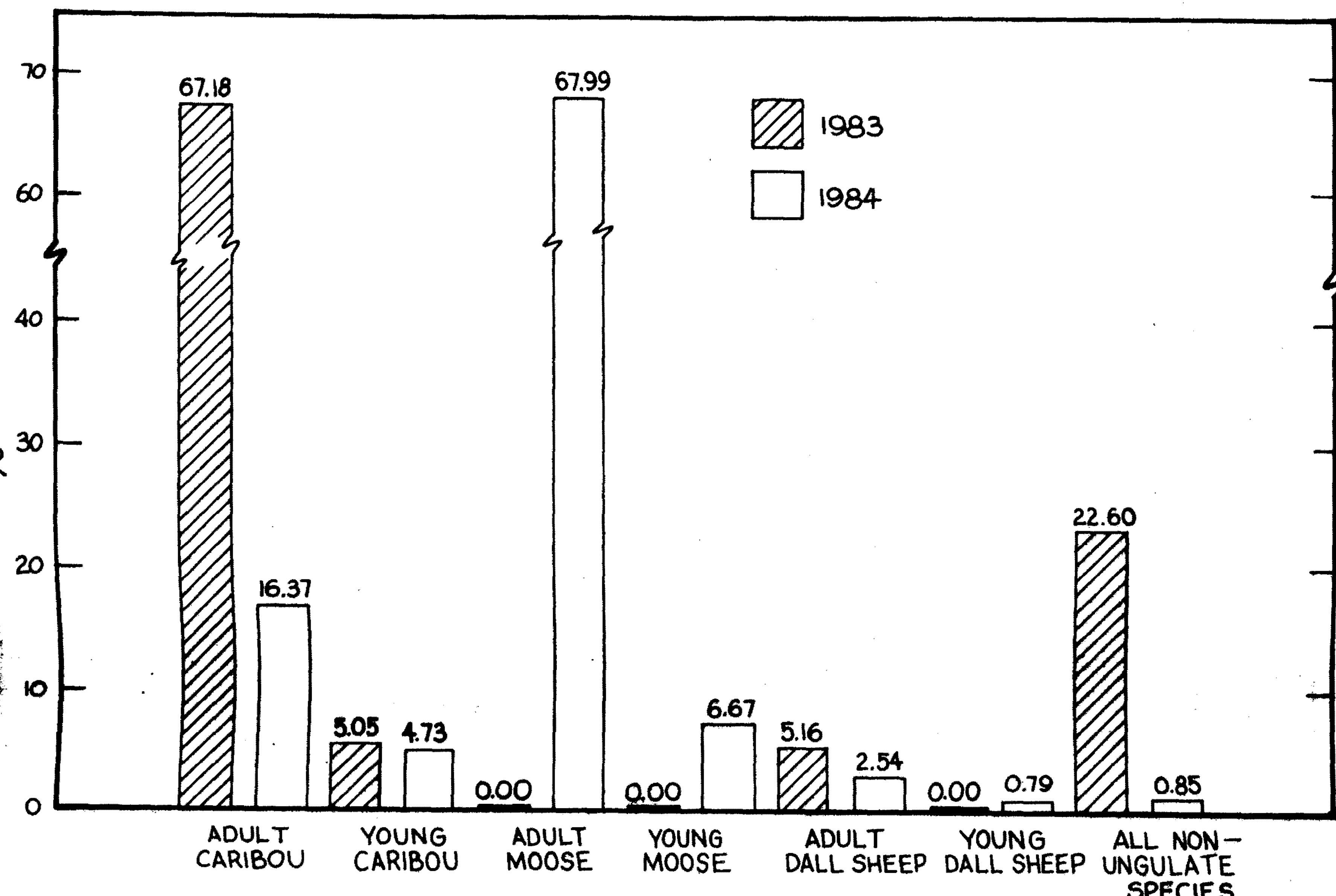


Fig. 4. Food habits (% composition) of wolves in the Canning River drainage during the denning period (April through August) of 1983 and 1984 within Arctic National Wildlife Refuge, Alaska.

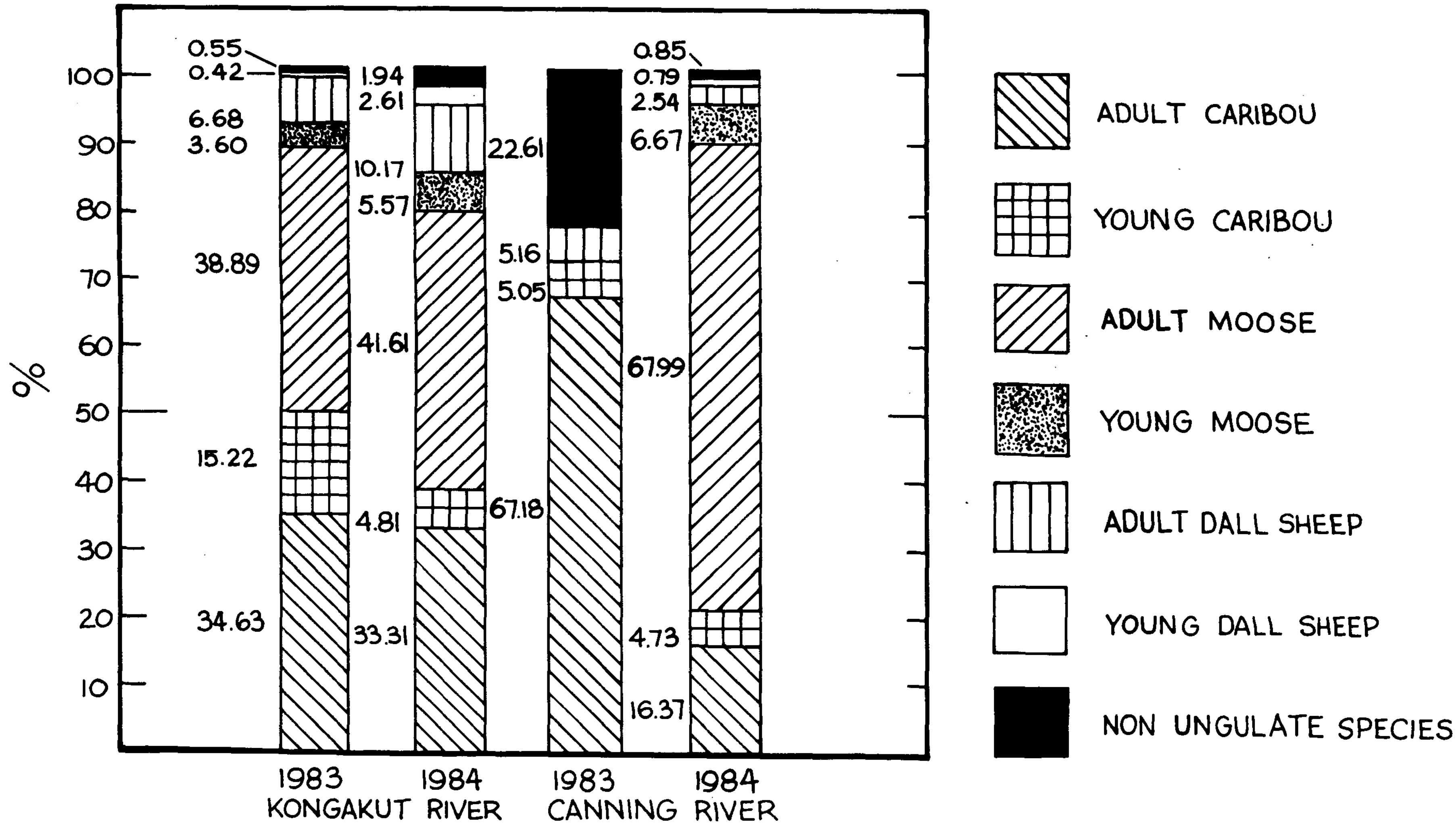


Fig. 5. Comparison of food habits (% composition) of wolves in the Canning and Kongakut River drainages during the denning periods (April through August) of 1983 and 1984 within the Arctic National Wildlife Refuge.

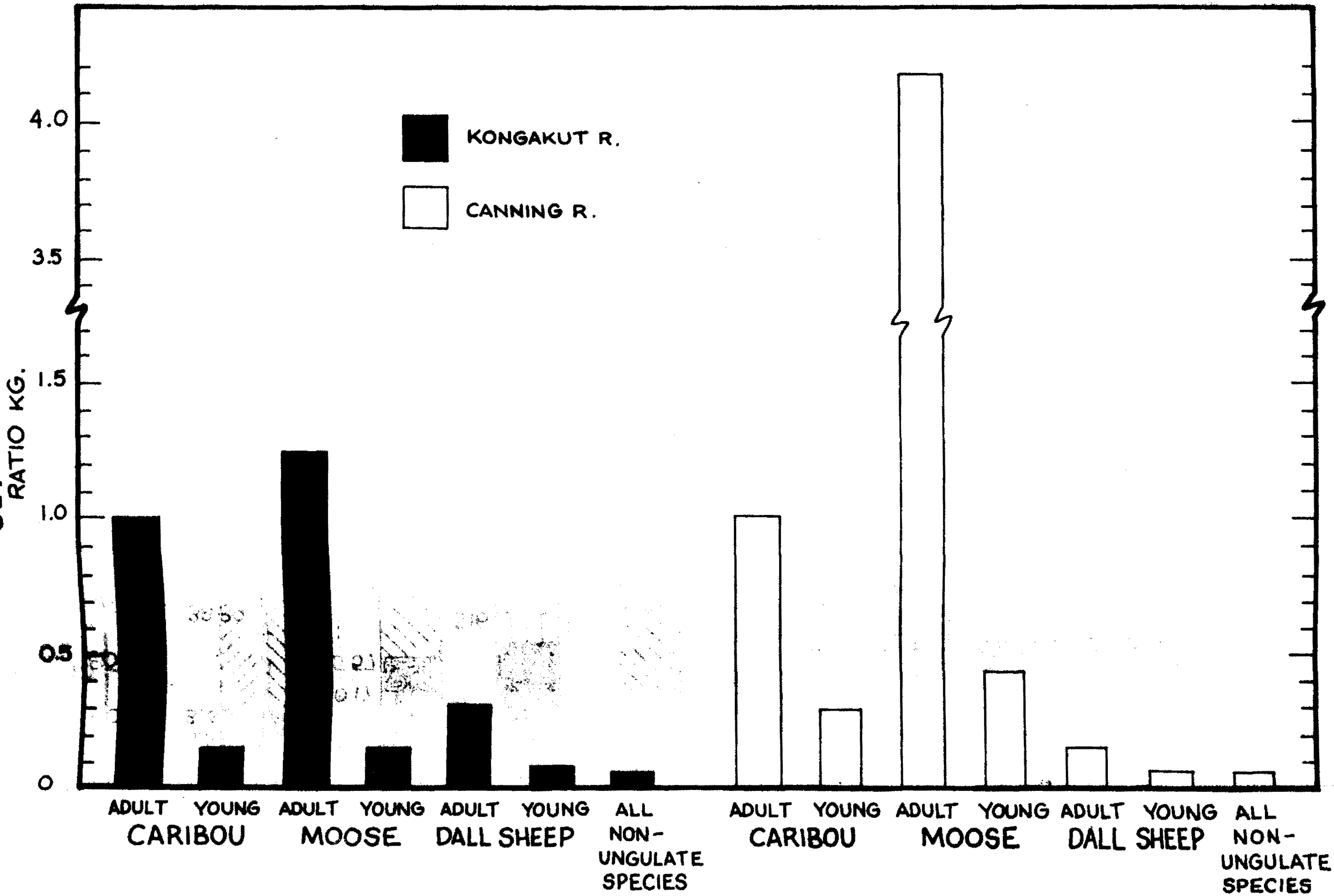


Fig. 6. Relative prey utilization (ratio kg eaten) by wolves in the Canning and Kongakut River drainages during the denning period (April through August) of 1984. Proportions of prey use are not comparable between years.

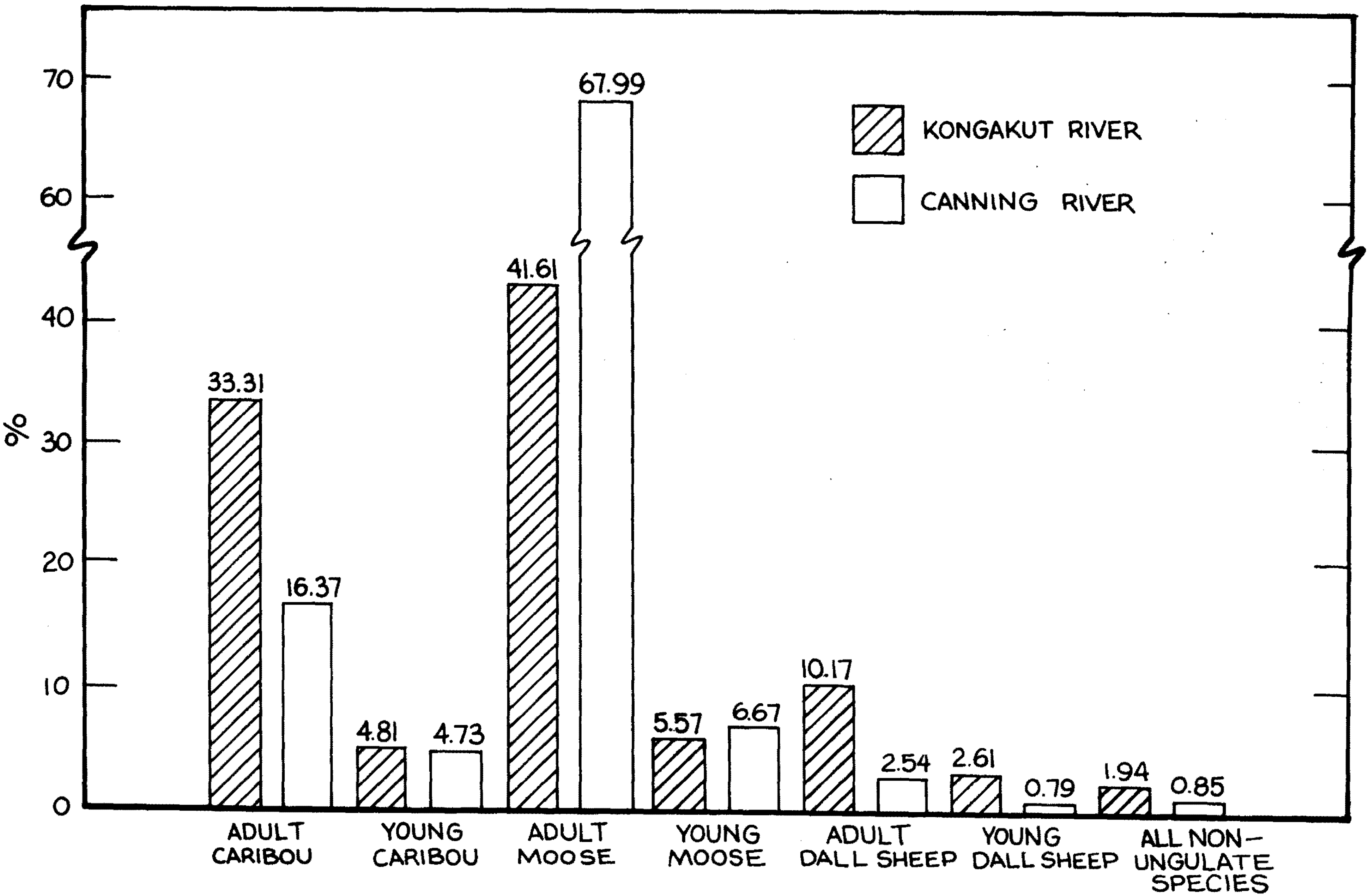


Fig. 7. Comparison of food habits (% composition) of wolves in the Canning and Kongakut River drainages during the denning periods (April through August) of 1984 within the Arctic National Wildlife Refuge.

study can provide information on whether denning wolves journey to the coastal plain to hunt caribou during the denning season, or whether they depend on available prey within the drainages.

Hunting in Relation to Caribou Movements

In 1983, caribou of the Porcupine herd migrated further west onto the coastal plain (in the vicinity of the Hulahula River). The herd did not move west across the Jago River in 1984. Caribou normally found in the Canning River drainage are members of the Central Arctic herd and usually does not appear in large numbers. Biologists (K. Whitten, pers. comm.) and (B. Lawhead, pers. comm.) could not document any differences in the numbers of Central Arctic Herd caribou available to wolves along the Canning River drainage in the two summers. Prey were scarce in the Canning River drainage compared to the Kongakut River camp in summer 1984. Due to an apparent lack of prey abundance, the Canning River wolves may have had difficulty finding enough food for pups.

In relation to the Kongakut River wolves, the Porcupine herd's movements may have been more favorable. On several occasions in summer 1984, caribou passed by the Kongakut coastal plain area on their movements to and from Canada during the period when many young calves are present in the herd. Approximately 10,000 caribou passed by the den site on 27 June, migrating east, and may have given the Kongakut River wolves ample opportunities to secure food for the pack. When caribou had moved out of the wolves' range earlier than usual, the wolves may have adjusted by hunting other available prey (Fig. 2).

Behavioral Observations of Kongakut Wolves

The Kongakut wolves were observed over a period of 54 days (28 May-20 July) during which 584 scheduled observation bouts were made. During 14 observation periods the view was obscured by fog or snow. Adult wolves were seen during 184 of the remaining 570 observation periods. Six adult wolves were observed in the Kongakut River pack, which successfully raised two pups, through July 1984. Adult wolves were sexed and aged from their appearance and behavior, and the two radio-collared wolves (USF&WS #7 and #9) were found to confirm these identifications. The composition and identity of members of the Kongakut pack were as follows:

- A: male leader wolf; probably 5 to 8 years old; coloration grey-black.
- M: female pup rearer; probably 3 to 5 years old; coloration grey with light saddle and dark on tail.
- F: female sub-dominant; probably 2-years old; coloration grey with black on rump and tail.
- S: male subordinate; probably yearling; coloration brown-black with white spot on chest. (USF&WS #7)
- L: female subordinate; probably 3 to 5 years old; coloration slate grey. (USF&WS #9)
- J: male subordinate; probably yearling; coloration slate grey.

Wolves S and L were captured and radio-collared on 27 June and 30 June, respectively (Weiler et al. 1985). Wolf S was never seen at the den following capture. L was often seen at the den following capture but did not show any sign of assisting in pup rearing.

Wolves A, M, and F were present at the den on 28 May and were the only wolves seen for two weeks. Wolf S was identified on 5 June and the two slate grey wolves (L & J) were first identified after 9 June.

During early morning of 15 June, after two days without observations, M seen carrying one pup from the natal den to the auxiliary den, and later the same day the second pup was also moved to the auxiliary den. After the first observation of the pups, they were seen regularly until 21 July. It is generally found that wolf pups emerge from the den around the age of 3-weeks (Young and Goldman 1944, Mech 1970), and if this age is assumed on 15 June, then their birth occurred sometime around 25 May, which is a normal time for pupping in this area (Chapman 1977). A herd of approximately 10,000 caribou passed near to the den site while migrating east. Wolves of the Kongakut pack were observed hunting caribou, but no kills were observed. The pups were observed receiving and eating meat, for the first time on 27 June.

After 27 June, only a few caribou were seen in the area of the den site. On 29 June, a grey wolf was observed that fit the description of M (the mother of the pups) hunting in the vicinity of at Caribou Pass, 25 km north of the Kongakut den site (C.A. Babcock pers. comm.). This incident may have been first long distance travel by the maternal female since the pups were born. Late June is approximately the normal time for weaning wolf pups (Mech, 1978). The parents (A & M) departed on 7 July and were absent until 15 July. During the absence of A and M, wolves F and L, were observed briefly with the pups, and only one regurgitation by F, was observed. Apparently, the only other food available to the pups during this period was whatever was left in the form of bones and cached meat.

The morning after the parents' departure on 8 July, nine rafters in three rafts with five tents camped on a temporal island on the same side of the river within 600 m of the dens. The rafters stayed until the afternoon of 10 July, during which time they hiked the hills in the area, approaching within 120 m of the pups. Wolf L may have avoided the den site during the time when the rafters were present as a wolf was observed crouching in willows 1 km south of the den at 1430 h on 10 July (K. Butters pers. comm). Following departure of the rafters wolf L returned to the den (observed at 1923 h) and behaved agonistically towards the pups when they solicited food.

Behavior of the pups changed markedly following departure of the rafters (afternoon 10 July). The length of pup behavior bouts (sleeping, playing, and eating activities) dropped from 15-30 min before 10 July, to 10-30 sec bouts after 10 July. The last night before the parents' return, the pups were seen sleeping in their outside bed, huddled together. One of the pups was often moving its head and rearranging its position, while the other lighter-colored pup did not move even though it was constantly disturbed by its sibling.

When J returned in the early morning of 15 July, both pups immediately rose from their beds solicited food by pawing at J's mouth while standing on their hind legs. The lighter-colored pup fell over on its back and appeared slow to recover. The pups appeared in need of food, and the lighter-colored pup may have been weakened by lack of food. It has been suggested that a period of 10-12 days without proper feeding could significantly influence condition of wolf pups at this age (B. Stephenson pers. comm).

Later in the morning of 15 July, wolf M returned and regurgitated for both pups, and allowed them to nurse briefly before she left the den site after 20 min. This nursing bout is within Young and Goldman's (1944) estimated age for weaning (six to eight weeks). During the following week, M was seen twice at the den on 16 July for 11 and 6 min and for 6.3 h on 19 July.

When wolf A returned on 15 July, it stopped abruptly where the rafters had apparently walked, shifted direction and moved, parallel to the rafters' route. It eventually crossed the apparent path of the rafters when approached by soliciting pups and regurgitated several times. Wolf A then rested at the crest of the mound for 10 h, remained "outside" the rafters' route. It was later seen for 1.5 min on 20 July at the den site, running and jumping up on its hind feet as if searching. At the same time the pups were seen 3 to 5 km downstream on the opposite side of the river by another investigator (Garner pers. comm.).

## Pack Behavioral Changes in Relative to the Pup Development

Before the pups were seen outside the den, the two parent wolves (A and M) showed a clear rhythmicity in their appearance in the den area (Fig. 8). It appears that the leader male wolf A would leave for hunts around 2100-2300 h, and return sometime in late morning 0700-1000 h and stay around the den site (usually sleeping among the willows out of sight) until the next evening. The mother wolf M showed much the same pattern, and is assumed to have been resting in the den with the pups during mid-day.

After the pups had been seen outside, M's appearance pattern changed, and she was seen outside with the pups during mid-day. The pattern during the remainder of the day was similar to before (Fig. 8). Apparently the mid-day may have been used by M to be together with the pups, and when they moved out of the den, M was seen more often. Wolf A appeared to leave for its excursions earlier (before 2100 h), and the returns seemed to peak around 0600 h. It is hypothesized that the presence of the pups outside the den would act as a stronger releaser initiating more intense hunting activity by the father, causing him to depart earlier, and to return as soon as possible. The behavior patterns of both A and M changed markedly after their eight day absence, and it is speculated that they were attempting to gather food for themselves and the two pups.

All of the lower ranking wolves showed a lower but constant appearance rate. This may be expected if subordinate wolves frequent the den for food and pup rearing reasons (Fig. 8). Harrington et al. (1983) discussed occurrences and behavior of auxiliary wolves around the den in relation to food abundance, suggesting that the appearance rate of the lower ranking wolves may indicate an attempt to be present when the hunters (the leader male) returned with food. Low ranking wolves may also frequent dens to pilfer from the caches in the area. The lower ranking wolves associated with the Kongakut den did not appear to change their pattern of appearance at the den area during the summer observation period.

It appeared that M was especially active gathering food following the parents' eight day absence. One of the pups was seen the den on 24 August, indicating that at least one had survived to that date. Two smaller wolves or pups were observed north of the den site with larger wolves after 24 August (L. Martin, pers. comm.).

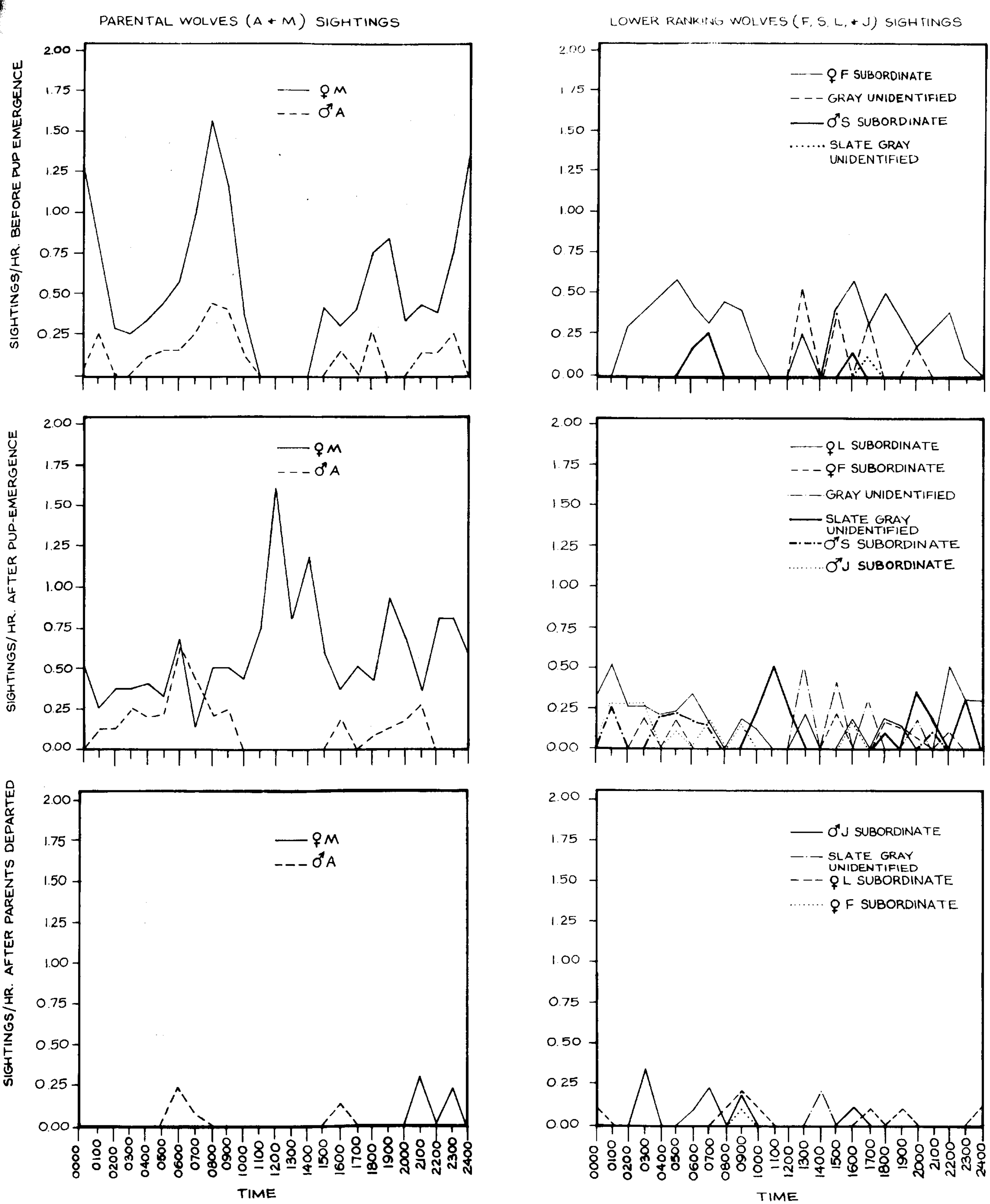


FIG. 8. WOLF ACTIVITY (SIGHTINGS PER HR) AT THE KONGAKUT RIVER DEN SITE DURING THREE TIME PERIODS FOR PARENTAL AND SUBORDINATE WOLVES ON THE ARCTIC NATIONAL WILDLIFE REFUGE, SUMMER [illegible].

Hunting

No successful hunting was observed, however, on three occasions single wolves were seen chasing caribou. During two of the three single-wolf chases other wolves were present, but there was apparently no communication between the wolves regarding the presence of the caribou. On 27 June five wolves were observed chasing caribou in a herd of about 10,000. The hunt was initiated by the maternal female. The remaining four wolves did not become involved until the caribou came within their field of vision. No cooperative hunting was observed, and it appeared that each wolf pursued the nearest caribou. All close encounters were observed when caribou were chased uphill, and at these times the wolves gained on the fleeing caribou. Caribou often avoided being caught by turning downhill, at which time the pursuing wolf would pursue the next available caribou.

An interaction was also observed involving a yearling caribou, the leader male wolf (A), a subordinate wolf (J), and a brown bear. Wolf J was observed chasing the caribou and was later joined in the chase by the brown bear and wolf (A). Wolf (A) appeared to be chasing the brown bear, which stopped and faced wolf (A). These two individuals alternately chased and fled from each other for several minutes, while wolf (J) passed out of sight over the crest, chasing the caribou. Later, wolf (A) and the bear also passed over the crest. After an hour, wolf (A) returned from the same direction with meat for the pups.

Physical Characteristics of the Inspected Dens

Canning River Den. The Canning River den was located on a small mound adjacent to a curve in the river bank. It was elevated approximately 4 m above the maximum water line and was between 15 and 25 m distant from the maximum river edge. The mound had a general east-west orientation and was approximately 50 m long. Six major holes and 15 smaller holes were dug into the mound on the south side, facing the river. The six holes extended over a distance of 25 m (Fig. 9).

Several well-used beds were located on the eastern and northern sides of the mound. The holes and the beds were located such that the river and the floodplain to the south could be observed from the den site. A well-used trail along the river edge could be observed upstream from the eastern beds. The Moose Creek alluvial fan with a mesh of trails leading to the north, could be observed from the bed on the north side of the mound.

The six major holes were all approximately 1 m in diameter. Only two of the holes (#2b & #5, Fig. 9) had tunnels of any considerable dimensions. Hole #5 led down into a 4 m long tunnel ending in a large chamber which had a smaller hole leading down into it from the surface. The tunnel was roughly round with a 0.7 m diameter. The chamber was between 1.2 and 1.5 m in diameter, and over 0.6 m high. There was ample room for a wolf with several pups to move around relatively freely. Hole #2b led into a tunnel going west parallel to the mound, ending in a smaller chamber 3 m from the opening. Several small tunnels were seen radiating out. The other four holes ended in small fist-sized tunnels.

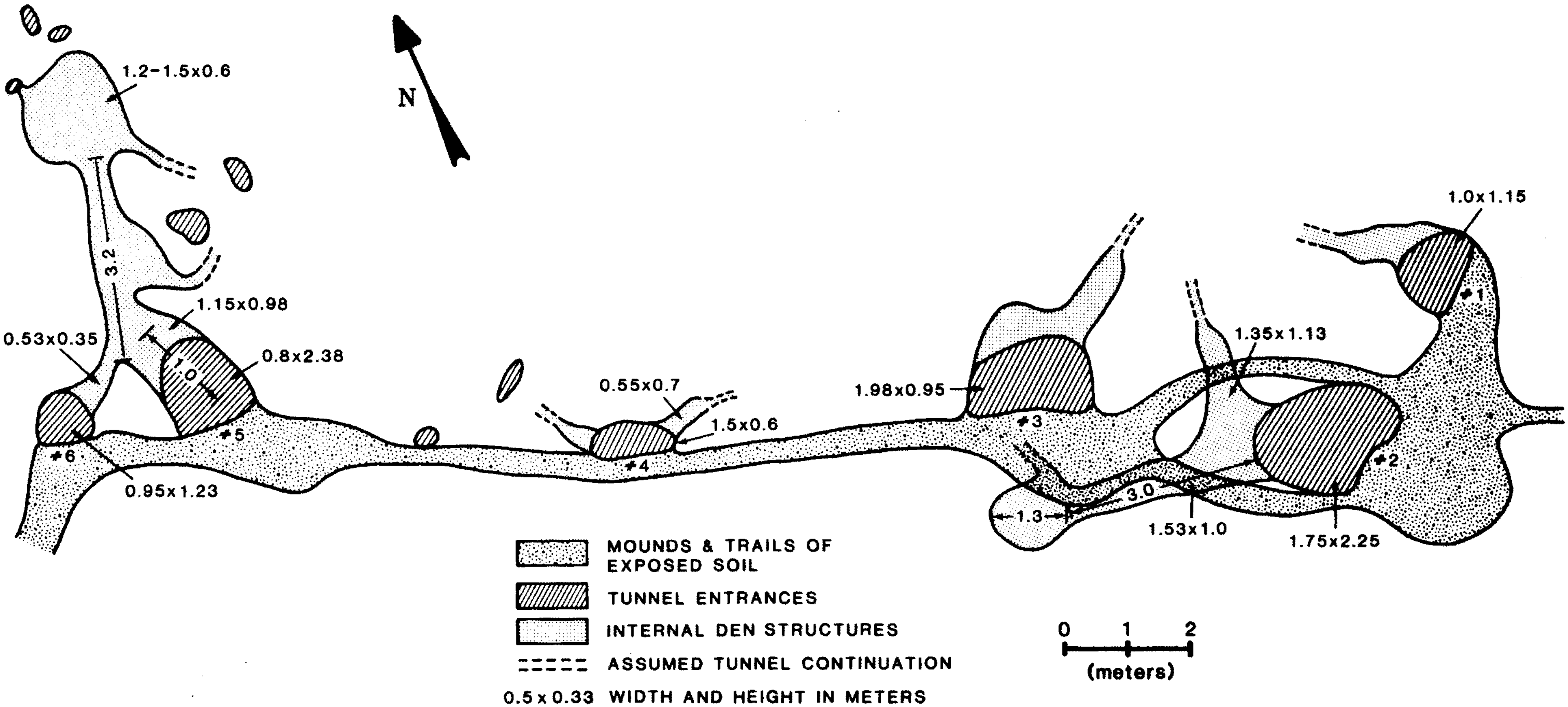


Fig. 9. Detail of the natal den at the Canning River den site on the Arctic National Wildlife Refuge, Alaska, 1984.

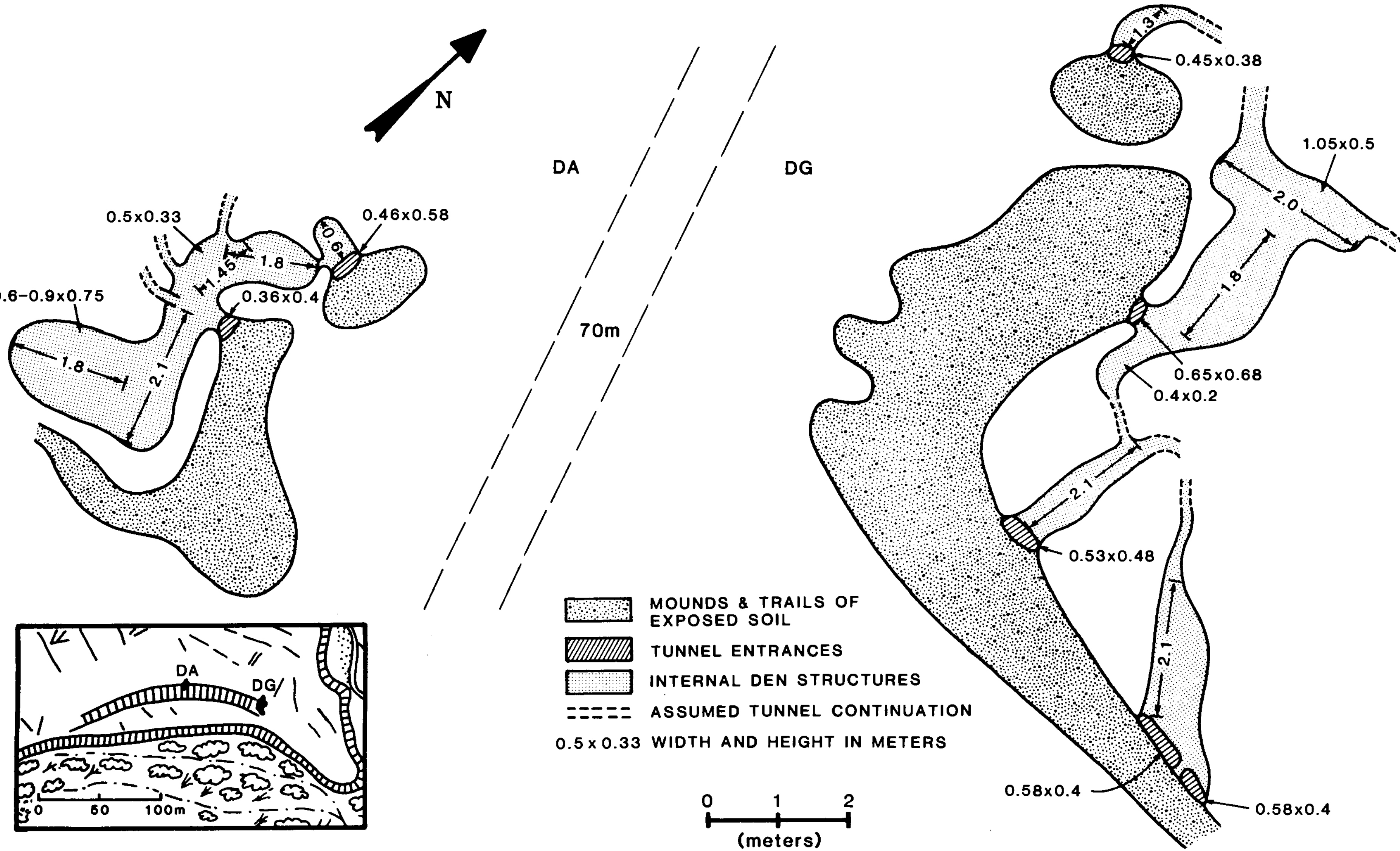


Fig. 10. Detail of the natal (DA) and secondary (DG) dens at the Kongakut den site on the Arctic National Wildlife Refuge, Alaska, 1984.

The entrances of the Canning River den tunnels were located on the top of the mound and were dug down into the horizontal surface. This differs from the Kongakut den which was located on the side of a mound. The dimensions of the entrances at the Canning den site were much larger than at the Kongakut den. The tunnels and chambers of the two den sites were of relatively similar in size.

Kongakut River Den. The two dens at the Kongakut den site (Fig. 10) are located within 80 m of each other on the south side of a ridge created by the Kongakut River on the south and east, and by Den Creek on the north. This ridge is located where caribou migrate northbound through two passes. The river valley widens considerably north of this point. Caribou arrive along three relatively predictable paths (two through the major pass, and one through an eastern pass) and spread out over the wide, flat open area north of the densite. The distance to the nearest water channel was about 50-100 m and 250-300 m to the main river channel.

Several beds were found in the area, and observations during the summer indicated that wolves stayed on the south side of the ridge, as well as a top of the ridge while at the den site. These locations provided vantage points to watch for prey passing north and south along the valley.

In contrast to Chapman's (1977) observations, the eastern (DG, Fig. 10) den was used as the whelping den, and the western (DA, Fig. 10) den was subsequently used as an auxiliary den. When the densite was examined on 24 August, four holes were found in the DG den (Fig. 10). One tunnel led into a larger chamber at the end of a "T". The tunnel width was 0.9 m and the height of the chamber was 0.5 m. The floor of the den was littered with small sticks, probably gnawed on by the pups. Three other holes in the DG den were all relatively short, and ended in small fist-sized tunnels. The angles and directions of these smaller tunnels might indicate that all the tunnels connect.

The auxiliary den (DA, Fig. 10) consisted of two holes that were interconnected by a short fist-sized tunnel. The major hole led into a "Z" shaped den perpendicular to the center bar. The major chamber was to the left and forward, into the mound. The internal measurements of this den were larger overall that the DG. Its larger size better accomodated the rapidly growing pups.

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Approved by: Gerald W. Garner Date: 29 March 1985

Gerald W. Garner, Supervising Wildlife Biologist,
Arctic National Wildlife Refuge

APPENDIX
ANWR Progress Report Number FY85-4

BOUT NO. ______
PAGE ______
OF ______

| | DATE | LOCATION | DIRECTION | PRE/POST | SLEEP | FEED | REGURGIE | STASH | CARRY | PLAY | GREET | SOUND | CONTACT | PEAC. BEH | AGON. BEH | InStCoPa | PredGrAc | SEX | ID OF FOCAL ANIMAL | IF SOCIAL ID OF RECIPIENT | PUPS # | TIME |
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FIGURE 1"A"

# LOCATION SQUARE
# WOLF BEHAVIOR – DATA FORM

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| | > | 100 | 30 | 10 | 3 | 1 | | 1 | 3 | 10 | 30 | 100 | > | |
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| | > | 100 | 30 | 10 | 3 | 1 | | 1 | 3 | 10 | 30 | 100 | > | |

Date: ______ Time: ______ Observer: ________________ Temp.: ______

Weather: ______ Wind: ______ Location: ____________________________

Activity: Sleeping ______ Pre-hunt ______ Playing A ______ Playing P ______ Playing A & P ______

Feeding A ______ Feeding P ______ Feeding A & P ______

ANWR Progress Report Number FY85-5

# WOLVES OF THE ARCTIC NATIONAL WILDLIFE REFUGE: THEIR SEASONAL MOVEMENTS AND PREY RELATIONSHIPS.

Gregory J. Weiler
Gerald W. Garner
Larry D. Martin
Wayne Regelin

Key words: Wolf, movements, northeastern Brooks Range, Arctic National Wildlife Refuge, food habits, reproduction.

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27 February 1985

Wolves of the Arctic National Wildlife Refuge: their seasonal movements and prey realtionships.

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Abstract: Five wolf (*Canis lupus*) packs were located on the northern portion of the Arctic National Wildlife Refuge (ANWR) in 1984. Eleven wolves were captured and radio-collared. Collared wolves included members of three packs along and six lone wolves. The two animals of the Old Man Creek pack were killed prior to denning and no members of the Canning River pack were collared. All four packs denned in 1984 and three of the den sites were located. Three packs reared a total of seven pups and an unknown number was raised by the Canning River pack. Minimum estimate of wolves using he northern portion of ANWR in late summer was 27 adults and 7 pups.

Wolves of the Arctic National Wildlife Refuge: their seasonal movements and prey relationships.

The gray wolf (Canis lupus) has the greatest natural range of any living mammal other than man (Nowak 1983). Wolves are found throughout those portions of the remote regions of the northern hemisphere which remain relatively undeveloped by humans (Mech 1970). In North America wolves once occupied nearly the entire continent. Today their range is restricted to most of Canada and Alaska, parts of northern Minnesota and Montana (Mech 1970), northern Wisconsin (Mech 1981), and certain regions of Mexico (Brown 1983). Most taxonomists recognize 32 subspecies of wolves, of which 24 occur in North America (Mech 1970). Wolves inhabiting the northern portion of the Arctic National Wildlife Refuge (ANWR) and the northeastern Brooks Range have been classified as C. l. tundarum, the Alaska tundra wolf (Nowak 1981). This subspecies classification has been challenged by Raush (1953 as cited by Nowak 1983) and Pedersen (1978), who contend that the differences between C. l. tundarum and C. l. pambasileus (the interior Alaskan wolf) are not defined well enough to warrant C. l. tundarum's classification as a separate subspecies.

Wolves are the largest wild members of the dog family (Canidae). Adult males from most areas average 43-45 kg, while adult females average 36-39 kg (Mech 1970). Their pelage ranges in color from white to gray, brown, tawny, and black.

Wolves are gregarious animals with a highly developed social behavior which is primarily manifested in the social unit or pack. Wolf packs are loosely associated groups of animals, often family members (Mech 1970). A hierachy system usually limits breeding activity to only the dominant male and female of the pack. However, multiple litters per pack have been recorded in Alaska (Packard et al. 1983, Stephenson pers comm). Breeding in Alaska occurs in late winter from late February through March (Rausch 1967). Dens are prepared or visited by the parturient female as much as 4-5 weeks prior to parturition (Chapman 1977). In arctic areas, pups are usually born in mid-May to early June (Chapman 1977). The average litter size is 4.0 to 6.5, but varies due to many factors (Mech 1970). Within 11 to 15 days of birth the pups' eyes open and at about three weeks of age they begin to emerge from the den opening (Chapman 1977). Whelping dens are used for varying lengths of time. In arctic areas, dens are usually abandoned in July; however, some may be occupied at late as August (Chapman 1977, Stephenson pers. comm). The pups are left at rendezvous sites while the adults are hunting during the summer. Both parents, as well as other members of the pack, hunt and care for the young.

Numerous naturally occurring processes influence mortality and population numbers of wolves. In utero mortality has been reported by Rausch (1967), but the causes of such mortality were undetermined. Post-parturition mortality factors such as canine distemper, rabies, malnutrition, parasites, cannibalism, predation (golden eagles Aquila chrysaetos, grizzly bears Ursus arctos), porcupine quill infection, and accidents (Murie 1944, Kuyt 1972, Stephenson and Johnson 1972, Chapman 1977 and 1978) influence wolf populations. In 1977 all known members of a wolf pack on the Hulahula River died of rabies (Chapman 1978). Data from 22 wolf litters in a variety of locations in North America, indicate an average summer survival rate of 85% for wolf pups (Chapman 1977). High mortality rates in wolf litters has been reported in cases where food supply was limited, or declined (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).

Large ungulates are the predominant food items in summer scats of wolves in the north-central and north-eastern Brooks Range (Stephenson 1975, James 1983, Haugen 1984). However, significant quantities of microtine rodents, ground squirrels (Spermophilus parryi), birds, eggs, and insects are also utilized during summer by wolves in arctic Alaska (Stephenson and Johnson 1973). During the remainder of the year, large ungulates are utilized even more exclusively. In the Northwest Territories of Canada (Kuyt 1972) and northwestern Alaska (Stephenson 1979, James 1983), wolves tend to shift their ranges in correspondence with seasonal migration of caribou (Rangifer tarandus) migrations. Similar shifts may not be as prevalent in the northcentral and northeastern Brooks Range due to a greater abundance of resident prey such as Dall sheep (Ovis dalli) and moose (Alces alces).

In the past, human activity has often had negative consequences for wolves. The extirpation of wolves from extensive areas of North America and Eurasia has been directly associated with human settlement activities. Predator control and bounty programs using guns, traps, and poison effectively removed wolves from major agricultural areas of the U.S. and Canada. Government sponsored aerial hunting and poisoning of wolves during the 1940's and 1950's greatly reduced wolf populations in some areas of Alaska (Rausch and Hinman 1977). Wolf populations in many of these areas have since recovered. Wolves were relatively abundant prior to aerial wolf hunting and predator contral activities which became intensive on the north slope of Alaska in the early-mid 1950's (Stephenson per. comm.). Between 1952 and 1958 more than 1500 wolves were killed on the north slope of the Brooks Range (Harbo and Dean 1983). In 1962 it was recognized that wolf numbers on the north slope were depressed and an annual bag limit of two wolves was imposed. The Alaska Department of Fish and Game abolished bounties on wolves except for a few areas in southwest Alaska in 1968. Aerial hunting of wolves on the north slope was banned in 1970; however, wolf populations on the north slope have remained low due in part to continued illegal aerial hunting and persistent local harvest with the use of snowmobiles (Stephenson, per comm.).

Wolf population density estimates for the north-central Brooks Range in 1971-1972 ranged from 1/320 $km^2$ to 1/194 $km^2$ (Stephenson 1975). Following surveys and studies of wolves in the National Petroleum Reserve - Alaska (NPR-A), estimated wolf densities were 1/520 $km^2$ (coastal plain) and 1/130 $km^2$ (foothills and mountains) (Stepheson 1974). In the Canning River area Quimby (1974) reported a density of 1/596 $km^2$ in spring 1973 and 1/181 $km^2$ in the fall. The determination of carrying capacity of wolf habitat is a complex question and is poorly understood. Apparently the density of wolves in a given range is influenced by factors such as prey abundance, social dynamics of packs, human disturbance and harvest levels, diseases, and other ecological factors (Mech 1970, Van Ballenberghe et al. 1975, Chapman 1977, Packard et al. 1983).

Examination of recent reported sightings of wolves on or adjacent to the ANWR coastal plain (Table 1) indicate that wolves have been sighted more often in the foothills and mountain valleys to the south of the coastal plain. Biological consultants working for Arctic Gas Limited in 1972 recorded 56 wolf sightings north of the continental divide in northeastern Alaska, only six of which were on the coastal plain (Quimby and Smarski 1974). In 1973, Quimby (1974) identified four wolf packs and their corresponding home ranges in the Canning River drainage south of the coastal plain. Wolf tracks and trail systems observed in the snow indicate that members of a wolf pack in the Cache-Eagle creeks area may occasionally travel across southern portions of the coastal plain in the vicinity of the Sadlerochit mountains (Thayer pers comm.).

Wolves are probably more abundant and range primarily in the arctic foothills and mountains of the Brooks Range because prey species such as Dall sheep and moose are also more abundant in these areas all year (Thayer pers comm., Stephenson, pers comm.). Wolves tend to be less abundant on the coastal plain of the refuge because prey is less abundant on a year-round basis and because terrain renders them more vunerable to harvest (Stephenson pers comm.). When caribou are abundant on the ANWR coastal plain (May and June), most wolves are occupied with denning activities in the mountains to the south. The hunting range of denning wolves is usually limited to about 32 km radius from the den site (Stepehson pers. comm.). Thus, wolf predation on caribou on the coastal plain during calving and post-calving is probably low. The locations of reported sightings indicate that wolves roam throughout the northeastern Brooks Range and probably utilize most habitats of the area. Information is insufficient to determine habitat or area preferences.

Den sites of wolves in arctic Alaska usually are found on moderately steep southern exposures where the soil is well drained and unfrozen during summer (Stephenson 1974). Land forms such as cut banks, escarpments, dunes, kames, and moraines are often associated with wolf dens (Stephenson 1974). During the past 10 years, active wolf dens were found in mountainous terrain of the Canning, Hulahula, and Kongakut River drainages. Although wolves are known to den on the coastal plain to the west of ANWR (Stephenson 1975), no dens were found on the ANWR coastal plain even though the basic habitat requirements for denning apparently were present.

The Alaska National Interest Lands Conservation Act (ANILCA) of 1980 opened portions of ANWR coastal plain to oil and gas exploration with seismic work starting in winter of 1983-84. Potential impacts of oil and gas development include displacement of parturient female caribou from traditional areas, increased calf mortality, displacement of muskoxen from traditional use and calving areas, scavenging by wolves at dump sites (Murie 1944, Grace 1976) and shifts of territories used by wolves in response to movements of prey species. Development of oil and gas resources on ANWR may directly and indirectly affect wolves and their prey base.

Wolves have not been intensively studied in the northeastern Brooks Range and adjacent coastal plain of Alaska. Although Chapman (1978) and Haugen (1984, 1985) conducted den site studies, data specific to numbers, movement

Table 1. Recent wolf sightings from the northeastern Brooks Range and adjacent coastal plain.

| Date | Location | Number/color | Activity | Source |
|---|---|---|---|---|
| 30 Mar. 1969 | coastal plain S. Barter Island | 2/gray | -------- | Griffin 1969 |
| 9 Apr. 1970 | Snow Cr. | 1/gray | standing | Thayer 1970 |
| 10 Apr. 1970 | Canning R. W. of Mt. Capleston | 1/gray 2/black | feeding on moose | Thayer 1970 |
| 10 Apr. 1970 | Hulahula R. S. of Kikitak Mtns. | 2/gray | running | Thayer 1970 |
| 29 May 1972 | Aichilik R. (foothills) | 2/N.A. | moving north | Blackhall 1972 |
| 14 July 1972 | Aichilik R. (foothills) | 1/gray 1/black | running | Doll et al. 1972 |
| 1972 | lower Aichilik R. (10 mi. from coast) | 1/black | | Quimby and Snarski 1974 |
| 1972 | 10 mi. SE Barter Island | 1/black | | Quimby and Snarki 1974 |
| 1972 | 15 mi. S. Barter Island | 1/black 1/gray | | Quimby and Snarski 1974 |
| 1972 | Itkilyariak Cr. near Sadlerochit Mtns. | 1/black | | Quimby and Snarski 1974 |
| 1972 | Jago R. (foothills) | 1/gray | | Quimby and Snarski 1974 |
| 1972 | Canning R. (10 mi. N. of Ignek Cr. | 1/black | | Quimby and Snarski 1974 |
| 1972 | Sadlerochit Mtns. (5 mi. E. of Katakturuk R.) | 2/black | | Quimby and Snarski 1974 |
| 1972 | Upper Sadlerochit R. | 2/black 1/gray | | Quimby and Snarski 1974 |
| 1972 | Canning R. (Cache and Eagle Cr.) | Numerous sightings | | Quimby and Snarski 1974 Magoun 1976 |
| 25 June 1977 | Marsh Cr. (12 mi. from coast) | 3/N.A. | resting | Magoun and Robus 1977 |
| July 1980 | Jago R.(25 mi. from coast) | 1/black | scavenging | Weiler, ANWR |
| July 1981 | Jago R. (coastal plain) | 1/gray | | Ross, ANWR |
| July 1982 | Kongakut R. (5 mi.S. of caribou pass) | 1 gray | harassment of bear | Weiler, ANWR |
| March 1982 | Canning R. (near Eagle Cr.) | 2/gray 5/black | feeding on kill | Ross, ANWR |
| 6 July 1982 | Kongakut R. | 1 Blk | | Phillips,ANWR |
| 9 July 1982 | Caribou Pass Area | 1 Gray | | Phillips,ANWR |
| 9-14 July 1982 | Caribou Pass Area | 1 Gray | on caribou carcass | Phillips,ANWR |

Table 1. (Continued)

| Date | Location | Number/color | Activity | Source |
|---|---|---|---|---|
| 18 July 1982 | Caribou Pass Area | 1 Gray | | Phillips,ANWR |
| 22 July 1982 | Caribou Pass Area | 1 Gray | | Phillips,ANWR |
| 9 July 1982 | Caribou Pass Area | 1 Gray | | Phillips,ANWR |
| 25 May 1983 | Kongakut R Caribou Pass Area | 1 Blk | | Phillips,ANWR |
| 28 May 1983 | Kongakut R. Caribou Pass Area | 2 Blk/Gray | | Phillips,ANWR |
| 3 June 1983 | Kongakut R. Caribou Pass Area | 1 Blk | | Phillips,ANWR |
| 22 June 1983 | Kongakut R. near VABM | 4 Blk/3 Gray | | Phillips,ANWR |
| 28 June 1983 | Kongakut R. Caribou Pass Area | 1 Blk | | Phillips,ANWR |
| 30 June 1983 | Whale Mtn. Kongakut | 2 Blk/Gray | howling | Haugen 1984 |
| 1 July 1983 | Whale Mtn. Kongakut | 1 Blk | | Haugen, 1984 |
| 1 July 1983 | Den Cr. Kongakut | 2 Gray | resting | Haugen, 1984 |
| 2 July 1983 | Kongakut R. Caribou Pass Area | 1 Blk | | Phillips,ANWR |
| 17 July 1983 | Hulahula | 1 White | traveling | Haugen 1984 |
| 20 July 1983 | Kongakut R. Caribou Pass Area | 1 Gray | | Phillips,ANWR |
| 23 July 1983 | Kongakut R. Caribou Pass Area | 1 Blk | | Phillips,ANWR |
| 25 July 1983 | Moose Cr. Canning R. | 1 pup | | Haugen, 1984 |
| 5 Aug 1983 | Kongakut R. Caribou Pass Area | 1 silver | | Phillips,ANWR |
| 6 Mar. 1984 | Kekiktuk R. | 7/black 1/gray | hunting caribou | Weiler, ANWR |

patterns, and requirements of wolves using the area is lacking. Therefore, a study was initiated during spring 1984 with the following objectives:

1. Define the seasonal ranges of individual wolves and associated packs that use the north slope of the Brooks Range and the coastal plain in the Arctic National Wildlife Refuge.

2. Determine seasonal availability of potential prey within the ranges of study wolves.

3. Determine the seasonal diets of study wolves and relate foods consumed to prey availability.

4. Document predatory behavior and social interactions of selected study wolves during the denning season. (This objective is being addressed in a secondary study being conducted by H. Haugen as part of a M.S. program through the University of Alaska).

## Methods and Materials

The study area included the coastal plain, adjacent foothills and mountains of the Arctic National Wildlife Refuge and extended south of the continental divide in the Brooks Range, east into Canada and west past the Canning River as necessary to follow movement of collared wolves. A detailed description of the 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 28 April to 8 November 1984. Wolves were captured between 19 May and 5 July using a Bell 206B Jetranger helicopter. Fixed-wing aircraft were used to help locate wolves and direct the helicopter with the capture crew to the site.

M 99 (Etorphine, 1mg/ml, D-M Pharmaceuticals) was injected using a Cap-Chur Rifle, 3cc syringes, and low power charges (Palmer Chemical and Equipment Co., Douglasville, GA). All animals recovered after the antidote (M 50-50, Diprenorphine, 0.2 mg/ml, D-M Pharmaceuticals) was administered at 1.5 the dosage of M-99. Two-thirds of the M 50-50 dosage was administered intravenously through the brachial artery in the front leg with the remaining one-third intramuscularly in the rump to offset potential recycling effect of etorphine. Captured animals were measured, weighed, ear-tagged, and fitted with a collar containing a radio transmitter (Telonics, Inc. Mesa, Az). Rectal temperatures were taken using a digital thermometer at the time of immobilization and at periodic intervals during processing. Photographs were taken of the animal with close ups of the teeth to be used at a later date in confirming age estimates. In addition, blood was drawn from the brachial artery using vacutainers (Bectian-Dickinson, Rutherford, NJ) for seriological study by Alaska Department of Fish and Game personnel.

Preliminary activity areas used by denning wolves were determined by plotting radio locations for the individual pack or wolf and subjectively encircling the locations based upon wolf movement patterns. This polygon represents a subjective interpretation of the area used by the wolves based on radio locations, tracks in the snow, and likely travel routes. Due to the limited number of observations of wolves at this stage of the project, these areas are used for discussion purposes and are not considered a measurement of territory size.

Active wolf dens were inspected on the ground following abandonment by the pack. The area surrounding each den was searched and all scats and bones were collected. Scats and food items will be analyzed to determine prey species utilized by the wolves. Scat analysis are partially complete for the Kongakut River den and Canning River den (see Haugen 1985). Scats collected at the Aichilik den sites are currently being analyzed.

## Results and Discussion

### Capture

Eleven wolves were captured and radio collared in the northern portion of ANWR between 19 May and 5 July 1984 (Table 2). Collared wolves included members of three different wolf packs and six lone wolves. In addition, two other wolf packs were located but no known members of these packs were captured. Four of the five packs denned in 1984 and three den sites were located. The fifth pack consisted of two wolves which were killed by local hunters prior to denning.

The first attempt to capture wolves occurred between 28 April-4 May. During the previous two weeks, there were seven reported sightings of wolves in drainages on the north slope portion of the ANWR by the Alaska Department of Fish and Game and USFWS personnel. Several sightings were of wolves digging at apparent den sites. Although searches were conducted using a helicopter and a fixed-wing spotter plane, wolves were only located twice, indicating that the wolves were still wandering and had not taken up residence at a den site. Inclement weather also hampered search efforts. Both times wolves were located, capture efforts were unsuccessful. On one attempt, the tracks of two wolves that had been sighted several times previously were being followed. However, local hunters killed both wolves before the capture crew could locate them. (see Old Man Creek pack history).

During the second effort, four wolves were located but inclement weather (snow storm) obscured the wolves before they could be darted. Subsequent capture efforts were opportunistic from May through July. Wolves were located during survey or capture efforts on other projects; most of the wolves captured were located during surveys for caribou.

Dark colored wolves were more readily located than gray colored wolves. This was true not only for initial sightings but also while radio-tracking wolves and maintaining visual contact with wolves until capture. Differential detectability of dark and gray wolves was not expected and contrasted with reports by Ballard et al. (1981).

Wolves were initially captured using 2.5 cc of M-99, but this dosage was increased to 2.75 cc and again to 3.0 cc after several wolves were not fully immobilized or attempted to escape when approached. No problems were

Table 2. Comparison of physical measurments of wolves captured between 19 May and 5 July 1984 on the Arctic National Wildlife Refuge, Alaska.

| Wolf No. | Date of Capture | Sex | Color | Estimated age | Weight lbs/kgs | Body length(cm) | Tail length(cm) | Heart girth(cm) | Upper canine (mm) | Lower canine (mm) | Reproductive condition |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 19 May | M | Dark brown | 1 yr | 84/38.1 | 128 | 46 | 76 | 26.1 | 26.1 | Testes withdrawn |
| 2 | 2 June | F | Tawny | 3 yrs | 85/38.6 | 121 | 43 | 70 | 25.5 | 22.5 | No evidence of breeding or suckling |
| 3 | 5 June | M | Gray | 1-2 yrs | 87/39.5 | 131 | 45 | 75 | 27.8 | 25.6 | |
| 4 | 25 June | M | Black | 2-3 yrs | 100/45.4 | 137 | 46 | 71 | 28.5 | 27.9 | Not fully distended |
| 5 | 25 June | M | Gray | 3-4 yrs | 94/42.7 | 121 | 46 | 79 | 31.8 | 26.9 | |
| 6 | 26 June | F | Dark brown | 2 yrs | 72/32.7 | 114 | 40 | 68 | 28.8 | 25.4 | No evidence of breeding or suckling |
| 7 | 27 June | M | Brown | 3 yrs | 99/44.9 | 140 | 46 | 78 | 28.5 | 25.8 | |
| 8 | 27 June | F | Brown | 2-3 yrs | 88/39.9 | 117 | 42 | 77 | 27 | 25.5 | No evidence of breeding or suckling |
| 9 | 30 June | F | Gray | 2-3 yrs | 88/39.9 | 134 | 48 | 83 | 24.3 | 23.5 | No evidence of breeding or suckling |
| 10 | 5 July | M | Gray | 4 yrs | 115/52.2 | 142 | 49 | 80 | 32.6 | 27.7 | Testes - left L-41mm W-22.2 mm |
| 11 | 5 July | F | Dark brown | 6-8 yrs | 65/29.5 | 117 | 45 | 59 | R - 18.4 L - 26.4 | R - 23.8 L - 24.2 | Has been suckling; L 11.4 W 8.3; Lactating |

encountered with wolves that were injected with 3.0 cc of M-99 initially. Recovery of wolves after the antagonist M 50-50 was administered intravenously averaged 61 sec with times ranging from 35 sec to 94 sec. Two wolves had M 50-50 injected intramuscularly and recovered in 10 min and 21 min respectively.

The spotter plane in combination with a helicopter for capture worked very well for wolf capture. Wolves on open tundra and in treeless valleys and were highly manuverable and were often pursued using the helicopter until they tired before being shot. The spotter plane maintained visual contact with the darted wolf and the helicopter landed some distance from the animal. This method allowed the wolves an opportunity to stop running and calm down before the drug took effect.

There was concern about the animals becoming overheated due to the warm summer temperatures and the length of the chase. Several wolves had elevated temperatures of 41.1°C. When temperatures were elevated, the animal was monitored until temperatures fell to 39.4°C before being processed. One wolf was immobilized on aufeis and her temperature dropped from 39.9°C to 35.9°C in 16 min. The wolf's body temperature returned to normal much faster than expected based on experience with brown bears in the same area.

Age Structure of Captured Wolves

Only two wolves (#10 and #11) were captured that were more that three years of age (Table 2). Wolf #11 was the only female that had previously bred and was lactating at the time of capture. Wolf #10 was the only male which, based upon testicular development, could have been a breeding male. Young, non-breeders comprised 82% of the wolves captured.

The age structure of captured wolves probably does not reflect the age structure of the population; however, several biases of the capture effort likely skewed the age structure of captured wolves towards young age animals. Young animals of the 2- to 3-year old age group may have been dispersing from established packs on both the north and south sides of the Brooks Range. Dispersing animals may center their activities around major concentrations of caribou and the lone wolves captured on the coastal plain of ANWR in 1984 may have been dispersing wolves. All lone wolves captured (#2, 3, 4, 5) were in the 1- to 4-year old age class (Table 2). Also, older wolves may have been more adept at avoiding aircraft. Avoidance reactions to aircraft could be the result of the wolves having experience with aerial hunting in the past. Another source of bias was the intentional avoidance of capturing wolves at or near a den site. Therefore, older animals active in rearing pups near the den site would not have been captured.

Movements and Activity Areas of Radio-collared Wolves

Sadlerochit Pack. The Sadlerochit pack consisted of three wolves. The den was not located, but the pack reared one pup in 1984. This pack was first observed on 6 March 1984 as they were hunting caribou. At this time the pack contained eight wolves, seven dark and one gray. Several days later three wolves from this pack were shot by local hunters.

On 26 June a brown 2-year old female (#6) was captured and a brown 6 to 8 year old female (#11) was captured on 5 July (Fig. 1). Wolf #11 was lactating at the time of capture. The third wolf, a large gray male, eluded capture twice. The pack utilized the area on and near the Sadlerochit River until late July. In late July and early August the pack expanded their range to include the Canning River and Cache and Eagle Creeks area. On 7 August a lone wolf pup was observed following an adult caribou in Ignek Valley. The pup was first observed with the pack on 29 August.

In mid-October a black wolf had joined the pack while the young female (#6) appeared to disperse east to the Okpilak River (Fig. 1). Wolf #6 was located five times between 15 October and 6 November. All sightings were on the Okpilak River with the exception of the 3 November location when the wolf was east of the Jago River near a caribou carcass. The remainder of the pack continued to use the same area as before. The last sighting of the pack was on 8 November.

Aichilik Pack. The Aichilik pack consisted of seven wolves - three gray, three dark brown, one black. The den site was located on 12 June (Fig 2). This pack reared four pups in 1984. The breeding female was a gray. Both collared wolves (a 1-year old and a 2- to 3-year old female) used the coastal plain in the vicinity of the Aichilik River extensively during the month of June. Wolf #1 dispersed east into Canada between 4-17 July and then returned to the vicinity of the Aichilik River. Wolf #8 dispersed east as far as the Kongakut River on 23 July and then returned to the Aichilik River area. Both of these dispersals were probably due to the wolves searching for caribou. The caribou migration had reached the mountains near the Upper Firth and Kongakut Rivers by the time these wolves dispersed, and few caribou remained on the coastal plain area. This probably explains the wolves' rapid return to the Aichilik River area. Both wolves were usually alone when they were radio tracked. Only twice after the pack left the den site was either collared animal found with the pack. Limited tracking data during August-November (mainly due to poor flying conditions) suggests that the wolves (and probably the pack) moved south as far as Double Mountain on the Sheenjek River (Fig. 2). They then moved north and crossed the divide into the Drain Creek upper Aichilik River area. These wolves seem to be hunting in the mountains and may cross back and forth across the continental divide area on a regular basis.

Canning River Pack. On 15 March, 1984 five gray wolves were found on the Canning river several km north of the Marsh Fork of the Canning River. This was likely the same pack that denned on the Canning River. Observations were difficult to obtain due to the location of the den site. Although no pups were seen, scats from pups were picked up after the wolves left the den area in late June-early July (See Haugen 1985).

On 26 June a small light brown wolf was found on the Canning River six to eight km north of the den site. This wolf eluded capture when it ran into a

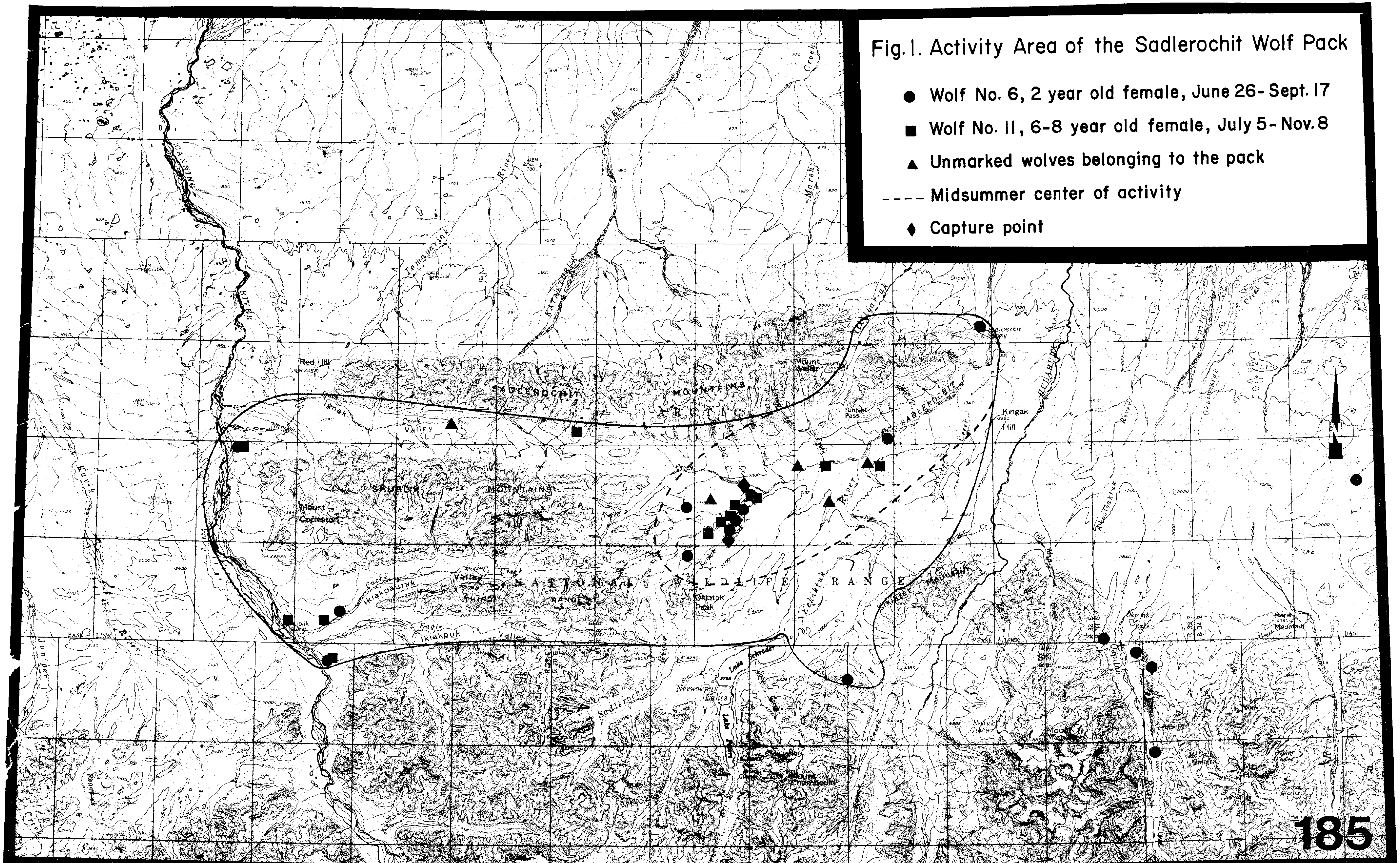


Fig. 1. Activity Area of the Sadlerochit Wolf Pack

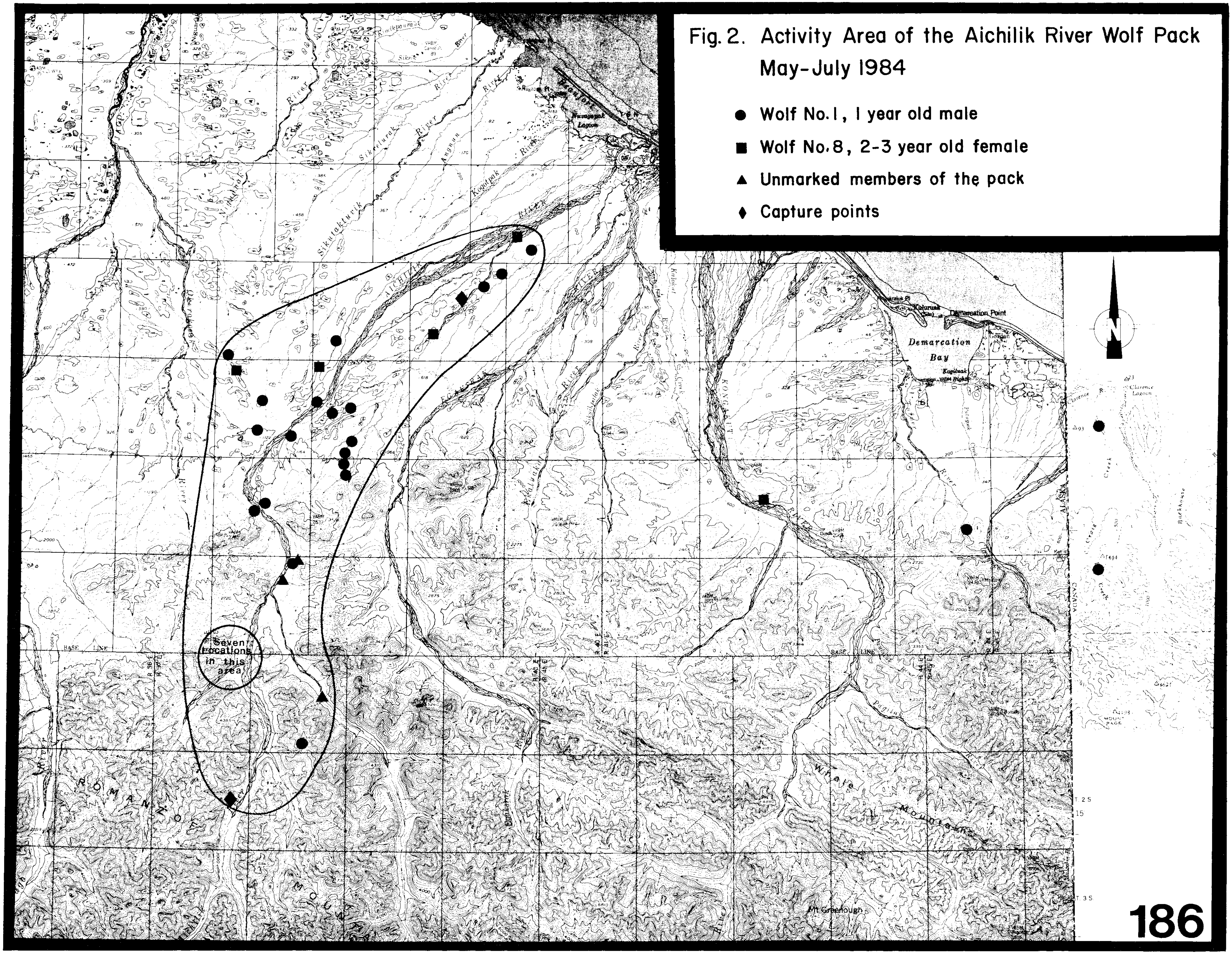


Fig. 2. Activity Area of the Aichilik River Wolf Pack May-July 1984

stream bottom with a heavy growth of high willows and could not be found. On July 5 a large gray wolf (#10, 4-year old male) was found at the same location that the light brown wolf was found. The gray was captured and was thought to have been a member of the Canning pack. This wolf was radio tracked three times between 7 July and 7 August. Each time the wolf was on the Marsh Fork and was alone. This wolf was not located after 7 August and the Canning pack was never found after it left the den. It was unknown whether wolf #10 was a member of this pack.

Wolf #2. Wolf #2 was a 3-year old, tawny colored female that was captured on 2 June 1984. This wolf was located 14 times between 2 June and 17 June, each time she was alone and on the coastal plain or in the foothills (Fig. 3). On 19 July she was located with a gray wolf. Wolf #2 was found with this gray wolf three more times and was with it on June 25 when the gray was captured. The gray wolf (#5) was a 3 to 4 year old male. The two wolves were located together five times between 26 June and 4 July, but had separated on 6 July. Between 17 July and 28 July wolf #2 traveled to the south side of the Brooks Range and was near Conglomerate Mountain which is approximately 106 km southwest of her last locations. Wolf #2 was not located again until 11 September when she was found back on the northside of the Brooks on the Kongakut River. On 29 October Wolf #2 was still in the same general area, but was with a black wolf. Wolf #2 was still with the black wolf on November 7, but had traveled east and was on the Firth River, approximately 40 km into Canada and 106 km from its last location.

Wolf #5. Wolf #5 was a 3- to 4-year old gray male. The first sighting was on 19 June when it was with wolf #2 (Fig. 4). It was observed three times between 14 June and 24 June running with wolf #2 and was captured on 25 June. Wolf #5 was located five times with wolf #2 between 26 June and 4 July. On 6 July it was separated from wolf #2. Wolf #5 remained alone and in the same general area between 6 and 9 July. After the location on 9 July it left the area and was not found again until 8 November when it was located on the Ivishak River with four other wolves, a move of approximately 217 km straight line distance southwest from the last location. The wolves with wolf #5 were very wary of the airplane and acted as if they had been exposed to aerial hunting while wolf #5 seemed unconcerned with the aircraft. This differential behavior suggested that wolf #5 may have recently joined this pack or may have previously been a member but had acclimated to aircraft during tracking flights on the coastal plain. Wolf #5 has not been found since 13 August.

Wolf #3. Wolf No. 3 was a gray 1- to 2-year old male. It was captured on 5 June 1984. It was located eighteen times between 5 June and 13 August (Fig. 5) . Wolf #3 stayed east of the Kongakut River until 9 June when it moved west. Between 6 June and 21 June it utilized the coastal plain between the Aichilik and Kongakut Rivers. On 25 June it had moved east, was located in Canada, south of Clarence Lagoon and was near the Clarence River on 27 June. These last two locations coincide with the movements of large concentrations of caribou as they started leaving the ANWR coastal plain (Whitten et al. 1985). Wolf no. 3 then moved west and was on the coastal plain near the Aichilik and Egaksruk River between 8 July and 13 August.

Wolf #4. Wolf No. 4 was a large, black, 2- to 3-year old male and was captured on 25 June 1984. This wolf was found on the coastal plain between the Clarence River and Craig Creek from 25-28 June (Fig. 6). When located on 17 July it had moved approximately 61 km southeast to the Firth River. The wolf was still at this location on 29 July. Wolf #4 was next located on 28 August near Ammerman Mountain approximately 112 km southwest of its last location. On 22 and 27 September wolf #4 was still in the vicinity of Ammerman Mountain with a gray wolf. A radio fix on 15 November showed it was still in the general area.

Kongakut River Pack. This pack consisted of six wolves and reared two pups in 1984. They denned at a site that was used in previous years. A graduate study at the den site was conducted by H. Haugen (see Haugen 1985). On 27 June, Haugen reported seeing several wolves of the Kongakut pack traveling up one of the tributary drainages of the Kongakut River. This drainage was searched and a brown, 3-year old male (wolf #7) was located and captured. Between 27 June and 28 July this wolf was located five times (Fig. 7). In each case, the wolf was alone and on the Kongakut River. This wolf then disappeared and was not located until 20 September. At this time it was in the vicinity of the Bell River in Canada, a move of over 193 km from its last location. On 6 December it was again located in the mountain west of Aklavik, Canada, a move of approximately 64 km. The last move coincided with the movement of caribou northeast into the area around Aklavik. Haugen reported two brown wolves frequenting the Kongakut den. After wolf #7 was captured, Haugen reported that the one brown wolf never returned to the den. Haugen was able to monitor the radio collar frequencies and confirmed that wolf #7 never returned to the den. Although it is possible that #7 was not a member of the Kongakut pack, Haugen's observations suggested that it was.

On 30 June wolf #9 (gray, 2- to 3-year old female) was captured on the Kongakut River. Wolf #9 was located six times between 30 June and 13 August and was alone and on the Kongakut River each time (Fig. 7). During this time, Haugen observed this wolf visiting the den on five occasions. On 19 September, it was located on Aspen Creek in Canada and had moved back to the den site on 28 October. When next located, on 8 November, it was on a tributary of the Kongakut River approximately 19 km south of her last location. Wolf #9 was never located with the pack after they left the den.

Two pups from the Kongakut pack were found 6 km north of the den on 19 July. The pups were alone and this was the first time the were observed away from the den site. During a moose survey on 31 October, a pack of wolves, consisting of three adults and two pups was found in a small drainage on the west side of the Kongakut River. These wolves probably belonged to the Kongakut Pack. This is the only sighting of the pack after it left the den site.

Old Man Creek Pack. This pack contained two wolves, a black 3 to 4-year old female and a tawny 2- to 3-year old male. These wolves were first located on Old Man Creek on 19 April. On 28 April they were found in the same area and tracks in the snow indicated that they were utilizing the Old Man Creek area between the Hulahula River and Okpilak River. These two wolves were killed on 2 May by local hunters. When the carcasses were examined, the female was carrying four pups, (two male, two female) within two to three weeks of parturition. These two wolves were probably going to den in the Old Man Creek area.

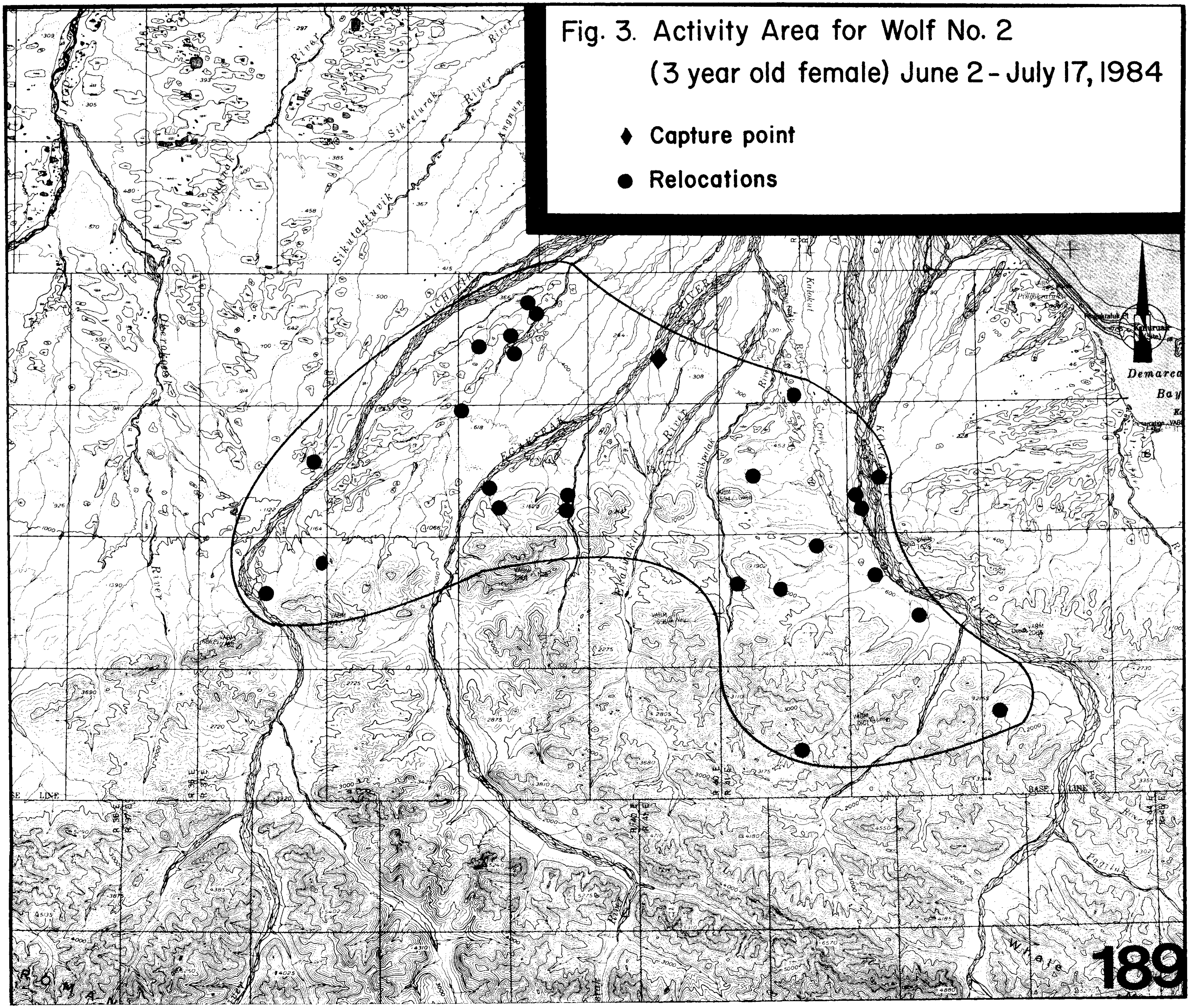


Fig. 3. Activity Area for Wolf No. 2 (3 year old female) June 2 - July 17, 1984

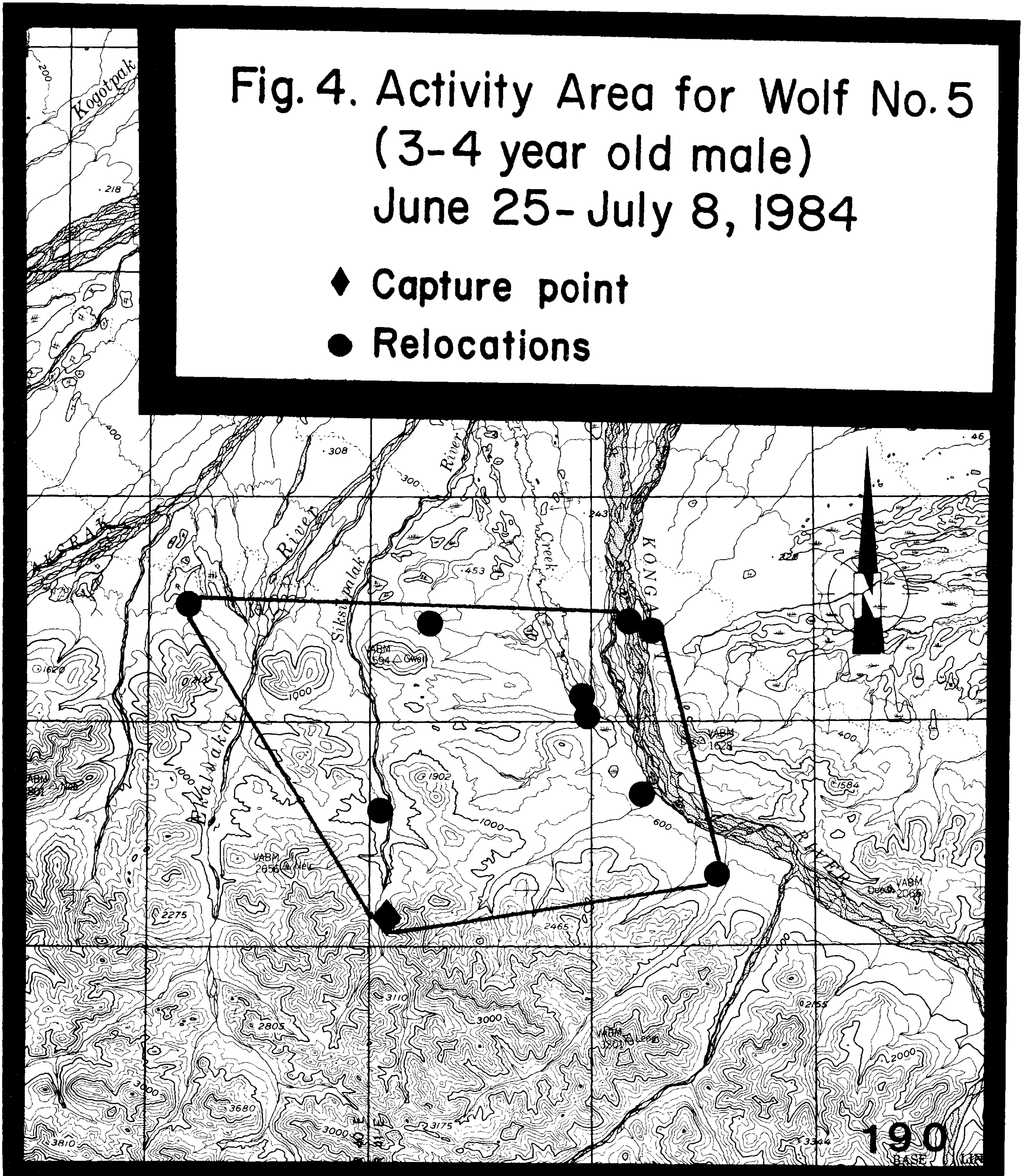


Fig. 4. Activity Area for Wolf No. 5 (3-4 year old male) June 25-July 8, 1984

♦ Capture point

● Relocations

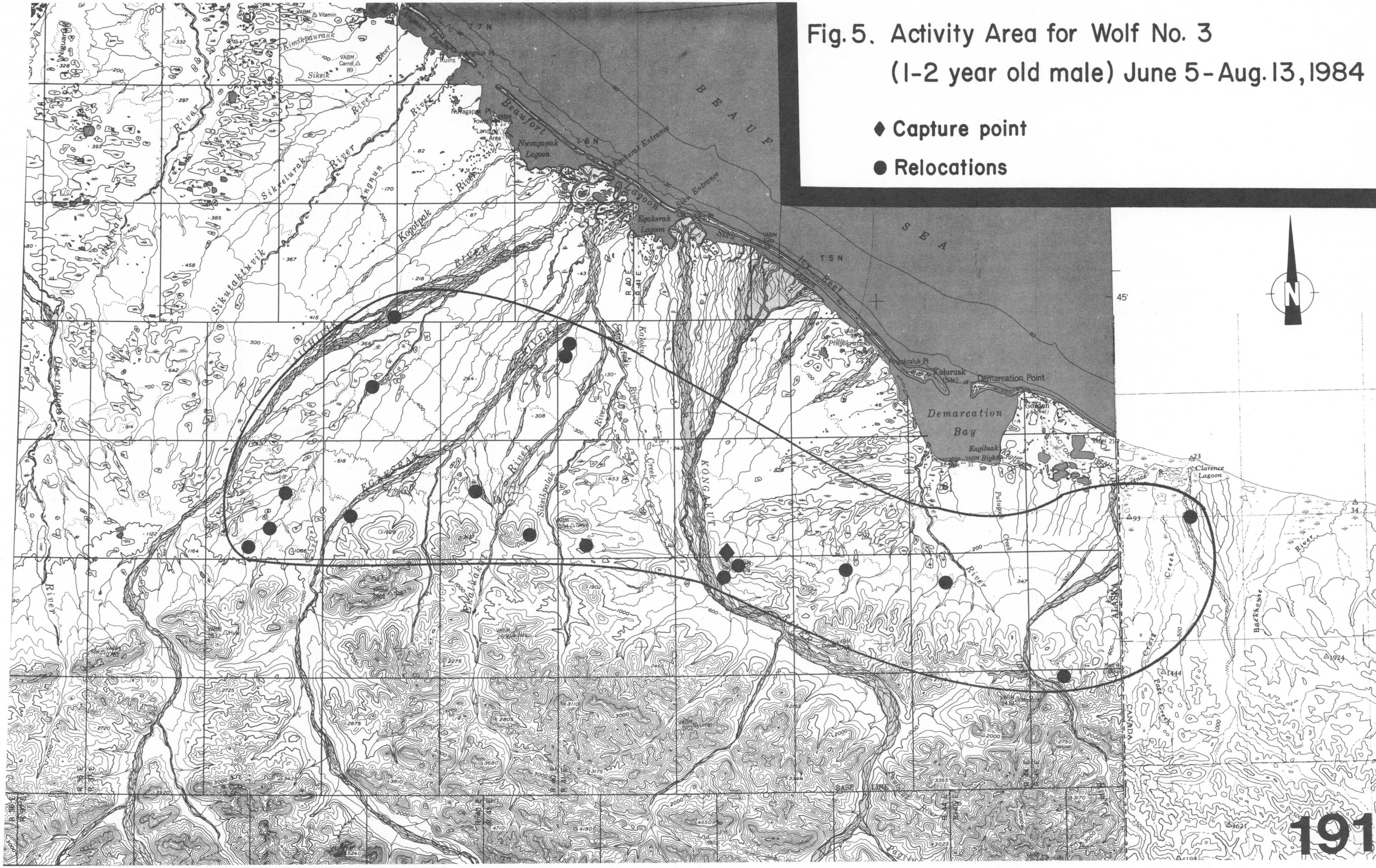


Fig. 5. Activity Area for Wolf No. 3 (1-2 year old male) June 5-Aug. 13, 1984

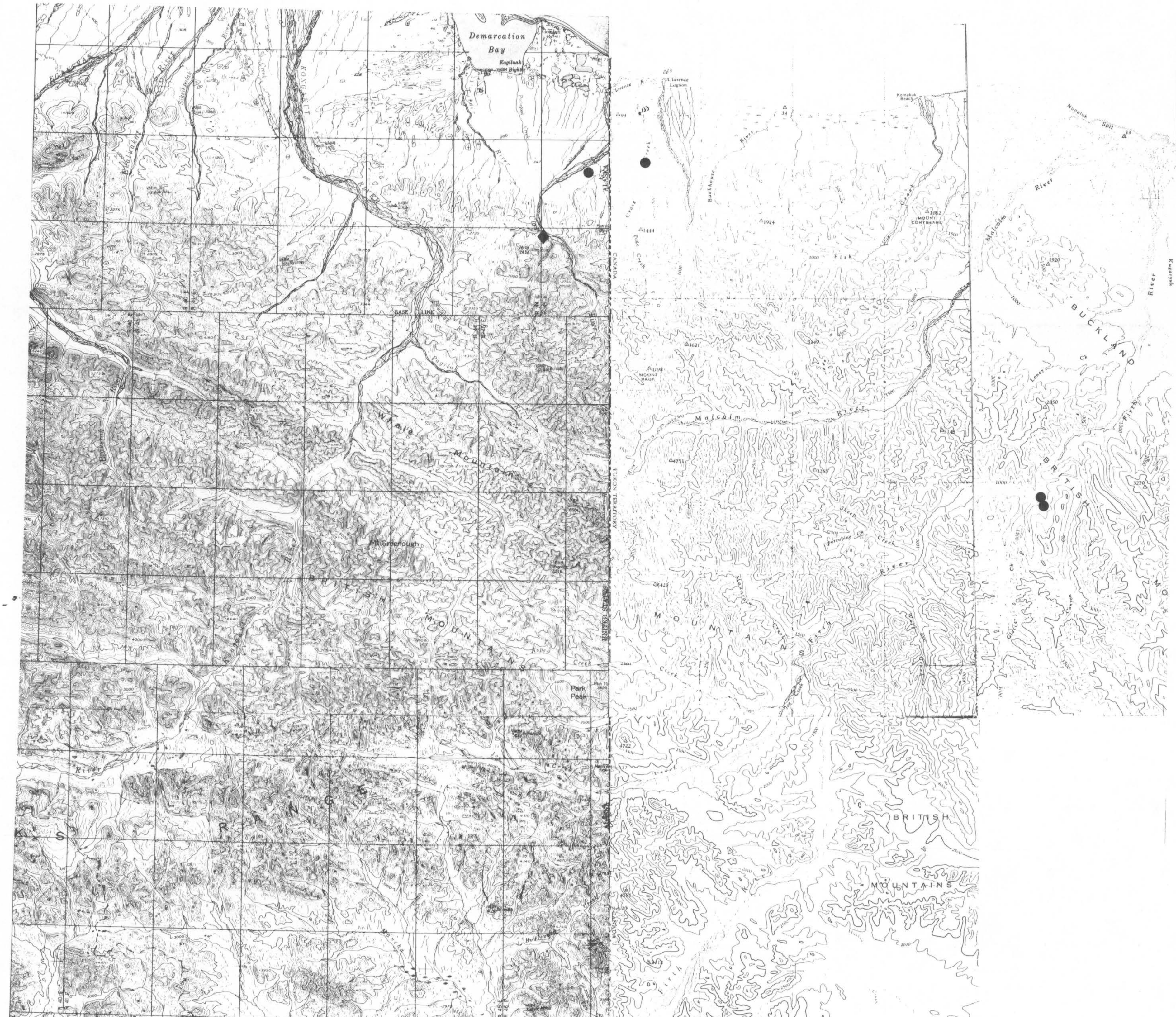


Fig. 6 Relocation for Wolf No. 4
(2-3 year old male)
June 25- July 8, 1984

♦ Capture point
● Relocations

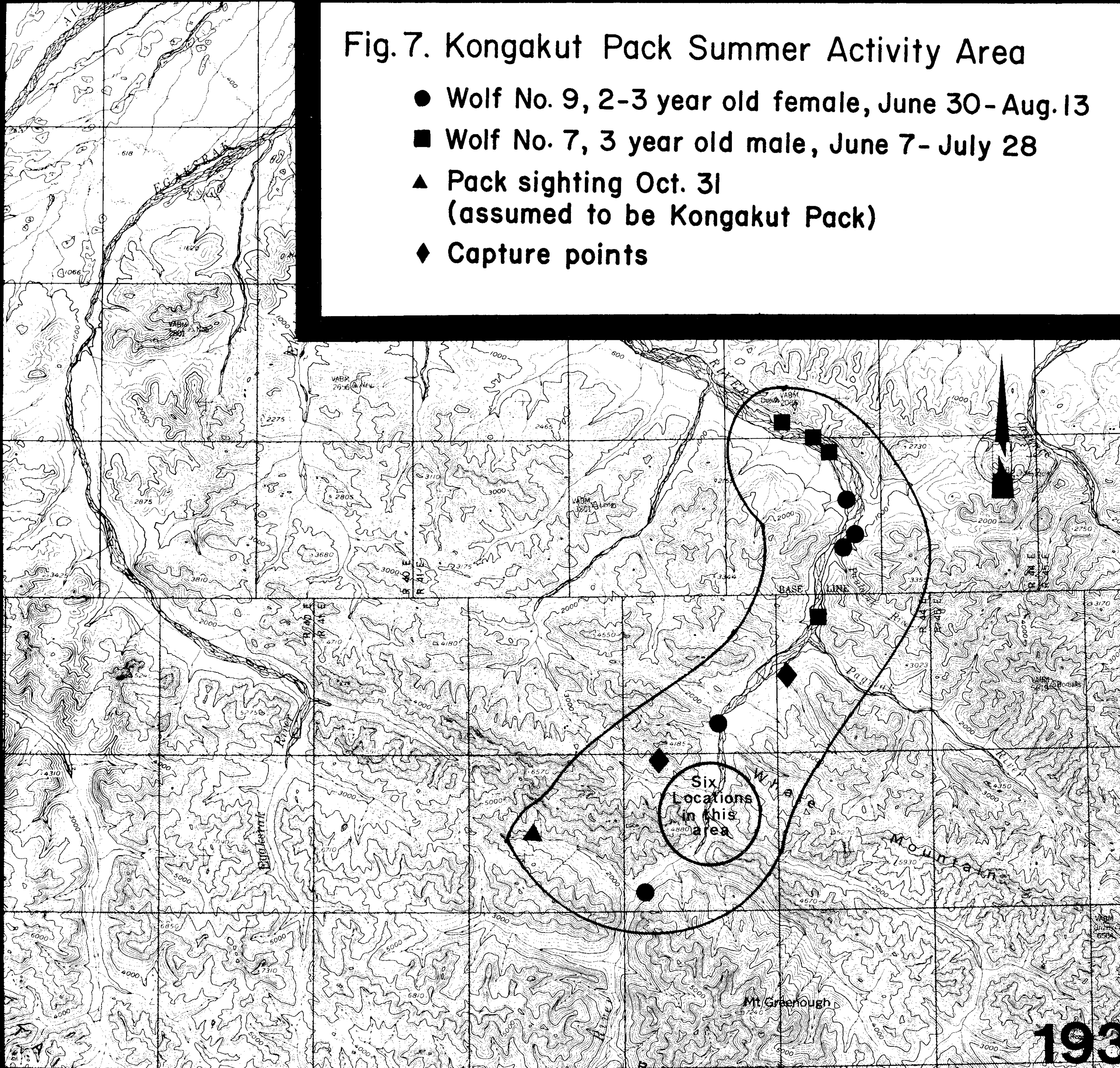


Fig. 7. Kongakut Pack Summer Activity Area

Other Wolf Packs. In 1977, rabies killed all known members of a wolf pack using the Hulahula River drainage (Chapman 1978). Since that time there have been no reported sightings of wolves in this drainage. However, tracks of wolves along the river are not uncommon and wolves have been heard howling in the area. During 1984 capture efforts three intensive helicopter searches were flown along the Hulahula and some of its tributaries. In addition, several flights with fixed-wing aircraft were flown. No wolves were located although tracks were found several times.

The reported sightings of wolves and tracks east of the Kongakut River as well as in the Caribou Pass area (Table 3, Fig. 8) indicated that there are more wolves using this area than were documented in the Kongakut River pack. Apparently there was another pack in the area between the Kongakut and Clarence Rivers near the head waters of the Pagilak River.

Distribution

Wolves used the coastal plain east of the Aichilik River extensively. The apparent non-use of the coastal plain to the west of the Aichilik River may be due to the distribution of caribou, however, the opportunistic capture effort which concentrated in western portion of the coastal plain probably biased such results. The Porcupine caribou herd had occupied the coastal plain as far west as the Jago River. Major concentrations of caribou had moved east of the Aichilik River by 21 June (Whitten et al. 1985). Eight wolves were captured after 25 June. The majority of these wolves were located by researchers surveying caribou. The use of the coastal plain by the wolves coincided with the distribution of caribou at that time (Whitten et al. 1985). Because wolves were captured in mid-late summer no observations are available for determining use of the coastal plain by wolves during late May to mid-June.

Population

Minimum estimate of wolves using the northern portion of ANWR in late summer 1984 was 27 adults and 7 pups (Table 4). These numbers included known lone wolves, adults and pups from three packs with an estimate of adults from the Canning pack. No estimates of pups from the Canning pack were possible. Five adult wolves were known to have been killed and three additional wolves were suspected to have been killed in late winter 1984, and these animals are not included in the late summer minimum population estimates.

Table 4. Numbers of known wolves using the northern portion of ANWR in late summer 1984.

| Pack | Number of adults | Number of pups |
|---|---|---|
| Lone wolves | 5 | - |
| Canning River | 5 (est.) | unknown |
| Sadlerochit River | 4 | 1 |
| Aichilik River | 7 | 4 |
| Kongakut River | 6 | 2 |
| Totals | 27 | 7 |

Table 3. Miscelaneous wolf sightings on the Arctic National Wildlife Refuge, Alaska, 1984.

| Date | Reference No.[a] | No. of Wolves | Color/s |
|---|---|---|---|
| 12 April | 20 | 1 | Gray |
| 14 April | 1 | 2 | Black, Gray |
| 15 April | 3 | 5 | Grays |
| 19 April | 5 | 2 | Black, Tawny |
| 20 April | 18 | 2 | Black, Gray |
| 28 April | 6 | 1 | Black |
| 28 April | 7 | 2 | Black, Tawny |
| 2 May | 8 | 2 | Black, Tawny |
| 4 May | 21 | 2 | 2 Dark, Gray |
| 4 May | 26 | 4 | 3 Gray, 1 Dark |
| 5 May | 4 | 1 | Blond |
| 20 May | 24 | 2 | Black, Gray |
| 5 June | * | 1 | Gray |
| 16 June | 14 | 1 | Unknown |
| 18 June | 13 | 1 | Brown |
| 14 June | 29 | 1 | Brown |
| 22 June | 10 | 1 | Gray |
| 22 June | 15 | 1 | Gray |
| 22 June | 16 | 1 | Gray |
| 22 June | 27 | 3 | 2 Gray, 1 Dark |
| 23 June | 12 | 1 | Brown |
| 23 June | 28 | 1 | Gray |
| 26 June | 2 | 1 | Lt. Brown |
| 28 June | 11 | 2 | Black, Gray |
| 29 June | * | 1 | Gray |
| 29 June | * | 1 | Gray |
| 30 June | * | 1 | Gray |
| 30 June | * | 1 | Black |
| 1 July | * | 1 | Gray |
| 1 July | * | 1 | Brown |
| 1 July | * | 1 | Gray |
| 2 July | * | 2 | Gray, Black |
| 3 July | * | 5 | 3 Gray, 2 Black |
| 10 July | * | 1 | Black |
| 19 July | 25 | 2 | pups |
| 17 Sept | 19 | 2 | Gray, Brown |
| 23 Sept | 9 | 1 | Brown |
| 30 Oct | 17 | 1 | Gray |
| 31 Oct | 22 | 5 | Gray, Black, White, 2 pups, tawny, gray |
| 31 Oct | 23 | 1 | Dark |

[a]Number corresponds to location number on Fig. 8.
*Located in area circled on Fig. 8.

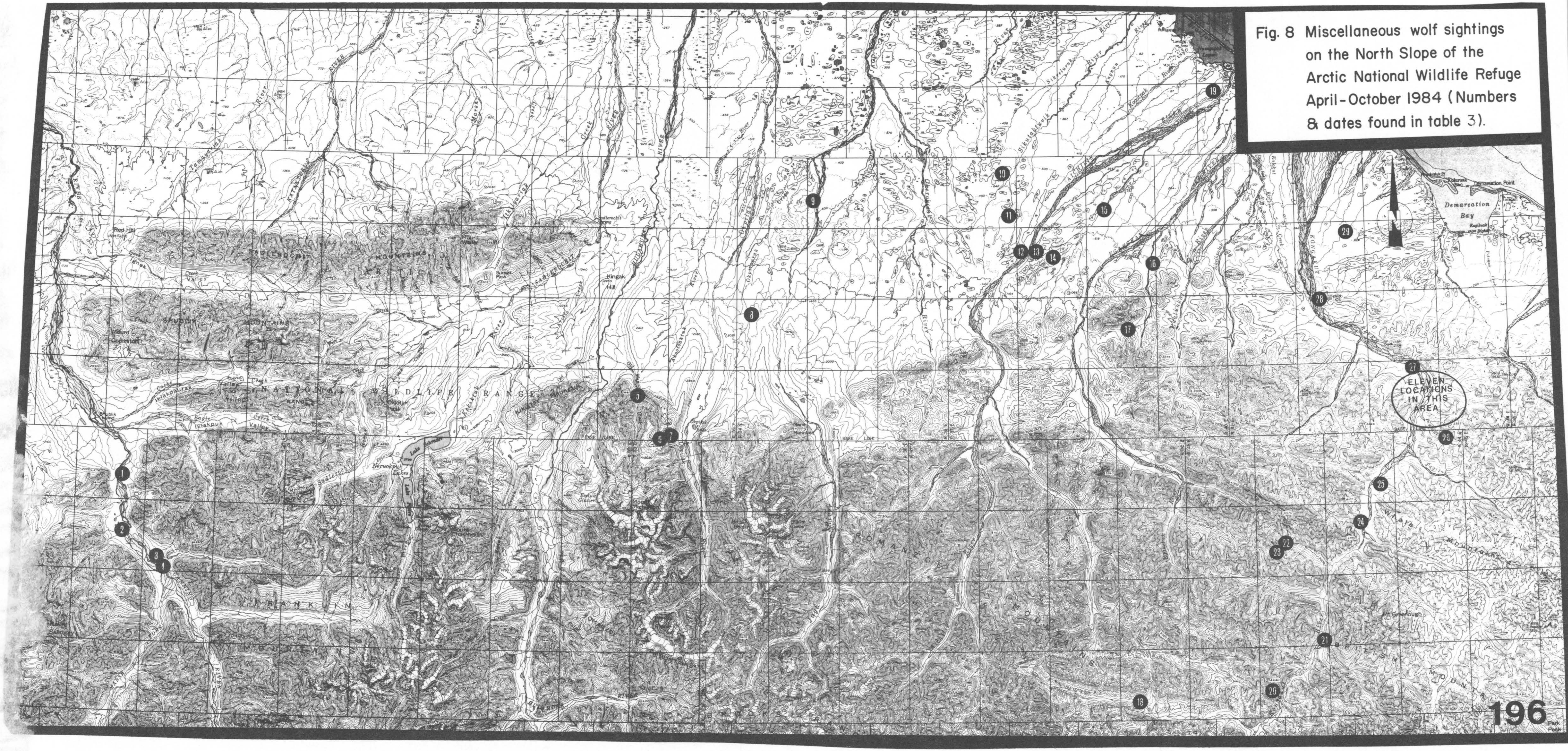


Fig. 8 Miscellaneous wolf sightings on the North Slope of the Arctic National Wildlife Refuge April-October 1984 (Numbers & dates found in table 3).

Predation

Wolves were often observed in the vicinity of caribou and frequently seen near carcasses. It was often difficult to determine if wolves were predators or scavengers in these cases. In one case a lone wolf was observed killing a caribou calf while in another instance a lone wolf was observed scavenging a caribou calf. In cases were caribou calves were examined, four mortalities were attributed to wolf predation (Whitten, et al. 1985). During fall and early winter four kill sites were found by researchers flying surveys. Three of the kills were sheep and one was a caribou. The sites were not visited and it is not known whether they were kills or scavenged carcasses.

Conclusions

Tracking data on wolves using ANWR is incomplete at this time. Several observations are presented for consideration. Wolf packs were less cohesive than expected with young animals ranging widely and often hunting alone. This phenomenon is not uncommon during the denning season with wolves hunting more as a pack in late fall and early winter. Tracking data to date have yet to document this regrouping into fall and winter packs after wolves abandon the den site in mid-summer.

Wolves unattached to packs may travel great distances to the north slope area during the summer and use the coastal plain extensively. These same wolves then leave the area after the caribou have departed and travel widely to locate the caribou again. Wolf packs denning on the north slope tend to drift south in September and October. These packs did not travel south and stay where caribou were wintering, but tended to roam more in the mountains where sheep and moose are more abundant than caribou. The Sadlerochit pack had not yet departed the territory that was used during the summer. In arctic wolf packs, shifts between summer and winter ranges were common, while a fixed territory was not documented.

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APPENDIX

ANWR Progress Report Number FY 85-5

Appendix Table 1. Park history of Sadlerochit wolf pack, summer and fall 1984.

| Date | Observation |
|---|---|
| 6 March | - Pack first located. Eight wolves - seven dark, one gray hunting caribou near junction of Kekiktuk River and Sadlerochit River. Unsuccessful in chase.<br>- Three wolves were shot in this area in the following week and assumed to be from this pack. |
| 26 June | - First time wolves have been located since the first sighting in March. Two wolves present - gray and brown. The brown was lying down within 100-150 ft of a bear with the gray - 300 ft away. The brown was captured. Wolf #6 - two year old female. The gray eluded us. |
| 1 July | - Radio fix on wolf number 6. Gray wolf is near by. |
| 5 July | - Wolf #6 located near Sadlerochit Spring - the farthest north location of the pack during 1984.<br>- Wolf #11 (six to eight year old female) was located three miles to the south of #6 and was captured. She had been nursing. |
| 7 July | - Gray male was located but once again eluded capture. Wolves #6 and #11 radio tracked but both were alone. |
| 8 July | - Wolves #6 and #11 radio tracked and found by themselves |
| 11 July | - Radio fixed on #6 and #11. |
| 23 July | - #6 and #11 radio tracked - both alone |
| 25 July | - #6 radio tracked - alone |
| 29 July | - #6 radio tracked (Fix) first time that any of the members of this pack has been located outside the rolling hills area between Sadlerochit Mountains and Lake Schrader. |
| 7 August | - Wolf #11 found in Cache Creek area. Wolf pup found near head waters of Katakturuk River. It was alone and following several yards behind an adult caribou. |
| 29 August | - Pack was located near Canning River - four wolves- gray, #6, #11, brown pup. |
| 14 September | - #6 located at Lake Schrader. |
| 17 September | - Pack located near Eagle Creek #6 was back with them. |
| 15 October | - #6 located on Okpilak River. |
| 17 October | - #6 located on Okpilak River - Rest of pack was near Kekikut River and had been joined by a black wolf. |

Appendix Table 1. (Continued).

| Date | Observation |
| --- | --- |
| 29 October | - Wolf #11, gray and black found on southside of Sadlerochit Mountains. Pup not seen. Animals around two kills that appear to be sheep. |
| 3 November | - Wolf #6 found in foothills east of Jago River near a caribou carcass. |
| 6 November | - Wolf #6 back at Okpilak River. |
| 8 November | - Wolf #11 found with pack near Canning River. (Two brown, one black, one gray). #6 not located. |

Appendix Table 2. Park history of Aichilik wolf pack, summer and fall 1984.

| Date | Observation |
|---|---|
| 19 May | - Wolf #1 (Brown, one year old male) was captured in the Aichilik River drainage. |
| 22 May | - Wolf #1 radio tracked - alone in mountains |
| 1 June | - Wolf #1 radio tracked - alone in foothills |
| 2 June | - Wolf #1 found feeding on a cow caribou on the coastal plain |
| 3 June | - Wolf #1 found alone on coastal plain |
| 6 June | - Wolf # found within 1/2 mile of gray wolf on Aichilik River in mountains. |
| 7 June | - Wolf #1 found alone on coastal plain |
| 8 June | - Wolf #1 found alone on coastal plain |
| 11 June | - Wolf #1 found alone on coastal plain |
| 12 June | - Den site located wolf #1 there with four other wolves. |
| 13 June | - Wolf #1 found alone on coastal plain |
| 14 June | - Wolf #1 at den site with three other wolves. |
| 15 June | - Wolf #1 found alone on coastal plain |
| 17 June | - Wolf #1 found on coastal plain with two other wolves |
| 18 June | - Radio fix in foothills |
| 20 June | - At den site with two others and three pups - first sighting of pups. |
| 22 June | - Start three days of den observation, #1 at den with three other wolves and three pups. |
| 23 June | - Four adults and three pups at den site; #1 on coastal plain. |
| 24 June | - Two adults and three pups at den - den observation ended. |
| 25 June | - Wolf #1 alone in foothills |
| 26 June | - Wolf #1 alone on coastal plain |
| 27 June | - Wolf #1 feeding on caribou calf on coastal plain<br>Wolf #8 captured on coastal plain (Brown two to three year old female). |
| 28 June | - Wolf #1 and #8 - alone on coastal plain |
| 4 July | - Wolf #1 disperses to east near Clarence River. |

Appendix Table 2. (Continued).

| Date | Observation |
|---|---|
| 6 July | - Wolf #8 at den site with adult gray. |
| 7 July | - Wolf #8 alone on coastal plain |
| 8 July | - Wolf #8 alone on coastal plain. Wolf #1 in Canada near Clarence Lagoon. |
| 17 July | - Wolf #1 in Canada near foothills on Craig Island. |
| 20 July | - Wolf #8 coastal plain. |
| 23 July | - Wolf #8 disperses east to Kongakut River. |
| 8 August | - Wolf #1 in mountains near upper Aichilik River. Wolf #8 found approximately four miles south of den with adult gray and four pups. First sighting of fourth pup and first sighting of pups away from den. |
| 12 September | - Wolf #1 mountains near upper Aichilik - Drain Creek area. Wolf #8 mountains to east of Aichilik within five miles of den. |
| 18 September | - Wolf #8 with five wolves south east of den on west fork of Aichilik River. |
| 17 October | - Wolf #1 and #8 with five other wolves in mountains between Aichilik River and Drain Creek. |
| 8 November | - Fix wolf #8 southside of Brooks at Double Mountain. |

Appendix Table 3. Wolf relocations/observations on the Arctic National Wildlife Refuge, Alaska 1984.

| Wolf number | Pack affiliation | Range of observation dates | Number of locations: individual | Number of locations: with pack/others |
|---|---|---|---|---|
| 1 | Aichilik | 19 May - 17 Oct | 24 | 7 |
| 2 | None | 8 June - 7 Nov | 23 | 9 |
| 3 | None | 5 June - 13 Aug | 18 | - |
| 4 | None | 25 June - 15 Nov | 7 | 2 |
| 5 | None | 25 June - 8 Nov | 4 | 7 |
| 6 | Sadlerochit | 26 June - 8 Nov | 15 | 3 |
| 7 | Unknown | 27 June - 6 Dec | 7 | - |
| 8 | Aichilik | 27 June - 17 Nov | 9 | 3 |
| 9 | Kongakut | 30 June - 8 Nov | 8 | 1 |
| 10 | Unknown | 5 July - 7 Aug | 4 | - |
| 11 | Sadlerochit | 5 July - 8 Nov | 6 | 6 |
| | Totals | | 125 | 38 |
| Misc. | Unknown | 6 March - 31 Oct | 31 | 27 |

ANWR Progress Report Number FY85-6

# POPULATION SIZE, COMPOSTION, AND DISTRIBUTION OF MOOSE ALONG THE CANNING AND KONGAKUT RIVERS WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, SPRING AND FALL, 1984

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

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4 February 1985

# Population size, composition, and distribution of moose along the Canning and Kongakut Rivers within the Arctic National Wildlife Refuge, Alaska, spring and fall 1984.

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Abstract: Population size, composition, and distribution of moose (*Alces alces*) along the Canning and Kongakut River drainages were studied using aerial surveys. Data were compared to previous years to determine population trends within the river drainages. Number of moose observed during the 1984 spring survey remained stable with the 1980 spring survey: 147 moose were observed in 1980, 149 moose were observed in 1984 for the Canning River; 123 moose were observed in 1980, 134 moose were observed in 1984 for the Kongakut River. The numbers of moose remained stable for the Canning River during the fall survey: 149 moose were observed in 1983, 158 moose were observed in 1984; while the Kongakut River showed a large increase in 1984, 158 moose were observed in 1983, 239 moose were observed in 1984. The large increase in population may be due to immigration from surrounding river drainages, which has been a factor in previous years.

Population size, composition, and distribution of moose along the Canning and Kongakut Rivers within the Arctic National Wildlife Refuge, Alaska, spring and fall, 1984

Population size, composition, and distribution of moose along the Canning and Kongakut River drainages were surveyed to determine trends in moose population levels which may be impacted by the ongoing oil and gas exploration within coastal plain of the Arctic National Wildlife Refuge (ANWR). Spring surveys were flown to determine overwinter mortality rates, while fall surveys were conducted to determine productivity and composition.

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), and ANWR staff conducted surveys from 1976-1978. The Kongakut River was not surveyed in 1974 or 1976. During spring 1980, surveys were conducted in both drainages by refuge staff.[1] Timing of these earlier aerial surveys (March-April or September-October), and survey coverage and intensity have varied between years (Appendix Table 1); therefore, direct comparisons of the resultant data sets are difficult. During the 1980 survey, standardized survey areas were established for the Canning and Kongakut Rivers (Figs. 1 and 2). These areas were surveyed during the 1983 and 1984 surveys.

Objectives of aerial moose surveys within 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

Survey routes were standardized for the Canning and Kongakut River drainages in 1980 (see Appendix Figs. 1 and 2). These standardized survey routes and areas were used in 1983 and 1984, and will continue to be used in future surveys of the two 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. A total of 6.7 h flight time was used for the spring survey of the Canning River, while 6.9 h of flight time was used for the spring survey of this river. The Kongakut River required 6.7 h flight time for the spring survey and 5.1 h flight time for the fall survey. 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 greater than 2 m 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 identification were made.

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[1]Spindler, M.A., Wildlife Biologist, Arctic National Wildlife Refuge. [Memo to the Refuge Manager, Arctic National Wildlife Refuge]. 28 May 1980.

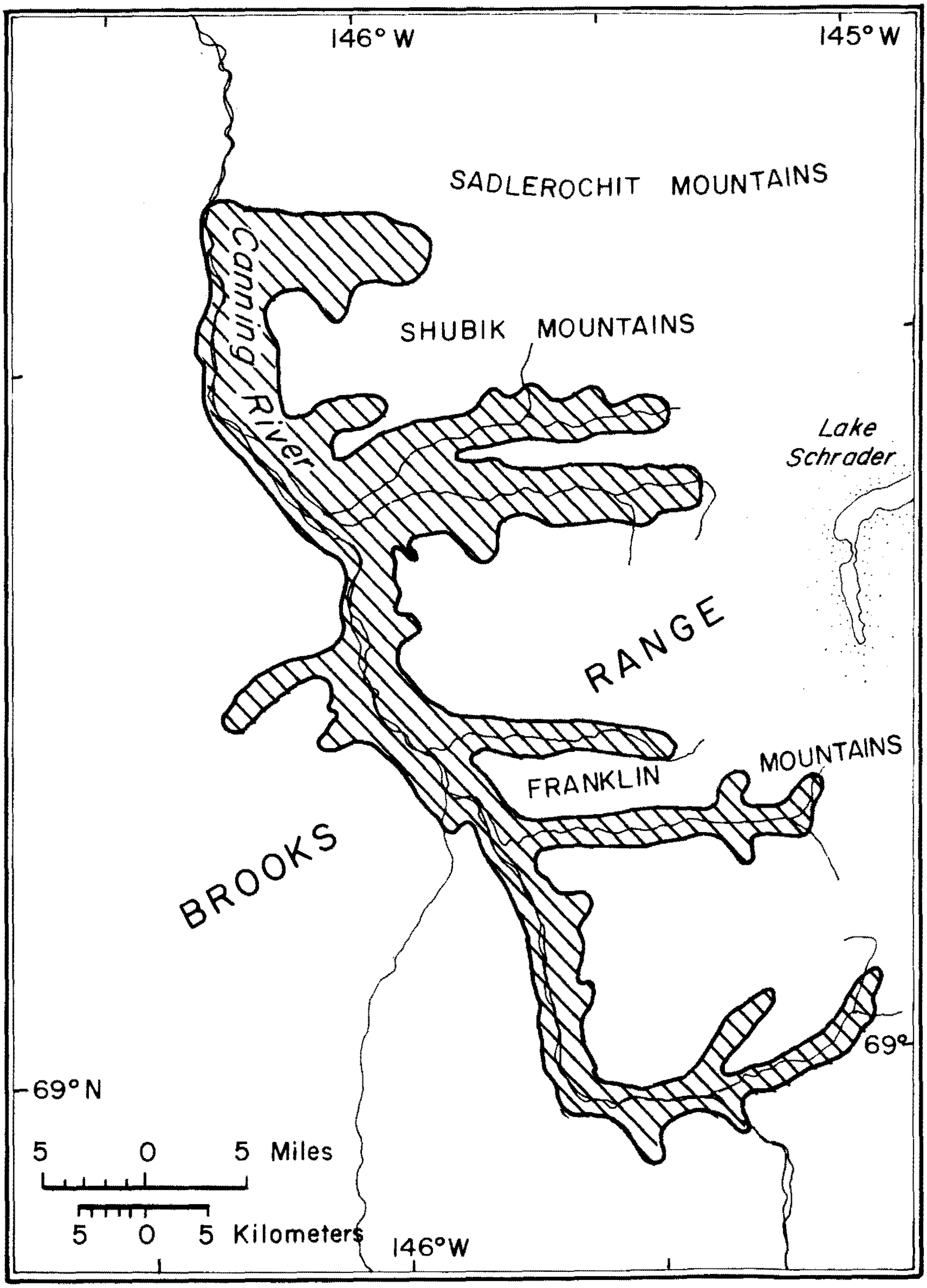


Fig. 1. Canning River moose survey area 1983 and 1984.

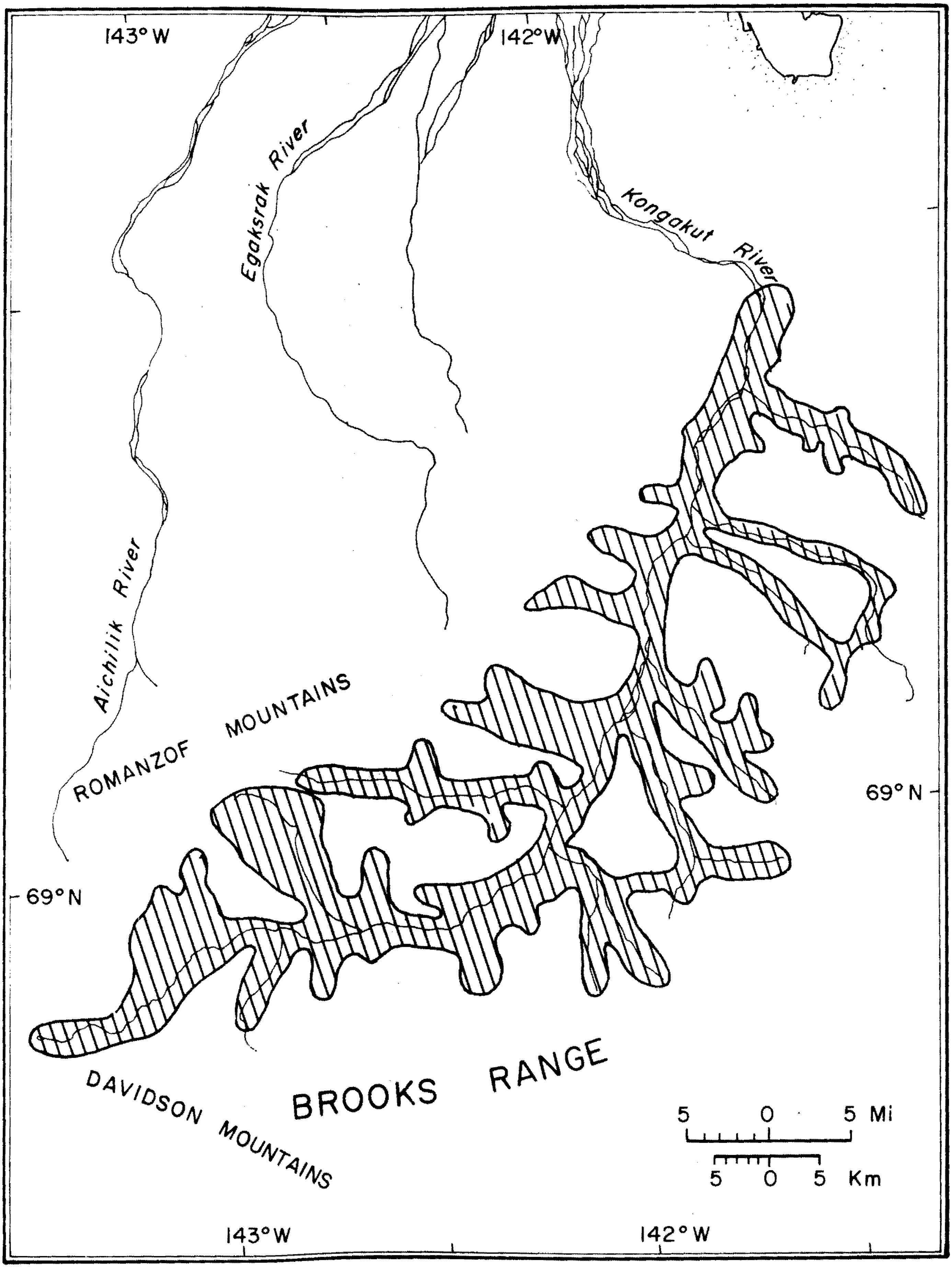


Fig. 2. Kongakut River moose survey area 1983 and 1984.

## Results and Discussion

For the purpose of this report, only the 1980, 1983, and 1984 surveys are used for direct comparisons. Surveys in previous years did not cover comparable areas, therefore direct comparisons of the earlier data with recent data are not possible. Three comparisons are discussed: 1) spring surveys conducted during 1980 and 1984 in both survey areas to assess annual variation in numbers of moose using the two drainages in the spring, 2) fall surveys conducted during 1983 and 1984 are compared for each of the two survey areas to assess annual variation in numbers of moose using the two drainages in the fall, 3)the fall survey in 1983 and spring survey in 1984 are compared to assess overwinter survival of calves for each river system.

### Canning River Drainage

Spring Survey. During the 20 April 1984 survey, a total of 149 moose were tallied (Table 1). Of the total, 69 (52.3%) were located within the Cache/Eagle Creek portion of the drainage, in contrast to 111 of 147 (75.5%) moose in the Cache/Eagle area in April 1980 (Appendix Table 1). Visibility was good throughout the 1984 survey, with 100% snowcover. Moose were easily seen during the survey and sightability was estimated at 95%. Moose that might have been in small side drainages and therefore missed during the survey are believed to be few in number.

Table 1. Number and compositions of moose observed during aerial surveys of the Canning River during the spring of 1980 and 1984, and the fall of 1983 and 1984.

| Category | Number of moose observed | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Spring surveys | | | | Fall surveys | | | |
| | April 1980 | | 20 April 1984 | | 30 Oct 1983 | | 2 Nov 1984 | |
| | # | % | # | % | # | % | # | % |
| Adult bulls | - | - | - | - | 44 | 29.5 | 47 | 29.8 |
| Yearling bulls | - | - | - | - | 7 | 4.7 | 19 | 6.3 |
| Cows | - | - | - | - | 73 | 49.0 | 77 | 48.7 |
| Total other than calf | 133 | 90.5 | 132 | 88.6 | 124 | 83.2 | 134 | 84.8 |
| Calves (short-yearlings) | 14 | 9.5 | 17 | 11.4 | 25 | 16.8 | 24 | 15.2 |
| Totals | 147 | | 149 | | 149 | | 158 | |

Numbers of moose recorded during the 1980 and 1984 spring survey were comparable (Table 1). Calves (short-yearlings) comprised similiar proportions of the population in each year (Table 1). These data indicate that the Canning River moose population has been relatively stable between 1980 and 1984.

Fall Survey. A total of 158 moose were tallied during the 2 November 1984 survey (Table 1). Of this total, 146 (92.4%) were located within the Cache/Eagle Creek portion of the drainage and is comparable to the 130 of 149 (87.3%) moose found in the same area in 1984 (Martin and Garner 1984, Appendix Table 1). In 1984, visibility was good throughout the survey with a snow cover of approximately 95%, with only small areas along the river being partially snow covered. Moose were easily seen during the survey and sightability was estimated at 95%. Moose that might have been in small side drainages and therefore missed during the survey are believed to be few in number.

There was a small increase in the number of moose observed from 1983 to 1984, however, the relative percentages throughout the population has remained relatively stable (Table 1). Fall surveys were not conducted in 1980, and no other comparable fall survey data exist for the Canning River drainage.

Overwinter Calf Survival. Number of calves observed within the Canning River drainage declined from 25 in October 1983 to 17 in April 1984 (Table 1). The number of moose observed was constant at 149 animals, however 32% of the calves present in fall 1983 were absent the following spring. Adult moose numbers increased from 124 in fall 1983 to 132 during the spring (Table 1). This decline in the number of calves may be attributed to several factors: 1)over-winter mortality through predation or other unknown causes, or 2) emigration from the Canning River drainage to the Kavik River or surrounding drainages. These data are insufficient to speculate on the cause for the decline in the number of calves. The increase in adults along the Canning River during the 1984 spring survey is probably due to immigration from the Kavik River or other surrounding drainages. The Canning River moose population has apparently been relatively stable since spring of 1980, when moose numbers and composition were essentially the same as spring 1984 (Table 1).

Kongakut River Drainage

Spring Survey. During the mid-April 1984 survey, a total of 134 moose were tallied (Table 2). Visibility was good throughout the surveys with 95% snow cover. Moose were easily seen and sightability was estimated at 95%. Numbers of moose detected during the 1984 spring survey are slightly larger than the number of moose detected during the 1980 spring survey. The 1984 survey showed an increase of 17 adults over the 1980 survey, while the calf numbers declined by 6 compared to the 1980 survey (Table 2). Reasons for the apparent decrease in calf numbers (Table 2) is probably due to the low calf production in 1983 (Martin and Garner 1983), when only 21 calves (13.3%) were observed among a total population of 158 moose during the 1983 fall survey.

Table 2. Number and composition of moose observed during aerial surveys of the Kongakut River during spring 1980 and 1984, and fall 1983 and 1984.

| Category | Number of moose observed | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Spring surveys | | | | Fall surveys | | | |
| | Apr 1980 | | 12,18, 19 Apr 1984 | | 27, 29 Oct 1983 | | 30 Oct, 1 Nov 1984 | |
| | # | % | # | % | # | % | # | % |
| Adult bulls | - | - | - | - | 59 | 37.3 | 83 | 34.7 |
| Yearling bulls | - | - | - | - | 16 | 10.1 | 16 | 6.7 |
| Cows | - | - | - | - | 62 | 39.2 | 102 | 42.7 |
| Total other than calf | 98 | 79.7 | 115 | 85.8 | 137 | 86.7 | 201 | 84.1 |
| Calves(short-yearlings) | 25 | 20.3 | 19 | 14.2 | 21 | 13.3 | 38 | 15.9 |
| Totals | 123 | | 134 | | 158 | | 239 | |

Fall Survey. A total of 239 moose were tallied during the 30 October and 1 November 1984 survey (Table 2). Visibility was good throughout the survey with an estimated snow cover of 95%, with only small areas along river valleys being partially snow free. Moose were easily seen during the survey and sightability was estimated at 95%. Number of moose detected during the 1984 fall survey shows a 51.3% increase over the 1983 fall survey, and is the highest number of moose recorded during any previous survey of the Kongakut River (Appendix Table 1). The overall composition changed only sightly with cows and calves increasing 6.1% and bulls declining by 6.6% (Table 2). The large overall increase in the moose population within the Kongakut River drainage cannot be attributed to reproduction. Only 134 moose was present in mid-April 1984 (Table 2),therefore large numbers of moose emigrated into the Kongakut River drainage during the summer and/or early fall of 1984. Origin of this immigration is probably the Sheenjek River draining to the south and/or the Firth River/Mancha Creek draining to the east (Roseneau and Stern 1974). Moose were also seen moving between the Kongakut River draining and Joe Creek to the east during spring and fall 1984 moose surveys.

Distribution of moose within the Kongakut River drainage was relatively constant in both spring and fall surveys conducted in 1983 and 1984. A small group of moose was located in the Pagilak River, while the major portion of the population was concentrated within the Tiklik Creek (Drain Creek), the upper Kongakut River above Tiklik Creek, and the tributaries draining into the Kongakut River from Joe Creek to the east. Interchange between moose populations in the Joe Creek drainage and the Firth River/Mancha Creek drainage to the east and the Sheenjek River drainage to the south could easily account for the highly variable numbers of moose occurring within the Kongakut River system.

Overwinter Calf Survival. Number of calves observed along the Kongakut River drainage declined from 21 calves in October 1983 to 19 calves in April 1984 (Table 2). The total number of moose observed also declined from 158 in October 1983 to 134 in April 1984. These decreases may be partly due to over-winter mortality /predation; however emigration is the more likely factor, in light of the highly variable nature of this moose population and its history of periodic emigration and/or immigrations (Roseneau and Stern 1974). No data exist to determine the relative roles of over-winter mortality and emigration/immigration for the Kongakut River drainage moose population.

Canning River and Kongakut River Moose Composition

Bulls (yearlings and adults) were more prevalent during fall surveys within the Kongakut River drainage than within the Canning River drainage, however, this prevalence declined from 47.4% versus 34.2% in 1983 to 41.4% versus 36.1% in 1984 for the Kongakut River drainage and the Canning River drainage, respectively (Tables 1 and 2). To further evaluate the relative composition of moose within the two drainages, Gasaway et al.'s (1983) adjustment for indistinguishable yearling (cows) was applied to the 1983 and 1984 fall survey data (Table 3). This adjustment estimates the number of cows 30 months of age in the fall surveys by subtracting the number of yearling males observed from the total number of cows observed. Yearling males are assumed to equal yearling females in number.

Adjusted adult ( 30 mo) sex ratios indicated that bull/cow ratios within the Kongakut River drainage for fall 1983 were almost double the ratio for the Canning River drainage in 1983 (Table 3). However, in the fall of 1984, the Kongakut River drainage sex ratios shifted to an almost even sex ratio, while the Canning River drainage sex ratio was relatively stable (Table 3). The shift in the Kongakut ratio was due to an influx of 24 bulls (40.7% increase in number of bulls) and 40 cows (87.8% increase in number of cows).

Apparently, a disproportionate number of cows immigrated into the Kongakut River drainage and reduced the preponderence of bulls within the drainage. The increase in the number and proportion of cows in the Kongakut River drainage was accompanied by a corresponding increase in the number (+17 calves) and proportion (81.0% increase) of calves in the population.

Table 3. Adjusted composition of moose occuring within the Kongakut River and Canning River drainages during fall surveys, 1983 and 1984.

| Sex/age class | | Kongakut River | | | | Canning River | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1983 | | 1984 | | 1983 | | 1984 | |
| | | # | % | # | % | # | % | # | % |
| Males | 30 mo | 59 | 37.3 | 83 | 34.7 | 44 | 29.5 | 47 | 29.8 |
| Males | 30 mo | 16 | 10.1 | 16 | 6.7 | 7 | 4.7 | 10 | 6.3 |
| Females | 30 mo | 46 | 29.1 | 86 | 36.0 | 66 | 44.3 | 67 | 42.4 |
| Females | 30 mo | 16 | 10.1 | 16 | 6.7 | 7 | 4.7 | 10 | 6.3 |
| Calves | | 21 | 13.3 | 38 | 15.9 | 25 | 16.8 | 24 | 15.2 |
| Totals | | 158 | | 239 | | 149 | | 158 | |
| Ratios: | | | | | | | | | |
| Males/ | 30 mo | 128/100 | | 96/100 | | 67/100 | | 70/100 | |
| 100 females | 30 mo | | | | | | | | |
| Calves/ | | 46/100 | | 44/100 | | 38/100 | | 36/100 | |
| 100 females | 30 mo | | | | | | | | |

Productivity of the two moose populations was similiar in both years with the Kongakut River population having a higher rate. Using the adjusted composition data, the Kongakut River moose averaged 45 calves/100 cows, while the Canning River moose population averaged 37 calves/100 cows (Table 3). Reasons for these difference are unknown, however, apparent calf survival from the fall 1983 to spring 1984 for the Kongakut River was at least 89.5% (Table 2), while calf survival for the Canning River was 68.0% for the same time period. These data indicate that the two moose population are viable and were above minimum recruitant levels necessary to sustain the populations (Franzmann 1978).

## North Slope Moose Surveys

During the spring of 1984 a survey was conducted of all major drainages from the Kavik River on the west to the Kongakut River on the east. River drainages surveyed in the eastern arctic included the Kavik River, the Canning River, including the Marsh Fork of the Canning, the Sadlerochit River, the Hulahula River, the Okpilak River, the Okpirourak River, the Jago River, the Aichilik River, the Egaksrak River, and the Kongakut River (See Appendix Fig. 3 for survey areas on these rivers). These surveys were conducted in coordination with the Alaska Department of Fish and Game to assist them in determining total moose populations using the north slope of Alaska. A total of 399 moose were located from the Kavik River to the Kongakut River(Table 4). Calf composition within the drainages surveyed ranged from a low of 12.7% within the Canning River drainage (including the Marsh Fork), to a high of 23.7% within the Kavik River drainage. The total survey results averaged 15.5% calves (Table 4). A majority (368 of 399) of moose tallied during the survey were located in three drainages (Kavik River, Canning River, and

Kongakut River). Previous spring surveys of the Kavik River in 1972, 1973, and 1974 recorded a total moose population of 24-25 moose (Lenar et al. 1974, Roseneau and Stern 1974). This subpopulation of the Canning River population has evidently increased three-fold; however, the 1972-1974 surveys were not exhaustive and may have missed some moose.

Table 4. Number and composition of moose observed during the 1984 spring survey of eastern north slope drainages between the Kavik and Kongakut Rivers.

| Drainage | Survey date | Number of moose observed | | |
|---|---|---|---|---|
| | | Adult | Calves(%) | Total |
| Kavik River | 27 April | 58 | 18(23.7) | 76 |
| Canning R./ Marsh Fork | 20,27 April | 138 | 20(12.6) | 158 |
| Sadlerochit River | 19 April | - | ---- | 0 |
| Hulahula River | 19 April | - | ---- | 0 |
| Okpilak River | 19 April | - | ---- | 0 |
| Okpirourak River | 19 April | 6 | 1(14.3) | 7 |
| Jago River | 19 April | - | ---- | 0 |
| Aichilik River | 19 April | 10 | 2(16.7) | 12 |
| Egaksrak River | 19 April | 10 | 2(16.7) | 12 |
| Kongakut River | 12,18,19 April | 115 | 19(14.2) | 134 |
| Totals | | 337 | 62(15.5) | 399 |

According to these data,the Aichilik and Egaksrak Rivers may have small overwintering populations (Table 4). During a 1977 spring survey, Hutson (1977) recorded 10 moose along the Aichilik River and 8 moose along the Egaksrak/Ekaluakut Rivers. These data are similar to numbers recorded during the 1984 survey (Table 4). The Okpirourak River supported a small group of moose in April 1984. These moose may occupy this area year-round or may have migrated from another large drainage.

Miscellaneous Moose Sightings

During the 1984 summer field season, incidental moose sightings were recorded on the coastal plain and along river valleys between the Canning and Kongakut Rivers (see Appendix Table 2). 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 or early June, however, moose were more common during July and early August. The origins of these moose are unknown, as are their over-wintering areas.

Lenarz et 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 River 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 widespread. Moose observed along the Hulahula River and other drainages to the east during 1984 may represent summer dispersals from either the Kongakut River or the Canning River(Appendix Table 2). They may also be animals overwintering in the Okpirourak, Aichilik, and Egaksrak Rivers.

Acknowledgements

Appreciation is extended to pilots D. Miller, E. Collison, and W. Audi for efficient aircraft operations. Appreciation is also extended to G. J. Weiler for serving as recorder for portions of the spring surveys.

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Prepared by: Gerald W. Garner Date: 24 March 1985

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APPENDIX
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Appendix Table 1. Numbers of moose observed during aerial surveys of the Canning and Kongakut Rivers on the Arctic National Wildlife Refuge, 1972-1984.

| Month - year | Drainage: Canning River (including Cache/Eagle Creeks) | Drainage: Cache/Eagle Creeks | Drainage: 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[d] | 79 | 42 | -- |
| October 1983[d] | 149 | 130 | 158 |
| April 1984[e] | 149 | 84 | 134 |
| October-November 1984[e] | 158 | 146 | 239 |

[a]Roseneau and Stern 1974
[b]Lenarz et al. 1974
[c]Arctic National Wildlife Refuge files
[d]Martin and Garner
[e]this study

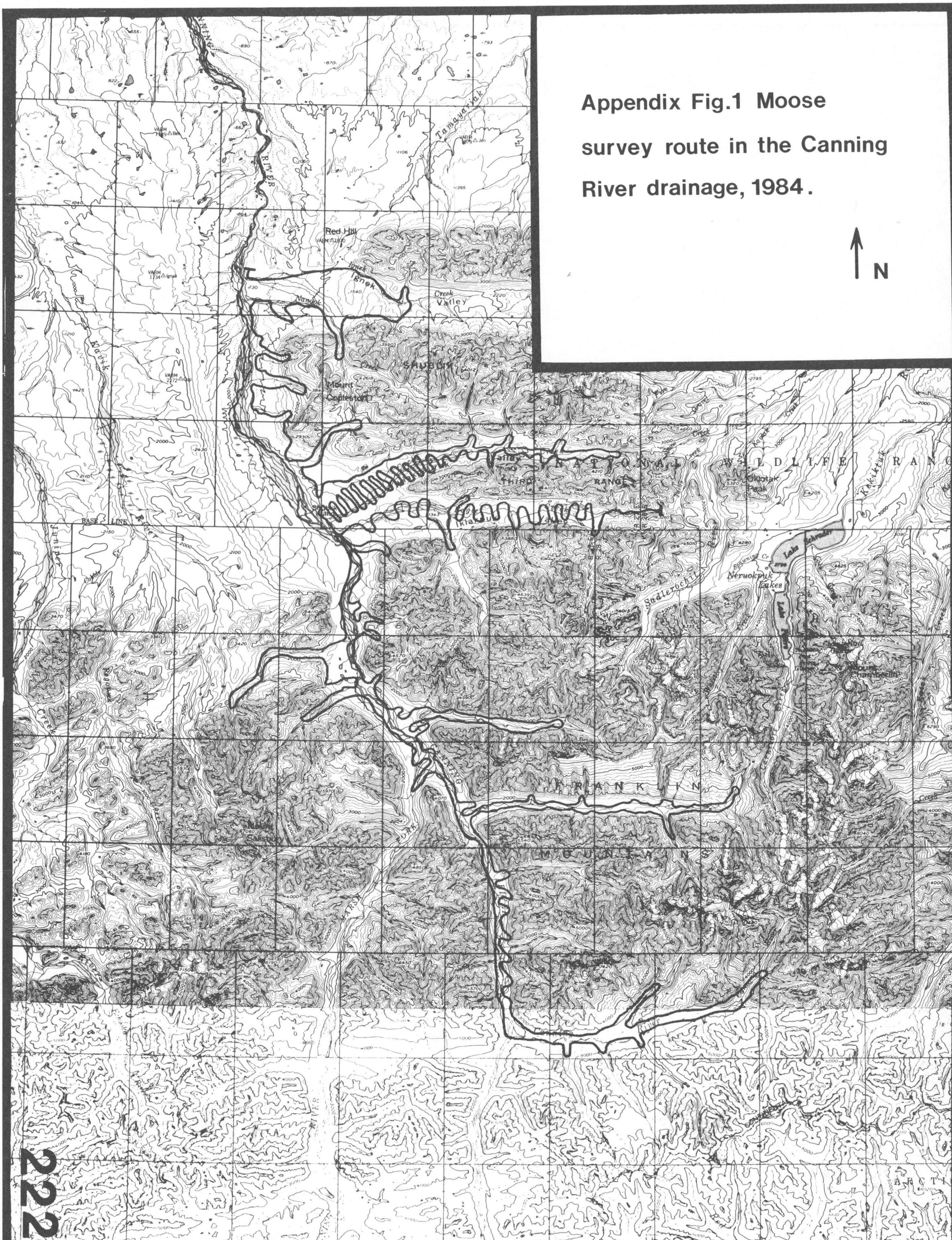
Appendix Table 2. Miscellaneous moose sightings on the Arctic National Wildlife Refuge coastal plain and mountains between the Canning and Kongakut Rivers, summer 1984.

| | | | Number of moose | | | | |
|---|---|---|---|---|---|---|---|
| Obs. #[a] | Date | Location | Bulls | Cows | Calves | Yearling | |
| 1 | 27 April | Pagilak River | | | | | 3 |
| 2 | 27 April | Paulaluk River | | | | | 3 |
| 3 | 27 April | Paulaluk River | | | | | 2 |
| 4 | 6 May | Pagilak River | | | | | 3 |
| 5 | 15 May | Pagilak River | | | | | 1 |
| 6 | 16 May | Egaksrak River | | | | | 8 |
| 7 | 5 June | Okpilak River | | 1 | 1 | 1 | |
| 8 | 7 June | Egaksrak River | | 1 | | | |
| 9 | 9 June | Hulahula River | | 1 | | | |
| 10 | 25 June | Katakturuk River | | 1 | 1 | | |
| 11 | 25 June | Nularvik River | 2 | | | | |
| 12 | 25 June | Sadlerochit Springs | | 1 | 1 | | |
| 13 | 25 June | Sadlerochit River | 1 | 1 | | | |
| 14 | 2 July | Tamayariak River | | 1 | 1 | | |
| 15 | 3 July | Marsh Creek | | 1 | 1 | | |
| 16 | 3 July | Katakturuk River | | 1 | | | |
| 17 | 3 July | Katakturuk River | | 1 | 1 | | |
| 18 | 4 July | W. of Sadlerochit R. | 1 | | | | |
| 19 | 5 July | Sadlerochit River | | 1 | 1 | | |
| 20 | 5 July | Sadlerochit River | 1 | | | | |
| 21 | 5 July | Sunset Pass | 1 | | | | |
| 22 | 5 July | Katakturuk River | 2 | | | | |
| 23 | 5 July | Nanook Creek | | | (Unknown) | | |
| 24 | 5 July | Nanook Creek | | | (Unknown) | | |
| 25 | 5 July | Cache Creek | | | (Unknown) | | |
| 26 | 9 July | Katakturuk River | 2 | | | | |
| 27 | 11 July | Marsh Creek | 1 | | | | |
| 28 | 11 July | Marsh Creek | 2 | | | | |
| 29 | 12 July | Nularvik | | 2 | | | |
| 30 | 13 July | Nularvik | 2 | | | | |
| 31 | 13 July | Jago River | | 1 | | | |
| 32[b] | 16 July | Carter Creek | | 1 | 1 | | |
| | 17 July | Carter Creek | | 1 | | | |
| 33 | 17 July | Carter Creek | 1 | | | | |
| 34 | 20 July | Okpilak River | | 1 | | | |
| 35 | 22 July | Okpilak River | | 1 | | | |
| 36 | 26 July | Hulahula River | | 1 | | | |
| 37 | 26 July | Okpilak River | 1 | | | | |
| 38 | 27 July | Hulahula River | | 1 | 1 | | |
| 39 | 28 July | Okpirourak River | 2 | | | | |
| 40 | 28 July | Okerokovik River | | 1 | 1 | | |
| 41 | 29 July | Katakturuk River | | 1 | 1 | | |
| 42 | 30 July | Niguanak River | 1 | 1 | | | |
| 43 | 1 Aug | Tamayariak River | 1 | | | | 1 |
| 44 | 2 Aug | Tamayariak River | 1 | 2 | | 2 | |
| 45 | 7 Aug | Sadlerochit Springs | 1 | | | | |
| 46 | 7 Aug | Sadlerochit River | 1 | | | | |

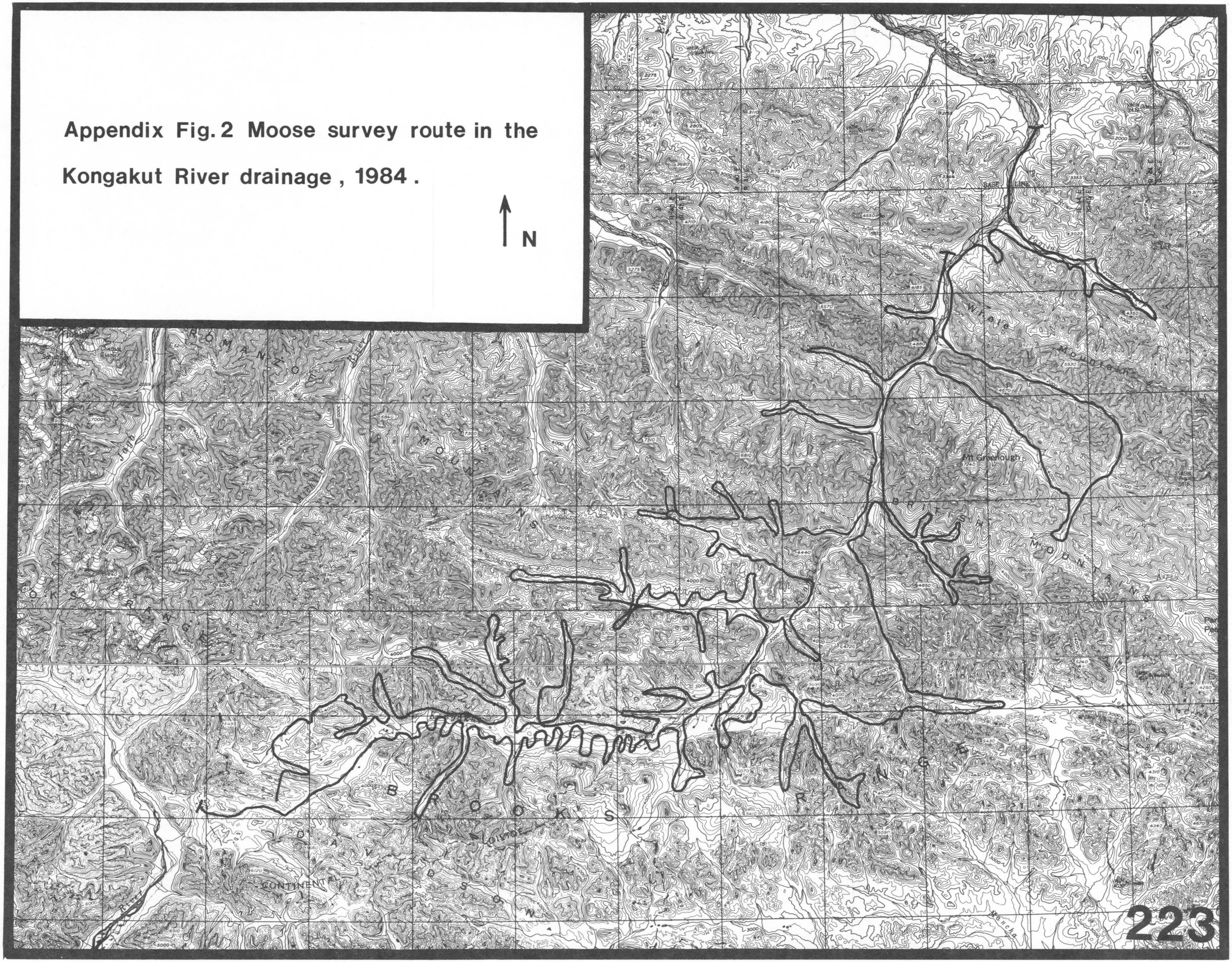
Appendix Table 2. (Continued).

| Obs. #[a] | Date | Location | Number of Moose | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bulls | Cows | Calves | Yearling | |
| 47 | 7 Aug | Karen Creek | 1 | | | | |
| 48 | 7 Aug | Karen Creek | 2 | | | | |
| 49 | 8 Aug | Katakturuk River | 1 | | | | |
| 50 | 8 Aug | Karen Creek | 3 | | | | |
| 51 | 8 Aug | Aichilik River | 2 | | | | |
| 52 | 8 Aug | Sikrelurak River | | | | | 1 |
| 53 | 11 Aug | Egaksrak River | | 1 | 1 | | |
| 54 | 13 Aug | Sadlerochit River | 1 | 1 | | | |
| | 15-20 Aug | Sadlerochit River | 1 | 2 | | | |
| 55 | 20 Aug | Sadlerochit Springs | | 1 | 1 | | |
| 56 | 31 Aug | Sadlerochit River | 1 | | | | |
| 57 | 31 Aug | Cache Creek | 2 | | | | |
| 58 | 31 Aug | Cache Creek | | 1 | 1 | | |
| 59 | 24 Sept | Jago River | 1 | | | | |
| 60 | 24 Sept | Jago River | 1 | | | | |
| 61 | 24 Sept | Barter Island | 1 | | | | |
| 62 | Unknown | Okerokovik | 1 | | | | |
| | Totals | | 42 | 31 | 14 | 3 | 22 |

[a] Observations #'s correspond to number on Appendix Fig.
[b] Absence of observation # indicates precise location of observation is unknown.

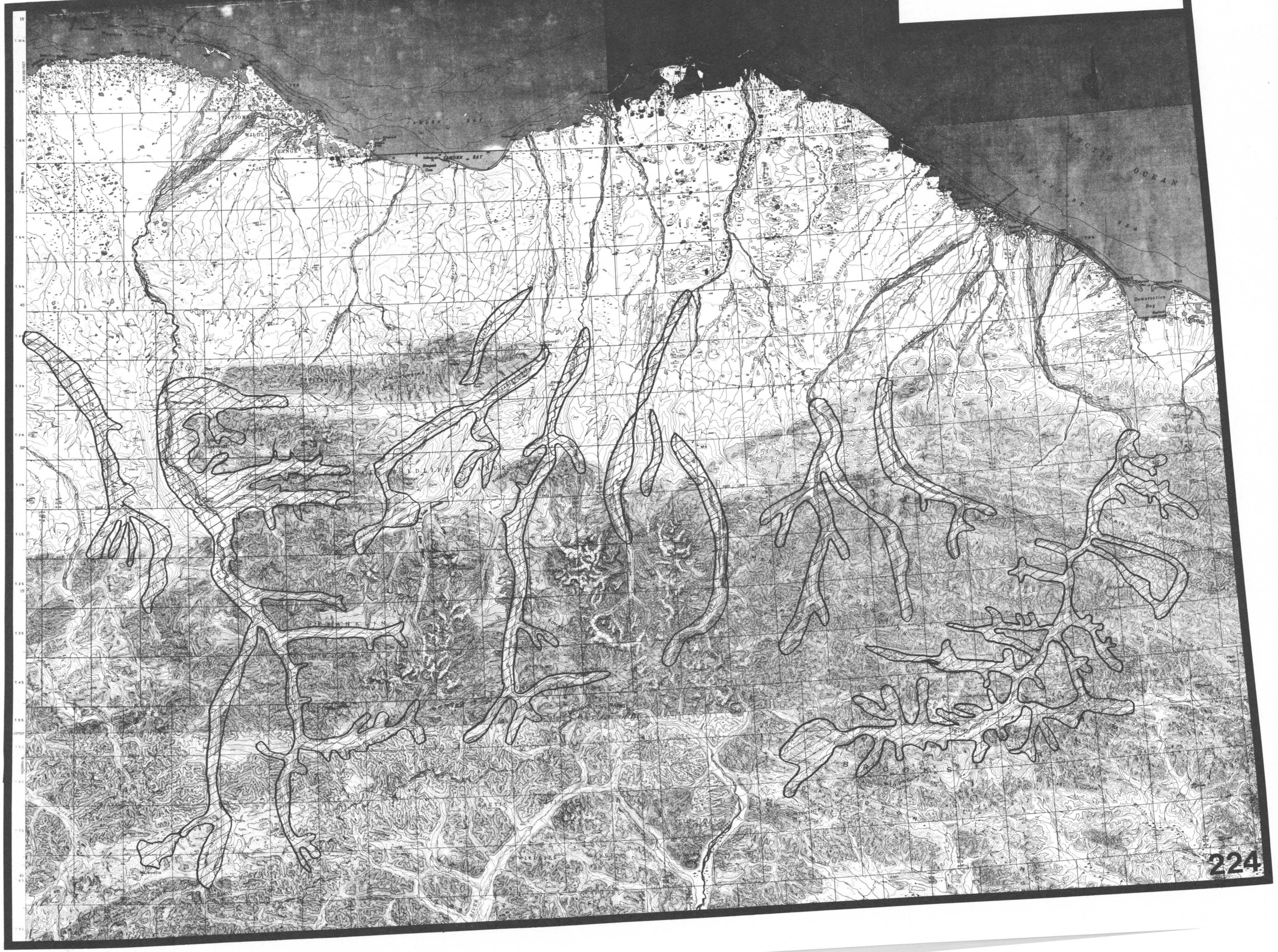


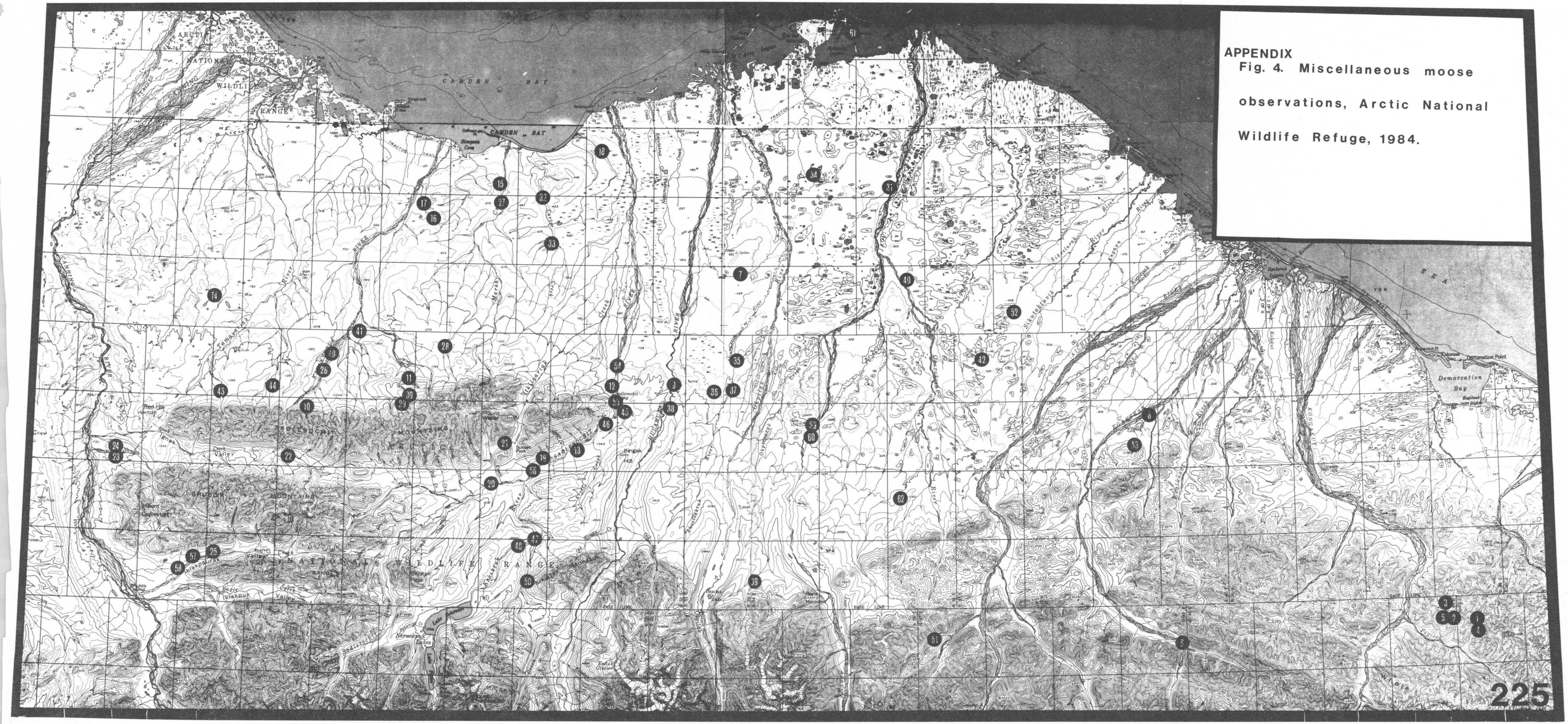

Appendix Fig.1 Moose survey route in the Canning River drainage, 1984.




Appendix Fig. 2 Moose survey route in the Kongakut River drainage, 1984.

Appendix Fig. 3. Moose Survey Areas, Spring, 1984






APPENDIX
Fig. 4. Miscellaneous moose observations, Arctic National Wildlife Refuge, 1984.

ANWR Progress Report Number FY85-7

# DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF FALL STAGING LESSER SNOW GEESE ON COASTAL HABITATS OF NORTHEAST ALASKA AND NORTHWEST CANADA, 1984

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Key Words: snow geese, Anatidae, waterfowl, staging waterfowl, population, Alaska, north slope, Arctic National Wildlife Refuge, Arctic-Beaufort

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25 February 1985

Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1984.

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Abstract: One reconnaissance flight and two survey route flights were conducted on 28 August and the 13 and 21 September respectively to provide visual estimates of staging lesser snow goose populations on the coastal plain of the Arctic National Wildlife Refuge in 1984. Black and white photographs were taken of flocks on the 13 and 21 September surveys to provide age ratio information and error estimates for visual estimates of flock sizes. The corrected peak staging population estimate for 13 September was 94,528 geese. The main influx of geese onto ANWR occurred between 30 August and 7 September. Major departure occurred from 17 to 25 September. Distribution within the refuge was similar to previous years. Photography was of insufficient quality for determination of population age-ratios.

Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1984.

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 thirteenth year since surveys were initiated in 1971 by L.G.L., Inc. (Schweinburg 1974). The 1984 surveys represented the seventh year of survey by refuge staff, and the sixth year of photographic age ratio sampling using methods standardized in preceding years (Spindler 1980, 1983a). Objectives of the study were to: (1) determine the chronology of migration and staging; (2) estimate the distribution and numbers of snow geese present during the peak of staging; (3) estimate the percent young present during staging; and (4) identify areas used consistently by staging snow geese.

## Methods and Materials

A predetermined 9.7 km-spaced grid of 2.4 km wide north-south aerial transects (Koski 1977b, Spindler 1983a) from Bathurst, Northwest Territories to Hulahula River, Alaska was flown using fixed-wing aircraft flying approximately 150 m above ground level at an airspeed of 200 kph. Flocks of birds encountered were assigned sequential numbers and recorded on 1:250,000 U.S.G.S. topographic maps, and estimated flock size and direction of movement were recorded. Staff of the Arctic NWR conducted the Hulahula River to Clarence River portion of the survey and CWS personnel simultaneously (whenever possible) flew the segment from Clarence River to Bathurst Peninsula to avoid double counting of flocks. Established minimum weather and survey standards (Spindler 1980, 1983a) were observed. Direction of movement information minimized double counting of flocks moving towards succeeding transects. Other information such as behavior, circling flight versus migrational flight, and photograph frame numbers (if any) were coded to the flock number in a separate notebook. A crew of three persons (a pilot and two observer/photographer/recorders) was used to simultaneously obtain photos and records. All persons helped find flocks. The observer sitting in the right front seat photographed the total flock at a distance for a flock size estimate. At this time the observer/photographers made an independent estimate of flock size, and recorded each estimate. The pilot then circled closer and age-ratio photographs were taken. To avoid excessive disturbances to the geese, care was taken to avoid circling a flock more than once.

A Mamyia RB-67 60x70 mm large format SLR camera was used on 13 September for the photography, in combination with a 250 mm telephoto lens and ASA 400 TRI-X PAN film. On 21 September, a 35 mm Canon SLR with a 70-210 mm zoom telephoto lens and ASA 50 H&W VTE PAN (Ferguson and Gilmer 1980) was used. Pilot and observer/ photographer/recorders 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 independently by two counters to obtain estimates of counter variability. Mean results of photo counts were regressed with survey estimates to determine estimation error and a correction equation. Calculation of the mean age-ratio was not possible due to an insufficient counter variability. Mean results of photo counts were regressed with survey estimates to determine estimation error and a correction equation. Calculation of the mean age-ratio was not possible due to an insufficient number of usable quality photographs. Composition counts of family groups were conducted from ground locations to estimate productivity of successful breeding pairs (Lynch and Singleton 1964, Prevett and MacInnes 1980).

In addition to the systematic procedures used for the 13 and 21 September surveys, a reconnaissance flight was made over the ANWR coastal plain on 28 August to provide more complete information on the arrival and staging of snow geese.

## Results and Discussion

### Estimation Error

Correlation between photograph counts by the two counters was significant (r=0.9967, P 0.01) and a significant linear relationship existed, although one observer consistently counted more geese (Fig. 1). This difference was probably the result of consistent but differential interpretation of clumps of geese superimposed in the photographs (Fig. 2) and increased with flock size (Fig. 1). Means of the results from the two counters were used as the final photograph counts.

Photo counts were significantly higher than survey estimates of flock size (t=6.55, n=59, P 0.001). Photo counts and survey estimates were also linearly related (Fig. 3). The resulting regression equation was used as a correction factor or calibration formula (Snedecor and Cochran 1967) and corrected estimates of all flocks observed were computed.

### Chronology and Numbers

Compilation and analysis of data from the Canadian territories were not completed in time for inclusion in this report, but will be reported in the 1985 update report. The first observations of snow geese on ANWR during the staging season were of a flock of 100 on the Aichilik delta and a flock of 20 on the Tamiyariak delta on 17 August. A flock of 60 geese was observed flying near the Tamiyariak River on 19 August. Sightings increased during the last week of August and a reconnaissance flight from the Hulahula River to Demarcation Bay was conducted on 28 August (Fig. 4, Table 1). This flight revealed an estimated total of 1290 snow geese in small flocks on the coastal plain with small concentrations on the lower Aichilik River and the Kongakut River delta.

The main influx of geese onto ANWR probably occurred between 30 August and 7 September. The first flight of the survey route was conducted on 13 September. The survey count of 36,875 geese in 149 flocks yielded a corrected estimate of 94,528 from Hulahula River in Alaska to the Clarence River in the Yukon Territory (Fig. 5). Mean flock size for the corrected values was 634.4. The second survey was conducted on 21 September and the observed estimate of 20,155 in 110 flocks was corrected to 48,405 geese with a mean flock size of 440.1 (Fig. 6). Numbers of geese at Jago Bitty declined from approximately 10,000 on 13 September to 5,000-6,000 on 23 September and on 24 September most geese on the refuge were apparently departing (Fig.7, Table 2). An aerial survey on 26 September revealed no geese within the eastern half of the refuge coastal plain staging area.

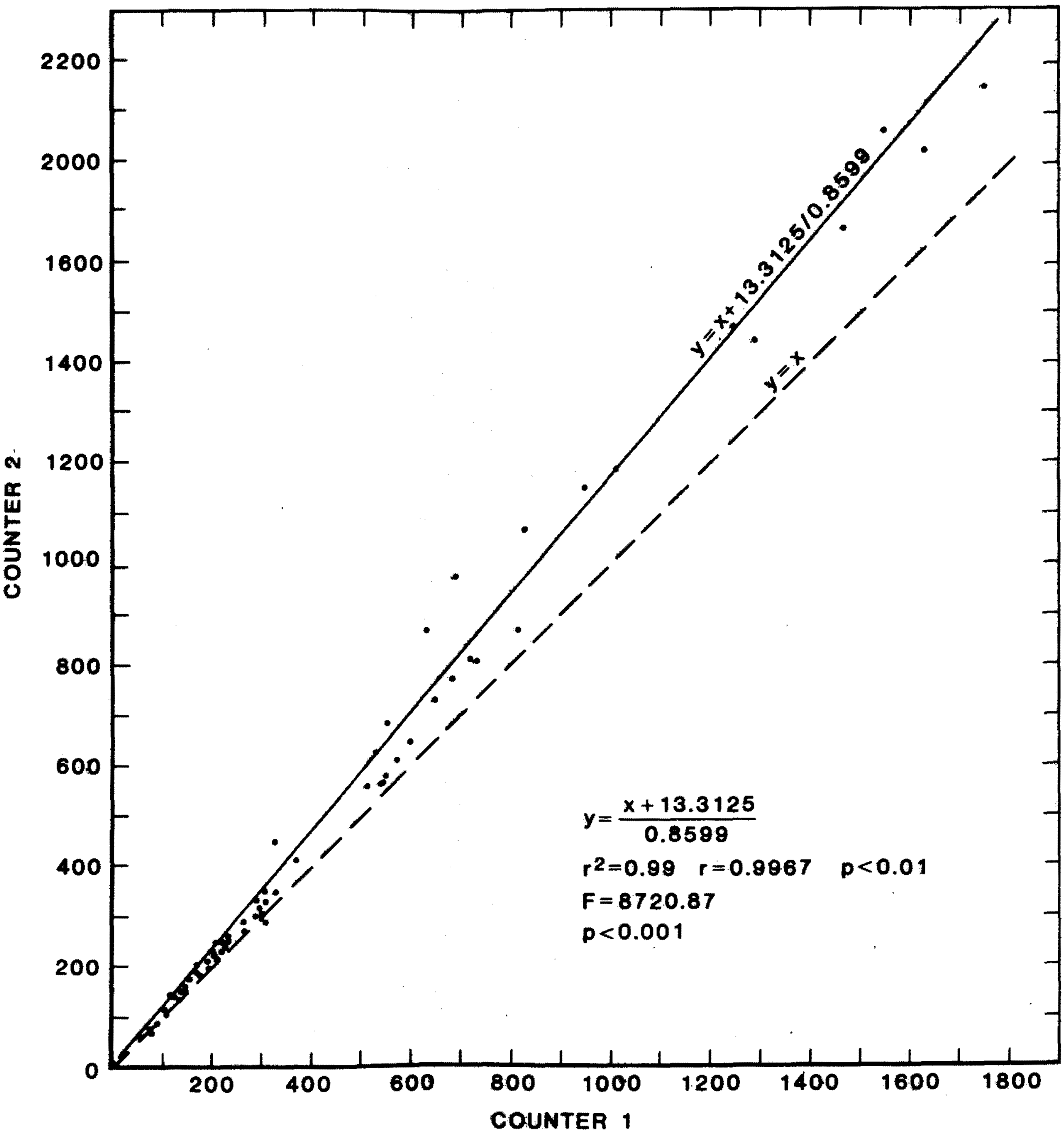


FIG. 1. CORRELATION AND REGRESSION RELATIONSHIPS BETWEEN COUNTS BY TWO COUNTERS OF SNOW GEESE IN PHOTOGRAPHS TAKEN IN 1984 ON THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA.

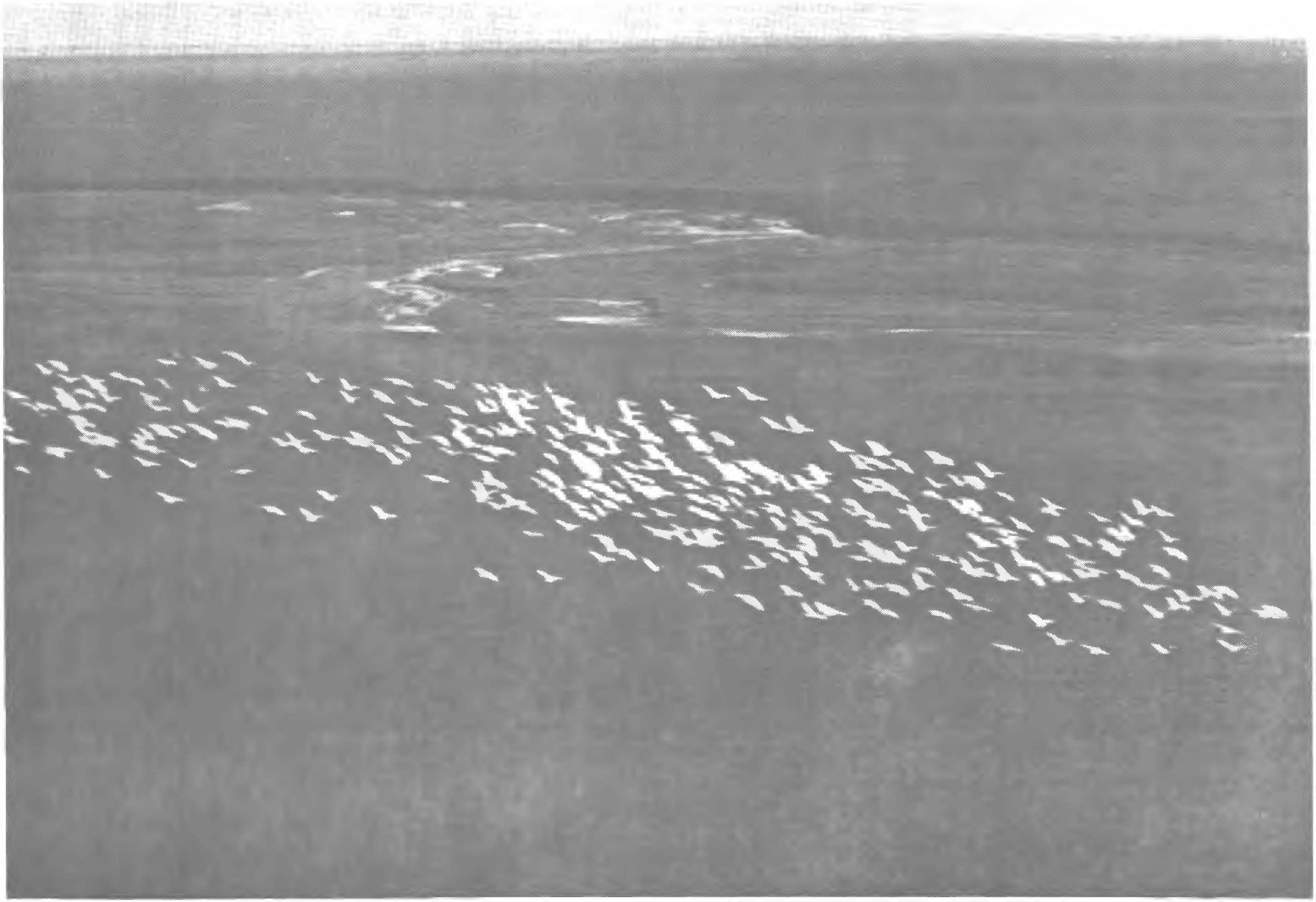

Fig. 2 Photograph of lesser snow geese used in calculation of 1984 staging population estimate, ANWR, showing clumps of superimposed geese.

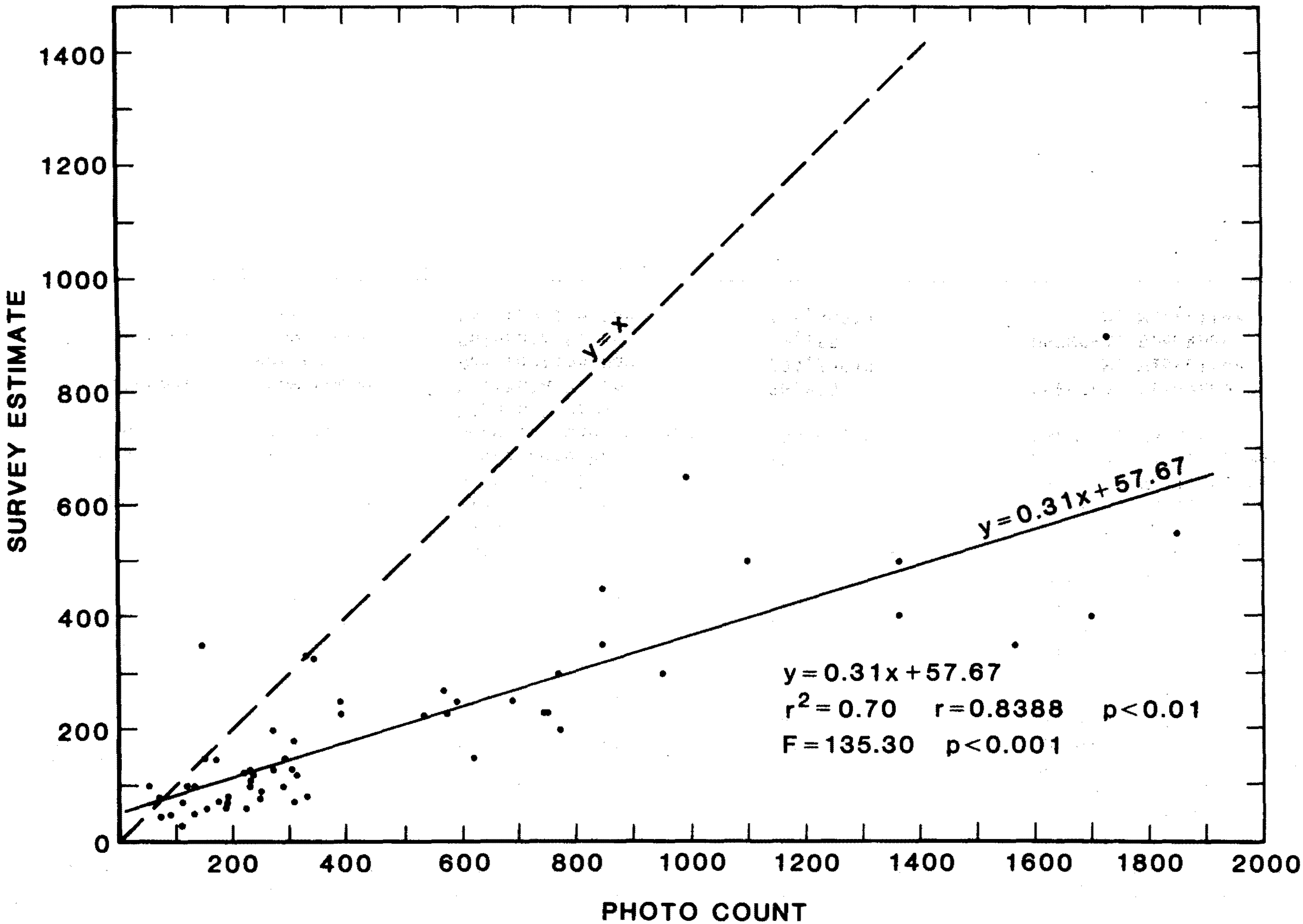


FIG. 3. REGRESSION OF SURVEY ESTIMATES ON PHOTO COUNTS OBTAINED FROM LESSER SNOW GOOSE SURVEYS ON THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1984.

Table 1. Results of aerial snow goose surveys and incidental observations taken during other surveys, coastal plain of Arctic National Wildlife Refuge, Alaska, 1984.

| Date | Survey type | and area | Estimated numbers | Observer(s) |
|---|---|---|---|---|
| 17 August | in transit | Aichilik Delta | 100 | USFWS-R. Glesne |
| 17 August | in transit | Tamayariak delta | 20 | USFWS-R. Glesne |
| 19 August | radio-tracking | Tamayariak | 50 | USFWS-J. Morton, J. Noll |
| 27 August | swan survey | Egaksrak Lagoon | 100 | USFWS-J. Morton, J. Noll |
| 27 August | swan survey | Simpson Cove | 120 | USFWS-J. Noll, M. Masteller |
| 27 August | swan survey | Lower Tamayariak R. | 20 | USFWS-J. Noll, M. Masteller |
| 27 August | swan survey | S. Barter Island | 40 | USFWS-J. Noll, M. Masteller |
| 27 August | swan survey | Oruktalik Lagoon | 5 | USFWS-J. Noll, M. Masteller |
| 27 August | swan survey | W. Jago River | 145 | USFWS-J. Noll, M. Masteller |
| 27 August | swan survey | Camden Bay | 25 | USFWS-J. Noll, M. Masteller |
| 28 August | in transit | W. Canning River | 40, 85 | USFWS-A. Brackney |
| 28 August | swan survey | Demarcation Bay | 160 (2 flocks) | USFWS-J. Noll, M. Masteller |
| 28 August | radio-tracking | W. Nuvagapak Point | 30 | USFWS-J. Morton, J. Noll |
| 28 August | snow goose recon | Hulahula R. to Demarcation Bay | 1290 (17 flocks) | USFWS-A. Brackney, M. Masteller |
| 29 August | swan survey | Aichilik delta | 230 | USFWS-J. Noll, M. Masteller |
| 29 August | swan survey | Oruktalik Lagoon | 40 | USFWS-J. Noll, M. Masteller |
| 29 August | swan sruvey | Lower Kongakut R. | 390 | USFWS-J. Noll, M. Masteller |
| 29 August | in transit | between Angun R. and Niguanik River | 200,60,30 | USFWS-G. Garner |
| 13 September | snow goose survey | Hulahula R. to Demarcation Bay | 36,875 (94,528)[a] | USFWS-A. Brackney M. Masteller |
| 21 September | snow goose survey | Hulahula R. to Demarcation Bay | 20,155 (48,405)[a] | USFWS-A. Brackney M. Masteller |

[a] Corrected estimate computed from correction equation $y=0.31x+57.67$.

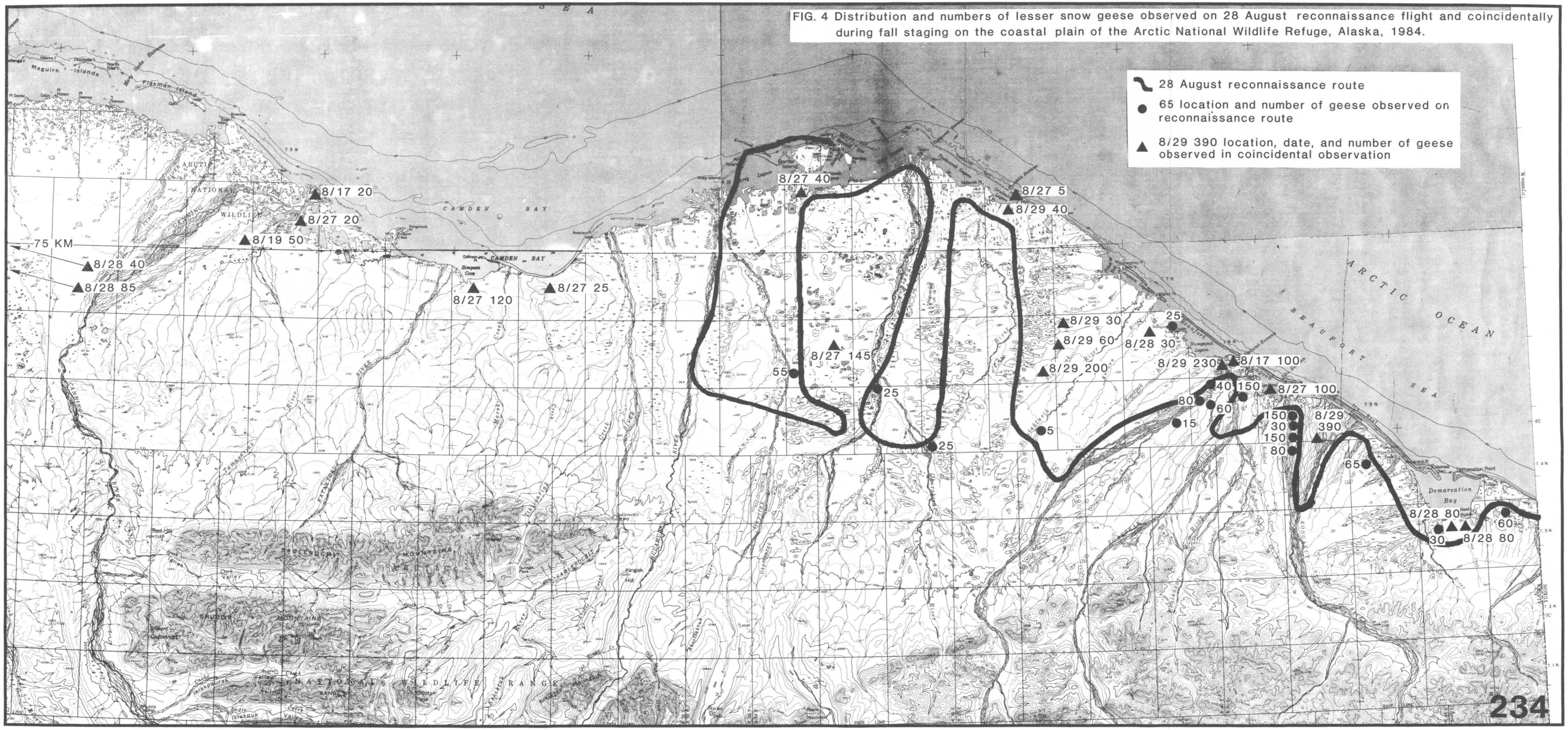


FIG. 4 Distribution and numbers of lesser snow geese observed on 28 August reconnaissance flight and coincidentally during fall staging on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1984.

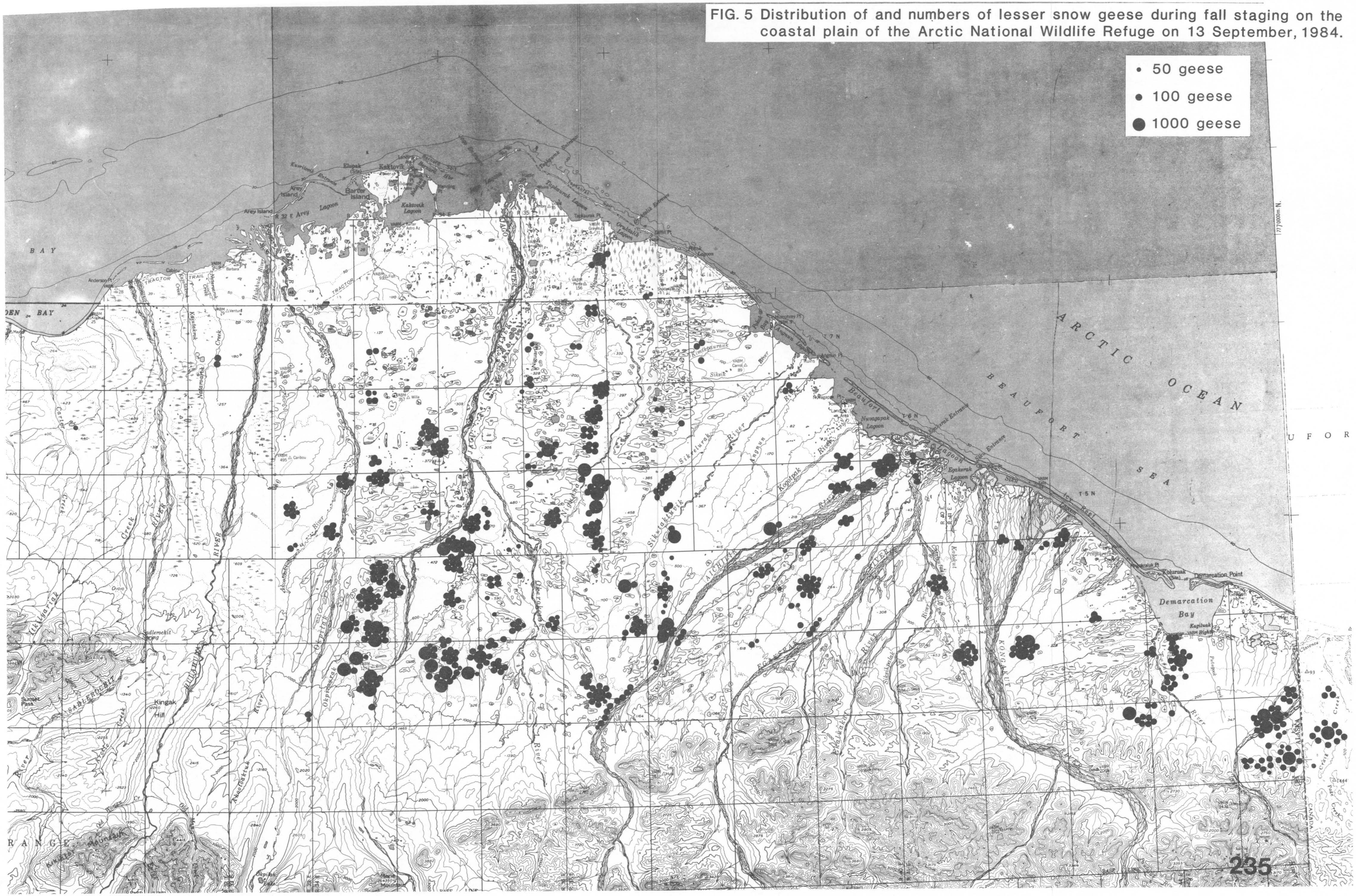


FIG. 5 Distribution of and numbers of lesser snow geese during fall staging on the coastal plain of the Arctic National Wildlife Refuge on 13 September, 1984.

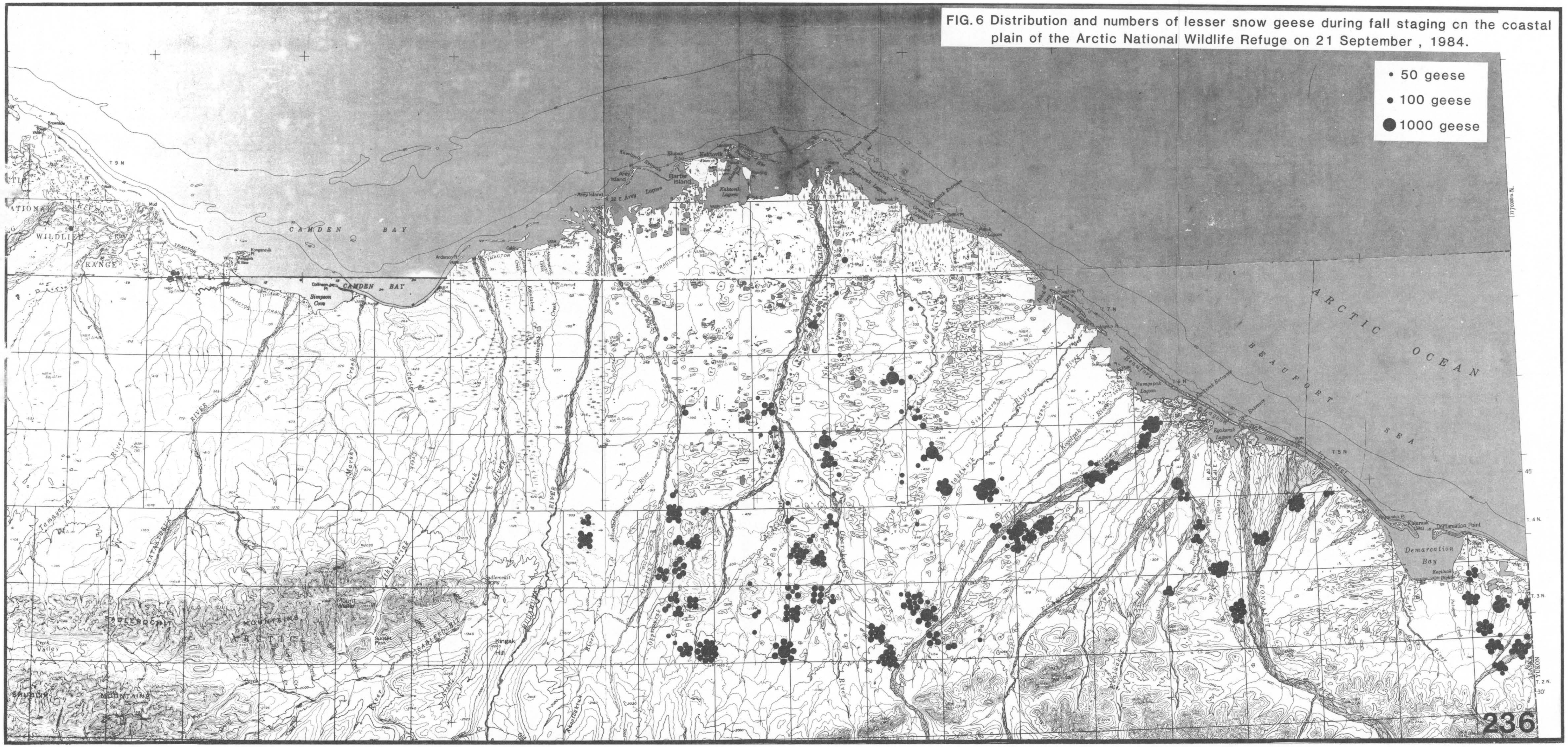


FIG. 6 Distribution and numbers of lesser snow geese during fall staging cn the coastal plain of the Arctic National Wildlife Refuge on 21 September , 1984.

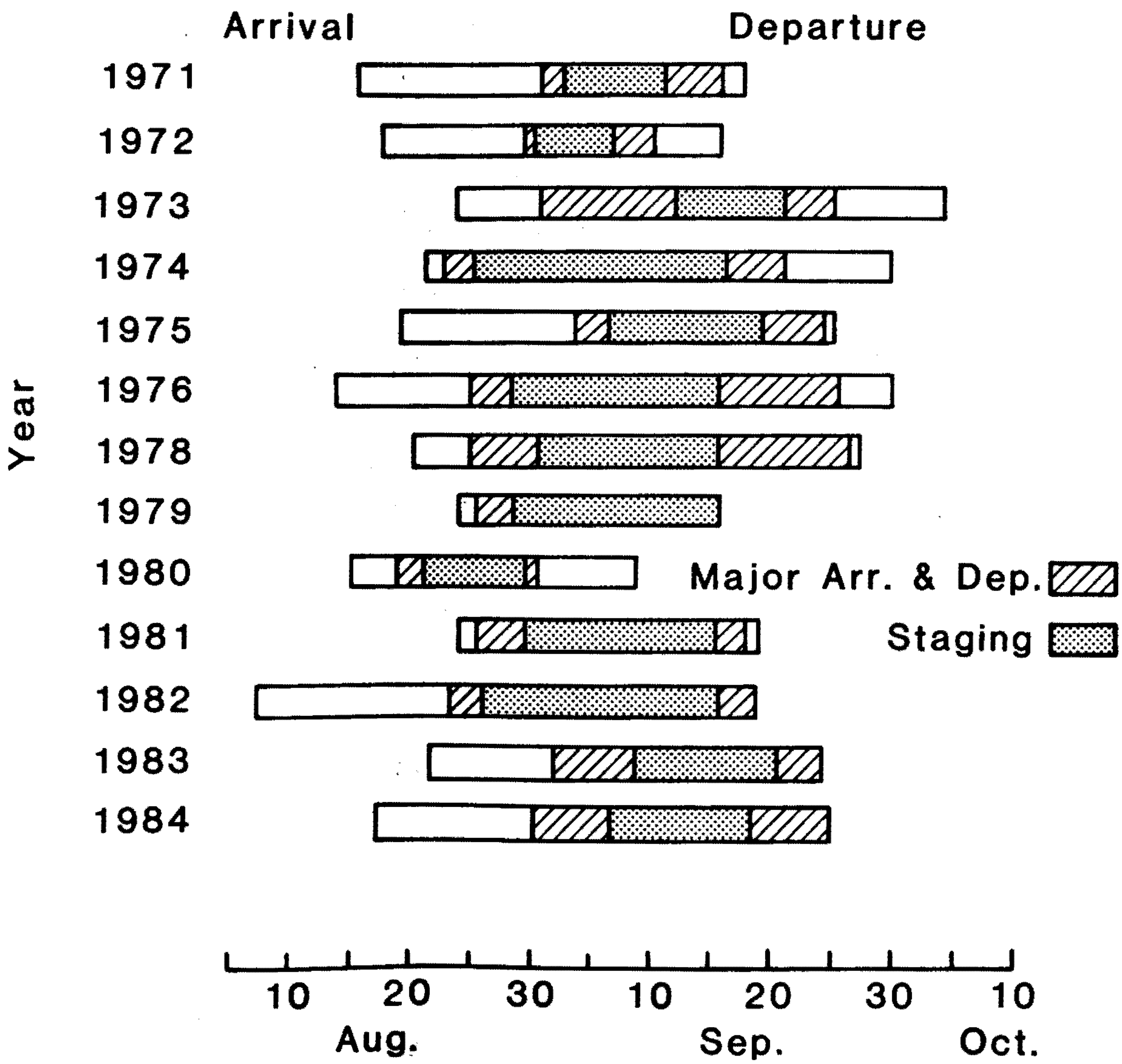


Fig. 7. Chronology of arrival, staging, and departure of the western arctic population of lesser snow geese using the coastal plain of the Arctic National Wildlife Refuge, Alaska, 1971-1984.

Table 2. Dates of arrival and departure of snow geese on the Mackenzie River delta, Yukon north slope, and eastern Alaskan north slope, August and September 1971-1976 and 1978-1984. The 1978-1982 and 1984 data are from Arctic National Wildlife Refuge only, other years include intensive sampling over entire staging area.

| Year | Date first flock sighted | Dates of major arrival | 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[m] | 20 Aug. | 25 Aug.- 2 Sept. | 16 | 21 Sept. | 21 Sept. | 1 June-26 Sept. |
| 1984 | 17 Aug. | 30 Aug.- 7 Sept. | 10 | 17-25 Sept. | 24 Sept. | 28 Aug.-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)

m Spindler (1984)

Table 3. Peak numbers of western arctic snow geese counted during August-September staging surveys, Arctic National Wildlife Refuge coastal plain and Canadian areas to the east, 1973-1983.

| Year | Alaska | Yukon north slope | Mackenzie River delta and east | Total | Percent Staging in Alaska | Survey dates |
|---|---|---|---|---|---|---|
| 1973[a] | 44,037 | 126,960 | 86,520 | 257,517 | 17.10 | Sept. 2,3,5,6,11,12,18,22,23,25 |
| 1974[a] | 48,591 | 37,435 | 28,913 | 114,939 | 42.18 | Aug. 24,31, Sept.5,11,16,25 |
| 1975[a] | 0 | 20,972 | 685,305 | 706,277 | 0.00 | Aug. 25-28, Sept.8,10,11,13,17-18,20,23 |
| 1976[a] | 228,793 | 224,401 | 18,363 | 471,557 | 48.52 | Aug.16-20,29-31, Sept.4-6,10-13,18-21 |
| 1978[b] | 325,760 | N/D | N/D | N/D | N/D | Sept. 13-14 |
| 1979[c] | 195,000 | 41,000 | N/D | N/D | N/D | Sept. 6-7 |
| 1980[d] | 8,996[e] | 7,500[f] | N/D | N/D | N/D | Sept. 9 |
| 1981[g] | 20,000[h] | 80,000[h] | 330,000[i] | 430,000[i] | 4.65 | Sept. 14,16,20 |
| 1982[j] | 107,072 | 117,892 | 6,155 | 231,000 | 46.35 | Aug.24,26,29,31;Sept.1,3,5,9,10,14,15,21,22 |
| 1983[k] | 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) | 3.26 | |
| 1984[l] | 94,528 | N/D | N/D | N/D | N/D | Sept. 13 |

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.
- l Numbers given are total estimated geese present on 13 September based on correction equation for estimation error.

Peak numbers of geese actually observed on ANWR in 1984 (94,528) were approximately 4.8 times the peak numbers observed in 1983 (19,787), but only 87% of the mean (109,120) for 9 previous surveys (extending over 10 years, excluding 1980, Table 3). However, the percentage of the western arctic breeding population which stage in Alaska was highly variable (Table 3) and was apparently not related to total population size (r=-0.5605, P  0.05). The number of geese staging in Alaska was probably more strongly related to weather conditions (particularly snow cover), but may also be influenced by prevailing winds, maturity of ericaceous berries, and availability of cotton grass (Eriophorum) and horsetail (Equisetum)(T.W. Barry, pers. comm.).

Spatial Distribution

Staging congregations were first observed in Alaska on 28 August on the lower Kongakut, Egaksrak and Aichilik Rivers (Fig. 4). Highest densities observed on the 13 September survey (the maximum observed distribution ) were on the upper Jago River in the vicinity of VABM Bitty and between the Jago and Okpilak Rivers (Fig. 5). Concentrations of geese were also observed on the Clarence River, and along the Niguanak, Aichilik and Kongakut Rivers.

The 21 September survey revealed that approximately half of the geese observed on 13 September had left the refuge (Fig. 6). The western most concentrations of geese represented a smaller proportion of the birds on the refuge on 21 September than on 13 September. Apparently, the areas west of the Aichilik River were the last to be occupied, received the highest densities of geese, and were the first to be vacated during staging (Figs. 4, 5, 6).

Productivity

Observers were unable to photograph sufficient numbers of geese to obtain reliable age-ratio estimates for ANWR. Composition counts by ground observers of 95 family groups yielded a mean of 2.56 (± 1.03 SD) young per successful breeding pair.

## Acknowledgments

Thanks are due pilot B. Carswell who flew the surveys and provided additional observations. T. Barry, CWS, Edmonton; continued his usual cooperation.

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APPENDIX
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Appendix Table 1. Photographic count results used to assess accuracy and develop a correction equation for visual flock size estimates of snow geese, 13 and 21 September, 1984, Arctic National Wildlife Refuge, Alaska.

| Photo I.D. (Roll & Frame) | Date Observed | Flock Number | Visual Estimate (y) | Photo Count[a] (x) |
|---|---|---|---|---|
| R1-15 | 9-13 | 1 | 650 | 997.5 |
| R2-6 | 9-13 | 14 | 350 | 1567.5 |
| R2-8A | 9-13 | 15 | 325 | 341.0 |
| R2-10A | 9-13 | 17 | 75 | 304.5 |
| R2-11 | 9-13 | 18 | 125 | 231.0 |
| R2-12A | 9-13 | 19 | 250 | 593.0 |
| R3-2A | 9-13 | 22 | 300 | 771.0 |
| R3-3A | 9-13 | 24 | 90 | 244.5 |
| R3-5A | 9-13 | 25 | 180 | 305.0 |
| R3-13 | 9-13 | 27 | 900 | 1729.0 |
| R4-1 | 9-13 | 29 | 110 | 216.0 |
| R4-2 | 9-13 | 30 | 60 | 220.5 |
| R4-11 | 9-13 | 36 | 400 | 1365.5 |
| R4-12 | 9-13 | 37 | 50 | 86.0 |
| R5-1 | 9-13 | 38 | 80 | 331.0 |
| R5-3A | 9-13 | 40 | 50 | 138.5 |
| R5-4A | 9-13 | 42 | 550 | 1855.5 |
| R5-8A | 9-13 | 44 | 225 | 574.5 |
| R6-2A | 9-13 | 46 | 500 | 1100.0 |
| R6-3A | 9-13 | 47 | 90 | 248.5 |
| R6-5 | 9-13 | 48 | 80 | 193.0 |
| R6-7 | 9-13 | 49 | 35 | 104.5 |
| R7-6 | 9-13 | 79 | 500 | 1364.0 |
| R7-11 | 9-13 | 89 | 60 | 154.5 |
| R7-10A | 9-13 | 90 | 70 | 112.5 |
| R8-4 | 9-13 | 91 | 200 | 273.5 |
| R8-7 | 9-13 | 93 | 150 | 147.0 |
| R8-9 | 9-13 | 100 | 125 | 224.0 |
| R8-11 | 9-13 | 99 | 150 | 165.5 |
| R8A-12 | 9-13 | 102 | 250 | 393.5 |
| R9-2 | 9-13 | 128 | 75 | 179.5 |
| R9-3A | 9-13 | 129 | 100 | 137.5 |
| R9-6 | 9-13 | 130 | 70 | 185.5 |
| R9-7A | 9-13 | 132 | 325 | 324.5 |
| R9-12 | 9-13 | 133 | 150 | 622.0 |
| R10-1 | 9-13 | 134 | 225 | 539.5 |
| R10-18 | 9-13 | 146 | 130 | 300.5 |
| R10-19 | 9-13 | 147 | 275 | 568.0 |
| R11-1 | 9-13 | 148 | 65 | 182.0 |
| R11-2 | 9-13 | 149 | 100 | 59.0 |
| R1-12 | 9-21 | 11 | 100 | 298.0 |
| R1-16 | 9-21 | 17 | 150 | 357.0 |
| R1-17 | 9-21 | 18 | 350 | 147.0 |

Appendix Table 1. (Continued).

| Photo I.D. (Roll & Frame) | Date Observed | Flock Number | Visual Estimate (y) | Photo Count[a] (x) |
|---|---|---|---|---|
| R1-18 | 9-21 | 19 | 100 | 130.5 |
| R1-14 | 9-21 | 14 | 450 | 484.0 |
| R1-27 | 9-21 | 35 | 400 | 1701.0 |
| R1-28 | 9-21 | 35 | 150 | 297.0 |
| R1-29 | 9-21 | 36 | 300 | 951.5 |
| R1-32 | 9-21 | 51 | 80 | 72.0 |
| R1-33 | 9-21 | 52 | 110 | 236.0 |
| R2-2 | 9-21 | 67 | 45 | 74.0 |
| R2-8 | 9-21 | 80 | 225 | 389.0 |
| R2-17 | 9-21 | 94 | 100 | 234.0 |
| R2-19 | 9-21 | 96 | 125 | 276.5 |
| R2-20 | 9-21 | 97 | 350 | 844.0 |
| R2-22 | 9-21 | 100 | 225 | 752.0 |
| R2-25 | 9-21 | 104 | 120 | 315.0 |
| R2-26 | 9-21 | 106 | 200 | 776.5 |
| R2-32 | 9-21 | 111 | 250 | 691.5 |
| Sum | | | 12325.0 | 28840.5 |
| Mean | | | 208.0 | 488.8 |

n=59

$R^2 = 0.8388$ $F = 135.3$ p 0.001

$y = 0.31x + 57.04$

Paired t = 6.55 p 0.001 n = 59

[a] Photographic count values represent means of results from two counters.

ANWR Progress Report Number FY85-8

# ECOLOGY OF LESSER SNOW GEESE STAGING ON THE COASTAL PLAIN OF THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, FALL 1984

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Key words: Snow goose, Anatidae, energetics, food habits, body weight, time budgets, behavior, Arctic-Beaufort.

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19 February 1985

Ecology of lesser snow geese staging on the coastal plain of the Arctic National Wildlife Refuge, Alaska, fall 1984.

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Abstract: A study was initiated in 1984 to examine the feeding ecology and energetics of fall staging lesser snow geese (Anser caerulescens)on the coastal plain of the Arctic National Wildlife Refuge (ANWR) with the purpose of determining the effects of disturbance by aircraft and ground activities. Thirty-six geese were collected during the staging period; 14 during the arrival phase and 20 during the departure phase. Mean weight gain was 23.4, 17.6, and 14.5 g/day for adult males, adult females, and juvenile males, respectively. An insufficient number of juvenile females were collected for comparison. The esophageal and proventricular contents of the geese were analyzed. Of the 24 geese which contained discernable food items in the gut, 91.7% had consumed cottongrass (Eriophorum angustifolium), which comprised 90.1% of the aggregate wet weight of the sample. Other food species included Eriophorum scheuchzeri (5.0% of aggregate weight) and horsetails (Equisetum variegatum) (2.0%). Time budgets were examined by recording the behavior of individual birds at 15 second intervals while they were on the ground, and by instantaneous counts of the number of flying and total geese in flocks. Adults spent 60.6% of the day (0500h - 1900h) feeding and juveniles spent 78.7% of the day feeding. Alert behavior by adults occupied 12.2% of the day compared to 1.5% by juveniles. Sleeping by juveniles was insignificant (1.0%), while adults spent 6.0% of the day sleeping. The estimated time spent flying by the geese was 5.8% of the day.

Ecology of staging lesser snow geese on the coastal plain of the Arctic National Wildlife Refuge, Alaska, fall 1984.

The lesser snow goose (Anser caerulescens) nests exclusively in the high arctic with a continental population which is segmented into eastern and western arctic populations. The eastern population nests in the vicinity of Hudson Bay and migrates around the fringe of Hudson Bay and through the Mississippi Valley to the Gulf Coast. The western arctic population nests on and near Banks Island in the vicinity of the Mackenzie River delta and migrates into Alberta and the western United States in the Pacific flyway (Bellrose 1980). A small population nests on Wrangel Island Siberia and migrates through and around Alaska to wintering areas in California and British Columbia.

Extensive studies on the eastern arctic population have demonstrated that the migration, staging, and wintering portions of the life cycle have a large influence on reproductive performance. When snow geese arrive on the breeding grounds they are at their peak weight of the annual cycle (Ankney 1982). At this time the females do not feed, but rely solely on stored fat and protein reserves to produce and incubate eggs (Ankney and MacInnes 1978). Those females without sufficient reserves may lay smaller clutches and may starve to death or abandon the nest if their body reserves are depleted prior to hatching of the eggs. At hatching, the body weights of both adults have reached the lowest level of the year (Ankney 1982). Although the adults gain weight during the brood rearing period, the demands of parental attentiviness reduces potential feeding time (Harwood 1977). Crowding on the breeding grounds and competition for food resources may prevent full restoration of body weight. Due to the short arctic season, protein and energy intake by the young must be maximized to prepare them for migration. As soon as the young are capable of sustained flight, the geese leave the nesting grounds for the staging areas (Barry 1967, Wypkema and Ankney 1979), presumably to find new feeding sites.

In the eastern arctic, the geese stage along the coastline of James Bay (Bellrose 1980). In the western arctic, the fall staging areas are the Bathurst Penninsula, the MacKenzie River Delta, the Yukon north slope and the ANWR coastal plain (Barry 1966, Koski and Gallop 1974, Spindler 1983). Large increases in fat and protein reserves, measured by indices, occurred in geese collected by Patterson (1974) during the fall staging period on the Yukon North Slope in 1973. In a study of fat and protein accumulation by snow geese on James Bay, Wypkema and Ankney (1979) concluded that without the fall staging period only males would accumulate sufficient energy reserves to fly to the next major migration stop in North Dakota.

Since September surveys were begun in 1973, between 9,000 and 325,000 snow geese have been estimated annually on the coastal plain of ANWR with the exception of 1975 when no snow geese used the ANWR coastal plain (Spindler 1984, Oates et al. 1985). Estimated numbers of snow geese staging on ANWR have averaged approximately 89,000 per year (Spindler 1984) and consisted of from 10 to 49% of the estimated western arctic population (exclusive of 1975). In order to reach the staging areas on ANWR, snow geese fly away from the migration corridor in the MacKenzie River valley and travel up to 360 km to the west. Why a segment of the population makes such a long trip and does not simply utilize the areas adjacent to the MacKenzie River Delta is not known. Possible explanations could include higher nutritional quality and availability of favored foods on ANWR, less disturbance by man or predators, or simply dispersion to avoid crowding and competition for feeding sites. The timing, numbers, and length of the staging period on ANWR is determined primarily by the weather (Johnson et al. 1975, Spindler 1984) or the accumulation of sufficient energy reserves (Koski 1977).

Fall surveys provide information on the timing, distribution, and numbers of staging snow geese utilizing the ANWR coastal plain, but more detailed knowledge of the ecology of the staging geese is needed. Proposed oil and gas exploration on the coastal plain of the refuge may potentially impact staging snow geese through habitat loss and disturbance. Davis and Wisely (1974) estimated a decrease of 20.4% in the fat reserves juveniles could accumulate during the staging period if aircraft overflights occurred at 2 h intervals. Although this estimate was not sufficiently precise to predict the extent of potential impacts under varying conditions, it did indicate that frequent aircraft overflights could have adverse impacts on the geese. Likewise, Wisely (1973) showed that the sound of gas compressor simulators caused staging geese to break their flight formation, to increase altitudes, and to avoid the disturbance by more than 800 m. A model of the energy budget of snow geese will be necessary to predict the effects of aircraft disturbance under various scenarios of weather, length of staging period, and intensity of disturbance. In addition, information on the feeding ecology of snow geese may elucidate the advantage gained by the geese in utilizing the ANWR coastal plain. To acquire the needed information this study was initiated in 1984 with the following objectives:

1) Quantify the normal daily activity patterns of staging snow geese.

2) Determine the types of foods consumed and the average daily food intake.

3) Quantify the changes in body weight, body protein levels, and lipid levels during the staging period on ANWR.

4) Determine the caloric and protein quality of foods ingested.

5) Develop a model of energy expenditure and intake by the staging snow geese to predict the consequences of varying levels of disturbance.

All analyses and conclusions presented in this report are preliminary and subject to revision following more complete data analyses.

## Methods and Materials

A total of 14 geese, both adults and juveniles, were collected by shooting at the beginning of the staging period (arrival phase) and 20 at the end at the staging period (departure phase) (Table 1). Two geese were collected between the arrival and departure phases. Immediately after collection, each goose was weighed to the nearest 25 g with a spring scale, aged by plumage charcteristics, and sexed by cloacal examination. Esophageal and proventricular contents were removed and retained for food habit analysis. The carcasses and gut contents were stored in a cool location, a pit dug in the permafrost, until they could be removed to Barter Island and frozen for later analysis. Prior to freezing, each carcass was reweighed to the nearest 0.1 g.

Table 1. Numbers, locations and dates lesser snow geese were collected on the Arctic National Wildlife Refuge coastal plain, 1984.

| Date | Location | Adults | | Juveniles | | Total |
|---|---|---|---|---|---|---|
| | | M | F | M | F | |
| 30 August | Kongakut Delta | 1 | - | 1 | - | 2 |
| 31 August | Kongakut Delta | 5 | 4 | 3 | - | 12 |
| 6 September | Aichilik Delta | | 1 | | | 1 |
| 7 September | Aichilik Delta | 1 | | | | 1 |
| 23 September | Jago Bitty | 1 | 1 | 4 | 2 | 8 |
| 24 September | Jago Bitty | 2 | 2 | 5 | 3 | 12 |
| Totals | | 10 | 8 | 13 | 5 | 36 |

Food items from esophageal and proventricular samples from each bird were sorted by plant species and identification was made with the aid of Hulten (1968). Food items were also compared to mounted specimens to verify identification. The items of each species were then counted and weighted to the nearest 0.1g.

Time budgets were taken on staging snow geese on the Aichilik River delta from 8-20 September 1984. A camp was set up on a lake immediately adjacent to the east bank of the river, 1.6 km south of the river mouth, on 7 September and all observations were made within a 1.6 km radius of the camp. Observations of individual geese were made during all daylight hours when flocks could be located. Once a flock was located, the observer selected an individual bird from the flock and watched it constantly with a spotting scope until the flock left the area or the individual could no longer be seen. The behavior of each individual was recorded at 15 sec intervals, timed by a metronome (Wiens et al. 1970). At the end of the 15 sec interval, the birds' behavior was recorded as one of three primary activities, (sitting, standing, or walking) and one of nine secondary behaviors as described by Frederick and Klaas (1982). The secondary behaviors included feeding, drinking, loafing, preening, calling, comfort movements, agonistic, alert, and sleeping. Loafing was recorded as a sitting and standing behavior only. Walking, without other non-loafing activities, was recorded simply as walking. The percentage of time spent flying was estimated with the instantaneous scan method (Altmann 1974). At a minimum of three min intervals, the number of geese in a flock were counted; the flock was then quickly scanned and the number of flying individuals was counted. Periodically during the day the temperature, wind direction, wind speed, and general weather conditions were recorded. Daily weather data for Barter Island was also obtained from the National Climatic Data Center of the National Oceanic and Atomspheric Administration.

For the purposes of this report, the total number of observations of each behavior of the time budget data were accumulated by age class within each of seven 2-h time blocks starting at 0500 h and ending at 1900 h. The percentages of each behavior in the time blocks were then averaged to obtain an estimate of the percentage of the day each behavior was exhibited by the geese. Preliminary two-sample t-tests were made on arcsine transformed proportions from each bird (Sokal and Rohlf 1969).

## Results and Discussion

### Body Weight

Although the sample sizes are small, each age/sex class showed a consistent weight gain over the staging period (Table 2). No juvenile females were collected at the beginning of the staging period, thus no estimate of weight gain could be made for that age/sex class. Weight gain for the other three age/sex classes ranged from 14.5 g/day for juvenile males to 23.4 g/day for adult males, based on a 23.5 day staging period. The increase in body weight over the staging period was 21%, 17%, and 15% in adult males, adult females, and juvenile males, respectively. The body weight for all age/sex classes were similar to those of geese collected in September 1973 on the Yukon north slope by Patterson (1974) (Table 3).

Table 2. Mean weights (g ± SD) of lesser snow geese collected during the arrival and departure phases of the staging period August - September 1984 on the Arctic National Wildlife Refuge coastal plain, Alaska.

| Weight and gain | Age and sex classes | | | |
|---|---|---|---|---|
| | Adult | | Juvenile | |
| | M | F | M | F |
| Arrival[a] weight | 2668.9 ± 114.7 n=6 | 2479.7 ± 95.3 n=4 | 2287.6 ± 45.0 n=4 | - |
| Departure[b] weight | 3219.4 ± 118.1 n=3 | 2890.4 ± 108.8 n=3 | 2627.3 ± 157.2 n=9 | 2496.2 ± 139.5 n=5 |
| Net gain | 550.5 | 410.7 | 339.7 | - |
| Gain/day[c] | 23.4 | 17.6 | 14.5 | - |

[a] Collected 30-31 August
[b] Collected 23-24 September
[c] Based upon a 23.5 day staging period between collections.

Table 3. Average body weights of lesser snow geese collected during two different years on the Yukon and Alaskan north slope.

| | | Arrival | | Departure | |
|---|---|---|---|---|---|
| Age | Sex | 1973[a] | 1984[b] | 1973[c] | 1984[d] |
| Adult | Males | 2757.6(24)[e] | 2668.9(6) | 3151.8(5) | 3219.4(3) |
| | Females | 2442.8(26) | 2479.7(4) | 2859.1(7) | 2890.4(3) |
| Juvenile | Males | 2224.3(22) | 2287.6(4) | 2435.2(13) | 2627.3(9) |
| | Females | 2000.8(28) | | 2461.8(12) | 2496.2(5) |

[a] collected 1-5 September 1973 by Patterson (1974)
[b] this study, collected 30-31 August 1984
[c] collected 21-26 September 1973 by Patterson (1974)
[d] this study, collected 23-24 September 1984
[e] sample size in parenthesis

## Food Habits

Foods consumed by collected geese were entirely vegetation (Table 4), consisting exclusively of shoots and rootstocks. Twelve of the 36 geese contained no food items in the esophagus or proventriculous. Cottongrass (Eriophorum spp.) averaged 88.2% of the wet weight of food in each bird and 96.2% of the aggregate weight of food found in all collected geese. The mean percent per bird method may be valid but is subject to more bias than the percent aggregate method of presenting food habit data (Swanson et al 1974). Since the geese contained varying quantities of food in their gut, the percent aggregate wet-weight data are probably more meaningful in this instance. With both methods the major food was the large stems and fleshy rootstocks of E. angustifolium. This species was found in 91.7% of the geese and made up 90.1% of the aggregate wet weight. Eriophorum scheuchzeri and horsetails (Equisetum variegatum) comprised 5.0% and 2.0% of the aggregate wet weight, respectively. Carex and grasses were conspicuously absent from the sample. Carex aquatilus and the grass Dupontia fisheri were the most abundant species in the graminoid tundra habitat sampled by Burgess (1984) at Demarcation Bay and by Webber (1978) at Point Barrow. At Demarcation Bay, E. angustifolium comprised only 0.3 to 2.8% of the cover from a wide range of undisturbed habits and microrelief conditions. If these data are representative of the ANWR coastal plain, geese were highly selective in the foods they consumed.

Table 4. Plant species eaten by 24 lesser snow geese collected between 30 August and 23-24 September 1984 on the coastal plain of the Arctic National Wildlife Refuge, Alaska.

| Plants in diet | Mean % wet weight | % aggregate wet weight | % occurrence | % geese |
|---|---|---|---|---|
| Eriophorum sp. | 4.2 | 1.2 | 0.4 | 4.2 |
| E. angustifolium | 78.4 | 90.1 | 62.1 | 91.7 |
| E. scheuchzeri | 5.6 | 5.0 | 7.5 | 16.7 |
| Equisetum variegatum | 2.6 | 2.0 | 26.9 | 16.7 |
| Carex sp. | 0.2 | 0.2 | 0.4 | 4.2 |
| Unknown | 9.0 | 1.5 | 2.6 | 16.7 |

Prevett et al. (1979) collected 273 lesser snow geese which were staging on James Bay and found they consumed C. aquatilus in only trace amounts. On ANWR, food habit information has been limited to ground observations on areas where the geese had fed. Those observations included C. membrenacea, C. aquatilus, E. angustifolum, Poa alpina, Arctogrostis latifolia (Spindler 1984), C. bigelowii (R. Lipkin unpublished data) and berries (Schmidt 1970).

On the breeding grounds, geese feed by grazing and regrazing new vegetation (S. Cargill pers. comm.). Such activity tends to stimulate vegetation growth which is favorable to geese. At that time, the protein needs of the young are high and the new vegetation likely provides a high protein source. During staging activities geese are attempting to increase their body fat (Patterson 1974). Thus, it is reasonable that they would feed heavily on the fleshy root stocks and large stems of cottongrass which may contain larger quantities of carbohydrates. Prevett et al (1979) observed a progressive increase in root intake by snow geese on James Bay during the fall. He thought the geese purposely sought roots to increase carbohydrate and lipid intake since at that time nutritive substances are translocated from the stalks to roots.

The consumption of roots and base stems by geese removes the entire plant. With the slow vegetation reproductive rates in the arctic it may take a number of years before those plants which are uprooted can be replaced. Cottongrass tends to be a pioneer species (Bliss and Wein 1972), thus the geese may also create favorable feeding areas for future use. However, large numbers of geese could deplete cottongrass in specific areas for several years into the future which may cause shifts in core concentration areas used by geese. Spindler (1984) noted a shift in core area from the Niguanak River, Sikutaktuvik River and Okerokovik River area in 1982 to the Aichilik-Egaksruk-Kongakut River deltas in 1983. In 1984, the major core area was the Jago Bitty-Okpilik River area (Oates et al. 1985). Distribution maps of geese on the Yukon north slope (Spindler 1983, Spindler 1984) show a similar pattern of differential use from year to year. Dispersion of the goose population over a wide area may be necessary to avoid areas heavily utilized in the past, and to maximize feeding efficiency of the geese during the short staging period by concentrating their feeding in areas of high food abundance. This may also explain why geese do not disperse over wide areas in the intermittent years of bad weather, but do disperse widely during years of favorable weather such as in 1984. Thus, the ANWR coastal plain may be important to the long term maintenance of the population at its present level. Further knowledge of food habits, food quality, and food availability both on ANWR and the Yukon north slope is needed to more clearly define this relationship.

Time Budgets

Time budget observations were made on a total of 266 individuals; 129 adults and 137 juveniles. The number of observations (5160) averaged 19.4 (± 1.0 SD) observations/goose with a range of 4-135. The short mean observation periods (4.75 min) was a result of nearly constant movement of the birds around low-center polygons and other areas of microrelief which often caused geese to disappear from sight. In addition, the long distances from which the birds were observed (300-800 m) also contributed to the short observation times. Heat waves rising from the ground in the afternoon reduced the effective observation distances during that time period on most days.

The proportion of each of the 18 combinations of primary and secondary behaviors which were observed are presented in Appendix Tables 1-4. The presentation of these data is preliminary in that data analysis is not complete. Possible correlations in behavior, within individual birds, of successive observations are possible, and make these data suspect as presented. However, the authors believe the information present here is representative of snow goose activity during the observation period.

Several behaviors such as calling and sitting-agonistic behavior were not observed. Some distinct differences between adult and juvenile behavior occurred and is evident in the time budget data (Table 5). Adults spent more time on alert and sleeping and less time feeding than did juveniles. Some preliminary two-sample t-tests on the arcsine transformed proportions displayed by each individual showed a significant difference in time spent feeding ($t=5.28$, $P=0.001$) and alert behavior ($t=7.47$, $P=0.001$) between the adult and juvenile geese. Feeding behavior occupied the majority of the daytime activity in both adults (60.6%) and juveniles (78.7%). These estimates agree with time budget data collected on fall staging snow geese by Davis and Wisely (1974) on the Yukon north slope. They used an intantaneous scan method which lumps juveniles and adults together, and estimated that the geese spent 57% of the daylight hours feeding. In contrast, Frederick and Klaas (1982) found that snow geese in Iowa during fall migration spent only 20.4% of the day feeding.

The percentage of time adults spent feeding varied greatly throughout the daylight hours (Fig. 1). Feeding by juveniles mirrored adults less intensely, but at a higher level. Less feeding occurred in the late morning (0900-1059 h) and in the early afternoon (1300-1459 h), when sleeping behavior (Fig. 2) and other resting behaviors (preening, loafing and comfort movements) (Fig. 3) were highest. Juvenile resting behavior tended to rise during the day and peak in the late afternoon (1500-1659 h). The extent of sleeping by juveniles was negligible.

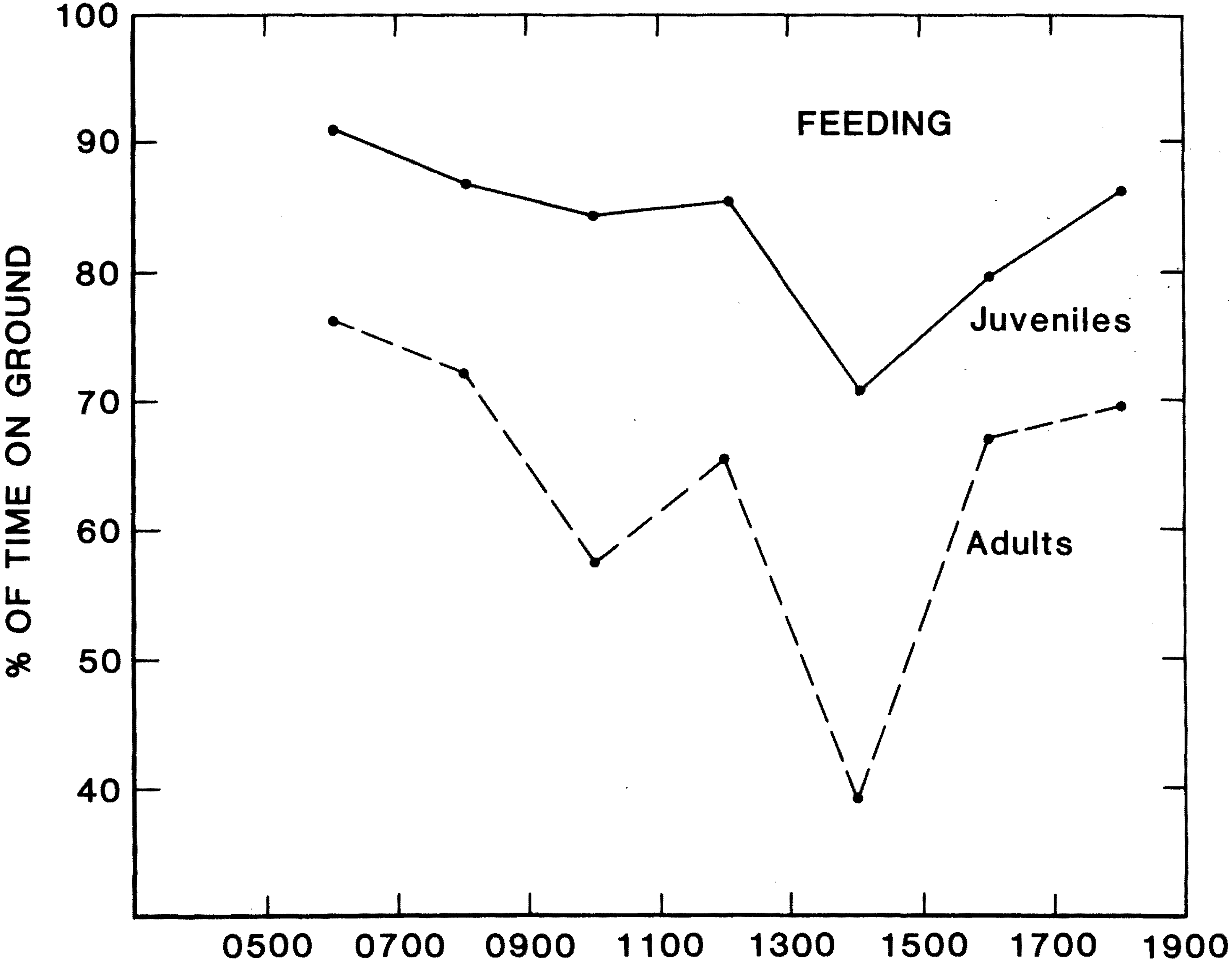


Fig. 1. Diurnal variation in the percentage of ground time lesser snow geese spent feeding on the Aichilik River delta, Arctic National Wildlife Refuge, September 1984.

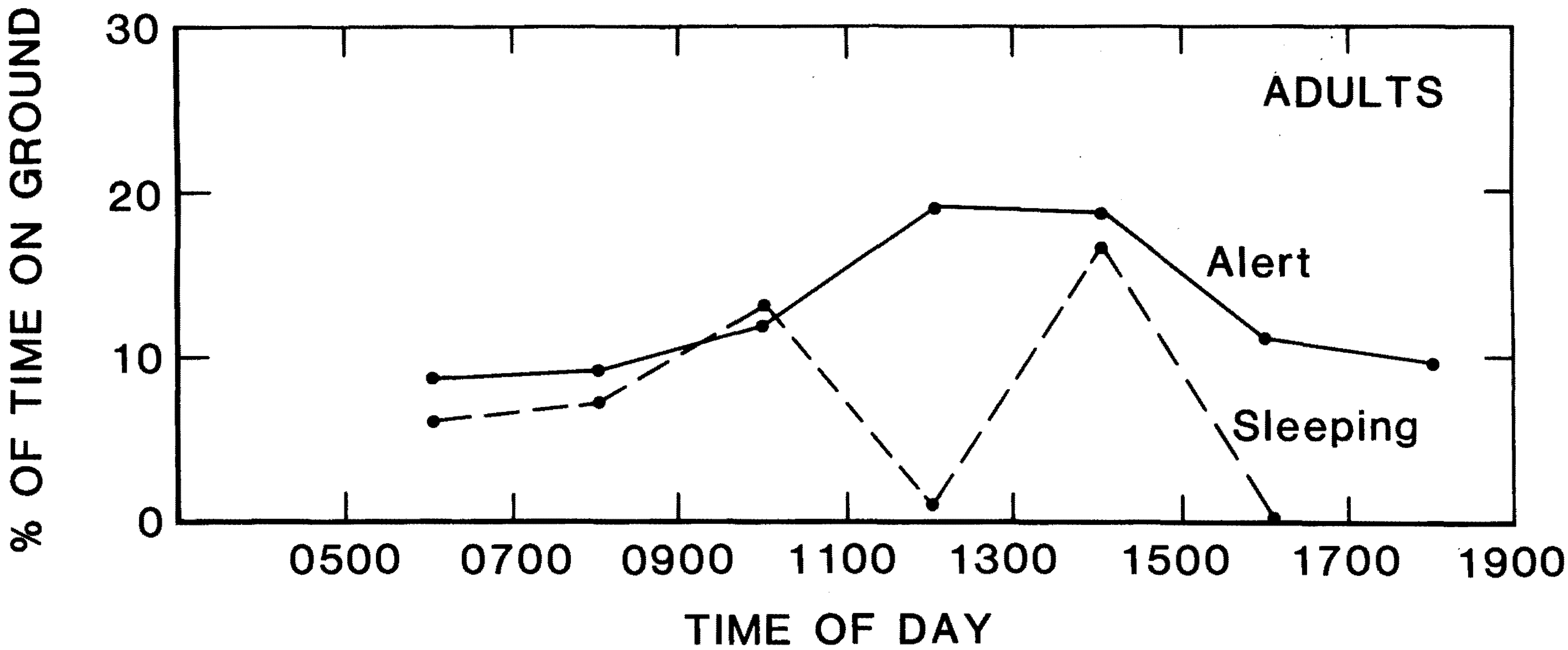


Fig. 2. Diurnal variation in the percentage of ground time adult lesser snow geese spent on alert and sleeping on the Aichilik River delta, Arctic National Wildlife Refuge, September 1984.

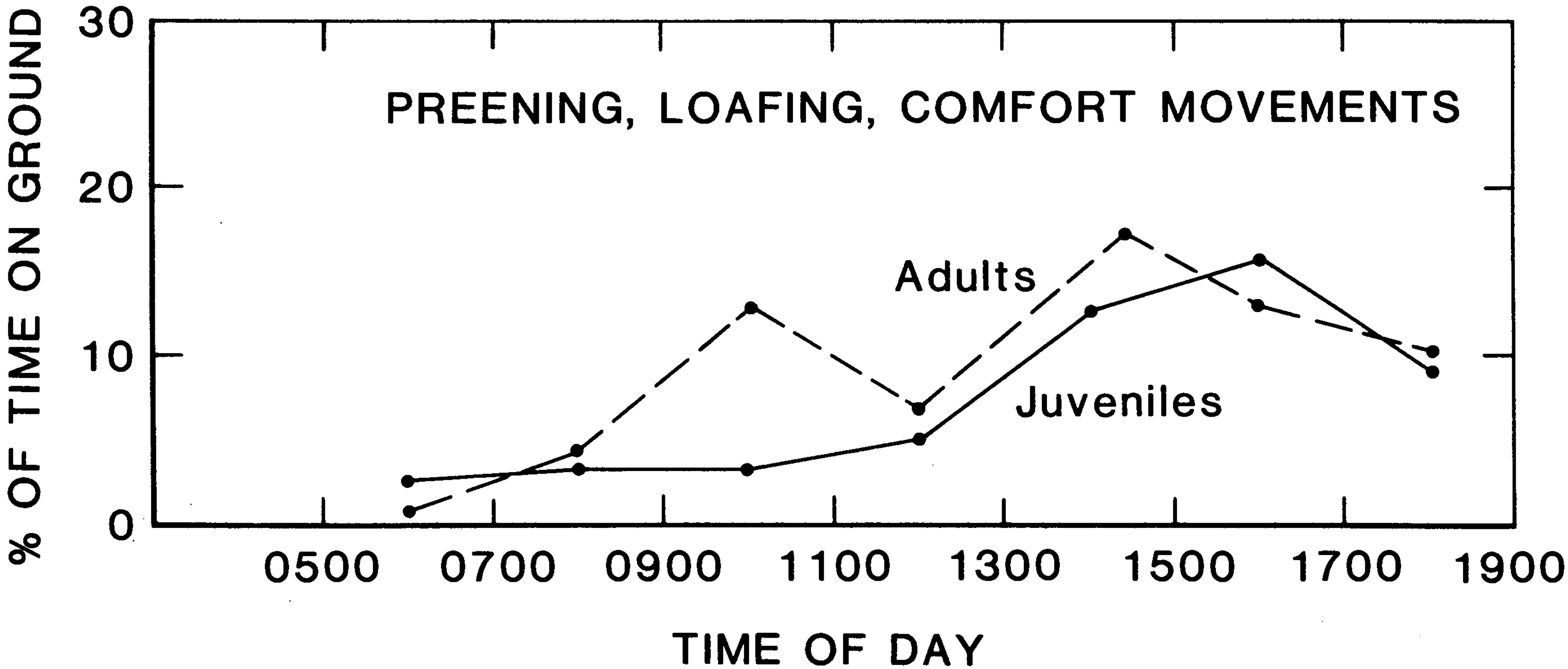


Fig. 3. Diurnal variation in the percentage of ground time lesser snow geese spent preening, loafing, and in comfort movements on the Aichilik River delta, Arctic National Wildlife Refuge, September 1984.

Table 5. The percentage of daylight hours spent at each of four primary and nine secondary activities by snow geese observed on the Aichilik River Delta area, Arctic National Wildlife Refuge, Alaska, September 1984.

| Activity | Age class | |
|---|---|---|
| | Adults | Juveniles |
| Primary | | |
| Sitting | 5.6 | 0.8 |
| Standing | 63.8 | 54.9 |
| Walking | 24.9 | 37.9 |
| Flying[a] | 5.8 | 5.8 |
| Secondary[b] | | |
| Feeding | 60.6 | 78.7 |
| Drinking | 0.1 | 0.2 |
| Alert | 12.2 | 1.5 |
| Agonistic | 0.3 | 0.1 |
| Loafing | 3.7 | 2.1 |
| Preening | 4.1 | 4.6 |
| Comfort movements | 1.9 | 0.7 |
| Sleeping | 6.0 | 1.0 |
| Walking | 5.5 | 5.5 |

[a] Based on 141 instantaneous flock observations. All other figures are based on the means of the percentages in each of seven daily two hour time blocks. The percentages were readjusted proportionally to equal approximately 100%.

[b] time spent flying was included in this category when the percentages were adjusted to 100%.

Of the four primary behaviors, juveniles spent 13.0% more time walking and 9.0% less time standing than did adults. These differences are primarily a result of more time spent walking during feeding activity by juveniles than adults. Juveniles spent 40.7% of their feeding time walking, and adults spent 29.9%. Although this difference was not consistent throughout the daylight hours (Fig. 4), it is an indication of less efficient feeding by juveniles since walking-feeding behavior is basically a function of searching activity by the geese during feeding. In addition to the apparent need of juveniles to obtain more food than adults, due to lower fat reserves, the inefficient feeding by juveniles may account for a portion of the greater amount of time they spent feeding.

The mean daily percentage of flying time was 5.8% based on 141 instantaneous scans of flocks. This estimate is similar to the 5.3% that Davis and Wisely (1974) found on the Yukon North Slope. Diurnal patterns in flying by geese (Fig. 5) were more pronounced in our study than those reported by Davis and Wisely but similar in relation to other activities. The greatest amount of time spent flying occurred during the early morning when geese were moving to feeding areas. Other peak periods of flying occurred in the late morning (0900-1059 h) and again in the early afternoon (1300-1459 h).

Additional time budget data will be needed to define variations in behavior affected by weather and the progression of the staging period. The apparent

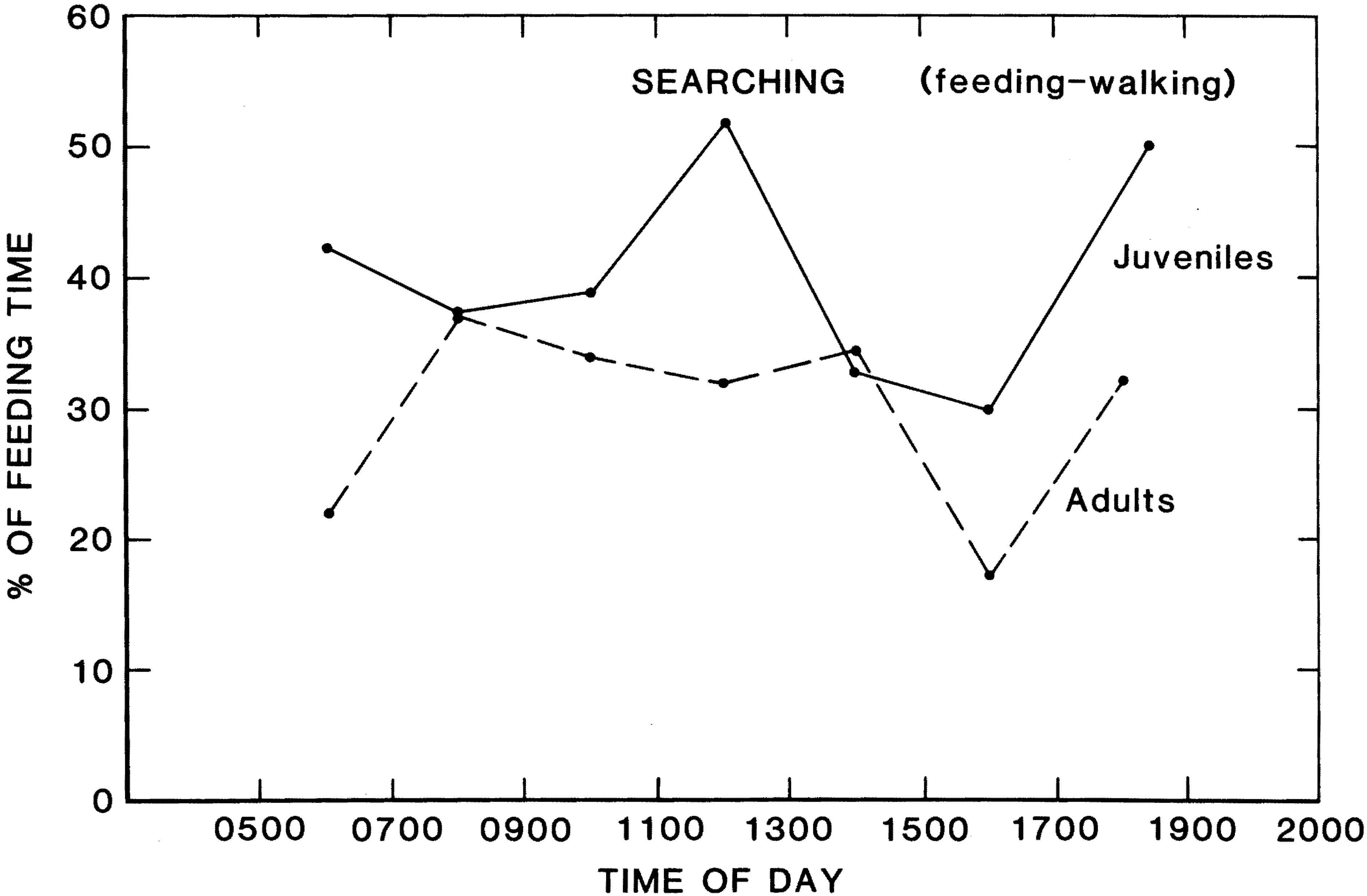


Fig. 4. Diurnal variation in the percentage of feeding time lesser snow geese spent walking on the Aichilik River delta, Arctic National Wildlife Refuge, September 1984.

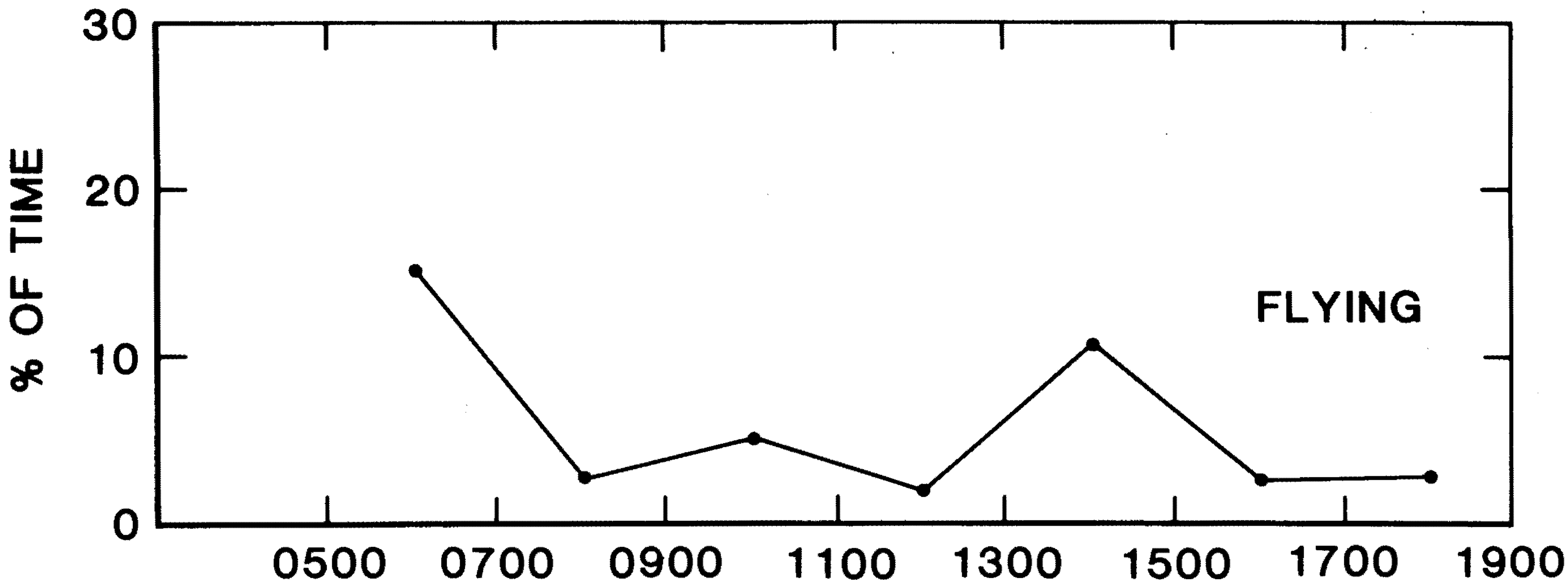


Fig. 5. Diurnal variation in the percentage of time lesser snow geese spent flying on the Aichilik River delta, Arctic National Wildlife Refuge, September 1984.

differences between juveniles and adults emphasizes the need to separate age classes in time budget studies of staging geese. The wide variation in adult behavior may be a result of the inability of observers to distinguish between sexes and between breeding, non-breeding, and unsuccessful breeding adults.


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APPENDIX

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Appendix Table 1. Means of the percentages of the relative frequency of the ground behaviors from seven daily time blocks shown by Lesser snow geese on the coastal plain of the Arctic National Wildlife Refuge, Alaska, September 1984.

| Activity | Adults | Juveniles |
|---|---|---|
| Sitting | | |
| Feeding | 0.65 | 0.04 |
| Alert | 0.66 | 0.02 |
| Agonistic | | |
| Loafing | 0.50 | 0.08 |
| Preening | 0.49 | 0.68 |
| Comfort movements | 0.70 | 0.01 |
| Sleeping | 2.61 | 0.68 |
| Standing | | |
| Feeding | 42.26 | 46.36 |
| Drinking | 0.06 | 0.17 |
| Alert | 9.91 | 1.38 |
| Agonistic | 0.23 | |
| Loafing | 3.15 | 1.99 |
| Preening | 3.56 | 3.91 |
| Comfort movements | 1.21 | 0.72 |
| Sleeping | 3.42 | 0.30 |
| Walking | | |
| Feeding | 17.71 | 32.28 |
| Alert | 1.63 | 0.06 |
| Agonistic | 0.06 | 0.08 |
| Walking | 5.49 | 5.47 |

Appendix Table 2. Percentages of the ground time staging adult Lesser snow geese spent in various activities on the Aichilik River Delta, the Arctic National Wildlife Refuge, Alaska, September 1984.

| Activity | Time period | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0500 | 0700 | 0900 | 1100 | 1300 | 1500 | 1700 |
| | n=197[a] | n=755 | n=438 | n=291 | n=228 | n=199 | n=259 |
| Sitting | | | | | | | |
| Feeding | 4.06 | 0.80 | | | | | |
| Alert | 0.51 | 0.13 | 1.50 | | 2.63 | | |
| Agonistic | | | | | | | |
| Loafing | | 0.40 | 1.14 | | 2.19 | | |
| Preening | | 0.40 | 1.14 | | 2.19 | | |
| Comfort movements | | 0.13 | 0.23 | | 0.44 | | |
| Sleeping | 6.60 | 7.55 | | 1.38 | 3.95 | | |
| Standing | | | | | | | |
| Feeding | 58.88 | 45.43 | 37.44 | 45.36 | 25.44 | 55.28 | 47.49 |
| Drinking | | | | | 0.44 | | |
| Alert | 7.11 | 7.29 | 6.39 | 17.18 | 15.79 | 11.06 | 9.27 |
| Agonistic | 1.52 | 0.13 | | | | 0.50 | |
| Loafing | 1.02 | 1.99 | 1.83 | 4.47 | 2.63 | 6.53 | 5.02 |
| Preening | 1.02 | 0.40 | 6.62 | 2.75 | 7.90 | 4.02 | 3.86 |
| Comfort movements | | 0.93 | 1.60 | 0.34 | 2.63 | 2.01 | 1.54 |
| Sleeping | | | 13.24 | | 12.28 | | |
| Walking | | | | | | | |
| Feeding | 17.26 | 26.76 | 19.41 | 20.62 | 13.60 | 11.56 | 22.39 |
| Alert | 1.02 | 1.72 | 4.11 | 2.75 | 1.32 | 0.50 | 0.77 |
| Agonistic | | 0.40 | | | | | 1.16 |
| Walking | 1.02 | 5.83 | 5.25 | 4.81 | 7.02 | 8.54 | 8.49 |

[a]Total number of 15 sec observations in that time block.

Appendix Table 3. Percentages of ground time staging juvenile Lesser snow geese spent in various activities on the Aichilik River Delta, Arctic National Wildlife Refuge, Alaska, September 1984.

| Activity | Time period | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0500 | 0700 | 0900 | 1100 | 1300 | 1500 | 1700 |
| | n=125[a] | n=975 | n=333 | n=126 | n126 | n=167 | n=258 |
| Sitting | | | | | | | |
| Feeding | | | | 0.30 | | | |
| Alert | | | 0.18 | | | | |
| Loafing | | 0.31 | | 0.30 | | | |
| Preening | 0.80 | 0.51 | 1.25 | | 0.79 | 1.71 | |
| Comfort movements | | 0.10 | | | | | |
| Sleeping | | 1.13 | 3.03 | 0.90 | | | |
| Standing | | | | | | | |
| Feeding | 52.00 | 53.95 | 50.98 | 40.84 | 47.62 | 55.11 | 43.02 |
| Drinking | | 0.31 | 0.36 | 0.60 | | | |
| Alert | 4.00 | 0.92 | 2.14 | 0.30 | 0.79 | 1.71 | 0.39 |
| Agonistic | | | | | | | |
| Loafing | 1.60 | 1.13 | 1.60 | 1.50 | 3.97 | 2.28 | 2.71 |
| Preening | 1.60 | 1.85 | 0.71 | 2.10 | 6.35 | 10.28 | 5.80 |
| Comfort movements | | 0.21 | 0.18 | 0.90 | 1.59 | 1.71 | 0.78 |
| Sleeping | | | 2.32 | | | | |
| Walking | | | | | | | |
| Feeding | 38.4 | 32.51 | 33.16 | 45.05 | 23.02 | 23.86 | 43.02 |
| Alert | 0.80 | | 0.18 | | | 0.57 | |
| Agonistic | | | 0.36 | 0.30 | | | |
| Walking | 0.80 | 7.08 | 3.57 | 6.91 | 15.08 | 2.84 | 4.264 |

[a]Total number of 15 sec observations in that time block.

Appendix Table 4. Frequency and percentages of time Lesser snow geese were observed flying in seven daily time blocks on the coastal plain of the Arctic National Wildlife Refuge, Alaska, September 1984.

| Hour | No. Flocks | No. Flying | Total No. Geese | % |
|---|---|---|---|---|
| 0500 - 0659 | 54 | 1412 | 9230 | 15.30 |
| 0700 - 0859 | 17 | 118 | 3850 | 3.07 |
| 0900 - 1059 | 34 | 705 | 12904 | 5.46 |
| 1100 - 1259 | 8 | 193 | 9600 | 2.01 |
| 1300 - 1459 | 4 | 175 | 1560 | 11.22 |
| 1500 - 1659 | 8 | 16 | 1090 | 1.57 |
| 1700 - 1859 | 16 | 71 | 4120 | 1.72 |
| Totals | 141 | 2690 | 42,354 | mean = 5.75 |

ANWR Progress Report Number FY 85-9

# 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: A total of 103 brown bears (*Ursus arctos*) were captured and marked in May, June, and July 1982-1984 on the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge (ANWR). Radio-transmitters were attached to a total of 74 different bears during this time period and these bears were monitored through denning (October-November) each year. 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. No natural mortalities occurred among sample bears in 1982, however, 10 apparent mortalities occurred among 17 young bears (cubs and yearlings) in 1983. In 1984, 13 of 24 young bears were apparent mortalities. Reasons for these high mortality rates in 1983 (58.9%) and 1984 (54.2%) among young bears is unknown. Three mortalities were recorded among female bears in 1984. A young female (4.5-year old) was killed by an adult male; a mature female (14.5-year old) died of accidental strangulation on a survey marker, and another mature female (20.5-year old) died of unknown causes in October. Brown bears were observed feeding on cariobu (*Rangifer tarandus*) carcasses (adults and calves) on 6 occasions in 1982, on 15 occasions in 1983, and 17 occasions in 1984. Preliminary analysis of radio-relocation data indicate that brown bears appear to shift habitat use patterns to coastal areas in June and early July to coincide with occupancy of those habitats by calving and post-calving caribou. Emergence from winter dens occurred in late April and throughout May in 1983, but was confined to late April through mid-May in 1984, with early emergence of males and non-parturient females and later emergence of females with cubs and females with young. Elevations of den sites averaged 816 ± 61 m (SE) in 1983, and 966 ± 46 m (SE) in 1984. Aspects of den sites were predominantly southeast facing slopes (mean aspect, 1983 = 145° ± 20° SE; 1984 = 150° ± 18° SE). Slope at den sites averaged 54 ± 4% (SE) in 1983 and 56 ± 2% (SE) in 1984. In October and November, bears moved south into to foothills and mountainous habitats to den in both years. Only two bears in 1983 and two bears in 1984 denned on the coastal plain and foothill habitats in the 1002c study area.

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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 denning, 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 three 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 19 April through 7 November 1984. Bears were captured between 21 May and 15 June using a Bell 205B Jet Ranger helicopter. Fixed-wing aircraft were used to locate bears and direct the helicopter and 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). Bears recovered after the antidote (M50-50, Dipremorphine, 0.2 mg/ml, D-M Pharmaceuticals, Rockville, MD) was administered intravenously (same dosage as M99) and intramuscallary in the rump at 1/2 the dosage of M99. Certain bears (large males, etc.) were immobilized with the sernylan (phencyclidine hydrochloride, Bio-Centic

Laboratories, St. Joseph, Mo) and acepromazine maleate (Ayerst Labs, New York) using the Cap-Chur equipment. Young bear (cubs) were captured by hand and were injected with sernylan and acepromazine for handling and processing. 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 (Telonics, Inc., Mesa Az). Young age animals were fitted with expandable breakaway collars. These animals will be recaptured annually 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 unit during the breeding season.

The two 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 1:63,360 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 1:63,360 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 1:63,360 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 three den sample periods were based on den site 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 den site, two 30.5-m bisecting lines were established, with one line along the axis of the slope (up-slope line) and the other line (cross-slope line) perpendicular to the first. The den site was 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 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 den site). 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.

Spring snow depths at each den site were recorded. Soil samples were taken at all sample locations to determine soil texture (Brady 1974). 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 bears were captured and marked between 28 May and 16 June 1983. In addition, 11 bears captured in 1982 were recaptured in 1983 and refitted with new radio-collars (Table 1). An additional 23 bears were captured and marked between 21 May and 15 June 1984. In addition 34 bears captured in 1982 and 1983 were recaptured in 1984 and refitted with new radio-collared (Table 1). A total 74 different bears were outfitted with radio-collared during 1982-1984. Distribution of capture locations for 57 bears captured in 1984 included 27 (13 males, 14 females) in coastal plain habitats, 16(4 males, 12 females) in foothills habitats, and 14 (7 males, 7 females) in mountainous habitats(Fig. 1).

Average weights of captured adult bears from 1982-1984 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). Bear captured in the current study were limited to spring and early summer capture periods.

Table 1. Physical characteristics of brown bears captured on the Arctic National Wildlife Refuge, Alaska, May June and July 1982-1984 (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 Cr. | 28 June 1982 |
| 1056 | M[a] | 22.5 | 350/159 | - | - | - | 68 | 130 | 22.6 | 35.6 | - | - | - | Niguanak R. | 10 June 1984 |
| 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 |
| 1182 | F[a] | 17.5 | 200/91 | - | - | - | 56 | - | 19.9 | 33.3 | - | - | - | Jago R. | 13 June 1984 |
| 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 |
| 1185 | F[a] | 20.5 | 220e/100 | - | - | - | 57 | 95 | 19.6 | 31.5 | - | - | - | Aichilik R. | 21 May 1984 |
| 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 |
| 1188 | M[a] | 6.5 | 350e/159 | - | - | - | 68 | 121 | 20.5 | 36.4 | - | - | - | Kongakut R. | 13 June 1984 |
| 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 |
| 1189 | F[a] | 7.5 | 185/84 | - | - | - | - | - | - | - | - | - | - | Turner R. | 21 May 1984 |
| 1189 | F[a] | 7.5 | - | - | - | - | - | - | - | - | - | - | - | Turner R. | 9 June 1984 |
| 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 |
| 1190 | F | 9.5 | - | - | - | - | - | - | - | - | - | - | - | Clarence R. | 10 June 1984 |
| 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 |
| 1194 | M[a] | 13.5 | 380/172 | - | - | - | 83 | 122 | 21.7 | 37.7 | - | - | - | Turner R. | 9 June 1984 |
| 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 |
| 1197 | F[a] | 10.5 | 200/91 | - | - | - | 58 | 103 | 19.5 | 31.5 | - | - | - | Aichilik R. | 9 June 1984 |
| 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 |
| 1200 | M[a] | 15,5 | 380/173 | - | - | - | 71 | - | 22.8 | 35.6 | - | - | - | Marsh Cr. | 12 June 1984 |
| 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 |
| 1202 | F[a] | 18.5 | - - | - | - | - | - | - | - | - | - | - | - | Nularvik R. | 21 May 1984 |
| 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 |
| 1203 | M[a] | 3.5 | - - | - | - | - | - | - | - | - | - | - | - | Nularvik R. | 21 May 1984 |
| 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 |
| 1204 | M[a] | 3.5 | - - | - | - | - | - | - | - | - | - | - | - | Nularvik R. | 21 May 1984 |
| 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 |
| 1205 | M[a] | 3.5 | - - | - | - | - | - | - | - | - | - | - | - | Nularvik R. | 21 May 1984 |
| 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 |
| 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 |

Table 1 (Continued.)

| Bear number | Sex | Cementum age | Weight (lbs./kg) | Total length | Body length | Hind foot | Neck | Girth | Head width | Head length | Upper Shoulder height | Lower left canine | General left canine | capture location | Date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1208 | F[a] | 9.5 | 205/93 | - | - | - | 58 | 95 | 19.5 | 32.1 | - | - | - | Hulahula R. | 12 June 1984 |
| 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 |
| 1210 | F[a] | 5.5 | - - | - | - | - | 58 | 92 | 18.1 | 31.1 | - | - | - | Okerokovik R. | 9 June 1984 |
| 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 |
| 1212 | F[a] | 15.5 | 220/100 | - | - | - | 54 | 98 | 21.0 | 31.7 | - | - | - | Okpirourak Cr. | 13 June 1984 |
| 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 |
| 1213 | F[a] | 14.5 | 200/91 | - | - | - | 67 | 92 | 18.1 | 30.9 | - | - | - | Katakturuk R. | 7 June 1984 |
| 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 |
| 1214 | F[a] | 4.5 | 175/79 | - | - | - | 51 | 84 | 17.2 | 30.6 | - | - | - | Carter Cr. | 12 June 1984 |
| 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 |
| 1216 | F[a] | 7.5 | 190/86 | - | - | - | 53 | 105 | 18.1 | 31.5 | - | - | - | Hulahula R. | 12 June 1984 |
| 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 |
| 1217 | F[a] | 14.5 | 225/102 | - | - | - | 63 | 101 | - | - | - | - | - | Okerokovik R. | 6 June 1984 |
| 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 |
| 1223 | M[a] | 8.5 | 210/95 | - | - | - | 63 | 104 | 19.6 | 34.6 | - | - | - | Okerokovik R. | 6 June 1984 |
| 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 |
| 1225 | M[a] | 19.5 | 390/177 | - | - | - | 67 | 119 | 22.4 | 34.1 | - | - | - | Egaksrak R. | 14 June 1984 |
| 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 |
| 1226 | M[a] | 12.5 | 400/181 | - | - | - | 76 | 126 | 23.3 | 37.1 | - | - | - | Kongakut R. | 14 June 1984 |
| 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 |
| 1230 | F[a] | 9.5 | 150/68 | - | - | - | 49 | 94 | 17.5 | 30.5 | - | - | - | Kongakut R. | 14 June 1984 |
| 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 |
| 1231 | F[a] | 3.5 | 145/66 | - | - | - | 49 | 84 | 16.1 | 29.1 | - | - | - | Angun R. | 8 June 1984 |
| 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 |
| 1232 | M[a] | 3.5 | 150/68 | - | - | - | 53 | 87 | 16.2 | 29.6 | - | - | - | Angun R. | 8 June 1984 |
| 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 |
| 1234 | F | 3.5 | 140/63 | - | - | - | - | - | - | - | - | - | - | Turner R. | 8 June 1984 |
| 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 |
| 1235 | F[a] | 3.5 | 140/63 | - | - | - | 46 | 15.8 | 29.4 | - | - | - | - | Kongakut R. | 14 June 1984 |
| 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 |

Table 1 (Continued.)

| Bear number | Sex | Cementum age | Weight (lbs./kg) | Total length | Body length | Hind foot | Neck | Girth | Head width | Head length | Upper Shoulder height | Lower left canine | General left canine | capture location | Date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 1248 | F[a] | 11.5 | – | – | – | – | 59 | 89 | 18.6 | 30.6 | – | – | – | Kongakut R. | 11 June 1984 |
| 1249 | F | 3.5 | 110/50 | 122 | 74 | 22 | 53 | 86 | 15.2 | 28.1 | 83 | – | – | Kongakut R. | 12 June 1983 |
| 1249 | F[a] | 4.5 | 130/59 | – | – | – | 48 | 84 | 16.0 | 28.5 | – | – | – | Kongakut R. | 10 June 1984 |
| 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 |
| 1252 | F[a] | 8.5 | 205/93 | – | – | – | 57 | 93 | 19.2 | 30.7 | – | – | – | Kongakut R. | 15 June 1984 |
| 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 |
| 1257 | F[a] | 9.5 | 190/86 | – | – | – | 53 | 89 | 18.8 | 31.8 | – | – | – | Okpilak R. | 13 June 1984 |
| 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 |
| 1259 | F[a] | 24.5 | 195/88 | – | – | – | 60 | 94 | 19.6 | 32.1 | – | – | – | Itkilyariak R. | 13 June 1984 |
| 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 |
| 1260 | F[a] | 11.5 | 255/16 | – | – | – | 58 | 110 | 19.5 | 32.4 | – | – | – | Egaksrak R. | 10 June 1984 |
| 1261 | F[a] | 7.5 | 190e/86 | – | – | – | 52 | 89 | 18.0 | 31.2 | – | – | – | Aichilik R. | 21 May 1984 |
| 1262 | M[a] | 10.5 | 395/179 | – | – | – | 82 | – | 24.0 | 35.9 | – | – | – | Okerokovik R. | 6 June 1984 |
| 1263 | M[a] | 11.5 | 300/136 | – | – | – | 71 | 108 | 21.5 | 36.6 | – | – | – | Katakturuk R. | 7 June 1984 |
| 1264 | M[a] | 11.5 | 445/202 | – | – | – | 79 | 129 | 24.1 | 38.2 | – | – | – | Aichilik R. | 8 June 1984 |
| 1265 | M | 0.5 | 22/10 | – | – | – | 26 | 43 | 10.7 | 16.5 | – | – | – | Aichilik R. | 9 June 1984 |
| 1266 | M | 0.5 | 17/8 | – | – | – | 25 | 40 | 10.1 | 15.0 | – | – | – | Aichilik R. | 9 June 1984 |
| 1267 | F[a] | 10.5 | 220e/100 | – | – | – | 63 | 103 | 19.3 | 30.4 | – | – | – | Jago R. | 9 June 1984 |
| 1268 | M[a] | 3.5 | 145/66 | – | – | – | 51 | 80 | 15.4 | 28.1 | – | – | – | Egaksrak R. | 10 June 1984 |
| 1269 | F[a] | 10.5 | 175/79 | – | – | – | 49 | 79 | 17.9 | 31.1 | – | – | – | Itkilyariak R. | 11 June 1984 |
| 1270 | M | 0.5 | 14/6 | – | – | – | 21 | 39 | 9.7 | 15.1 | – | – | – | Clarence R. | 11 June 1984 |
| 1271 | M | 0.5 | 15/7 | – | – | – | 23 | 37 | 9.7 | 15.6 | – | – | – | Kongakut R. | 11 June 1984 |
| 1272 | F | 0.5 | 17/8 | – | – | – | 25 | 41 | 9.9 | 15.0 | – | – | – | Kongakut R. | 11 June 1984 |
| 1273 | M[a] | 7.5 | 205/93 | – | – | – | 56 | 93 | 17.9 | 32.6 | – | – | – | Jago R. | 13 June 1984 |
| 1274 | M[a] | 4.5 | 165/75 | – | – | – | 51 | 93 | 15.9 | 27.3 | – | – | – | Niguanak R. | 13 June 1984 |
| 1275 | M[a] | 12.5 | 385/175 | – | – | – | 63 | 113 | 20.7 | 33.6 | – | – | – | Aichilik R. | 14 June 1984 |
| 1276 | F | 0.5 | 15/7 | – | – | – | 21 | 36 | 9.1 | 15.2 | – | – | – | Kongakut R. | 14 June 1984 |
| 1277 | M | 0.5 | 16/7 | – | – | – | 21 | 35 | 10.1 | 15.8 | – | – | – | Kongakut R. | 14 June 1984 |
| 1278 | F[a] | 8.5 | 185/84 | – | – | – | 50 | 99 | 18.5 | 31.0 | – | – | – | Paulaluk R. | 15 June 1984 |
| 1279 | M | 0.5 | 10/5 | – | – | – | 19 | 32 | 9.0 | 14.3 | – | – | – | Paulaluk R. | 15 June 1984 |
| 1280 | M | 0.5 | 14/6 | – | – | – | 22 | 37 | 10.3 | 15.0 | – | – | – | Paulaluk R. | 15 June 1984 |
| 1281 | M[a] | 6.5 | 260/118 | – | – | – | 61 | 106 | 19.9 | 33.9 | – | – | – | Aichilik R. | [illegible] June 1984 |
| 1282 | F[a] | 6.5 | 205/93 | – | – | – | 53 | 90 | 18.2 | 31.4 | – | – | – | [illegible] | [illegible] June 1984 |
| 1283 | M[a] | 4.5 | 195/88 | – | – | – | 56 | 70 | 14.0 | [illegible] | – | – | [illegible] | [illegible] | [illegible] 1984 |

[a]Radio-collared

[b][illegible]


Fig.1 Capture locations of brown bears on the Arctic National Wildlife Refuge, 1984.

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 | 26 | 145 | 93-202 | north slope, ANWR | This study 1982-1984 |
| Female | 33 | 93 | 68-116 | north slope, ANWR | This study 1982-1984 |

Productivity

Age structure of 75 captured bears and 21 associated unmarked young (Fig. 2) that were theoretically alive in late winter 1984 indicated a preponderance of males in age classes 5.5 years or less (15 males versus 8 females, plus 21 unidentified bears), while females predominated in age classes 6.5 years and older (31 females versus 21 males). Immature bears (4.5-years old or less) comprised 45.8% of the theoretical population in the late winter of 1984, with cubs, yearlings, 2.5-year old, 3.5-year old, and 4.5-year old comprising 24.0%, 1.0%, 6.3%, 10.4%, and 4.2% respectively. Adults comprised 54.2% of the theoretical population, while the sex ratio for the 75 captured bears was 36 males and 39 females.

This age structure differs from that presented for bears in northeast Alaska along the Canning River (Reynolds 1976). On the coastal plain and adjacent foothills and mountains of ANWR, 44 bears were captured that aged 3.5-11.5 years old, but only 22 bears captured aged 12.5 years and older. In contrast to the ANWR data, Reynolds (1976) captured more older age class bears (12.5+ years, n=43) than younger bears (3.5-11.5 years old, n=29) in the Canning River drainage. 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 population status of

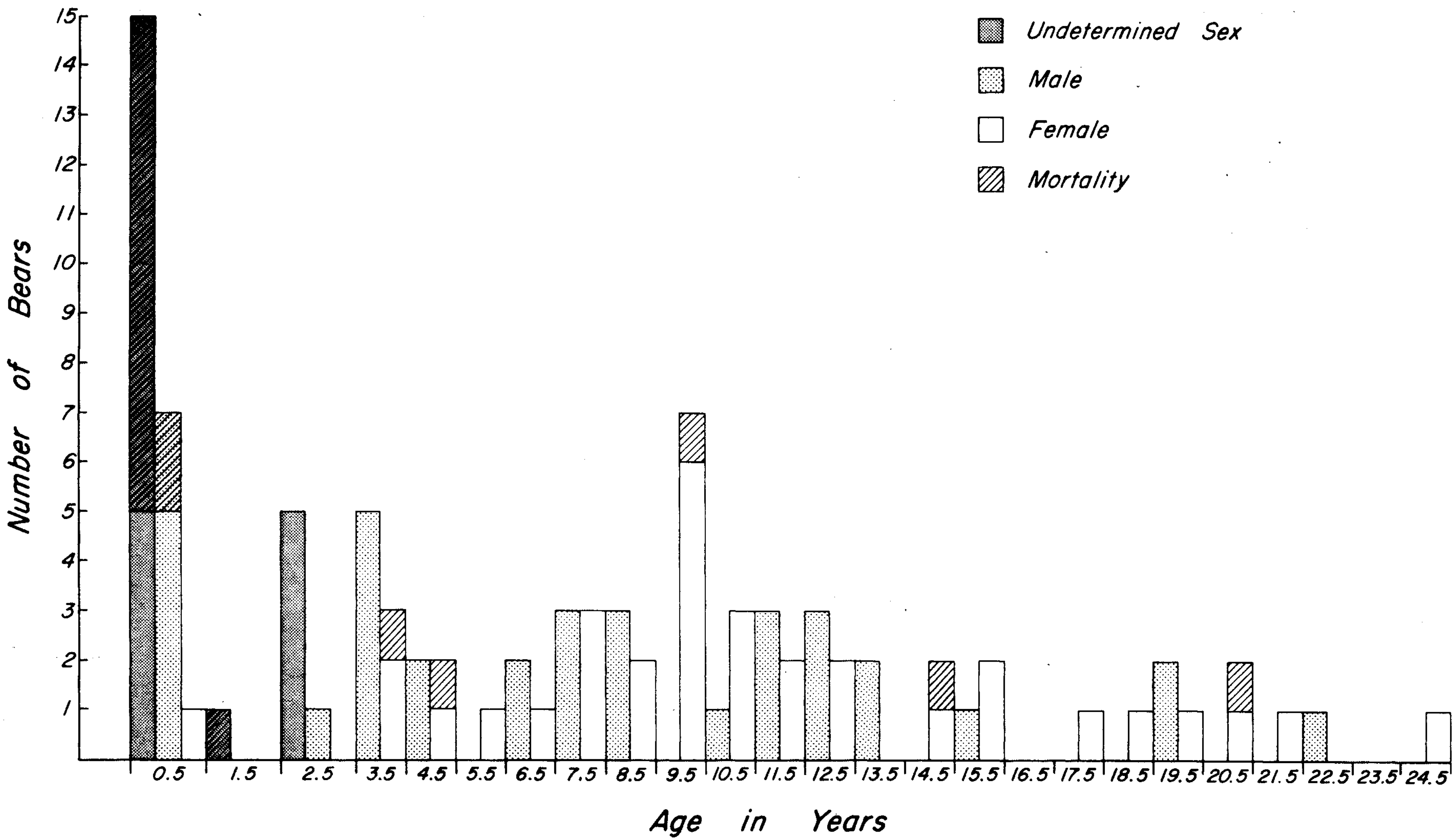


Fig. 2. Age structure of 75 captured bears and 21 associated unmarked young based upon known denning in fall 1983 an subsequent capture of new individuals in May and June 1984 in the northeastern portion of the Arctic National Wildlife Refuge, Alaska.

stable 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 relatively good survival of young bears through the first four years of life (Table 3). During 1982, nine 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). In 1982, mortalities were recorded for only two study related deaths and those data indicated a high survival rate for young bears from one 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 dying or disappearing from the maternal sow and are assumed dead. One radio-collared yearling (#1225) was killed by another bear in late June 1983. This apparent mortality represents a 58.9% mortality rate among the cubs and yearling cohorts in 1983. The 1984 survival data for young bears were similar to 1983, with 13 of 24 young bears (cubs and yearlings) either dying or disappearing from the maternal sow and are assumed dead (54.2% mortality rate). Reasons for the high mortality among young bears in 1983 and 1984 are undetermined at this time.

Two capture related mortalities occurred in 1984: bear 1190 (a 9.5-year old female with two cubs) and bear 1234 (a 3.5-year old female) died as a result of overheating while under the influence of M99. Capture procedures were modified following these two deaths. If body temperature was elevated at capture above 40°C, processing was suspended while the bear was placed in cold water or on snow fields until body temperature was lowered to approximately 38°C. The bear was then processed using normal procedures. Once this procedural change was implemented, overheating of immobilized bears was easily controlled. Three other mortalities occurred during 1984 (Fig. 2), bear 1249, a 4.5-year old female, was apparently killed on 30 August by bear 1226, a 12.5-year old male. On September 18, bear 1213 (a 14.5-year old female) was found dead at a survey monument on the coastal plain. The radio-collar was entangled in the metal survey stake and the bear had apparently suffocated due to strangulation. On 15 October, a wolverine (Gulo gulo) was feeding on the carcass of bear 1185 (a 20.5-year old female). The carcass was no inspected and the cause of death is unknown.

Breeding season normally extends from May through approximately 10 July, with peak of breeding occurring between 10-20 June. Observations of pairs in 1984 were common during this period (Fig. 3), and pairs observed after late July were probably short-term reassociations of siblings and/or family groups. Sexual maturity in females evidently occurs at 6.5 years of age, with 8 of 26 females with young breeding at 5.5 years of age (Table 4). Two females apparently successfully bred when 4.5 years of age. The loss of young bears (cubs and yearlings) noted earlier that occurs early in the summer often results in rapid recycling of the maternal females into the breeding cycle. Bears 1212 and 1217 each lost cubs in one year and produced another litter of cubs the following year (Table 4). Bears 1190 and 1197 lost yearlings and 2.5-year old respectively, and each produced cubs the following year(Table 4).

Table 3. Maternal females brown bears captured on the Arctic National Wildlife Refuge their associated offspring, and the fate of those offspring, 1982-1984.

| | Offspring | | | Time period with female | | |
|---|---|---|---|---|---|---|
| | 1982 | 1983 | 1984 | | | |
| Bear # | Number/age/sex | Number/age/sex | Number/age/sex | 1982 | 1983 | 1984 |
| 1182 | 2/cubs/FF | 2/yrlg/FF | no young | all season | both disappear-9 June | -- |
| 1185 | 2/yrlg | 2/2.5yr/FM | 3/3.5yr/FM | all season | all season | 2 separated 5 June |
| 1190 | 2/cubs/MM | 2/yrlg/MM | 3/cubs | all season | only 1 emerge den disappear 9 June | sow died at capture |
| 1193 | -- | 2/cubs | radio failed 83 | -- | through 7 Aug (radio failed) | -- |
| 1197 | 2/yrlg | 2/2.5yr | 2/cubs | all season | both disappear 27 June | 2 disappear 23 June |
| 1202 | 3/yrlg/MMM | 3/2.5yr/MMM | 3/3.5yr/MMM | all season | all season | 1 separated 8 June<br>2 separated 13 June |
| 1206 | -- | -- | 1/cub | -- | -- | disappear 1 June |
| 1208 | 2/cubs | 2/yrlg | no young | all season | 1 disappear 9 June<br>1 disappear 15 June | -- |
| 1212 | -- | 1 cub | no young emerge den | -- | all season | -- |
| 1213 | 1/2.5yr/F | 1/3.5/F | 1/4.5/F | all season | all season | separate 27 May |
| 1217 | -- | 1/cub | 2/cubs | -- | disappear 8 May | 2 disappear 16 May |
| 1220 | 1/3.5yr/M | -- | 2/cubs | until 23 Aug | -- | 1 disappear 19 July<br>1 all season |
| 1227 | 2/yrlg | 2/2.5yr/FF | collar failed 83 | all season | 1 separated 30 May<br>1 separated 9 June | -- |
| 1230 | -- | -- | 2/cubs/FM | -- | -- | all season |
| 1236 | -- | 2/2.5yr/FF | no young | -- | 2 disappear 9 June | -- |
| 1239 | -- | 2/yrlg | 2/2.5yr | -- | all season | 2 disappear 27 Aug? |
| 1245 | -- | 2/yrlg | 1/2.5yr | -- | 1 disappear 5 Sept<br>1 all season | disappear 15 May |
| 1248 | -- | 1/3.5yr/F | 2/cubs +1 | -- | disappeared 17 June | 1 disappear 25 June<br>2 with sow 28 July; collar failed |
| 1252 | -- | 1/yrlg/M | 1/2.5yr/M | -- | all season | disappear 5 June |
| 1257 | -- | 1/yrlg | no young | -- | disappeared-date? | -- |
| 1260 | -- | -- | 1/cub | -- | -- | disappear 8 June |
| 1261 | -- | -- | 2/cubs | -- | -- | 2 disappear 13 June |
| 1267 | -- | -- | 2/2.5yr | -- | -- | all season |
| 1269 | -- | -- | 3/cubs | -- | -- | all season |
| 1278 | -- | -- | 2/cubs | -- | -- | all season |

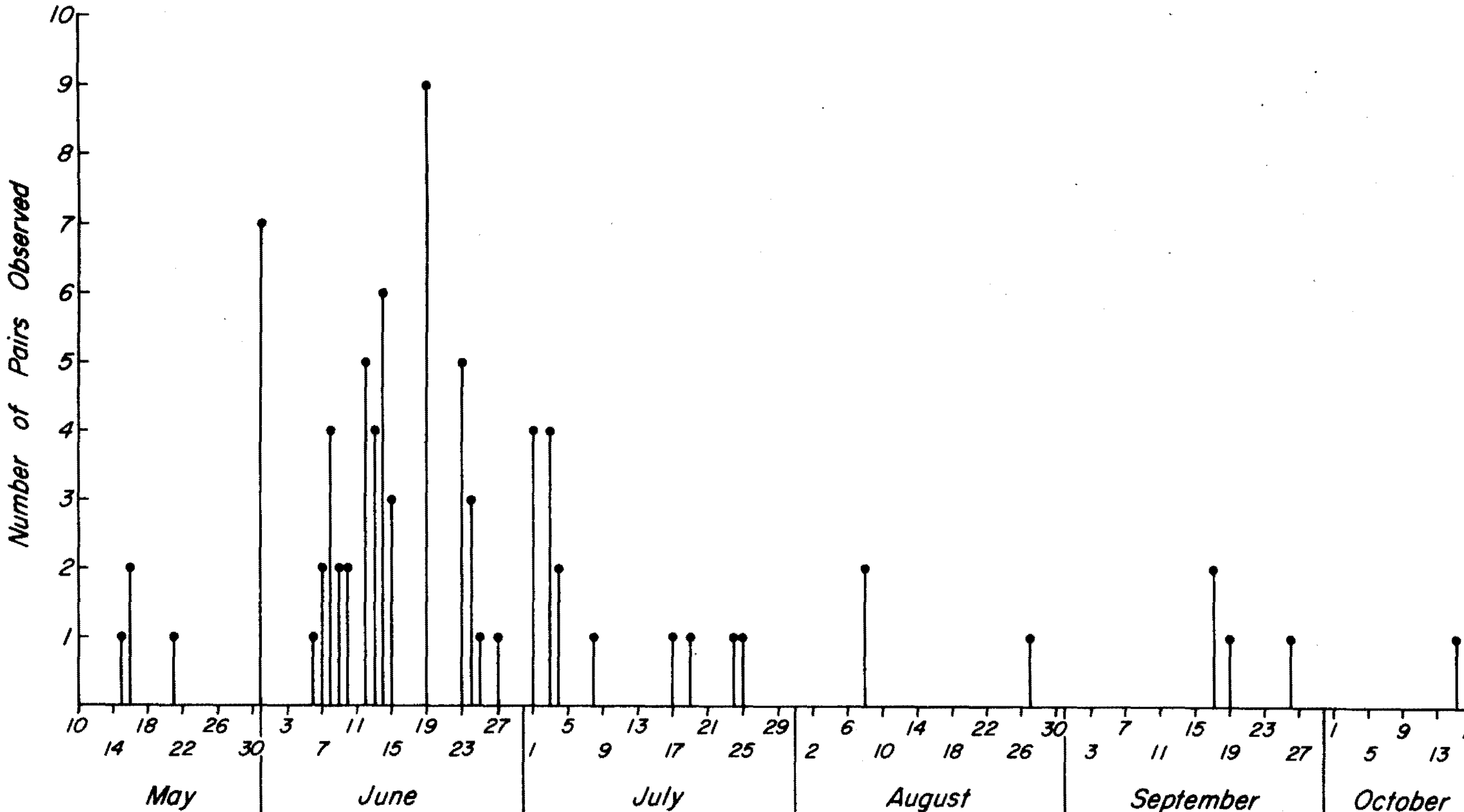


Fig. 3. Chronology of observations of brown bear pairs in the northeast portion of the Arctic National Wildlife Refuge, Alaska, 1984.

Table 4. Age of earliest observed breeding and known reproduction history for 26 female brown bears in the northeaster portion of the Arctic National Wildlife Refuge, 1982-1984.

| Bear # | Cementum age-1984 | Reproductive Status 1982 | 1983 | 1984 | Age at earliest breeding |
|---|---|---|---|---|---|
| 1182 | 17.5 | 2 cubs | 2 yrlgs | none | 14.5 |
| 1185 | 20.5 | 2 yrlg | 2-2yr | 2-3yr | 16.5 |
| 1190 | 9.5 | 2 cubs | 2 yrlg | 3 cubs | 6.5 |
| 1193 | 10.5 | none | 2 cubs | 2 yrlg | 8.5 |
| 1197 | 10.5 | 2 yrlg | 2-2yr | 2 cubs | 6.5 |
| 1202 | 18.5 | 3 yrlg | 3-2yr | 3-3yr | 14.5 |
| 1206 | 9.5 | none | none | 1 cub | 8.5 |
| 1208 | 9.5 | 2 cubs | 2 yrlg | none | 6.5 |
| 1212 | 15.5 | none | 1 cub | 2 cubs | 13.5 |
| 1213 | 14.5 | 1-2yr | 1-3yr | 1-4yr | 9.5 |
| 1217 | 14.5 | milk,no cubs | 1 cub | 2 cubs | 12.5 |
| 1220 | 12.5 | 1-3yr | 1-4yr | 2 cubs | 6.5 |
| 1227 | 15.5 | 2-2yr | 2-3yr | unknown | 10.5 |
| 1230 | 9.5 | none,no milk | none | 2 cubs | 8.5 |
| 1236 | 9.5 | -- | 2-yr | none | 5.5 |
| 1239 | 9.5 | -- | 2-yrlg | 2-2yr | 6.5 |
| 1245 | 15.5 | -- | 2 yrlg | 1-2yr | 12.5 |
| 1247 | 19.5 | -- | milk,no cubs | 2 cubs | 18.5 |
| 1248 | 11.5 | -- | 1-3yr | 2 cubs | 6.5 |
| 1252 | 8.5 | -- | 1 yrlg | 1-2yr | 5.5 |
| 1257 | 9.5 | -- | 1 yrlg | none | 6.5 |
| 1260 | 11.5 | -- | none,no milk | 1 cub | 10.5 |
| 1261 | 7.5 | -- | -- | 2 cubs | 6.5 |
| 1267 | 10.5 | -- | -- | 2-2yr | 7.5 |
| 1269 | 10.5 | -- | -- | 3 cubs | 9.5 |
| 1278 | 8.5 | -- | -- | 2 cubs | 7.5 |

Population Characteristics

Conclusions based on 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 three or four year period. Similarly, parameters describing population dynamics and productivity, especially litter size, reproductive interval, and survival of young must be recorded for more than three years in order to be accurate (Reynolds 1980, Reynolds and Hechtel 1983).

Age and Sex Structure. The age and sex by 1984 of 100 captured and 24 associated unnmarked bears (Table 5) indicates a relatively young age structure. In the 3.5 to 11.5-year old age classes, 62 bears are represented by 32 males and 30 females. However, the 12.5 and older age classes contained only 24 bears (12 males and 12 females). This age structure would indicate an apparently stable or increasing population. These data are biased towards those bears that frequent the coastal plain and adjacent foothills of ANWR. Bears were only captured along the edges of more mountainous terrain and the central mountains were not searched to capture bears for this study.

Table 5. Age and sex structure of brown bears and associated young captured in the Arctic National Wildlife Refuge, 1982-84.

| Age by cementum (yr) | Number of bears: Age at capture 1982 | | | Age at capture 1983 | | | Age at capture 1984 | | | Age, by 1984, of all bears captured[a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | Unk | M | F | Unk | M | F | Unk | M | F | Unk |
| 0.5 | 2 | 2 | 12 | 0 | 0 | 4 | 7 | 2 | 17 | 7 | 2 | 17 |
| 1.5 | 3 | 0 | 4 | 2 | 0 | 12 | 0 | 0 | 2 | 0 | 0 | 2 |
| 2.5 | 1 | 1 | | 1 | 5 | 2 | 0 | 0 | 5 | 3 | 2 | 5 |
| 3.5 | 4 | 1 | | 0 | 1 | | 1 | 0 | | 5 | 5 | |
| 4.5 | 5 | 0 | | 1 | 0 | | 2 | 0 | | 3 | 2 | |
| 5.5 | 2 | 3 | | 0 | 1 | | 0 | 0 | | 5 | 1 | |
| 6.5 | 5 | 1 | | 1 | 0 | | 1 | 1 | | 6 | 2 | |
| 7.5 | 0 | 4 | | 0 | 1 | | 1 | 1 | | 4 | 3 | |
| 8.5 | 0 | 2 | | 0 | 3 | | 0 | 1 | | 5 | 3 | |
| 9.5 | 0 | 0 | | 0 | 1 | | 0 | 0 | | 0 | 7 | |
| 10.5 | 1 | 1 | | 1 | 2 | | 1 | 2 | | 1 | 5 | |
| 11.5 | 1 | 0 | | 1 | 1 | | 2 | 0 | | 3 | 2 | |
| 12.5 | 0 | 2 | | 2 | 0 | | 1 | 0 | | 3 | 2 | |
| 13.5 | 1 | 2 | | 0 | 0 | | 0 | 0 | | 3 | 0 | |
| 14.5 | 0 | 0 | | 0 | 1 | | 0 | 0 | | 0 | 2 | |
| 15.5 | 0 | 1 | | 0 | 0 | | 0 | 0 | | 1 | 3 | |
| 16.5 | 0 | 1 | | 0 | 0 | | 0 | 0 | | 0 | 0 | |
| 17.5 | 1 | 0 | | 0 | 0 | | 0 | 0 | | 0 | 1 | |
| 18.5 | 1 | 1 | | 1 | 1 | | 0 | 0 | | 0 | 1 | |
| 19.5 | 0 | 0 | | 1 | 0 | | 0 | 0 | | 2 | 1 | |
| 20.5 | 1 | 0 | | 1 | 0 | | 0 | 0 | | 1 | 1 | |
| 21.5 | 0 | 0 | | 0 | 0 | | 0 | 0 | | 1 | 0 | |
| 22.5 | 0 | 0 | | 0 | 0 | | 0 | 0 | | 1 | 0 | |
| 23.5 | 0 | 0 | | 0 | 1 | | 0 | 0 | | 0 | 0 | |
| 24.5 | 0 | 0 | | 0 | 0 | | 0 | 0 | | 0 | 1 | |
| Total | 28 | 22 | 16 | 12 | 18 | 18 | 16 | 7 | 24 | 54 | 46 | 24 |

[a] These figures do not include bear # 1201F or 1215M, 5.5 yrs and 18.5yrs old respectively, which died of capture-related causes in 1982, bear no. 1255M, a 1.5 yr-old bear killed by another bear in 1983, or any unmarked offspring of marked females which disappeared from family groups and were presumed dead prior to 1984.

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 six years or longer (Reynolds In press, Reynolds and Hechtel 1983), accurate measures of reproductive rates require long-term observations. As mentioned earlier, the reproductive history of female brown bears in ANWR (Table 6) indicates a rapid recycling of females into the breeding cycle, when young cubs are lost early in the breeding season.

## Interaction Between Brown Bears and Caribou

Brown bears were observed in the vicinity of caribou (Rangifer tadarandus) throughout June on the coastal plain. In a majority of these instances, caribou did not react to bears, nor did bears react to caribou. Bears were observed chasing caribou on three occasions between 11-23 June, and were observed feeding on caribou calf carcasses on 10 occasions between 1-24 June. Bears were observed feeding on adult-sized caribou carcasses on six occasion between 1 June and 8 July, and large male bear was feeding on a caribou carcass on 16 October. These observations are in agreement with previous years data (Garner et al. 1984) and indicate that caribou are probably an important food source during June and early July. However, this use appears to be limited to the time when the Porcupine herd is present on the coastal plain and adjacent foothills. Detailed analyses of bear and caribou movement patterns and use of home ranges by bears will clarify this temporal relationship.

## Denning

During fall 1983, dens of 46 radio-collared and 12 unmarked brown bears were located (Garner et al. 1984). Beginning on 19 April 1984, 43 radio-collared bears were monitored regularly to determine approximate dates of emergence from winter dens (Table 7). One bear was out of the den on 19 April, 0 on 23 April, 7 on 27 April, 0 on 28 April, 1 On 1 May, 18 on 6 May, 7 on 7 May, 6 on 15 May, and 3 on 16 May 1984. In contrast to 1983 when 18 of 28 radio-collared bears were out of the den by 1 May (Garner et al. 1984), only 9 of 43 radio-collared bears were out of the den by 2 May 1984. No females with cubs of the year were out of the den by 6 May 1984. On 6 and 7 May, an additional 25 bears were out of the dens. This group included six sows with cubs of the year. By 16 May all 43 radio-collared bears were out of the den, including an additional three sows with cubs of the year (Table 7). Den emergence among radio-collared bears followed the general patterns of early emergence by males and no-paturient females and later emergence of females with new cubs and females with young (Quimby 1974, Ruttan 1974, Harding 1976). Den emergence of radio-collared bears in 1984 was more compressed than 1983, when emergence extended from 24 April through 30 May. In 1984, radio-collared bears were out of dens between 19 April and 16 May. Reasons for differences in emergence dates is unknown, but assumed to be related to variations in temperatures and snow cover.

Den sites of 38 radio-collared bears and 11 unmarked bears were inspected in late May 1984 and physical characteristics of each den were measured. Each

Table 6. Reproductive history and litter size for female brown bears in the Arctic National Wildlife Refuge, 1982-84.

| Bear # | Age in 1984[a] (yr) | Offspring No. | Offspring prior to capture | Reproductive history/litter size[b] 1982 | 1983 | 1984 | Comments[c] |
|---|---|---|---|---|---|---|---|
| 1182 | 17.5 | 1283F,1284F | Yes | 2 cub | 2 ylg/B | B | 1983: Mort 2 ylg |
| 1185 | 20.5 | 1231F,1232M | Yes | 2 ylg | 2 2yr/B | 2 3yr/B | w/2yr after B |
| 1187 | 8.5 | | No | B? | B | UN | |
| 1189 | 7.5 | | | B? | B | B | |
| 1190 | 9.5 | 1191M, 1192M; 1270M, 2Um Cub | Yes | 2 cub | 1 ylg/B | 3 cub | 1983: Mort 1 ylg; 1984: Capture mort, Mort 2 cubs |
| 1193 | 10.5 | 2UM cub | Yes | B | 2 cubs | UN | |
| 1197 | 10.5 | 2UM; 1265M 1266M | Yes | 2 ylg | 2 2yr/B | 2 cub/B? | 1984: mort 2 cubs |
| 1201 | 6.5[d] | | No | B | | | 1982: Capture mort |
| 1202 | 18.5 | 1203M,1204M, 1205M | Yes | 3 ylg | 3 2yr | 3 3yr/B | |
| 1206 | 9.5 | 1UM cub | Yes | B | B | 1 cub/B | 1984: Mort 1 cub |
| 1208 | 9.5 | 2UM cub | Yes | 2 cub | 2 ylg/B | B | W/ylg after B; 1 ylg mort |
| 1210 | 5.5 | | No | NB | B | B | |
| 1212 | 15.5 | 1UM cub | Yes | B | 1 cub | B | 1983/84: mort cub in den? |
| 1213 | 14.5 | 1214F | Yes | 1 2yr | 1 3yr/B | 1 4yr/B | W/3yr after breed |
| 1216 | 7.5 | | No | B? | B | B | |
| 1217 | 13.5 | 1UM cub; 2UM cub | Yes | B | 1 cub/B | 2 cub/B | 1983: 1 cub mort; 1984: mort 2 cubs |
| 1220 | 12.5 | 1221M; 2UM cub | Yes | 1 3yr | 1 4yr/B | 2 cub | 1984: mort 1 cub |
| 1227 | 15.5 | 1234F, 1235F | Yes | 2 ylg | 2 2yr/B | UN | |
| 1230 | 9.5 | 1276F, 1277M | Yes | B | B | 2 cub | |
| 1236 | 9.5 | 1237F, 1238F | Yes | 2 ylg | 2 2yr/B | B | 1983: Capture-related weaning? |
| 1239 | 9.5 | 2UM ylg | Yes | 2 cub | 2ylg | 2 2yr | |
| 1242 | 5.5 | | No | | B | UN | |
| 1243 | 12.5 | | Yes | | B | B | |
| 1245 | 15.5 | 2UM ylg | Yes | 2 cub | 2 ylg | 1 2yr/B | 1983: mort 1 ylg |
| 1247 | 19.5 | 2UM cub | Yes | | B | 2 cyb/B | 1984: mort 2 cub |
| 1248 | 11.5 | 1249F; 1271M, 1272F | Yes | 1 2yr | 1 3yr/B | 2 cub | 1984: mort 1 cub |
| 1249 | 4.5 | | No | | NB | NB | 1984: killed by no. 1226 |
| 1252 | 8.5 | 1253M | Yes | 1 cub | 1 ylg | 1 2yr/B | |
| 1257 | 9.5 | 1UM ylg | Yes | 1cub | 1 ylg | B | Separation at capture, mort? |
| 1258 | 10.5 | | Yes | | B? | UN | |
| 1259 | 24.5 | | Yes | | B | B | |
| 1260 | 11.5 | 1UM cub | | | B | 1 cub/B | 1984: mort 1 cub |
| 1261 | 7.5 | 2UM cub | Yes | | B | 2 cub | 1984: mort 2 cub |
| 1267 | 10.5 | 2UM 2yr | Yes | 2 cub | 2 ylg | 2 2yr | |
| 1269 | 10.5 | 3UM cub | Yes | | B | 3 cub | |
| 1278 | 8.5 | 1279M, 1280M | Yes | | B | 2 cub | May be 1983 Kongakut F |
| UM Hulahula, 1983 3 UMylg | | | Yes | 3 cub | 3 ylg | UN | |
| UM Kongakut, 1983 2UM 2yr | | | Yes | 2 ylg | 2 2yr/B? | UN | |
| UM Egaksrak, 1984 2UM ylg | | | | | 2 cub | 2 ylg | |
| UM Okerokovik, 1984 2 UM cub | | | | | B | 2 cub | |

a These ages were determined from dementum 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.

b Designations are as follows: UM, unmarked; UN, unobserved; B, bred during that season; NB, did not breed; cub, ylg, 2yr,3yr-female accompanied by cub, yearling, 2-year-old, or 3-year-old young; cub/B-cubs lost prior to breeding season, subsequent breeding by female; and, mort-mortality occurred. Litter sizes should be biewed as minimum since mortality to other offspring may have occurred prior to observation.

c Cub 1270 was placed with and adopted by female 1248 on 11 June 1984 after the capture-related death of female 1190. By 25 June 1984, one of 1248's cubs, either 1271 or 1272 had disappeared and was presumed dead.

d Age estimated from tooth wear.

Table 7. Approximate dates of emergence from winter dens for 43 radio-collared brown bears in the Arctic National Wildlife Refuge, 1984.

| Bear # | Age/sex | Date first observed out of den | Den type | Associated bears number/age/sex/bear# |
|---|---|---|---|---|
| 1056 | 22.5/M | 15 May | dug | none |
| 1182 | 17.5/F | 6 May | dug | none |
| 1185 | 20.5/F | 6 May | dug | 2/3.5-year old/FM/ 1231,1232 |
| 1188 | 6.5/M | 6 May | dug | none |
| 1189 | 7.5/F | 6 May | dug | none |
| 1190 | 9.5/F | 6 May | dug | 3/cubs |
| 1194 | 13.5/M | 27 April | dug | none |
| 1196 | 8.5/M | 6 May | dug | none |
| 1197 | 10.5/F | 16 May | dug | 2/cubs/MM/1265,1266 |
| 1198 | 7.5/M | 27 April | dug | none |
| 1200 | 15.5/M | 7 May | cave | none |
| 1202 | 18.5/F | 2 May | cave | 3/3.5-year old/MMM/1203,1204,1205 |
| 1206 | 9.5/F | 7 May | dug | 1/cub |
| 1208 | 9.5/F | 27 April | dug | none |
| 1210 | 5.5/F | 6 May | dug | none |
| 1212 | 15.5/F | 6 May | dug | none |
| 1213 | 14.5/F | 15 May | dug | 1/4.5-year old/F/1214 |
| 1216 | 7.5/F | 7 May | dug | none |
| 1217 | 14.5/F | 6 May | dug | 2/cubs |
| 1220 | 12.5/F | 16 May | dug | 2/cubs |
| 1223 | 8.5/M | 15 May | snow den | none |
| 1225 | 19.5/M | 16 May | dug | none |
| 1226 | 12.5/M | 6 May | dug | none |
| 1230 | 9.5/F | 6 May | dug | 2/cubs/FM/1276,1277 |
| 1233 | 13.5/M | 6 May | dug | none |
| 1234 | 3.5/F | 6 May | dug | none |
| 1235 | 3.5/F | 27 April | dug | none |
| 1236 | 9.5/F | 19 April | dug | none |
| 1239 | 9.5/F | 27 April | dug | 2/2.5-year old |
| 1240 | 7.5/M | 7 May | dug | none |
| 1241 | 19.5/M | 15 May | dug | none |
| 1243 | 12.5/F | 27 April | dug | none |
| 1244 | 12.5/M | 7 May | cave | none |
| 1245 | 15.5/M | 27 April | dug | 1/2.5-year old |
| 1246 | 11.5/M | 7 May | dug | none |
| 1247 | 19.5/F | 7 May | dug | 2/cubs |
| 1248 | 11.5/F | 15 May | dug | 2/cubs/MF/1271, 1272 |
| 1250 | 21.5/M | 6 May | dug | none |
| 1251 | 20.5/M | 6 May | dug | none |
| 1252 | 8.5/F | 6 May | dug | 1/2.5-year old/M/1253 |
| 1257 | 9.5/F | 6 May | dug | none |
| 1259 | 24.5/F | 15 May | dug | none |
| 1260 | 11.5/F | 6 May | dug | 1/cub |

den was revisited in late July and early August 1984 and the vegetational and soil characteristics of the den site were sampled. All dens were located in foothills and mountainous terrain except one den which was located in coastal plain tundra habitat. Elevations of all den sites averaged 965.7 $\pm$ 45.8 m (SE) with a range of 347-1649 m. Dens located in mountainous terrain (n=33) averaged 1106.4 $\pm$ 42.8 m (SE), while dens located in foothills terrain (n=12) averaged 637.3 $\pm$ 34.5 m (SE). The den located in tundra habitat on the coastal plain was 347 m in elevation (Table 8). The average elevation of all dens was similar to that found along the Canning River (975 m) by Reynolds et al. (1976) and is slightly higher in average elevation than reported for 29 den sites measured in 1983 by Garner et al. (1984) in the same area. Den sites were equally divided between the three slope positions of lower 1/3 (15), middle 1/3 (16), and upper 1/3 (15) in contrast with results of similar den surveys in 1983, when no den sites were located in the upper 1/3 of the slope (Garner et al. 1984).

Of the 45 dens inspected in late May, 25 were intact, 14 were partially collapsed, and 2 were collapsed (Table 8). One den was a snow den in 2 m of snow. The bed in this den was scraped tundra vegetation. Three dens were rock caves. In contrast, 31 dens were collapsed and 11 dens were partially collapsed in late July and early August. These data are in agreement with results reported for the same area in 1983 (Garner et al. 1984), and by Reynolds et al. (1976) and Reynolds (1980) for the Canning River and the western arctic areas in northern Alaska. No reuse of dug dens has been documented in the current study, however, reuse of rock caves does occur, and certain bears traditionally den in rock caves on ANWR (Bears 1202, 1203, 1204, 1205, and 1242, Table 8). All den sites were well drained and were located on slopes ranging from 26% to 99% ($\bar{x}$= 55.7 $\pm$ 1.90% SE). The incidence of collapsed dens in July and August agrees with Pearson's (1978) and Reynolds' (1980) conclusions that soil depth and moisture content are important factors in den site selection by northern brown bears (Table 8).

Aspects of den sites (Table 8) were examined using circular statistics (Batschelet 1981, Zar 1984). Aspects were concentrated in a southeast direction (Fig. 4), with a mean aspect of 150° (95% C.I, 132°-168°) with an angular dispersion of 52°. Aspects were not uniformly distributed in all directions (Raleigh's test; Z=16.3, P<0.001) and were strongly oriented in a southeast direction (mean aspect= 150°; V-test, u=3.25, 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 are also in close agreement with aspects (mean aspect= 145°) of 29 bear dens examined in 1983 (Garner et al. 1984). These data indicate that bear dens in the northeastern Brooks Range are located on slopes with aspects strongly oriented in a southeasterly direction. These slopes are warmer and are normally snow free earlier than northern facing slopes. Bears may be selecting southeastern facing slopes for the earlier warming trend; however, other edaphic factors may also be influencing this selection (i.e. permafrost depths, etc.)

During October and early November 1984, den sites of 41 radio-collared and two unmarked bears were recorded during den surveys. Distribution of these dens were 35 in mountainous terrain, six in foothills terrain, and two in coastal plain 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). Chronology of denning indicated that 3 bears were denned by 15 October, while an additional 31 bears were denned by the end of October

Table 8. Physical characteristics of 46 den sites used by brown bears during winter of 1983-1984 in the northeastern portion of the Arctic National Wildlife Refuge, Alaska.

| | | | | | Elevation(m) | | | Slope | | Den status | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Date inspected | | | | Valley | | position | | | |
| Den# | Bear # | 1984 | (%)Slope | Aspect | Den | floor | Crest | (1/3) | Topography | May 1984 | July 1984 |
| 84-1 | 1220 | 18 May & 20 July | 63 | 211° | 1311 | 1213 | 1829 | lower | mountains | partially collapsed | collapsed |
| 84-2 | 1212 | 18 May & 27 July | 70 | 169° | 1219 | 1000 | 1512 | mid | mountains | intact | collapsed |
| 84-3 | 1241 | 18 May & 25 July | 38 | 125° | 1338 | 835 | 1658 | mid | mountains | intact | collapsed |
| 84-5 | 1240 | 16 May & 21 July | 63 | 202° | 777 | 564 | 877 | upper | mountains | intact | collapsed |
| 84-6 | 1217 | 20 May & 28 July | 54 | 253° | 750 | 536 | 856 | upper | foothills | collapsed | collapsed |
| 84-6w | unmarked | 20 May & 28 July | 36 | 237° | 750 | 536 | 856 | upper | foothills | intact | collapsed |
| 84-7 | 1243 | 31 May | 75 | 88° | 981 | 640 | 1170 | mid | mountains | partially collapsed | collapsed |
| 84-10 | 1239 | 19 May & 29 July | 46 | 85° | 1384 | 1176 | 1487 | upper | mountains | intact | collapsed |
| 84-11 | 1185 | 20 May & 30 July | 62 | 132° | 835 | 579 | 1039 | mid | foothills | partially collapsed | collapsed |
| 84-12 | 1260 | 20 May & 30 July | 63 | 147° | 591 | 482 | 774 | mid | foothills | intact | partially collapsed |
| 84-12s | unmarked | 20 May & 30 July | 52 | 147° | 543 | 482 | 774 | lower | foothills | intact | partially collapsed |
| 84-13 | 1233 | 31 May | 65 | 154° | 1024 | 792 | 1250 | mid | mountains | partially collapsed | collapsed |
| 84-14 | unmarked | 19 May & 29 July | 68 | 242° | 1192 | 735 | 1414 | upper | mountains | partially collapsed | collapsed |
| 84-14L | unmarked | 19 May & 29 July | 59 | 242° | 1109 | 735 | 1414 | mid | mountains | intact | partially collapsed |
| 84-15 | 1056 | 18 May & 27 July | 55 | 106° | 1134 | 988 | 1500 | lower | mountains | partially collapsed | collapsed |
| 84-16 | 1230 | 20 May & 11 Aug | 65 | 145° | 866 | 518 | 963 | upper | mountains | partially collapsed | collapsed |
| 84-17 | unmarked | 31 May & 22 July | 57 | 192° | 1079 | 658 | 1170 | upper | mountains | partially collapsed | partially collapsed |
| 84-18 | 1235 | 4 May & 17 July | 52 | 194° | 938 | 774 | 1225 | mid | mountains | partially collapsed | partially collapsed |
| 84-19 | 1252 | 31 May & 22 July | 52 | 205° | 933 | 817 | 981 | upper | mountains | partially collapsed | collapsed |
| 84-22 | 1259 | 16 May & 24 July | 47 | 102° | 933 | 811 | 1186 | lower | mountains | intact | partially collapsed |
| 84-23 | 1202 | 16 May & 24 July | 99 | 220° | 890 | 652 | 975 | upper | mountains | cave | cave |
| 84-24 | 1200 | 16 May & 21 July | 72 | 112° | 872 | 594 | 1030 | mid | mountains | cave | cave |
| 84-25 | 1247 | 16 May & 24 July | 80 | 74° | 945 | 677 | 994 | upper | mountains | intact | collapsed |
| 84-26 | 1246 | 16 May & 21 July | 49 | 195° | 1067 | 991 | 1490 | lower | mountains | intact | collapsed |
| 84-27 | 1245 | 18 May & 25 July | 56 | 130° | 1341 | 1222 | 1621 | lower | mountains | partially collapsed | collapsed |
| 84-28 | 1208 | 18 May & 27 July | 56 | 108° | 1048 | 933 | 1378 | lower | mountains | intact | collapsed |
| 84-29 | 1236 | 2 May & 25 July | 46 | 46° | 1189 | 988 | 1207 | upper | mountains | intact | collapsed |
| 84-30 | 1244 | 2 May & 26 July | 60 | 135° | 1372 | 1231 | 1500 | mid | mountains | cave | cave |
| 84-32 | 1213 | 16 May & 24 July | 26 | 18° | 347 | 346 | 351 | lower | tundra | intact | collapsed |
| 84-33 | 1257 | 18 May & 28 July | 47 | 122° | 1649 | 1557 | 1743 | mid | mountains | intact | partially collapsed |
| 84-34 | unmarked | 18 May & 28 July | 50 | 100° | 1478 | 1262 | 1603 | mid | mountains | intact | collapsed |
| 84-35 | 1182 | 18 May & 20 July | 49 | 133° | 1048 | 866 | 1250 | mid | mountains | intact | collapsed |
| 84-36 | 1225 | 20 May & 28 July | 45 | 213° | 674 | 640 | 969 | lower | foothills | intact | collapsed |
| 84-37 | 1210 | 18 May & 22 July | 54 | 175° | 1634 | 1469 | 2444 | lower | mountains | intact | collapsed |
| 84-38 | 1197 | 20 May & 30 July | 67 | 46° | 613 | 573 | 671 | mid | foothills | intact | collapsed |
| 84-39 | 1223 | 20 May & 30 July | 35 | 121° | 573 | 475 | 607 | upper | foothills | snow den | -- |
| 84-40 | 1196 | 31 May -- | 68 | 114° | 1161 | 833 | 1234 | upper | mountains | partially collapsed | collapsed |
| 84-42 | 1234 | 20 May & 23 July | 58 | 161° | 859 | 805 | 1298 | lower | mountains | intact | collapsed |
| 84-43 | 1248 | 20 May & 11 Aug | 40 | 210° | 579 | 457 | 744 | mid | foothills | partially collapsed | partially collapsed |
| 84-44 | 1226 | 20 May & 10 Aug | 38 | 126° | 384 | 207 | 482 | mid | foothills | intact | collapsed |
| 84-45 | unmarked | 20 May & 17 July | 57 | 186° | 689 | 664 | 1131 | lower | mountains | intact | partially collapsed |
| 84-47 | unmarked | 20 May -- | 54 | 167° | 628 | 384 | 664 | upper | foothills | collapsed | collapsed |
| 84-48 | 1188 | 20 May & 19 July | 45 | 106° | 728 | 311 | 799 | upper | foothills | intact | collapsed |
| 84-49 | 1189 | 20 May & 23 July | 45 | 97° | 689 | 607 | 927 | lower | mountains | intact | partially collapsed |
| 84-57 | 1198 | -- 29 July | 58 | 176° | 1219 | 1146 | 1469 | lower | mountains | -- | collapsed |
| 84-58 | 1216 | 18 May & 26 July | 65 | 244° | 1061 | 902 | 2088 | lower | mountains | partially collapsed | partially collapsed |

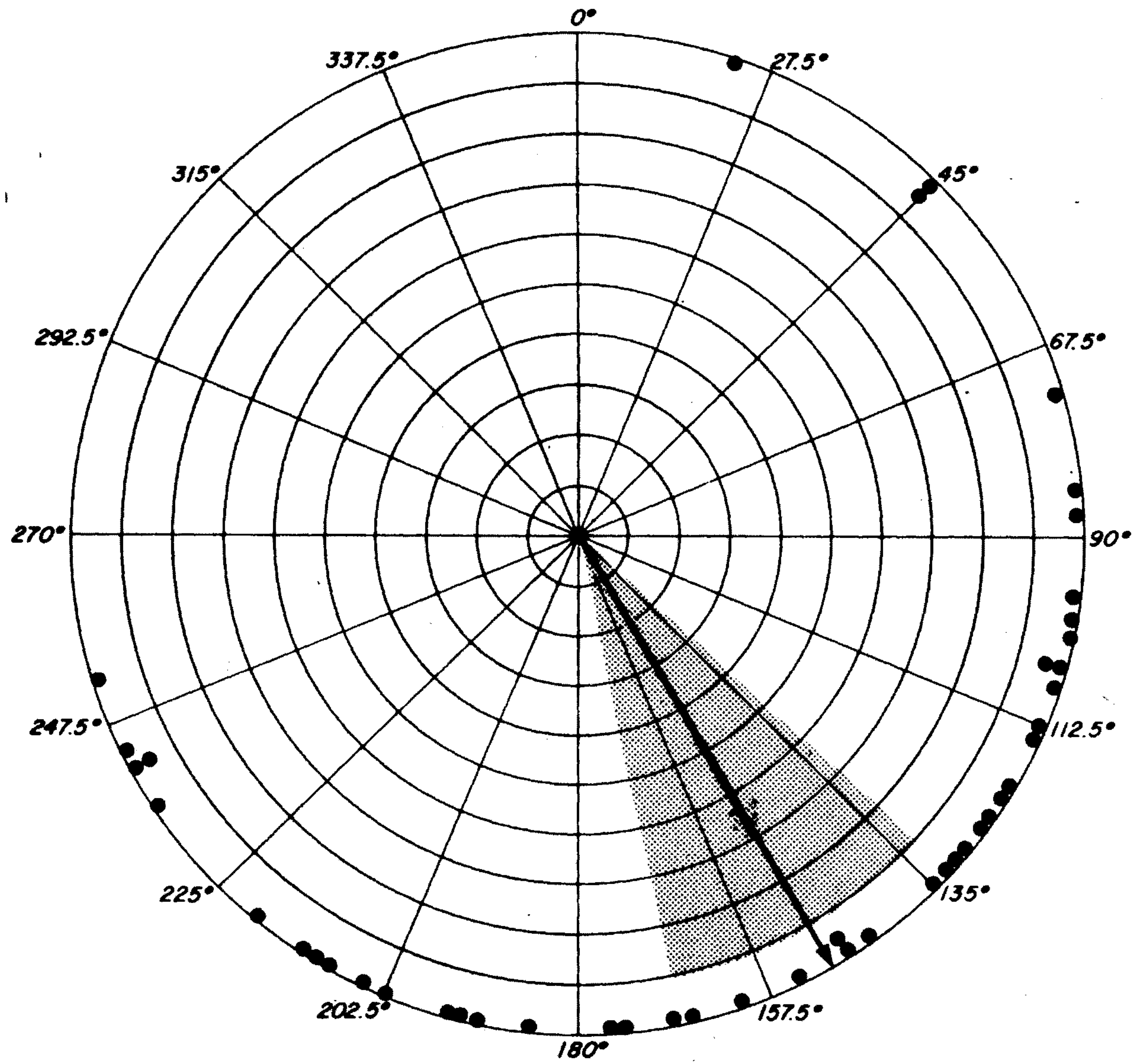


Fig. 4. Aspects, mean aspect (arrow), and 95% confidence interval (shaded arc) of 46 bear dens used during winter 1983-1984 on the Arctic National Wildlife Refuge, Alaska

Table 9. Fall denning characteristics of 43 brown bears in the northeastern portion of the Arctic National Wildlife Refuge, 1984.

| Bear # | Reproductive status | Terrain | Date observed denned | Estimated aspect | Estimated elevation(m) |
|---|---|---|---|---|---|
| 1056 | male | mountainous | 17 Oct | 105° | 1006 |
| 1182 | potential breeder | mountainous | 17 Oct | 77° | 1250 |
| 1188 | male | foothills | 6 Nov | 205° | 427 |
| 1189 | probable breeder | mountainous | 28 Oct | 184° | 686 |
| 1197 | potential breeder | foothills | 23 Oct | 254° | 762 |
| 1200 | male | mountainous | 16 Oct | 122° | 838 |
| 1202 | probable breeder | mountainous | 6 Oct | 200° | 671 |
| 1203 | male | mountainous | 16 Oct | 149° | 808 |
| 1204 | male | mountainous | 5 Nov | 92° | 747 |
| 1205 | male | mountainous | 16 Oct | 182° | 853 |
| 1208 | probable breeder | mountainous | 17 Oct | 120° | 1341 |
| 1210 | probable breeder | mountainous | 3 Nov | 22° | 1615 |
| 1212 | probable breeder | mountainous | 17 Oct | 143° | 1432 |
| 1214 | immature female | coastal plain | 5 Nov | 19° | 373 |
| 1217 | probable breeder | foothills | 29 Oct | 310° | 853 |
| 1220 | 1 cub | mountainous | 17 Oct | 181° | 1813 |
| 1223 | male | foothills | 28 Oct | 335° | 366 |
| 1226 | male | foothills | 7 Nov | 261° | 549 |
| 1230 | 2 cubs | mountainous | 28 Oct | 180° | 1036 |
| 1232 | male | mountainous | 23 Oct | 181° | 1493 |
| 1233 | male | mountainous | 23 Oct | 111° | 1006 |
| 1235 | immature female | moutainous | 28 Oct | 102° | 853 |
| 1236 | probable breeder | foothills | 5 Nov | 95° | 747 |
| 1239 | 2-2.5 year old? | mountainous | 23 Oct | 181° | 1173 |
| 1241 | male | mountainous | 16 Oct | 166° | 1265 |
| 1245 | probable breeder | mountainous | 29 Oct | 144° | 1189 |
| 1246 | male | mountainous | 29 Oct | 142° | 914 |
| 1247 | probable breeder | mountainous | 16 Oct | 99° | 731 |
| 1252 | probable breeder | mountainous | 28 Oct | 271° | 686 |
| 1257 | probable breeder | mountainous | 6 Nov | 242° | 1585 |
| 1259 | probable breeder | mountainous | 16 Oct | 113° | 930 |
| 1260 | probable breeder | mountainous | 29 Oct | 338° | 671 |
| 1261 | probable breeder | mountainous | 15 Oct | 236° | 701 |
| 1263 | male | mountainous | 5 Nov | 91° | 792 |
| 1264 | male | mountainous | 16 Oct | 174° | 808 |
| 1267 | 2-2.5 year old | mountainous | 16 Oct | 209° | 1021 |
| 1269 | 3 cubs | mountainous | 16 Oct | 160° | 777 |
| 1278 | 2 cubs | mountainous | 15 Oct | 232° | 640 |
| 1281 | male | mountainous | 23 Oct | 111° | 1067 |
| 1282 | young female | mountainous | 23 Oct | 142° | 808 |
| 1283 | male | coastal plain | 17 Oct | 277° | 114 |
| Unmarked | unknown | mountainous | 23 Oct | 153° | 1250 |
| Unmarked | unknown | mountainous | 5 Nov | 96° | 747 |

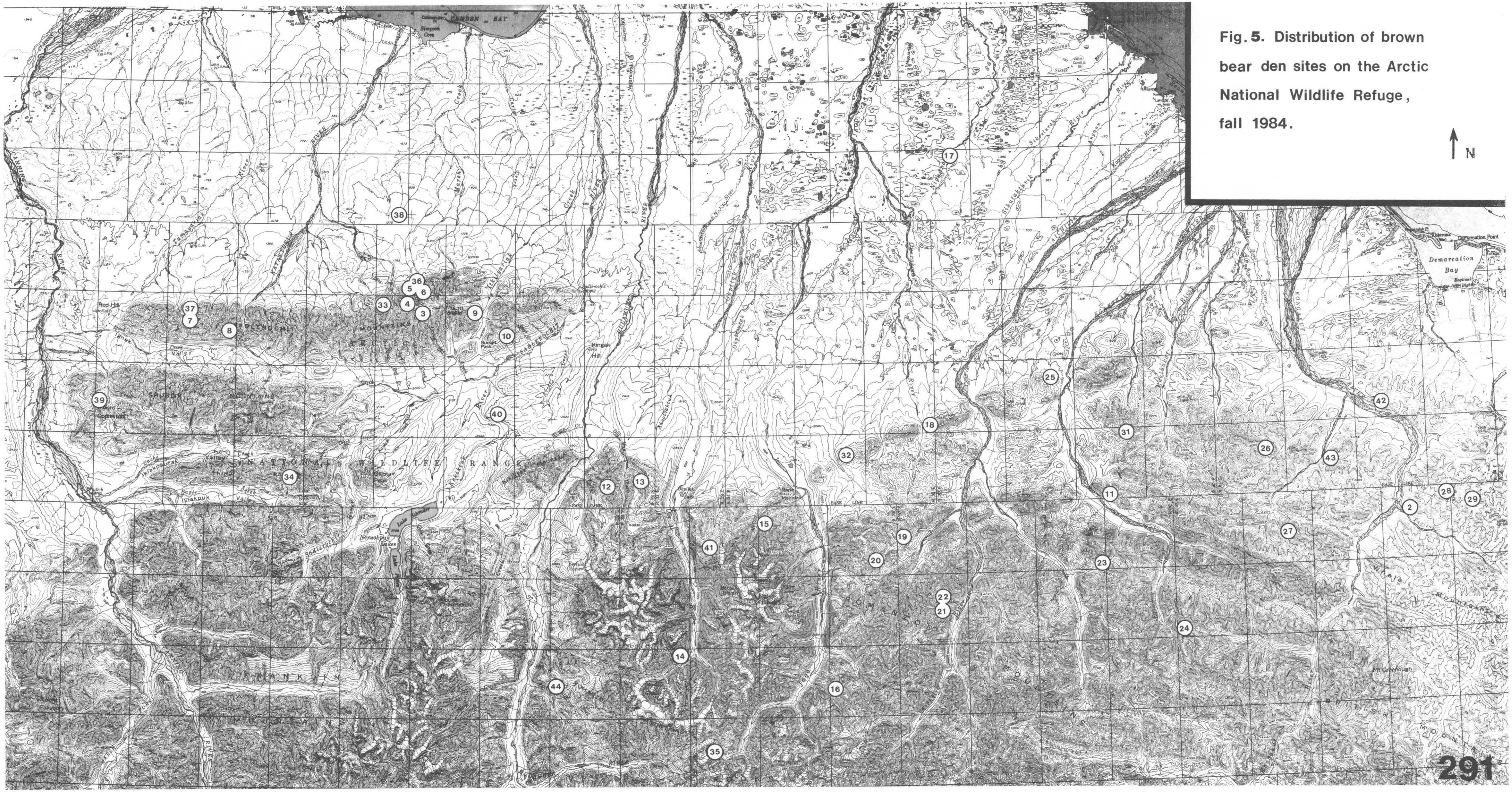


Fig. 5. Distribution of brown bear den sites on the Arctic National Wildlife Refuge, fall 1984.

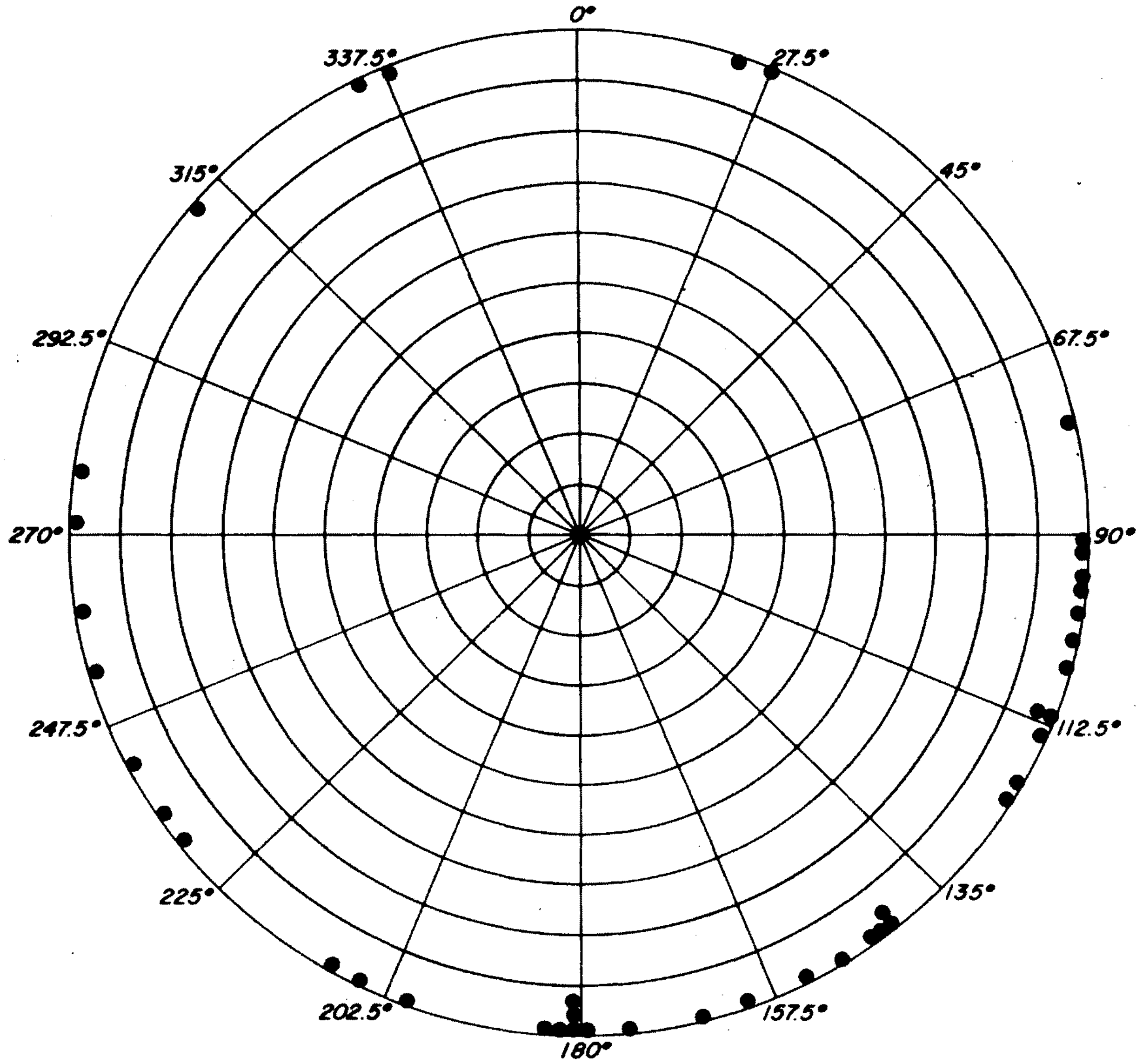


Fig. 6. Estimated aspects of 43 bear den sites located on the Arctic National Wildlife Refuge in October and November 1984.

(Table 9). In contrast to denning chronology in 1983, when only 3 of 46 radio-collared bears denned in early November (Garner et al. 1984), 9 bears were not denned in 1984 until 7 November (Table 7).

Elevations and aspects of the 43 fall den sites were estimated from 1:63,360 move to top of next pages scale topographic maps (Table 9). Average estimated elevation was 916 ± 54 m (SE) and is comparable to the average elevation of the 46 measured den sites in summer 1984. Estimated aspects for these 43 fall dens are depicted in Fig. 6. In general, estimated aspects of the 43 dens show a wider dispersion than the 46 den sites visited during summer 1984 (Figs. 4 and 6). However, the southeast and southwest quadrants contained a majority of the estimated aspects of den sites (27 and 13 respectively). These den sites will be inspected in early summer 1985 and actual aspects and elevation will be determined at that time.

## Acknowledgments

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ANWR Progress Report Number FY85-10

# DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF TUNDRA SWANS IN THE COASTAL WETLANDS OF THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1984

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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, 1984

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Abstract: Two aerial surveys to estimate the number of tundra swans (*Cygnus columbianus*) using coastal wetlands of the Arctic National Wildlife Refuge were flown in 1984. A pair/nesting survey was flown on 26-27 June and a productivity survey was flown on 23 and 27-29 August. Survey methods were those described by Bartels et al. (1983). The breeding population was an estimated 149 pairs. In the June survey, total swan pairs (149) and total nests (100 nests) increased 42% and 23%, respectively, over 1983. Cygnet production was slightly lower than 1983, but was higher than 1981 or 1982. Average brood size (2.7 cygnets/brood) was not significantly different (P=0.91) than 1983. The major portion of the additional nesting attempts in 1984 occurred on the Canning-Tamayariak delta which also experienced the lowest success rate (0.44 broods/nest). This reduced success may have been due to more pairs nesting at suboptimal locations, to weather-related effects on the accuracy of the survey, or to aircraft disturbance.

# Distribution, abundance, and productivity of tundra swans in the coastal wetlands of the Arctic National Wildlife Refuge, Alaska, 1984

Of the 58 avian species which are known to nest on the coastal plain of the Arctic National Wildlife Refuge (ANWR) (USFWS 1982), the tundra swan is the largest and most conspicuous. Past surveys have found between 330 and 552 swans utilizing the coastal plain (Spindler 1981, Bartels et al. 1983, Bartels and Doyle 1984,). The breeding population of tundra swans on the Alaskan north slope was estimated by J. King at 3000-4000 adults (Pacific Flyway Study Committee 1983). Thus it is likely that the tundra swans nesting on ANWR constitute a significant component of the north slope population. This fact is not surprising since ANWR is close to the species' primary migration routes in the MacKenzie River Valley and the large high-arctic breeding populations in the MacKenzie Delta-Liverpool Bay area (Barry 1960).

Proposed oil and gas exploration on and near the coastal plain of ANWR will result in increased ground activities and aircraft traffic. Past studies have shown a high degree of sensitivity by tundra swans to such disturbances (Hanson et al. 1956, Schmidt 1970, Anderson 1973, Barry and Spencer 1976). Therefore, it is important to monitor the nesting population, to examine annual flucuations in the breeding and nonbreeding segments of the population, and if possible, to determine the causes of the changes. This 1984 swan survey is a continuation of surveys begun in 1981 and is identical in area coverage to the 1981-1983 surveys. As in 1983, a June breeding pair/ nesting survey was flown to examine nesting distribution and nesting success of the population.

## Materials and Methods

Aerial surveys of the four major swan concentration areas (Fig. 1) were completed during the periods 26-27 June and 23, 27, and 29 August 1984. The Canning-Tamayariak River delta, and the Hulahula-Okpilak River delta were flown on 26 June, all other areas in the nesting survey were flown on 27 June. During the August survey the Canning-Tamayariak River delta was flown on 23 August, the Hulahula-Okpilak and Jago River deltas were flown on 27 August, and the remainder of the area was flown on 29 August 1984. Survey methods were described by Bartels et al. (1983). A Cessna 185 was used in both 1984 surveys. Crew members consisted of a pilot, an observer and an observer-recorder who plotted the survey route and the adult swan, nest, and brood locations on U.S. Geological Survey 1:63,630 scale topographic maps. Each concentration area was systematically searched from an altitude of 150 m and, if necessary, swans were circled briefly to locate nests or count brood sizes. Two assumptions were made during the surveys. First, all single swans found at a nest during the June survey were assumed to represent a pair. Secondly, two swans observed together were assumed to be mated. All statistical procedures follow Sokal and Rohlf (1981).

## Results and Discussions

### Breeding Population and Nesting Distribution

The number of nests and pairs recorded in the 1984 June survey (Fig. 1) were 23% and 42% higher, respectively, than in the 1983 survey (Table 1).

Table 1. Tundra swan population statistics for the 1983 and 1984 June nesting surveys for Arctic National Wildlife Refuge, Alaska.

| Area | # Nests | | # Pairs w/o nests | | Total # pairs | | # Unpaired singles + groups | | Total # adults | | Nest/$km^2$ | | Pairs/$km^2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 |
| Canning (490)[a] Tamayariak delta | 25 | 41 | 11 | 14 | 36 | 55 | 26 | 24 | 98 | 134 | 0.05 | 0.08 | 0.07 | 0.11 |
| Hulahula delta (168)[a] | 11 | 14 | 3 | 8 | 14 | 22 | 8 | 32 | 36 | 75 | 0.07 | 0.08 | 0.08 | 0.13 |
| Jago delta & wetlands (357)[a] | 5 | 4 | 1 | 6 | 6 | 10 | 1 | 3 | 13 | 23 | 0.01 | 0.01 | 0.02 | 0.03 |
| Aichilik/Egasksrak/ Kongakut deltas (259)[a] | 29 | 30 | 6 | 17 | 35 | 47 | 4 | 57 | 74 | 151 | 0.11 | 0.12 | 0.14 | 0.18 |
| Demarcation Bay (158)[a] | 2 | 7 | 1 | 2 | 3 | 9 | 10 | 3 | 16 | 21 | 0.01 | 0.04 | 0.02 | 0.06 |
| Other areas (171)[a] | 6 | 4 | 5 | 2 | 11 | 6 | 5 | 1 | 27 | 13 | 0.04 | 0.02 | 0.06 | 0.04 |
| All areas(1603)[a] | 78 | 100 | 27 | 49 | 105 | 149 | 54 | 120 | 264 | 402 | 0.05 | 0.06 | 0.07 | 0.09 |

[a] Area ($km^2$) surveyed within each survey area.

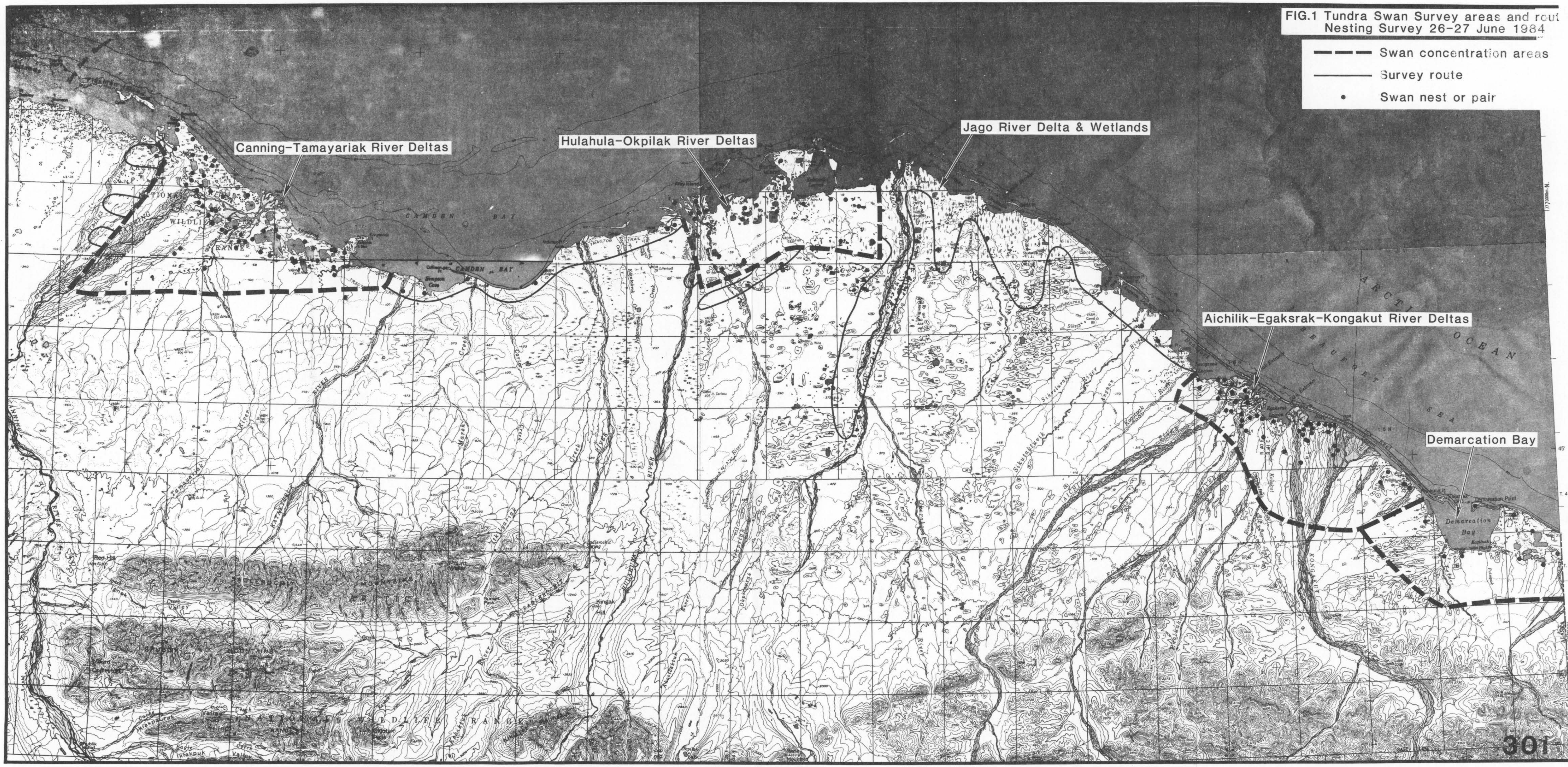

FIG.1 Tundra Swan Survey areas and rout
Nesting Survey 26-27 June 1984
Swan concentration areas
Survey route
Swan nest or pair
Canning-Tamayariak River Deltas
Hulahula-Okpilak River Deltas
Jago River Delta & Wetlands
Aichilik-Egaksrak-Kongakut River Deltas
Demarcation Bay
CAMDEN BAY
ARCTIC OCEAN
BEAUFORT SEA

Likewise, the number of nonbreeding adults increased 126% from 1983 to 1984. This increase in both breeding and nonbreeding individuals boosted the spring adult count to 402, an increase of 52% over 1983.

As in 1983, the Canning-Tamayariak and Aichilik-Egaksrak-Kongakut River deltas contained the highest numbers of nests (Table 1). An increase of 16 nests on the Canning-Tamyariak River delta over 1983 accounted for 89% of the additional nests counted in 1984. However, the Aichilik-Egaksrak-Kongukut River deltas continued to hold the highest densities of nests (0.12 nests/$km^2$), which ranged from 33% to 83% higher than other areas. The Hulahula River delta and the Canning-Tamayariak River delta contained the second highest nest densities (0.08 nests/$km^2$).

## Post-Nesting Population

The locations of swans observed during the August post-breeding survey are presented in Fig. 2. Although nesting attempts by tundra swans increased from 1983 to 1984, the total number of adults counted during the post-breeding survey (280) was lower than in any year since the surveys were standardized in 1981 (Table 2). The later dates of the August 1984 surveys may have influenced this figure. Since the number of pairs counted in the August 1984 survey (106) was lower than in the June survey (149), some unsuccessful breeding pairs may have left the refuge by the time the August survey was conducted. In 1983, the opposite situation occurred with 105 pairs counted in June and 132 in August. Therefore, either non-breeding swans or unsuccessful breeders entered the area prior to the August 1983 survey. Likewise, more singles and swans in flocks were counted in the August 1983 survey (113) than the August 1984 survey (68).

## Productivity

Cygnet production in 1984, although higher than in 1981 or 1982, was lower than in 1983 despite the increase in nesting attempts. Sixty-two broods and 165 cygnets were counted in August 1984 compared to 64 broods and 176 cygnets counted in 1983. Brood sizes averaged 2.7 cygnets ($\pm$ 1.1 SD) in 1984 and 2.8 cygnets ($\pm$ 1.2 SD) in 1983 (Bartels and Doyle 1984). A two sample t-test failed to show a significant difference ($t=0.18$, $P=0.91$) in brood sizes between the two years. Therefore, within-brood survival was probably similar in 1983 and 1984 provided clutch sizes were the same.

Apparent nest success was somewhat lower in 1984 than in 1983. Based on the ratio of broods to nests, the success rate was 62% in 1984 and 82% in 1983. Success rate may also be calculated from the ratio of broods to total pairs(Bartels and Doyle 1984) as a minimum possible success rate. Based on this approach, success was between 42% (broods/pair) and 62% (broods/nest). The 1983 figures were 61-82%.

The apparent differences in breeding success between 1983 and 1984 may be due to several factors. The majority of additional nesting attempts in 1984 occurred in the Canning-Tamayariak River delta which also experienced the lowest success rate. The brood/nest ratio on the Canning was 44% in 1984 compared to 100% in 1983 (Table 3). In the two other major concentrations areas, the Aichilik-Egaksrak-Kongakut and Hulahula River deltas, brood/nest ratios were higher or similar to those in 1983. The additional nesting birds

Table 2. Tundra swan population statistics for Arctic National Wildlife Refuge coastal areas, Alaska, during August production surveys, 1981-1984.

| Area | Number: Total | Number: Adults | Number: Cygnets | Number: Pairs | Number: Singles | Number: Flocks | Swans in flocks | %: Paired | %: Prs. w Yng | %: Yng | Number broods | Mean brood Size | Cygnets/ adults | Swans/ $km^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Canning/Tamayariak Delta: (490)[a] | | | | | | | | | | | | | | |
| 4 Aug 1981 | 186 | 140 | 46 | 30 | 3 | 10 | 77 | 43 | 57 | 25 | 17 | 2.7 | 1:3.0 | 0.38 |
| 12 Aug 1982 | 75 | 63 | 12 | 21 | 3 | 4 | 18 | 67 | 29 | 16 | 6 | 2.0 | 1:5.3 | 0.15 |
| 21 Aug 1983 | 188 | 125 | 63 | 48 | 7 | 4 | 22 | 77 | 52 | 34 | 25 | 2.5 | 1:2.0 | 0.38 |
| 23 Aug 1984 | 149 | 102 | 47 | 39 | 3 | 4 | 21 | 76 | 46 | 32 | 18 | 2.6 | 1:2.2 | 0.30 |
| Hulahula/Okpilak Delta: (168)[a] | | | | | | | | | | | | | | |
| 4 Aug 1981 | 80 | 67 | 13 | 9 | 0 | 8 | 49 | 27 | 44 | 16 | 4 | 0.3 | 1:5.2 | 0.48 |
| 12 Aug 1982 | 39 | 35 | 4 | 10 | 1 | 3 | 14 | 57 | 20 | 10 | 2 | 2.0 | 1:88 | 0.23 |
| 21 Aug 1983 | 94 | 62 | 32 | 20 | 5 | 3 | 17 | 65 | 45 | 34 | 9 | 3.5 | 1:2.1 | 0.56 |
| 27 Aug 1984 | 70 | 38 | 32 | 14 | 10 | 0 | 0 | 74 | 79 | 46 | 11 | 2.9 | 1:1.2 | 0.42 |
| Aichilik/Egaksrak/ Kongakut Delta (259)[a] | | | | | | | | | | | | | | |
| 4 Aug 1981 | 171 | 139 | 32 | 17 | 2 | 11 | 101 | 24 | 76 | 19 | 14 | 2.3 | 1:4.3 | 0.66 |
| 12 Aug 1982 | 171 | 157 | 14 | 19 | 2 | 7 | 97 | 37 | 21 | 8 | 6 | 2.3 | 1:11.2 | 0.66 |
| 21 Aug 1983 | 164 | 112 | 52 | 36 | 6 | 7 | 34 | 64 | 50 | 32 | 18 | 2.9 | 1:2.2 | 0.63 |
| 29 Aug 1984 | 130 | 70 | 60 | 32 | 6 | 0 | 0 | 91 | 72 | 46 | 23 | 2.6 | 1:1.2 | 0.50 |
| Jago Delta and Wetlands (357)[a] | | | | | | | | | | | | | | |
| 4 Aug 1981 | 12 | 8 | 4 | 2 | 1 | 1 | 3 | 50 | 50 | 33 | 1 | 4.0 | 1:2.0 | 0.03 |
| 12 Aug 1982 | 4 | 4 | 0 | 2 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0.0 | - | 0.01 |
| 21 Aug 1983 | 37 | 29 | 8 | 10 | 1 | 2 | 8 | 69 | 30 | 22 | 3 | 2.7 | 1:3.6 | 0.10 |
| 27 Aug 1984 | 46 | 38 | 8 | 10 | 1 | 4 | 17 | 53 | 40 | 17 | 4 | 2.0 | 1:4.8 | 0.13 |
| Demarcation Bay (158)[a] | | | | | | | | | | | | | | |
| 4 Aug 1981 | 24 | 18 | 6 | 6 | 0 | 1 | 6 | 67 | 33 | 25 | 2 | 3.0 | 1:3.0 | 0.15 |
| 12 Aug 1982 | 16 | 9 | 7 | 1 | 3 | 1 | 4 | 22 | 100 | 44 | 3 | 2.3 | 1:1.3 | 0.10 |
| 21 Aug 1983 | 20 | 14 | 6 | 6 | 2 | 0 | 0 | 86 | 33 | 30 | 2 | 3.0 | 1:2.3 | 0.13 |
| 29 Aug 1984 | 28 | 17 | 11 | 4 | 1 | 2 | 8 | 47 | 100 | 39 | 4 | 2.8 | 1:1.5 | 0.18 |
| Other Areas: (171)[a] | | | | | | | | | | | | | | |
| 4 Aug 1981 | 15 | 13 | 2 | 3 | 2 | 1 | 5 | 46 | 33 | 13 | 2 | 1.0 | 1:6.5 | 0.09 |
| 12 Aug 1982 | 25 | 20 | 5 | 3 | 1 | 3 | 15 | 20 | 100 | 20 | 2 | 2.5 | 1:5.0 | 0.15 |
| 21 Aug 1983 | 49 | 35 | 14 | 12 | 5 | 2 | 6 | 69 | 50 | 29 | 6 | 2.3 | 1:2.5 | 0.29 |
| 27 Aug 1984 | 20 | 15 | 5 | 7 | 1 | 0 | 0 | 93 | 29 | 25 | 2 | 2.5 | 1:3.0 | 0.12 |
| 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 | 176 | 132 | 26 | 18 | 87 | 70 | 48 | 32 | 64 | 2.8 | 1:2.2 | 0.34 |
| 1984 | 443 | 280 | 165 | 106 | 22 | 10 | 46 | 76 | 58 | 37 | 62 | 2.6 | 1:1.7 | 0.28 |

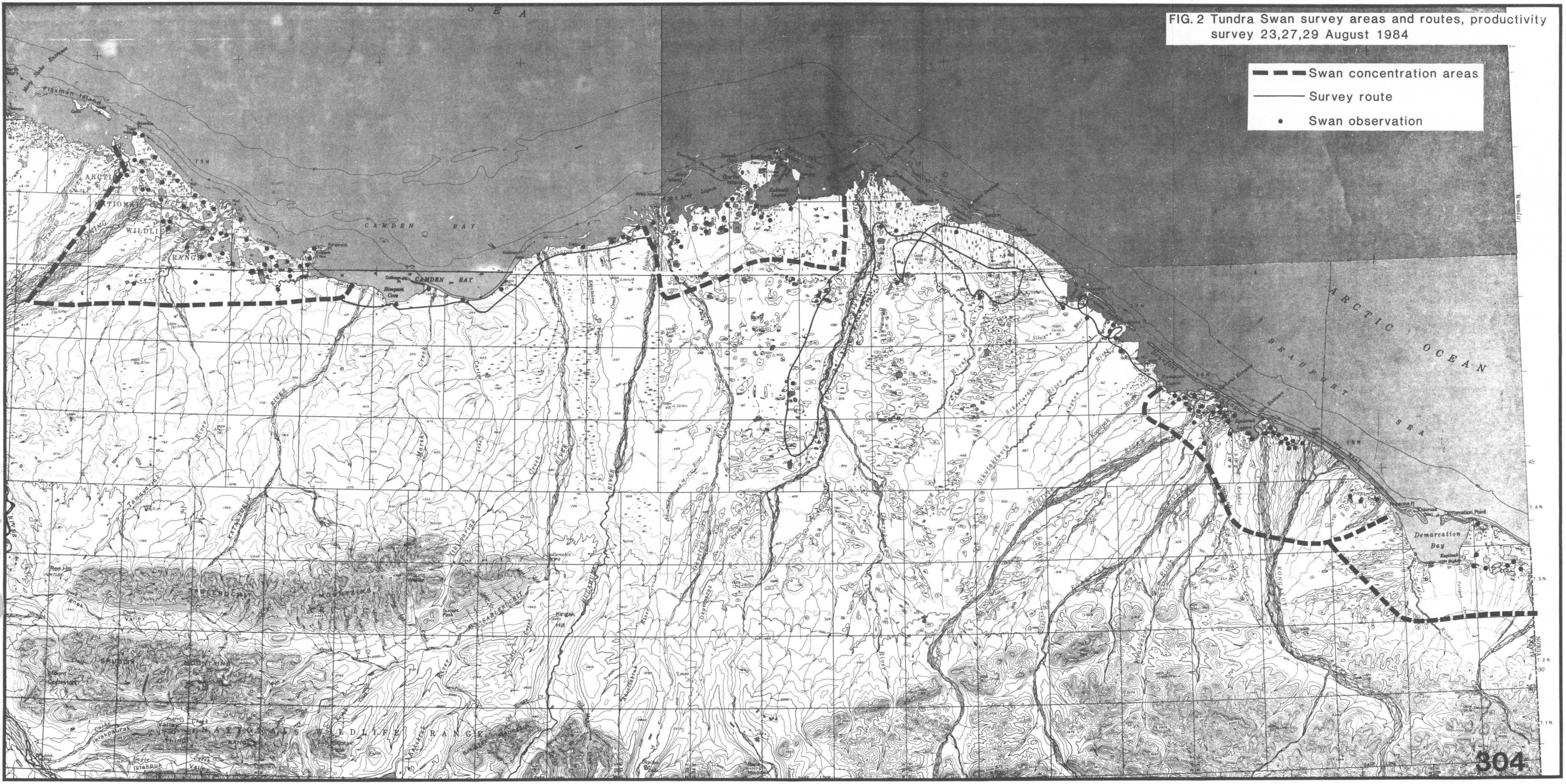

FIG. 2 Tundra Swan survey areas and routes, productivity survey 23,27,29 August 1984

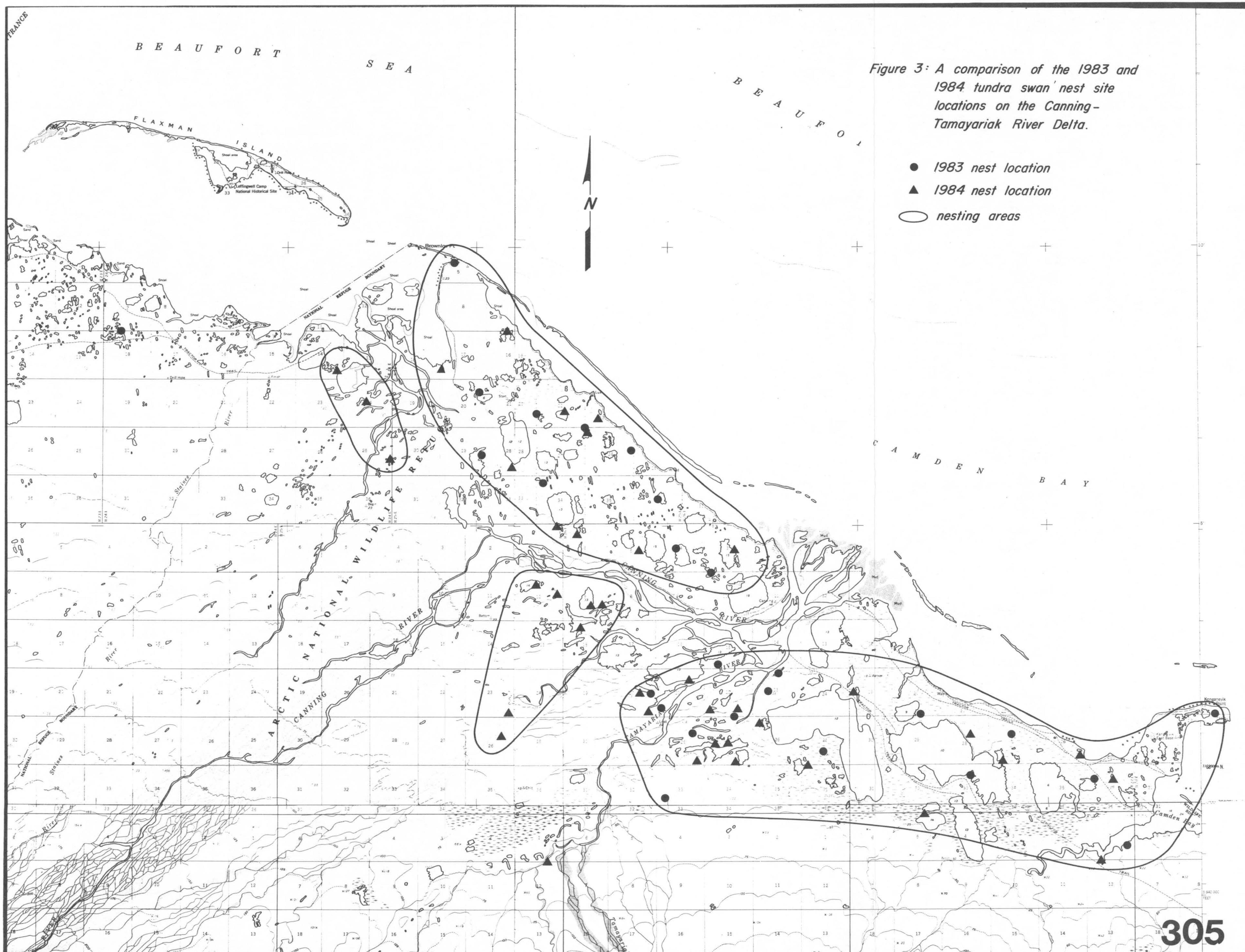


*Figure 3: A comparison of the 1983 and 1984 tundra swan nest site locations on the Canning-Tamayariak River Delta.*

on the Canning area may have attempted to nest in suboptimal areas after all optimum habitats were filled. This possibility was examined by comparing nest site locations from 1983 and 1984. The Canning-Tamayariak River delta was subdivided into five areas based on congregations of nests.(Fig. 3) Nest numbers in two areas were identical in 1983 and 1984. In a third area there were 13 nests in 1984 and 9 nests in 1983. The fourth and fifth areas had seven nests and three nests, respectively, in 1984 and no nests in 1983. Thus, not only did nest densities increase in at least one area, but nests were also initiated in areas not utilized in 1983. Calculations of nearest-nest distances showed a higher mean distance between nests (2.1 km $\pm$ 1.1 SD, $N = 18$) in 1983 than in 1984 (1.5 km $\pm$ 1.0 SD, $N = 27$), although this difference was not significant ($t=1.78$, $0.05 \leq P < 0.10$). Since nest densities in 1984 on the Canning area were lower than on the Aichilik-Egaksrak-Kongakut River deltas and similar to the Hulahula River delta, pair and brood spacing was probably not a factor in the reduced brood/nest ratios.

Table 3. Reproductive success ratios from the 1983 and 1984 swan surveys on the coastal plain of the Arctic National Wildlife Refuge, Alaska.

| Area | Broods/km$^2$ | | Broods/pair[b] | | Broods/nest[c] | |
|---|---|---|---|---|---|---|
| | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 |
| Canning-Tamayariak Delta (490)[a] | 0.05 | 0.04 | 0.69 | 0.33 | 1.00 | 0.44 |
| Hulahula Delta (168)[a] | 0.05 | 0.07 | 0.64 | 0.50 | 0.81 | 0.79 |
| Jago Delta and Wetlands (357)[a] | 0.01 | 0.01 | 0.50 | 0.40 | 0.60 | 1.00 |
| Aichilik-Egaksrak Kongakut (259)[a] | 0.07 | 0.09 | 0.51 | 0.49 | 0.62 | 0.77 |
| Demarcation Bay (158)[a] | 0.01 | 0.03 | 0.67 | 0.44 | 1.00 | 0.50 |
| Other Areas (171) | 0.04 | 0.01 | 0.55 | 0.33 | 1.00 | 0.50 |
| All areas (1603)[a] | 0.04 | 0.04 | 0.61 | 0.42 | 0.82 | 0.62 |

[a] Area (km$^2$) surveyed within each survey area.
[b] Number of broods counted in the August survey divided by the number of pairs counted in the June survey.
[c] Number of broods counted in the August survey divided by the number of nests counted in the June survey.

The second factor possibly responsible for the low nest/brood ratio may be related to difficulties experienced during the August survey. Initial attempts to start the survey prior to 23 August were postponed due to heavy fog and then only the Canning-Tamayariak River delta could be surveyed because of snow accumulation on the coastal plain. The Canning-Tamayariak River delta was surveyed under marginally suitable conditions, but due to additional fog and snow it could not be resurveyed. As a result, some broods and adults on the Canning-Tamayariak River delta may have been missed because of a light snow cover and reduced visibility. Finally, disturbance by aircraft is a possible contributing factor in the apparent low nesting success in the Canning-Tamayariak River delta. The delta is located along the flight path between Prudhoe Bay and Barter Island and is the only swan concentration area surveyed in this study which is subject almost daily to aircraft overflights. Aircraft disturbance has been directly implicated by several studies in nest abandonment by tundra swans (Schmidt 1970, Anderson 1973). Additional data and year to year comparisons are needed to determine the impact of this disturbance. Since conditions were not ideal on the other areas during the survey, survey efficiency was probably less of a factor in the observed low nesting success on the Canning-Tamayariak River delta then the large influx of new breeding pairs in 1984.


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# MIGRATORY BIRD USE OF THE COASTAL LAGOON SYSTEM OF THE BEAUFORT SEA COASTLINE WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1984

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# Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1984.

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Abstract: Aerial surveys were flown in 1984 on 14 lagoons and a 400 m wide strip adjacent to the shoreline and barrier beaches on the coast of the Arctic National Wildlife Refuge. A total of 21,228, 31,953, and 32,220 oldsquaw (*Clangula hyemalis*) were counted on 22 July, 5 August and 18 August, respectively, and comprised from 83.3 to 92.6% of the individuals of 26 species recorded during the surveys. Evidence is presented that the peak of the molt and oldsquaw abundance in 1983 and 1984 occurred during the period 7-13 August. Thus, the 1984 surveys in August occurred during the period of rapid increase and decrease in abundance. No set pattern of spatial distribution within the lagoon system could be detected, although oldsquaw showed a strong tendency to move offshore as the season progressed, as in past years.

Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1984.

The coastline of the Arctic National Wildlife Refuge (ANWR) is composed of a chain of estuarine lagoons each of which is protected by barrier beaches and flushed with freshwater from rivers flowing off the north face of the Brooks Range. In terms of biomass, estuaries are generally more productive than freshwater or marine habitats (Odum 1971). Substantial concentrations of breeding, nonbreeding, and post-breeding migratory birds use the Beaufort Sea coastal lagoons during the short open-water season and utilize the high biological productivity of the estuaries for food (Johnson and Richardson, 1981, Johnson 1984). Previous studies of Beaufort Sea coastal lagoons have found that oldsquaw undergoing post-breeding wing molt and premigratory staging is the predominant species present (Schmidt 1970, Bartels 1973, Gollop and Richardson 1974, Ward and Sharp 1974, Harrison 1977, Divoky and Good 1979, Spindler 1979, Johnson and Richardson 1981, Bartels and Zellhoefer 1983, Johnson 1983, Bartels and Doyle 1984).

Seismic exploration on the coastal plain of ANWR, as well as the Federal leasing of nearby offshore tracts and state leasing of nearshore areas will place industral activity in close proximity 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. A thorough knowledge of population levels and temporal and spatial distribution patterns of migratory birds using the lagoon system is essential to predict the potential effects of disturbance and pollution.

Aerial surveys of migratory birds using the lagoon system on the ANWR were initiated in 1970 and continued sporadically until they were standardized in 1981 (Schmidt 1970, Frickie and Schmidt 1974, Spindler 1978 and 1979, Bartels and Zellhoefer 1983, Bartels and Doyle 1984). The objectives of the 1984 season were as follows:

1. Obtain an index of relative numbers of migratory birds using coastal lagoons, especially oldsquaw molting in selected lagoons.

2. Continue investigating the validity of the 400 m strip aerial census by comparing data from 400 m strips 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

Three aerial surveys were conducted on the coastal lagoons of ANWR extending from the Canning River to the U.S.-Canada border. A fourth survey was not flown due to heavy fog in late August and September coupled with aircraft and manpower difficulties. Several alterations were made on the 1981-1983 survey methods. First, the 16 km offshore transects perpendicular to the shoreline were discontinued for safety reasons, but will be continued in 1985. Second, Sadlerochit lagoon, Kaktovik lagoon, Siku lagoon and the Angun lagoon-Pokok Bay area were surveyed (Fig. 1) in additon to the 10 lagoons surveyed in 1981-1983 (Bartels and Doyle 1984) to compare bird use in these lagoons with the 10 select lagoons. Finally, no attempt was made to examine relationships between abbreviated survey methods and the whole-lagoon surveys in 1984. This relationship will be investigated in 1985 with a complete data set composed of five years of survey data.

Aerial survey methods were those described by Bartels and Zellhoefer (1983). Two observers on opposite sides of the aircraft identified and counted or estimated the numbers of all birds seen within a 200 m strip on their respective sides. The aircraft followed predetermined routes at an altitude of 30 m and a ground speed of 160 kph across the lagoons, successively, until the entire lagoon had been covered. The counts were recorded on cassette tape and transcribed separately by observer into 200 m strip estimates. A standard 400 m offshore strip parallel to the shoreline and barrier island was also flown.

## Results and Discussion

A total of 26 bird species were observed in the lagoons with 19, 20, and 22 species found on the surveys of 22 July, 5 August and 18 August, respectively (Table 1). In past years, total species numbers have ranged from 25-32. These differences may be real or may be related to changes in observers from year to year. The total number of individuals counted during the 1984 surveys ranged from 24,021 on 22 July to 35,081 on 18 August. Oldsquaw were the most abundant and comprised 83.3% to 92.6% of the birds observed. Other groups of importance were scoters (*Melanitta sp.*) 2.2-5.3%, eiders (*Somateria sp.*) 1.5-3.0%, the glaucous gull (*Larus hyperboreus*) 1.4-2.2%, geese (*Anser spp.*, *Branta spp.*) 0.01-2.3%, and loons (*Gavia spp.*) 0.3-0.4%. A summary of the numbers of each species counted in each lagoon during the 1981-1984 surveys is presented in the Appendix.

### Oldsquaw

Temporal distribution. A total of 21,228, 31,953, and 32,220 oldsquaw were counted on 22 July, 5 August, and 18 August, respectively (Table 1). These totals contain the cumulative counts on 14 lagoons and are not comparable to past years in which only 10 lagoons were surveyed. The four additional lagoons accounted for 12.6%, 11.6%, and 12.7% of the oldsquaw observed during the 22 July, 5 August, and 18 August surveys (Table 2), respectively. When the numbers from these extra lagoons are removed, the 1984 oldsquaw counts were similar to those in 1981 and 1983, but higher than in 1982 (Table 3). The late-July 1984 oldsquaw count was higher than in late-July 1982 and similar to the late-July 1981 count. No late-July survey was made in 1983. The early-August 1984 survey, near the peak of the molting period, had 2,000 to 3,000 fewer oldsquaw than in 1981 or 1983 but was higher than 1982. Oldsquaw numbers in mid-August 1984 and 1983 (18 August 1984, 20 August 1983) were nearly identical.

Table 1. A summary of migratory birds counted during three surveys of coastal lagoons and 400 m offshore strips, Arctic National Wildlife Refuge, Alaska, 1984.

| Species group | Survey date | | |
|---|---|---|---|
| | 22 July | 5 August | 18 August |
| Oldsquaw | 21,228 | 31,953 | 32,220 |
| Eiders | 730 | 890 | 543 |
| Scoters | 1281 | 783 | 779 |
| Loons | 91 | 110 | 116 |
| Geese | 113 | 32 | 792 |
| Glaucous gulls | 530 | 503 | 491 |
| Other waterfowl | 43 | 113 | 47 |
| Other species | 5 | 113 | 93 |
| Total individuals | 24,021 | 34,497 | 35,081 |
| Number of species | 19 | 20 | 22 |

Table 2. Number of Oldsquaw counted in four lagoons surveyed in 1984 that were not surveyed in past years, Arctic National Wildlife Refuge, Alaska.

| Lagoon | Survey date | | |
|---|---|---|---|
| | 22 July | 5 August | 18 August |
| Siku | 41 | 58 | 22 |
| Angun/Pokok | 319 | 1464 | 1909 |
| Kaktovik | 1405 | 1441 | 822 |
| Sadlerochit | 903 | 752 | 1352 |
| Totals | 2668 | 3715 | 4105 |

Survey data for 1981-1984 in the 10 primary lagoons and 400 m offshore transect (Fig. 1) indicate that oldsquaw numbers tend to peak during the second week in August. The August 1984 surveys bracketed this peak and may have been flown when oldsquaw numbers were increasing and decreasing in the lagoon system. The highest count (33,427), on 10 August 1983, probably represents the temporal peak of oldsquaw use of the lagoon system. Survey dates in other years are spaced too widely over time to detect annual variation in timing of peak oldsquaw numbers.

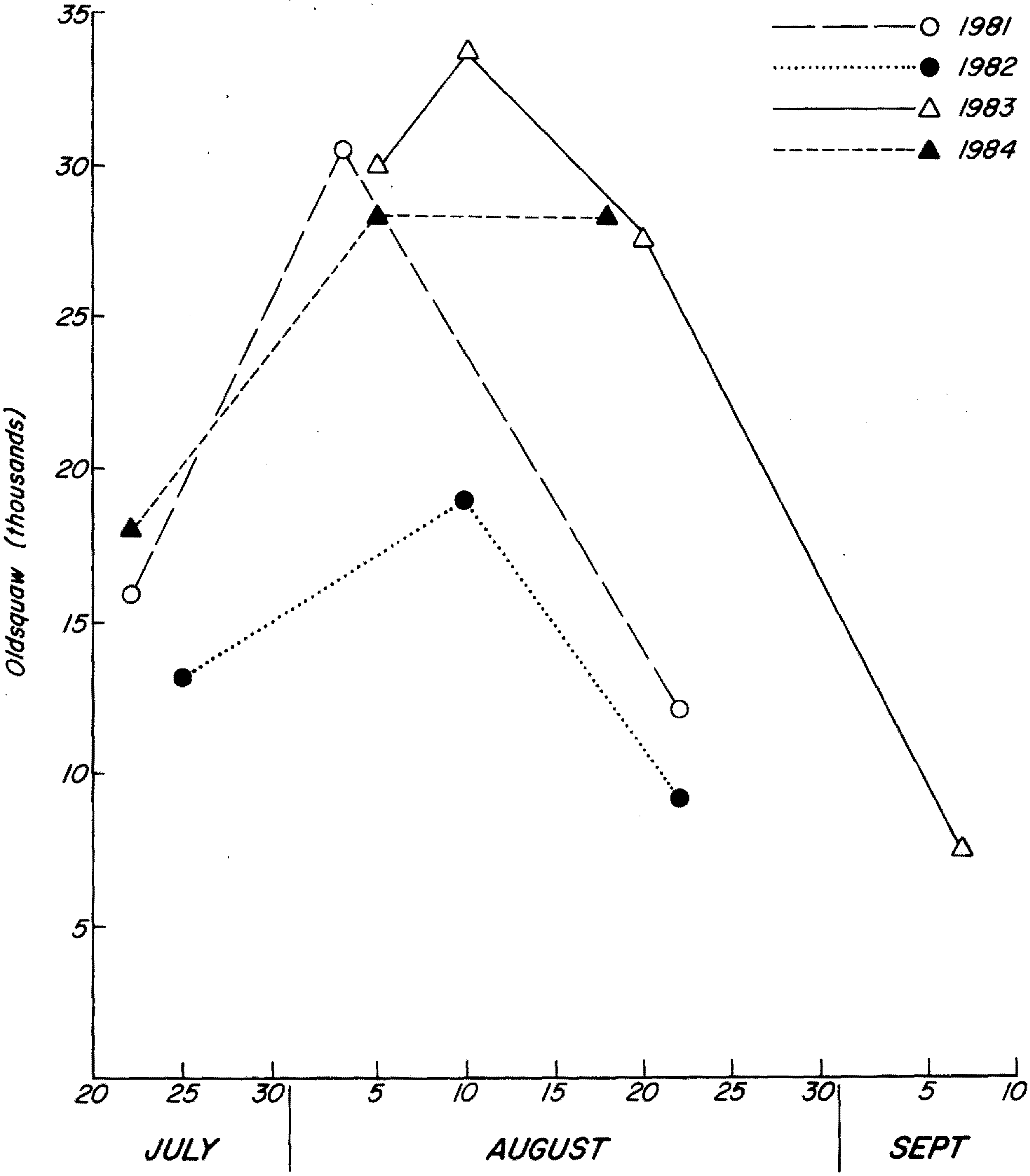


Fig. 1. Total numbers of oldsquaw counted on 10 select lagoons and a 400 m offshore strip on the Arctic National Wildlife Refuge, 1981-1984.

Table 3. Number of oldsquaw counted in 10 select lagoons and a 400m offshore strip in 1981-1984, Arctic National Wildlife Refuge, Alaska.

| | 1981[a] | | | 1982[a] | | | 1983[b] | | | | 1984 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lagoon | 22-23 July | 3-4 Aug | 22-26 Aug | 25-26 July | 7&13 Aug | 22 Aug | 4 Aug | 10 Aug | 20 Aug | 6-8 Sept | 22 July | 5 Aug | 18 Aug |
| Demarcation | 2,678 | 1,557 | 1,611 | 617 | 299 | 919 | 8,116 | 11,319 | 1,301 | 293 | 2,218 | 2,884 | 1,916 |
| Egaksrak | 107 | 355 | 97 | 82 | 234 | 61 | 324 | 314 | 205 | 6 | 98 | 445 | 520 |
| Nuvagapak | 1,427 | 2,448 | 1,004 | 126 | 2,669 | 1,422 | 5,689 | 4,572 | 1,076 | 222 | 732 | 2,996 | 2,417 |
| Oruktalik | 1,997 | 1,698 | 38 | 1,657 | 1,906 | 508 | 1,524 | 3,206 | 335 | 84 | 1,531 | 1,669 | 1,932 |
| Tapkauruk | 2,688 | 2,867 | 2,150 | 1,273 | 642 | 71 | 884 | 2,102 | 647 | 78 | 1,620 | 1,491 | 2,070 |
| Jago | 3,988 | 5,184 | 5,674 | 3,845 | 650 | 727 | 5,757 | 2,342 | 551 | 761 | 1,892 | 4,544 | 2,730 |
| Arey | 293 | 1,076 | 174 | 274 | 347 | 352 | 2,410 | 1,055 | 1,548 | 1,886 | 942 | 979 | 1,634 |
| Simpson Cove | 850 | 9,187 | 205 | 2,906 | 4,326 | 665 | 750 | 2,792 | 9,678 | 1,119 | 4,113 | 4,039 | 1,396 |
| Tamayariak | 162 | 2,606 | 150 | 625 | 5,202 | 321 | 565 | 276 | 3,116 | 344 | 2,165 | 1,503 | 1,945 |
| Brownlow | 50 | 693 | 95 | 415 | 711 | 204 | 45 | 70 | 750 | 150 | 453 | 310 | 560 |
| 400m offshore strip | 1,696 | 2,868 | 824 | 1,339 | 1,911 | 3,867 | 3,849 | 5,379 | 8,225 | 2,533 | 2,796 | 7,378 | 10,995 |
| Totals | 15,396 | 30,539 | 12,022 | 13,159 | 18,897 | 9,117 | 29,913 | 33,427 | 27,432 | 7,476 | 18,560 | 28,238 | 28,115 |

[a]Data from Bartels and Zellhoefer (1983).
[b]Data from Bartels and Doyle (1984).

Information on the stage of molt of the birds may help define the time of peak oldsquaw use. The stage of molt of oldsquaw captured or collected since 1982 in the lagoons is summarized in Table 4. The timing of the molt appears to be similar in both 1983 and 1984. Of 46 male oldsquaw captured in the period 7-10 August 1983 and 1984, 48% were in late molt, 41% were in mid-molt, and 17% were in early molt. Females showed a similar pattern. Only 8% of the male oldsquaw captured on 16-21 August 1983 were in early molt. Oldsquaw capable of flight are difficult to capture, so the percentage of individuals which had completed molt could not be determined precisely. However, during capture attempts at Simpson Cove on 10 August 1984, 10-25% of the individuals escaped capture by taking flight. Since few birds had taken flight during capture operations on 7 August 1984, these birds probably completed molt during the period 7-10 August. Thus the majority of oldsquaw were completing their wing molt and few birds were entering molt by 10 August 1983 and 1984. This information on the timing of molt by the oldsquaw lends support to the estimate of peak oldsquaw numbers occurring in the second week of August.

Spatial distribution. Oldsquaw distribution within the lagoon system in 1984 did not follow the patterns set in 1983. Although oldsquaw continued to use Simpson Cove, Jago Lagoon, and Demarcation Bay to the greatest extent, the distribution was more even than in 1983 (Table 3). From 22 July to 5 August 1984, oldsquaw numbers increased in Jago Lagoon, the Beaufort lagoons (Nuvagapak and Egaksrak lagoons) and Demarcation Bay. However, by 18 August decreases in oldsquaw numbers had occurred on Demarcation Bay, the Beaufort Lagoons, Jago Lagoon, and Simpson cove and were accompanied by increases in the Tapakurak and Oruktalik lagoons, Arey Lagoon, and the Canning lagoons (Brownlow and Tamayariak lagoons). Oldsquaw movements, therefore, appeared to be local rather than a general shift to the west as in 1983 (Bartels and Doyle 1983).

The distribution of oldsquaw in the lagoon system in 1983 (Table 3) was marked by an unusually large number in Demarcation Bay during the 4 and 10 August surveys (8,116 and 11,319, respectively) followed by a rapid increase in birds at Simpson Cove (9,128) by 20 August and large decreases in the other lagoons east of Barter Island. Oldsquaw numbers in Demarcation Bay in 1983 were 5,000 to 8,000 birds higher than in other years (Table 3). This large influx of oldsquaw into Demarcation Bay may account for the overall greater numbers of oldsquaw counted in 1983 than in other years.

In contrast to 1983 and 1984, the 1982 patterns (Table 3) show a decrease in oldsquaw numbers from the central lagoons (Jago, Tapukaurak, Oruktalik) from late July to early August and large increases in Simpson Cove and the Canning Lagoons west of Barter Island and in the Beaufort lagoons east of Barter Island. In 1981, large increases in oldsquaw in Simpson Cove and the Canning lagoons from late July to early August was followed by a near total departure of birds from these lagoons by mid-August. At the same time, Jago lagoon and Demarcation Bay maintained the same total numbers while nearly half of the oldsquaw left Tapakaurak Lagoon and the Beaufort lagoons (Table 3).

Table 4. Dates, locations, and stage of molt of adult oldsquaw captured or collected on the Arctic National Wildlife Refuge coastline, Alaska.

| Sex Source | No. Birds | Stage of molt[a] Prior | Early[b] | Middle[c] | Late[d] | Lagoon | Date |
|---|---|---|---|---|---|---|---|
| Males: | | | | | | | |
| Johnson (1983) | 22 | 11 (50)[e] | -- | -- | -- | Nuvagapak | 1- 8 Aug 1982 |
| Bartels et al. (1984) | 8 | 0 | 4 (50) | 0 | 4(50) | Tapakaurak | 7- 8 Aug 1983 |
| Brackney et al. (1985) | 26 | 0 | 0 | 12 (46) | 14(54) | Simpson Cove | 8-10 Aug 1984 |
| Brackney et al. (1985) | 12 | 0 | 1 (8) | 7 (58) | 4(33) | Tapakaurak | 7 Aug 1984 |
| Bartels et al. (1984) | 12 | 0 | 1 (8) | 5 (42) | 6(50) | Tapakaurak | 16-21 Aug 1983 |
| Females: | | | | | | | |
| Brackney et al. (1985) | 1 | 0 | 0 | 0 | 1(100) | Tapakaurak | 7 Aug 83 |
| Bartels et al. (1984) | 4 | 0 | 3 (75) | 0 | 1(25) | Tapakaurak | 7-8 Aug 83 |
| Bartels et al. (1984) | 6 | 0 | 0 | 5 (83) | 1(17) | Tapakaurak | 16 -18 Aug 83 |

[a]Based on measurement of 1st, 5th, and 10th primary feathers, except Johnson (1983).
[b]At least 1 primary feather less than or equal to 3 cm.
[c]All 3 primary feathers greater than 3 cm and less than 10 cm.
[d]At least 1 primary feather greater than or equal to 10 cm.
[e]Percentages by sex in parentheses.

No set pattern from year to year is evident in the data on total numbers of oldsquaw regarding movements or distribution between lagoons (Table 3). This lack of continuity may be a result of weather, yearly fluctuations in food resources within lagoons or within a season, or changes in the timing of molt from year to year or within sex and age classes in the population. If lagoon use is traditional to some extent, spatial and temporal variations could occur from year to year. Yearly fluctuations in the size of age and sex classes in the population, due to changes in reproduction and survival, could cause shifts in the time the peak numbers of oldsquaw enter each lagoon.

Oldsquaw densities were consistently higher in Oruktalik Lagoon in 1984 than other lagoons with densities between 174 and 219.5 birds/$Km^2$ (Table 5). Tamayariak also had consistently high densities (94.5 - 136.2 birds/$Km^2$). Low oldsquaw densities were found at Egaksrak Lagoon (7.0 - 37.1 birds/$Km^2$), Arey Lagoon (23.2 - 40.3 birds/$Km^2$) and Brownlow Lagoon (23.7 - 42.8 birds/$Km^2$). Flucuations in oldsquaw densities in 1984 did not occur to the extremes found in past years. For example, oldsquaw densities in Brownlow lagoon ranged from 3 to 57 birds/$Km^2$ in 1981. Oruktalik Lagoon had between 4.3 and 226.9 birds/$Km^2$ in 1981 and Nuvagapuk Lagoon varied from 4.0 to 85.5 birds/$km^2$ in 1982. Throughout the four year period, consistently high densities have occurred at Oruktalik Lagoon and relatively lower densities occurred at Egaksrak, Arey, and Brownlow Lagoons. The small size of Oruktalik Lagoon (8.8 $Km^2$) appears to influence density estimates in relation to other lagoons. The lagoons with lower densities do not show the opposite pattern of having a large surface area (Table 5). Other factors such as the length of barrier island, configuration and orientation of the Lagoon, and water depths probably influence oldsquaw distribution and numbers (Bartels and Doyle 1984).

The number of oldsquaw in the offshore transect increased during the 1984 survey period from 2,796 on 22 July to 7,378 and 10,995 on 5 August and 18 August, respectively (Table 3). This represents 13.2%, 23.1%, and 34.1% of the total oldsquaw counted in the first to last survey. A similar offshore movement was observed in 1983 (Bartels and Doyle 1984) and 1982, but the opposite occurred in 1981 (Bartels et al. 1983). Such offshore movements may be a dispersal in response to crowding and intraspecific interactions by birds which have completed molt, or may be an attempt to exploit offshore food resources. Oldsquaw in the lagoons feed primarily on mysids (Mysis sp.) and Amphipods (Johnson 1984) which are the most abundant prey species (Johnson 1984, Spindler and Meehan 1985). However, no information is available on offshore feeding habits of oldsquaw, or on prey availability for comparison with the lagoon data.

Scoters and Eiders

All three species of scoters were observed in the lagoons and offshore during the 1984 surveys. Surf scoters (Melanitta perspicillata) were the most common although difficulty in the identification of scoters to species prevented a complete breakdown of the abundance of each. Scoter numbers (Table 1) tended to decrease from the 22 July survey (1281) to the 18 August survey (779). Shifting patterns of scoter abundance obscured possible rankings of lagoons for scoter use. The highest totals changed from Jago lagoon (210) and Sadlerochit lagoon (198) on 22 July to Demarcation Bay on 5 August (195) and 18 August (349) (see Appendix). Demarcation Bay and Jago lagoon maintained consistently higher numbers throughout the survey period.

Table 5. Density (birds/km²) of oldsquaw counted in 10 selected lagoons and a 400m offshore strip in 1981-1984, Arctic National Wildlife Refuge, Alaska.

| Lagoon | Area km² | 1981[a] 22-23 July | 1981[a] 3-4 Aug | 1981[a] 22-26 Aug | 1982[a] 25-26 July | 1982[a] 7-13 Aug | 1982[a] 22 Aug | 1983[b] 4 Aug | 1983[b] 10 Aug | 1983[b] 20 Aug | 1983[b] 6-8 Sept | 1984 22 July | 1984 5 Aug | 1984 18 Aug |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Demarcation | 38.7 | 38.6 | 73.1 | 41.6 | 15.9 | 7.7 | 23.7 | 210 | 292 | 34 | 8 | 57.3 | 74.5 | 49.5 |
| Egaksrak | 14.0 | 7.6 | 25.4 | 6.9 | 5.9 | 16.7 | 4.4 | 23 | 22 | 15 | 0.4 | 7.0 | 31.8 | 37.1 |
| Nuvagapak | 31.2 | 45.7 | 78.5 | 32.2 | 4.0 | 85.5 | 45.6 | 182 | 147 | 34 | 7 | 23.5 | 96.0 | 77.5 |
| Oruktalik | 8.8 | 226.9 | 193.0 | 4.3 | 188.0 | 216.6 | 57.7 | 173 | 364 | 38 | 10 | 174.0 | 189.6 | 219.5 |
| Tapkauruk | 20.5 | 131.1 | 139.8 | 105.5 | 62.1 | 31.3 | 3.5 | 43 | 103 | 32 | 4 | 79.0 | 72.7 | 101.0 |
| Jago | 47.3 | 84.3 | 122.9 | 120.0 | 81.2 | 13.7 | 15.4 | 122 | 50 | 12 | 16 | 40.0 | 96.1 | 57.7 |
| Arey | 40.6 | 7.2 | 26.5 | 4.3 | 6.7 | 8.5 | 8.7 | 59 | 26 | 38 | 46 | 23.2 | 24.1 | 40.3 |
| Simpson Cove | 44.4 | 19.1 | 206.7 | 4.1 | 65.4 | 97.4 | 15.0 | 17 | 63 | 218 | 25 | 92.6 | 91.0 | 31.4 |
| Tamayariak | 15.9 | 10.2 | 163.9 | 9.4 | 39.3 | 327.2 | 20.2 | 35 | 17 | 196 | 22 | 136.2 | 94.5 | 122.3 |
| Brownlow | 13.1 | 3.8 | 52.9 | 7.3 | 31.6 | 54.3 | 32.9 | 3 | 5 | 57 | 11 | 34.6 | 23.7 | 42.8 |
| Total Lagoon | 274.5 | 51.9 | 100.8 | 40.8 | 43.1 | 61.9 | 19.1 | 95 | 102 | 70 | 18.0 | 57.4 | 76.0 | 62.8 |
| 400m offshore strip | 88.8 | 19.1 | 32.3 | 9.3 | 15.1 | 21.5 | 43.6 | 43.3 | 60.6 | 92.6 | 28.5 | 31.5 | 83.1 | 123.8 |
| All Areas | 363.3 | 43.9 | 84.1 | 33.1 | 36.2 | 52.0 | 25.1 | 82.3 | 92.0 | 75.5 | 20.6 | 51.1 | 77.7 | 77.4 |

[a]Data from Bartels and Zellhoefer (1983).
[b]Data from Bartels and Doyle (1984).

The majority of eiders counted during the surveys were females and juveniles, thus no meaningful breakdown of species could be due to the impossibility of identifying these age/sex classes into species from the air. The predominance of females and broods, which tend to be secretive, probably accounts for the inconsistency of eider numbers from survey to survey and between lagoons (Table 1). Local high counts were 142 on 22 July at Simpson Cove, 149 on 5 August at Demarcation Bay and 36 at Nuvagapak Lagoon on 18 August (Table 1, see Appendix).

## Loons and Gulls

Loon numbers were consistent throughout the surveys and probably reflect lagoon use by breeding adults foraging for fish (Table 1). Arctic loons (Gavia arctica) were most common, with somewhat lesser numbers of red-throated loons (Gavia stellata) and an occasional yellow-billed loon (Gavia adamsii), (Table 1, see Appendix).

Glaucous gulls showed consistent total numbers (491-503) from survey to survey, but as a transient and opportunistic species, numbers counted in each lagoon varied between surveys (Table 1, see Appendix).

## Geese

Numbers of geese counted rose sharply during the 18 August survey (792) probably due to the beginning of the staging period (Table 1). Black brant (Branta bernicla nigricans) feeding in deltas and brackish marshes made up the majority of geese observed. Those geese found during the first two surveys were in molt and flightless.

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Supervisory Wilflife Biologist, Arctic National Wildlife Refuge

APPENDIX
ANWR Progress Report Number FY85-11

Appendix Table 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, 1983 and 1984.

| | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| Species | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | 1 | 1 | | | | |
| Yellow-billed Loon | | | 2 | | | | |
| Arctic Loon | | | 2 | 2 | 4 | 3 | 5 |
| Red-throated Loon | 1 | 13 | 6 | | | 1 | 1 |
| Loon spp. | | 1 | 2 | 1 | 2 | | |
| Red-necked Grebe | | | | | | | |
| Tundra Swan | | | | | 2 | | 2 |
| Brant | | | | | | | |
| Snowgoose | | | | | | | |
| Goose spp. | | | | | 40 | | |
| Northern Pintail | | | | | | | |
| Scaup spp. | | | | | | | |
| Oldsquaw | 45 | 70 | 750 | 37 | 453 | 310 | 560 |
| Common Eider | | | | | | | |
| King Eider | | | | | | | |
| Spectacled Eider | | | | | | | |
| Eider spp. | | | | | 25 | 25 | 12 |
| White-winged Scoter | | | | | | | |
| Surf Scoter | | | | | | | |
| Black Scoter | | | | | | | |
| Scoter spp. | | | | | 5 | 5 | |
| Red-breasted Merganser | | | | | | | |
| Duck spp. | | | | | | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | | | | | | |
| Shalarope spp. | | | | | | | |
| Shorebird spp. | 3 | | | | | 20 | |
| Jaeger spp. | | | | | | | |
| Glaucous Gull | 8 | 8 | 39 | 27 | 6 | 12 | 15 |
| Herring-Thayer's Gull | | | | | | | |
| Black-legged Kittiwake | | | 6 | | | | |
| Sabines Gull | | | | | | | |
| Arctic Tern | 1 | | 15 | 97 | | | |
| Black Guillemot | | | | | | | |
| Passerine spp. | | | | | | | |
| Unidentified spp. | | | | | | | |
| Seal | | | | | | | |

Appendix Table 2. 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 and 1982.

| | Survey dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | | | 2 | | | |
| Arctic Loon | | 1 | 2 | 2 | 5 | |
| Red-throated Loon | | 1 | 1 | | | |
| Loon spp. | | | 5 | | | 2 |
| Red-necked Grebe | | | | | | |
| Tundra Swan | | | | | | |
| Brant | | | | | | 21 |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | | | | | | |
| Scaup spp. | | | | | | |
| Oldsquaw | 50 | 693 | 95 | 415 | 711 | 204 |
| 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. | | | | | 25 | |
| Jaeger spp. | | | | | | |
| Glaucous Gull | 2 | 8 | 6 | 21 | 3 | 2 |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | | | | | |
| Sabines Gull | | | | | | |
| Arctic Tern | | | | | | |
| Black Guillemot | | | | | 4 | |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Seal | | | | | | |

Appendix Table 3. Migratory bird species and numbers observed during aerial surveys of Tamayariak lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1983 and 1984.

| | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| Species | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | | | | | |
| Yellow-billed Loon | | | | | | | |
| Arctic Loon | | 2 | | | 5 | | |
| Red-throated Loon | 2 | 6 | | | 1 | | |
| Loon spp. | | | 3 | 2 | | | |
| Red-necked Grebe | | | 1 | | | | |
| Tundra Swan | | | | | | | 1 |
| Brant | | | | | | | 10 |
| Snowgoose | | | | | | 6 | 12 |
| Goose spp. | | | | | | | 50 |
| Northern Pintail | | | | | | 5 | |
| Scaup spp. | | | | | 2 | | 3 |
| Oldsquaw | 565 | 276 | 3,116 | | 2,165 | 1,503 | 1,945 |
| Common Eider | 1 | | | | | | |
| King Eider | | | | | | | |
| Spectacled Eider | | | | | | | |
| Eider spp. | | | | | 86 | 27 | 28 |
| White-winged Scoter | | 2 | | | | | 2 |
| Surf Scoter | | | | | | 4 | |
| Black Scoter | | 1 | | | | | 14 |
| Scoter spp. | | | 10 | 1 | 94 | 21 | |
| Red-breasted Merganser | | | | | | | |
| Duck spp. | 5 | | | | | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | | | | | | |
| Phalarope spp. | | 4 | | | | | |
| Shorebird spp. | | | | | | | |
| Jaeger spp. | | | | | | | |
| Glaucous Gull | 9 | 22 | 27 | 28 | 6 | 5 | 7 |
| Herring-Thayer's Gull | | | | | | | |
| Black-legged Kittiwake | | | | | | | |
| Sabines Gull | | | | | | | |
| Arctic Tern | | | 12 | 62 | | | |
| Black Guillemot | | | | | | | |
| Passerine spp. | | | | | | | |
| Unidentified spp. | | | | | | | |
| Seal | | | | | | | |

Appendix Table 4. 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 and 1982.

| | Survey dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | | | | | | |
| Arctic Loon | 1 | 2 | 1 | | | |
| Red-throated Loon | | | 3 | | 1 | 1 |
| Loon spp. | | | | | | 2 |
| Red-necked Grebe | | | | | | 1 |
| Tundra Swan | | | | | | |
| Brant | 9 | 29 | 9 | | | 4 |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | | 4 | 1 | | | |
| Scaup spp. | | | | | | |
| Oldsquaw | 162 | 2,606 | 150 | 625 | 5,202 | 321 |
| Common Eider | | | | | | |
| King Eider | | | | 3 | | |
| Spectacled Eider | | | | | | |
| Eider spp. | 1 | 81 | 1 | | 1 | |
| White-winged Scoter | | | | | | |
| Surf Scoter | | | | 269 | | |
| Black Scoter | | | | | | |
| Scoter spp. | | | | | | |
| Red-breasted Merganser | | | | 1 | | |
| Duck spp. | | 80 | | 4 | | |
| Sandhill Crane | | | | | | |
| Plover spp. | | | | | | |
| Phalarope spp. | | 38 | | | | |
| Shorebird spp. | | 3 | 40 | | 11 | |
| Jaeger spp. | | | | | | |
| Glaucous Gull | | | | 12 | 5 | 8 |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | | | | | |
| Sabines Gull | | | | 2 | | |
| Arctic Tern | | 3 | | | 1 | |
| Black Guillemot | | | | | 1 | |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Seal | | | | | | |

Appendix Table 5. Migratory bird species and numbers observed during aerial surveys of Simpson Cove along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1983 and 1984.

| | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| Species | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | 2 | | | | | |
| Yellow-billed Loon | | | 1 | | | | |
| Arctic Loon | 2 | 2 | 4 | 1 | 4 | 1 | 1 |
| Red-throated Loon | 1 | 5 | 1 | 5 | 2 | 1 | 1 |
| Loon spp. | | 3 | 9 | 9 | | 7 | |
| Red-necked Grebe | | | | | | | |
| Tundra Swan | | | | | 15 | 3 | |
| Brant | | | | | | | |
| Snowgoose | | | | | | | |
| Goose spp. | | | | | | | |
| Northern Pintail | | | | | | 17 | |
| Scaup spp. | | | 2 | | | | |
| Oldsquaw | 750 | 2,792 | 9,678 | 1,119 | 4,113 | 4,039 | 1,396 |
| Common Eider | | | | | 2 | | |
| King Eider | | | | | | | |
| Spectacled Eider | | | | | | | |
| Eider spp. | | 6 | | 60 | 140 | 37 | 4 |
| White-winged Scoter | | | | | | | |
| Surf Scoter | | | | | | | |
| Black Scoter | | | | | | | |
| Scoter spp. | 1 | 4 | | 11 | 151 | 21 | |
| Red-breasted Merganser | | | 50 | | | | |
| Duck spp. | 12 | | | 5 | | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | | | | | | |
| Phalarope spp. | | 2 | | | | | |
| Shorebird spp. | | | | | | 45 | |
| Jaeger spp. | 1 | | | 1 | | | |
| Glaucous Gull | 50 | 64 | 36 | 9 | 69 | 34 | 9 |
| Herring-Thayer's Gull | | 1 | | | | | |
| Black-legged Kittiwake | | | | | | | |
| Sabines Gull | | | | | | | |
| Arctic Tern | | | | 2 | 2 | | |
| Black Guillemot | | | | | | | |
| Passerine spp. | | | | | | | |
| Unidentified spp. | | | | | | | |
| Seal | | | | | | | |

Appendix Table 6. 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 and 1982.

| | Survey dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | | | | | | 1 |
| Arctic Loon | | 10 | | | 1 | 1 |
| Red-throated Loon | 1 | 11 | | | | |
| Loon spp. | | 1 | 5 | | | 2 |
| Red-necked Grebe | | | | | | |
| Tundra Swan | | | | | 2 | 1 |
| Brant | | | 10 | | | 10 |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | | | | | | |
| Scaup spp. | | | | | | |
| Oldsquaw | 850 | 9,187 | 205 | 2,906 | 4,326 | 665 |
| Common Eider | | | | | | |
| King Eider | | | | | | |
| Spectacled Eider | | | | | | |
| Eider spp. | 25 | 12 | 10 | 9 | 12 | |
| White-winged Scoter | | | | | | |
| Surf Scoter | | 7 | | | | |
| Black Scoter | | | | 40 | | |
| Scoter spp. | 12 | | | | | |
| Red-breasted Merganser | 1 | | | | | |
| Duck spp. | 3 | 4 | | 6 | | |
| Sandhill Crane | | | | | | |
| Plover spp. | | | | | | |
| Phalarope spp. | 3 | 1 | | | 2 | |
| Shorebird spp. | | 20 | 55 | 8 | | |
| Jaeger spp. | | | | | 1 | |
| Glaucous Gull | 15 | 83 | 32 | 46 | 25 | 26 |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | | | | | |
| Sabines Gull | | | | | | |
| Arctic Tern | | | | | | |
| Black Guillemot | | | | | | |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Seal | | | | | | |

Appendix Table 7. Migratory bird species and numbers observed during aerial surveys of Sadlerochit lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1984.

| Species | Survey dates | | |
|---|---|---|---|
| | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | |
| Yellow-billed Loon | 1 | | |
| Arctic Loon | 6 | | 1 |
| Red-throated Loon | 2 | | |
| Loon spp. | 6 | | |
| Red-necked Grebe | | | |
| Tundra Swan | 2 | | |
| Brant | | | |
| Snowgoose | | | |
| Goose spp. | | | |
| Northern Pintail | | | 4 |
| Scaup spp. | | | |
| Oldsquaw | 903 | 752 | 1,352 |
| Common Eider | | | |
| King Eider | | | |
| Spectacled Eider | | | |
| Eider spp. | 33 | 29 | 16 |
| White-winged Scoter | | | |
| Surf Scoter | 125 | 7 | |
| Black Scoter | | | |
| Scoter spp. | 73 | 72 | 15 |
| Red-breasted Merganser | | | |
| Duck spp. | | | |
| Sandhill Crane | | | |
| Plover spp. | | | |
| Phalarope spp. | | | |
| Shorebird spp. | | | |
| Jaeger spp. | | | |
| Glaucous Gull | 48 | 19 | 36 |
| Herring-Thayer's Gull | | | |
| Black-legged Kittiwake | | | |
| Sabines Gull | | | |
| Mew Gull | | 4 | |
| Arctic Tern | | | |
| Black Guillemot | | | |
| Passerine spp. | | | |
| Unidentified spp. | | | |
| Seal | | | |

Appendix Table 8. Migratory bird species and numbers observed during aerial surveys of Arey lagoon along the Beaufort Sea coastline in the Arctic National Wildlife refuge, Alaska, 1983 and 1984.

| | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| Species | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | | | | | |
| Yellow-billed Loon | | 1 | | | 1 | 1 | |
| Arctic Loon | 15 | 2 | 5 | 2 | 4 | 8 | 5 |
| Red-throated Loon | 2 | 3 | 1 | 1 | | 2 | |
| Loon spp. | 7 | 10 | 3 | 6 | 5 | 1 | |
| Red-necked Grebe | | | | | | | |
| Tundra Swan | | 2 | | 3 | 11 | 7 | |
| Brant | | 25 | 135 | 223 | | | |
| Snowgoose | | | | | | | |
| Goose spp. | | | | | | | |
| Northern Pintail | | 1 | | | | 14 | |
| Scaup spp. | | | | | | | |
| Oldsquaw | 2,410 | 1,055 | 1,548 | 1,886 | 942 | 979 | 1,634 |
| Common Eider | | | | | | 3 | |
| King Eider | | | | | | | |
| Spectacled Eider | | | | | 62 | 57 | 14 |
| Eider spp. | | 13 | | 6 | | | |
| White-winged Scoter | | | 10 | | | | 13 |
| Surf Scoter | | 50 | | | | 25 | 15 |
| Black Scoter | | | 50 | | 60 | 34 | 19 |
| Scoter spp. | 81 | 4 | | 29 | | | |
| Red-breasted Merganser | | | | | | | |
| Duck spp. | | | | | | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | | | | | | |
| Phalarope spp. | | 1 | 20 | | | | |
| Shorebird spp. | 4 | | 10 | | | 20 | |
| Jaeger spp. | | | | 1 | | | |
| Glaucous Gull | 22 | 66 | 67 | 413 | 20 | 57 | 2 |
| Herring-Thayer's Gull | | | | | | | |
| Black-legged Kittiwake | | | | | | | |
| Sabines Gull | | | | | | | |
| Arctic Tern | | | | 57 | | | |
| Black Guillemot | | | | | | | |
| Passerine spp. | | | | | | | |
| Unidentified spp. | | | | | | | |
| Seal | | | | | | | |

Appendix Table 9. 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 and 1982.

| | Survey dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | | | | | | |
| Arctic Loon | 1 | 7 | | 3 | | 3 |
| Red-throated Loon | 2 | 5 | | | | 2 |
| Loon spp. | 1 | 3 | 2 | 7 | 1 | 2 |
| Red-necked Grebe | | | | | | |
| Tundra Swan | | | | | 7 | |
| Brant | | | | | | 76 |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | | 47 | 2 | | | 10 |
| Scaup spp. | | | | | | |
| Oldsquaw | 293 | 1,016 | 174 | 274 | 347 | 352 |
| Common Eider | | | | | 4 | |
| King Eider | | | | | | |
| Spectacled Eider | | | | | | |
| Eider spp. | | 14 | | | 40 | |
| White-winged Scoter | | | | | | |
| Surf Scoter | | | | | | |
| Black Scoter | | | | | | |
| Scoter spp. | | 50 | | | | 11 |
| Red-breasted Merganser | | | | | | |
| Duck spp. | | | | | | 4 |
| Sandhill Crane | | | | | | |
| Plover spp. | 1 | | | | | |
| Phalarope spp. | | 100 | | | 4 | |
| Shorebird spp. | 46 | 2 | | | 48 | |
| Jaeger spp. | | | | | | |
| Glaucous Gull | 25 | 75 | 32 | 22 | 149 | 6 |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | | | | | |
| Sabines Gull | | | | | | |
| Arctic Tern | 4 | | | | | |
| Black Guillemot | | | 3 | | 3 | |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Seal | | | | | | |

Appendix Table 10. Migratory bird species and numbers observed during aerial surveys of Kaktovik lagoon along the Beaufort Sea coastline in the Arctic National Wildlife refuge, Alaska, 1984.

| Species | Survey Dates | | |
|---|---|---|---|
| | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | |
| Yellow-billed Loon | | | |
| Arctic Loon | | 3 | 6 |
| Red-throated Loon | 2 | | |
| Loon spp. | 2 | 1 | |
| Red-necked Grebe | | | |
| Tundra Swan | | | |
| Brant | | | |
| Snowgoose | | | |
| Goose spp. | | | |
| Northern Pintail | | | |
| Scaup spp. | | | |
| Oldsquaw | 1,405 | 1,441 | 822 |
| Common Eider | 55 | | |
| King Eider | | | |
| Spectacled Eider | | | |
| Eider spp. | 18 | 27 | 17 |
| White-winged Scoter | | | |
| Surf Scoter | 1 | | |
| Black Scoter | | | |
| Scoter spp. | 48 | | 1 |
| Red-breasted Merganser | | | |
| Duck spp. | | | |
| Sandhill Crane | | 1 | |
| Plover spp. | | | |
| Phalarope spp. | | | |
| Shorebird spp. | | | |
| Jaeger spp. | | | |
| Glaucous Gull | 50 | 49 | 5 |
| Herring-Thayer's Gull | | | |
| Black-legged Kittiwake | | | |
| Sabines Gull | | | |
| Arctic Tern | | | |
| Black Guillemot | | | |
| Passerine spp. | | | |
| Unidentified spp. | | | |
| Seal | | | |

Appendix Table 11. Migratory bird species and numbers observed during aerial surveys of Jago lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1983 and 1984.

| | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| Species | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | | | | | |
| Yellow-billed Loon | | | | | 1 | | |
| Arctic Loon | 9 | | | | 12 | 4 | 2 |
| Red-throated Loon | 6 | | 1 | 2 | | 3 | 1 |
| Loon spp. | 14 | 7 | | 1 | 2 | | |
| Red-necked Grebe | | | | | | | |
| Tundra Swan | | | | | | | |
| Brant | | | | | | | |
| Snowgoose | | | | | | | |
| Goose spp. | | | | | | | |
| Northern Pintail | | | | | | | |
| Scaup spp. | | | | | | | |
| Oldsquaw | 5,757 | 2,342 | 551 | 767 | 1,892 | 4,544 | 2,730 |
| Common Eider | | | | | | 1 | |
| King Eider | | | | | | | |
| Spectacled Eider | | | | | | | |
| Eider spp. | | | | | 16 | 45 | 10 |
| White-winged Scoter | | | | | | | |
| Surf Scoter | 158 | | 8 | | 7 | 85 | 145 |
| Black Scoter | 1 | 70 | 46 | | 21 | | 20 |
| Scoter spp. | 86 | 7 | 63 | 4 | 173 | 39 | 2 |
| Red-breasted Merganser | | | | | | | |
| Duck spp. | | | | | | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | | | | | | |
| Phalarope spp. | | 45 | | 25 | | | |
| Shorebird spp. | 27 | | | | | | |
| Jaeger spp. | | | | | | | |
| Glaucous Gull | 134 | 210 | | 1 | 26 | 82 | 123 |
| Herring-Thayer's Gull | | | | | | | |
| Black-legged Kittiwake | | | | | | | |
| Sabines Gull | | | | | | | |
| Mew Gull | 2 | | | | | | |
| Arctic Tern | | | 7 | 60 | | | |
| Black Guillemot | | | | | | | |
| Passerine spp. | | | | | | | |
| Unidentified spp. | | | | | | | |
| Seal | | | | | | | |

Appendix Table 12. 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 and 1982.

| | Survey dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | | 5 | | | | |
| Arctic Loon | 2 | | | | | |
| Red-throated Loon | | | | 2 | 2 | 2 |
| Loon spp. | 1 | 5 | | 7 | 2 | |
| Red-necked Grebe | | | | | | |
| Tundra Swan | | | | | | |
| Brant | | | | | | |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | 3 | | | | | |
| Scaup spp. | | | | 46 | | |
| Oldsquaw | 3,988 | 5,814 | 5,674 | 3,845 | 650 | 727 |
| Common Eider | | | | | | |
| King Eider | | | | 5 | 1 | 1 |
| Spectacled Eider | | | | | | |
| Eider spp. | | 11 | | | | |
| White-winged Scoter | | | | | | |
| Surf Scoter | 30 | 5 | 5 | 111 | | 32 |
| Black Scoter | | | | | 11 | 3 |
| Scoter spp. | | 16 | | | 6 | |
| Red-breasted Merganser | | | | 1 | | |
| Duck spp. | | | | 2 | 6 | |
| Sandhill Crane | | | | | | |
| Plover spp. | | | | | | |
| Phalarope spp. | 1 | | | | | |
| Shorebird spp. | 33 | | 2 | | 2 | 34 |
| Jaeger spp. | 1 | | | | | |
| Glaucous Gull | 68 | 36 | 304 | 170 | 126 | 251 |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | | | | | |
| Sabines Gull | | | | | | |
| Arctic Tern | | | 1 | | | |
| Black Guillemot | | | | | | 3 |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Seal | | | | | | |

Appendix Table 13. Migratory bird species and numbers observed during aerial surveys of Tapkaurak lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1983 and 1984.

| | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| Species | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | | | | | |
| Yellow-billed Loon | | | | | | | |
| Arctic Loon | | | | 2 | 8 | 6 | 1 |
| Red-throated Loon | | | | | | 1 | 2 |
| Loon spp. | | 3 | 3 | 1 | | | |
| Red-necked Grebe | | | | | | | |
| Tundra Swan | | | | | | | |
| Brant | | | | | | | |
| Snowgoose | | | | | | | |
| Goose spp. | | | | | | | |
| Northern Pintail | | 20 | | | | | |
| Scaup spp. | | | | | | | |
| Oldsquaw | 884 | 2,102 | 647 | 78 | 1,620 | 1,491 | 2,070 |
| Common Eider | | | | | 1 | | |
| King Eider | | | | | | | |
| Spectacled Eider | | | | | | | |
| Eider spp. | | | | | 2 | 12 | 6 |
| White-winged Scoter | | | | | | | |
| Surf Scoter | | | | 1 | 1 | | |
| Black Scoter | | | 3 | | 14 | 12 | |
| Scoter spp. | 3 | | 4 | 43 | 81 | 28 | 1 |
| Red-breasted Merganser | | | | | | | |
| Duck spp. | | | | | | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | | | | | | |
| Phalarope spp. | | | | 560 | | | |
| Shorebird spp. | | | | | | | |
| Jaeger spp. | | | | | | | |
| Glaucous Gull | | | 15 | | 9 | | 25 |
| Herring-Thayer's Gull | | | | | | | |
| Black-legged Kittiwake | | | | | | | |
| Sabines Gull | | | | | | | |
| Arctic Tern | | | | | | | |
| Black Guillemot | | | | | | | |
| Passerine spp. | | | | | | | |
| Unidentified spp. | | | | | | | |
| Seal | | | | | | | |

Appendix Table 14. 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 and 1982.

| | Survey dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | 1 | | | | | |
| Arctic Loon | | 1 | | 1 | | |
| Red-throated Loon | | | | | 2 | |
| Loon spp. | 1 | 2 | | 9 | | 3 |
| Red-necked Grebe | | | | | | |
| Tundra Swan | | | | | | |
| Brant | | | | | | |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | 3 | | 6 | | | |
| Scaup spp. | | | | | | |
| Oldsquaw | 2,688 | 2,867 | 2,150 | 1,237 | 642 | 71 |
| Common Eider | | | | | | |
| King Eider | | | | | 1 | |
| Spectacled Eider | | | | | | |
| Eider spp. | | | | | | |
| White-winged Scoter | | | | | | |
| Surf Scoter | | | | | | |
| Black Scoter | | | | | | |
| Scoter spp. | 6 | 2 | | | 20 | |
| Red-breasted Merganser | | | | | | |
| Duck spp. | | | | | 30 | 3 |
| Sandhill Crane | | | | | | |
| Plover spp. | | | | | | |
| Phalarope spp. | | 20 | | | | |
| Shorebird spp. | | | | | | |
| Jaeger spp. | | | | | | |
| Glaucous Gull | 21 | 5 | 3 | 21 | 8 | 6 |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | | | | | |
| Sabines Gull | | | | | | |
| Arctic Tern | | | | | | |
| Black Guillemot | | | | | | |
| Tufted Puffin | | | | | | |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Seal | | | | | | |

Appendix Table 15. Migratory bird species and numbers observed during aerial surveys of Oruktalik lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1983 and 1984.

| | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| Species | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | | | | | |
| Yellow-billed Loon | | 2 | | | | 1 | |
| Arctic Loon | | | | | 2 | | 7 |
| Red-throated Loon | | 3 | 1 | | | | 1 |
| Loon spp. | 7 | 1 | | | | 1 | 1 |
| Red-necked Grebe | | | | | | | |
| Tundra Swan | | | | | | | |
| Brant | | | | 10 | | | |
| Snowgoose | | | | | | | |
| Goose spp. | | | | | | | |
| Northern Pintail | | | | | | | 6 |
| Scaup spp. | | | | | | | |
| Oldsquaw | 1,524 | 3,206 | 335 | 84 | 1,531 | 1,669 | 1,932 |
| Common Eider | | | | | | | |
| King Eider | | | | | | | |
| Spectacled Eider | | | | | | | |
| Eider spp. | | | | | 5 | 7 | 3 |
| White-winged Scoter | | | | | | | |
| Surf Scoter | 1 | | | | 25 | 4 | |
| Black Scoter | | | | | 32 | 1 | 1 |
| Scoter spp. | | | | | | 47 | |
| Red-breasted Merganser | | | | | 3 | | |
| Duck spp. | | | | | | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | | | | | | |
| Phalarope spp. | | 10 | | 50 | | | |
| Shorebird spp. | | | | | | | |
| Jaeger spp. | | | | | | | |
| Glaucous Gull | 1 | 4 | | 6 | 6 | 3 | 5 |
| Herring-Thayer's Gull | | | | | | | |
| Black-legged Kittiwake | | | | 3 | | | |
| Sabines Gull | | | | 78 | | | |
| Arctic Tern | | | | 18 | | | |
| Black Guillemot | | | | | | | |
| Passerine spp. | | | | | | | |
| Unidentified spp. | | | | | | | |
| Seal | | | | | | | |

Appendix Table 16. Migratory bird species and numbers observed during aerial surveys of Oruktavik lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

| | Survey dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | 1 | | | | | |
| Arctic Loon | 2 | | | | | |
| Red-throated Loon | | | | | | |
| Loon spp. | 3 | | 2 | | 3 | |
| Red-necked Grebe | | | | | | |
| Tundra Swan | | | | | | |
| Brant | | | | | | 6 |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | 3 | | | | | |
| Scaup spp. | | | | | | |
| Oldsquaw | 1,997 | 1,698 | 38 | 1,657 | 1,906 | 508 |
| Common Eider | | | | | | |
| King Eider | | | | | | |
| Spectacled Eider | | | | | | |
| Eider spp. | 1 | | | | | |
| White-winged Scoter | | | | | | |
| Surf Scoter | | | | | | |
| Black Scoter | | | | | | |
| Scoter spp. | 1 | | | | | |
| Red-breasted Merganser | | | | | | |
| Duck spp. | | | | | | 2 |
| Sandhill Crane | | | | | | |
| Plover spp. | | | | | | |
| Phalarope spp. | | 5 | | | | |
| Shorebird spp. | 2 | | | 25 | | |
| Jaeger spp. | | | | | | |
| Glaucous Gull | 21 | 11 | | 22 | 49 | 29 |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | | | | | |
| Sabines Gull | | | 1 | | | |
| Arctic Tern | 1 | | | | | |
| Black Guillemot | | | | | | |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Seal | | | | | | |

Appendix Table 17. Migratory bird species and numbers observed during aerial surveys of Angun and Pokok lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1984.

| | Survey dates | | |
|---|---|---|---|
| Species | 22 July | 05 Aug | 18 Aug |
| Species | | | |
| Common Loon | | | |
| Yellow-billed Loon | | | |
| Arctic Loon | 1 | 8 | 8 |
| Red-throated Loon | | 1 | |
| Loon spp. | | 1 | |
| Red-necked Grebe | | | |
| Tundra Swan | 2 | | |
| Brant | | | |
| Snowgoose | | | |
| Goose spp. | | 26 | 3 |
| Northern Pintail | | | |
| Scaup spp. | | | 30 |
| Oldsquaw | 319 | 1,464 | 1,909 |
| Common Eider | | | |
| King Eider | | | |
| Spectacled Eider | | | |
| Eider spp. | 17 | 25 | 29 |
| White-winged Scoter | | | |
| Surf Scoter | 1 | | |
| Black Scoter | | | 1 |
| Scoter spp. | 1 | 26 | 14 |
| Red-breasted Merganser | | | |
| Duck spp. | | | |
| Sandhill Crane | | | |
| Plover spp. | | | |
| Phalarope spp. | | | |
| Shorebird spp. | | | |
| Jaeger spp. | | | |
| Glaucous Gull | 13 | 6 | 18 |
| Herring-Thayer's Gull | | | |
| Black-legged Kittiwake | | | |
| Sabines Gull | | | |
| Arctic Tern | | | |
| Black Guillemot | | | |
| Passerine spp. | | | |
| Unidentified spp. | | | |
| Seal | | | |

Appendix Table 18. Migratory bird species and numbers observed during aerial surveys of Nuvagapak lagoon along the Beaufort Sea Coastline in the Arctic National Wildlife Refuge, Alaska, 1983 and 1984.

| | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| Species | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | | | | | |
| Yellow-billed Loon | | | | | | 5 | |
| Arctic Loon | 5 | 4 | | 2 | 1 | | 5 |
| Red-throated Loon | 1 | 1 | 8 | 1 | | 4 | 3 |
| Loon spp. | 2 | 4 | 1 | 1 | | 1 | 4 |
| Red-necked Grebe | | | | | | | |
| Tundra Swan | 5 | | | | 2 | 15 | 2 |
| Brant | | | 580 | 20 | | | 200 |
| Snowgoose | | | | | | | |
| Goose spp. | | | | 50 | | | |
| Northern Pintail | | | | | | 25 | |
| Scaup spp. | 4 | | 3 | 40 | | | 2 |
| Oldsquaw | 5,689 | 4,572 | 1,076 | 222 | 732 | 2,996 | 2,417 |
| Common Eider | 1 | 10 | | | | | |
| King Eider | | | | | | | |
| Spectacled Eider | | | | | | | |
| Eider spp. | | | | 10 | 24 | 28 | 81 |
| White-winged Scoter | | | | | | | |
| Surf Scoter | 1 | | | | 2 | | |
| Black Scoter | | | | | | 4 | 2 |
| Scoter spp. | 11 | | 2 | | 8 | 66 | 34 |
| Red-breasted Merganser | | | 13 | 6 | 2 | 1 | 2 |
| Duck spp. | | | | | | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | 5 | | | | | |
| Phalarope spp. | | | | | | | |
| Shorebird spp. | 3 | | | | | 3 | |
| Jaeger spp. | | | | | | | |
| Glaucous Gull | 19 | 58 | 69 | 9 | 41 | 4 | 19 |
| Herring-Thayer's Gull | | | | | | | |
| Black-legged Kittiwake | | | | | | | |
| Sabines Gull | | | | | | | |
| Arctic Tern | 5 | | 3 | 174 | | | |
| Black Guillemot | | | | | | 1 | |
| Passerine spp. | | | | | | | |
| Unidentified spp. | | | | | | | |
| Seal | | | | | | | |

Appendix Table 19. 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 and 1982.

| | Survey Dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | 1 | 1 | | | 1 | |
| Arctic Loon | 5 | | | | 1 | |
| Red-throated Loon | 1 | 1 | | | 4 | |
| Loon spp. | 1 | 5 | 1 | | 3 | |
| Red-necked Grebe | | | | | | |
| Tundra Swan | 2 | 3 | | 5 | 60 | |
| Brant | | | | | | |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | | | 25 | | | |
| Scaup spp. | | | | | | |
| Oldsquaw | 1,427 | 2,448 | 1,004 | 126 | 2,669 | |
| Common Eider | | | | | | |
| King Eider | | | | | | |
| Spectacled Eider | | | | | | |
| Eider spp. | | | | 6 | 10 | |
| White-winged Scoter | | | | | | |
| Surf Scoter | | | | | | |
| Black Scoter | 4 | | | | | |
| Scoter spp. | | | | | | |
| Red-breasted Merganser | 13 | | | | 15 | |
| Duck spp. | 4 | 8 | 1 | | 5 | |
| Sandhill Crane | 2 | | | | | |
| Plover spp. | | | | | | |
| Phalarope spp. | | 5 | | | 50 | |
| Shorebird spp. | 2 | 1 | | | | |
| Jaeger spp. | | | | | 1 | |
| Glaucous Gull | 14 | 14 | 29 | 8 | 25 | |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | | | | | |
| Sabines Gull | | | | | | |
| Arctic Tern | 1 | | | | 1 | |
| Black Guillemot | | | | | | |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Seal | | | | | | |

Appendix Table 20. Migratory bird species and numbers observed during aerial surveys of Egaksrak lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1983 and 1984.

| | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| Species | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | | | | | |
| Yellow-billed Loon | | | | | | | |
| Arctic Loon | 1 | 9 | | | 1 | 2 | |
| Red-throated Loon | 3 | 1 | 1 | 1 | | | 1 |
| Loon spp. | 5 | 2 | | | | 1 | |
| Red-necked Grebe | | | | | | | |
| Tundra Swan | 14 | 10 | 3 | | | 8 | 1 |
| Brant | | | 1,265 | 20 | | | 430 |
| Snowgoose | | | | | | | |
| Goose spp. | | | | | | | |
| Northern Pintail | | | | | | 6 | |
| Scaup spp. | | | | | | | |
| Oldsquaw | 324 | 314 | 205 | 6 | 98 | 445 | 520 |
| Common Eider | | | | | | | |
| King Eider | | | | | | | |
| Spectacled Eider | | | | | | | |
| Eider spp. | | | | | | 26 | 2 |
| White-winged Scoter | | | | 10 | | | |
| Surf Scoter | | | | | | | |
| Black Scoter | | | | | 6 | | |
| Scoter spp. | 1 | | | | | | |
| Red-breasted Merganser | | | | | | 1 | |
| Duck spp. | | | | | | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | | | | | | |
| Phalarope spp. | | 45 | 25 | | | | |
| Shorebird spp. | 16 | | | | | | |
| Jaeger spp. | | | | | | | |
| Glaucous Gull | 71 | 30 | 53 | 9 | 39 | 47 | 32 |
| Herring-Thayer's Gull | | | | | | | |
| Black-legged Kittiwake | | | | | | | |
| Sabines Gull | | | | 174 | | | |
| Arctic Tern | | | | | | | |
| Black Guillemot | | | | | | | |
| Passerine spp. | | | | | | | |
| Unidentified spp. | | | | | | | |
| Seal | | | | | | | |

Appendix Table 21. 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 and 1982.

| | Survey dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | | | | | | |
| Arctic Loon | 1 | | | | | 1 |
| Red-throated Loon | 1 | | 3 | 1 | | |
| Loon spp. | 1 | 1 | 3 | | | 9 |
| Red-necked Grebe | | | | | | |
| Tundra Swan | 55 | 14 | 11 | | | 4 |
| Brant | | 3 | 350 | | 708 | 505 |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | 19 | | 4 | | | |
| Scaup spp. | | 1 | 10 | | | |
| Oldsquaw | 107 | 355 | 97 | 82 | 234 | 61 |
| Common Eider | 10 | | | 4 | | |
| King Eider | | | | 10 | | |
| Spectacled Eider | | | | | | |
| Eider spp. | | | | | | |
| White-winged Scoter | | | | | | |
| Surf Scoter | | | | | | |
| Black Scoter | | | | | | |
| Scoter spp. | | | | | | |
| Red-breasted Merganser | 3 | | | | | |
| Duck spp. | 18 | | | | | |
| Sandhill Crane | | | | | | |
| Plover spp. | | | | | | |
| Phalarope spp. | | 55 | | | 12 | |
| Shorebird spp. | 321 | 2 | 210 | | | |
| Jaeger spp. | | | | | | |
| Glaucous Gull | 8 | 10 | 12 | 14 | 12 | |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | | | | | |
| Sabines Gull | | | | | | |
| Arctic Tern | 2 | | | | 1 | |
| Black Guillemot | | | | | | |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Snowy Owl | 1 | | | | | |
| Seal | | | | | | |

Appendix Table 22. Migratory bird species and numbers observed during aerial surveys of Siku lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1984.

| Species | Survey dates | | |
|---|---|---|---|
| | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | |
| Yellow-billed Loon | | | |
| Arctic Loon | 1 | | 9 |
| Red-throated Loon | | 2 | 2 |
| Loon spp. | | 2 | 6 |
| Red-necked Grebe | | | |
| Tundra Swan | | | 3 |
| Brant | | | 7 |
| Snowgoose | | | |
| Goose spp. | | | |
| Northern Pintail | | | |
| Scaup spp. | | | |
| Oldsquaw | 41 | 58 | 22 |
| Common Eider | | | |
| King Eider | | | |
| Spectacled Eider | | | |
| Eider spp. | | 5 | 7 |
| White-winged Scoter | | | |
| Surf Scoter | | | |
| Black Scoter | | | |
| Scoter spp. | | 11 | |
| Red-breasted Merganser | | | |
| Duck spp. | | | |
| Sandhill Crane | | | |
| Plover spp. | | | |
| Phalarope spp. | | | |
| Shorebird spp. | | 7 | |
| Jaeger spp. | | | |
| Glaucous Gull | 103 | 50 | 5 |
| Herring-Thayer's Gull | | | |
| Black-legged Kittiwake | | | |
| Sabines Gull | | | |
| Mew Gull | | | 1 |
| Arctic Tern | 1 | | 2 |
| Black Guillemot | | | |
| Passerine spp. | | | |
| Unidentified spp. | | | |
| Seal | | | |

Appendix Table 23. Migratory bird species and numbers observed during aerial surveys of Demarcation Bay lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1983 and 1984.

| Species | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | | | 2 | | | |
| Yellow-billed Loon | | | | | | | |
| Arctic Loon | 5 | 6 | 2 | 1 | | 6 | 11 |
| Red-throated Loon | 3 | 2 | | 1 | | 2 | 13 |
| Loon spp. | 8 | 6 | 4 | 1 | | 12 | |
| Red-necked Grebe | | | | | | | |
| Tundra Swan | | | | 2 | | 10 | 3 |
| Brant | | | | 350 | | | 35 |
| Snowgoose | | | 52 | | | | |
| Goose spp. | | | | | | | |
| Northern Pintail | 1 | | | | | 2 | |
| Scaup spp. | | | 5 | | | | |
| Oldsquaw | 8,116 | 11,319 | 1,301 | 293 | 2,218 | 2,884 | 1,916 |
| Common Eider | | | 25 | | 11 | | |
| King Eider | | | | | | | |
| Spectacled Eider | | | | | | | |
| Eider spp. | | 15 | | | 13 | 149 | 57 |
| White-winged Scoter | | 5 | | | | | 20 |
| Surf Scoter | 61 | 60 | 63 | 74 | 46 | 6 | 34 |
| Black Scoter | | 1 | 1 | | 20 | 49 | 124 |
| Scoter spp. | 41 | 143 | 12 | 29 | 35 | 138 | 171 |
| Red-breasted Merganser | 6 | | | | | 2 | |
| Duck spp. | | | | | | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | | | | | | |
| Phalarope spp. | | | 5 | | | | |
| Shorebird spp. | 1 | | | | | 6 | |
| Jaeger spp. | | | | | | | |
| Glaucous Gull | 57 | 29 | 30 | 15 | 37 | 14 | 120 |
| Herring-Thayer's Gull | | | | | | | |
| Black-legged Kittiwake | | | | | | | |
| Sabines Gull | | | | | | | |
| Arctic Tern | | | | 108 | | | |
| Black Guillemot | | | | | | | |
| Passerine spp. | | | | | | 1 | |
| Unidentified spp. | | | | | | | |
| Seal | 1 | | | | | | |

Appendix Table 24. Migratory bird species and numbers observed during aerial surveys of Demarcation Bay lagoon along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

| | Survey dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | 1 | | | | | |
| Arctic Loon | 3 | 1 | | 3 | | |
| Red-throated Loon | 3 | 1 | | 1 | | 5 |
| Loon spp. | 1 | 2 | 4 | 3 | | |
| Red-necked Grebe | | | | | | |
| Tundra Swan | | 2 | | | | |
| Brant | | | | | | |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | | | | | | |
| Scaup spp. | 16 | 1 | | | | |
| Oldsquaw | 2,678 | 1,557 | 1,611 | 617 | 229 | 919 |
| Common Eider | | | | | 13 | |
| King Eider | | | | | 1 | |
| Spectacled Eider | | | | | | |
| Eider spp. | 3 | 11 | | | 9 | |
| White-winged Scoter | | | | | | |
| Surf Scoter | 4 | | | 165 | 38 | 69 |
| Black Scoter | | | | 15 | | |
| Scoter spp. | 137 | 29 | 1 | 30 | | 24 |
| Red-breasted Merganser | | | 5 | 8 | | |
| Duck spp. | 5 | | | | | 4 |
| Sandhill Crane | | | | | | |
| Plover spp. | | | | | | |
| Phalarope spp. | | | 35 | | 7 | |
| Shorebird spp. | 5 | | | | | |
| Jaeger spp. | | | | | | |
| Glaucous Gull | 8 | 5 | 11 | 7 | 155 | 40 |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | | | | | |
| Sabines Gull | | | | | | |
| Arctic Tern | 1 | | | | | |
| Black Guillemot | | | | | | |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Seal | | | | | | |

Appendix Table 25. Migratory bird species and numbers observed in 400 m offshore transect along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1983 and 1984.

| | Survey dates | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | |
| Species | 04 Aug | 10 Aug | 20 Aug | 6&8 Sep | 22 July | 05 Aug | 18 Aug |
| Common Loon | | 1 | | | | | |
| Yellow-billed Loon | | 2 | 1 | 1 | 1 | 1 | |
| Arctic Loon | 16 | 18 | 11 | | 6 | 5 | 16 |
| Red-throated Loon | 10 | 23 | 27 | 7 | 6 | 18 | 3 |
| Loon spp. | 23 | 42 | 29 | 11 | 3 | 5 | |
| Red-necked Grebe | | | | | | | |
| Tundra Swan | | | | | | | |
| Brant | | | | 95 | | | 35 |
| Snowgoose | | | 30 | | | | |
| Goose spp. | | | | 2 | | | 1 |
| Northern Pintail | | | | | | 13 | |
| Scaup spp. | | | | | | | |
| Oldsquaw | 4,207 | 5,632 | 8,255 | 2,808 | 2,796 | 7,378 | 10,995 |
| Common Eider | 47 | 19 | | 1 | 52 | | |
| King Eider | 52 | | | | | | |
| Spectacled Eider | | | | | | | |
| Eider spp. | | 74 | 38 | 129 | 168 | 378 | 157 |
| White-winged Scoter | | | | | | | |
| Surf Scoter | 9 | 12 | 27 | | 7 | | 3 |
| Black Scoter | | 2 | 11 | | 31 | 57 | 71 |
| Scoter spp. | 126 | 15 | 226 | 48 | 213 | 22 | 57 |
| Red-breasted Merganser | 2 | | | | | | |
| Duck spp. | 8 | | | | 1 | | |
| Sandhill Crane | | | | | | | |
| Plover spp. | | | | | | | |
| Phalarope spp. | 2 | | 82 | 16,425 | | | 11 |
| Shorebird spp. | | | | | | 6 | |
| Jaeger spp. | | 1 | | | | | |
| Glaucous Gull | 147 | 36 | 158 | 488 | 21 | 40 | 70 |
| Herring-Thayer's Gull | | | | | | | |
| Black-legged Kittiwake | | | 5 | | | | |
| Sabines Gull | | | 1 | 408 | | | |
| Gull spp. | | | 4 | | | | |
| Arctic Tern | 1 | 4 | 26 | 961 | | | 11 |
| Black Guillemot | 17 | | 2 | | | | 3 |
| Passerine spp. | | | | | | | |
| Unidentified spp. | | | | | | | |
| Seal | | | 2 | | | | |

Appendix Table 26. Migratory bird species and numbers observed in 400 m offshore transect along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

| | Survey dates | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| Species | 22&23 July | 3-4 Aug | 24&26 Aug | 25-26 July | 7&13 Aug | 22 Aug |
| Common Loon | | | | | | |
| Yellow-billed Loon | 8 | 3 | | | | |
| Arctic Loon | | 14 | 2 | 6 | 3 | 14 |
| Red-throated Loon | 4 | 20 | 2 | 4 | | 14 |
| Loon spp. | 2 | 23 | 3 | | 8 | 14 |
| Red-necked Grebe | | | | | | |
| Tundra Swan | | | | | | |
| Brant | | | | | | 220 |
| Snowgoose | | | | | | |
| Goose spp. | | | | | | |
| Northern Pintail | | 12 | | | | |
| Scaup spp. | 1 | | 82 | | 2 | |
| Oldsquaw | 1,696 | 2,868 | 824 | 1,339 | 1,911 | 3,867 |
| Common Eider | | 4 | | 3 | 2 | 1 |
| King Eider | | | | 8 | | |
| Spectacled Eider | | | | | | 1 |
| Eider spp. | 122 | 51 | 12 | 20 | 17 | 26 |
| White-winged Scoter | 20 | | | | | |
| Surf Scoter | 1 | | | 311 | | |
| Black Scoter | | | | 4 | | |
| Scoter spp. | 27 | 4 | | 14 | | |
| Red-breasted Merganser | 1 | | | | | |
| Duck spp. | | 3 | | 84 | 5 | 46 |
| Sandhill Crane | | 2 | | | | |
| Plover spp. | | | | | | |
| Phalarope spp. | | 29 | | | 7 | |
| Shorebird spp. | | 28 | 46 | 91 | 24 | 7 |
| Jaeger spp. | | | | | | 1 |
| Glaucous Gull | 52 | 194 | 115 | 43 | 57 | 54 |
| Herring-Thayer's Gull | | | | | | |
| Black-legged Kittiwake | | 1 | | | | |
| Sabines Gull | | | | | | 1 |
| Arctic Tern | 8 | 1 | | | 1 | 4 |
| Black Guillemot | 5 | | | | 9 | 4 |
| Passerine spp. | | | | | | |
| Unidentified spp. | | | | | | |
| Seal | | | | | | |

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# MOVEMENT OF MOLTING OLDSQUAW WITHIN THE BEAUFORT SEA COASTAL LAGOONS OF THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1984

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

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# Movements of molting oldsquaw within the Beaufort Sea coastal lagoons of the Arctic National Wildlife Refuge, Alaska, 1984.

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Abstract: Forty-four oldsquaw were (*Clangula hyemalis*) captured during the period 7-11 August 1984 on Simpson Cove and Tapkaurak Lagoon along the coastline of the Arctic National Wildlife Refuge. Radio-transmitters were placed on 28 oldsquaw and 88 relocations were obtained from aircraft on 7 occasions. A total of 21 (75%) of the 28 oldsquaw were confirmed mortalities prior to 1 October, 10 of which probably died prior to 12 August. Only 23 relocations were considered usable. These yielded nine movements which averaged 0.69 $\pm$ 1.29 km/day (mean $\pm$ SD.) with a range of 0.01 to 3.85 km/day. All movements were local. Possible causes of the high mortality of the oldsquaw are discussed. Habitat selection was examined by comparing habitat availability and the habitat locations of the combined 1983 and 1984 data. Lagoon-survey data were also used to test for differences in habitat selection and availability. Oldsquaw habitat preferences showed significant (P 0.05) deviations from availability in the relocation data and in 8 of the 14 lagoons surveyed. The habitats which were avoided were restricted to open water in the lagoon and ocean. Selected aquatic habitats in order of preference were areas within 200 m of the lagoon side of barrier islands, the ocean side of the barrier islands, lagoon mainland shorelines, passes between barrier islands, and ocean mainland shorelines. Lagoon survey data showed a similar avoidance by oldsquaw of open water and a selection for the area within 200 m of the barrier island in the lagoon.

Movement of molting oldsquaw within the Beaufort Sea coastal lagoons of the Arctic National Wildlife Refuge, Alaska, 1984.

Post-breeding oldsquaw (Clangula hyemalis) utilize the coastal lagoons of the Arctic National Wildlife Refuge (ANWR) in large numbers during July-September (Bartels and Zellhoefer 1983, Johnson 1983, Bartels et al 1984). Aerial surveys conducted annually since 1981 on ANWR have documented yearly highs between 18,000 and 33,000 molting oldsquaw within the lagoons and the immediate offshore area (Bartels et al 1984, Brackney et al. 1985). Although these surveys have provided data on gross fluctuations in numbers and lagoon use, specific information on oldsquaw movements, habitat selection, and timing of the molt and migration cannot be derived entirely from the surveys.

Potential exploration for oil and gas both on the coastal plain and offshore may impact oldsquaw directly through disturbance and pollution or indrectly through habitat modification or food chain perturbation. Knowledge of movements, residence time, and habitat preferences is needed to predict the potential effects of primary and secondary activities associated with petroleum exploration upon post-breeding oldsquaw.

## Methods and Materials

Equipment and capture methods were described by Bartels et al.(1984). Two capture sites were established in 1984, one on the 1983 capture area on Tapkaurak lagoon, 24 km east of Barter Island, and a second along the barrier islands at Simpson Cove, 51 km west of Barter Island. Camps were set up at each site and capture efforts were conducted simultaneously from 7 to 11 August 1984.

The trap design, similar to Bartels et al.(1984), consisted of three sections of 10 cm mesh mist net, each being 3 m wide by 18 m long. The ends of each net were attached to 3.6 m conduit poles pushed into the lagoon substrate. Each net was totally submerged except for a 30 cm portion, which was left above the water line to prevent oldsquaw from swimming over the net. The nets were set perpendicular to the barrier islands or gravel spits within the lagoon and rafts of 50-300 oldsquaw were herded into the net by two boats. Once the ducks reached the vicinity of the net they were rushed to cause some individuals to become entangled in the net.

Once captured, oldsquaw were placed in a capture box until all birds were removed from the net. Each captured bird was weighed to the nearest 10 g, and the length of the 1st, 5th, and 10th primary feathers were measured. The birds were then banded with a U.S. Fish and Wildlife Service band and selected birds were fitted with back-mounted radio-transmitters enclosed in a sealed cylinder. The unit weighed 28 g and was attached to the bird with a harness made of two elastic bands, 0.64 cm wide and 10 cm long, sewn into a circle. The harness fitted around each ulna-radius of the oldsquaw and held the radio on the back of the birds between the wings with a band around each wing. This configuration was fitted to a dead speciment and was subsequently lengthened by 3 cm from that used in 1983 because the shorter loops appeared to pin back the wings of the bird.

Relocation flights were begun on 12 August and continued every two to three days when the weather permitted. Due to heavy fog during much of late August and early September only seven relocation flights were conducted before they were discontinued on 13 September. Relocation flights were not begun immediately or conducted on a daily basis due to weather and manpower constraints. In addition, a float plane was not available at the time the relocation flights were begun. Flights were discontinued when no live individuals could be located.

Statistical procedures follow those described by Sokal and Rohlf (1980). Habitat selection was examined through the use of a Logarithmic Goodness-of-fit G Test and through Bonferoni confidence intervals on the proportions of the observed data. This procedure was recommended for utilization-availability data by Neu et al.(1974), Johnson (1980) and Byers et al.(1984).

## Results and Discussion

Forty-four live oldsquaw were captured during the period 7-11 August, and 28 were fitted with radio-transmitters (See Appendix). The body weights of 37 captured adults averaged 782.3g ($\pm$ 59.3SD). Juvenile mean weights were 715g ($\pm$ 91.7SD N = 5). Eighteen oldsquaw drowned in the nets during capture operations due to two problems. When a large number of ducks were caught at one time some individuals did not float to the surface. On separate occasions 3,8, and 5 oldsquaws drowned when totals of 10, 21, and 23, respectively, were caught. Debris and fish accumulated in the nets when they were left in the water too long, which tended to prevent some oldsquaw from floating to the surface. Although the nets were pulled to the surface as quickly as possible when a large number of individuals were captured, the crews were unable to bring the nets to the surface in time to prevent some birds from drowning. Additional boats with two crew members each, coupled with care to avoid capturing more than 8-10 oldsquaw at one time, should reduce the number of oldsquaw which drown during capture operations.

A total of 88 relocations were recorded during the study period (Table 1). However, after the third relocation flight on 28 August it was apparent that a significant amount of mortality had occurred in the oldsquaw fitted with transmitters. Between 30 August and 12 September, 10 transmitters were recovered. Three other birds were confirmed dead by ground tracking but the radios could not be recovered. A fourth oldsquaw was confirmed as a mortality due to the consistency of the location on a mudflat of the Hulahula River Delta. Relocation flights on 13 September and in mid-October, after freeze-up of the lagoons, revealed the location and mortality of seven additional oldsquaw. A total of 21 of the 28 oldsquaw (75%) were confirmed mortalities, 10 died prior to 12 August, 3 prior to 15 August, 5 prior to 28 August, and 2 prior to 30 August. One of the oldsquaw died between 30 August and mid-October. Of the remaining birds, contact was lost on two oldsquaw after 12 August, on three after 15 August, and on one after 30 August. One individual was not relocated after release.

Table 1. Status of 28 oldsquaw fitted with radio-transmitters on the Arctic Wildlife Refuge 1984.

| Radio No. | No. relocations | No. usable relocations | Final status |
|---|---|---|---|
| 1056 | 4 | 2 | Dead prior 28 Aug. |
| 1057 | 5 | 0 | Dead prior 12 Aug. |
| 1063 | 4 | 0 | Dead prior 30 Aug. |
| 1066 | 2 | 0 | Dead prior 28 Aug. |
| 1068 | 5 | 0 | Dead prior 28 Aug. |
| 1071 | 4 | 2 | Dead prior 28 Aug. |
| 1806 | 2 | 2 | Lost contact after 15 Aug. |
| 1807 | 2 | 1 | Dead prior 30 Aug. |
| 1808 | 4 | 2 | Dead prior 28 Aug. |
| 1809 | 3 | 3 | Dead after 30 Aug. |
| 1810 | 3 | 1 | Dead prior 15 Aug. |
| 1811 | 3 | 0 | Dead prior 12 Aug. |
| 1812 | 3 | 3 | Lost contact after 30 Aug. |
| 1813 | 4 | 0 | Dead prior 12 Aug. |
| 1814 | 3 | 0 | Dead prior 12 Aug. |
| 1815 | 2 | 0 | Dead prior 15 Aug. |
| 1816 | 2 | 2 | Lost contact after 15 Aug. |
| 1817 | 1 | 1 | Lost contact after 12 Aug. |
| 1818 | 1 | 1 | Lost contact after 12 Aug. |
| 1819 | 0 | 0 | Lost contact after release |
| 1820 | 3 | 0 | Dead prior 12 Aug. |
| 1821 | 5 | 1 | Dead prior 15 Aug. |
| 1822 | 4 | 0 | Dead prior 12 Aug. |
| 1823 | 3 | 3 | Dead prior 12 Aug. |
| 1824 | 2 | 2 | Lost contact after 15 Aug. |
| 1825 | 5 | 0 | Dead prior 12 Aug. |
| 1826 | 4 | 0 | Dead prior 12 Aug. |
| 1827 | 5 | 0 | Dead prior 12 Aug. |
| Total | 88 | 23 | |

The cause of the sudden and nearly complete mortality of the radio-fitted oldsquaw could not be determined. The lengthening the harness and loosening the backpack on the back may cause an increase in abrasion by the harness or radio, however, Dwyer (1972) recommended against tightening a harness to a tight fit. Slippage of the harness down the wing and over the phalanges is assumed to be the more serious problem associated with a loose harness. The infrequency of radiotracking prevented immediate conformation of mortalities and quick recoveries of the carcasses for examination. All but one of the individuals which were recovered consisted only of bone and some feathers. One recovered carcass was buried whole by a predator and on this bird the harness was fitted properly with no sign of abrasion or feather wear. There was no evidence of slippage of the harness over the phalanges on the carcasses recovered with an intact harness.

Past studies have shown that a critical adjustment period of several hours to several weeks is necessary for birds to adapt to the back-fitted transmitter (Boag 1972, Greenwood and Seargeant 1973, Gilmer et al. 1974, Wooley and Owen 1978). During this adjustment period, the radio-fitted oldsquaw may have been more vulnerable to predation and additionally stressed by their molt condition. Several days of high winds occurred immediately after their capture and release which may have also caused additional stress. Although the high mortality in 1984 (75%) appears to be a turnaround from the 1983 data, the 1983 mortality was high (44%) for a telemetry study. Movements by the radio-fitted oldsquaw in 1983 appeared to be normal. However, none of the surviving birds left the ANWR coastline until after 21 September (Bartels et al. 1984). A survey on 6-8 September 1983 showed that 84% of the total oldsquaw in the lagoons had departed the refuge (Bartels et al 1984). Although only two of the 1983 radio fitted oldsquaw died prior to 1 September, seven of the nine live birds stayed on the refuge coastline past 28 September. The 1983 radio-fitted oldsquaw may have been previously inclined to stay in the area, although the possibility also remains that the birds were unable to adjust to the back-mounted transmitters and harness sufficiently to begin migration sooner.

Problems associated with radio transmitters fitted by harness onto waterfowl have been documented in a number of telemetry studies. Known effects include abnormal behavior, aversion to water, disruption of feather insulation, skin and feather abrasion, weight loss, increased metabolism, increased preening activity, decreased feeding activity, and mortality (Greenwood and Seargeant 1973, Gilmer et al. 1974, Wooley and Owen 1978, Perry 1981). These problems are particularly acute in diving ducks. Perry (1981) experienced severe behavioral problems and mortality with back-fitted radios on canvasbacks (Aythya valisineria), and Woakes and Butler (1975) observed that back-fitted transmitters interfered with the normal diving behavior in pochards (A. ferina) and tufted ducks (A. fuligula). Korschgen et al.(1984) concluded that the problems caused by external mounts on diving ducks outweighed the usefulness of the technique. They recommended implantation of the transmitter into the body cavity as a solution. Although radio packages fitted by harness have been successfully used on dabbling ducks (Gilmer et al 1975, Ball et al 1975, Humberg et al 1978), the technique has apparently not been applied successfully to diving ducks. Researchers in southeast Alaska have glued radio-transmitters to the backs of marbeled murrlets (Brachyramphus marmoratus), a diving sea bird, without noticeable detrimental effects (S. Quinlan pers. comm.).

Movements

Problems encountered with weather and the mortality suffered by the transmitter-fitted oldsquaw severely limited the quantity of data collected. Only 23 relocations of the original 88 were judged to be usable. These yielded 9 movements which averaged 0.69 km/day ± 1.29SD. The movements ranged from 0.01 to 3.85 km/day. Thus, all movements were local and within or adjacent to the lagoon in which the birds were captured.

Habitat Selection

In order to examine habitat selection, the area utilized by the radio-fitted oldsquaw in 1983 and 1984 was subdivided into seven aquatic habitats. A pass was defined as a 200 m wide area consisting of a break or opening in the barrier islands between the lagoons and the ocean. Other habitats included areas within 200 m of the lagoon side of barrier islands, the oceanside of the barrier islands, lagoon mainland shorelines, ocean mainland shorelines and open water areas not included in other catagories. The proportions of each habitat type were calculated from linear measurements of 1:63,360 scale U.S. Geological survey topographics maps.

The oldsquaw relocations were compared to expected proportions with a Goodness-of-Fit G test (Sokal and Rohlf 1981) and the null hypothesis that oldsquaw selected habitats in proportion to their availability was rejected ($G=1143.9$, $P<0.005$). The large area in the open ocean used by the oldsquaw (1763 $km^2$, 80.7%)and the small proportion of relocations (13.8%) showed a definite avoidance of open ocean which contributed a large score to the Goodness-of-Fit G test. Therefore, a second test with Bonferoni confidence internals was run with open water locations in the Beaufort sea excluded. This test also showed a significant ($G=403.6$ $P<0.005$) deviation from expected habitat use. The distance of the expected proportion from the upper or lower bound of the Bonferoni confidence interval gave a measure of the degree of avoidance or selection (Table 2). Radio-fitted oldsquaw avoided open water in the lagoons to a high degree and selected habitats in the following order of preference: lagoon barrier island, ocean barrier island, lagoon mainland shoreline, pass, and ocean mainland shoreline.

Table 2. Proportions of observed and expected radio-relocations and Bonferoni confidence intervals of observed radio-relocations of oldsquaw in selected habitats along the Arctic National Wildlife Refuge Coastline, Alaska, 1983-1984.

| Habitat | Observed[a] | Expected | Confidence interval bounds | Closest interval bound minus expected |
|---|---|---|---|---|
| Lagoons | | | | |
| Open Water | 0.157 | 0.707 | 0.098 - 0.215 | -0.492[b] |
| Barrier Island[c] | 0.248 | 0.067 | 0.179 - 0.317 | +0.112 |
| Shoreline[c] | 0.234 | 0.134 | 0.166 - 0.301 | +0.032 |
| Pass[d] | 0.070 | 0.008 | 0.287 - 0.110 | +0.021 |
| Ocean | | | | |
| Barrier Island[c] | 0.226 | 0.067 | 0.159 - 0.293 | +0.092 |
| Shoreline[c] | 0.066 | 0.016 | 0.026 - 0.105 | +0.010 |

a N = 274 relocations

b Positive numbers refer to selection and negative numbers refer to avoidance.

c Catagories refer to the waters surface within 200 m of the barrier island or mainland shoreline.

d Pass refers to an area 200 m wide area located in breaks between the barrier islands.

A second measure of habitat selection was obtained through the calculation of Goodness-of-Fit G tests and Bonferoni confidence intervals on the cumulative number of oldsquaw, per lagoon, counted during the 1984 lagoon surveys (Brackney et al. 1985). The 200 m transects were classified by habitat as barrier island, open water, or mainland shoreline with the transect immediately adjacent to the inside of the barrier island or shoreline given that classification. The G Tests (Table 3) resulted in a significant difference ($P < 0.01$) between the expected and observed proportions in nine of the 14 lagoons surveyed in 1984. Of those nine lagoons, oldsquaw showed an avoidance of open water in all nine and a selection of the inside of the barrier island area in seven of the lagoons. Preferences by oldsquaw for the mainland shoreline were mixed with selection shown in 5 lagoons and avoidance shown in 2 lagoons. Thus, overall habitat selection by oldsquaw was similar in the lagoon survey data and the radio-telemetry data.

Table 3. The results of Goodness-of-Fit G tests of within lagoon survey data expected frequencies of oldsquaw in particular habitat types, and the distances of the expected proportions from the upper or lower end of the Bonferoni confidence intervals.

| Lagoon | Barrier island | Open water | Mainland shoreline | G Value | P |
|---|---|---|---|---|---|
| Brownlow | +0.163[a] | -0.114 | 0 | 12.77 | 0.002 |
| Tamayariak | - | -0.15 | +0.033 | 28.64 | <0.001 |
| Simpson Cove | +0.038 | -0.173 | +0.033 | 65.14 | <0.001 |
| Sadlerochit | - | - | - | 2.08 | 0.370 |
| Arey | +0.226 | -0.155 | -0.071 | 32.95 | <0.001 |
| Kaktovik | - | - | - | 3.07 | 0.220 |
| Jago | - | - | - | 4.06 | 0.140 |
| Tapkaurak | 0 | -0.133 | +0.042 | 49.48 | <0.001 |
| Oruktalik | +0.060 | -0.007 | -0.055 | 20.72 | <0.001 |
| Angun/Pokok | +0.189 | -0.216 | 0 | 38.82 | <0.001 |
| Nuvagapak | - | - | - | 5.16 | 0.070 |
| Egaksrak | +0.167 | -0.117 | +0.023 | 17.85 | <0.001 |
| Siku | - | - | - | 5.72 | 0.060 |
| Demarcation | +0.174 | -0.136 | -0.023 | 66.40 | <0.001 |

a Negative numbers indicate avoidance: the difference between the upper end of the Bonferoni interval and the expected proportion. Positive numbers indicate selection; the difference between the lower end of the Bonferoni interval and the expected proportion.

Oldsquaw habitat use, as shown by this analysis, is contradictory to studies on food availability which demonstrated higher abundance of favored prey items for oldsquaw in the middle, open water portion of the lagoons (Griffiths and Dillinger 1981, Spindler and Meehan 1985). The effects of weather, wind, and wave action were not considered in this analysis. Shelter from wave action may be as important as food availability (Spindler and Meehan 1985). On a number of occasions oldsquaw have been observed to disperse widely over the surface of lagoons during periods of calm. Additional information on habitat selection and associated behavior under varying weather conditions is needed to better define habitat needs of post-breeding oldsquaw.

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APPENDIX

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Appendix Table 1. Age, sex, weight and primary feather length on 61 oldsquaw captured on Simpson Cove and Tapkaurak lagoons, Arctic National Wildlife Refuge, 1984.

| | | | | Primary Feather length (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Bird No. | Age | Sex | Weight(g) | 1st | 5th | 10th | Date | Capture Location | Radio No. or status |
| 1 | A[a] | M[b] | 815 | 8.4 | 11.2 | 12.5 | 10 Aug | S[c] | 1056 |
| 2 | A | F | 690 | 8.5 | 11.0 | 13.0 | 10 Aug | T | 1068 |
| 3 | A | M | 830 | 7.6 | 9.1 | 7.9 | 7 Aug | S | 1063 |
| 4 | SA | M | 670 | 8.0 | 10.5 | 10.5 | 10 Aug | S | 1066 |
| 5 | SA | M | 830 | 8.0 | 10.0 | 9.0 | 7 Aug | T | 1068 |
| 6 | A | M | 765 | 8.1 | 9.1 | 8.9 | 7 Aug | S | 1071 |
| 7 | J | M | 685 | NA | NA | 3.0 | 10 Aug | S | 1806 |
| 8 | SA | M | 775 | 6.1 | 7.7 | 7.3 | 7 Aug | T | 1807 |
| 9 | A | M | 800 | 8.0 | 11.0 | 11.0 | 10 Aug | S | 1808 |
| 10 | A | M | 870 | 4.5 | 5.8 | 5.1 | 7 Aug | T | 1809 |
| 11 | A | M | 835 | 7.4 | 8.6 | 8.6 | 10 Aug | S | 1810 |
| 12 | SA | M | 810 | 6.8 | 8.5 | 7.6 | 7 Aug | T | 1811 |
| 13 | SA | M | 715 | 8.9 | 10.1 | 10.5 | 8 Aug | S | 1812 |
| 14 | A | M | 700 | 9.0 | 11.0 | 11.5 | 7 Aug | T | 1813 |
| 15 | A | M | 855 | 6.0 | 6.8 | 6.2 | 8 Aug | S | 1814 |
| 16 | A | M | NA | 2.5 | 3.4 | 3.0 | 7 Aug | T | 1815 |
| 17 | SA | M | 880 | 8.0 | 11.0 | 11.3 | 10 Aug | S | 1816 |
| 18 | A | M | 765 | 8.5 | 10.2 | 9.5 | 7 Aug | T | 1817 |
| 19 | A | M | 755 | 8.0 | 9.5 | 8.5 | 7 Aug | S | 1818 |
| 20 | SA | M | 790 | 6.3 | 7.7 | 7.0 | 7 Aug | T | 1819 |
| 21 | A | M | 810 | 9.0 | 11.0 | 11.5 | 8 Aug | S | 1820 |
| 22 | A | M | NA | 3.9 | 4.7 | 5.0 | 10 Aug | T | 1821 |
| 23 | SA | M | 700 | 8.5 | 12.0 | 11.0 | 7 Aug | S | 1822 |
| 24 | SA | F | 840 | NA | NA | NA | 10 Aug | T | 1823 |
| 25 | A | M | 735 | 8.5 | 11.5 | 11.7 | 7 Aug | S | 1824 |
| 26 | A | M | 845 | 4.4 | 4.8 | 4.8 | 10 Aug | T | 1825 |
| 27 | SA | M | 705 | 8.4 | 11.3 | 11.4 | 7 Aug | S | 1826 |
| 28 | A | M | 860 | 4.0 | 5.0 | 5.4 | 10 Aug | T | 1827 |
| 29 | J | M | 700 | <5 | <5 | <5 | 10 Aug | S | Banded |
| 30 | J | F | 765 | <5 | <5 | <5 | 10 Aug | S | Banded |
| 31 | J | M | 590 | NA | NA | NA | 10 Aug | S | Banded |
| 32 | J | M | 835 | NA | NA | NA | 10 Aug | S | Banded |
| 33 | SA | M | 795 | 5.5 | 6.9 | 7.0 | 10 Aug | S | Banded |
| 34 | A | M | 785 | 8.1 | 10.2 | 11.6 | 10 Aug | S | Banded |
| 35 | A | M | 755 | 8.0 | 10.1 | 9.0 | 10 Aug | S | Banded |
| 36 | A | M | 725 | 7.2 | 8.7 | 9.5 | 10 Aug | S | Banded |
| 37 | A | M | 780 | 6.8 | 8.4 | 8.1 | 10 Aug | S | Banded |
| 38 | A | M | 815 | 8.0 | 10.5 | 11.0 | 10 Aug | S | Banded |
| 39 | A | M | 745 | 8.2 | 10.3 | 9.6 | 10 Aug | S | Banded |
| 40 | A | M | 745 | 8.3 | 10.3 | 10.5 | 10 Aug | S | Banded |
| 41 | A | M | 720 | 8.0 | 9.1 | 9.8 | 10 Aug | S | Banded |
| 42 | A | M | 915 | 6.0 | 5.2 | 4.3 | 10 Aug | S | Banded |
| 43 | A | M | 785 | 6.9 | 8.8 | 7.7 | 10 Aug | S | Banded |
| 44 | A | M | 735 | 7.1 | 8.8 | 8.0 | 10 Aug | S | Banded |
| 45 | NA | NA | NA | NA | NA | NA | 7 Aug | T | Drown |
| 46 | NA | NA | NA | NA | NA | NA | 7 Aug | T | Drown |
| 47 | NA | NA | NA | NA | NA | NA | 7 Aug | T | Drown |
| 48 | NA | NA | NA | NA | NA | NA | 7 Aug | T | Drown |
| 49 | NA | NA | NA | NA | NA | NA | 7 Aug | T | Drown |
| 50 | NA | NA | NA | NA | NA | NA | 7 Aug | T | Drown |
| 51 | NA | NA | NA | NA | NA | NA | 7 Aug | T | Drown |
| 52 | A | M | NA | NA | NA | NA | 8 Aug | S | Drown |
| 53 | A | M | NA | NA | NA | NA | 8 Aug | S | Drown |
| 54 | A | M | NA | NA | NA | NA | 10 Aug | S | Drown |
| 55 | A | M | NA | NA | NA | NA | 10 Aug | S | Drown |
| 56 | A | M | NA | NA | NA | NA | 10 Aug | S | Drown |
| 57 | A | M | NA | NA | NA | NA | 10 Aug | S | Drown |
| 58 | A | M | NA | NA | NA | NA | 10 Aug | S | Drown |
| 59 | A | F | NA | NA | NA | NA | 10 Aug | S | Drown |
| 60 | J | - | NA | NA | NA | NA | 10 Aug | S | Drown |
| 61 | J | M | NA | NA | NA | NA | 10 Aug | S | Drown |

[a]A = Adult, SA = Subadult, J = Juvenile
[b]M = Male, F = Female
[c]S = Simpson Cove, T = Tapakaurak lagoon