ARCTIC NATIONAL WILDLIFE REFUGE COASTAL PLAIN
RESOURCE ASSESSMENT

1982 UPDATE REPORT BASELINE STUDY OF THE FISH, WILDLIFE, AND THEIR HABITATS

Section 1002C
Alaska National Interest Lands Conservation Act

U.S. Department of the Interior
U.S. Fish and Wildlife Service
Region 7
Anchorage, Alaska
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Edited by
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Conversion Table

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

Multiply Metric (Sl) Units	By	To obtain American Units
Centimeters (cm)	0.3937	Inches (in)
Meter (m)	1.0936	Yards (yd)
Kilometers (km)	0.6215	Miles (mi)
Grams (g)	0.0352	Ounces (oz)
Kilograms (kg)	2.2046	Pounds (lb)
Liters (L)	0.2642	Gallons (gal)
Square kilometers (km^2)	0.3861	Square miles (mi^2)
Square kilometers (km^2)	247.1050	Acres
Hectares (ha)	2.4711	Acres
Kilograms per hectare (kg/ha)	0.8262	Pounds per acre (lb/acre)
Cubic meters per second (m^3/s)	35.7143	Cubic feet per second (ft^3/s)
Degrees Celsius (^oC)	(^oCx1.8)+32	Degrees Fahrenheit (^oF)

ERRATA

Pages 118 and 295 are omitted due to a pagination error. All material presented in this document is complete.

Chapter 1

INTRODUCTION

Section 1002(h) of The Alaska National Interest Lands Conservation Act (ANILCA) which became law on 2 December 1980 (Public Law 96-487) provides for an annual update of new information to supplement the initial baseline report of 1981 (USFWS 1982). This report is a summary of studies of the Arctic National Wildlife Refuge (ANWR) coastal plain completed or on-going in 1982. Progress reports containing detailed descriptions of methods and results of studies conducted by U.S. Fish and Wildlife Service personnel during 1982 are included as appendices, and the reader should consult the corresponding report(s) when reviewing the respective narrative in the update report.

The report follows the format of the initial baseline report (USFWS 1982). Tables and figures cited in the chapter summaries can be found in the appendices unless no progress report was prepared, in which case they are included as part of the text. (e.g., Chapter 7).

Table 1 lists chapters discussed in the initial baseline report and related studies conducted in or adjacent to the ANWR coastal plain study area in 1982. New information was not availble for several chapters because no new work was done or reports were not completed in time for inclusion in this interim report.

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.

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

Initial Baseline Report Ch. No.	Title	Work conducted in 1982	Principle investigators	Report status
2.	Description of the study area	No new information obtained	--	--
3.	Soils and Vegetation	Verification of preliminary landsat classification	P. Webber, S. Walker, J. Brown: CRREL/ INSTAR	Report in prep., final 9/83
		Vascular plants at Sadlerochit Springs	D. Murray, U. of AK	Work in progress.
4.	Birds	Terrestrial bird populations and habitat use on coastal plain tundra of the Arctic National Wildlife Refuge.	M. Spindler, P. Miller, USFWS ANWR	ANWR progress report No. FY83-5, see Appendix
		Migratory bird use of the coastal lagoon system of the Beaufort sea coastline within the ANWR 1981 & 1982.	R. Bartels, M. Zellhoefer, P. Miller USFWS ANWR	ANWR progress report No. FY83-3, see Appendix
		Distribution, abundance, and productivity of whistling swans in the coastal wetlands of the ANWR.	R. Bartels, M. Zellhoefer, USFWS ANWR	ANWR progress report No. FY83-2, see Appendix
		Distribution, abundance, and productivity of fall staging lesser snow geese on coastal habitats of northeast Alaska and northwest Canada 1980-1981.	M. Spindler, USFWS ANWR	ANWR progress report No. FY83-1, see Appendix
		Distribution, abundance, and productivity of fall staging lesser snow geese on coastal habitats of northeast Alaska and northwest Canada 1982.	M. Spindler, USFWS ANWR	ANWR progress report No. FY83-4, see Appendix
5.	Mammals			
	Caribou	Evaluation of techniques for assessing neonatal caribou calf mortality	F. Mauer, G. Garner, L. Martin, G. Weiler USFWS ANWR	ANWR progress report No. FY83-6, see Appendix

Table 1. (Continued).

Initial Baseline Report Ch. No. Title	Work conducted in 1982	Principle investigators	Report status
	Fall, winter, and spring distribution of Porcupine caribou herd 1981-1982	K. Whitten, R. Cameron, ADF&G	ADF&G interim report 1982 Appendix
	Photocensus of the Porcupine caribou herd	K. Whitten, R. Cameron, ADF&G	Report in prep.
	Studies of the Central Arctic herd	R. Cameron, K. Whitten, ADF&G	Report in prep.
	Surveys of the Central Arctic herd	Renewable Resources Consulting Services Ltd.	Report in prep. Final 3/83
	Migratory energetics of caribou	L. Duquette U. of AK, Fairbanks (M.S. Thesis)	Work in progress.
Muskoxen	Population size, productivity and distribution of muskoxen in the ANWR	P. Reynolds, L. Martin, G. Weiler USFWS ANWR	ANWR progress report No. FY83-7, see Appendix
	Comparative habitat use by muskoxen in northern Alaska	C. O'Brian, U. of AK, Fairbanks (M.S. Thesis)	Work in progress.
Marine mammals	Polar bear surveys	S. Amstrup, USFWS research division	Report in prep.
Brown bear	Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge	G. Garner, L. Martin, G. Weiler USFWS ANWR	ANWR progress report No. FY83-8, see Appendix
	Habitat use and activities of grizzly bears in the Arctic National Wildlife	M. Philips, U. of AK, Fairbanks (M.S. Thesis)	Prelim. report, Dept. of Wildlife and Fisheries, U. of AK.

Table 1. (Continued).

Initial Baseline Report Ch. No. Title	Work conducted in 1982	Principle investigators	Report status
6. Fish	Aquatic studies on the north slope of the Arctic National Wildlife Refuge 1981-1982	M. Smith, R. Glesne, USFWS, Fisheries Fisheries Resources	Fisheries Resources progress report No. FY83-1, see Appendix
7. Human Culture and Lifestyle	Preliminary archaeological and historical resource reconnaissance of the coastal plain of the ANWR	Edwin Hall and Associates	Report in preparation, Final 1/83
	Kaktovik area cultural resource survey	D. Libbey, U. of AK, Fairbanks	Preliminary report, North Slope Borough, AK. Division Parks (see Chapter 7).
	Subsistence land use baseline for eastern and central north slope communities, Alaska.	S. Pederson, ADF&G, Subsistence Div.	Report in preparation, final early 1983 (see Chapt. 7).
	Sociocultural assessment of proposed ANWR oil and gas exploration	R. Worl, P. McMillan, T. Lonner, S. Beard, AEIDC, Anchorage	Report completed, AEIDC, Anchorage (see Chapt. 7)
8. Potential Impacts of Geophysical Exploration	No new information obtained		
9. Impacts of further exploration, development and production of oil and gas resources	No new information obtained		
Other Studies			
Invertebrates	Survey of benthic marine communities along the arctic coast	K. Dunton, Ins. Water Res., U. of AK, Fairbanks	Work in progress.
	Ecology of insects on the coastal plain	B. Strassmann, Cornell Univ.	Work in progress.
Lagoon studies	Environmental characteristics and biological use of lagoons along the ANWR coastline	L.G.L. Consulting Services, NOAA/OCSEAP	Report in preparation, Final 6/30/83

Chapter 2

DESCRIPTION OF THE STUDY AREA

No new information was obtained to update this chapter.

Chapter 3

SOILS AND VEGETATION

During the summer of 1982, researchers from the Cold Regions Research and Engineering Laboratory (CRREL) and the Institute of Arctic and Alpine Research (INSTAAR, Univ. of Colorado) continued their investigation of verifying a LANDSAT classification of vegetation and land cover in the ANWR study area. Five study sites provided information for the development of base maps of greater detail than LANDSAT-derived maps and established relationships between the structural and morphological characteristics of vegetation cover classes. A final report will be prepared by September 1983 and will be summarized in the next baseline update report.

D. Murray (Univ. of Alaska, Fairbanks) continued his investigations of vascular plants at Sadlerochit Spring. No report of this work has been completed.

Chapter 4

BIRDS

New information obtained on birds included studies of bird use on coastal plain tundras and in adjacent lagoons as well as continuing surveys for snow geese and whistling swans. These studies were conducted by USFWS biologists.

Bird Use of Tundra Habitats

M. Spindler, USFWS biologist, initiated a study of tundra bird populations in the summer of 1982 with the following objectives: 1) to determine annual and seasonal changes in populations of key tundra nesting species in near-coastline tundra; 2) to determine population levels and seasonal abundance of key tundra nesting species in inland tundra habitats; 3) to determine and compare populations and species richness in the major habitat classes defined by recent habitat mapping efforts (LANDSAT, etc.); 4) to compare the efficiency of small replicate plots (10 ha) versus larger plots (50 ha) for estimating levels of population and species richness. Methods and results are described in ANWR Progress Report No. FY83-5 (See Appendix).

Four 25-50 ha bird census plots established in 1978 on the Okpilak River delta in 4 different habitat types (Spindler 1979) were recensused in 1982. Four 10 ha plots were established in 1982 adjacent to these existing Okpilak delta plots in the same habitat types: Flooded, Mosaic, Wet Sedge, and Sedge Tussock.

In addition, interior coastal plain bird census plots were established along the Katakturuk River, 15-17 m inland from the Beaufort Sea. Two 10 ha plots were established in each of 3 habitat types: Riparian Willow, Tussock and Sedge Meadow. Okpilak plots were censused 4 times during June-July and once in August. Katakturuk sites were censused 3 times during June-July and once in August.

In 1982, 48 bird species, including 20 breeding species, were observed at the coastal site on the Okpilak delta. By comparison 57 species, including 23 breeding species, were observed in this same area in 1978 (Spindler 1979). At the inland site on the Katakturuk River, 35 species, of which 14 were breeding, were observed in 1982.

A late break-up in 1982 delayed migration and occupation of wetlands by shorebirds. Some species (e.g., red phalarope and northern phalarope) nested later in 1982 than in 1978. Unusually warm weather in late June accelerated green-up of vegetation and possibly caused some species (e.g., pectoral and buff-breasted sandpiper) to nest earlier.

Lapland longspur dominated every habitat type in 1978 (USFWS 1982) and in 1982, except on Flooded plots where phalaropes were the dominant species. Breeding pectoral sandpipers were abundant in 1982 compared with numbers observed in 1978. Breeding bird densities varied considerably between habitat types and among bird species in 1978 and 1982 at the Okpilak delta plots, but inter-year variation, particularly for shorebirds, was within the range observed in other arctic study areas.

A large segment of birds present in tundra habitat types were non-breeders. Mean summer populations were considerably higher than breeding densities on all plots, and fall populations on several plots tended to be higher than both mean summer and breeding densities because of the addition of young of the year and fall migrants. Graphs of seasonal fluctuations in bird numbers show changes which occurred during the summer of 1982: all coastal tundra plots on the Okpilik delta showed high bird numbers in mid-June, a decline in numbers in July and an increase again in August. In 2 of the 3 inland plots on the Katakturuk River, the August increase in shorebirds was not observed. Shorebirds did increase in Sedge Meadow plots, as did passerines in all Katakturuk habitats in August.

Breeding densities were highest in Riparian Willow plots and Mosaic plots, and lowest in Sedge Meadows and Flooded plots. Total summer and fall densities continued to be high in Riparian Willow and Mosaic plots and were also high in Flooded plots. Flooded and Mosaic plots had the highest number of species (greatest species richness) throughout the season. Sedge Meadow plots had the lowest density and fewest number of species.

Tundra areas studied on the ANWR coastal plain supported lower breeding densities of birds than did similar habitats near Prudhoe Bay and Barrow, but supported similar mean total densities in mid-summer.

An analysis of census methods used in 1982, indicated that either intensive nest searches for breeding birds or weekly censuses throughout the summer were needed to obtain consistently accurate estimate of bird densities which could be extrapolated. Comparisons of replicate 10 ha plots and the corresponding 25 or 50 ha plot indicates that the replicate plots and the singular large plot provided comparable estimates of mean summer total populations in the Wet Sedge and Sedge-Tussock pltos, but estimates were not comparable on the more populous diverse Flooded and Wet Sedge plots.

The status, breeding chronology, migration, and habitat use of 48 bird species observed on the Okpilak delta and 35 species observed on the Katakturuk area in 1982 were summarized in species accounts.

Bird Use of Lagoons and Offshore Habitats

USFWS biologists B. Bartels and M. Zellhoefer, and M. Spindler conducted aerial surveys in 10 coastal lagoons at the Arctic National Wildlife Refuge (ANWR) during 1981 and 1982. Objectives were as follows: 1) to obtain an index of relative numbers of migratory birds using the lagoons; 2) to determine if data collected in previous years using 400 m strip transects were comparable to information obtained in 1981 and 1982 when survey techniques were standardized; 3) to initiate a pilot project capturing and marking Oldsquaw in order to determine patterns of lagoon use by molting and migrating birds. Lagoons were overflown in a series of parallel 400 m wide strips during 3 surveys in July and August 1981 and 1982. A single 400 m strip was also flown seaward of the barrier islands to collect information on off-shore bird use. ANWR Progress Report No. FY83-3 describes methods and results (see Appendix).

Thirty species of birds were observed in 1982 compared to 32 species seen in 1981. Oldsquaw were the major species using the lagoons (over 80% of the total birds observed). The maximum number of oldsquaw observed was lower in 1982 (16,986) than 1981 (28,301) although 2 lagoons had higher totals in 1982, suggesting differences in spatial distribution in the 2 years. The temporal distribution of oldsquaw in lagoons was similar in both 1981 and 1982 with peak numbers occurring in mid-August. Numbers of oldsquaw observed along the offshore transect differed between 1981 and 1982. The 1982 peak (3867 oldsquaw) was higher and occurred later than the 1981 peak (2868 oldsquaw). Peak populations occurred later in the off-shore transect than in the coastal lagoons suggesting that post-molting male oldsquaw move offshore to feed. Sea ice may also affect movements. In late August 1982, the sea ice was densely packed against the barrier islands, possibly restricting the birds from moving further offshore to feed.

Density of migratory birds using coastal lagoons ranged from a low of 4.0 birds/km^2 in Brownlow lagoon in 1981 to a high of 328.4 birds/km^2 in Tamayariak lagoon in 1982. Spatial variation in numbers and density of oldsquaws occured within seasons and between seasons. The peak of molting oldsquaw can vary up to 2 weeks between years.

Relative numbers and densities of oldsquaws along a 400 m transect were significantly different from numbers and densities observed througout the entire lagoon (Appendix , Tables 5-7) indicating that oldsquaw are not randomly distributed in lagoons and that a single standardized strip can not be used as an index of oldsquaw numbers or density. Sampling the entire lagoon surface is necessary to eliminate differences between oldsquaw distributional patterns within lagoons.

Nine attempts were made to capture and mark oldsquaw in drive traps. Three birds were captured, fitted with leg bands and red nasal saddles, and released. Marked birds were not subsequently observed. Oldsquaw were very difficult to drive into traps and were adept at diving under nets and drive boats, or swimming over or through trap nets. Putting radio-transmitters on a few individuals from several lagoons may be a practical alternative to capturing and visually marking a large number of oldsquaw.

Snow Goose Surveys

The distribution, abundance, and productivity of lesser snow geese which staging in late August and early September in arctic coastal regions between Parry Penninsula, Northwest Territories and the Canning River, Alaska have been monitored by biologists from L.G.L. Ltd., the Canadian Wildlife Service, and the U.S. Fish and Wildlife Service since 1971. All portions of the staging area were surveyed in 1973-76 and 1981. Alaska and/or Yukon portions were surveyed in 1978-80. In 1982 fall staging was monitored on the ANWR coastal plain, Yukon Territory and Mackenzie River delta from 7 August to 22 September. Distribution and abundance were sampled by aerial survey, making visual estimates and taking photographs along transect lines. Methods and results of 1980, 1981 and 1982 surveys conducted by M. Spindler (USFWS biologist) are described in ANWR Progress Reports No. FY83-1 and FY83-4 (see Appendix).

Adults with young depart nesting colonies on Banks Island, Anderson River delta, and Kendall Island, N.W.T., in mid to late August, arriving first on the Parry Penninsula and then moving westward to the Mackenzie River delta occasionally as far west as the Canning River, Alaska. Non-breeding birds apparently also stage in the same areas. Barry (1982) estimated 100,000 non-nesting snow geese were present in the region in 1981.

First arrival dates of snow geese in the staging area between the Mackenzie delta and Barter Island varied between 13 August (1976) and 24 August (1979 and 1981). The onset of staging was earlier than usual in 1982 with the arrival of 7 birds on the Jago delta on 7 August. Major date of arrival ranged from 19 August (1980) to 3 September (1975). The staging periods, during which there is little movement, was a minimum of 7 days (1972) and a maximum of 22 days (1974), with a mean duration of 13.7 days. Departure tended to be more compressed than arrival with the last birds observed 4-15 days after major departure had begun. The onset of major departures occurred between 1 September (1980) and 22 September (1973). Departure may be influenced by the onset of freezing weather. See Appendix for detailed description of numbers and location of flocks observed in 1982.

Spatial distribution of staging snow geese within ANWR has been extremely variable. In 1974, 1976, 1978 and 1979 snow geese used a wide spread area of ANWR, between the Hulahula River and the Aichilik River from the coast inland to roughly the 305 m contour line. In other years staging was restricted to certain localities: in 1973 use centered along the Aichillik River northwest to the Niguanak River; in 1980 most of the population staged on the Yukon north slope. In 1981 most birds were observed between the Okpilak River to the Yukon north slope.

Total numbers of staging snow geese were estimated at a minimum of 114,939 in 1974, a maximum of 706,277 in 1975, 430,000 in 1981 and 231,100 ± 29,200 in 1982.

Productivity estimates based on age-ratios obtained from photographs of flocks were obtained in 1981 and 1982. Flocks of snow geese in the entire survey area (between the Mackenzie River delta and Barter Island) had 11.3% ± 4.1% young birds. In 1982 a sample of 15803 geese representing 49,092 geese was composed of 4.6% ± 0.7% young. Age ratios obtained in other years have been highly variable. The 1982 estimate is more reliable than other years, including 1981 when a large segment of the population was not sampled.

Spatial and temporal variations in the distribution of flocks containing young birds apparently occurred in 1981 and 1982.

Whistling Swan Survey

An aerial survey to determine the distribution, abundance and productivity of whistling swans utilizing ANWR coastal wetlands was conducted in 12 August 1982 by R. Bartels, M. Zellhoefer, and P. Miller (USFWS biologists). Methods and areas covered during this survey were the same as a swan survey completed in 1981 (USFWS 1982). Four major swan concentration areas (Canning-Tamayariak deltas; Hulahula-Okpilak delta; Aichillik-Egaksrak-Kongakut deltas; Demarcation Bay) were overflows in an intensive zig-zag search pattern. The coastline between the concentration areas and the Jago River delta and adjacent wetlands were overflown with a single linear transect.

The total numbers of swans observed declined by 32% between 1981 and 1982 as did the numbers of adults and cygnets (25% and 59%). In 1982, 75 birds (23% of total) were observed on the Canning-Tamayariak delta, compared with 186 birds (38% of total) in 1981. Fewer swans were seen on the Hulahula-Okpilak delta, Demarcation Bay, and the Jago delta in 1982 than in 1981. The number of swans using the Aichilik - Egaksrak - Kongakut delta remained the same in 1982 and 1981, but more adults and fewer cygnets were present. The number of pairs in this area increased by 59% between 1981 and 1982, but the proportion of pairs with young declined from 76% to 21% during the same period. This area had the highest density of swans during both years (0.66 swans/km) and appears to be an important area for non-breeding swans as well as unsuccessful nesters. Swans apparently arrive on the ANWR from the east and also depart from the east (Bellrose 1976, Salter et al 1980) In 1982 there were 9 fewer pairs on the Canning - Tamayariak delta than in 1981. Pairs without cygnets observed in the Aichilik - Egaksrak delta in August 1982 may have been unsuccessful nesting pairs from the Canning-Tamayariak delta which began their easterly movement before the normal migration date.

In addition to a decline in total numbers observed, swan productivity also declined. Numbers of total broods, mean brood size, percent pairs with young, total number of young and percent young in the population all declined between 1981 and 1982. However, the total number of pairs observed in 1982 (65) was almost identical to the number of pairs seen in 1981 (67) suggesting that nesting failures may have occurred. The 1982 decrease in productivity may have been the result of late spring snow storms which occurred during egg laying and incubation. A total of 13.7 cm of snow was recorded at Barter Island in June 1982 compared with only a trace of snow in June 1981. More than half of this snow fell during a storm on 16 June. Human disturbance, including aircraft traffic along the coast, may also have contributed to the decline in productivity, although no quantitative information is available to compare differences in human activities between 1981 and 1982.

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Chapter 5

Mammals

In addition to on-going research on caribou and polar bears, studies on caribou neonatal mortality, muskoxen and brown bears were begun in 1982 by USFWS biologists. Preliminary results of these studies are summarized in this chapter and progress reports are included as appendices. In 1982 graduate students at the University of Alaska, Fairbanks also conducted research in or adjacent to the ANWR coastal plain study area on caribou energetics, and brown bear habitat use and activities. Results of these graduate studies will be available for inclusion in future update reports.

Caribou (*Rangifer tarandus granti*)

Porcupine Herd

Fall, Winter, and Spring Distribution

Work on the Porcupine caribou herd continued in 1982. Fall, winter and spring distribution of the herd in 1981-1982 was described by Whitten and Cameron (1982). The study was a cooperative effort between the U.S. Fish and Wildlife Service, and the Alaska Department of Fish and Game with the following objectives: 1) to locate concentrations of Porcupine caribou migrating to and wintering in Alaska; 2) to monitor movements and distribution of Canadian-collared caribou wintering in Alaska; and 3) to radio-collar additional caribou to enlarge the sample size for studying mid-winter and spring movements. Complementary data are being collected in Canada by the Yukon Department of Renewable Resources.

Fixed-wing aircraft were used in early October 1981 to search for caribou. Twenty-five cariou were radio-collared in Alaska during the winter of 1981-1982. Wintering areas located during October were surveyed by fixed-wing aircraft 1 or more times monthly from November through May. Distribution and movements of Porcupine caribou in Canada were obtained from the Yukon Renewable Resources Department.

Three main routes are used by the Porcupine caribou herd during fall and spring migratons. The Richardson route follows the Richardson Mountains along the Yukon/Northwest Territories border to the Peel River Basin. The Old Crow Route traverses Old Crow Flats or the adjacent highlands and continues across the Porcupine River into the Ogilvie Mountains. The Chandalar Route leads westward along the southern foothills of the Brooks Range into the Coleen, Sheenjek, and Chandalar drainages.

Fall migration and early winter distribution of the Porcupine caribou herd followed traditional patterns. All 3 main migration routes and wintering areas were used. During October a major variation occurred, when about 20,000 caribou left the Ogilvie Mountains and continued south and west into traditional ranges of the Fortymile Herd. Past interchange between these herds has been widely speculated (Skoog 1968), but has never been documented (Davis et al. 1978). The most recent suspected interchange was in 1964 when Fortymile caribou supposedly invaded the Porcupine herd range. Since caribou do not live 17 years, the current mixing of the Porcupine and Fortymile herds cannot be explained by tradition or learned behavior. Spring migration for many Porcupine herd caribou in 1982 followed routes which had not been used by any caribou for at least 42 years. These observations suggest that weather and terrain features, along with an innate tendency to move in a given direction during certain times of the year, accounted for last year's unusual Porcupine herd distribution. Use of range and migration routes not occupied for many decades may also indicate that the Porcupine herd population is expanding.

Late snowmelt slowed the spring migration of many Porcupine herd caribou. Adverse conditions on traditional migration routes through the Brooks Range and on the coastal plain in Alaska directed Porcupine herd movements and calving east into Canada. Unlike the unusual winter distribution, however, this pattern of spring range use has been noted several times previously (Roseneau et al. 1975).

Estimates of numbers of caribou using the various migrations routes and wintering areas in 1982-82 (Richardson = 16,000; Old Crow - 40,000 in Ogilvie Basin plus 20,000 south of Yukon; Chandalar = 20,000; other areas in Yukon Territory = 6,000; Total = 102,000) approximate the estimated herd total of 110,000 plus (Whitten and Cameron 1980). Most likely, some or all of the winter range estimates were slightly low and there were probably no large groups of wintering caribou unaccounted for.

Neonatal Calf Mortality

In 1982, a study to evaluate techniques for assessing neonatal caribou calf mortality was begun by F. Mauer (USFWS biologist). The objectives were as follows: 1) to determine the feasibility of using mortality-sensing radio-transmitters to detect and determine causes of mortality; 2) to identify temporal and spatial patterns of calf mortality in calving and post-calving areas; 3) and to determine post-calving movements of caribou calves and their dams. Methods and results are found in ANWR Progress Report No. FY83-6 (see Appendix).

In 1982 spring migration of the Porcupine herd was late in departing from most wintering locations (Whitten and Cameron 1982). A concentrated calving area was on the coastal plain and foothills south of Herschel Island in northern Yukon Territory. Calving also occurred in the northern portion of the Old Crow Flats, the upper Firth and Coleen river drainages, and along migration routes in the British Mountains of Canada. In general, calving of the Porcupine herd in 1982 occurred in the eastern portion of the traditional calving area.

Twenty-three caribou calves were captured south of Herschel Island and instrumented with mortality-sensing radio-transmitters in early June 1982. Collared calves were monitored daily from fixed-wing aircraft for the first 2 days following capture, and at approximately 3 day intervals during the next month except when weather conditions precluded aircraft operations. Helicopters were used to retrieve carcasses as soon after detection of mortality as possible. Increased logistical considerations associated with the eastern calving distribution in 1982 prevented timely collection of conclusive mortality information in some cases.

Twelve (47.8%) of the 23 radio-collared calves died in June (Appendix , Table 3). Three mortalities occurred within 48 h of capture. Calf No. 2 died from wounds caused by a golden eagle, but was in starvation condition at the time of death. Calf No. 18 died within 48 h of possible exposure (hypothermia). Calf No. 12 died of starvation at 1 or 2 days of age. Its dam had fled the area immediately upon initiation of capture procedures and was not observed to return. Another calf (No. 15) died of starvation after 96 h. The maternal cow was observed striking this calf with her front feet, apparently rejecting the newly collared calf.

One calf (No. 5) apparently drowned while trying to cross the Firth River. Five collared calves were probebly killed by golden eagles. Two others were probably killed and/or scavanged by an avian or mammal predator.

Three unmarked calf carcasses were also retrieved, examined in the field and necropsied. One apparently was preyed upon by a golden eagle, one was killed or scavanged by a brown bear and one died of pneumonia.

It was not possible to be certain which calves were victims of predation, what factors predisposed calves to predation, or which calves had died from other causes and were later scavanged. Predation including scavanging appeared to by involved in 91.7% of the detected mortality (see Appendix). Based on the presence of chewed or broken bones, the arrangement of bones, and the presence of predator/scavanger sign, golden eagles appeared to the primary predator of collared caribou calves. Scavanging by avian species occurred in both cases of abandonment and the drowning and was involved in 25.0% of the mortality.

Twenty monitoring surveys were conducted between 8 June and 5 September. Collared calves remained in the general calving area until late June. In early to mid June collared calves were with large post-calving aggregations which occupied the coastal plain of northeast Alaska from the Hulahula River to the Clarance River. In late July collared calves were found in the mountains on both sides of the continental divide from the Jago River to the upper Firth River. Five collared calves were relocated on 19 August about 40-60 km northeast of Arctic Village, Alaska. Eleven of 12 collared calves were in the general vicinity of the upper Babbage and Blow Rivers between 30 August and 10 September.

Logistical limitations in monitoring and retrieving dead calves were major factors contributing to the inability to positively identify causes of caribou calf mortality. Recommendations include daily survey flights, immediate carcass retrieval and detailed examinations of mortality sites.

Other Studies

A photocensus of the Porucpine herd was completed in June and July 1982 by ADF&G, USFWS and Canadian biologists. L. Duquette, a graduate student at the University of Alaska, Fairbanks, began a study on the energetics of migration for a Masters of Science degree. Reports on these studies are not yet completed.

Central Arctic Herd

ADF&G biologists R. Cameron and K. Whitten continued their studies of the Central Arctic herd in 1982. Renewable Resources Consulting Services, Ltd. also conducted surveys in the ANWR on the Central Arctic herd in 1982. Their final report will be available in March 1983.

Muskoxen (*Ovibus moschatus*)

In 1982 C. O'Brian graduate student at University of Alaska, Fairbanks, began a comparative study of muskoxen habitat along the Tamayariak River, Sadlerochit River, and Okerokovik River. This continuing study will provide information for future update reports.

A study of muskoxen on the ANWR coastal plain was initiated by P. Reynolds (USFWS ecologist) in 1982. Its objectives were as follows: 1) to determine population size and composition of herds; 2) to located calving areas; 3) to document distributional patterns and movements of herds. Methods and preliminary results are described in ANWR Progress Report No. FY83-7 (see Appendix).

Surveys in April and October 1982 collected data on population size and productivity . The post-calving population was estimated to be between 240 and 257 animals. Comparison with previous years show that population growth was slow in the first 3-4 years after the 1969 and 1970 transplants, began to increase after 1974 and reached a maximum in 1979-1980. Rates of population growth varied between geographic areas.

In October 1982, 38 calves were counted for a ratio of 0.49 calves/cow 2 years and older and 0.19 calves/animal older than calf. Complete sex and age composition data for all herds are needed before an accurate estimate of productivity can be made. Composition data varied between geographic areas. Animals along the Sadlerochit River had a high percent of young aged animals compared with the Tamayariak area, where a large percentage of adult males were present.

Three adult mortalities were documented in 1982. One radio-collared female died within 15 days of being captured and marked. A 15 year old male died from wounds inflicted by another muskoxen. A second radio-collared cow died in late October. Necropsy of this animal has not yet been completed.

Fifteen muskoxen were captured and marked in mid-April 1982. Data from 3 radio-collared muskoxen showed that herds did not remain as discrete units throughout the year and that interchange occurred between geographic areas. Herds appeared to be more stable during early calving, the post-calving period in June and the rut. They were less stable in mid-summer and early winter. The largest herds were observed during winter (April and October); the smallest were seen during the rut.

Distribution and movements of muskoxen were determined by relocating radio-collared muskoxen from mid-April tthrough October. In May 60-70 muskoxen from the Sadlerochit area and the Tamayariak area calved in the hills east of Carter Creek. Other animals calved on the bluffs along the Tamayariak River, on a ridge between Arctic Creek and Kekiktuk River, and along the Niguanak River. Some female were observed alone during the birth of their calves. In June after the peak of calving, several animals moved into areas not used later in the summer. From July through October, muskoxen utilized riparian willow thickets along major river drainages. In mid-April animals were observed on wind-blown ridges above river valleys.

Average daily movements of radio-collared animals ranged from 0 to 6.7 km/day. Maximum distance traveled by each collared individual ranged from 9 to 52 km. Maximum movement for most animals occurred in July and August.

Marine Mammals

No new information was obtained on marine mammals except on-going polar bear studies being conducted by S. Amstrup (USFWS, Research Division, Anchorage). A report of work in progress had not been prepared in time for inclusion in this update summary.

Predators

Brown Bear (*Ursus arctos*)

Graduate student M. Philips (Univ. of Alaska, Fairbanks) began a study of brown bear habitat use and activities in the Caribou Pass/Kongakut River area adjacent to the ANWR coastal plain study area in 1982. A preliminary report entitled "Habitat use and activities of grizzly bears in the Arctic National Wildlife Refuge" is on file at the USFWS Arctic National Wildlife Refuge in Fairbanks, Alaska. Between late June and mid-August 1982, 12 different bears were observed and behavorial information was collected for 80 bear-unit hours. Bears were most often observed foraging (36.9%), feeding (30.8%), or resting (21.4%). Common food items utilized included *Boykinia richardsonii*, *Equisetum arvense*, and roots of *Hedysarum alpinum*. Bears wre observed in 5 typographical types: Gully cut bank/draw/creek, mountain slope/hillside, and valley flats were most commonly used (35.3%, 30.3% and 18.8% respectively). Bears were observed in 7 vegetation types with tussocks, *Equisetum*/wet sedge/grass, and short shrub the most common vegetation types used (44.8%. 27.3%, and 15.6% respectively).

G. Garner, USFWS biologist in cooperation with H. Reynolds of ADF&G, initiated a study of brown bears in and adjacent to the ANWR study area in 1982. Methods and preliminary results are reported in ANWR Progress Report No. FY83-8 (see Appendix).

Fifty brown bears (*Ursus arctos*) were captured between 23 June and 3 July 1982 in the coastal plain and adjacent foothills and mountains of the northeastern portion of ANWR. Radio-transmitters were attached to 32 of the 50 bears and these bears were monitored through denning in October and early November. More females were captured in age classes 6.5 year old and less, while males were more abundant in 7.5 year old and older age classes. Survival of immature bears appears good from year to year based on the percentage of captured bears in each age class. No mortality was detected within the immature age classes. Preliminary data interpretation indicate that the coastal plain and foothills habitats may be used more often by younger age classes and females with young than older bear without young. Preliminary calculations of range size indicated that young bears moved over larger areas than adult bears. In all cases, range sizes determined in this study were less than recorded for brown bears in northwest Alaska and northeast Alaska.

Brown bears were observed feeding on caribou (Rangifer tarandus) carcasses on 6 occasions during the study. These instances were the only recorded interactions between the 2 species, except one unsuccessful chase of a bull caribou by a bear on 23 August. Dens were located for 28 radio-collared bears and dens of 10 unmarked bears were located during aerial surveys for bear dens. Bears moved south into the foothills and mountainous habitats to den, except for 2 radio-collared bears. One brown bear denned in the coastal plain and one denned in the foothills of Marsh Creek. These 2 dens were the only bear dens located within the 1002c study area boundaries.

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Chapter 6

FISH

During 1981 and 1982, the Fairbanks Fishery Resource Station conducted aquatic studies on the ANWR coastal plain. Refuge methods and results are reported in Fisheries Resources Progress Report No. FY83-1 (Appendix). Major emphasis in 1981 was on monitoring movement and overwintering of arctic char and on general species distribution and life history in the Canning River. Char movement and overwintering was again studied on the Canning River in 1981. Fish distribution and life history in several other drainages including the Tamayariak, Katakturuk, Sadlerochit, and Aichilik rivers were also studied in 1982. Physical characteristics of these drainages were examined and related to potential overwintering habitat. Pools suitable for supporting overwintering populations of fish were rare, especially in the Katakturuk River which is devoid of established fish populations. Stream channels in the study area exhibit a high degree of braiding and have relatively steep gradients. The potential for suitable overwintering habitat was thought to be greatest in fourth and fifth order streams where gradient is less than 4% and there is an unbraided channel pattern.

Perennial groundwater sources, found on all of th rivers sampled during 1981 and 1982, were most abundant in the Canning River drainage. Both the Canning and Aichilik Rivers have populations of anadromous char and the spring areas are critical for their spawning and overwintering. The suitability of a spring area to anadromous char depends on access to and from the area and the amount and quality of the area that is suitable for overwintering (i.e. discharge, depth, etc.). During the study period, char movement into the Canning River ranged from mid July through August. The peak movement in numbers of fish appeared to occur around the third week of August. Overwintering pools appear to be limited on the Canning River. Only 13 pools deep enough to provide much overwintering habitat were located in a 75 km downstream reach of the mid and lower river. Radio tagged char and fall concentrations of char were located near these pools. Radio tagged char showed considerable movement throughout the winter. One fish moved 17 km downstream from October 1981 to January 1982. Another moved upstream 6.4 km during March and April 1982. Fall concentrations of char were observed in late September 1982 in the mid and upper reaches of the Canning River. Major spawning areas were located in the Marsh Fork and main river above the Marsh Fork confluence. Char concentrations were also located in the Aichilik River.

Grayling were widely distributed in all rivers studied except for the Katakturuk. They were generally collected in greatest abundance in lower and mid sections of rivers surveyed. Round whitefish were only collected in the Canning River. In the Canning River drainage, their distribution was similar to that of grayling except they were not collected in tributary streams. Three species of salmon were collected in the study area. One pink salmon, one red salmon, and several chum salmon were collected in the Canning River. Another pink salmon was collected in the Sadlerochit River.

Chapter 7

HUMAN CULTURE AND LIFESTYLE

In 1982 several studies were initiated and/or completed. Updated information is summarized by J. Liedberg (USFWS Outdoor Recreation Planner) and new references are included in this chapter.

Early History and Archaeology

During the summer of 1982, an archaeological and historic resources reconnaissance of the ANWR study area was completed by Edwin Hall and Associates under contract to the U.S. Fish and Wildlife Service (Hall 1982). An extensive helicopter survey of the entire study area was made with emphasis on areas where archaelogical or historic sites were most likely to be located. Sites which contained resources most susceptible to damage during winter seismic activities were identified. The locations of approximately 100 sites including sod houses, cache pits, ice cellars, graves and other sites with standing architecture as well as tent rings, flake scatters and modern tent sites were detailed. Some of the reported sites correspond to TLUI sites identified previously (Jacobson and Wentworth 1982) and show continued use by local people through present times.

This study also provided recommendations for protection of existing sites during oil and gas seismic exploration. Posting of sites, providing monitors with seismic crews, and avoidance of all sites by ground vehicles to the maximum extent possible were recommended.

Subsistence

Traditional Land Use Inventory Sites

During the summer of 1982, D. Libby (Univ. of Alaska) under contract to the North Slope Borough conducted an on-site survey of many of the sites originally identified by the North Slope Borough as "Traditional Land Use Inventory (TLUI)" sites (Nielson 1977). Resource people from the village of Kaktovik assisted Libby in documenting the actual locations of the sites, inventorying the surface material, and recording any ethnohistoric information available (Libbey 1982).

The area surveyed extended from the Canadian border west to Konganevik Point as identified on USGS topographic maps. Results supplement information compiled by Jacobson and Wentworth (1982) and expand on similar work conducted on sites to the west of ANWR (North Slope Borough 1980, Libbey 1981). Included in the narrative for each site is a brief history of site use and location and identification of structures, artifacts and graves (Libbey 1982). Thirty three sites were reviewed, 5 of which were not covered by Jacobson and Wentworth (1982),: Pattaktuq #1, Qapiloorauq, Kanigiluk, Sadlerochit, and Iqalugliurak (Fig. 1).

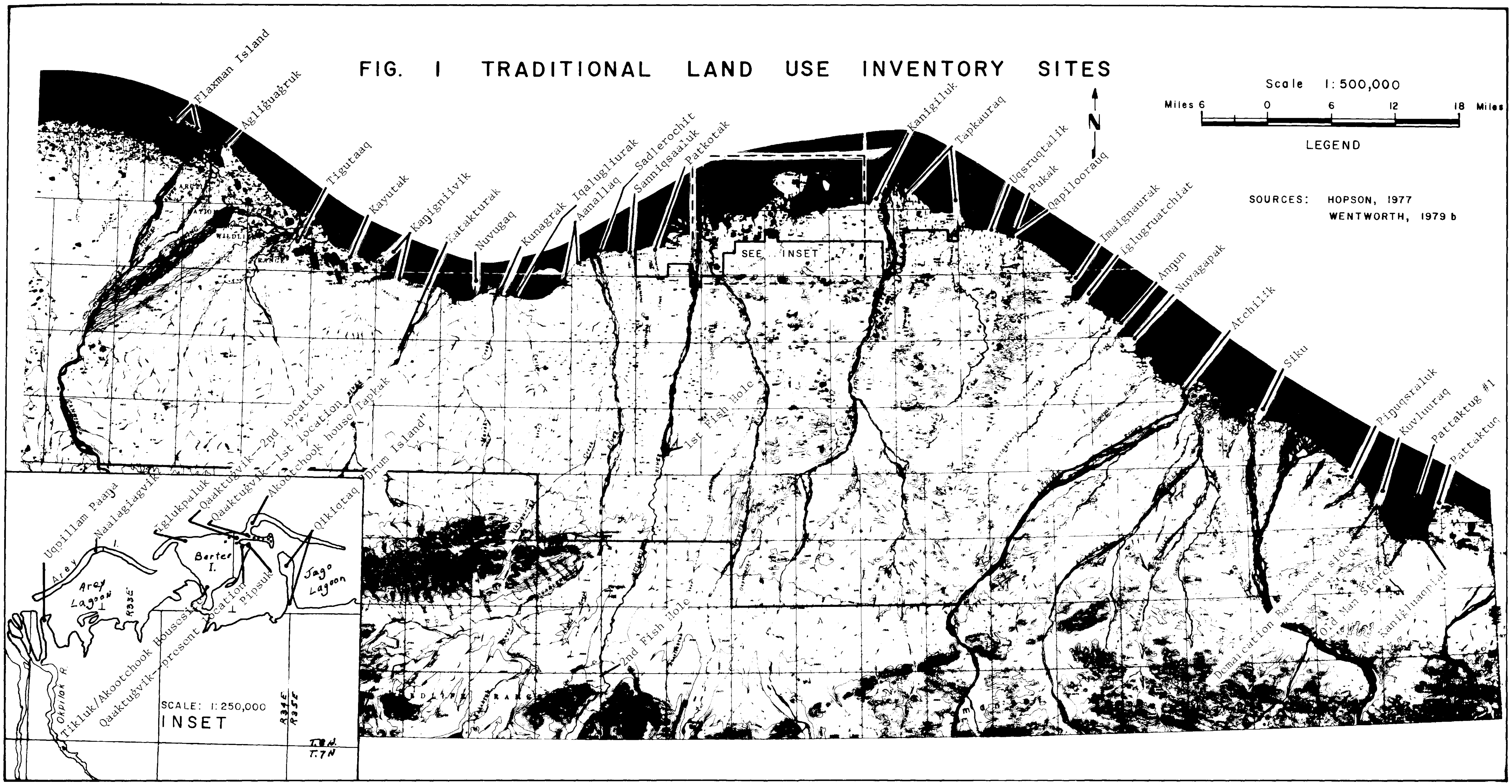
FIG. I TRADITIONAL LAND USE INVENTORY SITES
Scale 1:500,000
Miles 6 0 6 12 18 Miles
N
LEGEND
SOURCES: HOPSON, 1977
WENTWORTH, 1979 b
Flaxman Island
Agliguağruk
Tigutaaq
Kayutak
Kaŋigniivik
Katakturak
Nuvugaq
Kunagrak
Iqalugliurak
Aanallaq
Sadlerochit
Sanniqsaaluk
Patkotak
SEE INSET
Kaŋigluk
Tapkauraq
Uqsruqtalik
Pukak
Qapilooraq
Imaignaurak
Iglugruatchiat
Aŋŋun
Nuvagapak
Atchilik
Siku
Piŋuqsraluk
Kuvluuraq
Pattaktug #1
Pattaktuq
1st Fish Hole
2nd Fish Hole
"Drum Island"
Demarcation Bay—west side
Old Man Store
Kaniġluagniat
Uqpillam Paaŋa
Naalagiagvik
Iglukpaluk
Qaaktuġvik—2nd location
Qaaktuġvik—1st location
Akootchook house/Tapkak
Qikiqtaq
Arey I.
Arey Lagoon
Barter I.
Jago Lagoon
Pipsuk
Tikluk/Akootchook house site
Qaaktuġvik—present location
Okpilak R.
R33E
R34E
R35E
T.8N.
T.7N
SCALE: 1:250,000
INSET

Kaktovik

Resource use

On-going work by the Subsistence Division, Alaska Department of Fish and Game (ADF&G), will overlap and expand on earlier work which documented subsistence land and resource use by the people of Kaktovik (Jacobson and Wentworth 1982). Expected to be available in early 1983, the ADF&G study, "Subsistence Land Use Baseline for Eastern and Central North Slope Communities, Alaska", is part of a long term effort to document recent and historic land use by villagers in Kaktovik, Nuiqsut and Anaktuvik Pass, and to study changes in those uses over time. The study will also outline possible mitigating measures that may enable continuing subsistence use opportunities in those communities which face rapid industrial development in their communities and in subsistence use areas (Pederson 1982a). Two additional on-going ADF&G studies will provide additional information on the Dall sheep harvest in Kaktovik and its importance in the natural resource economy, and will document subsistence use of the Porcupine caribou herd (Pederson 1982a).

Resource harvest for the past regulatory year (July 1, 1981 - June 30, 1982) for Kaktovik included a Dall sheep harvest of approximately 36 animals (69% females, 31% males) with hunting activity peaks in October/November and April (Pederson 1982b) and a caribou harvest of 43 animals (Pedersen, pers. comm.). In July 1982, animals from the Porcupine caribou herd crossed from the mainland onto Barter Island and were very accessible to villagers; a preliminary estimate of total summer 1982 harvest was 150 caribou (Bartels, pers. comm.).

During the September 1982 whaling season, one bowhead whale was struck and lost, and on September 23, a 16 m male was landed in Kaktovik. Several crews participated in the hunt (S. Pederson, pers. com.).

Socioeconomic System

An additional socioeconomic study of Kaktovik was completed in 1982. Worl et al. (1982) found that although the Inupiat people of Kaktovik are actively seeking to modernize their society by obtaining material goods and modern services, they have apparently, consciously and unconsciously, defined their continuing relationship to the land and maintenance of the subsistence economy and culture as one part of their culture that they are unwilling to change. The basic factors which Chance (1966 as cited by Worl et al. 1982) found to be instrumental in helping the Inupiat culture respond positively to change appear to persist in Kaktovik today. These factors may give their society the ability to endure through the continuing changes on the North Slope today. Kaktovik is still closely bound by kinship and social, political, and economic relationships which integrate the community (Worl et al. 1982). Kruse (1981) found that despite higher average incomes and expanding wage opportunities, Inupiat retain a high interest in pursuing a wide variety of subsistence activities throughout the year, and that subsistence activities play an important economic and social role.

Worl et al. (1982) also reported a current summary of population composition, jobs, facilities, and services and cost of living in Kaktovik which will give baseline figures for future comparisons.

Other Villages

Porcupine caribou herd harvest information for interior Alaskan villages was unavailable at the time of this report.

A socioeconomic overview of Arctic Village was also completed in 1982 (Worl et al. 1982). The development of a strong tribal government and an assertion of sovereignty have been 2 prominent changes in the last decade. Subsistence remains a critical component of the economy and the major economic enterprise. Cash derived from other sources is but one important element which allows an individual to conduct subsistence activities. Subsistence activities in Arctic Village are very time consuming as they include cutting and hauling firewood and hauling water. The major natural resource upon which the community relies is the Porcupine caribou herd which they consider to be healthy but endangered by oil companies, roads and fly-in hunters (Worl et al. 1982). Current economic factors such as housing, facilities, services and income in Arctic Village were also summarized (Worl et al. 1982).

Recreation, Wilderness and Natural Landmarks

Recreation

No research on recreational uses of the study area was conducted in 1982.

Wilderness Values

An on-the-ground survey of the ANWR study area for wilderness values was conducted by A. Thayer (USFWS, Wilderness Specialist) during the summer of 1982. Documentary photographs are located in the refuge slide files. The study area is subject to Section 1317 of ANILCA and will undergo public notice and hearing as a wilderness study area along with the comprehensive planning process required in Section 304 (g) of ANILCA for the entire ANWR. The area qualifies for wilderness inclusion under the provisions of Section 2(c) of the Wilderness Act of 1964. As no further wilderness review of Alaska lands under BLM jurisdiction will occur, the importance of the ANWR study area as a potential wilderness area may increase.

NATURAL LANDMARKS

In addition to those described in the initial baseline report (USFWS 1982), one other site is awaiting action as a proposed natural landmark. The Beaufort Lagoon - Demarcation Bay site extends along the Beaufort Sea coast from Humphrey Point to Demarcation Bay, and includes the barrier islands, lagoons, and portions of the mainland (HCRS 1979). It should also be noted that the Sadlerochit Springs has been nominated as a site in its own right (HCRS 1979, 1980) as well as in a joint proposal with the Sadlerochit Mountains (Bliss and Gustafson, 1981). These sites were examined and evaluated in the field by Murray (1979).

The Beaufort Lagoon site has also been proposed for inclusion in the Ecological Reserve System for Alaska (Underwood and Juday, 1979).

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Chapter 8
POTENTIAL IMPACTS OF GEOPHYSICAL EXPLORATION

No new information was obtained to update this chapter.

Chapter 9
IMPACTS OF FURTHER EXPLORATION, DEVELOPMENT AND PRODUCTION OF OIL AND GAS RESOURCES

No new information was obtained to update this chapter.

APPENDICES

ANWR Progress Report Number FY83-1

DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF FALL STAGING LESSER SNOW GEESE ON COASTAL HABITATS OF NORTHEAST ALASKA AND NORTHWEST CANADA, 1980 and 1981

Michael A. Spindler

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

Arctic National Wildlife Refuge
U.S. Fish and Wildlife Service
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7 December 1982

Distribution, abundance, and productivity of fall staging Lesser Snow Geese in coastal habitats of northeast Alaska and northwest Canada, 1980 and 1981.

Michael A. Spindler. U.S. Fish & Wildlife Service, Arctic National Wildlife Refuge, Fairbanks, Alaska.

Abstract: Since 1971 biologists from L.G.L. Ltd., Canadian Wildlife Service, and U.S.F.W.S. have monitored the distribution, abundance, and productivity of lesser snow geese which stage in late August and early September in the arctic coastal regions between Parry Penninusla, Northwest Territories and the Canning River, Alaska. All portions of the staging area were surveyed 1973-76 and 1981; only the Alaska and/or Yukon portions were surveyed 1978-1980.
Lesser snow geese in the region originate from 3 nesting colonies in Canada: Banks Island, Kendall Island and Anderson River delta. Breeding birds were photo-estimated at 152,550 in 1976 and 207,525 in 1981, with an additional 100,000 non-breeding adults also present in the region. These 250-300,000 adults and a variable number of young snow geese produced on the colonies stage between Parry Penninsula in the east and the Canning River in the west. Total numbers were estimated at a minimum of 114,939 in 1974, a maximum of 706,277 in 1975 and 430,000 in 1981. Distribution during fall staging varies annually. In 1975 an estimated 20,972 snow geese used the Alaska and Yukon Territory areas and 685,305 were estimated staging on the Mackenzie delta. For 1978, 325,760 snow geese were estimated staging in the Alaskan portion alone. In 1981 an estimated 20,000 were staging on the Alaska coastal plain while an estimated 80,000 staged in the western half of the Yukon Territory coastal plain. Snow geese departed the area 16-18 September 1981 as the tundra lakes were freezing over. Major departure in previous years has ranged from 7 to 27 September. Age ratio varied between 1% young birds in 1974 and 119% young birds in 1973. In 1981, when the most extensive age ratio sampling to date was obtained, the percent young was greatest south of Liverpool Bay (30-40%), intermediate between the Mackenzie delta and Herschel Island (12%), and lowest between Komakuk Beach and Barter Island (7%). Such spatial variation in age ratio combined with high annual variation in distribution and abundance dictates that future sampling efforts be planned to include all major staging areas in the region, which will necessitate extensive surveys and coordination between Canadian and Alaskan biologists.

Distribution, abundance, and productivity of fall staging Lesser Snow Geese in coastal habitats of northeast Alaska and northwest Canada, 1980 and 1981.

The arctic coastal plain of eastern Alaska and Yukon Territory, the Mackenzie River delta and surrounding treeline habitats are a major fall staging area for an annually variable number (100,000-700,000) of lesser snow geese (Barry 1967, Gollop and Davis 1974, Patterson 1974, Schweinsburg 1974, Koski and Gollop 1974, Koski 1974, 1975, and 1977). In some years (e.g. 1976), a large proportion of these geese have spent up to three weeks staging on the north slope of the Arctic National Wildlife Refuge (Koski 1977, Spindler 1978). This report summarizes continued efforts at monitoring snow goose activities on ANWR after completion of the Arctic Gas studies in 1977. Specific objectives were to: 1) determine the chronology of migration and staging, 2) estimate the peak numbers of snow geese present during staging, 3) determine distribution and age ratios and 4) identify habitat areas and types used consistently.

Methods

Distribution and abundance were sampled by aerial survey of a grid first sampled in 1973 (Koski 1975). Transect lines were spaced 9.7 km apart, and extended from the Beaufort Sea coastline inland to about the 300 m contour in Alaska, and the 500 m contour in Yukon and Northwest Territories. Transect width was 1.6 km 1973-1975 (Koski 1973-1976) and 2.4 km 1976-1981 (Koski 1977, Spindler 1978a, Spindler 1979). The change to the 2.4 km-wide transect was made by Koski (1977) because it was shown to be better for estimating snow goose numbers than the 1.6 km width. Transects were flown at an altitude of 150 m above ground level, and an airspeed of 200 km/h. While on transect total number in each snow goose flock was visually estimated and also photographed. Flocks on and off transect were recorded on 1:250,000 topographic maps according to location, flock size, and direction of flight. In the studies since 1978 (Spindler 1978a, Spindler 1979, and this study) a deliberate attempt was made to record direction of flight and to keep track of where an airborne flock landed to avoid double-counting from an adjacent transect. Aerial photographs were taken of large flocks on the transect which when accompanied by visual flock size estimates assisted in quantifying estimation error and visibility bias. Usually a survey crew included 3 persons, pilot-observer, observer, and photographer, although some surveys were flown with only 2 persons. Aircraft types used during the surveys varied with availability, but included DHC-2T turbo-Beaver, Helio-courier H-295, Cessna 185, and Cessna 207. Age ratio was sampled along the same transects by visual counts 1973-1977, and by photography 1979-1981. A 35-mm camera with 135 mm telephoto lens was used.

Total goose population staging in the area, arrival and departure dates, and age-ratios among the various years of survey data are affected by the following factors that are not easily quantified or controlled: (1) differing dates of survey and portions of areas covered on particular dates, largely due to inclement weather and logistical difficulties; (2) varying seasonal weather conditions in each year, and: (3) annual, daily, and spatial variation in age ratio, populations, and distribution. Other major factors complicating comparisions, but which can be controlled, are survey methods employed in the various years (techniques are steadily being refined and improved) and standardization of environmental conditions under which the surveys are conducted.

In the first years of survey, 1971-1972, emphasis was on description of timing and size of migration movements, largely from ground observations but accompanied by aerial survey (Schweinsburg 1974, Gollop and Davis 1974). From 1973-1976 the most extensive systematic aerial surveys were conducted (Koski and Gollop 1974, Koski 1975, 1977a, 1977b): population estimates were derived from extrapolation of transect counts and age ratios were obtained from actual aerial and ground composition counts. The ANWR surveys made in 1978-1980 emphasized systematic transect surveys with population estimates made by extrapolation in 1978, and total flock counts combined with photographic counts in 1979 and 1980 (Spindler 1978a, 1979). Age ratios were determined from photographic counts in the latter 2 years. In 1981 the Mackenzie delta, Yukon north slope and Alaska north slope were surveyed using the transect survey grid and photography. Some portions of the Canadian area were surveyed a few days before the Alaska area, but the vast majority of flocks were sampled on both areas on the same day, hence, eliminating some of the temporal variability. This survey required simultaneous efforts on the part of FWS and CWS biologists. Additionally, in 1981, visual estimates of numbers and age ratios made by pilots (experienced at snow goose survey methods) were incorporated because a majority of the geese staged in an area that is rarely used for staging but which was not discovered to have been used in 1981 until after the survey was over (Barry 1982).

Results and Discussion

Chronology

Snow geese which stage in the study area nest in 3 colonies: Banks Island (Egg River 198,125 nesting birds; Anderson River delta, 8,359 birds; and Kendall Island, 1,041 birds (Barry 1982). An additional 100,000 non-nesting birds were estimated to have been present in the region in 1981 (Barry 1982). Adults with young depart the nesting colonies between mid- and late August, arriving first on the Parry Penninsula where they exercise and feed (Barry 1967). Depending on weather and the season, geese then spread westward from the Mackenzie River delta to occasionally as far west as the Canning River, Alaska. First arrival dates in the Mackenzie River delta to Barter Island area have varied between 13 August (1976) and 24 August (1979 and 1981) (Table 1, Fig. 1). Major date of arrival has ranged from 19 August (1980) to 3 September (1975). In some years the period between first arrival and major arrival was only 2 days (1979 and 1980) whereas in most other years it was 5-12 days (Fig.1).

The staging period, during which there is little movement, had a minimum duration of 7 days (1972) but in most years was 15-22 days long; maximum duration was 22 days (1974) (Fig.1). Mean duration of staging was 13.7 days (Table 1). Departure tended to be more compressed than arrival, with last date of observation 4-15 days after major departure had begun. The earliest major departure started 1 September (1980), and the latest major departure began 22 September (1973) (Table 1, Fig. 1). In 3 of the 10 years for which chronology data are available, the last snow goose observation was only 2-3 days after major departure ended. These were years in which freeze-up came suddenly. Koski (1974:13) suggested that weather most likely exerted the major influence upon timing and extent of arrival and departure movements.

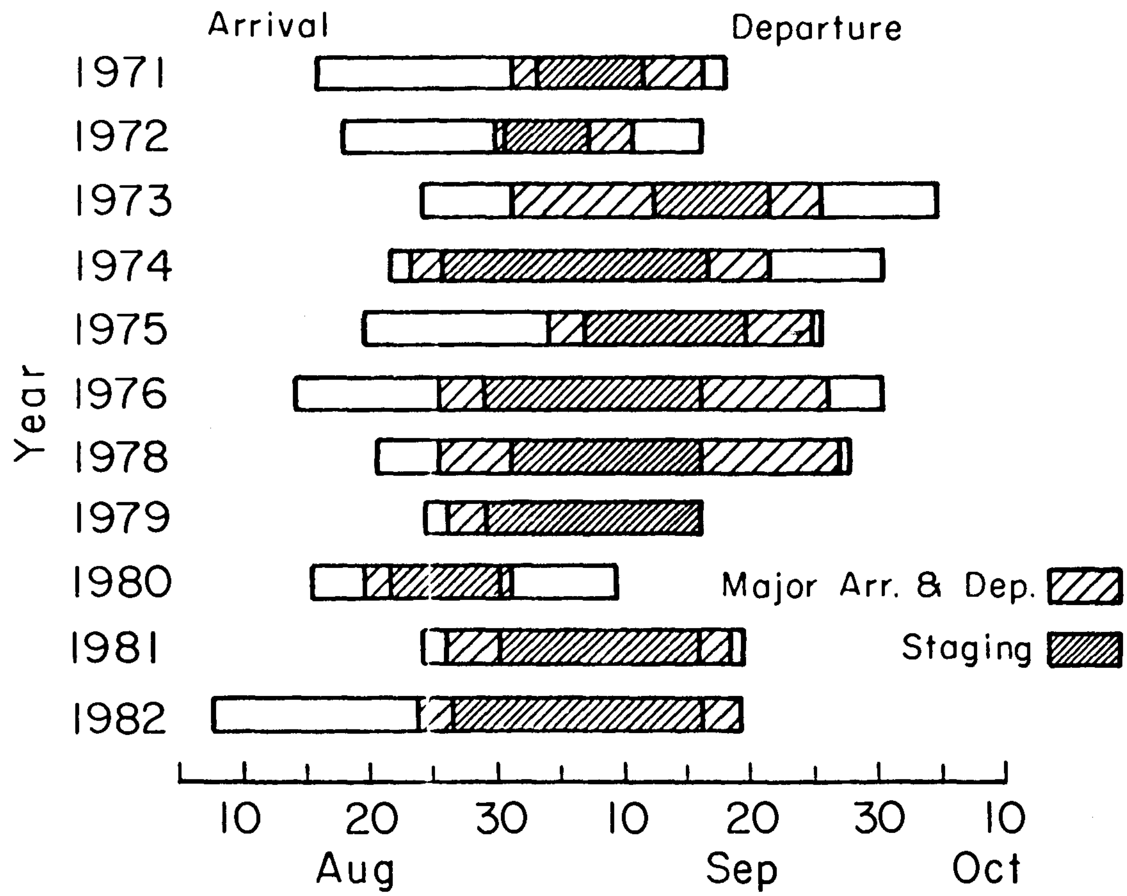


Fig. 1. Chronology of arrival, staging and departure of the western arctic opoulation of lesser snow geese using the coastal plain of the Arctic National Refuge, Alaska, the Yukon Territory north slope and the Mackenzie Rever delta, N.W.T.

Table 1. 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 1978-1981. The 1978-1981 data are from Arctic National Wildlife Refuge only.

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.

a Dates inclusive of aerial and ground observation period. Locations of ground observation and aerial survey coverage varied: 1971-1976 data emphasized Mackenzie and Yukon locations, while 1978-1981 data emphasized Alaskan locations. For details see respective sources:
b Schweinburg (1974)
c Gollop and Davis (1974)
d Koski and Gollop (1974)
e Koski (1975)
f Koski (1977a)
g Koski (1977b)
h Spindler (1978a)
i Spindler (1979)
j Spindler (1980)
k Unpublished data, ANWR files

Johnson et al. (1975) reported that the main departure from the north slope occurs just ahead of freeze-up.

Distribution

Patterns of spatial distribution on the Yukon north slope and Alaska north slope for 1973-1976 were presented by Koski and Gollop (1974) and Koski (1975, 1977a, 1977b). Analysis of snow goose distribution in the current study included that portion of the north slope staging area within ANWR, 1973-1981.

Generally, spatial distribution within ANWR has been extremely variable (Fig. 2-4). In 1974, 1976, 1978, and 1979, snow geese staged on a widespread portion of ANWR, generally east from the Hulahula River to the Aichilik River and extending inland from the coast to roughly the 305 m contour line. Staging in other years was restricted to certain localities or portions of the coastal plain. In 1973, the use centered along the Aichilik River and extended northwest to the Niguanak River (Fig. 2). In 1975 no large concentrations were observed staging on the ANWR coastal plain (Koski 1977a). Snow goose surveys were not conducted in 1977. In 1980, snow goose distribution, as determined from boat surveys along coastal lagoons in late August, extended from Demarcation Bay west to Beaufort Lagoon, however, it is not known how far inland the area was used (J. Levison, unpubl. data). When the 1980 aerial survey was conducted (9-10 September 1980), the only snow geese observed on the ANWR coastal plain were north of VABM Dar near the Kongakut River and directly on the U.S.-Canada border; much of the population had staged on the Yukon north slope (Spindler 1980). Distribution of snow geese on ANWR in 1981 was again fairly widespread, extending in a 20-25 km wide band north of the 305 m contour line from the Okpilak River east in the Yukon north slope. There was also a small aggregation close to the coast between the Hulahula and the Jago Rivers (Fig. 4).

The available data (1973-1981) indicate that some "core" snow goose staging areas on ANWR can be defined. In years of lower staging population on ANWR (e.g. 1973, 1974, 1980 - possibly, and 1981), staging occurred on limited portions of the ANWR coastal plain, but in all these years (except possibly 1980) 2 "core" areas were used: 1 between the Okerokovik and Jago Rivers north of the 305 m contour line, and the other between the Aichilik and Sikutaktuvik Rivers between the 122 and 305 m contour lines (Fig. 2-4). These core areas were also used in years of high staging population (e.g. 1976, 1978, 1979), but in those years staging also occurred in more widespread areas over the entire coastal plain east of the Hulahula River. Significant staging was documented west of the Hulahula, in 2 years, 1976 and 1979, (Fig. 3 and 4) although small groups of snow geese have also been observed at the Canning delta during the staging period (in 1975, 300 birds on 26 August 1979, 45 and 85 birds on 28 August 1980, 40 and 20 birds on 31 August 1979, and 16 birds on 9 September 1980) (Martin and Moitoret 1981). In 1976, a large staging aggregation was documented in the Carter Creek area and between the Hulahula River and Sadlerochit River (Fig. 3). In 1979 staging occurred along the lower 10 km of the Sadlerochit River (Fig. 2).

FIG. 2 DISTRIBUTION OF FALL STAGING SNOW GEESE

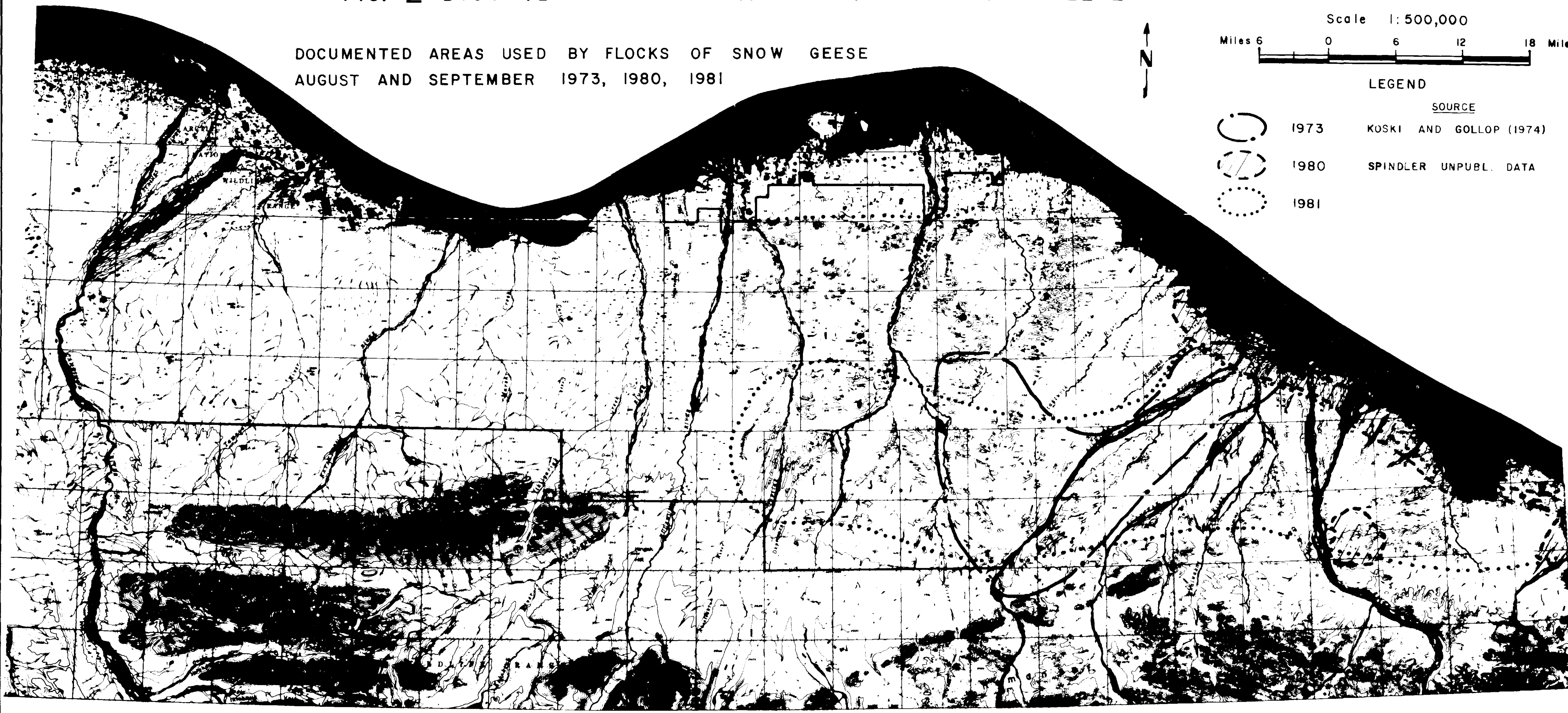


FIG. 3 DISTRIBUTION OF FALL STAGING SNOW GEESE

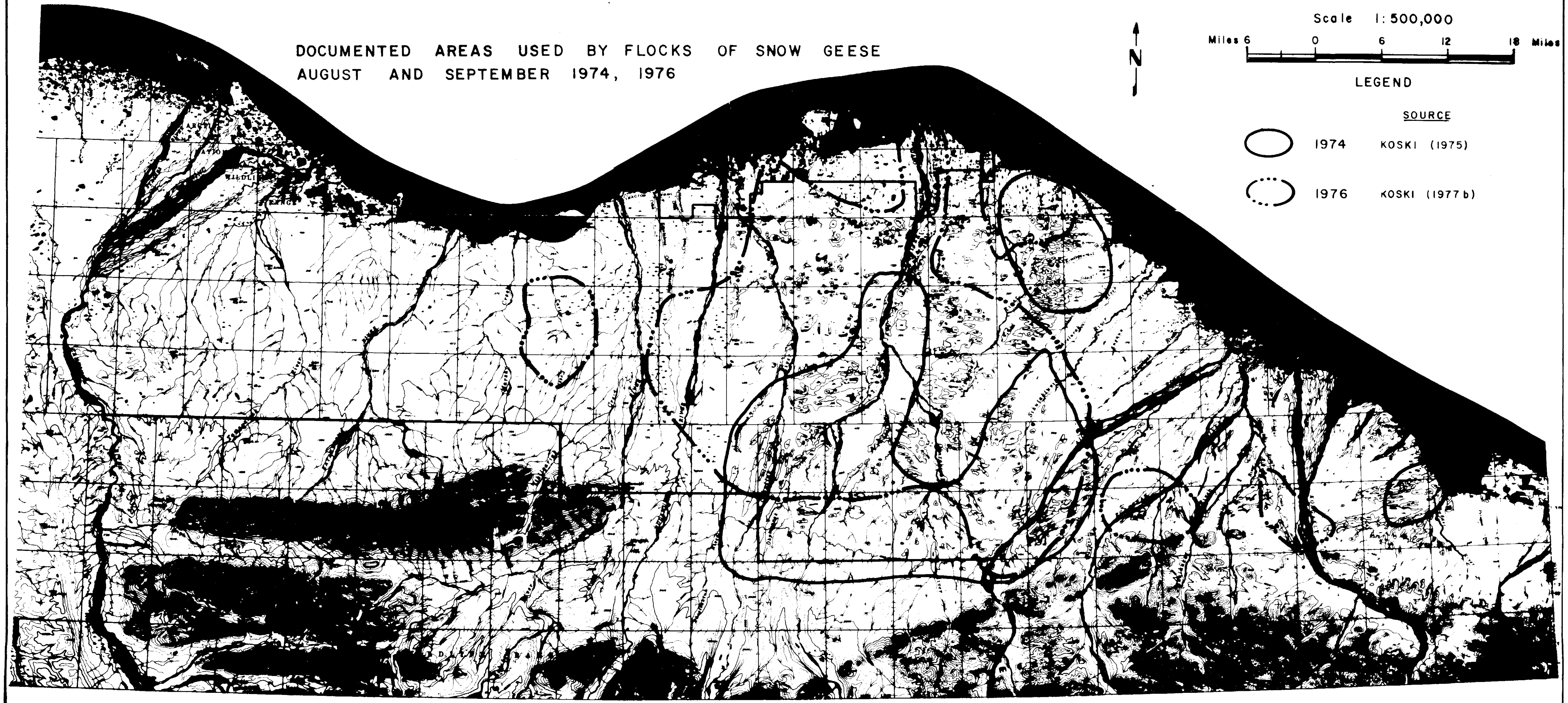
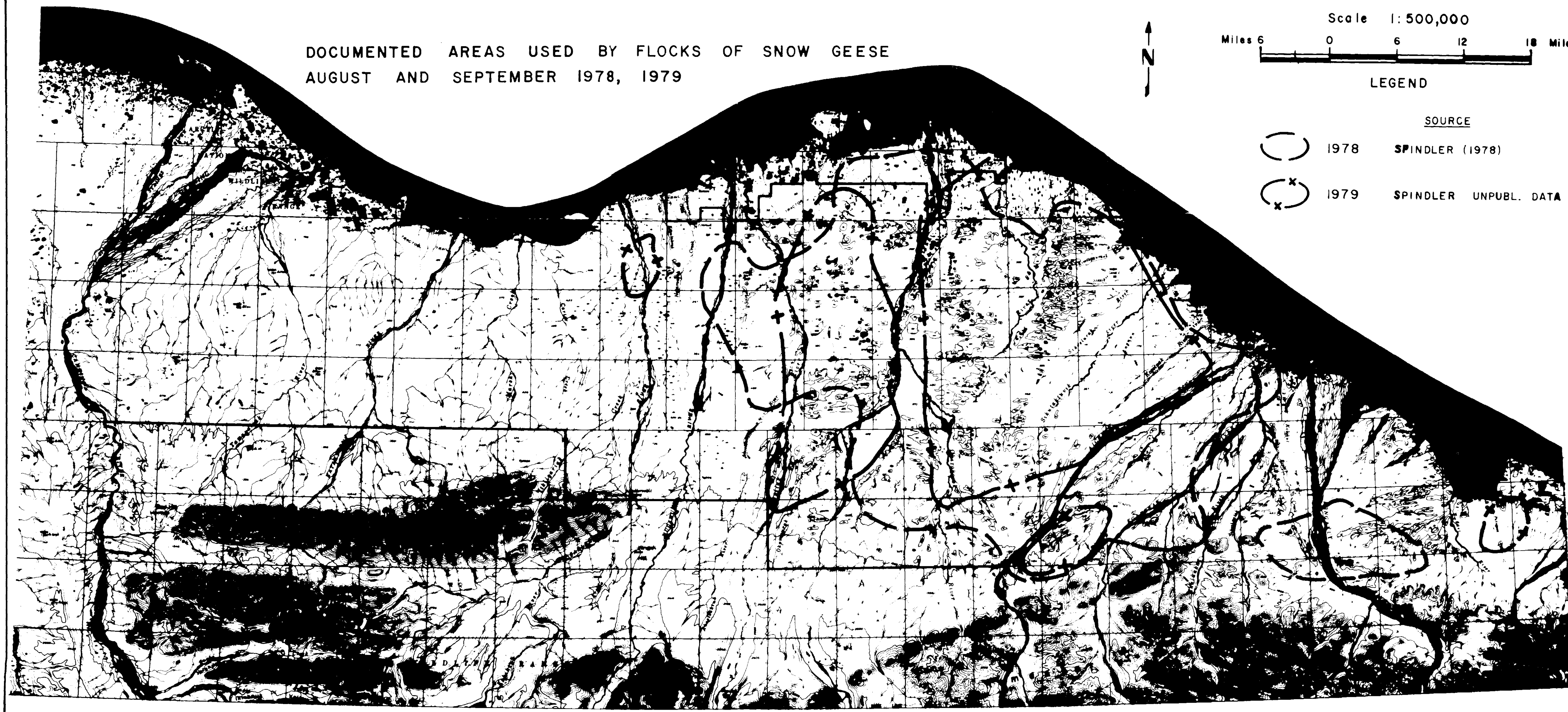


FIG. 4 DISTRIBUTION OF FALL STAGING SNOW GEESE



Habitat Use

Core concentration areas used by snow geese consisted of several tundra types, as determined from examination of snow goose distribution maps (this report) and LANDSAT vegetation maps (by Nodler 1977 [first name]; and USFWS 1982, [numeric abbrevation followed by name]). These habitat types are ranked in general order of their magnitude of use by snow geese.

1. Upland sedge meadow	5a	moist sedge-prostrate shrub tundra
2. Tussock meadow	6a,6b,7a,7b,7c	several moist tundra complexes
3. Wet sedge meadow	3a	wet sedge tundra
4. Flooded sedge meadow, Very wet sedge meadow	2b,3b,3c	wet sedge tundra- very wet complexes

Snow geese grazing on the outer coastal plain of ANWR have been observed feeding on sedge rootstocks. At the Okpilak River delta Spindler (1978b) described an area several ha in size in a homogeneous wet sedge-tundra habitat where 34 snow geese had been grazing overnight "... nearly every live Carex plant was uprooted and the tuber and green shoots eaten, leaving only the actual roots and dead or dying leaves in scattered feeding sites several m in diameter." Martin and Moitoret (1981) observed 300 snow geese grazing on wet sedge tundra-very wet complex (3c) and another flock of 45 grazing on wet sedge tundra-non complex on the Canning Delta. J. Levison (unpubl. data) observed snow geese clipping and uprooting Carex Bigelowii in the Beaufort Lagoon area in late August 1978. Schmidt (1970) reported that snow geese left the coastal tundra near Beaufort Lagoon in early September 1970 and migrated inland to feed primarily on berries (probably Empetrum nigrum) located in higher dry tundra. The relative importance of inland berry food sources compared to the coastal rootstock food sources is unknown. Also the extent of use of sedge rootstocks in the interior coastal plain is unknown.

Population

The maximum number of snow geese estimated using the Mackenzie delta and the north slopes of Yukon and Alaska was over 700,000 in 1975, a year when no geese were observed staging on ANWR (Table 2). Barry (1982) estimated 430,000 left the region for wintering grounds in September 1981 (Table 2). The maximum estimated numbers of snow geese occurring on ANWR was over 325,000 in 1978 (Table 2). Between 1973-1981, 3 years had estimated numbers on ANWR greater than 190,000; 3 years had between 20,000 and 50,000; and 2 years had less than 20,000 (Table 2). As mentioned previously, survey conditions and extrapolation methods have changed, and survey coverage was different among years, therefore, these abundance figures represent gross estimates of numbers present and should not be construed as accurate population estimates.

Productivity

The most extensive age-ratio sampling to date was obtained in 1981 (Table 3). The entire survey area (Mackenzie River delta west to Barter Island) had a photo-estimated ratio of 11.3% $\pm$ 4.1% young birds (weighted mean $\pm$ variance, Table 3). Additionally a "guestimated" composition of 30-40% young birds was made for the area west of Paulatuk, a rarely used staging area that harbored the majority of western arctic snow geese in early September 1981 (Barry 1982). Barry (1982) reported the distribution of snow geese in the Mackenzie delta area was radically different from previous years: "On 5-6 September...250,000 or more snow geese...staged in the vicinity of Paulatuk

Table 2. Total numbers of western arctic snow geese counted during August-September staging surveys, Arctic National Wildlife Refuge coastal plain and areas to the east, 1973-1981.

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

Sources:
- a Koski 1977b, extrapolation from transects at several points in time, not all areas covered on each date.
- b Spindler 1978a, extrapolation from transects at 1 point in time.
- c Spindler 1979; note Yukon count incomplete, Demarcation Bay to Phillips Bay, estimates of all flocks seen, and photograph counts, at 1 point in time.
- d Ground counts by J. Levison, estimates of all flocks seen in continuous count during daylight hours.
- e Estimated total; Actual photograph count was less; Demarcation Bay to Phillips Bay.
- f Visual estimates of flock size, Yukon sample includes only area from U.S.-Canada border to Phillips Bay.
- g Barry 1982. Includes 250,000 geese estimated to have staged south and west of Paulatuk, which is east of the Mackenzie delta.

and westwards across the Parry Penninsula and the plains of the middle part of the Horton, Anderson and Smoke Rivers near the tree line." This distribution resulted in separation of subgroups, with groups having higher young ratios using the Paulatuk area and groups of non-breeders or groups with lower young ratios using the Mackenzie River delta, and Yukon and Alaska north slopes. Apparently this separation of cohorts persisted throughout their fall migration in Canada (Barry 1982).

Spatial variation in age ratio is expected when family groups with higher proportions of young do not migrate as far west to stage as do those with lower proportions of young. This pattern is suggested by the data (Table 3) where mean percent young (weighted according to flock size $\pm$ weighted variance) was 7.4 $\pm$ 9.2% from Barter Island to Komakuk Beach, and 11.8 $\pm$ 8.3% from Herschel Island to Inuvik, both of which were sampled simultaneously on 16 September 1981. Additionally, the 250,000 birds containing 30-40% young reported from Paulatuk, still farther east, suggests a tendency of increasing precent young from west to east.

Age ratio data are available for western arctic snow geese from 1973-1981 (Table 4). Again, direct comparisons are not possible because of differing survey coverage and weather conditions in some years. For years with similar survey coverage and intensity (1973-1976) age ratios varied from a maximum of 119% young in 1973 to a minimum of 1% in 1974. Some variation in annual productivity was occurring, however these data do not provide a basis for accurately assessing this variation for the entire population. Productivity of the western arctic snow goose populations can be affected significantly by bad weather, particularly in June during hatching (Barry 1967).

Conclusions

Available distribution, abundance, and productivity data indicate a high degree of spatial and temporal variation. This variation is largely due to annually varying weather conditions, and within the staging season, variable survey conditions which caused differences in survey coverage and intensity between years and areas.

In order to maximize consistency of data collection wherever possible, the following are recommendations for standardizing survey methods and conditions:

(1) Continue cooperative USFWS-CWS surveys, by agreeing to areas of sampling responsibility and uniformity in sampling methods.

(2) Continue systematic sampling of the transects initiated by Koski (1973).

(3) Use a combination of photography and visual estimates to determine total flock size. Visual estimates are more efficient with extremely large flocks (greater than 10,000 birds) and small flocks (less than 400 birds). Include double sampling procedures to estimate accuracy of visual estimates.

(4) Use photography for age ratio estimation.

Table 3. Results from 1981 USFWS-CWS cooperative survey of age ratios of staging western arctic lesser snow geese, 11-24 September 1981. Percent young expressed as a mean followed by variance weighted according to flock size.

Location	Date	Adults	Young	Total	No. of flocks	% Young
Inuvik to Bathurst Penn.	24 Sept.	150	0	150	0	0
Tuktoyaktuk Penn., Liverpool Bay, Bathurst Penn.	11 Sept.	1030	43	2073	4	4.0.± 4.0
Mackenzie Delta, Shallow Bay, Southern Richards Island	12 Sept.	156	54	210	2	25.7 ± 321.2
Escape Reef, Blow River, Ellice Island	13 Sept.	40	0	0	1	0
Herschel Island to Inuvik to Outer Mackenzie Delta	16 Sept.	34,940	4713	39,653	46	11.8 ± 8.3
Barter Island to Komakuk Beach	16 Sept.	3377	272	3649	6	7.4 ± 9.2
All areas surveyed		39,693	5082	44,775	59	11.3 ± 4.1

Table 4. Comparison of age ratios for western arctic snow geese staging on the Alaska and Yukon north slope, and Mackenzie River delta 1973-1976 (Koski 1977b) and 1979-1981 (USFWS 1982, Barry 1982, and this study).

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

[a] Mean percent young ± variance weighted according to flock size of samples.
[b] MD- Mackenzie River Delta; YNS-Yukon North Slope; AK-ANWR, Alaska
[c] Since Paulatuk is a rarely used staging area, no quantitative survey was conducted. Data are estimates made by experienced biologist.

(5) Time survey to occur about 20 days after the first arrival date or 7 to 10 days after the major arrival dates each year, irrespective of calendar date. This timing would increase the likelihood that the survey would coincide with maximum staging population, and would minimize temporal variation of age ratio due to varying survey dates.

(6) Conduct the survey under the following minimum environmental conditions: (1) no snow cover, (2) ceilings greater than 150 m, (3) visibility greater than 16 km, and less than moderate turbulence (as defined by F.A.A.).

(7) Conduct the survey under good lighting conditions (i.e. allowing shutter speeds of 1/500 or 1/1000 second using ASA 400 film). Avoid heavy overcast days, or early morning/late evening hours. Use large format (6x7 cm) cameras with 250 mm telephoto lens whenever possible.

(8) The survey crew should be proficient in estimation of flock sizes, having recently practiced with photographs of known flock size or rice grains on a dark table. The crew should also be familiar with the area.

Normal north slope weather conditions, may preclude meeting all of these criteria, however, as much consistency as possible should be acheived. Most important of all is that an adequate extent of area be sampled in as short as possible a time during the peak of staging. Criteria 1, 5, 6, and 7 should be met or the survey is hardly worth conducting.

Acknowledgements

Thanks are due to the aircraft pilots without whose skilled flying this study could not have been conducted: Donald E. Ross, Bruce Connant, and Walt Audi. Several observers served during the recent years of FWS surveys, including Michael "Jake" Jacobson, Phil Koehl, David Densmore, and Gerald Garner. Darkroom work was patiently accomplished by Pat Young and Sue Schulmeister. Finally, I would like to thank Tom Barry, of the Canadian Wildlife Service, for his continued cooperation in this international survey.

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Appendix

ANWR Progress Report Number FY83-1

Table A-1. Photographic count results used to determine age ratios of snow geese in 1979, Arctic National Wildlife Refuge, Alaska and western Yukon Territory, north slope, 10 and 13 September 1979. (See Spindler 1979 for analysis of data). Specific area included in sample was between the Hulahula River and Kay Point.

Photo I.D. roll & frame	Flock number	Adults	Young	Total geese in sample	% young
10 September					
1-10A	Flock X	590	18	608	3.0
3-15	Flock 10	465	3	468	0.6
3-13	Flock 9	121	1	122	0.8
3-12	Flock 9	201	0	201	0.0
3-1	Flock 6	26	2	28	7.1
4-26	Flock 20	178	0	178	0.0
4-27	Flock 20	177	12	189	6.3
4-28	Flock 21	51	2	53	3.8
4-29	Flock 21	63	3	66	4.8
4-31	Flock 22	90	3	93	3.2
4-32	Flock 22	208	13	221	5.9
4-33	Flock 22	74	0	74	0.0
4-6	Flock 15	168	7	175	4.0
4-3	Flock 14	20	0	20	0.0
4-12	Flock 17	94	4	98	4.1
4-10	Flock 16	99	5	104	4.8
4-5	Flock 15	38	0	38	0.0
4-16	Flock 18	119	1	120	0.8
4-18	Flock 18	195	2	197	1.0
4-11	Flock 17	134	4	138	2.9
13 September					
5-4	Flock 1	300	5	305	1.7
5-6	Flock 2	53	11	64	17.2
5-7	Flock 3	51	29	80	36.3
5-11	Flock 6	184	0	184	0.0
5-14	Flock 7	93	1	94	1.1
5-15	Flock 7	79	0	79	0.0
5-16	Flock 8	404	7	411	1.7

Table A-2. Photographic count results used to assess accuracy of snow goose flock size visual estimates made in 1979, Arctic National Wildlife Refuge, Alaska and western Yukon Territory north slope, 10 and 13 September, 1979. (See Spindler 1979 for analysis of data).

Photo I.D. frame number	Snow geese as counted on photo after survey	Snow geese as estimated visually during survey
6A	533	1200
4A	2175	4000
10A	608	750
12A	748	1100
15A	4675	18,000
17A	2254	4000
19A	451	700
21A	179	150
22A	443	200
23A	2742	4500
25A	1020	600
27A	1690	600
29A	578	450
31A	1139	2500
32A	414	350

Table A-3. Photographic count results used to determine age ratio in 1980. Arctic National Wildlife Refuge, Alaska and western Yukon Territory north slope, 9 September 1980. (See Spindler 1980 for analysis of data). Specific area included in sample was between Demarcation Bay and Herschel Island.

Flock number	Flock size	Photo subsample								Total flock			
		Ad.	Young	Tot.	% Young	Ad.	Young	Tot.	% Young	Ad.	Young	Tot.	% Young
1	13	10	3	13	23.1					10	3	13	23.1
2	1115	410	4	414	2.8					410	4	414	2.8
3	542	60	0	60	0					60	0	60	0
4 A	458	76	2	78	2.6	63	7	70	10.0	139	9	148	6.1
4 B	158	50	5	55	9.1					50	5	55	9.1
5	25	22	3	25	12.0					22	3	25	12.0
6	188[a]	71	0	71	0	150	2	152	1.3	221	2	223	0.9
7 A	No data[b]	51	8	59	13.6					51	8	59	13.6
7 B	No data	46	3	49	6.1					46	3	49	6.1

A Subsample total exceeds total flock size, indicating photographs of flocks (subsamples) overlapped.
B Photographic quality unsuitable for counting.

Table A-4. Count results used to determine age ratios of snow geese in 1981, Arctic National Wildlife Refuge, Alaska, Yukon Territory north slope, and Mackenzie River delta area, N.W.T. 11-24 September, 1981. Specific areas included in samples are given below, all counts (visual) by T. Barry, Canadian Wildlife Service, except for 16 September (Photographic) by Arctic NWR.

Date	Adults	Young	Total geese in sample	% Young
11 September.	Tuktoyaktuk Peninsula, Bathurst Peninsula, South shore of Liverpool Bay. Fog Patches. (Visual).			
	500	0	500	0
	100	0	100	0
	330	18	348	5.2
	100	25	125	20.0
12 September.	Mackenzie Delta--Shallow Bay, Southern Richards Island. Fog on outer delta and coastal region to east and west. (Visual).			
	150	44	194	22.7
	6	10	16	62.5
13 September.	Escape Reef, Blow River, parts of Ellice Island. Snow squalls and fog. (Visual).			
	40	0	40	0
16 September.	Barter Island to Komakuk Beach: windy, tubulent, patchy fog. (Photographic).			
Photo I.D.				
1-18	556	19	575	3.3
2-6	548	26	574	4.5
2-11	170	7	177	4.0
2-21	316	24	340	7.1
2-32	995	59	1054	5.6
3-2	792	137	929	14.7
16 September.	Inuvik to Herschel Island to outer Mackenzie Delta. Blowing snow, fog, winds west-northwest 80 km/h. High turbulence. Migration had begun. (Visual).			
(in 30 flocks)	22,872	0	22,872	0
	500	300	800	37.5
	4	8	12	66.7
	6,500	2,275	8,775	25.9
	1,450	400	1,850	21.6
	4	6	10	60.0
	1,000	300	1,300	23.1

Table A-4. (Continued).

Date	Adults	Young	Total geese in sample	% Young
	115	60	175	34.3
	70	60	130	46.2
	600	550	1,150	47.8
	50	60	110	54.5
	340	60	400	15.0
	53	22	75	29.3
	12	12	24	50.0
	560	240	800	30.0
	40	30	70	42.9
	770	330	1,100	30.0
24 September.	Inuvik to Bathurst Peninsula. Freeze-up of higher lakes. (Visual).			
	150	0	150	0

Table A-5. Summary of photographic count efforts for snow goose age ratio and flock size determination, Arctic National Wildlife Refuge, Alaska, and Yukon Territory north slope.

Year	Frames exposed for total count	Frames usable for total count	Frames exposed for age ratio	Frames usable for age ratio
1979	39	15	118	27
1980	29	7	61	11
1981	47	Not performed (too poor light conditions)	77	6

ANWR Progress Report Number FY83-2

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

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Key words: Whistling Swans, Anatidae, Abundance, Age Composition, Reproduction, Arctic-Beaufort

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

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Abstract: An aerial survey to determine the distribution, abundance, and productivity of whistling swans utilizing coastal wetlands of the Arctic National Wildlife Refuge was conducted on 12 August 1982. Survey methods used were those described by Spindler (1981). Total swan numbers declined by 32% in 1982 compared to 1981, as did the numbers of adults and cygnets (25% and 59% respectively). Swan productivity declined also, although the total number of pairs observed in 1982 was almost identical to the number seen in 1982. Swan numbers on 1 major concentration area remained the same in 1982 as in 1981, while swan numbers on 3 other concentration areas decreased in 1982. Possible reasons for the general decline of swan productivity include inclement spring weather, increased aircraft overflights, or increased human disturbance.

ANWR Progress Report No. FY83-2.

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

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

The objectives of the whistling swan aerial surveys are to determine the distribution, abundance, and productivity of whistling swans utilizing coastal wetlands of the Arctic National Wildlife Refuge.

Methods

The study area included the 4 major swan concentration areas identified by Jacobsen (1979): Canning-Tamayariak River Deltas; Hulahula - Okpilak Delta; Aichilik - Egaksrak - Kongakut Delta; Demarcation Bay. In addition, these concentration areas were expanded in 1981 to include adjacent potential swan habitat. These 4 areas totaled 1075 km^2, and are outlined in Fig. 1. The remainder of the coastal area was sampled in both years. These lower use areas include the Jago River delta and adjacent wetlands as well as the remaining coastline between concentration areas.

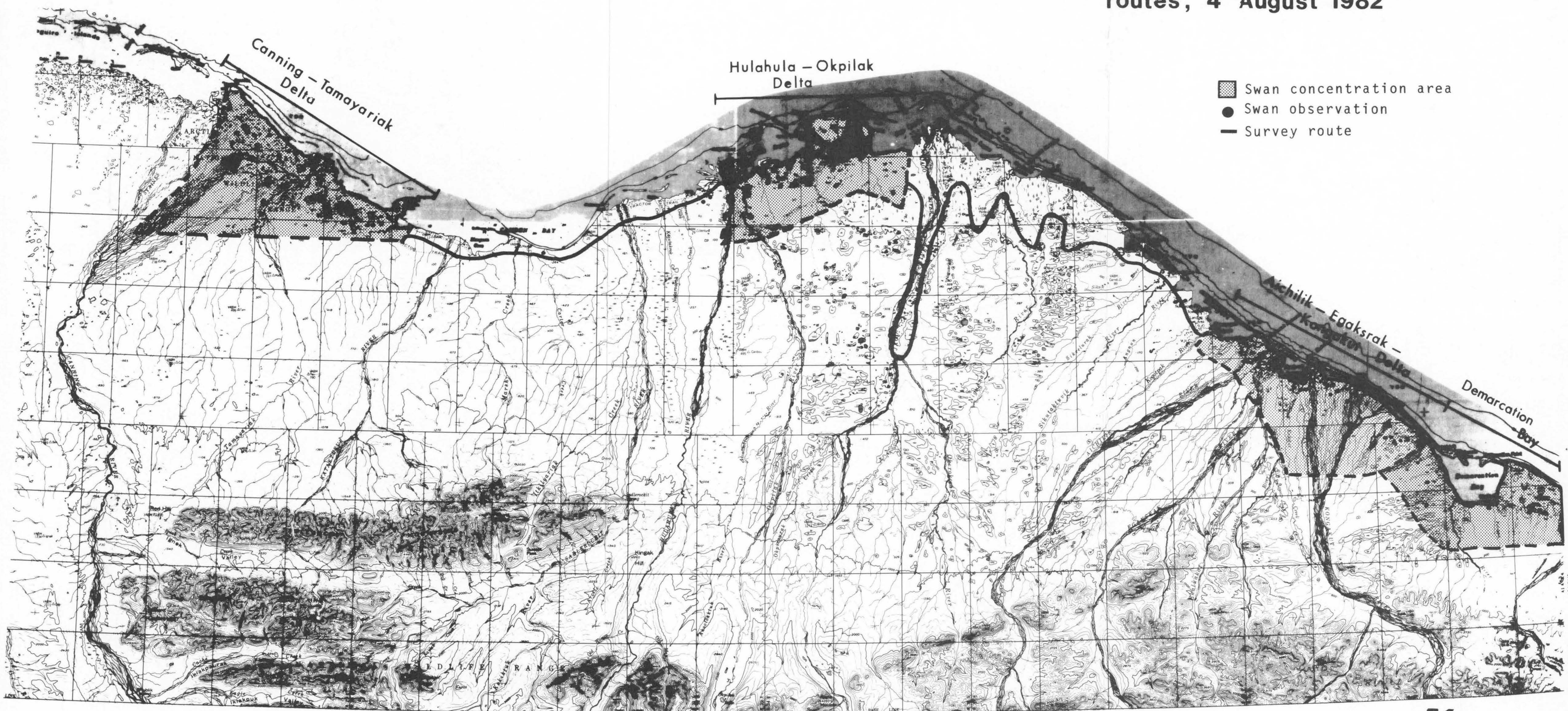
The 1982 survey was conducted on 12 August. An early to mid-August date was used to include non-breeding adult swans. Jacobsen (1979) determined that non-breeders depart the Arctic NWR coastal plain by early September. Prior to the August date, the small size of the cygnets make them difficult to count.

A Cessna 185 wheel plane with 2 observers in addition to pilot was used for this survey. Survey altitude was 366-457 m above-ground-level at an indicated airspeed of 161 kph. A total of 4.5 hours flight time was used to complete the survey. An intensive zig-zag search pattern was flown over the 4 concentration areas. Swans on northern Alaska tundra wetlands are highly visible from fixed-wing aircraft (Bartels 1973). Therefore, it is assumed that this pattern completely censused these areas.

A single linear transect 1.21 km on either side of the aircraft flight line was used to census the intermediate coastal areas not included in concentration areas. The Jago River delta and inland wetlands were sampled with this single transects (Fig. 1).

When swans were sighted, the aircraft circled over them if necessary, to obtain accurate count and location data. All swan locations were plotted on a 1:250,000 U.S.G.S. topographic map. Surface area of all sampled areas was calculated using a grid overlay on the 1:250,000 map.

Fig. 1. Whistling swan survey area and routes, 4 August 1982



Results and Discussion

For the purpose of this report, only data from 1981 and 1982 will be presented. Surveys in previous years did not census comparable areas, therefore comparisons of earlier data with recent data are not possible.

Distribution

The Canning-Tamayariak delta accounted for 186 swans (38% of total observed) in 1981. However, the number of swans declined to 75 birds (23% of total) in 1982. Similarly, the Hulahula-Okpilak delta, Demarcation Bay, and Jago delta all exhibited decreases in swan numbers (Table 1).

The number of swans using the Aichilik-Egaksrak-Kongakut delta remained the same in 1982 as in 1981 (171 swans). However, more adults and fewer cygnets were present. The number of pairs increased by 59% between 1981 and 1982. Yet, the proportion of pairs with young declined from 76% to 21% during the same period (Table 1). As Spindler (1981) suggested, the Aichilik-Egaksrak-Kongakut delta appears to be an important area for non-breeding swans. The observed increase in swan pairs without young could also indicate that this area is important for unsuccessful nesters. Pairs using the area may have either attempted to nest here earlier, or they moved here after nest failure in other locations. Current data do not provide a basis for accurately evaluating these possibilities.

Swans apparently arrive on ANWR from the east, and also depart to the east (Bellrose 1976, Salter et al. 1980). Therefore, unsuccessful nesting pairs may have begun their easterly movement before the normal migration date. On the Canning-Tamayariak delta there were 9 fewer pairs in 1982 than in 1981. Moving east, the Hulahula-Okpilak delta had an increase of 1 pair in 1982 over 1981. The Jago delta held the same number of pairs (only 2) in both years. The Aichilik-Egaksrak-Kongakut delta had an increase of 12 pairs in 1982. Therefore, it is possible that unsuccessful nesting pairs from the Canning-Tamayariak delta may have moved east and contributed to increase at Hulahula-Okpilak and Aichilik areas. The Demarcation Bay area had a decline of 5 pairs. If initially present, these pairs either could have moved east or, shifted westerly, against the trend to the nearby Aichilik-Egaksrak-Kongakut area.

Productivity

Total broods, mean brood size, percent pairs with young, total young, and percent young in population all declined in 1982 from 1981 (Table 1). The total number of pairs observed in 1982 (65) is almost identical to the number seen in 1981 (67). However, it is not possible to determine if these pairs attempted to nest on Arctic National Wildlife Refuge in 1982 and the observed declines in the above parameters were a result of nesting failure. The 1982 decrease in productivity may have been the result of a late spring snow storm on 16 June, which deposited 7.6 cm of snow. Weather data from Barter Island D.E.W. Site indicate a trace of snow in June 1981, while in June 1982, a total of 13.7 cm snowfall was recorded. June is the normal period of egg laying and incubation.

Table 1. Whistling swan population statistics for Arctic National Wildlife Refuge coastal areas, 1981 and 1982.

	Canning-Tamayariak Delta		Hulahula-Okpilak Delta		Aichilik-Kongakut-Egaksrak Delta		Demarcation Bay		Jago Delta and wetlands		Other areas		Total coastal area sampled	
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
Total swans	186	75	80	39	171	171	24	16	12	4	15	25	488	330
Total adults	140	63	67	35	139	157	18	9	8	4	13	20	385	288
Total cygnets	46	12	13	4	32	14	6	7	4	-	2	5	103	42
No. of flocks	10	4	8	3	11	7	1	1	1	-	1	3	32	18
Swans in flocks	77	18	49	14	101	97	6	4	3	-	5	15	241	148
No. of singles	3	3	0	1	2	2	0	3	1	-	2	1	8	10
No. of pairs	30	21	9	10	17	29	6	1	2	2	3	3	67	65
% Paired birds	43	67	27	57	24	37	67	22	50	100	46	20	35	45
% Pairs w/cygnets	57	29	44	20	76	21	33	100	50	-	33	100	57	29
% Young	25	16	16	10	19	8	25	44	33	-	13	20	21	13
No. of broods	17	6	4	2	14	6	2	3	1	-	2	2	40	19
$\bar{x}$ Brood size	2.7	2	3.3	2	2.3	2.3	3.0	2.3	4.0	-	1.0	2.5	2.6	2.2
Cygnets:adult Ratio	1:3.0	1:5.3	1:5.2	1:8.8	1:4.3	1:11.2	1:3.0	1:1.3	1:2.0	-0-	1:6.5	1:5.0	1:3.7	1:6.9
Km^2 sampled	490	490	168	168	259	259	158	158	357	357	171	171	1603	1603
Swans/Km^2	0.38	0.15	0.48	0.23	0.66	0.66	0.15	0.10	0.03	0.01	0.09	0.15	0.30	0.21

During 1982, there appreared to be an increase of air traffic along the coast. This added disturbance, particularly the increase in helicopter traffic, could have contributed to nest abandonment. Barry & Spencer (1976) found that low level flights by helicopters were the most disturbing factor to nesting waterfowl near a drill rig at the Mackenzie Delta, N.W.T. Schmidt (1970) witnessed the desertion of a swan nest near Beaufort Lagoon from a helicopter landing nearby. That increased air traffic may have been a factor causing the major decline in 1982 productivity is merely speculative. No quantitative data exist to substantiate or deny this hypothesis.

Human disturbance is another factor to be considered that may influence nesting whistling swans. In 1982, the Hulahula-Okpilak delta experienced a 50% decline in broods and a 50% decline in total swan numbers from 1981. In addition to weather and increased air traffic, human disturbances may have contributed to this decline in 1982. A biological field crew of a minimum of 6 people spent June and July camped on the Okpilak River delta, where an intensive bird nesting study over large blocks of habitat was conducted. The human presence and associated air support may have contributed to the decline in swan production and numbers in this area.

Population

A total of 188 adults and 42 cygnet whistling swans were observed on the Arctic NWR coastal plain in 1982. These data represent a 25% decrease in adults and a 59% decrease in cygnets over swan use observed in 1981 (Table 1). Total swan numbers in 1982 (330) represented a 32% decline from 1981 (488).

The causes of this decline are undetermined and may be a function of normal variation in whistling swan use on the coastal plain of ANWR. In order to more clearly elucidate productivity of whistling swans, it is recommended that an additional nesting swan survey be conducted in mid-June each year. This additional 5 hour survey flight would provide data to describe nesting efforts, nesting success, and population shifts during the season.

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MIGRATORY BIRD USE OF THE COASTAL LAGOON SYSTEM OF THE BEAUFORT SEA COASTLINE WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1981 and 1982

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Key words: Migratory birds, Oldsquaw, abundance, distribution, Arctic-Beaufort

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Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

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Abstract: Aerial surveys were conducted in 10 selected coastal lagoons of the Arctic National Wildlife Refuge during 1982 to obtain an index of relative numbers of migratory birds using the lagoons and to determine the relationship of data collected in previous years with a modified survey technique. A pilot project was initiated to capture and mark birds to determine patterns of lagoon use by molting and migrating oldsquaw. Oldsquaw were identified as the major species using the lagoons (over 80% of total population). The total number of oldsquaw observed in lagoons was lower in 1982 than in 1981. Although the temporal distribution of oldsquaw observed was similar in both years, the spacial distribution varied. The number of oldsquaw observed in offshore waters showed an unprecedented high in late August 1982 as compared to 1981. Comparison of oldsquaw numbers and density observed in a 400 m strip transect within the lagoon to the whole lagoon area showed that the birds were not randomly distributed and the strip transect can not be used as an index of oldsquaw numbers or density in the entire lagoon.

Migratory bird use of the coastal lagoon system of the Beaufort Sea coastline within the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

The shallow coastal lagoons of the Beaufort Sea are important habitat for molting and staging migratory birds (Bartels 1973, Gollop and Richardson 1974, Ward and Sharp 1974, Harrison 1977, Divoky and Good 1979, Johnson and Richardson 1981). Birds form concentrations in the lagoons during mid-summer molt and pre-migratory staging, especially oldsqauw and phalaropes. Surveys of migratory bird use of the lagoon system on the Arctic National Wildlife Refuge were initiated in 1970 and have continued sporadically to the present (Schmidt 1970, Frickie and Schmidt 1974, Spindler 1978, 1979). Information pertaining to these surveys was summarized in the Initial Report of the Baseline Study (USFWS 1982). Oldsquaw were identified as the major species using the lagoon system and several data gaps concerning the ecology of this species were discussed (USFWS 1982).

Aerial survey techniques were modified and standardized in 1981 and these were continued in 1982. In addition to the aerial surveys, a pilot project was initiated in 1982 to determine the use of coastal lagoons by oldsquaw. The objectives of this study were: 1) obtain an index of relative numbers of migratory birds using the coastal lagoons, especially oldsqauw molting in selected lagoons; 2) determine the relationship between data collected in previous years (400 m strips) with the modified survey (entire lagoon surface); 3) test the feasibility of using marked birds to determine patterns of lagoon use by molting and migrating oldsquaw.

Methods

The study area included the Beaufort Sea coastal portions of Arctic NWR, extending from the Canning River delta on the west to the U.S.-Canadian border on the east. Ten lagoons were selected and repeatedly surveyed in 1981 and 1982. The 10 lagoons were as follows: Demarcation Bay, Egaksrak Lagoon, Nuvagapak Lagoon, Oruktalik Lagoon, Tapkaurak Lagoon, Jago Lagoon, Arey Lagoon, Simpson Cove, Tamayariak Lagoon, and Brownlow Lagoon. The oldsquaw marking test was conducted in Tapkaurak Lagoon. This lagoon was selected due to logistical considerations, molting oldsquaw populations, and suitability for drive trapping.

Lagoons

A Cessna 206 floatplane with 2 observers in addition to the pilot was used to conduct the aerial surveys. The survey was flown at 30 to 46 m above the lagoon surface at an indicated airspeed of 160 kph. Each observer was responsible for identifying and counting all birds within the 200 m wide strip on their respective side of the flight line. Therefore, a 400 m wide strip was surveyed with each pass of the aircraft. Data were recorded on cassette tape recorders so that observers need not divert their attention from the survey area.

The lagoon portion of the survey consisted of 400 m wide strips flown parallel to the barrier islands until the entire lagoon surface area was surveyed. The 400 m strip adjacent to the barrier island was identified and these survey data were recorded separately. Data for the remainder of the lagoon surface were tallied without reference to successive strips. Therefore, it was possible to compare the 400 m strip results with the results of the entire lagoon surface. The offshore transect portion of the survey consisted of a single 400 m strip parallelling and directly seaward of the barrier islands. This transect ran along the entire coastline of ANWR. All birds were identified to species whenever possible. Oldsquaw were readily identifiable and were selected as the key indicator species. Therefore, comparisons between the 400 m strip and the entire lagoon used only oldsquaw data. The surface area of the 400 m strip and the total lagoon were determined using a planimeter on U.S. Coast and Geodetic Survey charts.

Aerial surveys were conducted only if the wind velocities were below 24 kph. Wind velocities above 24 kph produce excessive wave action and oldsquaw and other migratory birds are difficult to observe in these waves. Three surveys of comparable timing in 1981 and 1982 were used for analysis.

Oldsquaw

Field camp equipment and capture equipment was boated to the barrier island of Tapkuarak Lagoon on 31 July 1982. Due to other survey considerations and oldsquaw molt phenology, no attempt was made to capture oldsquaw until 4 August. A drive trap was constructed in a sheltered bay. The trap consisted of 3.6 m aluminum conduit sections pushed into the sandy bottom. Stretched between the poles was 1.8 m wide plastic garden netting with the bottom of the netting being weighted. The design was a single wing and a small catch pen near shore. Later a gill net was added at the center of the net to attempt to entangle flightless oldsquaw as they dove to escape. Three boats were used to drive oldsquaw toward the trap. Captured oldsquaw were fitted with U.S. Fish and Wildlife Service metal leg bands and color coded plastic nasal saddles.

Results and Discussion

The total number of bird taxa observed in 1981 was 32 and 30 in 1982. These species are listed by lagoon and survey in the Appendix. Differences in the number of species observed may be partially a result of different observers. Five different observers were used over the 2 year study.

Lagoons

The total number of oldsquaw observed in the 10 lagoons during the 2 years of aerial surveys show a similar distribution over time (Fig. 1a). The peak number of oldsquaw in 1981 (28,301 oldsquaw) was higher than the 1982 peak (16,986 oldsquaw). This trend is generally reflected in the data from individual lagoons; however, certain lagoons had higher numbers in 1982 than the comparable survey period in 1981 (Table 1). Also, 2 lagoons (Tamayariak and Brownlow) had higher totals in all 3 surveys in 1982 than in 1981.

The offshore 400 m strip survey of the entire coastline exhibited a different picture than lagoons. The peak number of oldsquaw in 1982 occurred later than that of 1981 (Fig. 1b). The 1982 peak (3,867 oldsquaw) also was higher than the 1981 peak (2,868 oldsquaw). This higher peak in 1982 was primarily the result of large numbers of oldsquaw in the offshore transect in late August (Table 2). These data indicate peak populations occurring later in the offshore transect than the coastal lagoons. It is possible that post-molting male oldsquaw may begin moving offshore to feed. To evaluate this hypothesis,

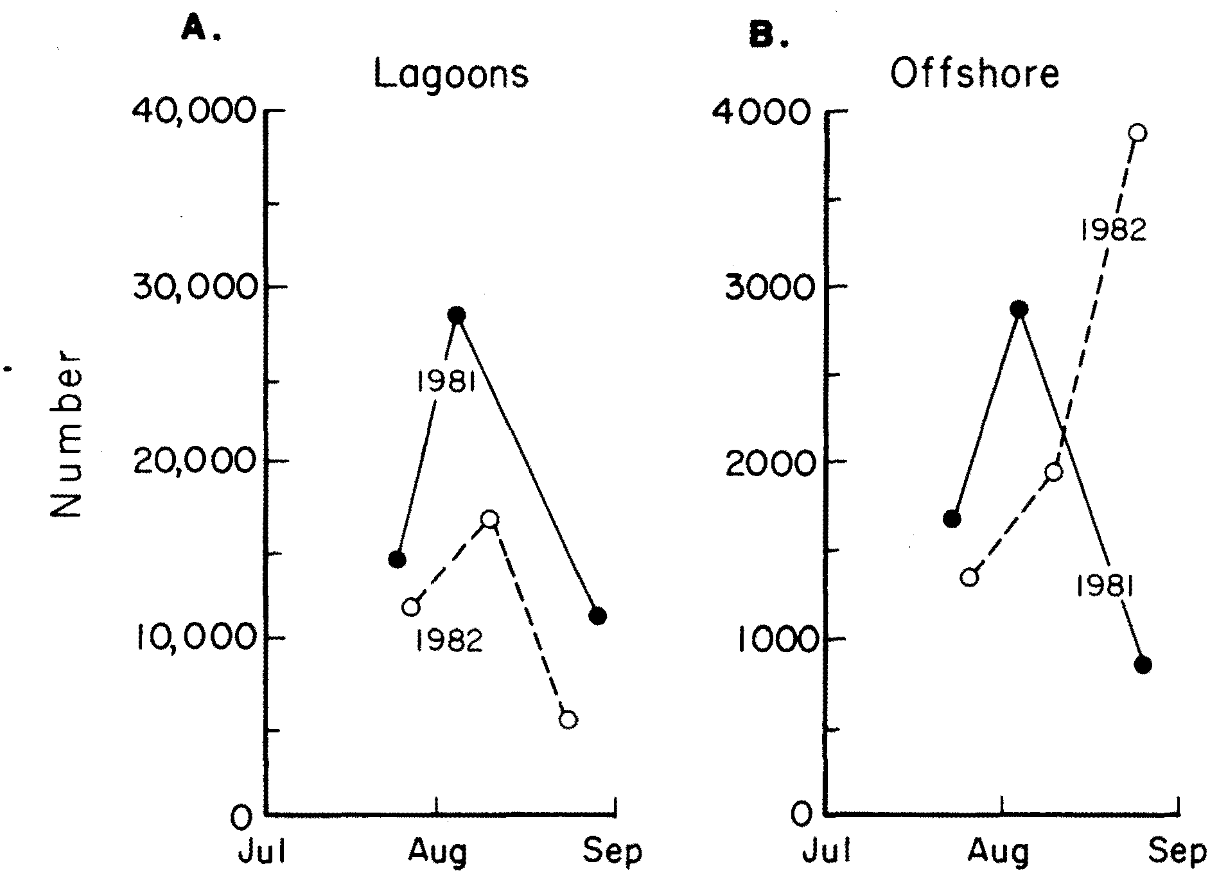

Fig. 1 Number of oldsquaw observed in coastal lagoons and offshore waters of the Beaufort Sea Coastline in the Arctic National Wildlife Refuge, 1981 and 1982.

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

Lagoon	Survey Dates					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Demarcation Bay (38.7 km^2)						
All Species	2865	849	1611	538	1667	1061
Oldsquaw	2678	617	1557	299	1611	919
No. Taxa	13	9	9	9	6	6
Egaksrak Lagoon (14.0 km^2)						
All Species	547	111	441	967	1146	580
Oldsquaw	107	82	355	234	97	61
No. Taxa	15	5	9	5	10	5
Nuvagapak Lagoon (31.2 km^2)						
All Species	1477	146	2486	2845	1060	2286
Oldsquaw	1427	126	2448	2669	1004	1422
No. Taxa	13	5	10	13	5	8
Orktalik Lagoon (8.8 km^2)						
All Species	2032	1704	1714	1958	41	545
Oldsquaw	1997	1657	1698	1906	38	508
No. Taxa	10	3	4	3	3	4
Tapkaurak Lagoon (20.5 km^2)						
All Species	2720	1304	2897	703	2159	85
Oldsquaw	2688	1273	2867	642	2150	71
No. Taxa	6	4	6	6	3	5
Jago Lagoon (47.3 km^2)						
All Species	4131	4189	5895	806	5986	1053
Oldsquaw	3988	3845	5814	650	5674	727
No. Taxa	12	9	8	9	5	8
Arey Lagoon (40.6 km^2)						
All Species	376	306	1319	603	209	456
Oldsquaw	293	274	1016	347	174	352
No. Taxa	12	4	10	9	4	8
Simpson Cove (44.4 km^2)						
All Species	920	3015	9296	4376	317	711
Oldsquaw	850	2906	9187	4326	205	665
No. Taxa	9	6	10	7	7	8
Tamayariak Lagoon (15.9 km^2)						
All Species	174	916	2846	5222	202	337
Oldsquaw	162	625	2606	5202	150	321
No. Taxa	5	7	10	7	6	6
Brownlow Lagoon (13.1 km^2)						
All Species	52	446	744	748	111	238
Oldsquaw	50	415	693	711	95	204
No. Taxa	2	4	5	5	6	6

Table 2. Species and numbers of migratory birds observed in 400 m offshore transects along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Species	Survey Dates					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	1696	1339	2868	1911	824	3867
Black brant	--	--	--	--	--	220
Glaucous gull	52	43	194	57	115	54
Sabine gull	--	--	--	--	--	1
Gull spp.	--	--	--	--	--	4
Blacklegged kittiwake	--	--	1	--	--	--
Arctic tern	8	--	1	1	--	4
Arctic loon	--	6	14	3	2	14
Red-throated loon	4	4	20	--	2	14
Yellow-billed loon	8	--	3	--	--	--
Loon spp.	2	--	23	8	3	14
King eider	--	8	--	--	--	--
Common eider	--	3	4	2	--	1
Eider spp.	122	20	51	17	12	1
Surf scoter	1	311	--	--	--	26
Common scoter	--	4	--	--	--	--
White-winged scoter	20	--	--	--	--	--
Scoter spp.	27	14	4	--	--	--
Pintail	--	--	12	--	--	--
Scaup spp.	1	--	--	2	82	--
Duck spp.	--	84	3	5	--	46
Red breasted merganser	1	--	--	--	--	--
Sandhill crane	--	--	2	--	--	--
Phalarope spp.	--	--	29	7	--	--
Shorebird spp.	--	91	28	24	46	7
Parasitic jaeger	--	--	--	--	--	1
Black guillimot	5	--	--	9	--	--

it would be necessary to conduct offshore surveys that sampled areas from the barrier islands directly out to sea. Another factor that may have influenced the numbers of oldsquaw in the offshore transect is the location of sea ice. In late August 1982, sea ice was densely packed against the barrier islands. This condition is not normal and oldsquaw movements to offshore feeding areas may have been restricted.

Density of migratory birds using the coastal lagoons ranged from a low of 4.0 birds/km^2 in Brownlow Lagoon in 1981 to a high of 328.4 birds/km^2 in Tamayariak Lagoon in 1982 (Table 3). In most instances, oldsquaw comprised over 80% of the birds using the lagoons.

Data for 1981 and 1982 indicate that much spatial variation in numbers and density of oldsquaw occurs during a particular season and also between seasons. This phenomenon was discussed previously for several years of survey data on ANWR (USFWS 1982). It was noted that the peak of molting oldsquaw can vary by up to 2 weeks between years. It is not possible to determine if either the 1981 or 1982 population data reflects the true peak, because a particular survey may or may not correspond to the peak. It is recommended that future efforts include several surveys conducted during the anticipated 2 week peak period of use.

The relative proportions of numbers of oldsquaw observed in the 400 m transect and the total lagoon surface were compared to the respective proportions of the lagoon area in each category (Table 4). Chi square was used to make these comparisons (Conover 1971). In all instances, there was a significant (p 0.0005) difference between the numbers of oldsquaw in the 400 m transect and the entire lagoon. Usually, a disproportionate number of oldsquaw occurred in the 400 m transect than in the entire lagoon (Table 4). These data confirm the hypothesis that oldsquaw are not randomly distributed in lagoons.

The relationship between the number and density of oldsquaw observed in the 400 m strip and corresponding number (Table 5) and density (Table 6) of oldsquaw observed in the total lagoon was examined using regression analysis (Draper and Smith 1966). Comparable survey periods in 1981 and 1982 were combined in this analyses. During most survey periods, the linear relationship between number and density of oldsquaw in the 400 m transect and the entire lagoon was statistically significant as was the associated correlation coefficient (Table 6). This relationship was more definitive for density than it was for numbers of oldsquaw (re. R^2 values in Table 7). However, due to the relatively large amount of variation not accounted for by the fitted regression equations (ranging from 95% to 36%), the predictability of these equations is questionable.

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

Table 3. Density (birds/km^2) of migratory birds observed using 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Lagoon	Survey Dates 22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Demarcation Bay (38.7 km^2)						
All Species	74.0	21.9	41.6	13.9	43.1	27.4
Oldsquaw	69.2	15.9	40.2	7.7	41.6	23.8
% Oldsquaw	93	73	97	56	97	87
Egaksrak Lagoon (14.0 km^2)						
All Species	39.1	7.9	31.5	69.1	81.9	41.4
Oldsquaw	7.6	5.9	25.4	16.7	6.9	4.36
% Oldsquaw	20	74	80	24	8	11
Nuvagapak Lagoon (31.2 km^2)						
All Species	47.3	4.7	79.7	91.2	34.0	73.3
Oldsquaw	45.7	4.0	78.5	85.5	32.2	45.6
% Oldsquaw	97	86	98	94	95	62
Orktalik Lagoon (8.8 km^2)						
All Species	230.9	193.6	194.8	222.5	4.6	61.9
Oldsquaw	226.9	188.3	193.0	216.6	4.3	57.7
% Oldsquaw	98	97	99	97	93	93
Tapkaurak Lagoon (20.5 km^2)						
All Species	132.7	63.6	141.3	34.3	105.3	4.2
Oldsquaw	131.12	62.1	139.9	31.3	104.9	3.5
% Oldsquaw	99	98	99	91	99	84
Jago Lagoon (47.3 km^2)						
All Species	87.3	88.6	124.6	17.0	126.6	22.3
Oldsquaw	84.3	81.3	122.9	13.7	120.0	15.4
% Oldsquaw	97	92	99	81	95	69
Arey Lagoon (40.6 km^2)						
All Species	9.3	7.5	32.5	14.9	5.2	11.2
Oldsquaw	7.2	6.8	25.0	8.6	4.3	8.7
% Oldsquaw	78	90	77	58	83	77
Simpson Cove (44.4 km^2)						
All Species	20.7	67.9	209.4	98.6	7.1	16.0
Oldsquaw	19.4	65.5	206.9	97.4	4.6	15.0
% Oldsquaw	92	96	99	99	65	94
Tamayariak Lagoon (15.9 km^2)						
All Species	10.9	57.6	179.0	328.4	12.7	21.2
Oldsquaw	10.2	39.3	163.9	327.2	9.4	20.2
% Oldsquaw	93	68	92	99	74	95
Brownlow Lagoon (13.1 km^2)						
All Species	4.0	34.1	56.8	57.1	8.5	18.2
Oldsquaw	3.8	31.7	52.9	54.3	7.3	15.6
% Oldsquaw	96	93	93	95	86	86

Table 4. Area of 400 m survey strip and entire lagoons, Arctic National Wildlife Refuge.

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

Table 5. Number of Oldsquaw observed in 400 m strip and total area of coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge Alaska, 1981 and 1982.

Lagoon	Survey Dates 22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Demarcation Bay						
Total Lagoon	2678	617	1557	299	1611	919
400 m Strip	1272	232	726	67	864	447
Egaksrak Lagoon						
Total Lagoon	107	82	355	234	97	61
400 m Strip	101	62	299	34	56	35
Nuvagapak Lagoon						
Total Lagoon	1427	126	2448	2669	1004	1422
400 m Strip	494	6	435	941	586	498
Oruktalik Lagoon						
Total Lagoon	1997	1657	1698	1906	38	508
400 m Strip	1828	840	517	1090	9	88
Tapkaurak Lagoon						
Total Lagoon	2688	1273	2867	642	2150	71
400 m Strip	2149	521	1082	572	97	25
Jago Lagoon						
Total Lagoon	3988	3845	5184	650	5674	727
400 m Strip	615	661	585	189	484	73
Arey Lagoon						
Total Lagoon	293	274	1076	347	174	352
400 m Strip	267	180	461	26	97	223
Simpson Cove						
Total Lagoon	850	2906	9187	4326	205	665
400 m Strip	180	725	1164	1952	47	310
Tamayariak Lagoon						
Total Lagoon	162	625	2606	5202	150	321
400 m Strip	78	210	860	4647	31	120
Brownlow Lagoon						
Total Lagoon	50	415	693	711	95	204
400 m Strip	50	415	690	705	94	204
Total						
Total Lagoon	14240	11820	28301	16986	11198	5250
400 m Strip	7034	3852	6819	10223	2365	2023

Table 6. Density (birds/km^2) of oldsquaw observed in 400 m strip and total area of coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Lagoon	Survey Dates					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Demarcation Bay						
Total Lagoon	38.6	15.9	73.1	7.7	41.6	23.7
400 m Strip	636.0	116.0	363.0	33.5	432.0	223.7
Egaksrak Lagoon						
Total Lagoon	7.6	5.9	25.4	16.7	6.9	4.4
400 m Strip	37.4	22.9	110.7	12.7	20.7	13.0
Nuvagapak Lagoon						
Total Lagoon	45.7	4.0	78.5	85.5	32.2	45.6
400 m Strip	83.7	1.0	73.7	159.4	99.3	84.4
Oruktalik Lagoon						
Total Lagoon	226.9	188.0	193.0	216.6	4.3	57.7
400 m Strip	823.4	381.0	235.0	495.4	4.0	40.0
Tapkaurak Lagoon						
Total Lagoon	131.1	62.1	139.8	31.3	105.0	3.5
400 m Strip	499.8	121.1	251.6	133.0	22.5	5.8
Jago Lagoon						
Total Lagoon	84.3	81.2	122.9	13.7	120.0	15.4
400 m Strip	113.9	122.4	108.3	35.0	89.6	13.5
Arey Lagoon						
Total Lagoon	7.2	6.7	26.5	8.5	4.3	8.7
400 m Strip	49.4	33.3	85.4	4.8	18.0	41.3
Simpson Cove						
Total Lagoon	19.1	65.4	206.7	97.4	4.6	15.0
400 m Strip	26.7	108.2	173.7	291.3	7.0	46.3
Tamayariak Lagoon						
Total Lagoon	10.2	39.3	163.9	327.2	9.4	20.2
400 m Strip	10.4	28.0	114.7	619.6	4.1	16.0
Brownlow Lagoon						
Total Lagoon	3.8	31.6	52.9	54.3	7.3	32.9
400 m Strip	8.1	66.9	111.2	113.7	15.2	32.9
Total						
Total Lagoon	51.9	43.1	103.1	61.9	40.8	19.1
400 m Strip	145.6	79.8	141.2	211.7	49.0	41.9

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

Survey period	Variable	R^2	Fitted regression equation	Observed significance level	Correlation coeffiecent	Observed significant level
23 July 1981 and 25-26 July 1982	Numbers	0.41	= 540.98 + 1.4X	0.01	0.64	0.01
3-4 Aug. 1981 and 7 & 13 Aug. 1982	Numbers	0.29	= 1210.33 + 1.2X	0.05	0.54	0.05
24 & 26 Aug. 1981 and 22 Aug. 1982	Numbers	0.26	= 210.27 + 2.8X	0.05	0.51	NS
23 July 1981 and 25-26 July 1982	Density	0.61	= 19.10 + 0.21X	0.0001	0.78	0.01
3-4 Aug. 1981 and 7 & 13 Aug. 1982	Density	0.64	= 21.28 + 0.43X	0.0001	0.80	0.01
24 & 26 Aug. 1981	Density	0.05	= 23.84 + 0.07X	NS	0.23	NS

Oldsquaw

Nine attempts were made to drive oldsquaw into the traps. These efforts resulted in the capture of 3 oldsquaw. These birds were fitted with leg bands and red nasal saddles. Marked birds were not subsequently observed. There are few publications describing capture technique for sea ducks, such as oldsquaw (Alison 1975). Oldsquaw proved to be a most difficult duck to drive into a trap. They are extremely adept at diving under nets, drive boats, or even swimming over trap nets. Future efforts will include attempts to capture oldsquaw using a mist net drive trap as described by Alison (1975). It appears that it may be difficult to capture large enough numbers of molting oldsquaw to make color marking and re-observation practical. Therefore, it may be more practical to capture a small number of oldsquaw in several lagoons and install short-lived radio transmitters. A single aircraft flight over the lagoon system should relocate these birds.

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APPENDIX

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Table A-1. Migratory bird species and numbers observed during aerial surveys of 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Species	Demarcation Bay					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	2678	617	1557	299	1611	919
Black brant						
Glaucous gull	8	7	5	155	11	40
Sabine gull						
Gull spp.						
Arctic tern	1					
Arctic loon	3	3	1			
Red-throated loon	3	1	1			5
Yellow-billed loon	1					
Loon spp.	1	3	2		4	
King eider				1		
Common eider				13		
Eider spp.	3		11	9		
Surf scoter	4	165		38		69
Common scoter		15				
White-winged scoter				8		
Black scoter						
Scoter spp.	137	30	29		1	24
Pintail						
Greater scaup						
Scaup spp.	16		1			
Duck spp.	5	8				4
Red breasted merganser					5	
Canada goose						
Sandhill crane						
Whistling swan			2			
Northern phalarope					35	
Phalarope spp.				7		
Shorebird spp.	5					
Ruddy turnstone						
Plover spp.						
Parasitic jaeger						
Pomerane jaeger						
Jaeger spp.						
Black guillimot						
Tufted puffin						
Common murre						
Snowy owl						

Table A-2. Migratory bird species and numbers observed during aerial surveys of 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Species	Egaksrak Lagoon					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	107	82	355	234	97	61
Black brant			3	708	350	505
Glaucous gull	8	14	10	12	17	
Sabine gull						
Gull spp.						
Arctic tern	2			1		
Arctic loon	1					1
Red-throated loon	1	1			3	
Yellow-billed loon						
Loon spp.	1		1		3	9
King eider		10				
Common eider	10	4				
Eider spp.						
Surf scoter						
Common scoter						
White-winged scoter						
Black scoter						
Scoter spp.						
Pintail	19				4	
Greater scaup						
Scaup spp.			1		10	
Duck spp.	18					
Red breasted merganser	3					
Canada goose						
Sandhill crane						
Whistling swan	55		14		11	4
Northern phalarope			15			
Phalarope spp.			40	12		
Shorebird spp.	321		2		210	
Ruddy turnstone						
Plover spp.						
Parasitic jaeger						
Pomerane jaeger						
Jaeger spp.						
Black guillimot						
Tufted puffin						
Common murre						
Snowy owl	1					

Table A-3. Migratory bird species and numbers observed during aerial surveys of 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Species	Nuvagapak Lagoon					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	1427	126	2448	2669	1004	1422
Black brant				60		810
Glaucous gull	14	8	14	25	29	17
Sabine gull						
Gull spp.						
Arctic tern	1			1		
Arctic loon	5			1		5
Red-throated loon	1		1	4		1
Yellow-billed loon	1		1	1		
Loon spp.	1		5	3	1	1
King eider						
Common eider						
Eider spp.		6		10		
Surf scoter						
Common scoter						
White-winged scoter						
Black scoter						
Scoter spp.	4					10
Pintail					25	
Greater scaup						
Scaup spp.						
Duck spp.	4		8	5	1	
Red breasted merganser	13			15		
Canada goose						
Sandhill crane	2					
Whistling swan	2	5	3			
Northern phalarope			2			
Phalarope spp.			3	50		
Shorebird spp.	2		1			20
Ruddy turnstone						
Plover spp.						
Parasitic jaeger						
Pomerane jaeger						
Jaeger spp.				1		
Black guillimot						
Tufted puffin						
Common murre						
Snowy owl						

Table A-4. Migratory bird species and numbers observed during aerial surveys of 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Species	Oruktalik Lagoon					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	1997	1657	1698	1906	38	508
Black brant						6
Glaucous gull	21	22	11	49		29
Sabine gull						
Gull spp.						
Arctic tern	1				1	
Arctic loon	2					
Red-throated loon						
Yellow-billed loon	1					
Loon spp.	3			3	2	
King eider						
Common eider						
Eider spp.	1					
Surf scoter						
Common scoter						
White-winged scoter						
Black scoter						
Scoter spp.	1					
Pintail	3					
Greater scaup						
Scaup spp.						
Duck spp.						2
Red breasted merganser						
Canada goose						
Sandhill crane						
Whistling swan						
Northern phalarope			4			
Phalarope spp.			1			
Shorebird spp.	2	25				
Ruddy turnstone						
Plover spp.						
Parasitic jaeger						
Pomerane jaeger						
Jaeger spp.						
Black guillimot						
Tufted puffin						
Common murre						
Snowy owl						

Table A-5. Migratory bird species and numbers observed during aerial surveys of 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Species	Tapkaurak Lagoon 22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	2688	1237	2867	642	2150	71
Black brant						
Glaucous gull	21	21	5	8	3	6
Sabine gull						
Gull spp.						
Arctic tern						
Arctic loon		1	1			
Red-throated loon				2		
Yellow-billed loon	1					
Loon spp.	1	9	2			3
King eider				1		
Common eider						
Eider spp.						
Surf scoter						
Common scoter						
White-winged scoter						
Black scoter						
Scoter spp.	6		2	20		
Pintail	3				6	
Greater scaup						
Scaup spp.						
Duck spp.				30		3
Red breasted merganser						
Canada goose						
Sandhill crane						
Whistling swan						
Northern phalarope			20			
Phalarope spp.						
Shorebird spp.						
Ruddy turnstone						
Plover spp.						
Parasitic jaeger						
Pomerane jaeger						
Jaeger spp.						
Black guillimot						
Tufted puffin						2
Common murre						
Snowy owl						

Table A-6. Migratory bird species and numbers observed during aerial surveys of 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Species	Jago Lagoon					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	3988	3845	5814	650	5674	727
Black brant						
Glaucous gull	68	170	36	126	304	251
Sabine gull						
Gull spp.						
Arctic tern	4		3		1	
Arctic loon	2					
Red-throated loon		2		2		2
Yellow-billed loon			5			
Loon spp.	1	7	5	2		
King eider		5		1		1
Common eider						
Eider spp.			11			
Surf scoter	30	111	5		5	32
Common scoter				11		3
White-winged scoter						
Black scoter						
Scoter spp.			16	6		
Pintail	3					
Greater scaup		46				
Scaup spp.						
Duck spp.		2		6		
Red breasted merganser		1				
Canada goose						
Sandhill crane						
Whistling swan						
Northern phalarope						
Phalarope spp.	1					
Shorebird spp.	33			2	2	34
Ruddy turnstone						
Plover spp.						
Parasitic jaeger						
Pomerane jaeger						
Jaeger spp.	1					
Black guillimot						3
Tufted puffin						
Common murre						
Snowy owl						

Table A-7. Migratory bird species and numbers observed during aerial surveys of 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Species	Arey Lagoon					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	293	274	1016	347	174	352
Black brant						76
Glaucous gull	25	22	75	149	32	6
Sabine gull						
Gull spp.						
Arctic tern	4			3		
Arctic loon	1	3	7			3
Red-throated loon	2		5			2
Yellow-billed loon						
Loon spp.	1	7	3	1	1	2
King eider						
Common eider				4		
Eider spp.			14	40		
Surf scoter						
Common scoter						
White-winged scoter						
Black scoter						
Scoter spp.			50			11
Pintail			47		2	
Greater scaup						
Scaup spp.						
Duck spp.						4
Red breasted merganser						
Canada goose						
Sandhill crane						
Whistling swan				7		
Northern phalarope						
Phalarope spp.			100	4		
Shorebird spp.	46			48		
Ruddy turnstone			2			
Plover spp.	1					
Parasitic jaeger						
Pomerane jaeger						
Jaeger spp.						
Black guillimot						
Tufted puffin						
Common murre						
Snowy owl	1					

Table A-8. Migratory bird species and numbers observed during aerial surveys of 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Species	Simpson Cove					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	850	2906	9187	4326	205	665
Black brant					10	15
Glaucous gull	15	46	43	25	32	26
Sabine gull						
Gull spp.						
Arctic tern						
Arctic loon			10	1		1
Red-throated loon	1		11			
Yellow-billed loon						1
Loon spp.			1		5	2
King eider						
Common eider						
Eider spp.	25	9	12	12	10	
Surf scoter			7			
Common scoter		40				
White-winged scoter						
Black scoter						
Scoter spp.	12					
Pintail	10					
Greater scaup						
Scaup spp.						
Duck spp.	3	6	4			
Red breasted merganser	1					
Canada goose						
Sandhill crane						
Whistling swan				2		1
Northern phalarope						
Phalarope spp.	3		1	2		
Shorebird spp.		8	20		55	
Ruddy turnstone						
Plover spp.						
Parasitic jaeger				1		
Pomerane jaeger						
Jaeger spp.						
Black guillimot						
Tufted puffin						
Common murre						
Snowy owl						

Table A-9. Migratory bird species and numbers observed during aerial surveys of 10 coastal lagoons along the Beaufort Sea coastline in the Arctic National Wildlife Refuge, Alaska, 1981 and 1982.

Species	Tamayariak Lagoon					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	162	625	2606	5202	150	321
Black brant	9		29		9	4
Glaucous gull		12		5		8
Sabine gull		2				
Gull spp.						
Arctic tern			3	1		
Arctic loon	1				1	1
Red-throated loon				1	3	2
Yellow-billed loon			2			
Loon spp.						1
King eider		3				
Common eider						
Eider spp.	1		81	1	1	
Surf scoter		269				
Common scoter						
White-winged scoter						
Black scoter						
Scoter spp.						
Pintail			4		1	
Greater scaup						
Scaup spp.						
Duck spp.		4	80			
Red breasted merganser		1				
Canada goose						
Sandhill crane						
Whistling swan						
Northern phalarope						
Phalarope spp.			38			
Shorebird spp.			3	11	40	
Ruddy turnstone						
Plover spp.						
Parasitic jaeger						
Pomerane jaeger						
Jaeger spp.						
Black guillimot				1		
Tufted puffin						
Common murre						
Snowy owl						

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

Species	Brownlow Lagoon					
	22-23 July 1981	25-26 July 1982	3-4 Aug. 1981	7&13 Aug. 1982	24-26 Aug. 1981	22 Aug. 1982
Oldsquaw	50	415	693	711	95	204
Black brant						21
Glaucous gull	2	21	8	3	6	2
Sabine gull						
Gull spp.						
Arctic tern						
Arctic loon		2	1	5	2	
Red-throated loon			1		1	
Yellow-billed loon					2	
Loon spp.					5	2
King eider						
Common eider						
Eider spp.			38			
Surf scoter						
Common scoter						
White-winged scoter						
Black scoter						
Scoter spp.						
Pintail						
Greater scaup						
Scaup spp.						
Duck spp.		8				8
Red breasted merganser			2			
Canada goose						
Sandhill crane						
Whistling swan						
Northern phalarope						
Phalarope spp.						
Shorebird spp.				25		
Ruddy turnstone						
Plover spp.						
Parasitic jaeger						
Pomerane jaeger						
Jaeger spp.						
Black guillimot				4		
Tufted puffin						
Common murre						
Snowy owl						

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DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF FALL STAGING LESSER SNOW GEESE ON COASTAL HABITATS OF NORTHEAST ALASKA AND NORTHWEST CANADA, 1982

Michael A. Spindler

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

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9 December 1982

Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1982.

Michael A. Spindler. U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge, Fairbanks, Alaska.

Abstract: Fall staging of the western arctic lesser snow goose population was monitored on the coastal plain of the Arctic National Wildlife Refuge (ANWR), Yukon Territory and the Mackenzie River delta from 7 August to 22 September 1982. The onset of staging in 1982 was earlier than usual, but major arrivals were normal, occurring 24-26 August. The duration of the staging period (20 days) was the second longest observed since 1971. A gradual buildup in numbers occurred through late August and early September with 30-40,000 birds estimated using the ANWR coastal plain at that time. Peak snow goose numbers were estimated on 14-15 September at 107,072 ± 13,866 in Alaska; 117,892 ± 15,279 in Yukon, and 6155 in the Mackenzie delta, for a total western arctic population estimate of 231,119 ± 29,242. Estimated productivity was low, at 4.6% young. Spatial variation in productivity was observed, with concentrations of higher productivity occurring in Alaska as compared to farther east, a pattern opposite to that observed in 1981. Medium telephoto lenses with a large-format 60 x 70 mm camera and ASA 400 film on cloudy days and a 35 mm camera and ASA 50 fine-grain film on sunny days produced the best photos for counting geese.

Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1982.

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 eleventh year since surveys were initiated in 1971 by L.G.L., Inc. (Schweinsburg 1974). The 1982 surveys represented the fifth year of survey by refuge staff, and the fourth year of photographic age ratio sampling using methods standardized in preceeding years (Spindler 1980, 1982). Objectives of the study were to: (1) determine the choronology of migration and staging, (2) estimate the peak numbers of snow geese present during staging, (3) determine distribution and age ratios and (4) identify habitat areas and types used consistently. Emphasis was added in 1982 to more frequently monitor temporal and spatial changes in distribution of snow geese within the arctic coastal plain study area of ANWR.

Methods and Materials

Sampling procedures employed a predetermined 9.7 km-spaced grid of 2.4 km wide north-south aerial transects (Koski 1977b, Spindler 1982). All transects were flown with a Cessna-185 aircraft flying about 150 m above ground level (AGL) at an airspeed of 200 kph. Methods of recording and avoidance of double counting were as described in Spindler (1982); however, crew size and function, and photographic methods changed slightly. A crew of 3 persons (2 photographers and 1 recorder) plus pilot was necessary to simultaneously obtain adequate photos and records. All persons, including the pilot helped find flocks. The primary photograher sitting in the right front seat then photographed the total flock at a distance for a flock size estimate. At this time the primary photographer, backup photographer and recorder all made independent estimates of flock size, and then came to an agreement as to which estimate would be recorded (usually all estimates agreed to within 10%). The pilot circled closer and age ratio photographs were then taken. Care was taken to not circle a flock more than once to avoid excessive disturbances to the geese.

A Mamyia RB-67 60 x 70 mm large format SLR camera was primarily used for the photography, in combination with a 250 mm telephoto lens and ASA 400 TRI-X PAN film. Secondarily, a 35 mm Pentax SLR with 135 mm telephoto lens and ASA 50 H&W VTE PAN (Ferguson and Gilmer 1980) was used. Pilot, photographers, and recorder used headsets interconnected through an aircraft intercom to facilitate coordination of photography, airplane movements, and record keeping.

In addition to the systematic procedures used for the main 14-15 September survey, several reconnaissance flights were made over the ANWR coastal plain study area to provide more complete information on arrival, build up, and emigration of snow geese. Both Cessna-185 and 207 aircraft were used in the reconnaissance, which followed a varying survey route, usually dependent on weather conditions and available daylight.

Photographs were enlarged so that each snow goose flock occupied a 20 x 25 cm sheet of photographic paper. Geese were counted with the aid of a light table. Calculation of the mean age ratio weighted according to flock size was allowable because no correlation was found between percent young and total flock size (r^2= -0.152). Calculation of weighted mean and its variance weighted by flock size was according to the formulae recommended by S.J. Harbo (pers. comm.):

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

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

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

Age ratio in various groups was compared with F test and students-t (Steel and Torrie 1960). Estimation of flock size and actual photo count comparisons were done using paired-t and linear regression (Steel and Torrie 1960). Confidence limits were determined for regression-adjusted estimates (Draper and Smith 1966).

Results and Discussion

Staging Chronology and Numbers

Snow geese were first observed on the coastal plain in mid-June; flocks were seen 14, 18, 24, 25 June and 12 July 1982. In previous years occasional small migratory or loafing flocks varying in size from 4-50 birds were typically observed on the coastal plain in early summer (USFWS 1982:121). Large flocks were not usually observed until late summer when staging birds depart the Canadian nesting colonies near the Mackenzie River delta and on Banks Island, frequently flying as far east as Barter Island before remaining to rest and feed. Onset of staging was earlier than usual, with the arrival of 7 birds on the Jago River delta on 7 August 1982 (G. Zemansky, pers. comm.). Date of major arrival was normal, occurring 24-26 August 1982 (Table 1, Fig. 1). On 24 August 890 birds were seen incidentally during large mammal telemetry surveys near the upper Okerokovik River, and middle Nigunak and Jago Rivers (Table 1). Estimated numbers increased to approximately 9000 birds by 26 August, when all geese observed were within 8 km of the coast, the majority between the Nigunak River delta and the Kongakut River delta, with the exception of a sizeable flock (2000+) also seen that day 3.2 km south of Camden Bay.

The period of maximum staging use was taken 26 August and 16 September 1982 (Table 2). These data indicate that 30-40,000 snow geese were present on the coastal plain of the refuge between 26 August and 3 September. On 3 and 4 September the influx of snow geese westward into ANWR continued as several large flocks were observed flying west past the Kongakut River (T. Kerasote, pers. comm.) Dense fog shrouded the coastal plain between 3 and 13 September and prevented survey flights to document the final build-up to peak snow goose numbers. On 14 September, a partial grid survey of the ANWR coastal plain was conducted. Patchy fog and low ceilings restricted this survey to a wide area

Table 1. 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 1978-1982. The 1978-1982 data are from Arctic National Wildlife Refuge only.

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.

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 survey period includes 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 (1979)

j Spindler (1980)

k Spindler (1982)

l This report.

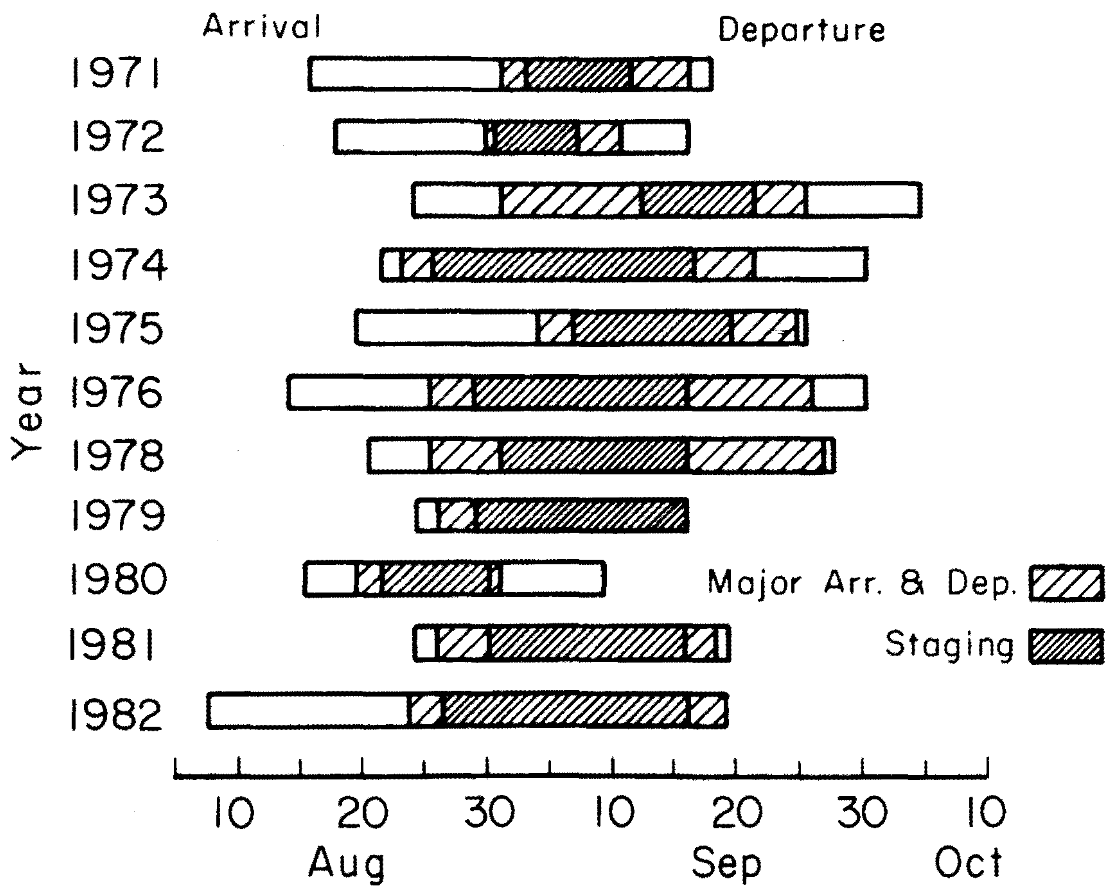

Fig. 1. Chronology of arrival, staging and departure of the western arctic population of lesser snow geese using the coastal plain of the Arctic National Wildlife Refuge, Alaska, the Yukon Territory north slope and the Mackenzie River delta, N.W.T.

reconnaissance covering about 85% of the coastal plain east of the Hulahula River, and 25% of the coastal plain west of the Hulahula River. An estimated 20% of the overall area where geese could have been seen was not covered. A total of 102,000 snow geese was estimated during this survey (which excluded parts of the coastal plain within 6-8 km of the coastline and terrain with elevations greater than the 460 m ceiling).

The survey was continued into Canada on 15 September when the weather cleared and the grid was completed as originally planned from Komakuk Beach to the Mackenzie River. An estimated total of 111,975 snow geese was seen on the Yukon Territory coastal plain portion of the staging area (Table 2). Nearly continuous east winds from mid-August to mid-September 1982 in the northwest Canadian Arctic (T. W. Barry, pers. comm.) and on ANWR (N.O.A.A. records from Barter Island) could have contributed to the extent and duration of westward movement by geese in 1982.

On 15 September several flocks of snow geese totalling about 1000 birds were seen migrating east between Komakuk Beach and the Babbage River during the aerial grid survey in the Yukon. Similar numbers of snow geese were observed migrating east past Demarcation Bay on the same date (S.R. Johnson and D. Herter, pers. comm.). Eastward migration was apparently beginning, and calm winds between the evening of 14 September until the morning of 16 September may have contributed to this onset of migration.

The staging period ended at mid-day on 16 September when westerly winds increased to about 32 kph. A heavy first snow (6-8 cm) fell on the coastal plain between 16 and 18 September. Several flocks of snow geese totalling 400 on 17 September and totalling 1400 on 18 September were seen flying to the southeast, up the Aichilik River valley where it departs the mountains (R. Glesne, E. Nelson, and J. Akaran, pers. comm.). These observations suggest that major departure started on or about 16 September and ended sometime before 21 September, when no snow geese were seen on the ANWR coastal plain (Table 2, Fig. 1).

Distribution of Staging

In late August distribution of snow geese on the ANWR coastal plain was initially restricted to mid-coastal plain portions of the Jago, Okerokovik, Niguanak, Aichilik, and Egaksrak Rivers (Fig. 2). Two days later the size of area occupied by snow geese had not changed significantly, but the Aichilik-Egaksrak concentration moved coastward 8 km, and the Jago-Niguanak concentration split, 1 west of the Jago, the other in the upper-middle third of the Okerokovik and Niguanak River drainages. Major distributional changes occurred between 31 August and 3-5 September: a separate large concentration was established in the upper coastal plain third of the Akutoktak and Okpilak Rivers; the Jago-Okerokovik-Niguanak concentration expanded by moving northward to Niguanak Ridge, and southeastward almost to the Aichilik River (Fig. 2). The separate Aichilik-Egaksrak group had apparently coalesced into another group. The most extensive distribution was observed on 14 September, when a large concentration occurred between the Hulahula and Egaksrak River occupying a majority of the coastal plain between the foothills and 11 km inland (Fig. 2). Another large concentration was located south of Demarcation Bay.

Table 2. Results of aerial snow goose surveys and incidental observations taken during other aerial surveys, coastal plain of the Arctic National Wildlife Refuge, Alaska, Yukon north slope, and Mackenzie River delta August - September 1982.

Date	Alaska Daylight Time	Flight time	Survey type	Estimated numbers seen[a]	Observers
24 August	12:45-17:30	N/A	Incidental obs.	890	L. Martin and J. Koschak
26 August	06:40-17:00	N/A	Incidental obs.	8800	L. Martin, J Koschak, R. Bartels
29 August	16:00-19:00	3.0 hrs.	Reconnaissance for distribution and photographs for age ratio	30,985	L. Martin, M. Spindler, P. Miller
31 August	15:00-16:22	1.3 hrs.	Reconnaissance for distribution	38,515	L Martin, G. Garner
1 September	20:00	N/A	Incidental obs.	20,000	W. Audi
3 September	17:30-18:19	1.3 hrs.	Reconnaissance for distribution	34,250	L. Martin, J. Koschak,
5 September	14:30-18:40	N/A	Incidental obs.	9,830	L. Martin, J. Koschak, P. Miller
9 September	N.D.	N.D.	Bathurst Penninsula distribution and age ratio	4,705	T.W. Barry
10 September	N.D.	N.D.	Mackenzie delta west to Tent Island distribution and age ratio	1,460	T.W. Barry
14 September	13:45-17:50 18:26-19:20	5.0	ANWR distribution and photographs for age ratio	101,684	L. Martin, M. Spindler, P. Miller M. Spindler, P. Miller, L. Aucoin
15 September	09:55-13:45 15:15-13:45	7.5	Yukon Terr. north slope east to Tent Island distribution grid and photographs for age ratio	111,975	L. Martin, M. Spindler, P. Miller
21 September	N.D.	2.6	Reconnaissance for distribution	0	L. Martin, J. Koschak
22 September	N.D.	1.9	Reconnaissance for distribution	0	L. Martin, J. Koschak

[a]Numbers based on visual estimates.

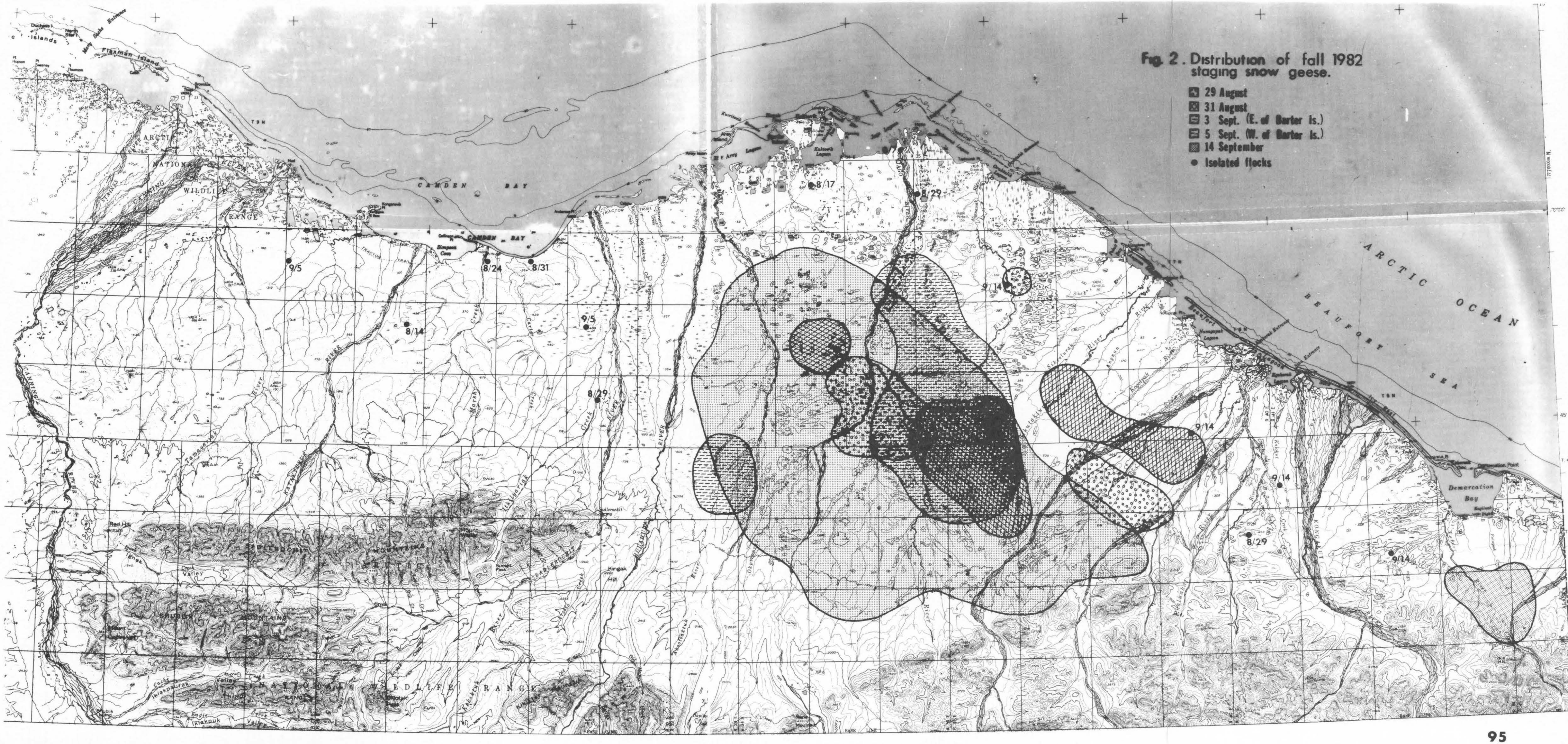

Fig. 2. Distribution of fall 1982 staging snow geese.

The Yukon north slope survey was planned to coincide with peak numbers and distribution on the Alaska staging grounds. Major concentrations of geese were seen in 6 locations: just south of the Buckland Hills west of the Firth River; on the mainland just south of Herschel Island; where the Crow and Trail Rivers leave the foothills; north of Hidden Lake and east of Ladas Creek; south of Shingle Point near the lower Walking and Blow Rivers; and south of Whitefish Station near Rapid Creek (Fig. 3). When compared to the Alaska side of the staging ground, the Yukon north slope had larger flocks (several of 7-10,000 birds) which were more widely dispersed (Fig. 4). The relative proportion of area used by staging snow geese appeared similar in the Alaska and Yukon portons of the staging area, even though concentrations in Yukon were more widely separated (Fig. 4).

Productivity

Age ratio sampling coverage was greater than previous years, largely due to 2 days of favorable weather near the end of the peak staging period. A total of 196 frames of 35 mm and 60 mm film were exposed, 82 were printed, and 33 were usable for age ratio determinations. A total sample of 15,803 geese representing 49,092 estimated geese was included in the photographic sample. The overall mean age ratio was $4.6 \pm 0.7\%$ young, which represents a decline since 1981, but is greater than both the 1979 and 1980 photo estimates (Table 3). During 1981 and 1982, photo estimation has covered the majority of the traditional staging grounds. The 1982 estimate is considered more representative than the 1981 estimate since the 1981 survey missed a large segment of the populaton that staged in and migrated through an unusual route east of Paulatuk, N.W.T., where no sampling was planned or accomplished (Spindler 1981). In 1982 extensive concurrent surveys were flown east of the Mackenzie River to Paulatuk and no birds were found (T.W. Barry unpubl. data). Therefore, it is unlikely that a large segment of the population was missed in 1982 as it was in 1981.

Spatial variation in age ratio apparently occurred but was statistically significant only for 2 rather large subgroups (Fig. 3): Hulahula River to Canada border and Canada border to Mackenzie River. A slightly higher percent young was detected west of the border in Alaska (5.6%) as compared to east of the border in Yukon (4.0%) (Table 4). This pattern is opposite to that found in 1981 in the same areas, when percent young generally increased along a gradient eastward from Barter Island to the Mackenzie River (Spindler 1982). No differences were detected between smaller subgroups in 1982 (see Appendix Table A-1).

Temporal variation in age ratio was suggested by the lack of young birds detected in flocks photographed during a preliminary reconnaissance survey on 29 August. No young were detected in photographs of 4 flocks totalling 7330 birds and representing a 24% sampling of the 30,985 geese estimated to have been present (Appendix Table A-1).

Population and Estimation Error

In order to estimate peak population using the staging ground in 1982, several sources of error must be addressed: (1) completeness and extent of area surveyed, (2) timing of survey segments -- concurrent or nearly so, or otherwise, (3) weather conditions under which surveys were conducted and, (4) estimation error for flock size. These factors were standardized so that (1)

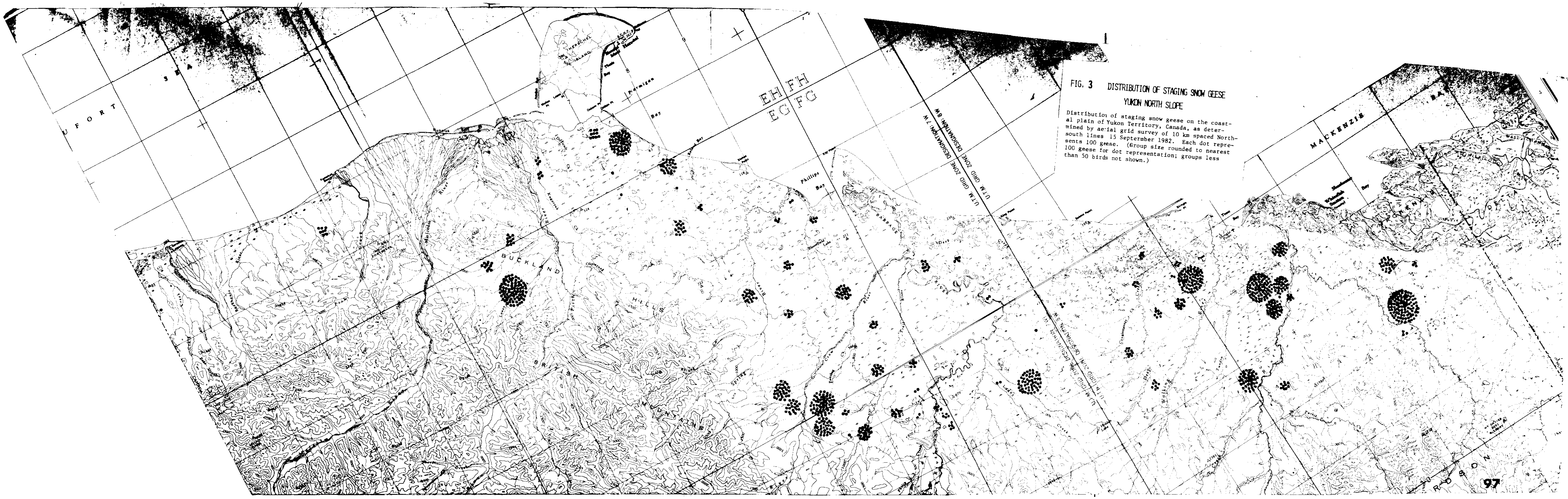

FIG. 3 DISTRIBUTION OF STAGING SNOW GEESE
YUKON NORTH SLOPE

Distributio: of staging snow geese on the coast-
al plain of Yukon Territory, Canada, as deter-
mined by aerial grid survey of 10 km spaced North-
south lines 15 Septermber 1982. Each dot repre-
sents 100 geese. (Group size rounded to nearest
100 geese for dot representation; groups less
than 50 birds not shown.)

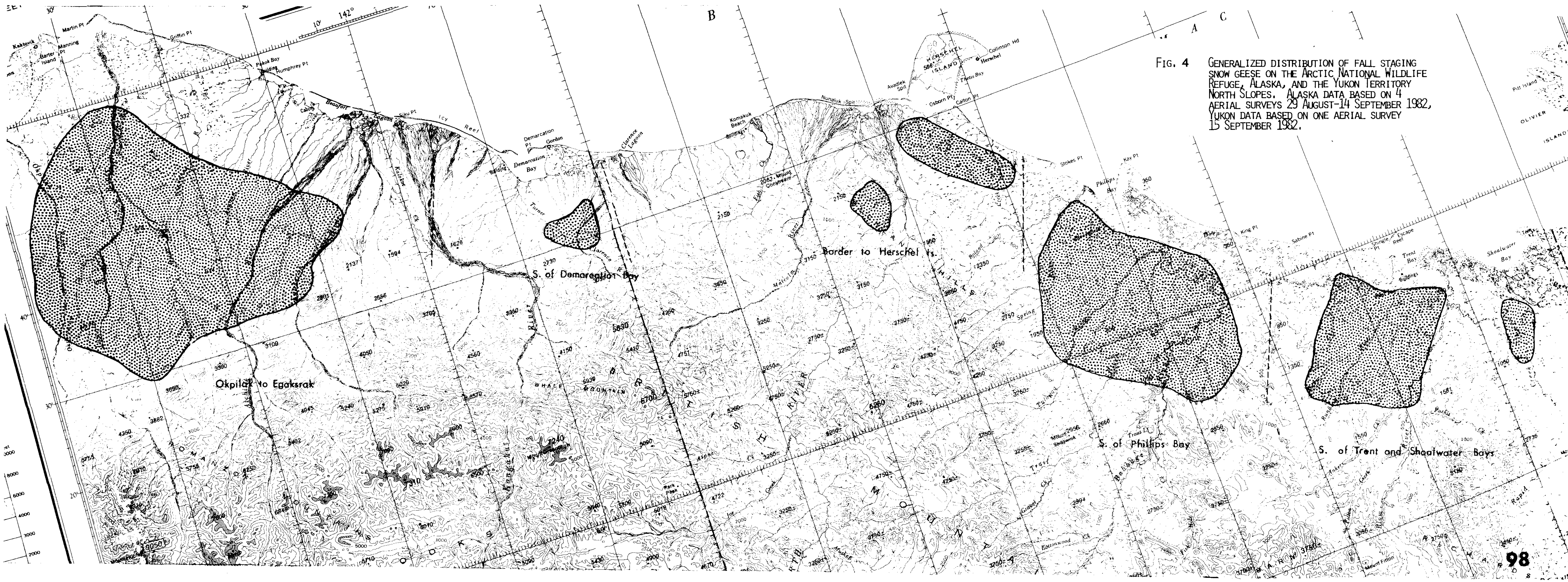

Fig. 4 Generalized distribution of fall staging snow geese on the Arctic National Wildlife Refuge, Alaska, and the Yukon Territory North Slopes. Alaska data based on 4 aerial surveys 29 August-14 September 1982, Yukon data based on one aerial survey 15 September 1982.

Table 3. Age ratios for western arctic snow geese staging on the Alaska and Yukon north slope, and Mackenzie River delta 1973-1976 (Koski 1977b) and 1979-1981 (Barry 1982, Spindler 1982, USFWS 1982, and this study).

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

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

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

c Since Paulatuk is a rarely used staging area, no quantitative survey was conducted. Data are estimates made by experienced biologist.

Table 4. Spatial differences in age ratio of snow geese, Arctic National Wildlife Refuge, Alaska, Yukon Territory north slope, 14-15 September, 1982.

Area	Mean	Variance	n	F	Unpaired-t	d.f.
Hulahula River to Egaksrak River	4.9	1.6	15	1.313	1.375	21
Border to Herschel Island	4.1	2.1	8			
Arctic National Wildlife Refuge	5.6	2.0	16	1.606	3.274[a]	27
Yukon Territory north slope	4.0	1.2	13			

[a] $p < 0.001$

area of coverage was complete using a systematic survey pattern; (2) the FWS and CWS portions of the survey were scheduled to occur concurrently, if possible (concurrent is ideal) (3) certain weather and survey minimum conditions were met (Spindler 1982). Estimation error was first addressed for the 1982 survey data.

Actual numbers of snow geese detected on 26 total flock photos were compared to the instantaneous visual estimates of the same flocks made during the aerial survey. The actual photo counts were significantly greater than the visual estimates ($t = 3.241$, $n = 26$, $P < 0.01$), and a linear relationship existed between the 2 values ($Y = 158.5 + 1.051X$, $r^2 = 0.920$, $P < 0.005$). The survey crew consistently underestimated total flock size by 19%. This relationship was used to adjust visual estimates to give a minimum estimate of actual numbers of geese present in the survey areas (Table 5)

Table 5. Adjusted estimate of lesser snow geese staging in 1982.

Area	Visual estimate	Adjusted by regression	±	95% confidence interval
Alaska-ANWR	101,684	107,072	±	13,866
Yukon	111,975	117,892	±	15,279
Total	213,659	224,806	±	29,242

These estimates (Table 5) for the Alaska and Yukon staging grounds must be added to the 6155 geese visually estimated to have staged on the outer Mackenzie River delta and Bathurst Penninsula a few days earlier, yielding a 1982 total for the western arctic population of 231,100 ± 29,200. This estimate represents a minimum estimate because (1) birds may have been missed in the patchy fog conditions which obscured about 20% of the Alaska area on 14 September, and (2) some birds may have moved between the 9-11 September survey dates flown by CWS personnel, and the 14-15 September survey dates flown by FWS. The relationship between flock estimates and flock size in 1982 was useful in adjusting the estimates. This relationship must be evaluated each year since survey crew and conditions are likely to change. For example, similar comparison of 15 flocks photographed in 1979 with accompanying visual estimates indicated that the estimates exceeded actual photo counts by a factor of 2 (Spindler 1979). Also, estimation error is not consistent between various flock sizes.

Evaluation of Photographic Techniques

Quality photography is critical to the successful outcome of age ratio estimation. The best quality photographs were obtained using various combinations of camera and film, depending on light conditions. On sunny days, the 35 mm camera with a high-quality 135 mm telephoto lens and ASA 50 H&W VTE PAN film produced the best photos because of camera manuverability and rapid shooting characteristics. The same combination produced poor results on cloudy overcast days due to slow shutter speed required by the slow film speed, and to poor contrast. If higher speed ASA 400 TRI-X PAN film was used with the 35 mm camera, the resolution dropped considerably making the large format camera more desireable. On cloudy, overcast days the 60 x 70 mm camera with 250 mm telephoto lens and ASA 400 TRI-X PAN film produced better results because high film speed and high resolution of the large size format compensated for poor lighting conditions. The 60 x 70 mm/TRI-X PAN combination also produced good results on sunny days, but its large size, awkward handling, and slow shooting characteristics made it a poor choice if sunshine allowed the use of the 35 mm with VTE PAN. Seating of the primary photographer in the right front seat of the aircraft worked best so the pilot could easily determine the proper shooting angle and distance and subsequently manuver the plane in to the correct position. Location of the back-up photographer in the right rear seat also worked well but that position had a limited shooting angle. Both photographers should practice shooting on the ground, and in the air, before transects are initiated. Exposures should be adjusted +1 or 2 f-stops for aerial photography on sunny days, and panning is always recommended to alleviate motion problems. Accurate cross referencing of flock numbers with roll and frame numbers of each photograph is crucial and was readily accomplished by the recorder using an intercom system.

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I would like to thank the USFWS Arctic National Wildlife Refuge staff, specifically G. Garner, J. A. Koschak, L. D. Martin, and P. A. Miller who assisted with the survey flights. Walt Audi flew all the surveys and contributed many hours worth of additional observations. T. W. Barry, of the Canadian Wildlife Service continued his usual cooperation from Tuktoyaktuk and Edmonton.

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APPENDIX

ANWR Progress Report Number FY83-4

Table A-1. Age ratios of snow geese as determined by photograrhic counts on 29 August and 14-15 September, 1982, Arctic National Wildlife Refuge, Alaska, and Yukon Territory north slope.

Location date, and photo I.D.	Flock number	Adults	Young	Sample total	Estimated total	% young	$\bar{X} \pm$ SD
Sadlerochit to Jago Rivers (29 August)							
1-9	17A	89	0	89	3500	0.0	
1-10	17B	473	0	473	3500	0.0	
2-10	26	86	0	86	250	0.0	
3-3	28	29	0	29	80	0.0	0 ± 0
Total		677	0	677	7300		
Hulahula to Egaksrak Rivers (14 September)							
3-6	56	282	0	282	282	0.0	
3-9	57	97	0	97	97	0.0	
4-1	61	70	0	70	1750	0.0	
5-2	76	773	0	773	800	0.0	
5-3	78	1019	11	1030	1030	1.1	
5-8	80	336	14	350	3000	4.0	
7-1	95	124	11	135	600	8.1	
7-2	96	192	12	204	204	5.9	
7-3	97	573	30	603	2500	5.0	
8-1	110	130	6	136	5000	4.4	
8-7	115	420	16	436	675	3.7	
8-10	117	552	44	596	1000	7.4	
9-4	120	255	26	281	1000	9.3	
9-5	121	383	52	435	1250	12.0	
9-8	122	176	26	202	882	12.9	5.0 ± 1.6
South of Demarcation Bay (14 September)							
9-10	126	300	40	340	1200	11.8	11.8 ± 0
Border to Herschel Island (14 September)							
VTE 2-27	137A	188	108	296	1000	36.57)	19.0[a]
VTE 2-28	137B	851	135	986	1000	13.7)	
10-4	139	71	39	110	110	35.5	
VTE 2-30	140	864	73	937	937	7.8	
VTE 2-32	141	406	29	435	435	6.7	
VTE 2-33	142	762	6	768	1000	0.8	
10-8	142	1993	47	2040	2040	2.3	
VTE 2-35	143	1055	16	1071	6000	1.5	4.1 ± 2.1
South of Phillips Bay (14 September)							
VTE 2-37	159	771	39	810	3500	4.8	
VTE 3-3	185	264	68	332	800	20.5	7.7 ± 29.8
South of Trent Bay to S. of Shoalwater Bay (14 September)							
VTE 3-6	192	566	13	579	7250	2.2	
12-9	205	723	16	739	1500	2.2	
12-10	206	708	22	730	2250	3.0	2.4 ± 1.9
Totals		14,904	899	15,803	49,092	Overall	4.6 ± 0.7

[a]Pooled value for subsamples used in mean calculations.

Table A-2. Photographic count results used to assess accuracy of snow goose flock size visual estimates made 29 August and 14-15 September, 1982. Arctic National Wildlife Refuge, Alaska, Yukon Territory north slope.

Photo I.D. roll and frame	Flock number	Snow geese as counted on photo (Y)	Snow geese as estimated visually (X)
29 August			
VTE 1-12	15	894	750
1-7	15	1377	750
1-3	13	4635	4500
1-8	16	1207	1250
2-1	18	1297	1000
2-4	20	884	650
2-8	24	493	300
2-9	25	1517	2000
14 September			
3-6	56	282	200
3-9	57	97	60
3-10	60	225	125
4-8	66	3701	2750
5-2	76	776	800
5-3	78	1030	1000
5-10	85	462	500
7-2	96	204	75
8-3	112	3020	2500
8-7	115	646	375
9-8	122	882	750
9-9	125	37	35
VTE 2-28	137	986	1000
10-4	139	110	125
VTE 2-30	140	937	400
VTE 2-32	141	435	350
10-8	142	2040	1000
12-1	201	493	100
Mean		1103	898
Standard deviation		± 1123	± 1025

Linear regression (R^2) 0.920

ANOR $F_{1,24}$ = 276.1[a]

Equation $Y = 158.5 + 1.051X$

Ratio For each estimated goose, there were 1.2 counted on photos

Paired-t:			
	All observations	n=26	3.241[a]
	Flocks < 1000	n=17	3.476[a]
	Flocks 1000-3000	n=6	1.117
	Flocks > 3000	n=3	2.271

[a] $p < 0.005$

ANWR Progress Report Number FY83-5

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

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Key Words: Anseriformes, Charadriiformes, waterfowl, shorebirds, tundra, wetlands, breeding bird census, populations, habitat use, community structure, status and distribution, Alaska, Arctic National Wildlife Refuge

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

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Abstract: Four large (25-50 ha) bird census plots established in 1978 on the Okpilak River delta, 11-16 km southwest of Kaktovik, were recensused in 1982. Additionally, 4 10 ha plots were placed adjacent to the existing large plots at Okpilak delta, and 6 10 ha plots were established and censused in 3 inland coastal plain habitat types along the Katakturuk River. Objectives were to estimate breeding, summer total, and fall bird populations, and to determine the relative efficiency of using replicate 10 ha plots instead of singular large plots for these estimates. A late break-up delayed migration and occupation of wetlands by shorebirds, but warm late June weather accellerated green-up of vegetation and possibly caused some species (pectoral and buff-breasted sandpipers) to nest earlier, while others nested later (red and northern phalarope) than in 1978. Twenty bird species bred on the Okpilak delta and 14 species bred in the Katakturuk area. Breeding densities were highest in Riparian Willow and Mosaic tundra plots, while lowest densities were recorded in Flooded and Sedge Meadow tundra plots. Overall breeding densities on the Okpilak delta plots were relatively constant for 1978 and 1982, varying from a 2% decrease on the Mosaic plot to 61% decrease on th. Flooded plot; however, certain species breeding efforts increased, with the largest increase being a 200% increase in pectoral sandpipers. These changes in total breeding effort were within the range observed elsewhere on the north slope. Total summer population, which included migrating and non-breeding individuals, was greater than breeding populations, and included 48 species at Okpilak and 35 species at Katakturuk. Highest total populations were observed in Riparian Willow and Flooded plots. Numerous birds used but did not breed in the Flooded plot. Lowest total summer population was observed in the Sedge Meadow plot. Within year changes in summer total populations were similar to those observed for breeding populations, and ranged from a 7% increase in the Mosaic plot to a 59% increase in the Wet Sedge plot. Changes in total summer population of northern phalarope, red phalarope, and semipalmated sandpiper were most pronounced, with the former increasing sharply and the latter 2 decreasing. In August, shorebirds using Okpilak coastal habitats increased while shorebird use at the inland Katakturuk area declined. Fall staging populations of shorebirds in the Flooded plot reached a peak in excess of 500 birds/km^2, higher than any density reached in that plot throughout the season, and higher than any other plot at that time of year. At the Okpilak delta, the replicate 10 ha plots provided larger estimates of breeding density and total summer density than did the large plot, except in the Wet Sedge habitat. Comparisons of replicate 10 ha plots and the corresponding 25 or 50 ha plot indicated that the replicate plots and the singular large plot provided comparable estimates of mean summer total population in the Wet Sedge and Sedge-Tussock plots, but estimates were not comparable on the more populous and diverse Flooded and Wet Sedge plots. Instead of censusing plots weekly throughout the summer, plots were censused once every 7-10 days during the breeding season and once in August. Based on recalculations of Canning River delta bird census data, this abbreviated census period provided the same

ranking for nesting species; however, total summer densities of the species and species groups were not comparable. The short mid-June to mid-July breeding season also places constraints on data extrapolation due to the difficulties in consistently duplicating search effort and pattern between differing census crews and crew leaders, as well as duplicating nest-finding skills among observers and between years.

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

A thorough knowledge of terrestrial bird populations and the relative importance of habitat types which they occupy is a prerequisite for the assessment and minimization of impacts due to increased energy exploration and development activity (Brooks et al. 1971, Bergman et al. 1977, Myers and Pitelka 1980, Derksen et al. 1981). Several terrestrial bird census projects have been conducted in the Arctic National Wildlife Refuge (ANWR) on near-coastline thaw lake plain tundra, including the Canning River Delta (Martin and Moitoret 1981), the Okpilak River Delta (Spindler 1978), and Demarcation Bay (Burgess in prep.). Additionally, 2 extensive census projects were performed, 1 at Beaufort Lagoon (Schmidt 1970) and 1 for several areas between the Jago and Katakturuk Rivers (Magoun and Robus 1977). Data from these studies indicated that habitat use patterns by nesting and transient populations of the more common species a) varied spatially between differing habitats and within the same habitat type and b) varied seasonally and annually within the same habitat type (USFWS 1982). To establish baseline population levels for assessing seasonal and annual variation in habitat use patterns it is desirable to examine multi-year data sets and multiple sample sites (Bell et al. 1973, States et. al. 1978, Myers and Pitelka 1980, Anderson et al. 1981, Hilden 1981, Martin and Moitoret 1981, Svensson 1981, Wiens 1981). Additionally, data are not available for bird use of inland coastal plain tundra and riparian areas. Based on the observations by Magoun and Robus (1977) on ANWR and data from NPR-A (Derksen et al. 1981), bird populations on ANWR are hypothesized to be lower on inland sedge tundra and higher in riparian shrub habitats as compared to near-coastal Tundra Species composition is hypothesized to be different between inland and near-coastal tundra areas.

Objectives of this study were to:

1. Determine annual and seasonal changes in populations of key tundra nesting bird species in near-coastline tundra.

2. Determine population levels and seasonal abundance of key tundra nesting species in inland tundra habitats.

3. Determine and compare population and species richness levels of birds in the major habitat classes defined by recent habitat mapping efforts (LANDSAT, etc).

4. Compare the efficiency of small plot (10 ha) versus large plot (50 ha) size for estimating levels of population and species richness.

Methods

Study Areas

Two study areas were located on the arctic coastal plain, a relatively flat 790,000 ha portion of the 7,300,000 ha Arctic National Wildlife Refuge. The near-coastline tundra study area, which included or was adjacent to large wetland areas on the Okpilak River delta, was located 1-6 km inland from marine waters of the Beaufort Sea and 11-16 km southwest of the village of Kaktovik on Barter Island (Fig. 1). The Okpilak River Delta study area was the site of bird censuses in 1978 (Spindler 1978) and was the base camp in 1982. The inland tundra study area was located on the interior coastal plain along the Katakturuk River, 15-17 km inland from the Beaufort Sea and 75 km west-southwest of Kaktovik (Fig 2). The Katakturuk River study area differed from the Okpilak River delta study area by the presence of riparian habitat with erect and more extensive growth of willows (Salix spp.) more extensive prostrate shrub ground cover in the sedge and tussock tundra, absence of extensive wetlands, and greater topographic relief.

Habitat Descriptions

Botanical data collection consisted of 2 phases. First was familiarization with the various taxa, noting the time of flowering, and visual estimation of relative abundance. The second was the qualitative description of plant communities on newly established census plots. Plant communities were described in mid-July during a bird census, when some graminoids were not yet at anthesis. Therefore, communities were identified only to the Level IV specification, as described by Viereck et al. (1982). Plant names are from Hulten (1968), except for Salix which follows Viereck and Little (1972).

Plot Census Methods

Four intensive bird census plots at the Okpilak delta that were established in 1978 were recensused in 1982: Flooded 50 ha, Mosaic 50 ha, Wet Sedge 50 ha, Sedge-Tussock 25 ha. (Fig 1, See Appendix Table A-1). In addition to these large plots, a 10 ha plot was censused adjacent to each large plot, but within the same habitat type (Fig 1, See Appendix Table A-1). Two 10 ha portions of each large 10 ha plot was delineated and subsequent data collections were designed to tally bird use within the subsamples of each large plot. This method of sampling provided data on 10 ha replicate samples of nesting and population density within each habitat type and was used to determine the relation efficiency of sampling plots for future extensive studies of bird use within different habitat types.

At the Katakturuk River study area, 2 10-ha plots were established in each of 3 broad habitat types: Riparian Willow, Tussock, and Sedge Meadow (Fig 2, See Appendix Table A-2). All plots were surveyed and gridded on a 50 x 50 m system using hand compass and 50 m surveyors chain. Intersections of grid lines were marked with wire-shafted surveyors wands, which were removed at the end of the summer. The corners of each plot were marked with steel re-bar and 50 x 50 mm wood stakes, 0.2-0.5 m tall, labelled with aluminum tags. Census plot locations were documented on aerial photographs of 1:4,000 and 1:6,000

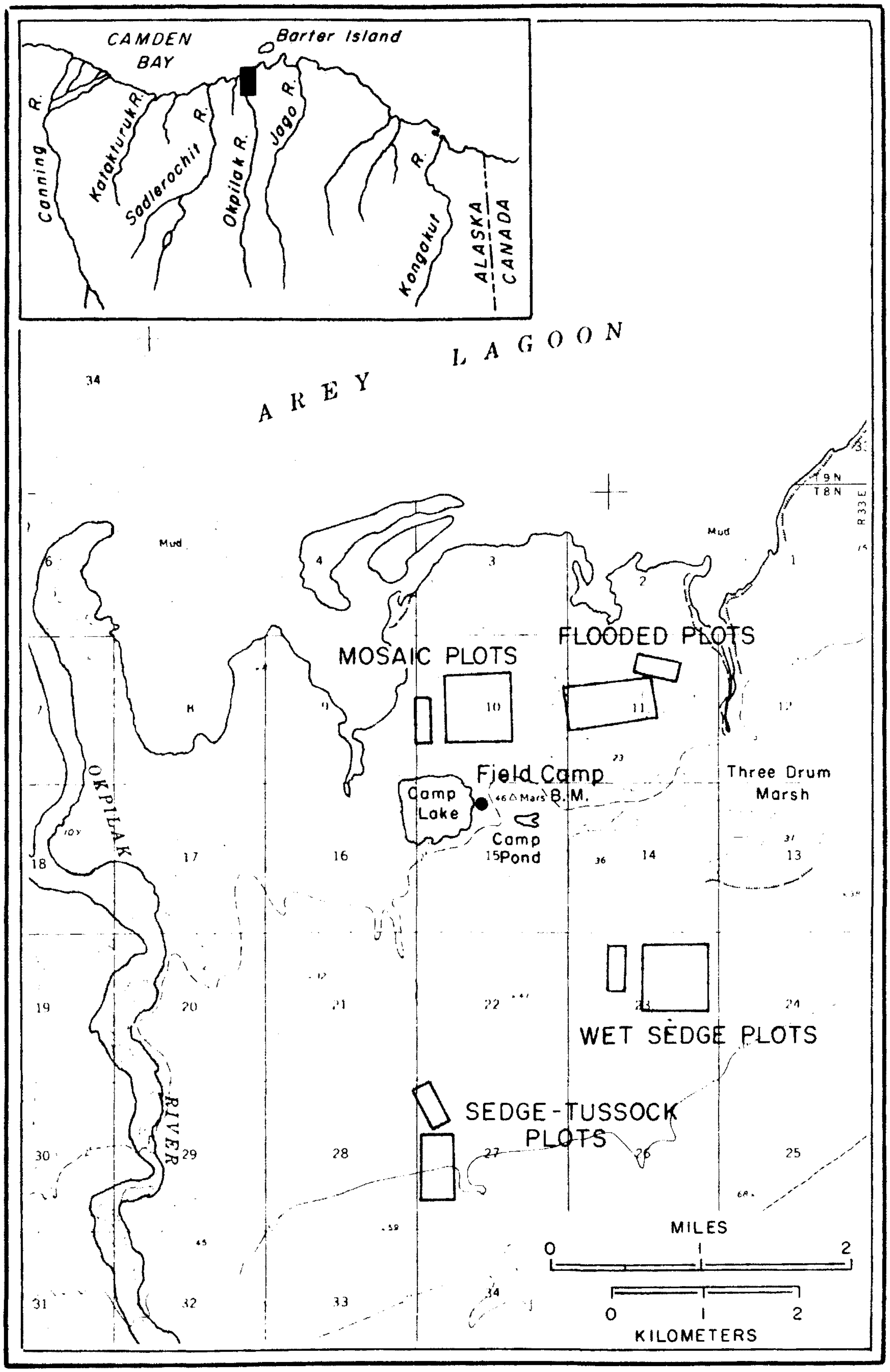


Fig. 1. Okpilak River delta study area, Arctic National Wildlife Refuge, Alaska.

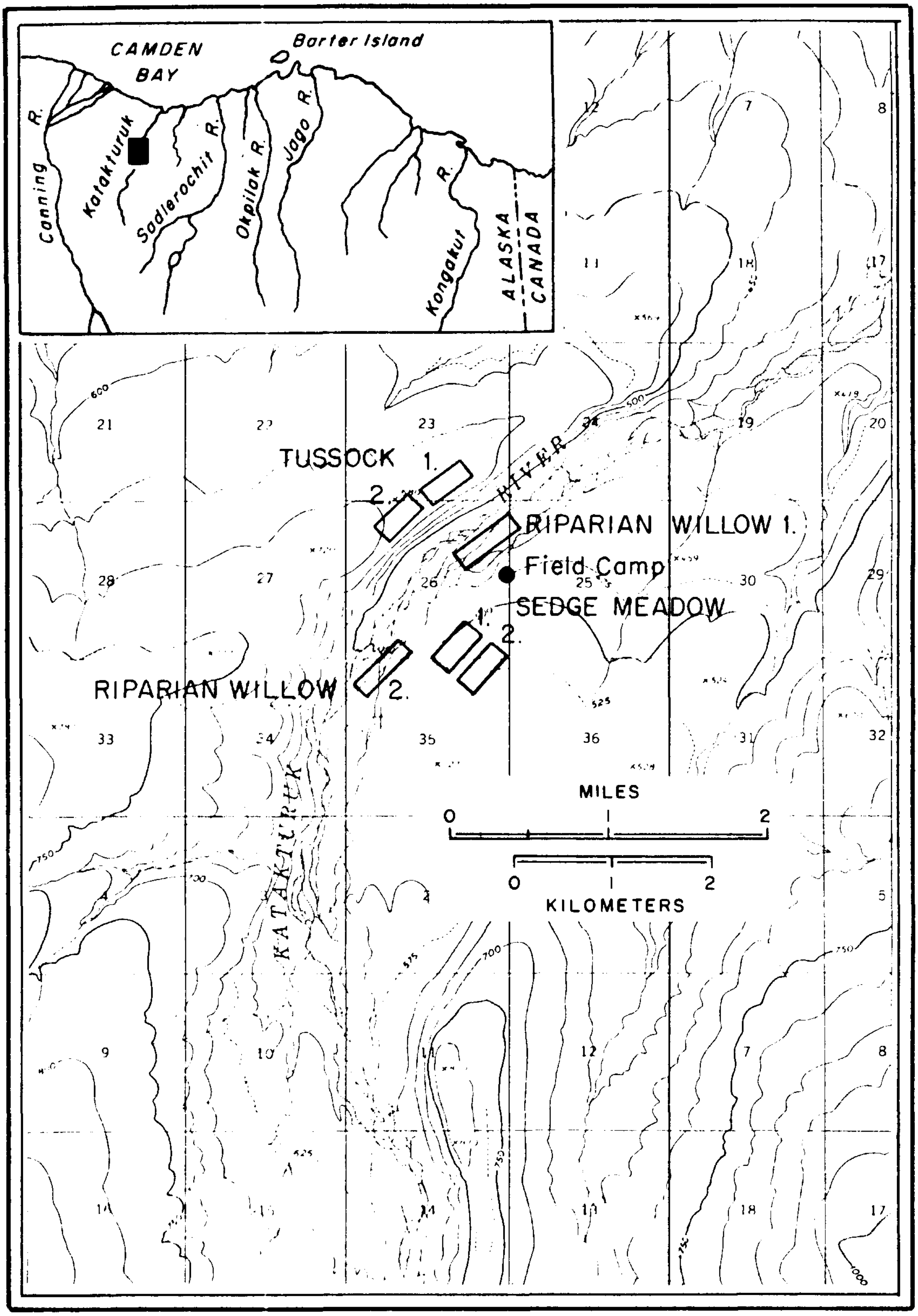


Fig. 2. Katakturuk River study area, Arctic National Wildlife Refuge Alaska.

scale for the Okpilak study area and 1:6000 and 1:18,000 scale for the Katakturuk River (on file at the ANWR office, Fairbanks, Alaska).

Okpilak plots were censused 4 times during June-July and once in August (See Appendix Table A-1). Katakturuk sites were censused 3 times during June-July and once in August (See Appendix Table A-2). Censuses consisted of 2 types of surveys: 1) intensive search for nests, and mapping of territories to estimate breeding bird density during June-July, and 2) census of all birds present to estimate total bird populations in summer (June-July) and fall (August). Methods described by Spindler (1978) and Martin and Moitoret (1981) were used to allow comparison with previous studies. Each census used 2-7 people (usually 5) walking abreast, evenly spaced, between the grid lines. Species, sex, behavior, direction of flight, and location of all birds seen were recorded on a scaled map of the plot. Special note was made of any behavior suggesting a nearby nest, and extra effort was made to find nests in such situations. Incubated eggs in unoccupied nests were identified using Harrison (1978).

Breeding bird population estimates for arctic tundra species have usually been based on number of nests found in intensive nest searches of plots for most non-Passerine species, and by using territory mapping supplemented by nest data for Passerines (Myers and Pitelka 1975, Hohenberger et al. 1980, Jones et al. 1980). Accordingly, breeding population density estimates in this study were based on nest search data for all species except Passerines and semipalmated sandpiper, for which territory mapping supplemented by nest search data was considered a more accurate estimator. For species with particularly difficult nests to find (e.g. American golden plover, long-billed dowitcher, and pectoral sandpiper) probable nest locations, as determined by behavioral observations, were also considered. Actual numbers of nests located for all species and estimated numbers of male pectoral sandpiper territories defended were also determined for each plot.

Mean summer total population density for each species (including breeders, transients, and migrants) in each plot, was estimated by averaging the total number of birds (per km^2) observed on each of the 3-4 censuses during the summer (June-July). The totals of the fall (August) census were analyzed separately as fall density. Seasons were defined as spring (20 May-20 June), summer (21 June -31 July), and fall (August). Bird names are according to the A.O.U. Checklist (1957), and supplements (1973, 1976).

Analytical

Rarefaction, and Community Species Richness. Rarefaction is a statistical technique for estimating the number of species expected [E(S)] in a random sample of individuals taken from a census or collection (James and Rathbun 1981). Given the number of individuals in each species for the census, the number of species expected in a smaller sample of n individuals can be calculated (Hurlbert 1971, Fager 1972, Simberloff 1978, Heck et al. 1975). By means of a series of predictions for successively smaller numbers of individuals, a rarefaction curve can be defined for the community. A computer program for this procedure was adopted from Simberloff (1978) by Walker. The method permits comparisons of the species richness among communities when the samples differ in total numbers of individuals or in area encompassed.

Rarefaction was used to standardize species richness estimates to a common sample size, even though original sample size (plot area) differed among habitats; therefore, standardizing the species area curve for one sample size.

Plot Size Effects. To assess the effects of differing plot size on estimates of species richness, species abundance, and composition, the 2 square 50 ha census plots at Okpilak were analytically subsampled into 1 each of the following plot sizes: 10, 20, 30 and 40 ha. Only the first 4 censuses corresponding to the breeding season were included. The results of each subsample census (observed) were compared to the results of the original 50 ha census (expected) using chi-square goodness of fit, Wilcoxon signed ranks, and students-t test (Steel and Torrie 1970, Conover 1971).

Use of replicate 10 ha plots. To determine if replicate 10 ha plots are a feasible alternative to single large plots, each large plot at Okpilak was paired with a smaller 10 ha replicate in as close to identical habitat as practicable. Each large plot was subsampled with 2 randomly located, independent, 10 ha subsample plots of identical dimensions and orientation as the 10 ha replicate, hence yielding 3 independent 10 ha samples. An exception was the Flooded plot where only 1 subsample could be taken due to the wet-dry gradient that had to be matched with the separate replicate. The results were analyzed separately for breeding population and mean summer total density, using chi-square goodness of fit (Conover 1971). For the mean summer total density, only the 4 censuses in June and July corresponding to the breeding season were included in the analysis.

Results and Discussion

Weather

Temperatures at the Okpilak River delta study site averaged 1.1°C minimum, and 8.3°C maximum in June. Average July temperatures (to end of census period) were 3.9°C minimum and 10.0°C maximum. Mean daily temperatures at Barter Island (NOAA observation station, 11 km northeast) were 2.7°C in June, 2.6°C above normal; 6.6°C in July, 2.1°C above normal; 3.8°C in August, no departure from normal. Precipitation at the same location was 23 mm in June, 9 mm above normal; 12 mm in July, 17 mm below normal; and 26 mm in August, 7 mm below normal. At the inland Katakturuk study site mean daily temperatures during census days averaged 6.6°C in June and 11.1°C in July. The Katakturuk site was considerably warmer due to the distance from the Beaufort Sea, and reduced occurrence of coastal fog. Similarily, snow melt was 100% complete at the inland site by 8 June, but was only 15% complete at the coastal site. The Okpilak site was 95% snow free by 17 June, which was approximately 1 week later than normal. Snow melt over the outer coastal plain was delayed in 1982 due to cool weather early in the month, combined with late snow storms on 12 and 16 June, each of which deposited 2-3 cm of new snow. On 21 June weather improved, with the last week of the month being sunnier and warmer than normal. The nearly constant prevailing winds in summer were northeast to east with monthly means of 12.2-21.6 kph (See Appendix Table A-3). On 21 August at the Okpilak site, there was a storm with southwest winds at 55 gusting to 70 kph. Although there were more periods of calm recorded at the Katakturuk River field site, winds often funnelled up the valley bringing coastally-influenced weather, especially fog, inland towards the Sadlerochit mountains.

Plant Phenology

First observed flowering dates for the more common plant species found on the Okpilak River delta in 1978 and 1982 were compared to assess phenological differences between the 2 years of census (See Appendix Table A-4). Dates on which the peak of first flowering activity occurred were not greatly different between 1982 and 1978. In 1982 the greatest number of first flowering species, 16, occurred on 2 July, compared to the maximum of 10 species newly flowering on 1 July 1978. A majority of the plant species flowered earlier in 1982: a total of 24 species were found flowering an average of 4.5 days earlier in 1982 than in 1978; whereas only 11 species were found flowering an average of 3.4 days later in 1982 than in 1978. Overall, Julian dates for 35 species flowering in both years were significantly earlier in 1982 (Wilcoxon signed rank test, p 0.005). Even though the unusually cold weather of the first 3 weeks of June caused a late break-up, the unusually warm weather the last week of that month may have offset the late break-up and actually accellerated flowering activity, causing the numerous early flower dates.

Habitat Descriptions

Vegetation types and bird habitat features of the 4 large Okpilak plots have been described quantitatively, based on systematic samples of quadrats for species percent ground cover, frequency, microhabitat diversity, and micro-relief (Spindler 1978). The following descriptions of these 4 plots are a summary of the quantitative data and classification of each plot according to Acevedo et al. (1982) and Viereck et al. (1982). On the newly-established Katakturuk plots, qualitative information gathered in 1982 was used for habitat descriptions. In the descriptions, a shortened capitalized "common name" for each plot is followed by non-capitalized Acevedo et al. (1982) detailed vegetation names and abbreviations (See Appendix Table A-5). These are cross-referenced to non-capitalized Viereck et al. (1982) level IV names and to Nodler (1977) LANDSAT types.

Flooded: pond complex (2a); aquatic tundra-pond complex (2b); wet sedge tundra-very wet complex (3b). The east and west sides of the 50 ha plot contained extensive open water and pond complex with Arctophila fulva and Carex aquatilis emergent wetlands. The center two-thirds of the plot contained homogeneous very wet sedge tundra with mostly flooded centers of low-center polygons. Micro-relief between low points (polygon centers, polygon troughs) and high points (polygon ridges and mounds) was minimal, averaging only 0.2-0.3 m. Quantitative microhabitat description based on 120 point samples was: low-center polygon-69%; pond complex-22%; polygon ridge-7%; high-center polygon-2%. Ground cover was dominated by the sedges Carex aquatilis, C. rariflora C. cordorrhiza, and C. bigelowii; the grass Arctophila fulva; the prostrate shrubs Salix planifolia pulchra, S. reticulata, and S. arctica. Quantitative ground cover estimates, based on 52 systematically-located 0.25 m^2 quadrats were: water-32%, litter-20%, sedge-19%, moss-8%, mud-5%; the remaining percentage in prostrate shrubs, forbs, lichens, algae and grasses. The plot was bordered on the north by higher moist tundra and a pingo; on the east and west by pond complex wetlands; on the south by a large lake. The nearest marine waters were Arey Lagoon 1.6 km to the north. Topography was flat with an elevation of 7 m. The 10 ha replicate plot was similar to the 50 ha plot in having a central pond complex (2a) rimmed by aquatic tundra-pond complex (2b) and a large area of wet sedge tundra-very wet complex (3b). The pond complex and aquatic tundra area was larger and the wet sedge tundra correspondingly smaller in the 10 ha plot as compared to the 50 ha plot.

Mosaic: wet sedge tundra-moist complex (3c). Both the 50 and 10 ha plots were composed of structurally-diverse tundra consisting of a mosaic of 1) wet sedge low-center polygons with fairly high and dry polygon ridges, and 2) moist sedge high-center polygons with low, wet polygon troughs. The "fine-grained" juxtaposition of wet, dry, and moist microhabitats resulted in a high microhabitat diversity that was associated with a mean micro-relief of 0.5 m. Quantitative microhabitat description on the 50 ha plot based on 120 point samples was: high-center polygon-30%, polygon trough-20%, low-center polygon-17%, polygon ridge-15%, intermediate-center polygon - 13% pond complex-5%. Ground cover was dominated by the prostrate shrubs *Dryas integrifolia*, *Salix reticulata*, *S. planifolia pulchra*; the sedges *Carex aquatilis*, *C. misandra*, *C. Bigelowii*, *Eriophorum vaginatum*, and *E. angustifolium*. Quantitative ground cover estimates based on 60 systematically-located 0.25 m^2 quadrats on the 50 ha plot were: litter-35%, prostrate shrubs-26%, sedges-16%, moss-6%, water - 5%; the remaining percentage in lichen, forbs, grasses, and mud. Both plots were bordered on the west, north, and east by similar habitat, and on the south by pond complex wetlands. They were 0.5 km east of Arey Lagoon, the nearest marine waters. Topography was flat with an elevation of 7 m. Qualitatively, both the 50 ha and 10 ha plots appeared similar in habitat diversity.

Wet Sedge: wet sedge tundra-non complex (3a). On both the 50 ha and 10 ha plots, vegetation and microhabitat were homogeneous, having only small differences in micro-relief (mean of 0.3 m). Polygon centers were evenly vegetated with wet sedge and the polygon ridges were of low relief, harboring a wet sedge or occassionally moist sedge community. There were widely scattered dry ridges and mounds that contained some moist sedges with prostrate willows, birches, and Ericaceous shrubs. On the 50 ha plot quantitative microhabitat description based on 120 point samples was: low-center polygon-54%, polygon ridge-13%, intermediate-center polygon-10%, peat ridge-9%, polygon trough-9%, pond complex-3%, mound-1%, high-center polygon-1%. Ground cover was dominated by the sedges *Carex saxatilis*, *C. aquatilis*, *C. cordorrhiza*, and *Eriophorum angustifolium*; the prostrate shrubs *Betula nana*, *Salix planifolia pulchra*, and *S. reticulata*; and the forb *Pedicularis sudetica*. Quantitative ground cover estimates based on 32 systematically-located 0.25 m^2 quadrats were: litter-32%, sedges-31%, prostrate shrubs-14%, moss-10%, water-7%; the remaining percentage in forbs, mud, lichens, and grasses. Both plots were bordered on all sides by similar habitat, and were 4.2 km south of Arey Lagoon, the nearest marine waters. Topography was flat with an elevation of 12 m.

The 10 ha plot differed from the 50 ha plot in the amount of homogeneity and number of Karst thaw pits. The 10 ha plot was almost entirely wet sedge tundra, with small amounts of other types, whereas the 50 ha plot had substantially more sedge-willow tundra replacing the wet sedge tundra (Table 1). Also, the 10 ha plot had fewer Karst thaw pits and deep water-filled polygon troughs and intersections than did the 50 ha plot.

Sedge-Tussock: moist sedge-prostrate shrub tundra (5a). The east side of the 25 ha plot was mostly Eriphorum vaginatum tussock tundra mixed with prostrate Ericaceous shrubs, dwarf birches, and willows. The west half was wetter, with low-center polygons composed of sedge meadow and water, and drier polygon ridges also with Ericaceous shrubs, dwarf birches, and willows. Micro-relief was comparatively high, averaging 0.5 m. Quantitative microhabitat description based on 72 point samples was: high-center polygon-40%, polygon trough-15%, peat ridge-13%, polygon ridge-11%, intermediate-center polygon-10%, low-center polygon-6%, river terrace-5%. Ground cover was dominated by the prostrate shrubs Salix planifolia pulchra, S. reticulata, Vaccinium vitis-idaea, Cassiope tetragona, Betula nana, Dryas integrifolia; and the sedges Carex Bigelowii, Eriophorum angustifolium, and E. vaginatum. Quantitative ground cover estimates based on 36 systematically-located 0.25 m^2 quadrats were: litter-32%, prostrate shrubs-24%, moss-17%, sedges-16%, lichen-3%; the remaining percentage in forbs, water, mud, and grasses. Both plots were bordered on the east by a creek and on the other sides by similar habitat; both were 4.5 km southeast of Arey Lagoon, the nearest marine waters. Topography was flat with an elevation of 15 m.

The 10 ha plot was nearly indentical to the 25 ha plot except that it was drier on the west side, having less wet sedge meadow tundra and correspondingly more sedge-willow tundra than the 25 ha plot (Table 1). Both plots had their driest areas on an Eriophorum vaginatum tussock ridge adjacent to the creek, with a gradient of increasing wetness proceeding away from the creek. Due to the greater distance inland, development of dwarf and prostrate shrubs was more extensive than on the near-coastal Mosaic and Flooded plots.

Riparian Willow: dry prostrate shrub-forb tundra (4b); partially vegetated areas-river bars (9a); barren ground or rock (10). For riparian willow habitats the Acevedo et al. (1982) classification was cumbersome, since the names did not recognize the existence of riparian willow thickets. The dry prostrate shrub-forb tundra (4b) included 3 Viereck et al. (1982) Level IV types which were distinct, easily described, and dominated the Katakturuk riparian communities: willow, low-willow, and Dryas-herb tundra (Table 1).

The willow community was characterized by thickets of 0.6-2.0m tall Salix alaxensis. The canopy was closed with 75-85% cover and relatively few other taxa were common in this area. The 2 most frequently encountered species beneath the willow were bearberry (Arctostaphyllos rubra) and anemone (Anemone parviflora). As the willows extended into seemingly less favorable sites, Salix alaxensis clusters became shorter and the canopy opened to less than 50% cover. In the low willow community, Salix alaxensis was common, as were other willow species Salix brachycarpa niphoclada, S. novae-angliae, and S. lanata Richardsonii. These willows were about 0.5 m tall and maintained an open canopy with 25-50% cover. Common prostrate shrubs found here were Dryas integrifolia, and Arctostaphyllos rubra. An abundance of herbs and lack of

Table 1. Relative percent coverage of Viereck et al. (1982) Level IV vegetation classes on the bird census plots, surveyed June-August 1982, Arctic National Wildlife Refuge, Alaska.

Plot	2B(1)a willow	2C(1)c *Dryas*-herb tundra	2C(1)d *Cassiope* tundra	2C(1)e low-willow tundra	2C(2)b low willow	2C(2)r willow-sedge tundra	3A(2)d tussock tundra	3A(2)g mesic grass-herb meadow tundra	3A(2)h sedge-willow tundra	3A(2)j sedge-*Dryas* tundra	3A(3)a wet sedge meadow tundra	3A(3)e fresh grass marsh	3B(1)a seral herbs	3C(1)b *Dryas*-lichen tundra	3C(2)s willow-grass tundra	Barren gravel
Okpilak River Delta																
Flooded 50 ha								5			60	35				
Flooded 10 ha								5			25	70				
Mosaic 50 ha									5	10	80			5		
Mosaic 10 ha									5	5	85			5		
Wet Sedge 50 ha									30		60				10	
Wet Sedge 10 ha									10		80				10	
Sedge-Tussock 25 ha			5	5					50	5	35					
Sedge Tussock 10 ha			0	5					65	5	25					
Katakturuk River																
Riparian Willow 1	25	25			35								10			5
Riparian Willow 2	15	25			40								10			10
Tussock 1					12	60	15				13					
Tussock 2					12	65	10				13					
Sedge Meadow 1										15	85					
Sedge Meadow 2										15	85					

graminoids was obvious. Especially common between and under willows were Astragalus alpinus, Hedysarum mackenzii, Hedysarum alpha, Oxytropis boreale, O. campestre, and O. arctica (See Appendix Table A-6). Common non-leguminous herbs were Anemone parviflora, Arnica alpha angustifolia, Pedicularis verticillata, and P. capitata. As the willow in this community graded into small, more widely spaced clusters, Dryas integrifolia became more common.

The Dryas-herb community contained a less diverse flora in areas where Dryas was most abundant. In the most exposed areas, only Oxytropis nigrescens, Saxifraga oppositifolia, and lichen occurred with a mat of Dryas. On more favorable sites additional taxa included Oxytropis campestre, O. borealis, Salix reticulata, and Hedysarum alpha.

The partially vegetated areas-river bars supported a seral herb community of Artemisia arctica and Castilleja caudata. On bars with more constant plant covering, the following additional species became common: Epilobium latifolia, Hedysarum alpha, Astragalus alpha, and Hedysarum Mackenzii. The smallest portion of the plots consisted of barren gravel and braided river channel, which usually lacked vegetation and carried low volumes of water, hence exposing relatively large areas of gravel bar.

The Riparian Willow 1 plot (Fig. 2) was bordered on the north and south by channels of the Katakturuk River and on the other sides by similar habitat. The Riparian Willow 2 plot was bordered on the west by the Katakturuk River, the east by Dryas river terrace, and on the other sides by similar habitat. Topography on both plots was flat, elevation was 145 m on Riparian Willow 1 and 152 m on Riparian Willow 2. The Riparian Willow 1 was 15.7 km south, and Riparian Willow 2 was 17.2 km south of Camden Bay, the nearest marine waters. Both plots were nearly identical with respect to vegetation composition, except for a slightly higher occurrence of barren gravel or rock and slightly lower occurrence of willows on the Riparian Willow 2 plot.

The two Riparian Willow plots had the greatest number of plant species observed (47) (See Appendix Table A-6) of the 3 different habitat types studied at Katakturuk. The higher plant diversity could have been attributed to the variety of seral stages derived from riverine action, and to varying degrees of exposure. Gravel bar vegetation also seemed to follow a decreasing moisture gradient (increasing exposure gradient) from an erect community, to a prostrate Dryas-herb community in the most exposed places.

Tussock: moist dwarf shrub-sedge tussock tundra (7a); moist sedge tussock-dwarf shrub tundra (6a). The 2 Acevedo et al. (1982) components of this habitat reflected a dominance of dwarf shrub cover and sedge tussock cover, respectively. Within the dwarf shrub-sedge tussock type was a willow-sedge tundra dominating both plots and comprised by willow (Salix planifolia pulchra) about 0.1 m tall and the sedge Carex Bigelowii, all of which was underlain by moss. Clumps of willow in protected depressions formed a low-willow community consisting of 0.05-0.10 m stands of Salix planifolia pulchra also over a thick mat of moss. The sedge tussock-dwarf shrub type existed on relatively drier microsites. Tussocks of Eriophorum vaginatum were spaced 1-2 m apart with prostrate shrubs growing on moss between them. Willows (Salix planifolia pulchra, S. reticulata and S. phlebophylla) were common, as was mountain cranberry (Vaccinium vitis-idea). Also in the sedge tussock-dwarf shrub type were small pockets of wet sedge meadow tundra covered almost exclusively by either Carex Biglowii and moss, or on very wet sites, an association characterized by a lush growth of sedges, such as Eriophorum angustifolium and Carex aquatilis. Carex chordorrhiza was also fairly common in the assemblage, around pools and in spring melt-off drainages. Both plots were bordered on 3 sides by similar habitat. The southeast sides were within 100-200 m of a steep clay river bluff having incised gullies of wet sedge in the bottom and willow thickets on the sides. The nearest marine waters were 15.0 km and 15.5 km, to the north of Tussock 1 and Tussock 2 plots, respectively (Fig. 2). Topography on both plots was flat, although they were immediately adjacent to the 60 m high bluff. Elevation was 195 m for Tussock 1 and 205 m for Tussock 2. The Tussock plots supported the second highest number (32) of plant species, (See Appendix Table A-6) of the 3 habitat types censused at Katakturuk. The vegetation on Tussock 1 and Tussock 2 was nearly identical (Table 1). Tussock 2 had slightly less tussock cover and slightly more willow-sedge cover.

Sedge Meadow: moist sedge-prostrate shrub tundra (5a) - The Katakturuk Sedge Meadow plots were characterized by strangmoor and low-center polygons. Most of the area remained water-soaked through mid-July with strangs and polygon rims raised only 2-4 cm above the saturated areas. Two different communities were identified in the habitat: wet sedge meadow tundra and sedge-Dryas tundra. Wet sedge meadow tundra was found on the water-soaked soils of polygon centers. The community of sedges was composed of Carex aquatilis, C. rariflora, C. saxatilis laxa, Eriophorum angustifolium and E. russeollum. The sedge-Dryas tundra community was atop strangs and polygon rims and supported a flora with mixed herbs and dwarf shrubs while still maintaining graminoinds as the abundant. Important species in this sedge-Dryas tundra community were the sedges Carex Biglowii, and C. aquatilis, Eriophorum angustifolium the prostrate shrubs Dryas integrifolia, Arctostaphyllos rubra, Salix lanata Richardsonii, S. arctica, and S. reticulata. Other common taxa, but of more random occurrence, were Equisetum sp. and Pedicularis sudetica. Equisetum was abundant through both polygon rims and centers in a 2 ha portion of Sedge Meadow Plot 2. Pedicularis sudetica was common in many low-center polygons throughout the study area but seemed to be absent in the wettest of polygon centers.

Both plots were surrounded by similar habitat on all sides except for the southwest side of Sedge Meadow 1 which bordered a Dryas river terrace of the Katakturuk River. The nearest marine waters were 17.7 km to the north at Camden Bay. Topography of both plots was flat with an elevation of 152 m. The Sedge Meadow plots contained the lowest number (13) of plant species observed (See Appendix Table A-6) of any plot studied in both the Katakturuk and Okpilak study areas. Vegetation on both plots was similiar (Table 1).

Breeding Bird Communities

Twenty bird species bred at the Okpilak River delta (15 on census plots) and 14 bred at the Katakturuk River study area (9 on census plots) in 1982. Breeding bird densities were highest in Riparian Willow 1 plot in the interior coastal plain at Katakturuk River, followed by Katakturuk Riparian Willow 2 plot and the Mosaic (10 ha) plot in the outer coastal plain at Okpilak River delta (Table 2, See also Appendix Tables A-7 and A-8). Lowest breeding densities were recorded at the Sedge Meadow plots at Katakturuk followed by the Flooded plot (50 ha) at Okpilak. For all habitats censused at the Okpilak delta, estimated nesting densities were higher for the 10 ha plots compared with their larger (25 or 50 ha) counterparts except for Wet Sedge plots.

Breeding densities were related to mean total summer densities (Fig. 3; $R^2 = 0.66$) with largest outliers being for the Flooded plot which had low breeding density but high summer density, and the Riparian Willow 1 plot which had higher breeding density than would be expected from its total summer density value.

There was a strong relationship between species richness and breeding densities on the 10 ha census plots (Fig. 4; $R^2=0.74$). There was no correlation between species richness and density for the larger plots ($R^2 = 0.01$) but these all had greater species richness than the 10 ha plots. Highest species richness was recorded for the Mosaic (50 ha) plot which had 8 breeding species and lowest in the Sedge Meadow 2 plot with only 1 species (See Appendix Tables A-7 and A-8).

Breeding density dominance structures were similar for most census plots with 2 species dominating the population, except on the Flooded plots which had a more even distribution and the Riparian Willow 1 plot which had an evenly declining structure (Fig. 5 and 6). Lapland longspur was the most abundant breeder on all plots, with pectoral sandpiper co-dominant in all Okpilak plots except Sedge-Tussock (25 ha) where oldsquaw co-dominated. At Katakturuk, co-dominant species varied among the plots between redpoll, semipalmated sandpiper, savannah sparrow, and rock ptarmigan. Breeding of Lapland longspurs was earlier at the Katakturuk River study area than at Okpilak River delta, but chronology was similar between the areas for semipalmated sandpipers and American golden plover (Fig. 7 and 8).

Okpilak Delta Plots

Flooded: pond complex (2a), aquatic tundra-pond complex (2b), wet sedge tundra-very wet complex (3b) - The Flooded plot (50 ha) had the lowest breeding density of the 4 outer coastal plain habitats on the Okpilak delta and the third lowest breeding density of all plots censused on the coastal plain in 1982. However, Flooded tundra had the second highest species richness of all habitats. The habitat was dominated by Lapland longspurs and pectoral sandpipers which together comprised over half (58%) of the total population (Fig. 5); northern phalaropes were also numerous. This was the only habitat in which breeding red-throated loons, king eiders and parasitic jaegers were found.

Breeding species composition of the Flooded 10 ha plot differed from the larger plot by the presence of a glaucous gull colony and nesting arctic loons. northern phalarope densities were higher on the 10 ha plot.

Table 2. Breeding densities (nests-territories/km^2), mean summer total population densities (birds/km^2), and fall population densities (birds/km^2) in 7 habitat types at the Okpilak River delta and Katakturuk River on the coastal plain of the Arctic National Wildlife Refuge, Alaska, June-August 1982.

Plot	Plot size	Breeding densities	Mean summer total population density	Fall population density	No. breeding species	No. breeding species and summer visitors	No. species in fall	Total no. species (breeding, summer, fall)
Flooded (2a,2b,3b)	50 ha	38	267	534	7	20	13	22
	10 ha	60	212	320	5	14	10	16
Mosaic (3c)	50 ha	81	202	244	8	18	7	18
	10 ha	115	245	320	4	12	14	14
Wet Sedge (3a)	50 ha	64	178	132	7	19	5	19
	10 ha	40	98	170	2	5	3	6
Sedge-Tussock (5a)	25 ha	68	188	124	5	16	5	16
	10 ha	80	193	410	3	10	3	10
Riparian Willow 1	10 ha	168	430	420	6	10	6	13
(4b, 9a, 10) 2		115	403	280	5	12	5	14
Tussock (6a, 7a) 1	10 ha	88	200	240	4	8	4	10
2		83	153	120	3	7	1	7
Sedge Meadow 1	10 ha	20	53	130	2	6	2	7
(5a) 2		10	66	210	1	6	2	6

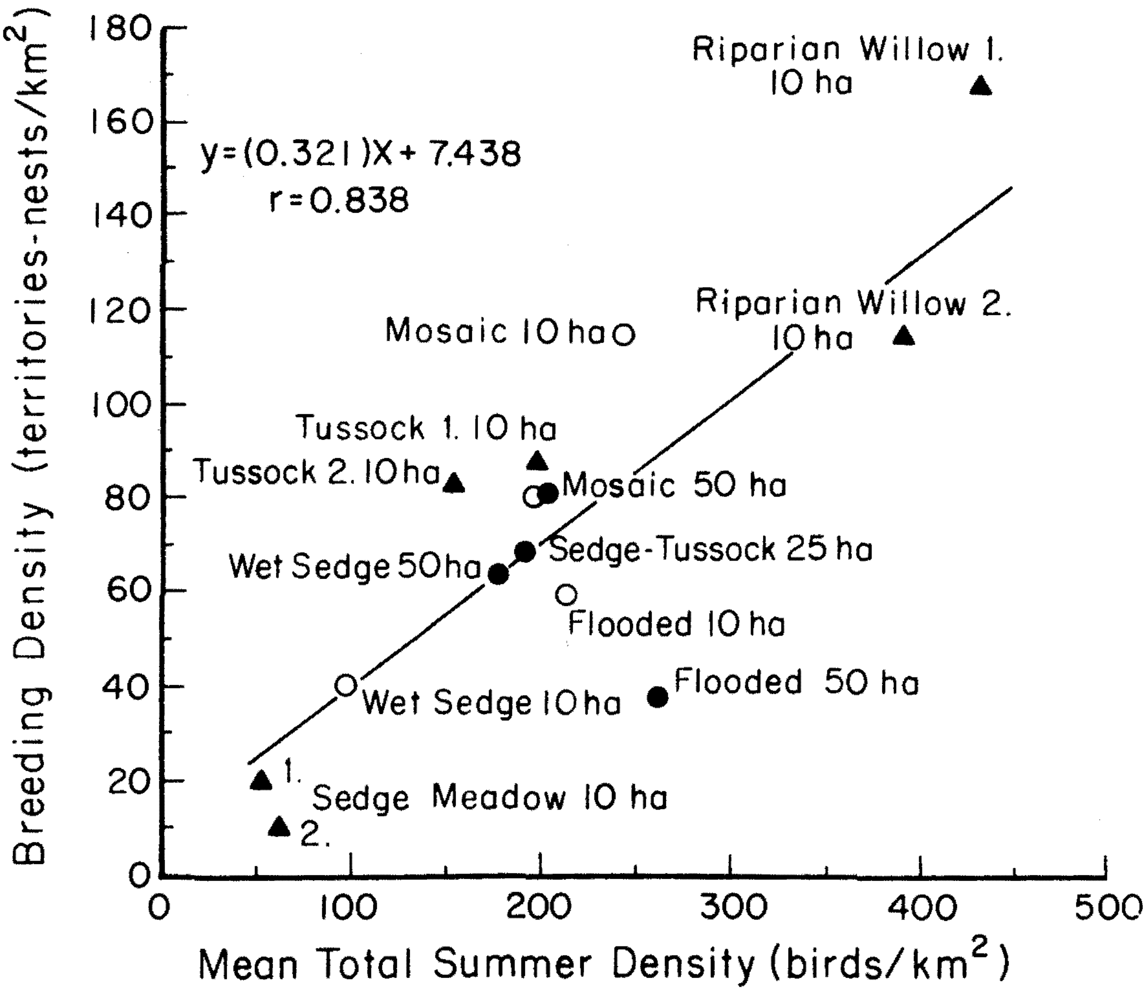


Fig. 3. Relationship between mean summer total density and breeding density based on 14 bird census plots, Arctic National Wildlife Refuge, Alaska, June-July 1982.

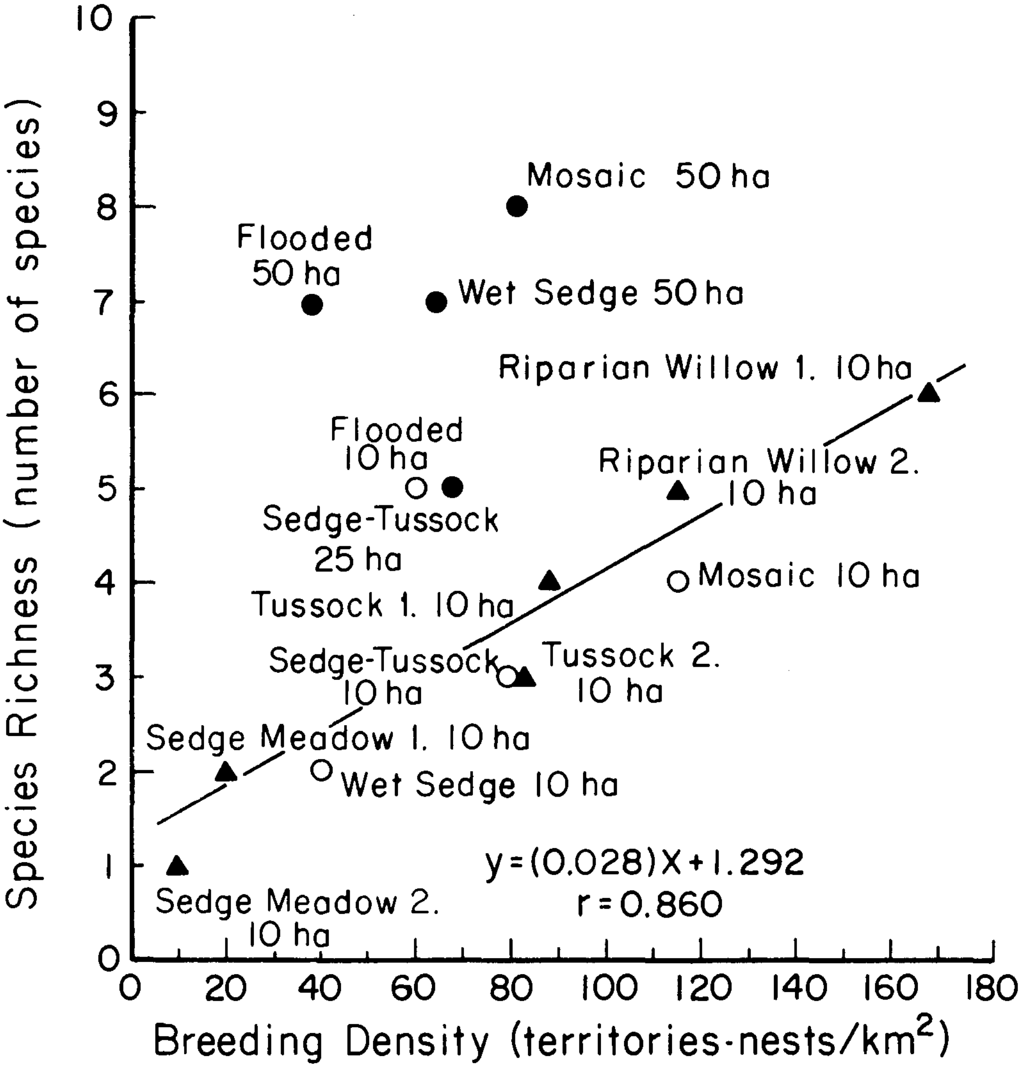


Fig. 4 Relationship between breeding density and breeding species richness based on 14 bird census plots, Arctic National Wildlife Refuge, Alaska, June-July 1982.

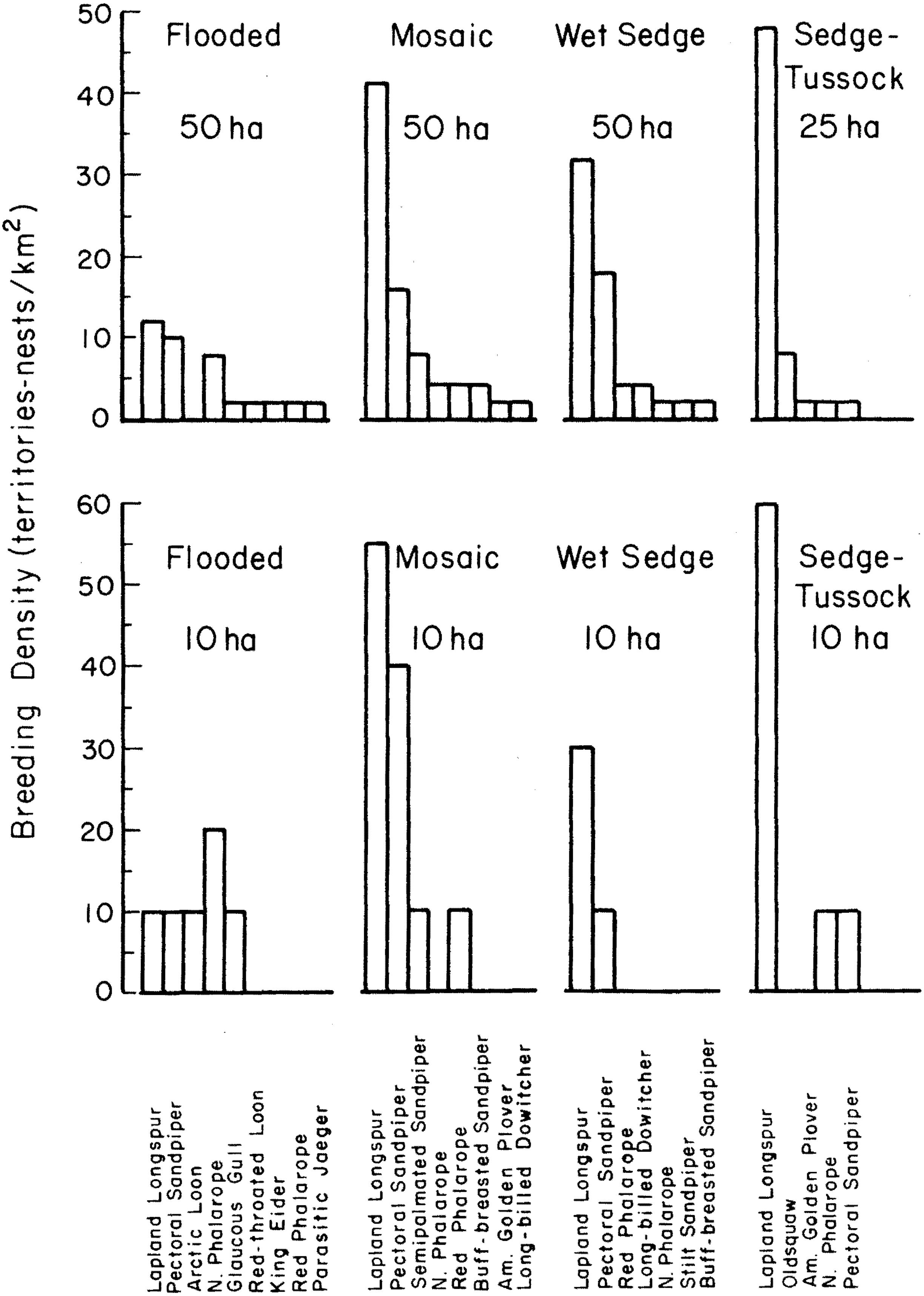


Fig. 5 Breeding density dominance structure for 8 plots in 4 tundra habitat types at Okpilak River delta, Arctic National Wildlife Refuge, Alaska, June-July 1982.

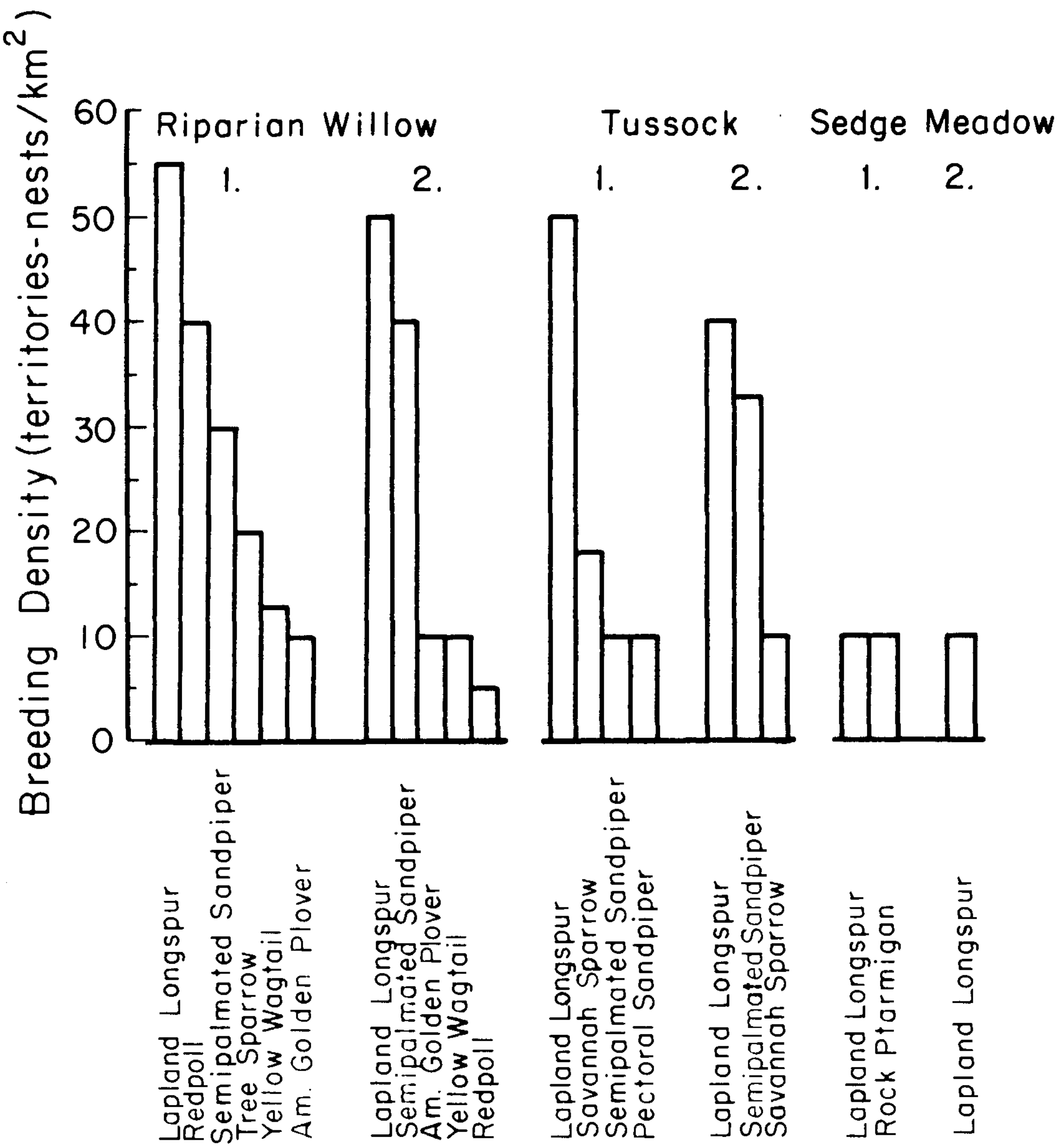


Fig. 6 Breeding density dominance structure for 6 plots in 3 tundra habitat types, Katakturuk River, Arctic National Wildlife Refuge, Alaska, June-July 1982.

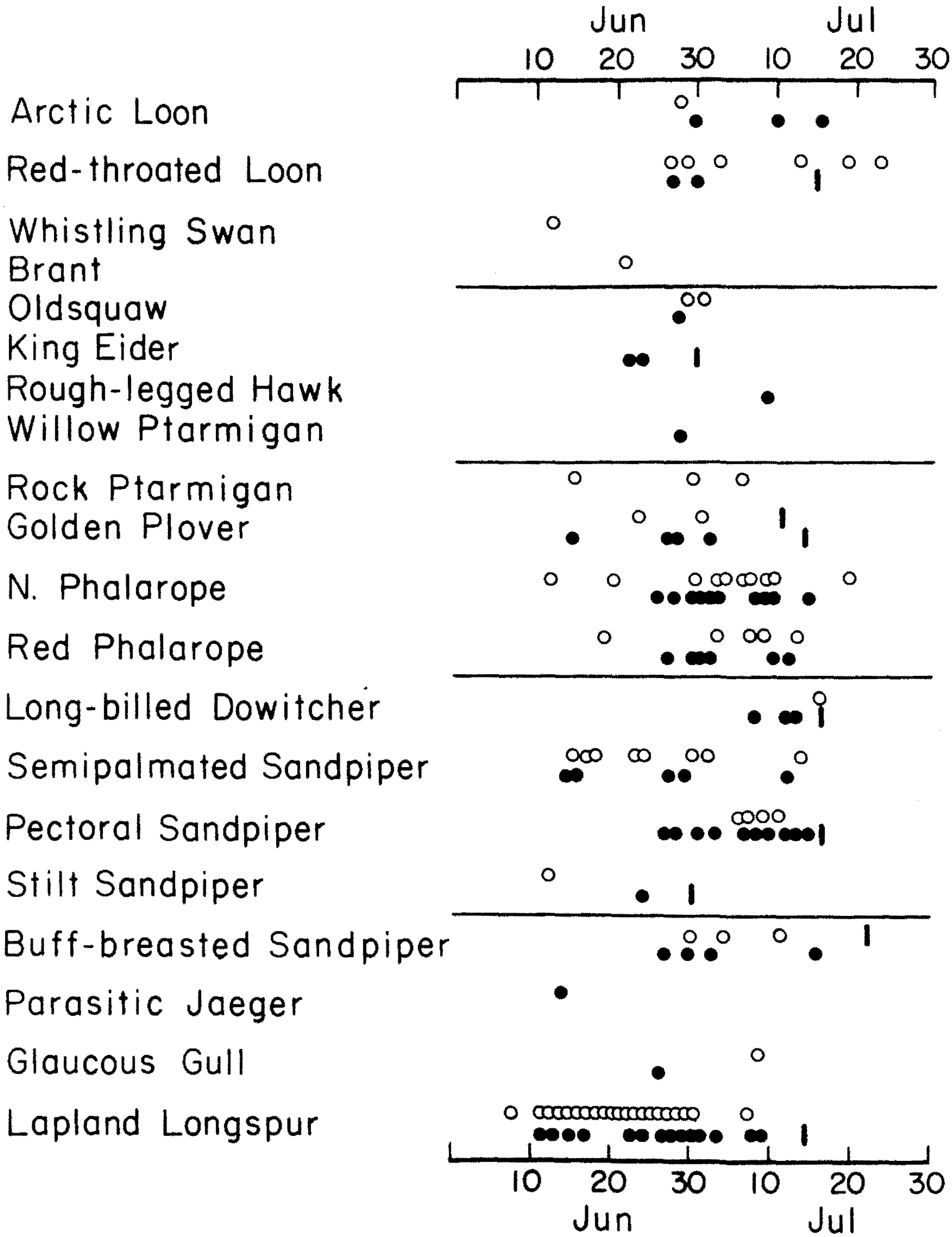


Fig. 7. Chronology and duration of nesting at Okpilak River delta, Arctic National Wildlife Refuge, Alaska, 1978 and 1982. First date each nest was found (open circles - 1978, solid circles - 1982) and last date active nests were relocated (bar).

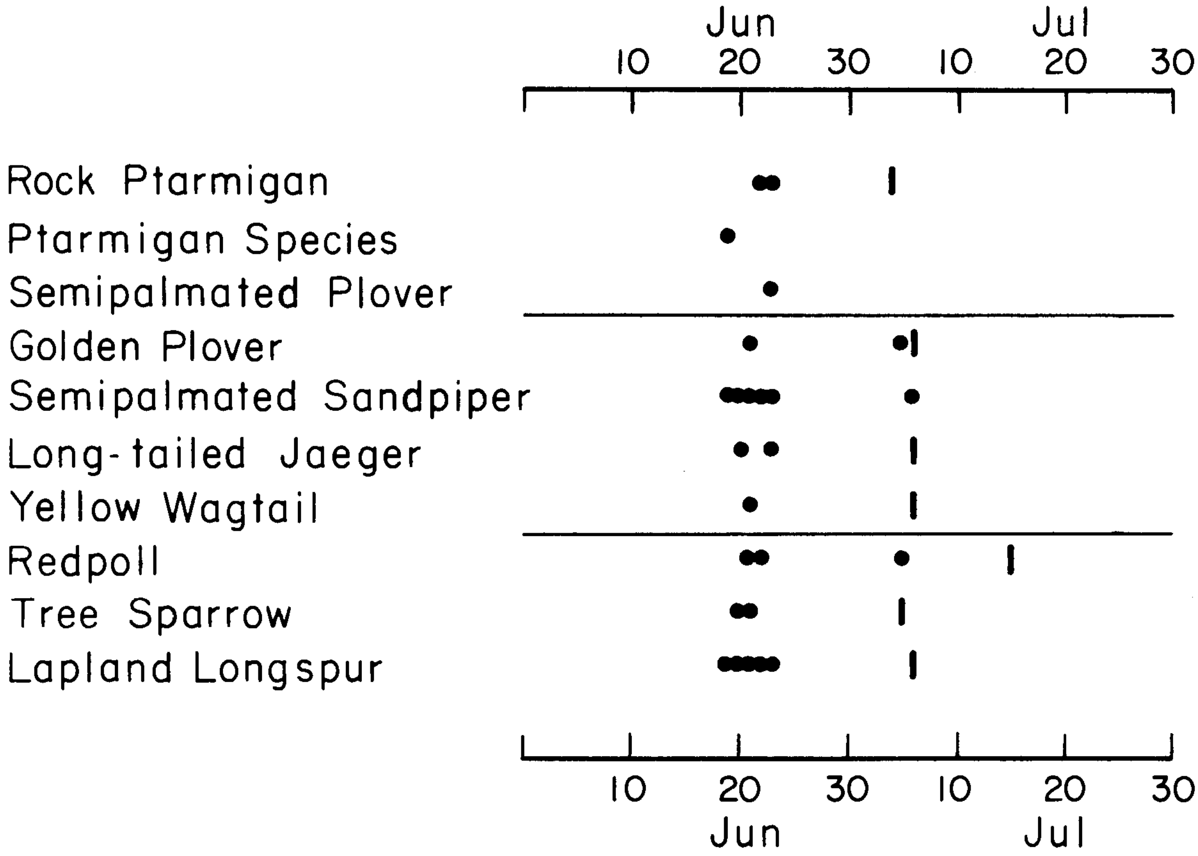


Fig. 8. Chronology and duration of nesting at Katakturuk River, Arctic National Wildlife Refuge, Alaska. First date each nest was found, (open circle) and last date active nests were relocated (bar).

Mosaic wet sedge tundra-moist complex-(3c) - The Mosaic plots supported the highest breeding populations of the 4 outer coastal plain tundra types censused on the Okpilak delta and had the greatest breeding species richness of all plots censused (Fig. 5). This habitat was dominated by Lapland longspurs which comprised half of the breeding density, and along with pectoral sandpipers comprised 70% of the total breeding density. Semipalmated sandpiper, northern phalarope, and red phalarope were other abundant species. Buff-breasted sandpipers reached their greatest abundance on the Mosaic plot (Fig. 5). Species richness was lower on the 10 ha plot relative to the larger plot, but breeding densities were higher with a greater occurrence of pectoral sandpipers (Fig. 5). Red phalaropes and semipalmated sandpipers achieved their greatest densities on the Mosaic (10 ha) plot.

Wet Sedge: wet sedge tundra-non complex (3a) - The Wet Sedge plot had the second lowest breeding population density and breeding species richness of the 4 outer coastal plain tundra habitats (Fig. 5). Density was one of the lowest among all plots censused, but species richness ranked third highest. Lapland longspur was the most abundant species with 50% of the breeding density. Pectoral sandpipers also dominated the breeding community and together with Lapland lonspurs comprised 78% of the total density. Red phalaropes were another common breeder. Long-billed dowitchers reached their greatest abundance in the Wet Sedge plot and stilt sandpipers were found nesting only in this habitat (Fig. 5).

The 10 ha plot was characterized by similarly low breeding and substantially lower species richness with nesting by only the 2 dominant species of the larger plot, Lapland longspur and pectoral sandpiper.

Sedge-Tussock: moist sedge tussock-prostrate shrub tundra (5a) - The Sedge-Tussock plot had the second highest breeding populations but lowest breeding species richness of the 4 outer coastal plain tundra habitats (Fig. 5). In comparison with all habitats censused in the coastal plain, it had intermediate species richness and density. Lapland longspurs dominated the plot with 70% of the total density. Oldsquaw ranked next in abundance with this being the only habitat where it was found breeding. Pectoral sandpiper, American golden plover, and northern phalarope were other breeders. Pectoral sandpipers and northern phalaropes had higher densities on the 10 ha plot than on the larger one (Fig. 5). Canada geese apparently bred in this habitat which was the only one where this species was found breeding.

Katakturuk Inland Plots

Riparian Willow: Dry prostrate shrub-forb tundra Dryas river terrace (4b), partially vegetated areas-river bars (9a), barren gravel or rock (10) - Riparian Willow plots along the Katakturuk River supported the highest breeding densities of any habitats censused on the coastal plain in 1982 (Fig. 6). Breeding species richness was intermediate, with a variety of Passerine species in the population, in contrast to the avian communities of the outer coastal plain which primarily consisted of 1 Passerine species (Lapland longspur) and a diversity of shorebirds and other species. The most abundant breeding species in Riparian Willow 1 plot were Lapland longspur, redpoll, and semipalmated sandpiper, which comprised 74% of the breeding density. The Riparian Willow 2 plot differed in species composition and dominance with only Lapland longspurs and semipalmated sandpipers comprising a similar segment of the breeding density (Fig. 6). Tree sparrows were common breeders exclusively on Riparian Willow 1 plot, but yellow wagtails and American golden plovers were uncommon breeders on both plots (Fig. 6).

Tussock: moist sedge tussock-dwarf shrub tundra (6a), moist dwarf shrub-sedge tussock tundra (7a) - Tussock plots at Katakturuk River in the interior coastal plain had higher breeding densities than all outer coastal plain plots except the Mosaic (10 ha) plot, but lower densities than the Katakturuk Riparian Willow plots (Fig. 6). Breeding densities were similar to those recorded for the Okpilak outer coastal plain Sedge-Tussock plots. Breeding species richness was relatively low. Lapland longspur and savannah sparrow were the most abundant species on Tussock 1 plot, comprising 77% of total density with pectoral sandpipers and semipalmated sandpipers also common breeders. Tussock 2 plot differed with lapland longspurs and semipalmated sandpipers comprising 88% of total density, and an absence of breeding pectoral sandpipers (Fig. 6).

Sedge Meadow: moist sedge-prostrate shrub tundra (5a) - Sedge Meadow plots in the interior coastal plain at Katakturuk supported the lowest breeding density and fewest species of any of the habitats censused (Fig. 6). Rock ptarmigan and Lapland longspur were the only breeders, with rock ptarmigan present only in Sedge Meadow 1 plot.

Overall chronology of nesting activities was not significantly different from that observed in 1978 (Fig. 7). Species nesting earlier in 1982 on the Okpilak Delta than in 1978 were pectoral sandpiper, long-billed dowitcher, and buff-breasted sandpiper (Fig. 7). Species nesting later in 1982 than in 1978 were red and northern phalarope. There were no detractable differences between the majority of the other species which nested on the Okpilak Delta in both years. Observations did not begin early enough at Katakturuk to compare nesting chronology with that of Okpilak (Fig. 8).

Changes in Breeding Bird Densities, 1978 to 1982 at Okpilak Delta. The extent of changes in breeding bird density varied considerably between habitat types and among bird species during the 2 years of study at the Okpilak River delta (Table 3). Overall breeding densities on the Mosaic plot remained nearly constant, decreasing only 2% from 1978 to 1982. While densities of most species were similar on this plot between years, 1982 breeding populations of shorebirds increased 43% from 1978 levels, whereas Lapland longspur densities decreased 25% in this time period. The largest increase in total breeding densities was recorded for the Wet Sedge plot, where an increase of 47% occurred from 1978 to 1982. This difference was accompanied by a 129% increase in numbers of breeding shorebirds in 1982. Breeding densities increased 39% from 1978 to 1982 on the Sedge-Tussock plot with a 50% increase in shorebird populations and a smaller proportion of the increase due to Lapland longspurs. The largest decline (61%) in total breeding populations from 1978 to 1982, occurred on the Flooded plot, where shorebirds again accounted for the largest percentage of the decline.

Similar or greater inter-year breeding population changes have been reported for other locations on the arctic coastal plain. Annual increases of 53-58% between 1979 and 1980 were documented at the Canning River delta. Maximum densities were 38-65% above the minimum densities observed at Barrow and

Table 3. *Breeding bird densities (nests and territories/km²) from various locations on the arctic coastal plain. Range of densities is presented for sites which have been censused for more than one year except at Katakturuk River where densities are given for 2 sites in 1 habitat type sampled during the same year. The category "others" includes ptarmigan, waterfowl, loons, etc.*

Location	Years	Breeding densities Shorebirds	Longspurs	Others	Total
ANWR-COASTAL					
Demarcation Bay (2b, 3b, 5b)[a]	1978-1979	47-90	43-67	3-10	123-143
Okpilak River Delta[b]					
Flooded 50 ha (2a,2b,3b)	1978,1982	38,20	10,12	13, 6	61, 38
Mosaic 50 ha (3c)	1978,1982	28,40	55,41	4, 0	87, 85
Wet Sedge 50 ha (3a)	1978,1982	14,32	29,32	2, 0	45, 66
Sedge-Tussock 50 ha (5a)	1978,1982	8,12	40,48	5, 8	49, 68
Canning River Delta					
Upland (5b)	1979,1980	31,39	20,35	0, 4	51, 78
Lowland (3b)	1979,1980	48,67	11,22	0, 4	59, 93
Mosaic (3c)	1980	74	51	12	137
ANWR-INLAND					
Katakturuk River					
Riparian Willow (4b, 9a, 10)					
1	1982	40	55	73	168
2	1982	50	50	15	115
Tussock (6a,7a)					
1	1982	20	50	18	88
2	1982	33	40	10	83
Sedge Meadow (5a)					
1	1982	0	10	10	20
2	1982	0	10	0	10
BARROW					
Wet Coastal Plain Tundra I[c]	1975-1979	67-118	30-44	6-25	113-171
Wet Coastal Plain Tundra II[c]	1975-1979	71-118	15-69	6-44	114-157
Wet Coastal Plain Tundra III[c]	1978-1979	41-70	43-88	0-12	96-158
PRUDHOE BAY					
IBP sites[d]	1971-1972	87-91	7-9	0	93-100
Wet Coastal Plain Tundra[e]	1979-1980	74-101	44-45	7	126-152
Waterflood Project[f]					
Experimental	1981	57	14	3	74
Control	1981	45	18	4	67
INLAND SITES					
Atkasook[c]	1977-1979	94-146	42-96	36-46	172-284
Pipeline Corridor (Franklin Bluffs)[g]	1979-1980	27-37	25-29	0-14	72- 76

[a] R. Burgess pers. comm.
[b] Spindler 1978a + this study
[c] Myers and Pitkela 1980.
[d] Norton et al. 1975.
[e] Hohenberger et al. 1980; Hohenberger et al. 1981.
[f] Troy 1982.
[g] Jones et al. 1980; Garrot et al. 1981.

Atkasook between 1975 and 1979 (Table 3). Smaller annual changes were noted for study sites at Prudhoe Bay and inland coastal plain sites along the Trans-Alaska Pipeline Corridor where maximum densities were only 6-21% higher than minimum densities (Table 3). Myers and Pitelka (1980) pointed out that the magnitude of annual changes in nesting densities in their arctic tundra study areas at Barrow and Atkasook were about the same as those experienced in temperate North American grasslands and less than the changes observed in desert bird communities.

The high degree of inter-year variation in shorebird populations seen for the Okpilak plots parallels the findings from studies of other arctic coastal plain areas (Myers and Pitelka 1980, Martin and Moitoret 1981 and Troy 1981). Species with particularly marked fluctuations in breeding at the Okpilak delta were northern phalarope, red phalarope, pectoral sandpiper, and semipalmated sandpiper. Myers and Pitelka (1980) noted that red phalarope and pectoral sandpiper were among the more annually variable species at Barrow and Atkasook. At Okpilak, inter-year fluctuations of pectoral sandpipers were the largest of any shorebird species. Pectoral sandpipers were more abundant in 1982, with densities on all plots increasing 100-200% from 1978 (Spindler 1978, See Appendix Table A-7). This increase in breeding pectoral sandpipers, juxtaposed with a decline in breeding phalarope densities in most habitats, caused them to be the dominant shorebird species on all plots in 1982. Fluctuations in pectoral sandpiper were also high at Demarcation Point, where sandpiper nesting density dropped 78% in 1 year (USFWS 1982). Decreases in red and northern phalarope breeding populations were most pronounced on the Okpilak Flooded plot, the area where they achieved their highest densities, with declines of 86% and 56%, respectively, between 1978 and 1982. On the Canning River delta Lowland plot (3b), northern phalaropes dropped considerably between 1979 and 1980, while red phalarope nesting density approximately doubled in the same period (USFWS 1982: 67-68). Semipalmated sandpiper nesting density increased on the Canning delta Upland plot (5b) between 1979 and 1980. Semipalmated sandpipers were more widely distributed breeders at Okpilak in 1978, although slightly greater densities were found on the Mosaic plot in 1982 (Spindler 1978, See Appendix Table A-7). Inter-year changes in shorebird species which have smaller populations were also noted, with long-billed dowitcher, stilt sandpiper, and buff-breasted sandpipers being more common breeders in 1982 as compared to 1978 (Spindler 1978, See Appendix Table A-7).

Inter-year fluctuations in breeding populations of Lapland longspurs were less between 1978 and 1982 at Okpilak delta than those observed at other areas (Table 3). Breeding Lapland longspurs increased 10-20% from 1978-1982 on all Okpilak plots except on the Mosaic plot where a decline of 25% was detected. In contrast, at the Canning River delta, breeding Lapland longspurs doubled on the Lowland plot and increased 75% on the Upland plot between 1979 and 1980 (Martin and Moitoret 1981). Longspur breeding densities also increased 75% at Demarcation Point during the same period. At Barrow and Atkasook, maximum breeding densities of longspurs ranged from 33-360% above the minimum densities observed during studies from 1975 to 1979 (Myers and Pitelka 1980). Comparing the 1978 and 1982 studies at Okpilak delta, inter-year differences in breeding species richness were greatest on the Flooded plot, where richness decreased from 10 to 7 species (Table 2, Spindler 1978). At the other Okpilak plots, species richness was similar in both years, although there were differences in species composition.

Comparison of Breeding Bird Densities, Inland Versus Near Coastline Tundra. Breeding bird densities in habitats censused during 1982 ranged from the highest to lowest yet recorded on the arctic coastal plain of ANWR (Table 3). The minimum and maximum extreme densities were both recorded for the inland site at Katakturuk. The Katakturuk Riparian Willow 1 plot had the highest reported breeding density and both Riparian Willow plots surpassed densities of all but the Mosaic plot at the Canning River delta (Table 3). In contrast, the Katakturuk Sedge Meadow plots had the lowest breeding densities of any habitats yet censused on the ANWR coastal plain. These low densities may be due to the inland location of a rather homogeneous habitat; where a lack of wetlands and micro-relief may not provide suitable habitats for nesting shorebirds and the lack of vertical structure in the vegetation may not be as attractive to passerines as nearby Riparian Willow. The habitat of Katakturuk Tussock plots was more diverse (in both vegetation and relief) than the Sedge Meadow plots and had correspondingly higher breeding populations which were intermediate compared to other coastal plain habitats in ANWR. This high breeding density in the inland Tussock plots was unexpected (Table 3). Further study, including replicate plots in geographically-separated similar habitat types in ANWR inland coastal plain tundra may clarify the reason for these high densities. Myers and Pitelka (1980) compared breeding densities of an inland coastal plain site at Atkasook to coastal locations at Barrow, finding similar breeding populations between the 2 areas, both of which were higher than densities for most areas in ANWR (Table 3). Moreover, the habitat studied at Atkasook was far more diverse than the Katakturuk study site, and included more wetlands as typifies the coastal plain further to the west of ANWR. Breeding densities in the coastal locations in ANWR for Flooded, Mosaic and Sedge-Tussock plots at Okpilak were generally lower than in their counterparts at the Canning River delta (Table 3).

Breeding bird community composition differed between interior and coastal habitats as well as among coastal tundra habitats in ANWR. The Katakturuk Riparian Willow plots had a species composition distinct from all other habitats yet studied on the ANWR coastal plain (USFWS: 67-68, See Appendix Table A-7). Unique attributes were dominance of a variety of passerine species prevalent in the breeding population such as yellow wagtail, redpoll, and tree sparrow, which do not commonly breed in other coastal plain habitats. In addition to the Lapland longspurs, a fairly high shorebird breeding population was observed in conjunction with willows. Lapland longspur was the single most abundant species on all plots sampled at Katakturuk and it outnumbered total shorebird breeding densities. This pattern of longspur dominance also existed for Okpilak plots except on the Flooded plot where breeding shorebirds were a majority of the breeding bird community in both years. At the Canning River delta, Lapland longspur was also the single most abundant species, but shorebirds as a group were more abundant breeders on all plots (Table 3). Since breeding densities of longspurs were similar for comparable plots on the Canning and Okpilak deltas, the higher shorebird component appears to contribute to the higher overall densities found at the Canning delta (Table 3). This increasing shorebird component to the west was observed outside ANWR as well, with the higher densities of shorebirds near Prudhoe Bay and Barrow (Table 3). Regional differences in species distribution apparently account for some of the disparities between breeding density and species composition on the Okpilak delta and the Canning delta and other areas further to the west. Breeding densities of red phalaropes were substantially higher in lowland habitat at

Canning River than in any Okpilak plots. Dunlin were only a rare visitor at Okpilak, yet bred on both Mosaic and Upland plots at the Canning Delta.

Breeding bird densities on the arctic coastal plain were generally higher at Prudhoe Bay and Barrow (Table 3) a pattern probably due to the more extensive wetlands in these coastal areas as well as in the inland areas such as Atkasook, where there was a higher degree of interspersion of wetland and upland habitats (Myers and Pitkela 1980) than was present at the Katakturuk River site.

Community species richness. The highest expected species richness [$E(S)_5$] was observed in the Flooded and Riparian Willow plots, whereas the lowest was observed in the Wet Sedge (10 ha), Sedge Meadow, and Sedge-Tussock plots (Table 4). Plots with highest expected species richness were not necessarily the ones with highest species richness: Mosaic (50 ha) and Wet Sedge (50 ha) had 8 and 7 breeding species, respectively, but they ranked intermediate in expected species richness (Table 4). The rates of accumulation of additional species per increase in number of individuals in the above 2 communities were not as high as their species richness values suggest (Table 4, Fig. 9). Relatively high initial rates of accumulation of additional species were observed for the Flooded (50 ha), Riparian Willow 1, Riparian Willow 2, Mosaic (50 ha), Wet Sedge (50 ha), Tussock I and Sedge Tussock (25 ha) plots (Fig. 9). Overall rates of accumulation were difficult to assess because curves of all small plots ended before their asymptote was reached due to limited community size (Fig. 9). The 10 ha plots in most tundra types on ANWR had too few individuals to generate a complete rarefaction curve, and with the data set of mixed plot sizes, breeding density was a poor predictor of expected species richness (R^2 = 0.030). The best comparator of expected species richness among the 1982 ANWR plots was simply $E(S)_5$ from Table 4 because the curves were truncated and the density/expected richness relation was so poor.

Further to the west, species richness was greater, with the following species, which were only visitors on coastal plots on ANWR, present as breeders in coastal habitats in Barrow and sites in NPR-A: Baird's sandpiper, ruddy turnstone, western sandpiper, white-rumped sandpiper, common snipe, spectacled eider, white-fronted goose, snow goose, black-bellied plover, arctic tern, Sabine's gull, pomarine jaeger (Myers and Pitelka 1980, Derksen et al. 1981). Steller's eider and white-rumped sandpiper were breeding species in the western coastal areas that were not found breeding in ANWR. Additional breeding species found in inland areas at Atkasook and in NPR-A were greater scaup, yellow-billed loon, green-winged teal and bar-tailed godwit. All but the bar-tailed godwit breed or probably breed on the ANWR interior coastal plain, however, they were not abundant enough to be measured quantitatively using plot methods.

Mean Summer Total Populations

A total of 48 species was observed at the Okpilak River delta (32 on census plots) and 35 species were seen at Katakturuk River (19 on census plots) during summer 1982 (Table 5). Mean summer total bird populations were highest in the Riparian Willow plots at Katakturuk River as was also the case for breeding densities on the coastal plain. Total summer densities for the Flooded plots at Okpilak River delta were next in abundance whereas their breeding densities ranked far lower. The Sedge Meadow plots had lowest mean summer total populations, the same rank they held among breeding densities.

Table 4. Breeding bird community rarefaction statistics for all 14 plots censused, arctic coastal plain. Arctic National Wildlife Refuge, Alaska, June-July 1982.

Plot	Area	Raw breeding density	Species richness	$E(S)_5$	Var. $E(S)_5$
Flooded	50	19.0	7	3.5	0.6
Flooded	10	6.0	5	4.3	0.6
Mosaic	50	41.5	8	3.1	0.8
Mosaic	10	12.0	4	2.8	0.5
Wet Sedge	50	32.0	7	2.9	0.7
Wet Sedge	10	4.0	2	1.7[a]	0.2[a]
Sedge-Tussock	25	17.0	5	2.4	0.7
Sedge-Tussock	10	8.0	3	2.2	0.4
Riparian willow 1	10	16.8	6	3.5	0.6
Riparian willow 2	10	12.0	5	3.2	0.6
Tussock 1	10	8.8	4	2.9	0.5
Tussock 2	10	8.8	3	2.6	0.3
Sedge meadow 1	10	2.0	2	b	b
Sedge meadow 2	10	1.0	1	b	b

[a] $E(S)_4$ given because not enough individuals in population to calculate $E(S)_5$.
[b] Not enough individuals in population to perform rarefaction.

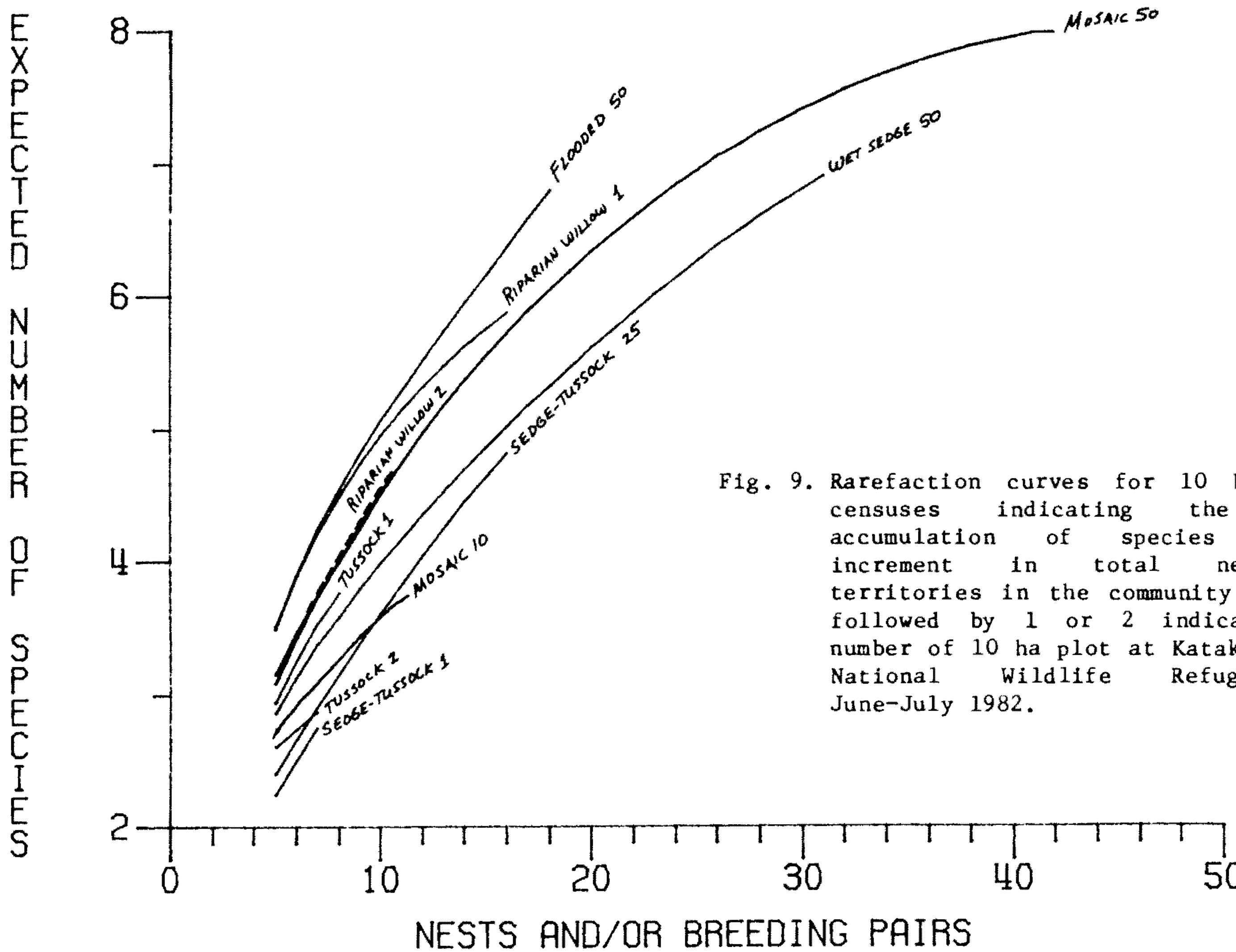


Fig. 9. Rarefaction curves for 10 breeding bird censuses indicating the rate of accumulation of species with each increment in total nests and/or territories in the community. Plot names followed by 1 or 2 indicate replicate number of 10 ha plot at Katakturuk, Arctic National Wildlife Refuge, Alaska, June-July 1982.

As with breeding densities, higher summer total population densities were estimated at the Okpilak River delta for the 10 ha replicate plots relative to the 25 or 50 ha plots, except for the Wet Sedge plot.

There was a strong relationship between mean total densities and species richness for the Katakturuk census plots (R^2 = 0.90) and among the Okpilak 10 ha plots (R^2 = 0.99), but only a weak relationship existed for the larger Okpilak plots (R^2 = 0.38; Fig. 10). Species richness was higher for all Okpilak 50 or 25 ha plots compared to the 10 ha plots, with greatest numbers of species (20) found on the Flooded plot. Lowest species richness was observed in the Okpilak Wet Sedge (10 ha) plot (5 species) with Katakturuk Sedge Meadow plots having only 1 more species.

Total summer population density dominance structures (Fig. 11 and 12) were similar to breeding population structures. Lapland longspurs had highest mean summer total populations in all areas except the Flooded plots where pectoral sandpipers (50 ha plot) and glaucous gull (10 ha plot) had highest densities. Co-dominant species in the total summer populations varied among census plots and consisted of pectoral sandpiper, northern phalarope or red phalarope at Okpilak River delta sites and consisted of semipalmated sandpiper, savannah sparrow, rock ptarmigan, or parasitic jaeger on plots at the Katakturuk River.

<u>Flooded: pond complex (2a), aquatic tundra-pond complex (2b), wet sedge tundra-very wet complex (3b)</u> - The Flooded (50 ha) plot had the highest mean summer total bird densities of all sample sites on the outer coastal plain at Okpilak River delta and was only exceeded in density by the Riparian Willow plots at Katakturuk. The Flooded (10 ha) plot exceeded all but the Flooded (50 ha) plot, Mosaic (10 ha) plot and Riparian Willow plots in terms of mean summer total density (Table 5). The high total densities on the Flooded plots at Okpilak relative to other sites indicated their importance to tundra bird populations despite low levels of breeding occurring there in 1982. Total summer population species richness was greatest in the Flooded plot (50 ha) with respect to all coastal plain sites censused in 1982. Pectoral sandpiper, red phalarope, and northern phalarope were dominant species comprising 74% of the mean total summer populations (Table 5), but only comprising 53% of the breeding population. These species, especially the phalaropes, heavily utilized this habitat for feeding and staging activities but not breeding in 1982. Summer populations of these species were higher on the Flooded plot than in any other coastal plain habitats (Table 5). Lapland longspur was next most numerous in summer population, whereas it had been the most abundant breeding species in the habitat. Waterfowl species, including whistling swan, Canada goose, pintail, and oldsquaw reached their highest total densities on the Flooded plots and loons were only observed in the Flooded plot (Table 5).

Summer populations on the Flooded (10 ha) plot differed from the larger plot primarily due to 1) existence of a glaucous gull colony and numerous non-breeders associated with it, and 2) lower red phalarope densities.

<u>Mosaic: wet sedge tundra-wet/moist complex (3c)</u> - The Mosaic plots had the third highest mean summer total population density and species richness of plots sampled in 1982, ranking just below Flooded and Riparian Willow (Table 5). Lapland longspur and pectoral sandpiper were dominant species comprising a 64% of the summer total density, similar to their dominance in the breeding population. Density dominance structures paralleled breeding

Table 5. Mean summer bird populations (birds/km^2) on bird census plots in outer coastal plain, Okpilak River delta, and interior coastal plain, Katakturuk River, Arctic National Wildlife Refuge, Alaska, June-July 1982.

Species	Flooded (2a,2b,3b)		Mosaic (3c)		Wet Sedge (3a)		Sedge-Tussock (5a)		Riparian Willow (4b,9a,10)		Tussock (6a,7a)		Sedge Meadow (5a)	
	50 ha	10 ha	50 ha	10 ha	50 ha	10 ha	25 ha	10 ha	10 ha 1	10 ha 2	10 ha 1	10 ha 2	10 ha 1	10 ha 2
Arctic loon	5.0	17.5												
Red-throated loon	2.5	5.0												
Whistling swan	2.5	5.0												
Canada goose	1.5													
White-fronted goose							2.0							
Pintail	6.5	15.0	3.5		1.0		1.0				3.3			
Oldsquaw	4.0	7.5	5.5		1.5		2.0	5.0						
King eider	1.0				1.0									
Rough-legged hawk										3.3			3.3	
Marsh hawk					0.5									
Willow ptarmigan							4.0							
Rock ptarmigan			0.5	7.5			1.0	2.5		6.7	3.3	6.7	10.0	
Sandhill crane					1.5									
Semipalmated plover									6.7	6.7				
American golden plover	0.5		3.0	12.5	2.5		4.0	7.5	23.3	20.0				
Whimbrel	3.5													
Ruddy turnstone										10.0				
Northern phalarope	58.5	67.5	7.5		17.0	2.5	22.0	12.5				3.3		
Red phalarope	60.5	12.5	7.0	10.0	5.0		2.0	5.0						
Phalarope sp.	0.5													
Long-billed dowitcher	7.5	12.5	4.5	2.5	10.5									
Semipalmated sandpiper	2.5	12.5	10.5	7.5			1.0	2.5	60.0	100.0	30.0	53.3		
Baird's sandpiper									3.3	3.3				
Pectoral sandpiper	77.0	22.5	45.5	55.0	32.0	30.0	20.0	20.0			20.0			3.3
Stilt sandpiper			0.5		4.0									
Buff-breasted sandpiper	1.0		14.0	10.0	1.5	5.0				10.0	3.3			
Pomarine jaeger			4.5	2.5	0.5		4.0							
Parasitic jaeger	2.5	5.0	5.0	2.5	5.0		4.0	2.5					6.7	6.7
Long-tailed jaeger	4.5		2.5	5.0	5.0	5.0	5.0	7.5	10.0	16.7	6.7		3.3	6.7
Glaucous gull	3.5	7.0	2.5											
Herring gull		2.5												

Table 5. (Continued).

Species	Flooded (2a,2b,3b) 50 ha	Flooded (2a,2b,3b) 10 ha	Mosaic (3c) 50 ha	Mosaic (3c) 10 ha	Wet Sedge (3a) 50 ha	Wet Sedge (3a) 10 ha	Sedge-Tussock (5a) 50 ha	Sedge-Tussock (5a) 10 ha	Riparian Willow (4b,9a,10) 10 ha 1	Riparian Willow (4b,9a,10) 10 ha 2	Tussock (6a,7a) 10ha 1	Tussock (6a,7a) 10 ha 2	Sedge Meadow (5a) 10 ha 1	Sedge Meadow (5a) 10 ha 2
Snowy Owl	1.0		1.5	2.5	1.0									
Short-eared owl			0.5		1.5							3.3		3.3
Horned lark									6.7					
Barn swallow							1.0							
Common raven					0.5									
Yellow wagtail									26.7	23.3		6.7		
Redpoll									60.0	36.7			3.3	3.3
Savannah sparrow											43.3	16.7		
Tree sparrow									43.3					
Fox sparrow							1.0							
Lapland longspur	20.5	20.0	83.5	127.5	86.0	55.0	114.0	127.5	190.0	166.7	90.0	63.3	26.7	43.3
Total density	266.5	212.0	202.0	245.0	177.5	97.5	188.0	192.5	430.0	403.4	199.9	153.3	53.3	66.6
Total species	20	14	18	12	19	5	16	10	10	12	8	7	6	6

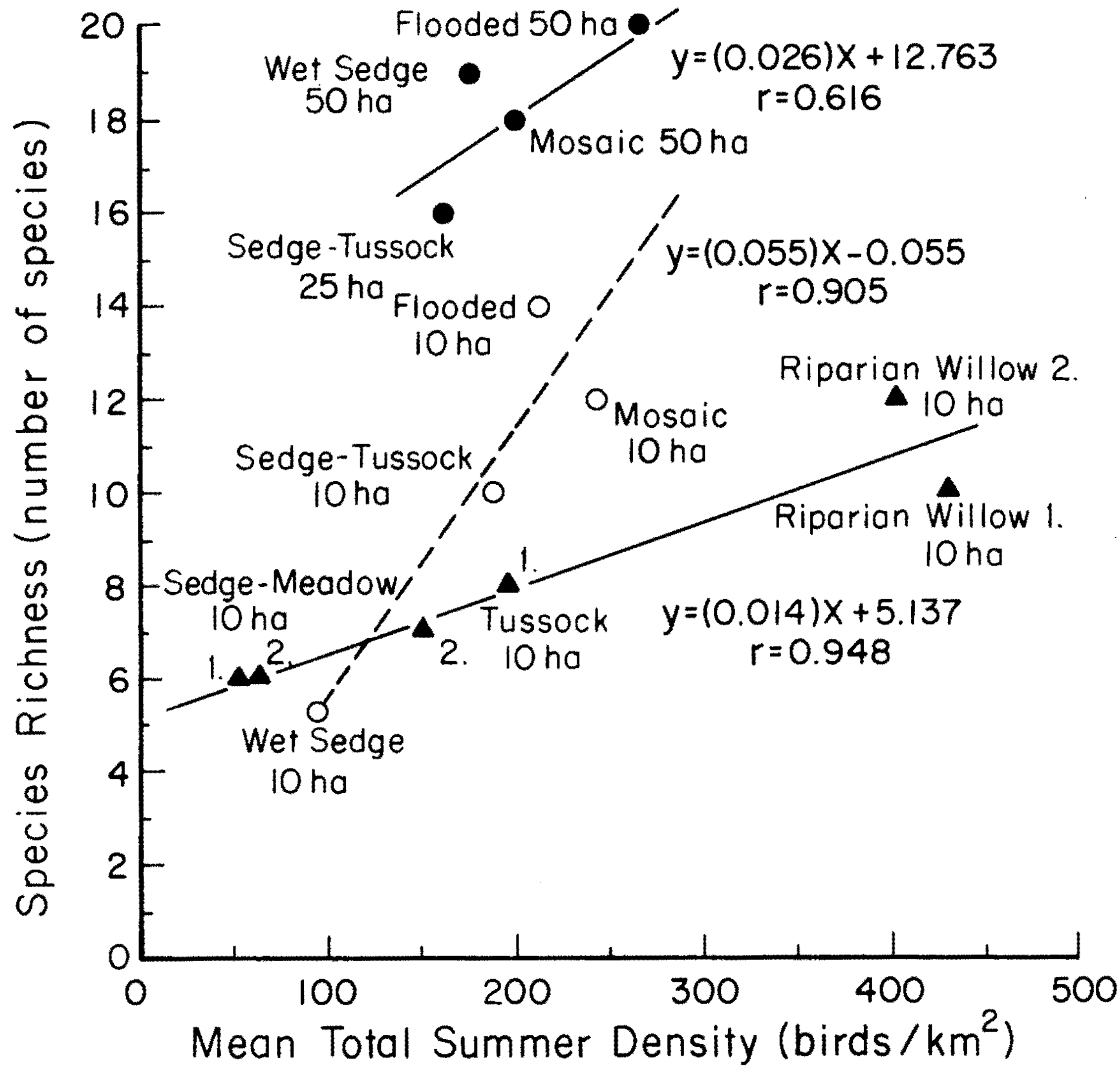


Fig. 10. Relationship between mean summer total density and summer species richness for Okpilak large plots (solid circles) Okpilak 10 ha plots (open circles) and Katakturuk 10 ha plots (triangles), Arctic National Wildlife Refuge, Alaska, June-July 1982.

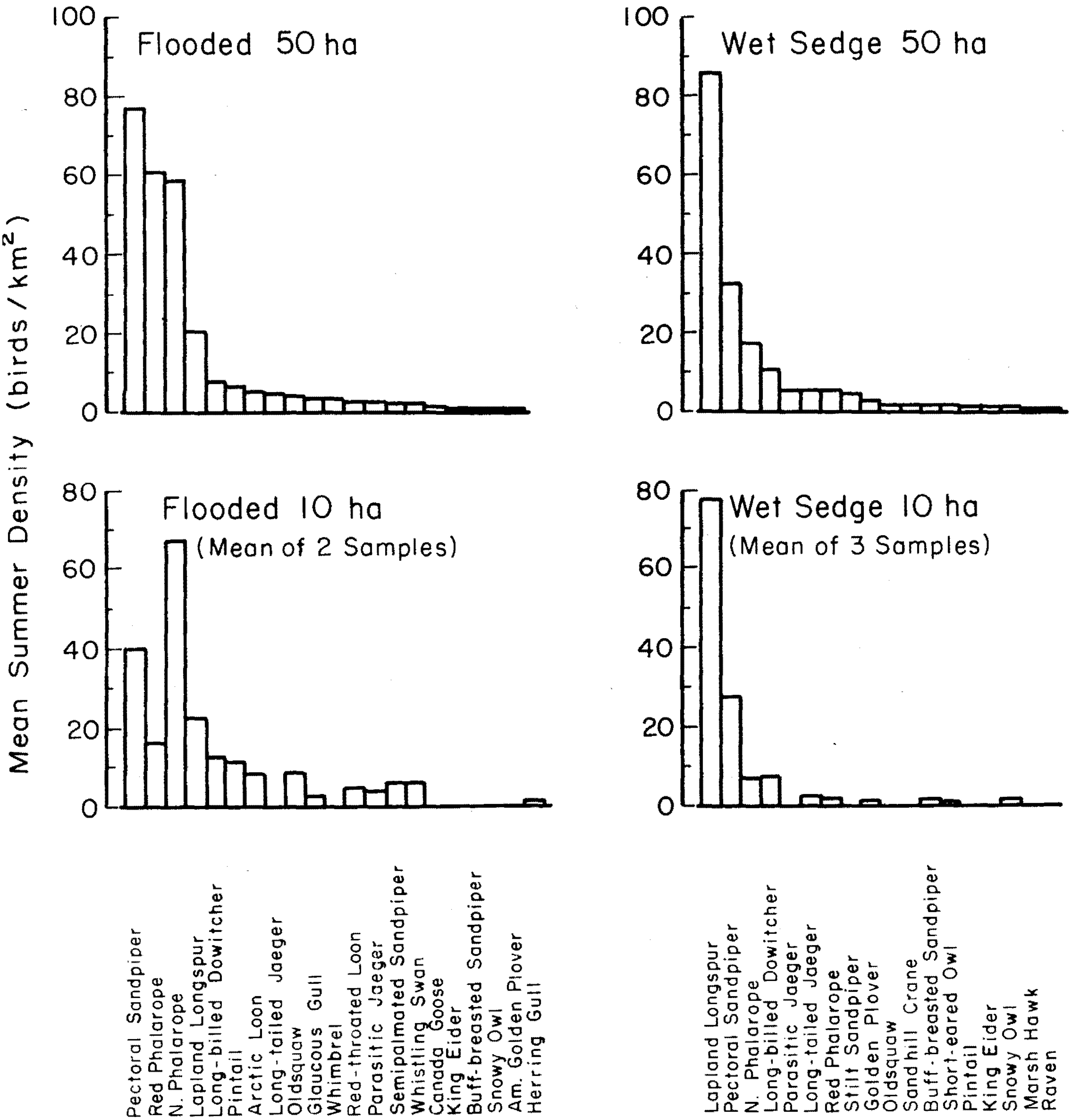


Fig. 11. Density dominance structures for mean summer total density of 50 ha Flooded and Wet Sedge plots compared to mean of replicate 10 ha plots, Okpilak River delta, Arctic National Wildlife Refuge, Alaska, June-July 1982.

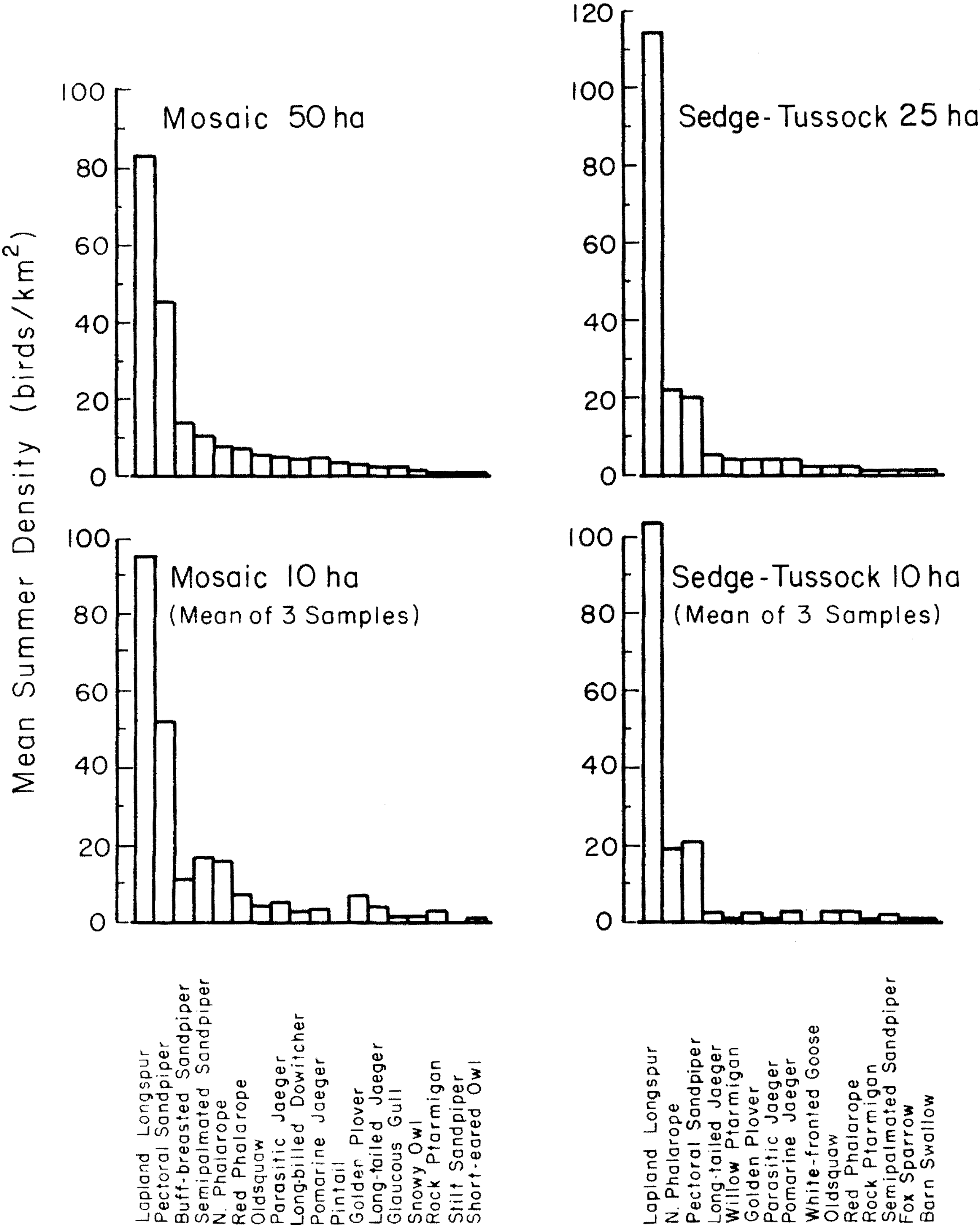


Fig. 12. Density dominance structures for mean summer total density of large Mosaic and Sedge-Tussock plots compared to mean of replicate 10 ha plots, Okpilak River delta, Arctic National Wildlife Refuge, Alaska, June-July 1982.

population data, with buff-breasted sandpiper, semipalmated sandpiper, northern phalarope, and red phalarope similarly important components of total summer population. Summer total populations on the Mosaic (10 ha) plot differed from the 50 ha plot by lower numbers of species present and with notable absence of northern phalarope (Table 5).

Wet Sedge: wet sedge tundra-non complex (3a) - The Wet Sedge plot (50 ha) had the lowest summer total population density of all habitats censused at the Okpilak River delta and among the lowest of all plots sampled in the coastal plain, yet species richness was second highest of all plots (Table 5). Species which were found breeding made up the major part of the total population with Lapland longspurs and pectoral sandpipers having a dominance value of 67%. Northern phalaropes had relatively high densities compared to their breeding numbers. Long-billed dowitchers and red phalaropes were other important members of the total summer population.

The Wet Sedge (10 ha) plot had the lowest species richness for any plot censused with only 5 species observed. Lapland longspur and pectoral sandpipers represented 87% of the total population.

Sedge-Tussock: moist sedge tussock-prostrate shrub tundra (5a) - The Sedge-Tussock plot had intermediate summer population density (Table 5). Species richness was lowest for large Okpilak plots, but higher than other plots censused on the coastal plain. Lapland longspurs were the most abundant species, comprising 61% of the mean summer density. Northern phalaropes, pectoral sandpipers, and long-tailed jaegers were other abundant species. Oldsquaw and American golden plover ranked higher in breeding population than in total population (Table 5).

Riparian Willow: dry prostrate shrub-forb tundra Dryas river terrace (4b), partially vegetated areas-river bars (9a), barren gravel or rock (10) - Riparian Willow plots had the highest mean total population densities of all habitats censused on the coastal plain (Table 5). Summer species richness ranked highest for study plots in the interior coastal plain, but was lower than nearly all plots on the Okpilak River delta, thereby differing with its breeding species richness which was fourth highest among all coastal plain plots (Table 2). The summer total populations dominance structure in the Riparian Willow plots paralleled that of breeding species composition. Lapland longspur, semipalmated sandpiper, and redpoll made up 72% of the density in plot 1 and 75% in plot 2 with semipalmated sandpiper more numerous and redpolls half as abundant in plot 2. Long-tailed jaegers were a common species on plot 2 but used nearby habitats for breeding.

Tussock: moist sedge tussock-dwarf shrub tundra (6a), moist dwarf shrub-sedge tussock tundra (7a) - Tussock plots had intermediate and low mean summer total population densities, in contrast to ranking high among breeding population densities of all coastal plain plots (Tables 2 and 5). Species richness for summer total populations paralleled the breeding population ranking with low values. Lapland longspur was the most abundant species, co-dominated by savannah sparrow for 67% of total density on plot 1 and with semipalmated sandpiper for 76% of total density on plot 2.

Table 6. Mean seasonal total bird densities (birds/km^2) from various locations on the arctic coastal plain, Alaska. Separate mean summer and fall densities are presented for ANWR sites: Okpilak River delta (only summer determined by Spindler 1978); Canning River delta - summer and fall densities estimated for census periods comparable to studies at Okpilak from data in Martin and Moitoret (1981). Seasonal densities for NPR-A sites consider the period June-August (Derksen et al. 1981). Data for Prudhoe Bay are from Troy (1982).

Location	Years	Mean summer total densities								Fall densities							
		Shorebirds		Longspurs		Others		Totals		Shorebirds		Longspurs		Others		Total	
ANWR - COASTAL																	
Okpilak River delta																	
Flooded 50 ha	1978,1982	208.8	211.5	9.6	20.5	26.8	34.5	245.2	266.5		452.0		62.0		20.0		534.0
Mosaic 50 ha	1978,1982	82.0	92.5	96.0	83.5	10.0	26.0	188.0	202.0		132.0		106.0		6.0		244.0
Wet Sedge 50 ha	1978,1982	42.4	72.5	62.5	86.0	7.0	29.0	111.9	177.5		48.0		80.0		4.0		132.0
Sedge-Tussock 25 ha	1978,1982	25.7	49.0	97.3	114.0	12.0	25.0	135.0	188.0		44.0		76.0		4.0		124.0
Canning River delta																	
Upland	1979,1980	61.3	42.4	61.7	97.3			127.0	145.1	39.2	90.1	74.5	109.8			113.7	199.9
Lowland	1979,1980	125.6	115.5	31.1	56.7			156.9	171.4	233.1	281.2	99.9	59.2			333.0	329.3
Mosaic	1980		115.8		121.5				235.0		51.0		43.1				94.1
ANWR - INLAND																	
Katakturuk River																	
Riparian willow (1,2)	1982	93.3	150.0	190.0	166.7	146.7	86.7	430.0	403.4	10	10	180	150	230	120	420	280
Tussock (1,2)	1982	53.3	56.6	90.0	63.3	56.6	33.4	199.9	153.3			150	120	90		240	120
Sedge meadow (1,2)	1982		3.3	26.7	43.3	26.6	20.0	53.3	66.6	40	190	90	20			130	210
NPR-A - COASTAL																	
East Long Lake	1977,1978	113.2	77.6	64.2	47.6	36.6	25.7	214.0	150.9								
Island Lake	1978		44.9		24.3		25.1		94.3								
Meade River delta	1977	86.0		24.1		13.8		123.9									
Storkerson Point	1977,1978	90.6	99.3	20.4	36.7	25.0	17.5	136.0	153.5								
NPR-A INLAND (Near Foothills)																	
Singiliuk	1977	60.9		42.3		26.3		129.5									
Square Lake	1978		62.3		42.5		21.6		126.4								
PRUDHOE BAY - COASTAL																	
Waterflood Project:																	
Experimental	1981	161.8		71.4				262.6									
Control	1981	95.1		43.1				153.0									

[a]includes loons, waterfowl, ptarmigan, raptors, and passerines except for Lapland longspur.

Sedge Meadow: moist sedge-prostrate shrub tundra (5a) - Sedge Meadow plots had lowest mean summer total bird densities and second lowest total species richness of any plots censused on the coastal plain (Table 5). Lapland longspur and rock ptarmigan, the only species which bred on plot 1, dominated total populations comprising 69% of the density. On plot 2, 65% of the total density consisted of Lapland longspurs, which were the only breeding species in this plot.

Changes in Mean Summer Total Populations, 1978 to 1982 at Okpilak Delta. Inter-year changes in mean summer total bird populations at the Okpilak River delta varied to a larger degree than did breeding populations. Total summer densities were 7-59% higher on all plots in 1982 compared to 1978 despite lower breeding densities on 2 plots (Table 6). These increases may be partly due to a more intensive census effort, with 29-86% more person-hours spent censusing plots in 1982; however, this increase would also be reflected in breeding densities which was not the case. As in the breeding populations, the Mosaic plot had the least fluctuation between the 2 years. Shorebird total populations on the Mosaic plot increased 13%, while Lapland longspur populations decreased an equivalent degree, though changes for those groups within the total population varied less than within the breeding population. The largest discrepancy occurred on the Flooded plot where total summer populations remained fairly constant, with 2 increasing slightly through the season; however, breeding populations declined substantially from 1978 to 1982. This decrease in breeding shorebirds on the Flooded plot from 1978 to 1982 was not reflected in the total shorebird density which remained at a constant level between the 2 years. Lapland longspur densities on the Flooded plot increased 114% from 1978 to 1982, and was the largest fluctuation for this species in any habitat at Okpilak. This increase was not proportinate to the corresponding increase in breeding populations. Greatest increase from 1978 to 1982 in total summer bird populaton densities occurred on the Wet Sedge plot. Percentage increase in total summer populations on the Sedge-Tussock plot between the 2 years was equal to the change in breeding population, although there was a greater increase for the shorebird segment of total population. While shorebird summer populations increased in all plots from 1978 to 1982, the largest increase was experienced on the Sedge-Tussock plot. In a pattern opposite to that observed on the Okpilak River delta, inter-year changes in total summer populations at the Canning River delta were less substantial than the breeding population fluctuation (Tables 3 and 6).

Inter-year changes in species richness occurred on the Okpilak delta plots, although there were only slight variations on the Flooded plot (2 fewer species in 1982) and Mosaic plot (2 more species in 1982). Species richness was substantially greater on the Wet Sedge and Sedge-Tussock plots in 1982 compared with 1978, largely due to increased visitation by waterfowl and predators including marsh hawk, jaegers, and owls (Table 5, Spindler 1978).

Changes in total summer shorebird densities between 1978 and 1982 at Okpilak delta were most pronounced for northern phalarope, red phalarope, and semipalmated sandpiper. Total summer populations of northern phalarope substantially increased (52-450%) from 1978 to 1982 on all plots except the Mosaic (Table 5, Spindler 1978), whereas breeding densities decreased during this time period, suggesting greater use by staging northern phalaropes in the

Okpilak area during 1982. Red phalarope mean summer densities decreased from 1978 to 1982 on the Flooded and Mosaic plots, with the change in the summer population on the Flooded plot less dramatic than the change in breeding densities. Summer densities of red phalarope on the Wet Sedge and Sedge-Tussock plots showed increases in 1982 as compared to 1978. Semipalmated sandpiper summer populations decreased in all habitats in 1982 which was reflected in lower breeding populations. While pectoral sandpiper breeding densities showed the largest fluctuations of any shorebird species from 1978 to 1982, a similarly large increase in mean total summer population was only noted for the Sedge-Tussock plot (199%), whereas densities on Mosaic and Wet Sedge plots increased 1-2% and decreased 11% on Flooded plot. These data suggest that either a higher percentage of breeders in the total population occurred in 1982, or the differences may be due to greater success at finding pectoral sandpiper nests in 1982. Long-billed dowitcher, stilt sandpiper, and buff-breasted sandpiper were more abundant and more widely distributed in Okpilak habitats in 1982. Inter-year comparisons of loons and waterfowl at Okpilak delta plots showed similar distributions and densities between years. Densities of avian predators were generally higher in 1982, as were observations of lemmings during censuses.

The Flooded plot at Okpilak was consistently higher in total summer density than the Lowland plot on the Canning River delta, a similar flooded tundra type. The Mosaic plot at Canning in 1980 supported higher total density than the Mosaic at Okpilak in either 1978 or 1982 and, unexpectedly, it exceeded the Lowland plot at Canning as well (Table 6).

<u>Comparison of Mean Summer Total Populations, Inland Versus Near Coastline Tundra</u>. No clear pattern was apparent when mean total density observation from the ANWR outer coastal plain were compared to those of the interior coastal plain (Table 6). The Riparian Willow plots, both inland, exceeded all other plots in summer total density, yet the Sedge Meadow plot, also inland, had the lowest observed densities (Table 6). Flooded and Mosaic plots, both Canning and Okpilak, ranked just under the Riparian Willow plots in terms of mean summer total density, while Wet Sedge, Sedge Tussock, Tussock, Upland and Lowland (latter 2 at Canning) ranked intermediate to low in mean summer total density (Table 6).

There have been few censuses on the Alaska north slope that have enumerated mean total density; most have focussed on breeding populations. Available data from elsewhere on the north slope indicate that ANWR total densities in comparable habitat types are about equivalent to those further west. For example, wet sedge types in ANWR ranged from a low of 119.1 birds/km^2 for the Wet Sedge (50 ha) plot in 1978 to a high total of 188.0 birds/km^2 on the Sedge Tussock (25 ha) plot in 1982. Similar ranges occurred in NPR-A: 94.3 birds/km^2 at Island Lake in 1978 to 214.0 birds/km^2 at East Long Lake in 1977 (Table 6). The inland sedge tundra densities at NPR-A were higher than some coastal sites, (Meade River, Island Lake) but lower than most others, as was found in ANWR (Table 6). At Prudhoe Bay, the total density estimate of 262.6 birds/km^2 exceeded other Wet Sedge tundra estimates of total density and was equivalent to the ANWR Flooded plot estimates of 245.2-266.5 birds/km^2.

Shorebirds occupied over 50% of the total density on the Okpilak Flooded and Canning Lowland plots; on all other ANWR plots, Lapland longspur occupied a majority of mean total density (Table 6). In contrast, at all NPR-A sites shorebirds occupied a greater percentage of mean total density than did Lapland longspur (Table 6). There were some specific community composition differences between the Okpilak and Canning areas within ANWR as well. The Canning delta showed lower mean densities of northern phalarope whereas the Mosaic plot, had higher semipalmated sandpiper densities than the Okpilak. The Canning area also had Dunlins present on plots in quantifiable numbers (Martin and Moitoret 1981), but they did not occur on the Okpilak delta. Another difference between 2 north slope areas in 1982 was the observed high abundance of pectoral sandpipers at Okpilak and unusually low numbers of semipalmated sandpipers (Table 5); 200 km to the west at Prudhoe Bay, Troy (pers. comm.) observed the opposite pattern, with a paucity of pectoral snadpipers and abundance of semipalmated sandpipers.

Total Fall Bird Populations

Total fall population densities were higher than mean summer population densities in all habitats censused on the coastal plain in 1982 (Table 2). For all plots censused in the fall, highest densities and second highest species richness were recorded on the Flooded (50 ha) plot (534 birds/km^2 and 13 species) and greatest richness (14 species) was found on the Mosaic (10 ha) plot. Lowest density and species richness occurred on Tussock #2 plot at Katakturuk (120 birds/km^2, 1 species). In contrast to breeding and summer populations, the relationship between species richness and fall total densities was poorly defined (R^2 = 0.38, Fig. 13). Sixteen species were observed at Okpilak River delta and 10 species were recorded at Katakturuk River during fall censuses (Table 7).

Shorebird densities were higher in the fall at Okpilak River delta study plots than during July, but only on the Mosaic plots did fall densities exceed peak numbers recorded in June (Fig. 14 and 15). Dominant shorebird species were long-billed dowitcher, pectoral sandpiper, and American golden plover (Table 7). Long-billed dowitchers were the most abundant shorebird on the Mosaic and Wet Sedge plots and second most abundant on the Flooded plot during fall. Pectoral sandpipers were the most abundant shorebird on the Flooded plot and were common in all habitats except the Sedge-Tussock (25 ha) plot where American golden plovers were the most abundant shorebird (Table 7). Greatest shorebird species richness (7 species) as well as abundance of shorebirds was reached in the Flooded (50 ha) plot. Northern and red phalaropes had low densities in fall, in contrast to the breeding season when they were dominant species.

At the Katakturuk River study area the trend in shorebird density was reversed, with fewer shorebirds observed in the fall in all habitats except the Sedge Meadow plots where densities increased, largely due to the presence of flocking pectoral sandpipers (Fig. 16 and 17). Semipalmated sandpipers, which had been the most common shorebird species in summer, were absent in fall.

Density of passerines increased in the fall over numbers recorded in July on all coastal plain plots except Sedge-Tussock (10 ha) and Mosaic (10 ha) where it decreased (Fig. 14-17). Fall densities were equivalent to or greater than peak summer densities on half the plots censused. Lapland longspur was the most abundant bird species on all plots in fall except on the Flooded plots, the Sedge Meadow 2 plot, and on the Mosaic (10 ha) plot where longspur

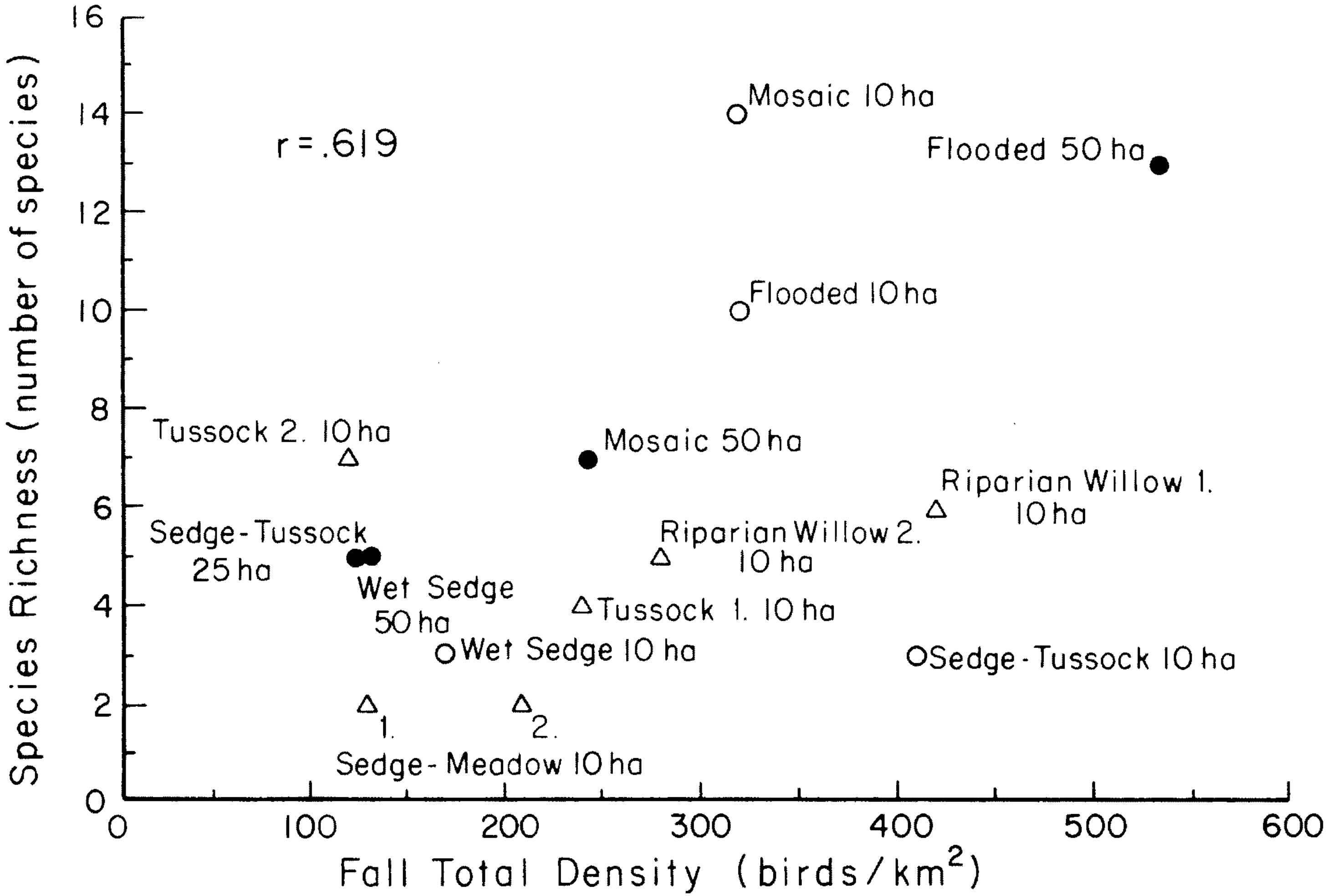


Fig. 13. Relationship between fall total density and fall species richness for 14 bird census plots, Arctic National Wildlife Refuge, Alaska, August 1982.

Table 7. Fall bird populations (birds/km^2) on plots in outer coastal plain, Okpilak River delta, and interior coastal plain, Katakturuk River, Arctic National Wildlife Refuge, Alaska, August 1982.

Species	Flooded (2a,2b,3b)		Mosaic (3c)		Wet Sedge (3a)		Sedge-Tussock (5a)		Riparian Willow (4b,9a,10)		Tussock (6a,7a)		Sedge Meadow (5a)	
	50 ha	10 ha	50 ha	10 ha	50 ha	10 ha	25 ha	10 ha	10ha 1	10 ha 2	10ha 1	10 ha 2	10ha 1	10 ha 2
Arctic loon		10												
Red-throated loon	2													
Pintail	4	20												
Oldsquaw	2													
Marsh hawk										10				
Rock ptarmigan											10			
Willow ptarmigan											20			
American golden plover	8		2	90			24			10				
Black-bellied plover	6	10												
Northern phalarope	2	10			6		16	20						
Red phalarope	8	10	4											
Long-billed dowitcher	196	40	70	90	28	10								
Pectoral sandpiper	212	80	56	50	14	40	4	40	10				40	190
Stilt sandpiper	20													
Parasitic jaeger	8		4		4		4							
Long-tailed jaeger			2											
Glaucous gull	4	30												
Arctic tern		40												
Water pipit									120	30	60			
Redpoll									20	80				
Savannah sparrow									10					
Tree sparrow									80					
Lapland longspur	62	70	106	90	80	120	76	350	180	150	150	120	90	20
Total densities	534	320	244	320	132	170	124	410	420	280	240	120	130	210
Total species	13	10	7	14	5	3	5	3	6	5	4	1	2	2

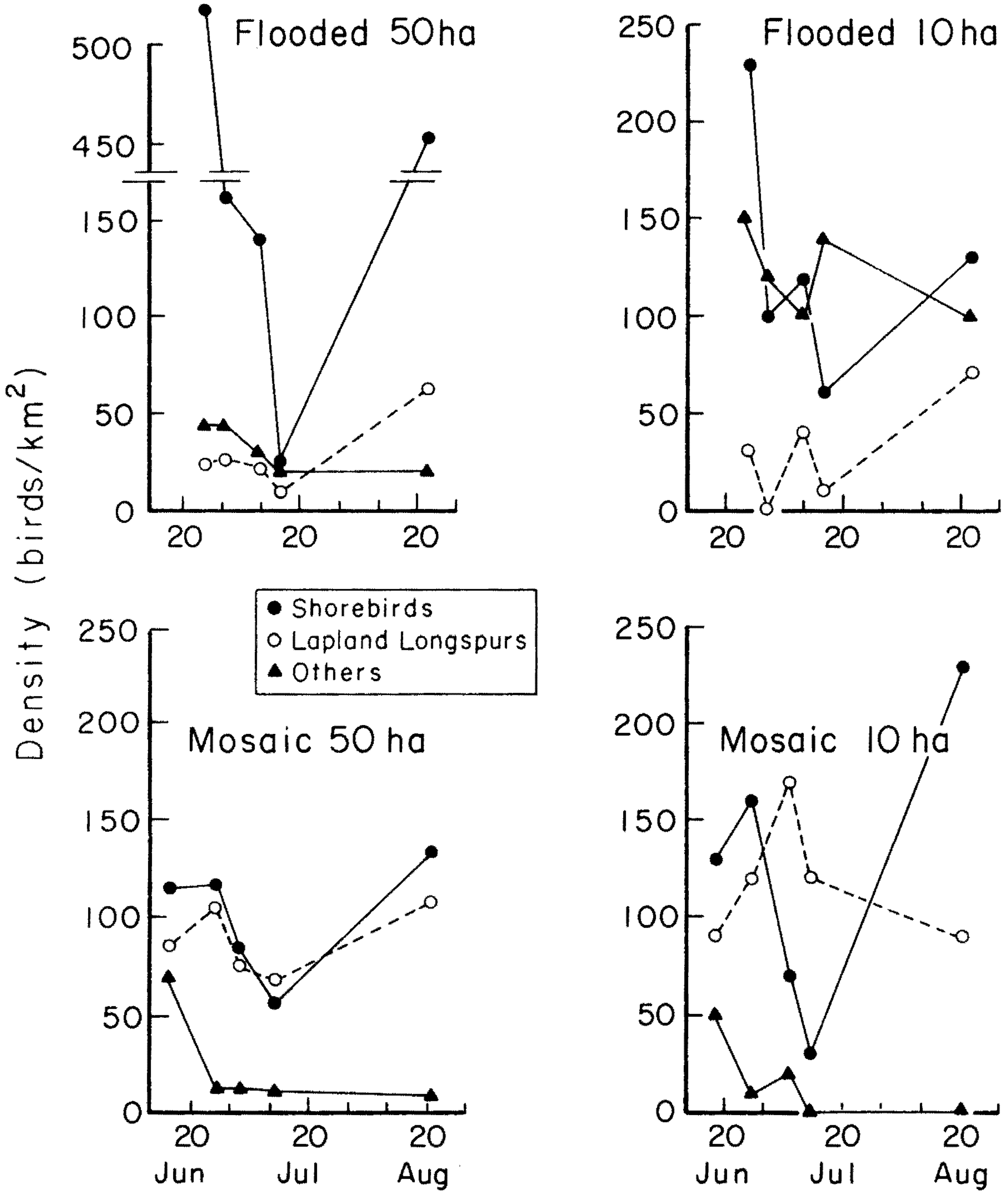


Fig. 14. Densities of shorebirds (solid circles), Lapland longspurs (open circles), and other bird species (triangles) on Flooded and Mosaic plots, Okpilak River delta, Arctic National Wildlife Refuge, Alaska, June-July 1982.

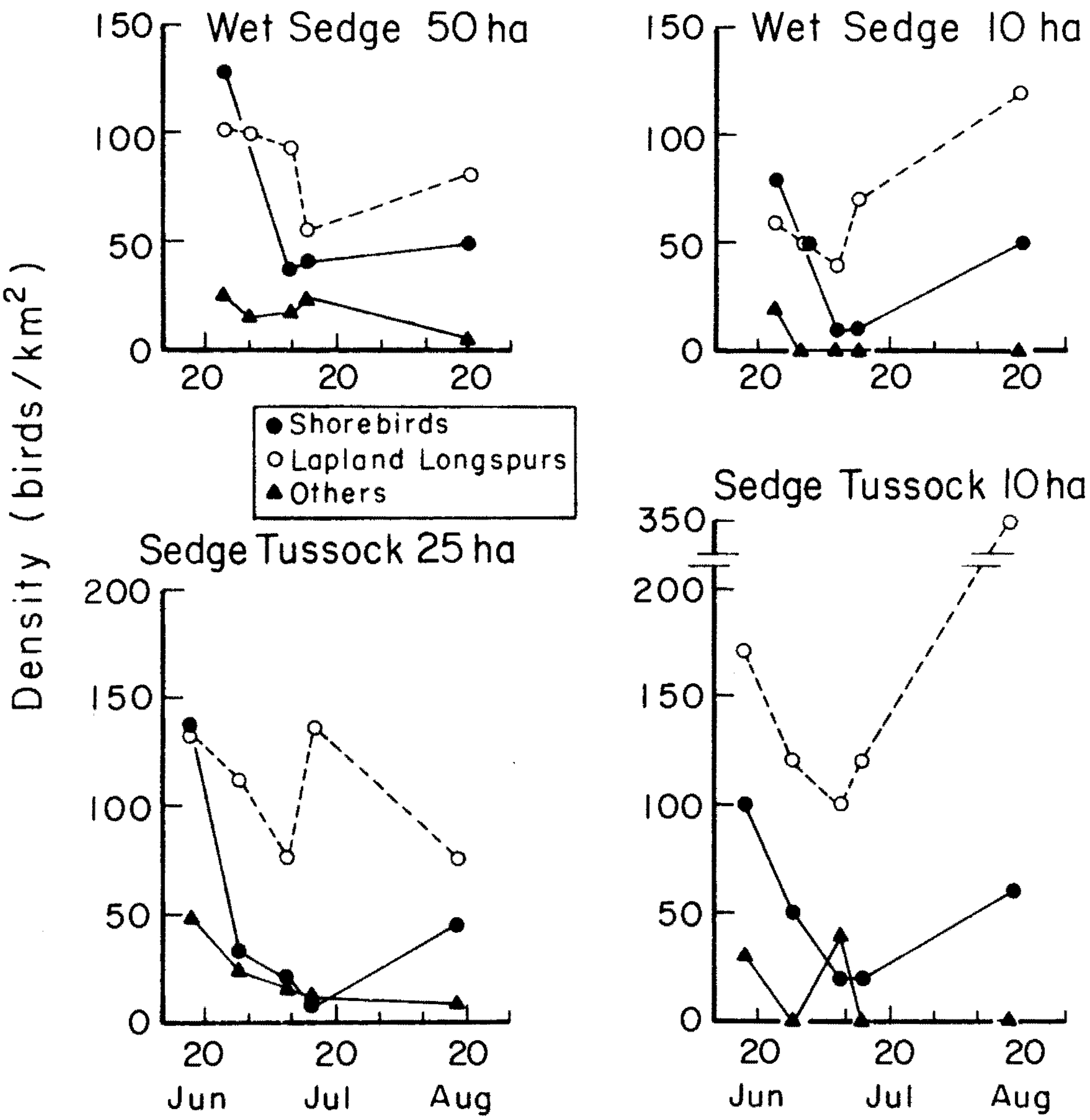


Fig. 15. Densities of shorebirds (solid circles), Lapland longspurs (open circles), and other bird species (triangles) on Wet Sedge and Sedge-Tussock plots, Okpilak River delta, Arctic National Wildlife Refuge, Alaska, June-August 1982.

densities were equivalent to those of 2 predominant shorebird species in fall (Table 7). At the Katakturuk River study area passerine species composition was similar to the summer, including all breeders except yellow wagtails which were absent in fall. Greater numbers of water pipits were seen in the fall (Table 7).

Densities of other bird species including loons, waterfowl, ptarmigan and jaegers decreased in the fall on all but the Tussock 1 plot (Fig. 14-17), where ptarmigan were particularly more abundant (Table 7).

Differences in seasonal bird use levels on ANWR between the Okpilak and Canning were large for the Flooded and Lowland plots, respectively. The Flooded plot at Okpilak had high shorebird numbers in mid-June 1982 (Fig. 13), yet these were not evidenced at the Canning Lowland plot in 1979 or 1980 (Martin and Moitoret 1981). A central low point in late-July shorebird numbers followed by a peak in August was, however, similar between the 2 areas. An August increase in Lapland longspurs was seen at all Katakturuk plots (Fig. 16 and 17), at the Flooded, Mosaic (50 ha), and Wet Sedge plots at Okpilak (Fig. 14 and 15) that was also observed on the Canning River delta Lowland plot in late August 1979 and mid-August 1980; on the Upland plot in early August both years; and on the Mosaic plot in 1980 (Martin and Moitoret 1981).

Spatial differences in seasonal abundance patterns identified between the Okpilak and Katakturuk sites, where August shorebird abundance dropped sharply at inland sites (Fig. 16 and 17) and increased sharply at coastal sites (Fig. 14 and 15) was also identified at western north slope sites by Myers and Pitelka (1980) and Derksen et al. (1981).

Plot Size Effects

Subsampling data for the 2 square 50 ha plots at Okpilak into 5-10 ha increments indicated that the species area curve for the Mosaic plot was asymptotic (Fig. 18), which is typical for area-species richness relationships (Rice and Kelting 1955, Kilburn 1966, Engstrom and James 1981, James and Rathbun 1981). A plateau in additional species per increment gain in area was reached at 30 ha. This pattern was not observed for the Wet Sedge plot (Fig. 18), where a continual increase in species occupied with each incremental increase in area. The high habitat diversity and species richness of the Mosaic habitat may indicate that species packing has occurred, even in very small areas, and that such packing was not observed in less diverse homogeneous habitats such as Wet Sedge (See Appendix Tables A-9 and A-10).

In the Mosaic plot, all subsamples except the 10 ha plot, estimated mean summer total density to within 90% of the estimate from the 50 ha plot (See Appendix Table A-9). Species abundance values (density) from smaller subsamples of the 50 ha plot were not statistically different from the large plot (See Appendix Tables A-9 and A-11). Chi-square tests indicated that the 10 ha plot density was statistically different (P 0.01) from the density of the larger plot (See Appendix Table A-11).

The Wet Sedge plot showed a different pattern for incremental subsample estimates of mean summer total density and individual species values with several absences of species detected on the smaller subsamples of 10-30 ha. Only the 40 ha subsample produced a mean total density estimate within 90% of

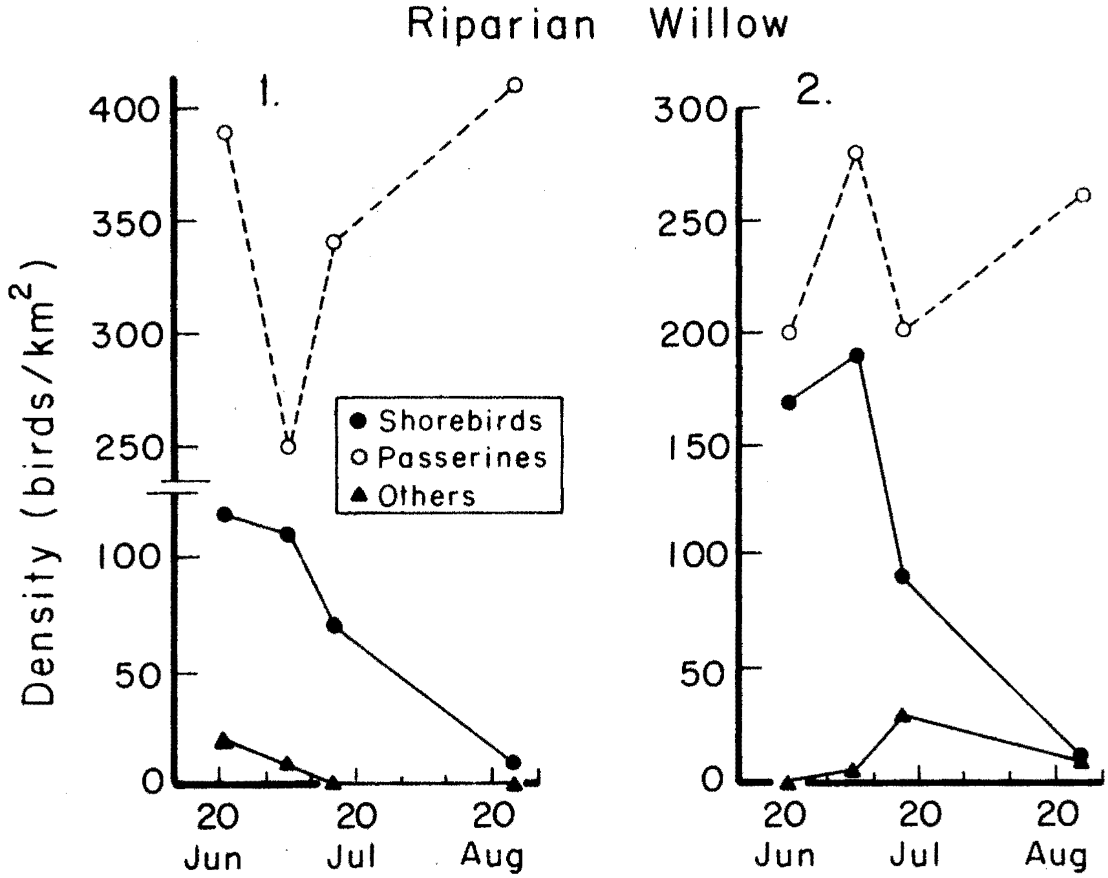


Fig. 16. Densities of shorebirds (closed circles), Passerines (open circles), and other bird species (triangles) on Riparian Willow plots, Katakuruk River, Arctic National Wildlife Refuge, June-August, 1982.

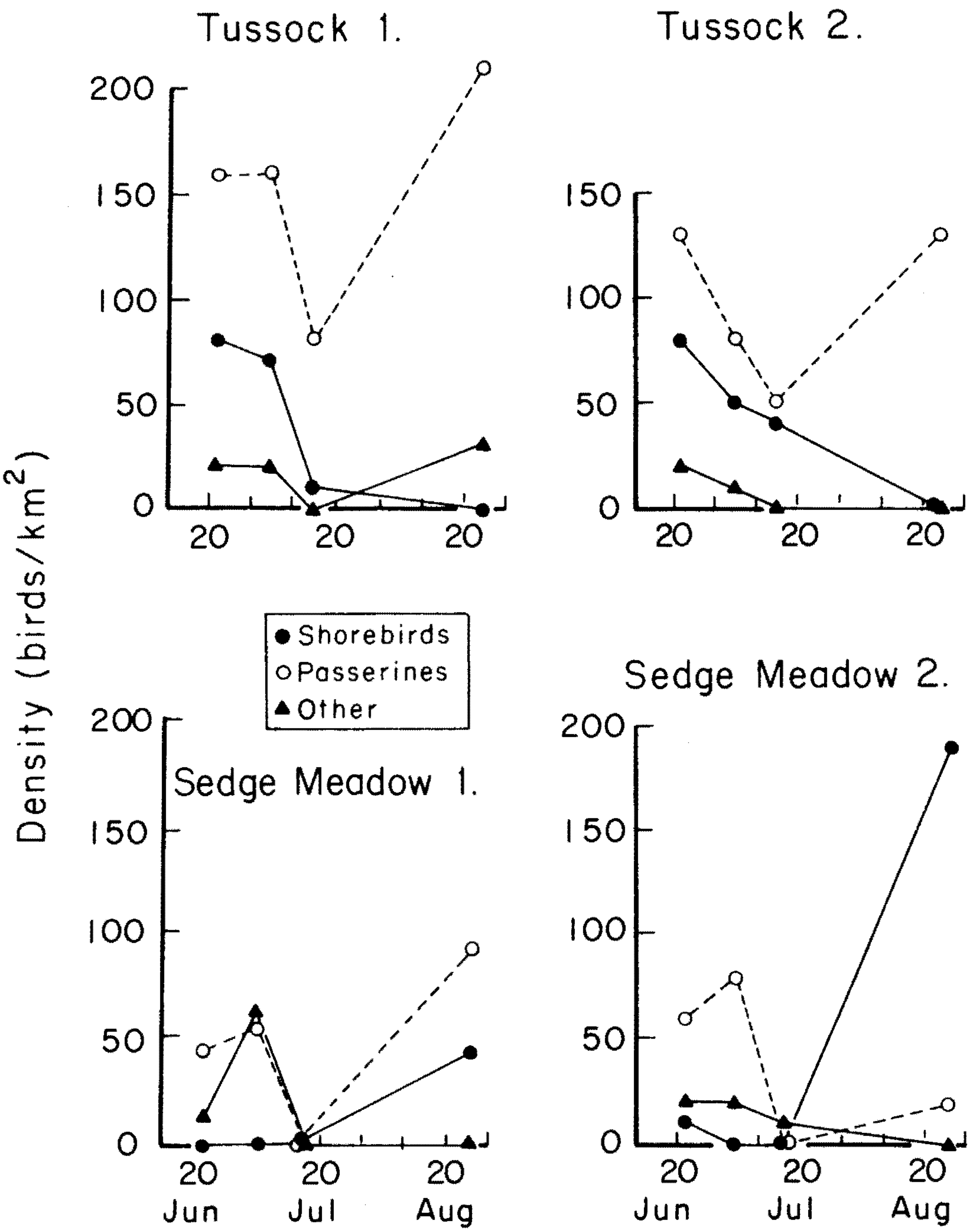


Fig. 17. Densities of shorebirds (solid circles), Passerines (open circles), and other bird species (triangles) on Tussock and Sedge Meadow plots, Katakuruk River, Arctic National Wildlife Refuge, June-August, 1982.

the original 50 ha plot. Species abundances were also different, with indicated statistical difference for the 10 ha subsample (P 0.005), and for the 20 and 30 ha subsamples (P 0.010) (See Appendix, Table A-11). Only the 40 ha subsample produced community species abundances that were not different from the 50 ha original plot.

Re-calculation of mean seasonal total density using 4 June-July breeding season censuses and 1 late August census selected from the weekly censuses June-August at Canning River delta (Martin and Moitoret 1981, Tables II 11-14) to develop comparable data sets for the 1982 Okpilak data caused a -16% to +15% change in the resulting density estimate, depending on habitat type. The recalculation with fewer censuses did not change in the overall ranking of plots by total density. The shorter mid-June to mid-July census period used to determine breeding population appears more time-efficient; however, manpower and time required to consistently find all nests may cause makes the shorten sampling effort to be difficult to duplicate between years using different census crews and leaders.

Use of Replicate 10 ha Plots

Breeding Density. In 3 of 4 habitat types estimates of species breeding density obtained from 2-3 replicate 10 ha plots differed significantly from those obtained from a single large plot (P 0.005, See Appendix Table A-12). The Flooded plot had the widest discrepancy in total breeding density, 91%, while the Mosaic and Wet Sedge plots had intermediate discrepancies, 28% and 34%, repsectively. Only the Tussock plot showed similar estimates of total breeding density from the 2 sampling schemes with a 16% difference in values. For individual species breeding densities, the Tussock plot showed similar values, while the Wet Sedge plot showed similar values only for the most common species, Lapland longspur. Several species had similar breeding density values on the Mosaic plot, notably northern phalarope, red phalarope, and Lapland longspur. Two shorebirds northern phalarope and pectoral sandpiper, showed similar breeding densities between the Flooded plot replicated samples and the singular large plot sample. It was evident from density estimates provided by 10 ha replicates, that the replicates produce different values than the single large plot, except for the Tussock plot. Advantages for using replicate plots are the ability to extrapolate the results to all similar habitats and attach confidence limits to those extrapolations. The question of which sampling scheme provided the more accurate estimate is unknown as replicate 50 ha plots in the same habitat were not sampled.

Subsampling of a 50 ha plot on the Okpilak delta into incrementally smaller square samples of 40, 30, 20, and 10 ha indicated that a single 10 ha plot provided estimates of mean breeding season total density from the 50 ha plot in the Mosaic habitat, but a single 10 ha plot did not develop comparable estimates in the Wet Sedge Tundra habitat.

Mean Summer Total Populations. The estimates of mean summer total density for all species derived from the mean of 2-3 10 ha replicates were within 20% of the estimate made by a single 50 ha plot (See Appendix Table A-13). The closest approximation of total population (5%), was for the Wet Sedge plot; the poorest approximation, (20%), was for the Flooded plot. In the Flooded plot only 2 species of major abundance, (northern phalarope and Lapland longspur) had close population estimates, whereas other common species, (red

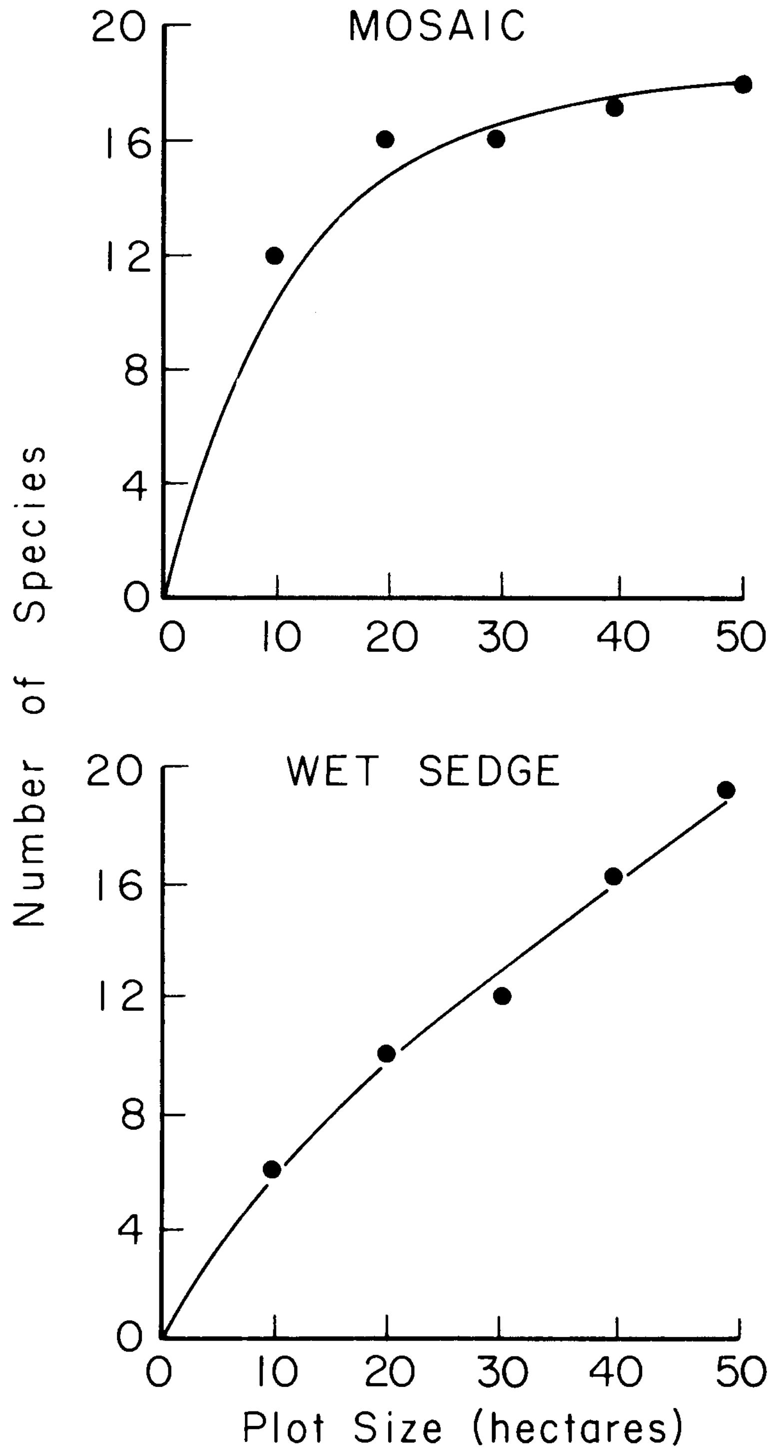


Fig. 18. Breeding season species-area curves for Mosaic and Wet Sedge 50 ha bird census plots subsampled at 10, 20, 30, and 40 ha, Okpilak River delta, Arctic National Wildlife Refuge, Alaska, June-July 1982.

phlarope and pectoral sandpiper) showed major differences (Fig. 11). There was better correspondence for density levels of the more common species on the Mosaic plot, with the exception of northern phalarope, semipalmated sandpiper, and buff-breasted sandpiper. The best estimated species total densities using replicate 10 ha plots were not statistically different for both the Wet Sedge and Tussock plots (P 0.05, See Appendix Table A-13).

The replicated 10 ha plots provided comparable estimates of mean total density to the 50 ha values and individual species abundance values on 2 of 4 Okpilak plots, but comparably estimated breeding density on only the homogeneous Wet Sedge. Troy (1982) used small 10 ha plots to compare effects of road disturbance on certain shorebird species at Prudhoe Bay. Sixty 10 ha plots, 30 experimental and 30 control, were required to detect differences in key species abundances because variances were high. Standard deviations (See Appendix Table A-12) suggest that a similarly large number of samples would be required to statistically detect differences in most species mean summer density.

There was a tendency for the Okpilak 10 ha plots to provide estimates of breeding density and mean summer total density that were larger that the large 25 or 50 ha plots estimates. Only the Wet Sedge plots had breeding or total density estimates higher in the 50 ha plot than its adjacent 10 ha replicates. This pattern has also been observed in taiga habitats (Spindler and Kessel 1980). Examination of census effort indicated that person/hrs./ha expended was fairly uniform, but was somewhat less for the 10 ha plots (See Appendix Table A-1). One factor contributing to larger estimates on the 10 ha plots may be the 212-288% greater linear edge on the 10 ha rectangular plots vs. the larger 50 ha square plot, hence allowing more room for boundary determination and extrapolation errors.

SPECIES ACCOUNTS

The following species accounts describe status, breeding chronology, migration and habitat use of 48 bird species on the Okpilak River delta and 35 species on the Katakturuk River study area during June-August 1982. Each species discussion is specific to the particular study area. Information for species at the Katakturuk River is more limited due to less field time in this area. Comparisons between species data for the Okpilak River delta in 1982 and during 1978 study by Spindler (1978) are discussed when differences are apparent.

Status and abundance terminology for birds follows Kessel and Gibson (1978) using these catagories: abundant, common, fairly common, uncommon, rare, casual, accidental, resident, migrant, breeder, visitant. Species accounts are presented in phylogenetic order.

The following bird species were observed on the Okpilak River delta in 1978 (Spindler 1978), but were not recorded during 1982:

green-winged teal	European wigeon
greater scaup	semipalmated plover
ruddy turnstone	lesser yellowlegs
white-rumped sandpiper	least sandpiper
sanderling	water pipit

Okpilak River Delta Birds

<u>ARCTIC LOON</u> - Common breeder. Migrating loons were observed flying east over the coastal plain in groups of 6-25 birds on 6 and 7 June, with 113 counted in 3 hr on 6 June. Small groups of migrating arctic loons were seen on 9, 13 and 14 June. Arctic loons were first observed in Okpilak wetlands on 8 June with 2 pairs calling and swimming in Camp Pond. First courtship displays were seen at the Flooded plot on 14 June. By 24 June, courtship calling from Camp Pond and Three-Drum Marsh was common, especially at night. Three nests were located in aquatic tundra - pond complexes (<u>Arctophila</u> wetlands) in the vicinity of the Flooded plots. Incubation was first observed on 1 July. A nest located on a small island on the Flooded plot (10 ha) contained 1 unincubated egg on 10 July, although there was a pair of birds in the area; this nest was found depredated by fox on 15 July. Another nest was being incubated near the Flooded plot on 16 July. Estimated mean total summer density in 1982 in the Flooded plot (50 ha) was 5.0 birds/km^2 with no nests found, as compared to 5.2 birds/km^2 with breeding density of 2.0 nests/km^2 in 1978 (Spindler 1978). Densities on the Flooded plot (10 ha) in 1982 were higher, with breeding density 10 nests/km^2 and 17.5 birds/km^2 mean total density. Arctic loons remained in the study area through the last week of observations, when as many as 6 were seen flying between Camp Pond and Camp Lake on 20 August.

<u>RED-THROATED LOON</u> - Common breeder. Red-throated loons were first seen flying over the Okpilak camp area on 9 June. On 12 June courtship calls were heard near camp from 1945-2145 hr. By 13 June, courtship displays and calling were common at Camp Pond and Three-Drum Marsh, where 16 were counted. The first nest was found in wet sedge tundra - very wet complex on 27 June and contained 1 unincubated egg. Another nest located on 1 July in the Flooded plot consisted of a small platform among sedges surrounded by deeper open water and

contained 2 incubated eggs. Nesting and mean summer total densities of red-throated loons on the Flooded plot in 1982 (2.0 nests/km^2 and 2.5 birds/km^2) were down from 1978 densities (6.0 nests/km^2 and 6.4 birds/km^2), recorded by Spindler (1978). Red-throated loons were still in the study area as of our last field day, 22 August, calling and flying between Camp Pond and Camp Lake.

WHISTLING SWAN - Uncommon breeder. First observation of whistling swans was on 6 June when 3-4 groups totalling about 13 were displaying courtship and territorial behavior on ice and water in the Mosaic plot. Singles or pairs were seen feeding or swimming on Flooded plot and adjacent pond complex wetlands and Camp Pond throughout June and July. A probable swan nest was located in wet sedge tundra-very wet complex at the edge of Three-Drum Marsh where a swan seemed to be incubating with its mate nearby, but the area was not approached to avoid disturbance. Swans had nested in this location in 1978 (Spindler 1978). Evidence of successful swan breeding effort in the Okpilak study area consisted of an observation on 17 July of 2 downy cygnets swimming along the creek adjacent to the Sedge-Tussock plot, and observations during the aerial swan survey (Bartels et al. 1982) on 12 August of a pair with 3 young near the coast north of the Flooded plot and 3 adults with 1 young north of Camp Lake.

CANADA GOOSE - Rare breeder. Canada geese were frequently seen during spring migration, with the first pair seen flying east on 7 June. Other sightings were a single bird flying over camp on 14 June, a pair flying west over the Wet Sedge plot on 30 June, and 3 birds which flew in from the west to rest and feed on the Flooded (50 ha) plot on 1 July. The only breeding effort was 2 adults brooding at least 2 goslings on the Sedge-Tussock plot (10 ha), after moving from the adjacent creek on 15 July.

BRANT - Common spring migrant. Eastward migration of brant was underway on 6 June, when flocks totaling 680 were counted. On 7 June 1300 brant were counted as they travelled over the study area. The peak of brant migration was recorded in 1979 and 1980, during the last week of May and first week of June (Martin and Moitoret 1981) and on 4-6 June 1978 (Spindler 1978), both earlier than field observations in 1982. Brant were also seen flying locally on 7 June. Flocks were less frequently observed in eastward migration through 18 June (28 on 9 June, 15 on 10 June, 12 on 12 June, 20 on 13 June, 45 on 15 June, and 2 on 18 June). Brant rarely used tundra wetland habitats in 1982: 2 pairs were seen at Three-Drum Marsh on 13 June; approximately 20 were seen on the Flooded Plot displaying aggressive behavior and swimming on 14 June. In 1978 a breeding colony of 15 pairs was located in aquatic tundra-pond complex (*Arctophila* wet lands) 100 m to the east of the Flooded plot, but breeding was not observed in 1982. A 10 ha Flooded plot was established in this area in 1982, and resulted in greater disturbance of the area, which may have caused nesting brant to avoid the area.

WHITE-FRONTED GOOSE - Rare spring migrant and summer visitant. White-fronted geese were rare spring migrants with the first pair observed briefly circling the camp on 7 June. Spring migrants flying west were infrequently observed: 2 on 15 June; 4 on 18 June; and 6 on 1 July. Two white-fronted geese were present on Sedge-Tussock plot on 17 June and 4 were resting on wet sedge tundra-moist complex and wet sedge tundra-non complex habitats near camp on 28 June.

SNOW GOOSE - Uncommon spring migrant, rare summer visitant. First observations of migrating snow geese were a pair flying north with 2 brant on 7 June. Twelve birds were seen flying southwest over the Flooded plot on 14 June. Other observations of spring migrants flying northeast included: 18 on 18 June; 37 on 24 June; and 14 on 25 June which landed on moist sedge-prostrate shrub tundra approximately 3 km south of camp. Four snow geese landed in the northeast corner of Camp Lake on 12 July.

PINTAIL - Fairly common breeder and fall migrant. Spring migration of pintails through the study area was not apparent. Pintails were first observed on 6 June when 2 males with 1 female was seen flying over the area. Small flocks of males, numbering up to 16 individuals, and pairs were seen flying over and landing in all habitats during June and early July, with greatest number of sightings in the Flooded and Mosiac plots.Breeding was documented in 1982, whereas it was not observed in 1978 (Spindler 1978). Six pintails, apparently nearly flight - capable young-of-the-year, were seen swimming in sedge habitat at the edge of the creek near the Sedge-Tussock plot on 18 July. A barely flight-capable female, which flushed from wet sedge tundra-very wet complex near camp lake, was accompanied by a non-flying Class III chick on 22 August. In the fall, a flock of 60 flew east on 18 August and a flock of 12 flew east on 21 August. Two pintails were seen on the Flooded plot on 23 August.

AMERICAN WIGEON - Rare spring migrant. A single American wigeon was seen flying east over camp with a pair of pintails on 9 June.

OLDSQUAW - Common spring migrant and breeder. Greatest numbers of oldsquaw during eastward spring migration were seen on 6 June, when flocks totalling 92 were counted. Other migrating birds counted were: 18 on 8 June; 22 on 9 June; 30 on 12 June; and 52 on 15 June. Groups totalling 40 were seen feeding in thawed ponds on 7 June, which was the same date oldsquaws were first seen on wetlands in 1978 (Spindler 1978). Paired birds were first seen swimming in a small pond near camp on 8 June. Sightings of oldsquaw pairs were made in all habitat types censused, Camp Pond, and Camp Lake during June and July, with the last sighting of an oldsquaw pair on 8 July on a pond in wet sedge tundra-non complex. On 13 June a pair with a female exhibiting brooding behavior was observed on the Wet Sedge plot, but a nest was not located. Courtship chasing among 3 pairs of oldsquaw was observed on 18 June on the Mosiac plot, as was 1 male still in winter plumage. Display flights of oldsquaw continued through 24 June with 2 pairs observed on Camp Pond. Two oldsquaw nests were found in the Sedge-Tussock plot on 28 June. One nest consisted of 1 egg buried under grasses and another was on a mound and had been depredated with its 4 eggs broken and down scattered. Juvenilles seen were 8 flight capable young with a pair of adults swimming in Camp Lake on 17 July; an adult with 7 not flight-capable young in aquatic tundra-pond complex and wetlands on the Flooded plot on 23 August. First molting male was seen on 11 July swimming in a creek approximately 1.5 km east of VABM Mars. A group of 11 males and 2 females were observed on Camp Lake on 16 July.

COMMON EIDER - Uncommon spring migrant. Common eiders were seen only during spring migration: on 7 June a flock of 200 and on 9 June a flock of 30 were seen flying east.

KING EIDER - Uncommon Breeder. Spring migrants observed were a flock of approximately 10 flying over the tundra on 9 June. A pair was first observed on the Flooded plot on 7 June, and was resighted on 14 June. A female incubating 2 eggs was found on 26 June on the Flooded plot atop a mound adjacent to aquatic tundra-pond complex, but the nest was subsequently found destroyed on 1 July, with no eiders seen in the area. Unsuccessful nesting effort for king eiders also occurred in wet sedge tundra-non complex habitat adjacent to Wet Sedge plot (10 ha): a female was found incubating a nest with 3 eggs on 24 and 30 June, but the nest was destroyed by 13 July.

SPECTACLED EIDER - Uncommon spring migrant. A pair of spectacled eiders was first observed on 13 June resting in aquatic tundra-pond complex (Arctophila wetlands) at Camp Pond. On 14 June, 2 pairs were observed feeding in 1 m deep water present over frozen wet sedge tundra-very wet complex on the Flooded plot. On 15 June, a pair was present in the northeast corner of the Mosiac plot and another pair was observed along the shores of Camp Lake. Latest observation of spectacled eiders was on 17 June when 3 pairs flew past Camp Pond. Spectacled eiders were not found during 1978 (Spindler 1978).

WHITE-WINGED SCOTER - Rare spring migrant. A pair was observed flying south near the Mosiac plot on 15 June.

ROUGH-LEGGED HAWK - Rare breeder. First observation was of a rough-legged hawk flying over the Mosiac plot on 8 June. A single bird soared over the Wet Sedge plot on 24 June. On 28 June, breeding in the area was suspected, because a pair of birds was seen on the ground approximately 1.5 km southeast of the Sedge-Tussock plot with 1 of the birds occasionally flying over the area and screaming. A nest with 2 incubated eggs tended by a pair was found on 9 July on a small mound in flat open tundra with no river, creek bluff, or hills nearby. The nest could not be relocated on 18 July, although 2 nest sites with feathers were located. There was no activity in the area and it was suspected that the nest was destroyed. This was the first recorded nesting attempt by rough-legged hawks in open tundra without relief on the arctic coastal plain within the Arctic National Wildlife Refuge. Last observation of rough-legged hawk was on 20 August, when 1 hunted over aquatic tundra-pond complex and wet sedge tundra-very wet complex at Three-Drum Marsh. Rough-legged hawks were more numerous in 1982 than in 1978 (Spindler 1978).

GOLDEN EAGLE - Rare summer visitant. A molting immature bird was observed on 24 June hunting over wet sedge tundra-non complex. On 28 June an eagle roosted on moist sedge-prostrate shrub tundra about 200 m from the Sedge-Tussock plot. On 2 July an eagle roosted on moist sedge-prostrate shrub tundra near Camp Lake. Similar observations of golden eagles in outer coastal plain areas of the Okpilak Delta were not made in 1978 (Spindler 1978).

MARSH HAWK - Uncommon summer visitant. First observation was of a female hunting on the Wet Sedge plot on 24 June. On 28 June, a female was seen hunting over the Flooded plot throughout the day, and on 30 June a marsh hawk hunted over the area east of Wet Sedge plot. A single observation was made late in the season with 1 female hunting over a wet sedge tundra-non complex along a creek channel near camp on 19 August. Marsh hawks were not observed during the 1978 study (Spindler 1978).

ROCK PTARMIGAN - Uncommon probable breeder. Two males in winter plumage and 1 female in tansition from winter to summer plumage were observed on 6 June. A male in winter plumage was foraging in the vicinity of camp on 7 and 10 June and a female was observed near camp on 8 June. First male courtship display flight was observed on 12 June near camp and another on the Mosiac plot on 15 June. Rock Ptarmigan were infrequently observed on Mosiac and Sedge-Tussock plots from 7 -9 June and 15-18 June, but nests were not located. Evidence of probable breeding was 4 subadults flushed from the Mosiac plot on 22 August. Breeding densities in 1978 were highest on the Mosiac plot (4.0 nests/km^2).

WILLOW PTARMIGAN - Uncommon breeder. First observation was on 11 June which flushed from the Wet Sedge plot with the male in courtship plumage and the female in summer plumage. Courtship display was noted on 17 June on the Sedge-Tussock plot. Males were again seen 9 and 14 July on this plot. A nest containing 6 eggs being incubated by a female was found on 28 June approximately 3 km south of camp in moist sedge-prostrate shrub tundra .

SANDHILL CRANE - Uncommon summer visitant. First observation was of a single bird which landed on the Flooded plot on 7 June. A crane was heard calling west of camp on 25 June, 1 was observed flying west over the Flooded plot on 26 June, and a single crane was seen flying west and then east over the Mosiac plot on 27 June. Cranes were heard east of the Mosiac (10 ha) plot on 7 July. Greatest numbers of cranes were observed on 13 July when 3 flew in from the east and landed on the Wet Sedge plot; later in the day, 3 were seen flying from the west to the Three-Drum Marsh area. The 3 birds were probably the same 3 birds. Two additional pairs travelled east past camp during the evening of 13 July.

AMERICAN GOLDEN PLOVER - Fairly common breeder, common fall migrant. This species was one of the first shorebirds to arrive on the study area, being present on 6 June, with single birds resting on exposed polygon ridges, and flying over the Mosiac plot and east over an upland moist sedge-prostrate shrub ridge. Courtship display was first noted on 7 June on the Flooded plot where the 7 birds were also observed feeding. By 9 June territorial displays were common in the area with a minimum of 30 counted on Mosiac and Flooded plots throughout the day. On 12 June defense postures were observed suggesting presence of a nest on the Mosiac plot, but no nest was found. Copulatory behavior was observed on 18 June at the Mosiac (10 ha) plot. The first nest with 3 eggs was found on 15 June on the Mosiac plot. Three other nests each containing 4 eggs were found on the Sedge-Tussock plot and on a polygon ridge in wet sedge tundra-very wet complex (27 and 28 June, 2 July). Hatching occurred by 12 July with some nests containing incubated eggs on 11 and 14 July. Highest mean total summer population densities of plovers occurred on the Mosaic (10 ha) plot, followed by Sedge-Tussock plots. Total breeding population and nesting densities were similar to those recorded in 1978 except for a higher density in 1982 on the Mosaic 10 ha plot. In the fall, small flocks flew eastward and 6 roosted on moist sedge-prostrate shrub tundra on 18 August. Primarily juvenile birds in small flocks (2-4 birds) roosted on upland areas at VABM Mars in wet sedge tundra-moist complex and wet sedge tundra-very wet complex, on 20-23 August. Groups of 6 to 7 were present on the shore of Camp Lake on 21 August.

BLACK-BELLIED PLOVER - Rare spring and fall migrant. Observations of were made on 14 June of 3 birds seen on the Flooded plot and 1 flying near VABM Mars. In the fall, 4 plovers were observed feeding and roosting in wet sedge tundra-moist complex near camp on 19 August.

WHIMBREL - Rare summer visitant. Seven birds were seen flying over the Flooded plot on 10 July. Whimbrels were not recorded in 1978 (Spindler 1978).

NORTHERN PHALAROPE - Abundant breeder. The first observation was of 3 pairs in small melted pools on the Mosaic plot on 6 June. A few pairs were seen feeding and swimming in the increasingly larger melted areas on the Flooded plot on 7 June with a major influx of birds occurring on 8 June. The majority of birds observed were pairs swimming and feeding at the edges of polygon centers and troughs pools and lakes through about 27 June. Copulation was observed on 24 June on the Wet Sedge plot and 4 pairs were observed copulating on 26 June on the Flooded plot. Peak of courtship behavior was apparent on the Flooded plot on 26 June. Most phalaropes seen at this time were paired and foraged together but some groups of as many as 6 were also seen swimming together. Highest numbers were seen during the first censuses from 15 to 26 June. Seventeen nests containing incubated eggs were found between 26 June and 15 July in the 4 major habitat types studied. Males were seen incubating nests on 16 occasions, while only one female was flushed from a nest. About 82% of the nests had 4 eggs with the remaining ones having 2 or 3 eggs (Fig. 19). Hatching occurred by 10 July at 2 nests. A nest was in the process of hatching on 14 June, with 3 newly hatched chicks and 1 warm egg still remaining. First downy fledged young were seen on 15 July in a group of 3 swimming in an aquatic tundra-pond complex on the Flooded plot. They were defended by 2 territorial northern phalarope males, and 1 red phalarope male. Highest breeding as well as total summer densities were recorded on the Flooded plots, as was the case in 1978 (Spindler 1978). Females were rarely seen after 1 July. Flocking had begun by 30 June when a mixed flock of 13 northern and red phalaropes was seen at Three-Drum Marsh. Most intensive flocking activity was recorded on 11 July when a flock of 35 was feeding and flying together in aquatic tundra-pond complex and wet sedge tundra-very wet complex at Three-Drum Marsh, and groups of 28 and 100 swam together on small ponds in wet sedge tundra-moist complex near camp. Flocks were observed through 18 July. In fall, small numbers were seen on Flooded, Wet Sedge and Sedge-Tussock plots during 18-23 August.

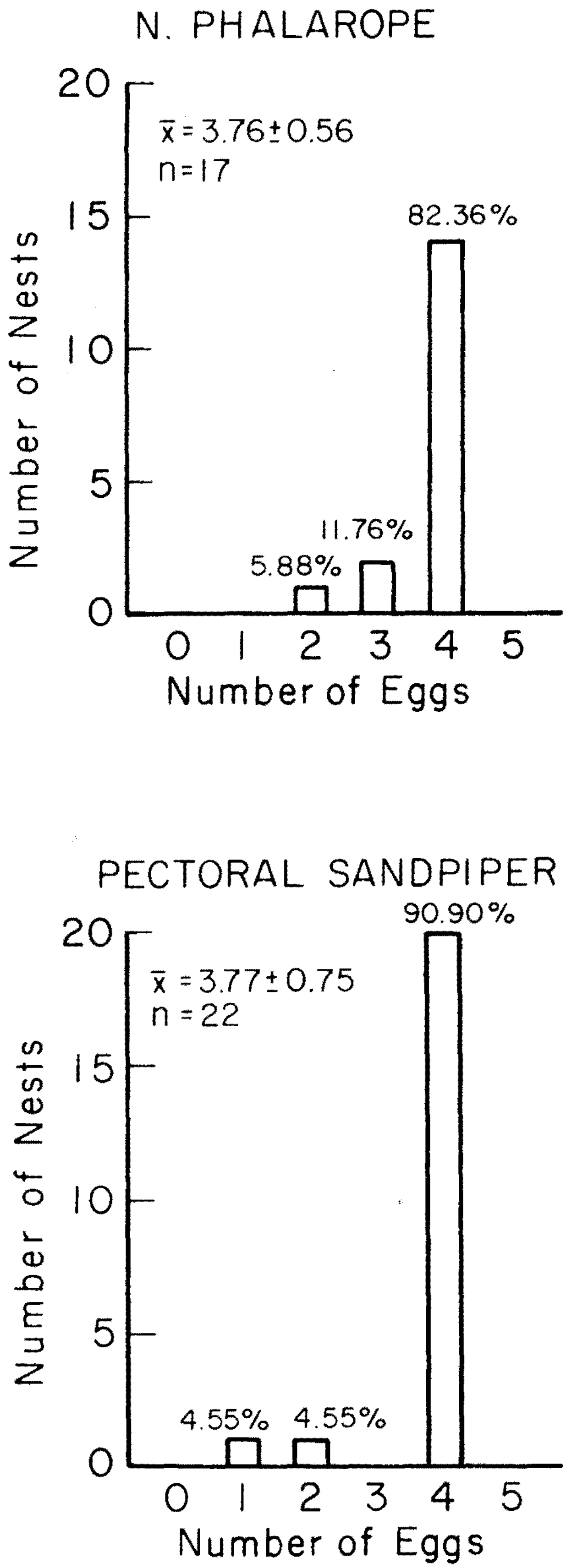


Fig. 19. Clutch sizes of northern phalarope and pectoral sandpiper nests, Okpilak River delta, Arctic National Wildlife Refuge, Alaska, June–July 1982.

RED PHALAROPE - Common breeder. The first observation was of 2 females and 1 male feeding in 1 of the few small melted ponds on the Flooded plot on 7 June. By 9 June, large numbers of red phalaropes had arrived. Peak of breeding activity and numbers observed occurred on 26 June on the Flooded plot with numerous pairs of birds seen feeding together and 3 occurrences of copulation noted. Eight nests were found between 27 June and 12 July in Flooded, Mosaic, and Wet Sedge plots. Two nests contained 3 eggs, the remainder held 4 eggs and only males were flushed from nests. Hatching probably began by 8 July. The only young seen were 3 downy chicks attended by a defensive male swimming among sedges on the Flooded plot (10 ha) on 15 July. Flocks of 7-32, mostly females, were seen on 26 June and a mixed flock of 13 red and northern phalaropes was seen at Three-Drum Marsh on 20 June. The last female was seen on 10 July. Nest density was highest on the Mosaic (10 ha) plot followed by Mosaic (50 ha), Wet Sedge (50 ha), and Flooded (50 ha) plots. Nesting densities on the Flooded plot (2 nests/km^2) were substantially lower than in 1978 (14 nests/km^2, Spindler 1978). However, total summer densities in 1982 on the Flooded plot (60.5 birds/km^2) were similar to those recorded in 1978 (68 birds/km^2). The surges in use of the Flooded plot occurred on 26 June 1982 and on 3 July 1978 were probably due to post-breeding flocking by females and non-breeding males. This habitat was apparently used for feeding purposes, but was not heavily utilized for breeding. In the fall, small numbers of birds were observed on Mosaic and Flooded plots and a flock of 19 flew to the east over the Mosaic plot on 22-23 August.

LONG-BILLED DOWITCHER - Uncommon breeder, abundant fall migrant. First observation was on 24 June, when a pair was seen feeding on the Wet Sedge plot. On 26 June a major influx occurred with numerous pairs seen feeding in the Flooded plot. Other birds were still moving around, as flocks of 8 and 17 travelled eastward over the study area on 26 June and 12 were seen flying east on 27 June. Dowitchers are late June arrivals at Okpilak (Spindler 1978) and at Canning delta (Martin and Mortoret 1980). The first courtship display flight and call occurred on 26 June and ended by 10 July. Evidence of a female nesting (reclusion behavior by a female) was observed at the Mosaic plot on 3 July, but first nests were not located until 8 July. Three nests were found in the Wet Sedge plot and an adjacent area, and 1 on the Mosaic plot. Three nests contained 4 eggs and 1 had 3 eggs. Dowitchers did not readily flush from nests until we approached to within 1-3 m, therefore some nests were probably overlooked. One nest apparently hatched by 13 July, as only 1 cold egg remained in it, but other nests were still being incubated on 13 and 16 July. One barely flight capable juvenile was seen 23 August on the Flooded plot. Another juvenile was seen being captured by a pair of long-tailed jaegers west of the Flooded plot on 23 August. Mean summer total population densities were highest for the Flooded plot (10 ha), followed by Wet Sedge and Mosaic plots. Nesting populations were higher in 1982 in Wet Sedge and Mosaic plots than in 1978. Total population densities were higher in 1982 for all habitats except Sedge-Tussock Tundra where they were absent in 1982, but occurred then in 1978. Dowitchers were the most abundant bird species in the fall and had higher population densities in all habitats than during the breeding season. Fall population densities were highest in the Flooded plot, with Mosaic and Wet Sedge plots also being utilized. Numerous groups of 1-17 birds flushed from foraging areas in very wet sedge communities in these habitat types. Eastward migration was evident on 18 August with flocks of 2-7 birds being observed. Peak migration movement was on 22 August when 41 flocks of 1-20 birds were seen flying over the Mosaic plot in addition to the foraging birds flushed during the census.

SEMIPALMATED SANDPIPER - Common breeder. Semipalmated sandpipers were present on the study area on 6 June. Aerial flight displays were heard in all habitats between 6 June and 3 July, but seemed to be most frequent in Wet Sedge tundra-moist complex between 9 and 18 June. Peak of displays was not clearly defined since displays were not performed during periods of high winds, rain or snow which were frequent throughout early and mid-June. Few displays were noted between 24 and 26 June even though the weather was good, but there was an apparent resurgence of territorial displays on the Mosaic plot on 27 June, probably related to nest defense. Seven nests were found between 14 June and 12 July in Wet Sedge tundra-moist complex with 3 of those on the Mosaic plot. Two nests contained 3 eggs and the remainder had 4 eggs. The first nest hatched by 27 June, but others were still being incubated on 12 July. Flocking by 12 adults foraging in wet sedge tundra-very wet complex near Three-Drum Marsh was observed on 11 July. Three pairs defended territories in wet sedge tundra-moist complex on 17 July the last date semipalmated sandpipers were observed. Total population densities were lower than 1978 levels for all habitats except the Flooded (10 ha) plot. Semipalmated sandpiper breeding density was higher in 1982 in Mosaic tundra plots (8-10 territories/km^2) than in 1978 (6 territories/km^2), but nesting was only detected on the Mosaic plot in 1982, whereas nesting also occurred on the Flooded plot in 1978 (2 territories/km^2, by Spindler 1978).

BAIRD'S SANDPIPER - Rare summer visitant and fall migrant. First observation was of a single bird near camp on 10 June. Two birds were seen on 13 June and a displaying male was observed on 24 June in the wet sedge tundra-very wet complex of Three-Drum Marsh. No nests were located and the species was not seen again until the fall when 5 foraged in the company of black-bellied plovers in wet sedge tundra-wet/moist complex near camp on 19 August.

DUNLIN - Rare spring migrant. The only observation was of 4 dunlin feeding in melted ponds on the Flooded plot on 7 June.

PECTORAL SANDPIPER - Abundant breeder and fall migrant. Pectoral sandpipers arrived on 7 June with small numbers observed feeding on exposed ground in Mosaic and Flooded plots. Larger numbers were seen after 15 June, with peak population densities recorded on census plots from 24 to 27 June. First male courtship display was heard on 8 June. First females were seen on the Mosaic plot on 15 June and by 24 June females were abundant. Male courtship displays peaked between 24 and 27 June. On 24 and 26 June, territorial chasing among groups of up to 6 males was very common and copulation was noted. By 27 June, flight displays were still common but less flocking and chasing occurred among males and males tended to be more commonly paired with females. Males were rarely seen by 28 June, with the last courtship display and record of a male being on 3 July. Females were first observed defending nests on 24 June on the Wet Sedge plot. Nests were found from 27 June to 15 July in all habitat types. Females characteristically flushed from nests when observers approached to within 10-30 m, then behaved defensively near the nest with the broken wing distraction display for a few minutes. The females then flew 50-200 m away and slowly returned to the nest, thus making it difficult and time consuming to find nests. A total of 91% of the nests contained 4 eggs (Fig. 19). A 90% nesting success and 89% hatching success were recorded for 10 nests that had sufficient information to make the determination. On 12 July the first hatching was observed, with 1 nest found empty, 1 nest with 4 downy chicks, and an egg pipping in another nest. First independent downy young were seen being brooded by a female on 14 July on the Sedge-Tussock plot. Post breeding flocking began as early as 24 June on the Flooded plot where flocks of up to 17 birds were observed feeding. A flock of 8 was seen feeding in wet sedge tundra-very wet complex near Three-Drum Marsh on 11 July. Numerous flocks of 4-8 pectorals travelled eastward on 13 July and flocks of 7-60 birds fed along Camp Lake and in a wet sedge tundra-very wet complex near Three-Drum Marsh on 17-18 July. Highest mean summer total population densities for any shorebird species were by pectoral sandpipers on the Mosaic plot in 1982, and on the Flooded plot in 1978. In 1982 greatest pectoral sandpiper nesting density was recorded on the Mosaic (10 ha) plot, followed by the Wet Sedge (50 ha) plot, however, number of male territories was highest on the Mosaic (50 ha) plot. Breeding densities were higher in 1982 (4-40 nests/km^2) as compared to 1978 (2-8 nests/km^2). Mean summer total populations were similar in both years, being somewhat lower on the Flooded plot and higher in the Sedge-Tussock plot in 1982. In the fall, pectoral sandpipers were the second most common shorebird species ranking just below long-billed dowitcher in mean abundance throughout the study area, but with higher population densities than dowitchers on the Flooded plots. Fall populations of pectoral sandpipers were higher than mean summer total populations on all but the Sedge-Tussock and Mosaic (10 ha) plots. Small flocks (1-14 birds) flew eastward over camp on 18 and 19 August. Singles and flocks of 2-24 birds were flushed from all habitat types during the fall census period. Birds were feeding and roosting in the plots from 18 to 23 August.

STILT SANDPIPER - Uncommon breeder and fall migrant. First observation was of a pair feeding among sedges at Camp Pond on 8 June. Another pair was seen at VABM Mars on 10 June. Flight displays were heard on 17 and 28 June and 9 July over Wet Sedge plot, wet sedge tundra-very wet complex, and wet-sedge tundra-non complex habitats. One nest containing 4 eggs was found on 24 June on the Wet sedge plot. The female did not flush until the observer was within 0.5 m of the nest. The nest site was located on a polygon ridge vegetated by Cassiope, moss, and Carex Biglowii, and was within 2 m of water in a low polygon center. The nest was empty on 8 July and chicks were presumed to have hatched. Other nests were probably located in wet sedge tundra-non complex habitat 1.6 km south of camp and in wet sedge tundra-wet/moist complex about 1.6 km east of camp where pairs of defensive adults were observed on 9 and 11 July, respectively. In the fall, 10 stilt sandpipers foraged on the Flooded plot on 23 August.

BUFF-BREASTED SANDPIPER - Uncommon breeder, rare fall migrant. The first observation was on 8 June of 1 bird on the Mosaic plot. Most observations of buff-breasted sandpipers were in the vicinity of the Mosaic plot although birds were also seen near camp, and to the south. First courtship display by 1 individual of a pair was seen on 12 June. Courtship displays peaked between 15 and 17 June with 4 displaying in a lek on the Mosaic plot and 4 displaying near camp. Displays were seen as late as 27 June. A female was seen carrying nest material on 15 June in the Mosaic plot. Nests containing 4 incubated eggs each were found on 27 and 30 June, and 3 July on Mosaic and Wet Sedge plots. First hatching apparently occurred by 8 July at 1 nest and on 16 July downy young were present in 1 nest and 4 were found in another nest. Three independent downy chicks were seen with a female on 17 July near camp. Mean summer total population density (14 birds/km^2) and breeding density (4 nests/km^2) estimates were higher for the Mosaic plot in 1982 compared to total density (5 birds/km^2) and breeding density (3 nests/km^2) in 1978. In 1982 buff-breasted sandpipers bred on the Wet Sedge plot, and were observed on the Flooded plot, areas where they were not found in 1978 (Spindler 1978). In the fall, a single buff-breasted sandpiper was seen flying past camp on 18 August.

POMARINE JAEGER - Common spring migrant, uncommon summer visitant and fall migrant. Pomarine jaegers were observed migrating east on 6 June. The migration period was from 6 to 15 June with peak movement occurring on 8-10, and 15 June when flocks numbering 4-8 were seen flying over the study area. These data are low when compared to the migration peaks at the Okpilak River delta from 4-7 June 1978 when 2000-5000 were estimated (Spindler 1978) or during 30 May - 8 June 1980 at Canning River delta when 1200 were estimated (Martin and Moitoret 1981). The absence of systematic migration counts as well as a later date of initiating field work in 1982 may be partially responsible for the low 1982 values. Primarily singles, but also groups of 2-8 jaegers, were observed hunting and resting in all habitat types between 6 and 18 June. During summer observations consisted of: 5 hunting over Wet Sedge plot on 24 June; 2 on the Flooded (10 ha) plot on 1 July; 2 flying south southeast across Sedge-Tussock plot on 9 July; and 1 travelling over the Mosaic plot on 12 July. Mean summer total population densities of pomarine jaegers were higher on Mosaic (4.5 birds/km^2), Wet Sedge (2.5 birds/km^2), and Sedge-Tussock plots (4.0 birds/km^2) in 1982 compared to 1978 when they were only recorded on the Flooded plot at a lower density (0.8 birds/km^2, Spindler 1978). In the fall, a single bird hunted over wet sedge tundra-moist complex and wet sedge tundra-non complex habitats, and was attacked by 3 shorebirds on 19 August. On 20 August 1 bird was seen hunting near the Wet Sedge plot.

PARASITIC JAEGER - Rare breeder, common summer visitant, common fall migrant. Parasitic jaegers arrived later than other jaeger species, with the first observation made on 9 June and consisting of 3 hunting over wet sedge tundra-non complex and wet sedge tundra-moist complex habitats. There was no apparent spring migration movement. Groups of 1-4 jaegers were seen hunting in all habitat types from 9 June to 17 July. Dark phase birds were commonly observed. One nest was found on 14 June when a pair defended a nest with 2 eggs located on a polygon ridge on the Flooded plot. By 26 June, the nest had apparently been depredated and no parasitic jaeger activity was observed in the vicinity. Mean total summer densities were higher in 1982 (2.5-5.0 birds/km^2) than in 1978 (0.8-2.0 birds/km^2), and evidence of breeding was not found in 1978 (Spindler 1978). In the fall, parasitic jaegers were the most common jaeger species. They were observed hunting over all habitat types in groups of 1-4 birds during 18-23 August and occurred in densities of 4-8 birds/km^2 on the plots. On 23 August, 2 adult jaegers were seen chasing a long-billed dowitcher over the Flooded plot. At first the dowitcher was able to out-maneuver the jaegers, but after a minute of pursuit, 1 jaeger caught the dowitcher with its legs, pecked it in mid-air, then dropped it to the ground where the other jaeger picked it up and did the same.

LONG-TAILED JAEGER - Common spring and summer visitant. First observation was on 6 June of 1 bird hunting near camp. There was no apparent spring migration movement of long-tailed jaegers. Groups of 1-5 jaegers were seen hunting in all habitat types from 6 June to 17 July, although sightings were less frequent in July. Mean total summer densities were highest on the Sedge-Tussock (10 ha) plot where 7.5 birds/km^2 were found. Summer densities were higher in 1982 (2.5-7.5 birds/km^2) than in 1978 (0.8-4.0 birds/km^2). Nesting was not observed in either 1978 or 1982 at Okpilak. Date of last observation was 17 July 1982.

GLAUCOUS GULL - Common spring migrant, uncommon breeder, common summer visitant and fall migrant. The first observation of glaucous gulls was made on 6 June when 10 birds flew over the Mosaic and Flooded plots. No major migration movement was recorded, but eastward moving flocks of 4-24 gulls were seen on 8, 14, 26, and 27 June. Gulls were frequently seen foraging over Mosaic and Flooded plots, Camp Pond, Camp Lake, and Three-Drum Marsh between 6 June and 11 July. Highest mean total summer density was recorded for the Flooded (10 ha) plot (7.0 birds/km^2) where a colony was located. One nest containing 1 egg was found on 26 June 1982, but this nest was not successful. Two nests were found in this area in 1978 (Spindler 1978). Gulls were observed hunting in the fall on the Flooded plots on 23 August and flying over the Mosaic plot and Camp Pond on 20 and 22 August.

HERRING GULL - Rare summer visitant. One herring gull was observed flying with glaucous gulls on the Flooded (10 ha) plot on 26 June. Herring gulls were not observed in 1978 (Spindler 1978).

THAYER'S GULL - Rare summer visitant. One Thayer's gull was seen flying over the Flooded plot on 14 June. Thayer's gulls had not been observed in 1978 (Spindler 1978).

SABINE'S GULL - Rare spring migrant and summer visitant. On 7 and 14 June, 2 birds were observed flying over the Flooded plot, and on 12 July, 5 were observed flying northeast over wet sedge tundra-moist complex.

ARCTIC TERN - Uncommon spring migrant and possible breeder. First observation of terns was on 8 June when 1 flew west over the frozen Camp Lake. Two terns were seen flying north over camp on 9 June, 2 over the Flooded plot on 14 June, and 3 over Camp Lake on 15 June. A pair was observed feeding at the creek mouth which emptied into Camp Lake near camp on 13, 15, and 18 June, with copulation being observed on 15 June. A single tern was seen feeding at Camp Pond and Camp Lake on 24 and 25 June respectively. No nests were found in the study area. In the fall, arctic terns were observed hunting over the Flooded (10 ha) plot on 23 August.

SNOWY OWL - Common spring, summer, and fall visitant. Date of first observation was 6 June, when 1 was seen hunting 1.6 km northeast of Camp. Single owls were observed roosting on mounds or hunting on Mosaic, Flooded, and Wet Sedge plots and moist sedge-prostrate shrub tundra from 9 to 17 June.

A major influx of owls occurred on 24 June, when 5 were counted at 1300 hr and 16 counted at 2030 hr around the Wet Sedge plot. On 30 June, 8 owls were recorded in this same area, but numbers diminished after this date, with 1-3 owls seen hunting or roosting in all habitat types from 1 to 17 July. No evidence of nesting was found. Mean total summer densities were higher in 1982 (1.0-2.5 birds/km^2) than in 1978 (0.4 birds/km^2). In the fall, 1-2 owls were observed on mounds in moist sedge-prostrate shrub tundra and wet sedge tundra-moist complex on 20-23 August.

SHORT-EARED OWL - Uncommon spring and summer visitant. Four short-eared owls were observed hunting in an area north of VABM Mars on 6 June. Single birds were seen hunting over Mosaic, Wet Sedge, and Sedge-Tussock plots on 8-11, 14, 24 and 28 June. Short-eared owls were less frequently observed in July with a single sighting on 13 July of 2 owls, one with brown lemming prey. Nesting was not evident in the study area.

BARN SWALLOW - Accidental spring migrant. A single barn swallow was observed flying low over the Mosaic plot on 9 June, and over the Sedge-Tussock plot on 17 June.

COMMON RAVEN - Uncommon summer visitant. The first observation was on 27 June of 2 birds flying eastward past camp. Other observations were of a single bird hunting at Three-Drum Marsh on 30 June, 2 hunting near the Wet Sedge plot on 8 July, 2 flying north of the Flooded plot on 10 July, and 1 flying east over VABM Mars on 13 July.

REDPOLL - Rare summer visitant. A single bird was heard flying over wet sedge tundra-moist complex on 24 June. Five redpolls were observed along the creek adjacent to the Sedge-Tussock plot on 28 June.

FOX SPARROW - Casual summer visitant. One fox sparrow was observed on 28 June foraging at bear diggings on a mound on the Sedge-Tussock plot.

LAPLAND LONGSPUR - Abundant breeder. Lapland longspurs were present in the study area on 6 June, being common wherever the ground was exposed. Male courtship flight song displays were heard from 6 June to 8 July, but were infrequent in July. The first nest was found on 12 June in wet sedge tundra-moist complex. A total of 47 nests were located between 12 June and 7 July, a slightly later period than noted for 1978 (Fig. 7). Clutch size ranged from 0-7 eggs, with a mean of 4.5 (Fig. 20). Nesting success was 92% and hatching success rate 87% for 38 nests. First date of hatching was 27 June, with 3 young and 2 incubated eggs seen in a nest on the Mosaic plot. Hatching occurred as late as 14 July, when 2 young approximately 1 day old and 2 eggs were found in a nest. First fledglings were observed on 3 July. In the fall, singles and small flocks of 2-9 longspurs were seen foraging in all habitat types from 18 to 23 August. Fall densities were highest on the Sedge-Tussock (10 ha) plot (350 birds/km^2), with a large portion of birds present being juveniles.

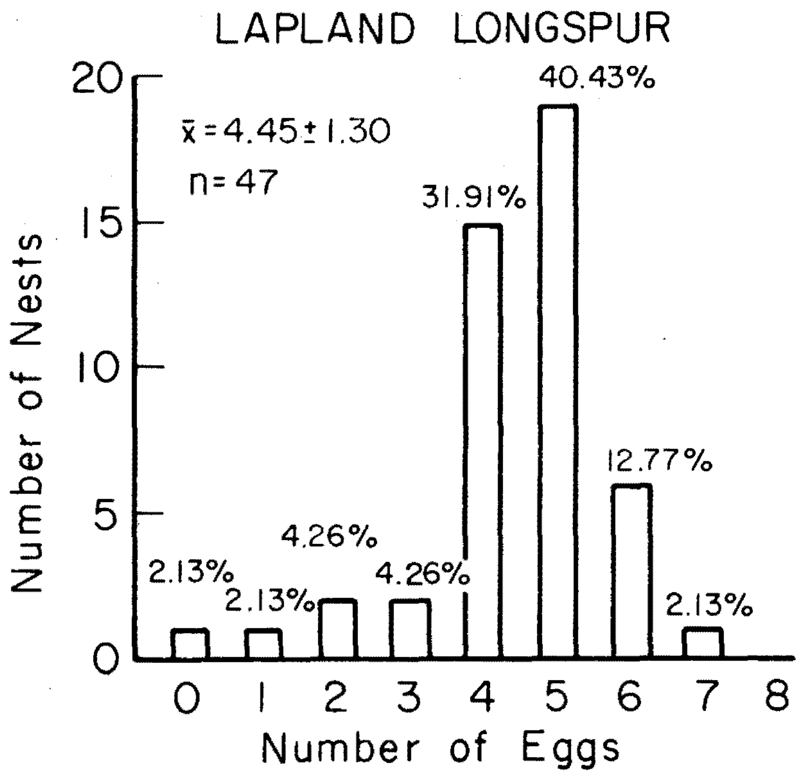


Fig. 20. Clutch sizes of Lapland longspur nests, Okpilak River delta, Arctic National Wildlife Refuge, Alaska, June-July 1982.

SNOW BUNTING - Uncommon spring visitant. Snow buntings were first observed on 8 June when 3 were seen flying over the Mosaic plot. On 14 June, 1 was observed flying over the Flooded (10 ha) plot. One snow bunting was seen walking on snow and feeding in areas of exposed tundra near Camp on 15 June.

Katakturuk River Birds

WHISTLING SWAN - Rare summer visitant. One adult was observed flying north over Riparian Willow 2 plot on 16 July.

PINTAIL - Uncommon breeder. A pintail was observed nesting on 19 June. A female was flushed from a nest containing 6 eggs found at the base of a *Salix alaxensis* cluster along a river bar. A male was seen flying in the area later that day and again on 21 June. Two pairs flushed from Tussock plots on 20 June. A brood of 6 downy young was found adjacent to Tussock plots in similar habitat on 5 July.

HARLEQUIN DUCK - Uncommon summer visitant. Harlequin ducks were seen along the Katakturuk River in June. A single female swam in the river on 19 June, and on 20 June, 1 swam to a cut bank sheltered by willows. Two adult females flew downstream on 22 June. On 23 June, a male flushed from riparian willows and flew upstream approximately 1.5 km north of camp. No sightings were made later in the season.

RED-BREASTED MERGANSER - Rare spring migrant. One pair was observed flying upstream along the Katakturuk River on 20 June.

ROUGH-LEGGED HAWK - Uncommon summer visitant. A Rough-legged hawk was seen atop a willow during an aerial reconnaisance flight on 8 June. One to 2 hawks hunted and soared over the Katakturuk River bluffs, *Dryas* river terrace, moist sedge tussock-dwarf shrub tundra, and moist sedge-prostrate tundra from 20 to 23 June and on 4 July. Both light and dark phase individuals were observed.

GOLDEN EAGLE - Uncommon summer and fall visitant. A single adult hunted over river bluffs on 20 and 23 June. In fall, 1 immature bird soared over river bluffs on 25 August and 3 immature eagles soared over river bluffs and moist sedge-prostrate shrub tundra on 26 August.

MARSH HAWK - Rare summer and fall visitant. A single female hunted in *Dryas* river terrace and moist sedge-prostrate shrub tundra at base of the Katakturuk River bluffs south of camp on 23 June, over moist sedge-prostrate shrub tundra on 24 August, and over riparian willow and river bars on 26 August.

PEREGRINE FALCON - Rare summer visitor. Two sightings were made of falcons which were probably peregrines, although positive identification was not verified. On 20 June a falcon was observed hunting over the river bluffs west of camp. On 5 July a falcon hunted over the Tussock plots and river bluffs.

WILLOW PTARMIGAN - Uncommon fall visitant. Willow ptarmigan were first observed on 25 August, with 1 seen on a ridge along the river bluffs and 2 flushed from Tussock 1 plot. It is possible that willow ptarmigan were present earlier in the season but were not identified to species.

ROCK PTARMIGAN - Common breeder and fall resident. Rock Ptarmigan were present on the study area on 19 June. Primarily males were observed from 19 to 23 June in riparian willow, moist sedge tussock-dwarf shrub tundra, and moist sedge-prostrate shrub tundra. Peak of male courtship displays was observed on 23 June. Molting males were seen on 22, 23 June and 4, 6 July. Two nests were found: 1 on the Sedge Meadow 1 plot contained 5 eggs and was incubated by a female on 22 June and 4 July, but was depredated on 15 July. Another nest being incubated by a female was found on 23 June in moist sedge tussock-dwarf shrub tundra upstream from camp. A pair was seen on Tussock 1 plot on 20 June, and a pair behaved defensively on Tussock 2 plot on 22 June, but the nest was not found. In the fall, 1 rock ptarmigan was flushed from moist sedge-tussock-dwarf shrub tundra on 25 August.

SEMIPALMATED PLOVER - Uncommon breeder. Semipalmated plovers were first observed on 19 June. Small numbers (1-2 birds) were seen on Katakturuk River bars from 19 to 23 June and on 5, 6, 15, and 16 July. A nest with 4 eggs, defended by a pair of plovers, was found on 23 June on Dryas river terrace near a river bar approximately 3 km upstream from camp. Three eggs fitting the measurements and description for semipalmated plover (Harrison 1978) were found in and beside an American golden plover nest, along with 3 regular sized American golden plover eggs on 5 July. A semipalmated plover was chased away from this nest site several times by the American golden plover pair. Semipalmated plovers were seen on 16 July on river bars near camp and on Riparian Willow plots acting defensively, indicating probable chicks, but none were found.

AMERICAN GOLDEN PLOVER - Common breeder, uncommon fall migrant. This species was common on Dryas river terrace and river bars with sparsely scattered willows on 19 June. Courtship display flights were observed from 20 to 22 June. Two nests with 4 incubated eggs were found on 21 June on the Riparian Willow 2 plot in Dryas river terrace habitat. A nest found on 5 July in Riparian Willow 1 plot had the unusual contents of 3 American golden plover eggs and 2 smaller eggs with a third next to the nest, apparently having been laid by a semipalmated plover present in the vicinity of the nest. Hatching was in progress on 6 July at a nest with 1 chick and 3 eggs still being incubated. Adults displayed defensive behavior between 23 June and 16 July, with 5 pairs of adults seen within a 1.5 km radius of camp, but no additional chicks were found. Plovers were observed feeding in moist sedge-prostrate shrub tundra and moist sedge tussock-dwarf shrub tundra between 22 and 23 June. Riparian Willow plots had higher mean total summer densities (20-23 birds/km^2) and higher breeding densities (10 nests/km^2) than plots at Okpilak River delta (0.5-12.5 birds/km^2 total density and 2-4 nests/km^2 breeding density). In the fall, this species was uncommonly observed, with a single individual sighted on the Riparian Willow 2 plot and a flock of 12 birds flying to north over the Sedge Meadow 1 plot on 26 August.

RUDDY TURNSTONE - Uncommon probable breeder. Ruddy turnstones were present in small numbers on 19 June. During 19 to 23 June, singles or pairs were observed feeding in riparian willow habitat, *Dryas* river terrace, and flying along the river. On 16 July, several individuals were defensive around probable chicks in riparian willow habitat. In the fall 1 flew past camp and 1 was feeding on the river bar on 26 August.

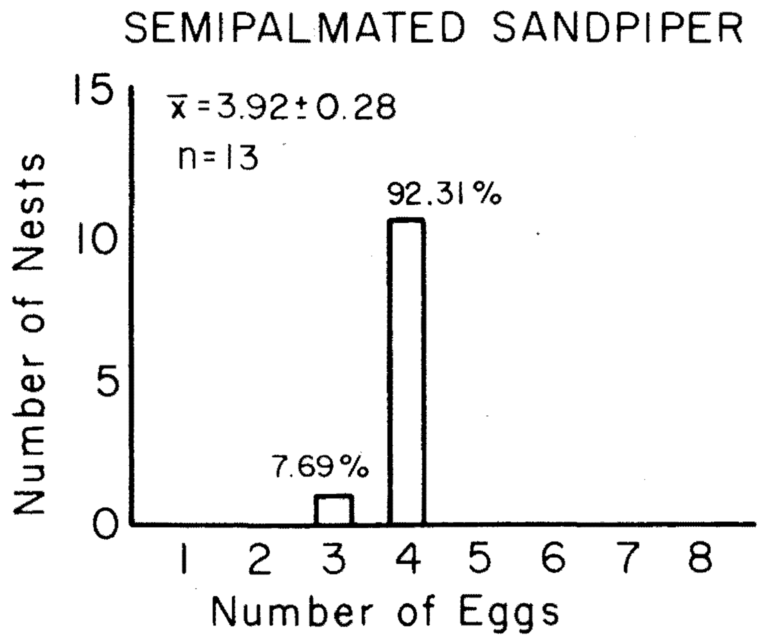
NORTHERN PHALAROPE - Rare breeder. A single observation was made on Tussock 2 plot on 15 July. A male individual defended 3 chicks at the only polygon trough filled with water in the vicinity at this time.

SANDERLING - Rare breeder. Two observations of sanderlings were made in the Katakturuk study area. One individual was observed on 19 June on *Dryas* river terrace behaving as if a nest was probably in the vicinity. One defensive adult in nuptial plumage was accompanied by 2 chicks in riparian willow and *Dryas* terrace habitats on 14 July.

SEMIPALMATED SANDPIPER - Abundant breeder. Semipalmated sandpipers were present on 19 June. Courtship flight displays were common from 19 to 23 June. Of 13 nests found between 19 June and 5 July, 92% contained 4 eggs (Fig. 21). One nest was found on Tussock 2 plot, but the majority were in riparian willow (8 nests) or *Dryas* river terrace (4 nests). The first hatched chicks were found in a nest on 5 July and hatching occurred at 2 other nests on 6 July. Fledged downy young were also observed on 5 and 6 July. Groups of as many as 6 adults were defensive and conducted territorial displays in the vicinity of nests and chicks on 5 and 6 July. The first flight capable young-of-the-year was a single bird observed accompanied by 4 adults on an unvegetated river bar on Riparian Willow 2 plot on 16 July. Mean total summer densities on Riparian Willow and Tussock plots (30.0-100.0 birds/km^2) were higher than those recorded for Flooded, Mosaic, and Sedge-Tussock plots at the Okpilak River delta (1.0-12.5 birds/km^2). Breeding densities were higher in Katakturuk Riparian Willow plots (30-40 nests/km^2), and higher or equivalent in Katakturuk Tussock plots (10-30 nests/km^2) than densities in Mosaic plots at Okpilak River delta (8-10 nests/km^2). Semipalmated sandpipers were not seen in the fall.

BAIRD'S SANDPIPER - Uncommon possible breeder. Baird's sandpiper was present in the study area on 19 June. Groups of 1-3 birds were observed feeding on Katakturuk River bars, *Dryas* river terrace and riparian willow areas between 19 and 23 June. Male display flights were seen on 21 and 23 June in riparian willow, river bluffs, and along the river. One observation of Baird's sandpiper on moist sedge-prostrate shrub tundra was made on 4 July. Several individuals were defensive, possibly near chicks, in riparian willow habitat on 15 and 16 July.

PECTORAL SANDPIPER - Uncommon breeder, common fall migrant. Pectoral sandpipers were first observed on 20 June and were observed feeding in moist sedge tussock-dwarf shrub tundra from 20 to 23 June, and in moist sedge-prostrate shrub tundra on 22 June. Breeding occurred on Tussock 1 plot



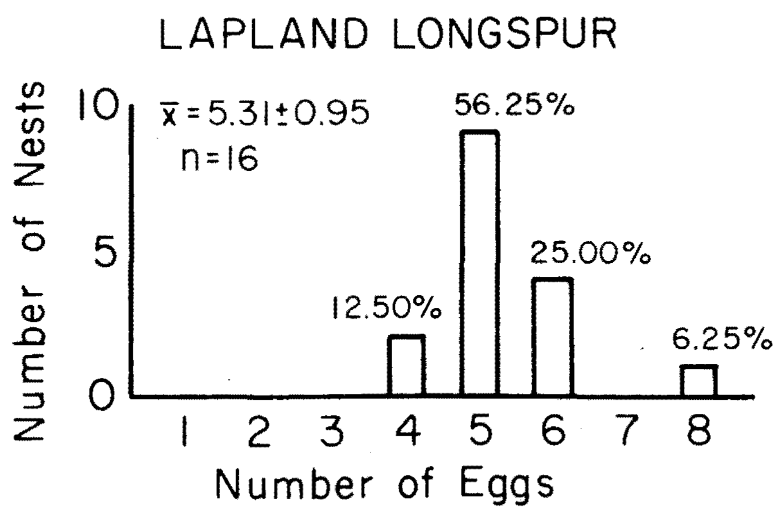


Fig. 21. Clutch sizes of semipalmated sandpiper and Lapland longspur nests Katakturuk River, Arctic National Wildlife Refuge, Alaska, June-July 1982.

where an adult female with 2 chicks was found on 15 July. Adults were seen flying over Sedge Meadow and Riparian Willow plots on 16 July. Pectoral Sandpipers were most abundant during fall migration when they were the most numerous shorebird species. A single bird was seen flying east over Dryas river terrace on 24 August. There was a large influx of birds on 26 August with flocks ranging in size from 4-17 birds being flushed from wet areas in Sedge Meadow plots, a flock of 5 foraged on a river bar, and other flocks of 5-25 birds travelled west at high and low altitudes over the tundra.

BUFF-BREASTED SANDPIPER - Uncommon summer visitant. First observation was a lek with 3 displaying sandpipers on Dryas river terrace on 19 June. Three birds were seen on Riparian Willow 2 plot on 21 June and 1 on Tussock 1 plot on 5 July.

POMARINE JAEGER - Rare spring migrant. A single bird flying south over riparian willow habitat on 21 June was the only observation of this species.

PARASITIC JAEGER - Uncommon possible breeder. Parastic jaegers were present in the Katakturuk study area on 19 June. Jaegers were seen hunting over Dryas river terrace, moist dwarf shrub-sedge tussock tundra, and moist sedge-prostrate shrub tundra between 19 and 23 June, and 4 July. Dark phase birds were primarily observed. A nest was suspected in moist sedge-prostrate shrub tundra on 23 June. Parasitic jaegers were less numerous in late July, with a single sighting on 16 July. In August, jaegers were again more abundant, with 4 seen hunting over moist sedge-prostrate shrub tundra on 24 August, and 2 on 25 August.

LONG-TAILED JAEGER - Common breeder. Long-tailed jaegers were present in the study area on 19 June. Five nests were found in Dryas river terrace habitat within a 9.5 km radius of camp from 20 to 23 June. Pairs of Jaegers defended 3 nests containing 2 eggs, 1 nest with 1 egg, and at 1 nest in which a bone was incubated with no eggs present. Hatching took place on 6 July at 1 nest which had 1 chick and 1 egg in the process of hatching, and earlier at another nest which held 2 downy chicks on this date. Jaegers hunted in Dryas river terrace, riparian willow, and moist sedge-prostrate shrub tundra on 19-23 June and 4-6 and 16 July. A jaeger with collared lemming prey was noted at a nest on 23 June. Last observations of long-tailed jaegers were made on 16 July when 2 adults defended an approximately 10 day old downy chick. On this date, up to 5 long-tailed jaegers hunted nearby on Dryas river terrace.

GLAUCOUS GULL - Rare spring migrant. One glaucous gull was seen feeding and a group of 3 travelled north along the Katakturuk River on 20 June.

HERRING GULL - Rare spring migrant. One herring gull was observed flying over riparian willows along the Katakturuk River on 21 June.

SNOWY OWL - Rare summer visitant. A snowy owl was observed flying and resting at the base of Katakturuk River bluffs on 6 July.

SHORT-EARED OWL - Uncommon summer visitant. A short-eared owl was first observed on 21 June, hunting in moist sedge-prostrate shrub tundra. One owl flushed from Tussock 2 plot on 22 June and 5 July, with a second individual also seen hunting on 22 June. Last sighting was an owl flushed from Sedge Meadow 2 plot on 16 July.

HORNED LARK - Rare summer visitant. Horned larks were first observed on 21 June with 2 adults observed feeding on Dryas river terrace on Riparian Willow 1 plot. Four horned larks displayed and foraged on a sparsely vegetated ridge top south of camp on the east side of river on 23 June.

COMMON RAVEN - Rare summer visitant. Common ravens were observed flying through the study area on 21 June, 17 July, and 25 August. In July, a raven was chased by long-tailed jaegers.

YELLOW WAGTAIL - Fairly common breeder. Yellow wagtails were present on 19 June. Courtship calling from willow perches and display flights were noted from 19 to 23 June in riparian willow thickets, and infrequently over moist sedge tussock-dwarf shrub tundra. Defensive behavior was observed in riparian willow thickets on 20 and 23 June and on 6 and 15 to 16 July. A presumed yellow wagtail nest was found beneath low willows on Riparian Willow 2 plot . It contained 3 incubated eggs on 21 June and hatched chicks on 6 July when a pair of wagtails behaved defensively in this area. One adult acted defensively with a nest probably nearby on 15 July in moist sedge-prostrate shrub tundra that was adjacent to willow thickets along the river bluff west of camp. One pair was seen feeding a fledging on Riparian Willow 2 plot on 16 July. The fledging was olive brown in color with blackish throat and eyeline markings. Yellow wagtails were not observed in the fall.

WATER PIPIT - Rare probable breeder, fairly common fall migrant. Water pipits were first observed on 15 July. Evidence of breeding was shown by 2 adults carrying food and acting defensive on a river bluff west of camp and east of Tussock plots, but intensive searching did not reveal nests. Water pipits were more abundant during fall migration. As many as 12 birds foraged on river bars and mudflats in Riparian Willow plots and perched in willows on 25 and 26 August. Pipits also flushed from Tussock 1 plot and were seen flying over Sedge Meadow 1 plot during this same time period.

REDPOLL - Abundant breeder. Redpolls were present on 19 June. Courtship display fights were common in riparian willow thickets between 19 and 23 June. Nesting activities were well underway on 21 June, when 2 nests with incubated eggs and 1 nest containing 3 eggs and 2 young were found on Riparian Willow 1 plot. Three young were found on 22 June in a nest on Dryas river terrace. The 3 nests on Riparian Willow 1 plot were empty by 5 July. One additional nest was found with 2 eggs and 3 young on 5 July; 5 young nearly ready to fledge were still in the nest when rechecked on 15 July. The first flight capable fledglings were seen on 16 July in Riparian Willow 2 plot . Redpoll breeding densities were higher in Riparian Willow 1 plot (40 nests/km^2) than in Riparian Willow 2 plot (5 nests/km^2). Willow 1 plot had more extensive and taller willows. Redpolls were present during fall with a flock of 6 observed foraging among willows and on the river bar on Riparian Willow 2 plot. Smaller groups were seen flying over the study area on 25 and 26 August.

SAVANNAH SPARROW - Uncommon probable breeder, rare fall visitant. Savannah Sparrows were first observed on 20 June. Singing was heard in riparian willow, moist dwarf shrub-sedge tussock tundra, and moist sedge-prostrate shrub tundra from 20 to 23 June and on 7 July. A pair was seen gathering food on Tussock 1 plot on 5 July. On 15 July, adults were commonly heard calling on Tussock plots and were probably defending chicks, but none were found. Savannah sparrows achieved highest mean summer densities on Tussock plots (16.7 and 43.3 birds/km^2). In the fall a single observation was made of a bird singing on Riparian Willow 1 plot 25 August.

TREE SPARROW - Fairly common breeder. Tree sparrows were present in riparian willow thickets on 19 June. Males were heard singing from 19 to 23 June and 1 was still singing on 16 July. Two nests containing 4 and 5 eggs were found on 20 and 21 June on the ground under willows on Riparian Willow 1 plot. Young were present in nests when rechecked on 5 July, with 1 clutch nearly ready to fledge. Tree sparrows were only present on Riparian Willow 1 plot with breeding densities of 20 territories/km^2. In the fall, adults and juveniles called from willow perches in Riparian Willow 1 plot on 25 August.

CHIPPING SPARROW - Casual summer vistant. A single observation was made of a singing bird in a riparian willow area upstream from camp on 23 June.

LAPLAND LONGSPUR - Abundant breeder. Lapland longspurs were observed on 19 June. Aerial flight displays were common in riparian willow, *Dryas* river terrace, moist sedge tussock-dwarf shrub tundra, and were occasionally observed in moist sedge-prostrate shrub tundra from 19 to 23 June. Aerial displays had ceased by 5 July. Sixteen nests were found between 19 June and 6 July with mean clutch size of 5.3, ranging from 4-8 eggs (Fig. 21). The majority of nests (11) were found in Riparian Willow plots and habitats, 3 on Tussock plots, 1 on Sedge Meadow 1 plot, and 1 in *Dryas* river terrace. First hatching occurred at a nest which contained 3 young and 3 eggs on 21 June. Nests held young ranging in age from approximately 2 days old to clutches nearly ready to fledge between 4 and 6 July. The first fledgling was seen flying on Tussock 1 plot on 5 July. Groups of female longspurs were seen flocking together in riparian willow habitat on 15 July. Breeding densities were highest in Riparian Willow plots (50 and 55 territories/km^2) and lowest in Sedge Meadow plots (10 territories/km^2). These breeding densities were similar to densities on plots at the Okpilak River delta (10-60 territories/km^2). Mean summer total densities were higher for Katakturuk Riparian Willow plots (166.7 and 190.0 birds/km^2) than highest longspur densities found at Okpilak River delta plots (127.5 birds/km^2 for 10 ha Mosaic and 10 ha Sedge-Tussock plots. In the fall, Lapland longspurs, with a high percentage of young birds, were found in all habitats, with greatest densities on Riparian Willow plots.

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APPENDIX

ANWR Progress Report Number FY83-5

Table A-1. Bird census plot dimensions, areas, line azimuths, witness to benchmarks, and census coverage, at outer coastal plain, Okpilak River delta, Arctic National Wildlife Refuge, Alaska, June-August 1982.

	Flooded (2a, 2b, 3b)		Mosaic (3c)		Wet Sedge (3a)		Sedge-Tussock (5a)	
Area (ha)	50	10	50	10	50	10	25	10
Dimensions (meters)	900x556	500x200	707x707	500x200	707x707	500x200	743x336	500x200
Line azimuths from NE, NW, SE SW corners (degrees true)	260°, 170° 80°, 350°	190°, 100° 010°, 280°	280°, 190° 100°, 010°	280°, 190° 100°, 010°	270°, 180° 090°, 000°	270°, 180° 090°, 000°	270°,175° 090°,352°	246°,156° 066°,336°
Witness to Benchmarks	From SW cor. 893m at 217° to VABM MARS (highest marker)	From NE cor. 50 ha plot, 100 m at 280°to NW cor. 10 ha plot.	From SE cor. 506m at 190° to VABM MARS (highest marker)	From SW cor. 50 ha plot, 100m at 280° to SE cor. 10 ha plot	From NW cor. 200m at 328° to NW cor., NE 1/4 Sec. 23 T8N R33E, U.M.	From NE cor. 220m at 020° to NW cor., NE 1/4 Sec. 23 T8N R33E, U.M.	From NW cor. 600m at 336° to NW cor 10 ha	From NW cor. 188m at 013° to cor. Secs 21 22, 27, 28, T8N R33E, U.M.
Census Coverage (date/time)	6/26 0914-1843 7/1 1335-2100 7/10 1030-1845 7/15 2250-0345 7/16 8/23 1215-1755	6/26 1905-2020 7/1 1145-1300 7/10 1145-1450 7/15 2100-2230 8/23 1025-1140	6/15 1450-2140 6/27 1130-2000 7/3 0930-1730 7/12 1115-1745 8/22 0915-1535	6/18 1525-1720 6/27 2000-2120 7/7 1127-1305 7/12 1800-1910 8/21 1708-1755	6/24 1315-2035 6/30 1300-2115 7/8 1105-1750 7/13 1150-1705 8/20 1135-1708	6/24 2115-2225 6/30 1137-1230 7/8 1815-1910 7/13 1045-1140 8/20 1740-1827	6/17 1600-2030 6/28 1350-1725 7/9 1240-1530 7/14 2255-0215 7/15 8/18 1602-1812	6/17 2110-2211 6/28 1130-1250 7/9 1638-1738 7/14 2120-2240 8/18 1840-1930
Total person-hours of census	140.9	25.2	156.0	26.3	148.8	22.3	79.9	26.5
Person/hrs/ha	2.8	2.5	3.1	2.6	3.0	2.2	3.2	2.7

Table A-2. Bird census plot dimensions, areas, line azimuths, witness to benchmarks and census coverage, at interior coastal plain, Katakturuk River, Arctic National Wildlife Refuge, Alaska, 1982.

	Riparian Willow (4b, 9a, 10)		Tussock (6a, 7a)		Sedge Meadow (5a)	
	1	2	1	2	1	2
Area (ha)	10	10	10	10	10	10
Dimensions (meters)	660x150	660x150	500x200	500x200	500x200	500x200
Line azimuths from NE, NW, SE SW corners. (degrees true)	315°, 225° 135°, 045°	308°, 218° 128°, 038°	314°, 225° 134°, 045°	315°, 225° 135°, 045°	311°, 220° 131°, 040°	311°, 221° 131°, 041°
Census coverage (date, time)	6/21 1055-1345 7/5 1425-1630 7/15 2140-0000 8/25 1000-1155	6/21 1555-1847 7/6 0955-1245 7/16 1145-1350 8/26 1120-1250	6/22 1110-1250 7/5 1845-2010 7/15 0210-0415 8/25 1512-1631	6/22 1255-1425 7/5 1730-1840 7/15 0455-0600 8/25 1708-1811	6/22 1740-1837 7/4 1315-1222 7/16 1445-1555 8/26 1458-1539	6/22 1640-1735 7/4 1430-1530 7/16 1600-1650 8/26 1552-1633
Total person-hours of census	37.4	37.1	23.6	18.2	14.9	12.9
Person/hrs/ha	3.7	3.7	2.4	1.8	1.5	1.3

Table A-3. Sky cover, precipitation and wind conditions at outer coastal plain, Okpilak River delta, 6-19 and 24-30 June, 7-18 July and 18-23 August, 1982, and at interior coastal plain, Katakturuk River, 19-23 June, 4-6 July, 25-26 August, 1982.

	Okpilak River Delta			Katakturuk River		
	June	July	August	June	July	August
Sky cover (% of observations)						
Clear	30	60	50	60	0	100
Partly cloudy	7	7	17	0	60	0
Cloudy	63	33	33	40	40	0
Precipitation (# of days)						
Rain	4	3	2	0	1	0
Snow/sleet	5	0	0	0	0	0
Fog	4	6	2	3	3	1
Wind direction (% of observations)						
Calm	10	21	0	0	17	100
Northeast	2	0	0	0	0	0
Northeast-east	71	69	34	88	83	0
East	7	0	0	0	0	0
Southwest	7	3	33	0	0	0
West	3	7	33	22	0	0
Northwest	2	0	0	0	0	0
Mean Wind Speed (kph)	14.1	12.3	21.6	19.0	12.3	--

Table A-4. First-observed flowering dates for the more common plant species found in the Okpilak River delta study area Arctic National Wildlife Refuge, Alaska, June-July 1978 and 1982.

Species	1978	1982
Alopecurus alpinus	2 July	
Andromeda polifolia	14 July	8 July
Androsace chamaejasme Lehmanniana	2 July	2 July
Anemone parviflora	4 July	20 June
Astragalus alpinus alpinus	9 July	8 July
Astragalus umbellatus	5 July	2 July
Betula nana	6 July	30 June
Caltha palustris arctica	3 July	29 June
Cardamine bellidifolia	1 July	29 June
Cardamine hyperborea	8 July	
Carex aquatilis		10 July
Carex Bigelowii	30 June	
Carex misandra		9 July
Carex rariflora		10 July
Carex saxatilis x rostrata		8 July
Cassiope tetragona tetragona	1 July	
Cerastium Beeringianum Var. grandiflorum	3 July	
Chrysanthemum arcticum arcticum	17 July	
Cochlearia officinalis	30 June	
Corydalis pauciflora	6 July	8 July
Dodecathon frigidum	13 July	
Draba alpina	6 July	2 July
Draba barbata	1 July	
Draba fladnizensis	5 July	
Draba pseudopilosa	2 July	
Dryas integrifolia integrifolia	1 July	
Equisetum variegatum	17 July	
Eriophorum angustifolium		26 June
Eriophorum russeolum		30 June
Eriophorum vaginatum	5 June	10 June
Eutrema Edwardsii	16 June	
Hierochloe alpina	8 July	8 July
Hierochloe pauciflora	16 July	
Juncus arcticus alaskanus	16 July	
Lagotis glauca	1 July	29 June
Luzula confusa	16 July	2 July
Luzula tundricola	16 July	
Melandrium apetalum arcticum	13 July	2 July
Minuartia arctica	6 July	
Oxyria digyna	1 July	26 June
Oxytropis Maydelliana	4 July	2 July
Oxytropis nigrescens bryophila	28 June	29 June
Papaver lapponicum occidentale	4 July	8 July
Papaver Macounii	1 July	

Table A-4. (Continued)

Species	1978	1982
Parrya nudicaulis	28 June	29 June
Pedicularis capitata		6 July
Pedicularis Kanei Kanei	22 June	24 June
Pedicularis Langsdorffii arctica	5 July	
Pedicularis sudetica		
Petasites frigidus	1 July	2 July
Polmonium acutiflorum	15 July	
Polemonium boreale boreale	3 July	2 July
Polygonum bistorta plumusum	6 July	
Polygonum viviparum	16 July	
Potentilla hyparctica		30 June
Potentilla palustris	29 June	
Potentilla pulchella	3 July	2 July
Primula borealis	1 July	2 July
Ranunculus nivalis	22 June	24 June
Ranunculus pedatifidus affinis	15 June	2 July
Rubus chamaemorus	6 July	
Salix arctica		29 June
Salix brachycarpa niphoclada	17 July	
Salix fuscescens	7 July	
Salix lanata	29 June	
Salix phlebophylla	29 June	24 June
Salix planifolia pulchra	30 June	27 June
Salix polaris	30 June	
Salix reticulata	30 June	
Saxifraga caespitosa	18 July	2 July
Saxifraga cernuua		2 July
Saxifraga foliosa foliosa	9 July	
Saxifraga foliosa multiflora	14 July	
Saxifraga hieracifolia		30 June
Saxifraga oppositifolia	10 June	8 June
Saxifraga punctata Nelsoniana	1 July	25 June
Sedum rosea integrifolium	20 July	
Senecio atropurpureus frigidus	13 July	
Senecio congestus	16 July	
Senecio yukonensis	6 July	
Silene acaulis acaulis	5 July	2 July
Stellaria crassifolia	9 July	
Stellaria Edwardsii	14 July	
Stellaria laeta	29 June	
Taraxacum lacerum	16 July	
Vaccinium uliginosum	5 July	8 July
Valeriana capitata	5 July	

Table. A-5. Approximate equivalent habitat type names for bird census plots in 7 habitat types studied on the coastal plain of the Arctic National Wildlife Refuge, Alaska June-August 1982.

Plot Common Name	Abbreviation	Acevedo et al. (1982)	Nodler (1977)	Viereck et al. (1982) Level IV
Flooded (50 ha and 10 ha)	2a 2b 3b	pond complex aquatic tundra-pond complex wet sedge tundra-very wet complex	flooded tundra very wet sedge tundra	3A(3)e fresh grass marsh 3A(3)a wet sedge meadow tundra 3A(2)h sedge-willow tundra 3A(2)g mesic grass-herb meadow tundra
Mosaic (50 ha and 10 ha)	3c	wet sedge tundra-moist complex	intermediate wet-moist tundra	3A(3)a wet sedge meadow tundra 3A(2)h sedge-willow tundra 3A(2)j sedge-*Dryas* tundra 3C(1)b *Dryas*-lichen tundra
Wet Sedge (50 ha and 10 ha)	3a	wet sedge tundra-non complex	wet sedge meadow	3A(3)a wet sedge meadow tundra 3A(2)h sedge-willow tundra 3C(2)s willow-grass tundra
Sedge-Tussock (25 ha and 10 ha)	5a	moist sedge-prostrate shrub tundra	upland sedge meadow upland tussock meadow	3A(3)a wet sedge meadow tundra 3A(2)h sedge-willow tundra 3A(2)j sedge-*Dryas* tundra 2C(1)d *Cassiope* tundra 2C(1)e low-willow tundra
Riparian Willow (1 and 2 - 10 ha)	4b (*Dryas* river terrace) 9a 10	dry prostrate shrub-forb tundra partially vegetated areas-river bars barren gravel or rock	*Dryas* terrace community partially vegetated ground partially vegetated ground	2B(1)a willow 2C(2)b low willow 2C(1)c *Dryas*-herb tundra 3B(1)a seral-herbs
Tussock (1 and 2 - 10 ha)	6a 7a	moist sedge tussock-dwarf shrub tundra moist dwarf shrub-sedge tussock tundra	upland tussock meadow	2C(2)r willow-sedge tundra 3A(2)d tussock tundra 3A(3)a wet sedge meadow tundra 2C(2)b low willow
Sedge Meadow (1 and 2 - 10 ha)	5a	moist sedge-prostrate shrub tundra	upland sedge meadow 3A(2)j sedge-*Dryas* tundra	3A(3)a wet sedge meadow tundra

Table A-6. Relative abundance of plant species observed during vegetation studies of the 3 different habitats censused for birds, Katakturuk River, Arctic National Wildlife Refuge, Alaska, June-July 1982. The plant list does not presume to be exhaustive, but includes the more readily recognizable taxa reaching anthesis by mid-July. A=Abundant; C=common; U=Uncommon; R=Rare.

Species	Riparian Willow	Tussock	Sedge Meadow
21-22 June:			
Anemone parviflora	A		
Empetrum nigrum		U	
Eriophorum vaginatum		C	R
Pedicularis Kanei	C	C	C
Salix alaxensis	A		
Salix phelbophylla		C	
Saxifraga punctata	U	U	
Thlaspi arcticum	R		
4-5 July:			
Anemone Richardsonii	R		
Astragalus alpinus	A		
Astragalus umbellatus	C		
Caltha palustris	U	R	
Cassiope tetragona		U	
Castilleja caudata	C		
Corydalis pauciflora		R	
Dodecatheon frigidum		R	
Dryas integrifolia	A	A	A
Hedysarum alpinum	A		
Hedysarum Mackenzii	A		
Juncus biglumis	U	R	
Lagotis glauca		U	
Ledum palustre		U	
Lloydia serotina	U		
Lupinus arcticus	U	R	
Minuartia arctica	U		
Myosotis alpestris asiatica	R		
Oxytropis arctica	A		
Oxytropis borealis	A		
Oxytropis campestris	A		R
Oxytropis Maydelliana	U	R	
Oxytropis nigrescens	A		
Papever Macounii	C	U	U
Parnassia Kotzebuei	R		
Parrya nudicaulis	U	R	
Pedicularis capitata	C	U	R
Pedicularis sudetica	U	U	C
Petasites frigidus		C	

Table A-6. (Continued)

Species	Riparian Willow	Tussock	Sedge Meadow
Polemonium acutiflorum	U		
Polemonium boreale	R		
Pyrola grandiflora		U	
Rhododendron lapponicm			R
Rumex arcticus			R
Rubus chamaemorus		U	
Salix reticulata	U	C	C
Saxifraga bronchialis	R		
Saxifraga hieracifolia		U	
Tofielda coccinea	U		
Vaccinium vitis-idaea		C	
Valeriana capitata	U	U	R
15-16 July			
Achillea borealis	U		
Arctagrotis latifolia	U	U	
Arnica alphina	U		
Artemisia arctica	U		
Bromus Pumpellianus arcticus	U		
Carex aquatilis	R	C	A
Carex saxatilis		U	C
Crepis nana	R		
Epilobium latifolium	U		
Pedicularis verticillata	U		
Poa arctica	U		
Polygonum viviparum	U	U	
Potentilla fruticosa	R		
Senecio lugens	U		
Senecio resedifolius	U	U	

Table A-7. Breeding bird densities (nests-territories/km^2) on plots in the outer coastal plain, Okpilak River delta, and interior coastal plain, Katakturuk River, Arctic National Wildlife Refuge, Alaska, June-July 1982.

Species	Flooded (2a,2b,3b)		Mosaic (3c)		Wet Sedge (3a)		Sedge-Tussock (5a)		Riparian Willow (4b,9a,10)		Tussock (6a,7a)		Sedge Meadow (5a)	
	50 ha	10 ha	50 ha	10 ha	50 ha	10 ha	25 ha	10 ha	10ha 1	10 ha 2	10ha 1	10 ha 2	10ha 1	10 ha 2
Arctic loon		10												
Red-throated loon	2													
Oldsquaw							8							
King eider	2													
Rock ptarmigan													10	
American golden plover			2				4		10	10				
Northern phalarope	8	20	4		2		4	10						
Red phalarope	2		4	10	4									
Long-billed dowitcher			2		4									
Semipalmated sandpiper[a]			8	10					30	40	10	33		
Pectoral sandpiper[b]	10(26)[c]	10(18)	16(27)	40(25)	18(10)	10(15)	4(12)	10(20)			10(18)			
Stilt sandpiper					2									
Buff-breasted sandpiper			4		2									
Parasitic jaeger	2													
Glaucous gull		10												
Yellow wagtail[a]									13	10				
Redpoll									40	5				
Savannah sparrow[a]											18	10		
Tree sparrow[a]									20					
Lapland longspur[a]	12	10	41	55	32	30	48	60	55	50	50	40	10	10
Total nests	38	60	81	115	64	40	68	80	168	115	88	83	20	10
Total breeding species	7	5	8	4	7	2	5	3	6	5	4	3	2	1

[a]male territories/km^2.
[b]nests plus probable incubating females plus probable nests/km^2.
[c]number of male territories.

Table A-8. Numbers of nests found on plots in outer coastal plain, Okpilak River delta, and interior coastal plain, Katakturuk River, Arctic National Wildlife Refuge, Alaska, June-July 1982.

Species	Flooded (2a,2b,3b)		Mosaic (3c)		Wet Sedge (3a)		Sedge-Tussock (5a)		Riparian Willow (4b,9a,10)		Tussock (6a,7a)		Sedge Meadow (5a)	
	50 ha	10 ha	50 ha	10 ha	50 ha	10 ha	25 ha	10 ha	10ha 1	10 ha 2	10ha 1	10 ha 2	10ha 1	10 ha 2
Arctic loon		1												
Red-throated loon	1													
Oldsquaw							2							
King eider	1													
Rock ptarmigan													1	
American golden plover			1				1		1	1				
Northern phalarope	4	2	2		1		1	1						
Red phalarope	1		2	1	2									
Long-billed dowitcher			1		2									
Semipalmated sandpiper			3						1	4		1		
Pectoral sandpiper	3		6	4	3	1								
Stilt sandpiper					1									
Buff-breasted sandpiper			2		1									
Parasitic jaeger	1													
Glaucous gull		1												
Yellow wagtail										1				
Redpoll									4					
Tree sparrow									2					
Lapland longspur	3		12	1	11		8	2	1	5	2	1	1	
Total nests	14	4	29	6	21	1	12	3	9	11	2	2	2	0
Nests/km^2	28	40	58	60	42	10	24	30	90	110	20	20	20	0
No. species with nests	7	3	8	3	7	1	4	2	5	4	1	2	2	0

Table A-9. Subsampling results from 10, 20, 30, and 40 ha originally censused 15 June - 12 July 1982 on the 50 ha Mosaic Tundra plot, Okpilak River delta study area, Arctic National Wildlife Refuge, Alaska. Figures are mean birds/km^2 ± standard deviation over 4 censuses.

	10 ha	20 ha	30 ha	40 ha	50 ha
Pintail		2.5 ± 5.0	1.7 ± 3.3	4.4 ± 8.8	3.5 ± 7.0
Oldsqauw		7.5 ± 15.0	6.7 ± 9.4	8.8 ± 14.4	5.5 ± 8.5
Rock ptarmigan					0.5 ± 1.0
Golden plover	7.5 ± 1.5	3.8 ± 7.5	4.2 ± 8.3	3.1 ± 6.3	3.0 ± 6.0
Northern phalarope	10.0 ± 8.2	6.3 ± 4.8	5.8 ± 5.7	10.6 ± 8.5	7.5 ± 7.2
Red phalarope				2.5 ± 3.5	7.0 ± 3.7
Long-billed dowitcher		6.3 ± 9.5	5.8 ± 9.6	6.9 ± 12.2	4.5 ± 7.7
Semipalmated sandpiper	7.5 ± 9.6	16.3 ± 16.0	15.8 ± 13.7	15.0 ± 10.2	10.5 ± 8.5
Pectoral sandpiper	45.0 ± 33.2	37.5 ± 24.0	38.3 ± 20.1	43.8 ± 29.3	45.5 ± 27.1
Stilt sandpiper		1.3 ± 2.5	0.8 ± 1.7	0.6 ± 1.3	0.5 ± 1.0
Buff-breasted sandpiper	5.0 ± 5.8	6.3 ± 4.8	8.3 ± 7.9	12.5 ± 15.2	14.0 ± 21.35
Pomarine jaeger	5.0 ± 10.0	6.3 ± 12.5	4.2 ± 8.3	3.1 ± 6.3	4.5 ± 7.7
Parasitic jaeger	7.5 ± 15.0	6.3 ± 7.5	5.0 ± 4.3	6.3 ± 2.5	5.0 ± 2.0
Long-tailed jaeger	5.0 ± 5.8	2.5 ± 2.9	2.5 ± 3.2	2.5 ± 2.1	2.5 ± 1.0
Glaucous gull	2.5 ± 5.0	7.5 ± 11.9	5.0 ± 3.2	3.8 ± 6.0	2.5 ± 3.8
Snowy owl	5.0 ± 10.0	3.8 ± 4.8	2.5 ± 3.2	1.9 ± 2.4	1.5 ± 1.9
Short-eared owl	2.5 ± 5.0	1.3 ± 2.5	0.8 ± 1.7	1.3 ± 1.5	0.5 ± 1.0
Lapland longspur	90.0 ± 45.5	73.8 ± 34.5	86.7 ± 23.1	87.5 ± 21.2	83.5 ± 15.5
Total species	12	16	16	17	18
Species/ha	1.2	0.8	0.5	0.4	0.4
Total density birds/km^2	192.5 ± 57.4	188.8 ± 81.0	194.2 ± 61.4	214.4 ± 73.1	208.5 ± 72.6
Coefficient of seasonal variation	0.30	0.43	0.32	0.34	0.35
Total density % deviation from 50 ha	7.7	9.4	6.9	2.8	--

Table A-10. Subsampling results from 10, 20, 30, and 40 ha square plot subsamples taken of mean summer bird populations originally censused 24 June - 13 July 1982 on the 50 ha Wet Sedge Tundra plot, Okpilak River delta study area, Arctic National Wildlife Refuge, Alaska. Figures are expressed as mean birds/km^2 ± standard deviation over 4 censuses.

	10 ha	20 ha	30 ha	40 ha	50 ha
Pintail					1.0 ± 2.0
Oldsquaw			0.8 ± 1.7	1.9 ± 3.8	1.5 ± 3.0
King eider				1.3 ± 2.5	1.0 ± 2.0
Marsh hawk					0.5 ± 1.0
Sandhill crane				0.6 ± 1.3	1.5 ± 3.0
American golden plover		3.8 ± 4.8	3.3 ± 4.7	3.1 ± 4.7	2.5 ± 5.0
Northern phalarope	15.0 ± 12.9	16.3 ± 4.8	16.7 ± 11.5	18.8 ± 10.1	17.0 ± 8.3
Red phalarope		1.3 ± 2.5	5.0 ± 3.3	6.3 ± 4.3	5.0 ± 2.0
Long-billed dowitcher	12.5 ± 9.6	6.3 ± 4.8	7.5 ± 7.4	8.8 ± 6.0	10.5 ± 8.9
Pectoral sandpiper	30.0 ± 34.6	26.3 ± 25.0	27.5 ± 26.3	25.0 ± 21.9	32.0 ± 26.1
Stilt sandpiper				5.0 ± 6.8	4.0 ± 5.7
Buff-breasted sandpiper				0.6 ± 1.3	1.5 ± 1.9
Pomarine jaeger					0.5 ± 1.0
Parasitic jaeger		3.8 ± 4.8	5.8 ± 1.7	4.4 ± 1.3	5.0 ± 2.0
Long-tailed jaeger	5.0 ± 10.0	5.0 ± 5.8	4.2 ± 3.2	6.3 ± 3.2	5.0 ± 2.6
Snowy owl			0.8 ± 1.7	0.6 ± 1.3	1.0 ± 2.0
Short-eared owl	2.5 ± 5.0	1.3 ± 2.5	0.8 ± 1.7	0.6 ± 1.3	1.5 ± 1.9
Common raven		1.3 ± 2.5	0.8 ± 1.7	0.6 ± 1.3	0.5 ± 1.0
Lapland longspur	50.0 ± 25.8	70.0 ± 23.5	83.3 ± 17.4	85.0 ± 14.3	86.0 ± 21.6
Total species	6	10	12	16	19
Species/ha	0.6	0.5	0.4	0.4	0.4
Total density birds/km^2	115. ± 65.6	135.0 ± 51.8	157.5 ± 55.3	168.8 ± 48.9	177.5 ± 60.2
Coefficient seasonal variation	0.57	0.38	0.35	0.29	0.34
Total density % deviation from 50 ha	35.2	23.9	11.3	4.9	--

Table A-11. Chi-square goodness of fit, (Wilcoxon, signed-ranks, and paired-t tests) comparing distribution of species abundance (density) in 10, 20, 30, and 40 ha square subsamples of the 50 ha square Mosaic and Wet Sedge census plots, Okpilak River delta, 15 June - 12 July 1982. Asterisks indicate statistical significance.

	Subsample plot size (ha)				
	10	20	30	40	n
Mosaic					18
Chi square (X^2)	56.21	36.76	19.73	13.37	
p	$<$0.010	$<$0.250	$<$0.900	$<$0.995	
Wilcoxon (T)	66.5	74.0	65.0	50.5	
p	0.635	0.906	0.877	0.218	
Paired-t (t)	-0.537	-0.671	-0.562	1.318	
p	$<$0.500	$<$0.500	0.500	$<$0.200	
Wet Sedge					19
Chi-square (x^2)	41.98	23.21	12.97	20.11	
p	$<$0.005	$<$0.250	$<$0.900	$<$0.500	
Wilcoxon (T)	17.5	15.0	21.0	76.0	
p	0.003	0.002	0.005	0.445	
Paired-t (t)	-1.766	-2.556	-3.254	-1.066	
p	$<$0.100	$<$0.020	$<$0.010	$<$0.300	

Table A-12. Chi-square goodness of fit tests comparing estimates of species breeding density made from replicate 10 ha plot samples and from a single large 25 or 50 ha plot on the Okpilak River delta, Arctic National Wildlife Refuge, June-July 1982.

Species	Flooded		Mosaic		Wet Sedge		Tussock-Sedge	
	2-10 ha plots $\bar{X} \pm$ S.D.	50 ha plot	3-10 ha plots $\bar{X} \pm$ S.D.	50 ha plot	3-10 ha plots $\bar{X} \pm$ S.D.	50 ha plot	3-10 ha plots $\bar{X} \pm$ S.D.	25 ha plot
Arctic loon	5.0 ± 7.0	0						
Red-throated loon		2.0						
Oldsquaw							3.3 ± 5.8	8.0
King eider		2.0						
American golden plover			3.3 ± 5.8	2.0			0	4.0
Northern phalarope	10.0 ± 14.1	8.0	10.0 ± 10.0	4.0		2.0	3.3 ± 5.8	4.0
Red phalarope	5.0 ± 7.0	2.0	3.3 ± 5.8	4.0		4.0		
Long-billed dowitcher				2.0	6.7 ± 11.6	4.0		
Semipalmated sandpiper	5.0 ± 7.0	0	10.0 ± 0	8.0				
Pectoral sandpiper	10.0 ± 0	10.0	26.7 ± 15.3	16.0	6.7 ± 5.8	18.0	3.3 ± 5.8	4.0
Stilt sandpiper						2.0		
Buff-breasted sandpiper			3.3 ± 5.8	4.0		2.0		
Parasitic jaeger		2.0						
Glaucous gull	5.0 ± 7.5	0						
Lapland longspur	32.5 ± 31.8	12.0	47.3 ±	41.0	25.3 ± 6.4	32.0	48.0 ± 10.6	48.0
Total nests /territories/km^2	72.5 ± 60.1	38.0	104.0 ± 12.1	81.0	38.7 ± 10.1	64.0	58.0 ± 19.3	69.0
Total species	4.5 ± 2.1	7	4.7 ± 0.6	8	2.0 ± 1.0	7	2.0 ± 1.0	5
Chi-square (X^2)	46.02		20.71		20.32		7.01	
P	$<$0.005		$<$0.005		$<$0.005		$<$0.250	
d.f.	6		7		6		4	

Table A-13. Chi-square goodness of fit, Wilcoxon signed ranks, and paired-t tests comparing estimates of species mean summer density made from replicate 10 ha plot samples and from a single large 25 or 50 ha plot, Okpilak River delta, Arctic National Wildlife Refuge June-August 1982.

Species	Flooded		Mosaic		Wet Sedge		Tussock	
	2-10 ha plots X ± S.D.	50 ha plot	3-10 ha plots X ± S.D.	50 ha plot	3-10 ha plots X ± S.D.	50 ha plot	3-10 ha plots X ± S.D.	25 ha plot
Arctic loon	8.8 ± 12.4	5.0						
Red-throated loon	5.0 ± 0	2.5						
Whistling swan	6.3 ± 1.8	2.5						
Canada goose		1.5						
White-fronted goose								2.0
Pintail	11.3 ± 5.3	6.5		3.5		1.0	1.7 ± 1.4	1.0
Oldsquaw	8.8 ± 1.8	4.0	4.2 ± 7.2	5.5		1.5	2.5 ± 2.5	2.0
King eider		1.0			1.7 ± 2.9	1.0		
Marsh hawk						0.5		
Willow ptarmigan							0.8 ± 1.4	4.0
Rock ptarmigan			2.5 ± 4.3	0.5			0.8 ± 1.4	1.0
Sandhill crane						1.5		
American golden plover		0.5	6.7 ± 5.2	3.0	0.8 ± 1.4	2.5	2.5 ± 4.3	4.0
Whimbrel		3.5						
Northern phalarope	67.5 ± 0	58.5	15.8 ± 21.3	7.5	6.7 ± 3.8	17.0	19.2 ± 7.6	22.0
Red phalarope	16.3 ± 5.3	60.5	6.7 ± 5.8	7.0	1.7 ± 2.9	5.0	2.5 ± 2.5	2.0
Phalarope sp.		0.5						
Long-billed dowitcher	12.5 ± 0	7.5	2.5 ± 0	4.5	7.5 ± 6.6	10.5		
Semipalmated sandpiper	6.3 ± 8.8	2.5	16.7 ± 8.8	10.5			1.7 ± 1.4	1.0
Pectoral sandpiper	40.0 ± 24.8	77.0	51.7 ± 10.4	45.5	27.5 ± 6.6	32.0	20.8 ± 1.4	20.0
Stilt sandpiper		1.0		0.5		4.0		
Buff-breasted sandpiper			10.8 ± 6.3	14.0	1.7 ± 2.9	1.5		
Pomarine jaeger			3.3 ± 3.8	4.5		0.5	2.5 ± 2.5	4.0
Parasitic jaeger	3.8 ± 1.8	2.5	5.0 ± 2.5	5.0	2.5 ± 2.5	5.0	0.8 ± 1.4	4.0
Long-tailed jaeger		4.5	4.2 ± 1.4	2.5	5.0 ± 0	5.0	3.3 ± 3.8	5.0
Glaucous gull	3.5 ± 5.0	3.5	0.8 ± 2.5	2.5				
Herring gull	1.3 ± 1.8	0						
Snowy owl		1.0	0.8 ± 1.4	1.5	1.7 ± 2.9	1.0		
Short-eared owl			0.8 ± 1.4	0.5	0.8 ± 1.4	1.5		
Horned lark								
Barn swallow							0.8 ± 1.4	1.0
Common raven						0.5		
Fox sparrow							0.8 ± 1.4	1.0
Lapland longspur	22.5 ± 3.5	20.5	95.0 ± 56.3	83.5	77.5 ± 23.8	86.0	105.8 ± 19.4	114.0
Total individuals	213.5 ± 2.1	266.5	227.5 ± 95.0	202.0	169.2 ± 91.7	177.5	166.7 ± 26.3	188.0
Total species	12.0 ± 2.8	22	11.7 ± 0.6	18	7.3 ± 2.5	19	9.0 ± 1.7	16
Chi-square (x^2)	95.40		36.80		23.99		11.15	
P	<0.001		<0.010		<0.250		<0.750	

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EVALUATION OF TECHNIQUES FOR ASSESSING NEONATAL CARIBOU CALF MORTALITY IN THE PORCUPINE CARIBOU HERD.

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Key words: Caribou, Porcupine herd, neonatal mortality, predation, techniques, Arctic-Beaufort, north slope

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Evaluation of techniques for assessing neonatal caribou calf mortality in the Porcupine caribou herd.

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Abstract: Twenty-three caribou (Rangifer tarandus) calves were captured and instrumented with mortality-sensing radio-transmitters in early June 1982. Calves were monitored to determine the feasibility of using radio-telemetry techniques to assess neonatal calf mortality on the calving grounds and post-calving aggregation areas of the Porcupine caribou herd. Available telemetry equipment was suitable for assessing neonatal mortality of caribou; however, logistical requirements for monitoring marked calves on the extent calving grounds were the major factors contributing to the inability to positively identify causes of mortality for marked calves. Recommendations for improving monitoring and carcass recovery techniques include daily survey flights, immediate carcass retrieval, and detailed examination of mortality sites. Logistical operations must be upgraded to support an intensive study. This preliminary study indicates that available telemetry techniques can provide valued data to assess the timing and causes of neonatal calf mortality. In this preliminary study, 12 marked calves died. Probable causes of mortality included exposure, abandonment, drowning, and avian and mammalian predation. Golden eagles were involved (either as predator or scavenger) in 50% of the mortality. An additional case of golden eagle predation was detected (unmarked calf), and brown bear killed another unmarked calf. One unmarked calf died of pneumonia. Wolf predation on neonatal calves was not detected, however wolves were observed chasing groups of caribou.

Evaluation of techniques for assessing neonatal caribou calf mortality in the Porcupine caribou herd.

Caribou (Rangifer tarandus) from both the Porcupine and Central Arctic caribou herds utilize portions of the coastal plain of the Arctic National Wildlife Refuge for calving, post-calving aggregations, and insect relief activities during the spring and summer (USFWS 1982). Parturient female caribou and post-parturient females with young calves are sensitive to disturbance associated with human activity (de Vos 1960, Lent 1964, Bergerud 1974, Cameron et al. 1979, Davis and Valkenberg 1979). Studies conducted annually since 1974 have shown that female caribou with young calves avoid the Prudhoe Bay oil field and the adjacent Trans-Alaska Pipeline corridor (Cameron and Whitten 1976, 1980). It has been suggested that displacement of parturient female caribou and females with young from traditional areas may cause increased calf mortality which could ultimately contribute to population decline (Bergerud 1976, Calef and Lent 1976, Klein 1980).

Mortality factors and rates associated with potential displacement habitats need to be assessed to make predictions regarding calf survival and herd productivity if traditional calving habitats are explored and developed for petroleum production. Consequences of displacement from traditional insect relief areas and preferred forage areas, and the overall impacts of human/industrial disturbances also need to be evaluated. This study focuses on evaluating techniques for determining neonatal caribou calf mortality on the calving grounds and post-calving areas of the Porcupine caribou herd.

The most common technique used to evaluate caribou calf mortality is aerial survey to measure the chronology and over-all magnitude of caribou calf mortality on an annual basis (Kelsall 1968, Davis et al. 1980). The gregarious nature of parturient and post-parturient females and the relatively high level of calving synchrony exhibited by migratory caribou, contribute to the utility of aerial survey methods (Bergerud 1974, Dauphine and McClure 1974.) The achievement of accurate calf mortality estimates, however, is often complicated by difficulties in identification of age and sex classes from the air and by frequent mixing of barren females and non-productive yearlings with productive females (Miller and Broughton 1974). Another problem is that comparative cow-calf ratios developed from aerial survey data do not provide information on causes of mortality or the spatial and temporal distribution of that mortality.

Intensive searches for calf carcasses using helicopters for low-level flight over calving and post-calving areas have provided data on causes and spatial distribution of neonatal caribou calf mortality (Miller and Broughton 1974, Miller et al. 1982). However, this technique only provides data on mortalities that are found and does not provide an inference base for overall calf mortality in a given year. Recently techniques using expandable neck collars with attached mortality sensing radio-transmitters have produced improved data on neonatal mortality rates and factors for several species of ungulates (Cook et al. 1967, 1971, Logan 1972, Beale and Smith 1973, Garner et al. 1976, Schlegel 1976, Franzmann and Peterson 1978, Franzmann et al. 1980, Ballard et al. 1981, Bjärvall and Frazen 1981). This technique has not been applied to the study of neonatal caribou calf mortality in North America. Advantages of radio-telemetry techniques are the ability to relocate individually marked calves to determine their movements and activities, and most importantly, to recover carcasses soon after death to accurately determine causes of mortality (Cook et al. 1967). Detailed information on chronology and location of mortalities can be obtained and inferences can be made for over-all mortality of calves in the population.

In order to assess the hypothesis that caribou calf mortality will increase if industrial developments occur within traditional calving areas, it is necessary to determine suitable techniques for measuring mortality factors/rates that occur naturally in traditional and peripheral calving areas. Because radio-telemetry techniques using mortality sensing transmitters have potential for identifying causes and rates of mortality as well as confirming the chronology and spatial location of mortalities, this feasibility study was initiated.

The objectives of the study were as follows:

1. Determine the feasibility of using mortality sensing radio-transmitters to detect and determine causes of mortality in neonatal caribou calves.

    a. Develop appropriate capture, marking, and handling procedures.

    b. Determine feasibility of identifying causes of observed mortality.

    c. Determine feasibility of separating study-induced mortality from natural mortality.

    d. Determine feasibility of using previously radio-collared cows and their calves as a control group.

    e. Develop monitoring procedures.

    f. Define logistical considerations necessary to implement a more intensive study.

    g. Test expandable collar/transmitter package to determine if design is functional.

2. Identify temporal and spatial patterns of caribou calf mortality on the calving and post-calving areas of the Porcupine caribou herd.

3. Determine post-calving movement patterns of caribou calves and their dams.

Methods and Materials

Spring migration, calving, and post-calving activities of the Porcupine caribou herd were monitored by conducting aerial surveys using radio telemetry equipment to locate previously collared caribou. This effort was cooperative between Alaska Department of Fish and Game, Yukon Department of Renewable Resources, and U.S. Fish and Wildlife Service. Additional data on locations and movements of the herd were obtained from other pilots and field researchers. Based on the results of these surveys, an area of concentrated calving activity located on the coastal plain of northern Yukon Territory was selected for the calf capture effort.

Caribou groups were approached by helicopter (Bell Jet Ranger 206) with a capture crew of 3 persons aboard. The helicopter landed approximately 200 m from the caribou and a person got out and took a sitting position on the right skid. The helicopter then proceeded towards the group and a calf was selected for capture. Selections were based on visual assessment of the relative running ability of a calf. Calves that appeared small and had a wobbly gait were avoided. The selected calf was pursued by flying approximately 1 m above the ground. When the helicopter was judged near enough to the running calf, the person on the skid stepped off to the side, ran, and grasped the calf. Disposable rubber gloves were worn by personnel handling captured calves and were discarded after each handling. Unused burlap material was used as a shield against possible transfer of odor from the handler's clothing to the pelage of the calf and as a precaution against transfer of infectious agents. Each bag was used once and discarded. When a calf was captured, the helicopter landed and the remaining members of the capture crew assisted in processing the calf. In most cases the helicopter remained within 15-30 m of the processing site with the engine running. In some instances when the maternal cow did not exhibit defensive behavior by returning to the vicinity of the calf, vocalizing, and head bobbing (Lent 1964), the helicopter moved 100-200 m away from the processing site in an opposite direction from the cow and the captured calf.

Captured calves were sexed, weighed, and measured for total body length, right hind foot length, head length, ear length, new hoof length (Haugen and Speake 1958), and neck circumference. In cases where the maternal female failed to display defensive behavior, some measurements were omitted to reduce processing time and possibly prevent study-induced abandonment. Characteristics of the umbilicus (moist, dry, intact, absent), and hooves (degree of wear), were noted as described by Miller and Broughton (1974). Age of calves was estimated using general criteria described for white-tailed deer (Odocoileus virginianus) by Haugen and Speake (1958), elk (Cervus canadensis) by Johnson (1951), and caribou by Miller (1972). Each calf was also examined for abnormalities, and time at capture and release were recorded. Whenever possible, notes were kept on cow-calf behavior during capture, processing, and release of the calf.

An expandable white elastic collar supporting a mortality sensing transmitter (Telonics Inc., Mesa, Az.), weighing approximately 270 g was installed around the neck of the calf. Mortality mode for transmitter units was a doubling of normal pulse rate following a 4 hr motion free period. Estimated battery life was 15 months. Each collar was constructed from a 3.75 cm wide elastic band. Adjustment of the initial collar size at installation was acheived by fastening the left and right ends of the elastic collar band together with aluminum "pop" rivets. Three separate expansion folds per collar were sewn with incremental amounts of cotton thread stitching. Each expansion fold provided an additional 7 cm of collar circumference. The maximum expansion circumference of each collar was 53 cm. Collars were also constructed to breakaway after the last expansion loop was used. A sample tranmitter and expandable collar was also installed on a captive reindeer calf (University of Alaska, Fairbanks) of known age. Periodic checks of this test collar were made to evaluate collar function in relation to neck growth.

Fixed-wing aircraft were used to monitor for mortality signals and to periodically relocate individual calves. Study calves were monitored daily for the first 2 days following processing. Monitoring for mortality signals during the following month occurred at approximately 3 day intervals, except when weather conditions precluded aircraft operation. Radio signals were monitored from elevations of 600-3,000 m above sea level. Visual confirmation of a subsample of study calves (2-4) was attempted on each monitoring flight.

Relocations were plotted on 1:250,000 scale topographic maps and notes were taken whenever possible on group size/composition, direction of movements, habitat, status of radio-collars, and cow-calf behavior. Observations of predators sighted during aerial surveys were recorded. Information on caribou movements, and activities was obtained during censusing and other activities.

Helicopters were used to retrieve calf carcasses as soon after detection of mortality as possible. Each carcass and mortality site was examined for information on the cause of death. Photographs were taken to document each site. Evidence of predators/scavangers at the carcass site were noted and collected. Each carcass was placed in a plastic garbage bag, labeled, and frozen for later study. Laboratory necropsies were performed on carcasses when sufficient remains were present. In cases where only hair and bones remained, measurements of weight, right hind foot length, and new hoof length was recorded whenever possible. The location of each retrieved carcass was plotted on a 1:250,000 scale topographic map. Criteria used to determine the category (Cook et al. 1971) and to identify the cause of each mortality (Table 1) were developed from descriptions of predator kills and feeding characteristics in the literature (Murie 1948, Thompson 1949, Johnson 1951, Borg 1962, Atwell 1964, Mech 1970, Wiley and Bolen 1971, Alford and Bolen 1972, Cole 1972, White 1973, Miller and Broughton 1974, Bolen 1975, Henne 1975, Miller 1975, Mysterud 1975, Buskirk and Gipson 1978).

Results and Discussion

Distribution of Calving

Spring migration of the Porcupine herd was late in departing from most wintering locations (Whitten and Cameron 1982). At calving (1-12 June), cows were widely scattered throughout the northern portion of the Old Crow Flats, the upper Firth and Coleen river drainages, and along migration routes in the British Mountains of Canada. Relatively small numbers of cows were also scattered along migration routes in the Kongakut, Egaksarak, and Aichilik river drainages. Few cows were found in the more traditional calving area (coastal plain and foothills between the Jago and Aichilik rivers) at calving time. An area of concentrated calving activity was found on 4 June, on the coastal plain and foothills between the Firth and Spring Rivers in northern Yukon Territory (Fig. 1). Four adult females which had been radio-collared near Central, Alaska during December 1981 were in this area of concentration on 4 June and 3 had newborn calves. A reconnaisance flight over traditional calving grounds of the Central Arctic caribou herd on the Canning River delta on 5 June, revealed that this herd was not using that area for calving.

Similar calving distribution patterns for the Porcupine Herd occurred in 1972 when there was also a late spring (Roseneau and Stern 1974). Delayed spring migrations have been reported and are usually associated with late spring weather, deep snow along migration routes, or snow conditions which make travel by migrating caribou difficult (Scott 1953, Lent 1966, Calef and Lortie

Table 1. Criteria used to determine category for observed mortalities of caribou calves.

Criteria	Category
I. Carcass lacks sign of being bitten, chewed, or disturbed by predators.	I. Predation-excluded
1. Milk curds absent from abomasum and intestinal tract. Lack of mesentary and subcrutaneous fat. Rumen may be packed with vegetation.	1. Starvation (abandonment probable)
2. Milk curds present or absent from abomasam or intestinal tract. Mesentary and subcutaneous fat present. Absence of any signs of starvation.	2. Exposure
3. Disease syndrome present, or diesase syndrome noted at capture.	3. Disease
II. Carcass bitten, chewed, and/or partially eaten.	II. Predation-involved
A. Lack of blood in wounds, lack of frothy blood in nares and trachea, no bruises surrounding tooth marks, or no subcutaneous hemorrages present.	A. Carcass scavenged
1. Bones gnawed and chewed, feeding pattern generally not restricted to the upper portion of carcass.	1. Mammalian scavanger
2. Bones not chewed, feeding limited to upper portions of carcass.	2. Avian scavenger
B. Blood in wounds, frothy blood in nares and trachae, bruises surrounding wounds, and subataneous hemmorages present.	B. Predator kill
1. Debilitation physical disorder, or disease syndrome present.	1. Predator kill and other factors
2. No debilitating physical disorder or disease syndrome present.	2. Predator kill
a. Talon wounds on back and sides of body. Talon wounds on neck. Only upper portion of carcass fed upon. Ribs broken off at backbone. Leg bone usually intact.	a. Golden eagle kill
b. Teeth wounds on neck, sides or legs. Carcass fed upon extensively, bones chewed and carcass parts scattered.	b. Mammalian predator
c. Extensive trauma to carcass. Large portions of carcass missing. Bones broken or crushed. Skull crushed. In older calves, rumen not consumed.	c. Brown bear

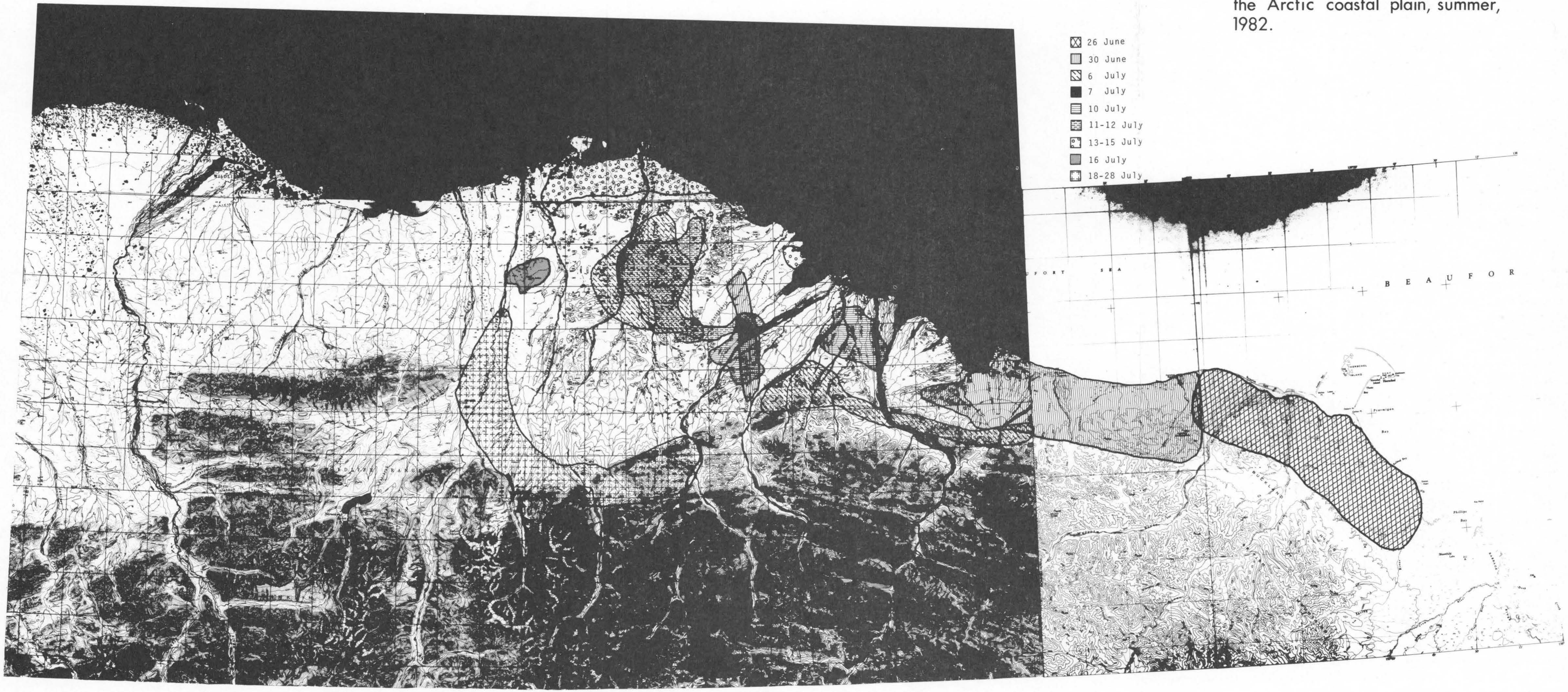

Fig. 1. Temporal distributions of caribou on the Arctic coastal plain, summer, 1982.

1971, McCourt et al. 1974, Roseneau and Stern 1974, Roseneau et al. 1975, Thompson 1978).

Calf Capture and Processing

On 7 June, 20 caribou calves were captured, processed, and released in the concentrated calving area. An additional 3 calves were captured and radio-collared on 9 June (Table 2). All but 2 calves which were selected and pursued were successfully captured. Unsuccessful attempts were due to the ability of these calves to outrun the human pursuer. Successful pursuit time of individual calves ranged from less than 1 min to about 3 min. Unsuccessful pursuits were 5 and 15 min duration. Processing time for calves ranged from 3.0 to 19.0 min; with an average of 5.8 min. After determining approximate neck size on calf No. 1, remaining collars were riveted at a circumference of 25 cm. The remaining transmitters were installed by stretching each collar over the calf's head. Collar fit was satisfactory and no problems regarding collar size were observed.

Twelve males and 11 females were collared (Table 2). Males averaged slightly larger in over-all body size and weight. Based on the condition of the hooves, umbilici, physical appearance, and swiftness, as well as observed calving chronology in the capture area, the minimum age of all calves captured was estimated to be between 1 and 5 days old (Table 2). Only 1 female accompanied by a calf at capture time (7-9 June) had shed its antlers. While the timing of antler drop by post-parturient females may vary from 5 days (Curatolo and Roseneau 1977) to a week or more (Lent 1965, Epsmark 1971), the preponderance of females with hard antlers observed during capture operations provides further confirmation of the estimated upper age limit for study calves.

Most calves were captured while attempting to run from the helicopter and pursuer. Two were caught while lying motionless on the ground. All calves struggled during handling and most calves bleated several times while being handled. In 3 instances (No. 5, 14, 23), the released calf attempted to follow the capture crew. Lent (1961) reported that cows with very young calves would readily leave them lying motionless on the ground when approached by humans. Lent (1964) reported that caribou calves only a few hours old would attempt to follow handlers. Calves observed exhibiting such behavior in this study were 3 of the smaller calves captured during the study, but none of these calves appeared to be only a few hours old.

There was considerable variation in behavior of maternal cows during the capture operation. Three cows exhibited defensive behavior such as charging the helicopter during the pursuit phase of capture operations. Defensive behavior of maternal females has been reported (Lent 1964). It has been suggested that older, experienced females tend to be more defensive of their young (Kelsall 1960, as cited by Lent 1964), and that young females with their first offspring may abandon their young more frequently (Miller and Broughton 1974). Eleven cows remained within sight (55-274 m) during processing of their offspring. In most cases the capture crew did not remain in the vicinity following calf release and post-processing behavior of the mother and infant was not observed regularly. Five reunions of mother and offspring were observed. Twelve cows were observed running away from the capture/process scene and no reunions were observed in these cases. Lent (1964) noted that

Table 2. Sex and physical measurements of caribou calves radio-collared on the coastal plain south of Herschel Island, northern Yukon Territory, 7-9 June 1982.

Calf No.	Date	Sex	Weight (kg)	Length (cm)	Hind foot (cm)	Head length (cm)	Neck (cm)	Ear length (cm)	New hoof length (mm)	Estimated age (days)
1	7 June	M	7.9	79.5	34.5	22.0	23.0	7.8	-	5
2	7 June	M	6.0	77.0	32.2	20.2	22.5	6.8	10.0	2-4
3	7 June	F	5.9	79.8	33.0	21.0	21.0	5.5	9.5	2-4
4	7 June	M	5.7	79.0	34.0	21.0	20.0	6.0	5.0	2
5	7 June	F	4.7	79.0	31.0	20.0	18.0	5.6	5.0	2
6	7 June	F	6.2	84.0	33.0	21.0	21.0	7.0	6.0	2
7	7 June	F	6.3	87.0	34.0	21.0	23.0	7.2	8.5	4-5
8	7 June	F	6.8	-	34.5	20.5	20.5	7.2	9.5	4-5
9	7 June	M	6.7	70.1	33.5	20.0	21.0	7.0	6.0	3-4
10	7 June	M	7.5	89.0	35.0	20.5	21.0	7.6	11.0	5-6
11	7 June	F	6.1	82.0	31.2	20.5	21.2	7.4	9.0	2-3
12	7 June	F	4.5	69.0	39.0	18.0	18.0	-	-	1-2
13	7 June	F	6.7	-	32.5	20.0	18.0	-	-	4-5
14	7 June	F	5.3	-	-	-	-	-	-	1-2
15	7 June	M	7.2	77.0	32.0	19.5	21.0	-	-	4-5
16	7 June	F	5.7	78.0	32.5	19.0	19.0	-	-	2-4
17	7 June	M	7.7	80.0	36.0	21.0	20.0	-	-	5-6
18	7 June	M	5.4	78.0	32.0	20.0	18.0	-	-	2-4
19	7 June	F	6.3	80.0	32.0	20.0	18.0	-	-	2-4
20	7 June	M	9.0	83.0	35.5	21.0	23.0	-	-	5-6
21	9 June	M	6.7	81.0	33.2	-	18.0	-	10.0	3-4
22	9 June	M	5.6	74.0	34.0	20.0	18.0	-	10.0	3-4
23	9 June	M	4.7	73.0	32.5	19.5	21.0	-	7.0	2
Male averages			6.7 (n=12)	78.4 (n=12)	33.7 (n=12)	20.4 (n=11)	20.5 (n=12)	8.4 (n=7)	7.0 (n=7)	
Female averages			5.9 (n=11)	79.9 (n=8)	33.3 (n=10)	20.1 (n=10)	19.8 (n=10)	6.5 (n=6)	6.6 (n=6)	

most cows that fled initially, later returned, searched for and recovered their calves.

Twelve (52.2%) of the 23 radio-collared calves died in June (Table 3). Detailed case histories on each mortality are included in the Appendix. Three mortalities (No. 2, 12, 18) occurred within 48 h of capture. Calf no. 2 died from wounds caused by a golden eagle, but was in starvation condition at the time of death. Calf No. 12 was 1-2 days old and died of starvation. The dam fled that area immediately upon initiation of capture procedures and was not observed to return. Calf no. 18 probably died of exposure. Calf No. 15 was dead 96 h after capture and was also in starvation condition. The maternal cow was observed striking this calf with her front feet, apparently rejecting the newly collared calf. Similar observations of agonistic behavior have been reported, usually when a female caribou is approached by a foreign calf (de Vos 1960, Lent 1964). Female caribou rely primarily on scent to identify their young from other calves (Lent 1974); therefore, human scent on calf No. 15 after processing may have caused the agonistic behavior.

Abandonment by the maternal female and subsequent avian scavenging was verified by necropsy findings for 2 calves (Table 3). Starvation/abandonment was also involved in the death of calf No. 2, however, the cause of death was predation by a golden eagle. These mortalities represent a cumulative abandonment rate of 8.7 to 13.0%. Natural abandonment rates of 21% and 6% of all calf mortalities were reported on the calving grounds of the Kaminuriak and Beverly Caribou Herds respectfully (Miller and Broughton 1974, Miller et al. 1982). It was also found that most abandonment occurred soon after parturition (Miller and Broughton 1974) and is consistent with behavioral aspects of cow/calf bond formation (Lent 1964). In studies with reindeer, Neiminen et al. (1982) reported an abandonment rate of 8.6% and associated it with the physical condition of young females. Baskin (1982) reported an abandonment rate of 0.38% for a reindeer herd in Russia.

Apparently natural abandonment of calves occurs for a number of possible reasons: young females lack experience and may tend to abandon their young to join other migrating adults; disturbance by predators on the calving grounds may result in some permanent separations; and physiological disorders such as mastitis may lead to abandonment or starvation of the calf (Miller and Broughton 1974). Lent (1961) documented only 1 (1%) case of study-induced abandonment resulting from a capture and ear-tagging study of neonatal caribou calves. Due to logistical considerations in the current study, it was not possible to differentiate between study-induced or "natural" abandonment in all cases. Procedures to minimize study induced abandonment were employed; however, observations of acceptance by the maternal cow and subsequent nursing bout was not made in 2 of the abandonment cases (No. 2, 12; Table 3).

One calf (No. 5) was an apparent drowning (Table 3). This calf was captured on the east side of the Firth River. Live signals were received on 8,9,11,15,20,22 and 26 June from locations east of the Firth. Visual identification of the calf was made on 24 June also on the east side of the river. On 30 June a live signal was received from the Firth River delta area. An attempt was made to establish visual contact from the fixed-wing aircraft without success. The carcass was retrieved on July 2 from a gravel bar within 1 m of a river channel. The carcass was decomposed, and apparently scavanged by avian species. On 30 June large groups of cows and calves were west of the Firth River and moving rapidly west towards Alaska. This calf

Table 3. Causes of mortality for 12 of the 23 radio-collared caribou calves captured on 7 and 9 June 1982.

Category	Number of calves	% of total mortality
Mortalities:		
I. Predation-excluded deaths		
2. Exposure probable (No. 18)	1	8.3
II. Predation-involved deaths		
A. Scavenging plus other factors		
1. abandonment (starvation), avian scavengers (No. 12, 15)	2	16.7
2. drowning probable, avian scavengers (No. 5)	1	8.3
B. Predation/Scavenging		
a. Avian predation, probable golden eagle (No. 10, 11)	2	16.7
b. Avian predation/scavenging, probable golden eagle (No. 3, 19, 23).	3	25.0
c. Avian predation, golden eagle plus other factors - starvation (No. 2)	1	8.3
d. Avian predation probable, plus mammalian scavenging, species undetermined (No. 16)	1	8.3
e. Mammalian predator probable, species undetermined. (No. 7)	1	8.3
Totals	12	100.0

probably drowned while attempting to cross the Firth River as groups of caribou began to move west.

Predation including scavenging was involved in 91.7% of the detected mortality (Table 3). All mortalities in this study (except Calf no. 18) were reduced to varying amounts of partially consumed carcasses, scattered bones, and hair. It was not possible to determine with absolute certainty which calves were victims of predation, what factors may have predisposed these calves to predation, or which calves had died from other causes and were later scavenged. Scavenging by avian species occurred in both cases of abandonment and the drowning, and was involved in 25.0% of the mortality. Avian predation was involved in 58.3% all mortalities; 50.0% of the total mortality involved golden eagles as either the probable predator or as a predator/scavenger. Bjärvall and Frazen (1981) found that predators and scavengers almost completely consumed reindeer calf carcasses in 24 to 48 hours. Based on the presence of chewed or broken bones, the arrangement of bones (limbs connected and attached to vertebrae, etc.), or the presence of predator/scavenger sign, it is concluded that avian predators/scavengers (primarily golden eagles) were the primary predators/scavenger involved in the mortality of radio-collared calves.

Sub-adult golden eagles were observed in the vicinity of calving and post-calving caribou of the Porcupine Herd in 1982. Such occurrance has been previously reported during other studies of caribou (Calef and Lortie 1973, Roseneau and Curatolo 1976, Curatolo and Roseneau 1977). In this study golden eagles were documented preying on 1 unmarked caribou calf and were implicated as either predator or scavenger in 6 of the radio-collared calf mortalities. Based on these data, it appears that golden eagles may play an important role in predation and/or scavenging of neonatal caribou calves on the calving and post-calving grounds of the Porcupine caribou herd.

Mortality information was also obtained for 3 unmarked caribou calves from carcasses found during this study and other field projects. Field observations and necropsy investigations indicate that 1 was preyed on by a golden eagle, 1 was preyed on by a brown bear (Ursus arctos), and 1 died of pneumonia (see mortality case history in Appendix).

One case of brown bear predation on a caribou calf was documented in this study. The incident was observed on 8 June in the area where study calves were captured. Brown bears were commonly observed in the vicinity of calving and post-calving caribou of the Porcupine herd (Garner et al. 1982). Based on evidence gathered at each calf carcass site such as the arrangement of bones, the presence or absence of broken or chewed bones, and predator sign, it is reasonable to conclude that a large mammalian predator/scavenger (grizzly bear or wolf) may have been involved in 2 of the study calf mortalities (Calf no. 7, no. 16; Table 3). Brown bear habitat use and activity field studies near "Caribou Pass" on the Kongakut River during 27 June to 11 August did not record any utilization of caribou by brown bears during 87.6 hours of bear observations (Phillips 1982).

There were no verified cases of wolf (Canis lupus) predation on caribou calves. Two mortalities (Calf no. 7, no. 16; Table 3) may have had wolf involvement, either as a predator or scavenger. Reports were received on 3 occassions of wolves interacting with caribou. An adult gray wolf was pursuing a large group of caribou near the lower Okpilak River on 15 July (Evans pers. comm.). A similar observation was made on 22 July near the Jago

River foothills (Evans pers. comm.). No kills were made during these observations. On the Kongakut River, 2 wolves were observed moving past a small group of caribou, however, no attempt was made to pursue the caribou (Phillips pers. comm.).

Calf No. 18 apparently died of exposure (Table 3) between capture on 7 June and mortality detection on 9 June. Necropsy findings did not indicate starvation. Weather data (see Appendix) for Komakuk Beach indicate that high winds ($\bar{X}$ = 42.6 kph) and mild temperature ($\bar{X}$ = 3.8°C) on 7 June may have combined to produce conditions severe enough (-42.1 adjusted degree days; Miller and Broughton 1974) to cause death due to exposure (hypothermia). In general, temperatures remained cool and there were several brief periods with strong winds during the 2 weeks following capture of calves. Weather data from Komakuk Beach and Shingle Point indicate a marked warming trend occurred during the last week of June (see Appendix). The most severe weather conditions occurred during capture efforts on 7 June and later from 10-12, 15-16, and 19-23 June at Komakuk, and during 14-17 June at Shingle Point. Monthly total net degree day values of -593°C and -833°C for Komakuk and Shingle Point respectfully indicate relatively moderate weather conditions.

The potential use of previously radio-collared females as a control group was only partially tested. As stated previously, 4 radio-collared females were located in the concentrated calving area south of Herschel Island and 3 of these cows had calves on 4 June. Periodic relocation efforts and observations of the cow/calf pairs were not conducted. Attempts were made to relocate collared cows once the herd moved west into Alaska; however, it was not possible to make consistent observations of cow/calf pairs. Large group size and grouping of calves made accurate indentification of cow/calf pairs difficult. No efforts were made to relocate and observe radio-collared cows following emigration from the coastal plain in Alaska.

All detected mortalities occurred during the month of June (Fig. 2) and the chronology of this mortality is consistent with that reported by Davis et al. (1980), Miller and Broughton (1974), and Miller et al. (1982), which indicate a majority of calf mortality occurs during and immediately after calving. The timing of calf mortalities found in this study differs from Calef and Lortie (1973), who reported a high calf mortality during post-calving movements in July; however, 4 mortalities (33.3 % of observed mortality) occurred when the Porcupine herd moved west onto the coastal plain of ANWR (Fig. 1). This movement occurred between 26 and 30 June, and the 4 mortalities were detected on 30 June. Also, 2 mortalities of unmarked calves were detected in early July (see mortality case histories in Appendix).

Chronology of observed mortality by estimated ages indicated that 50.0% occurred within the first 10 days of life and 66.7% occurred with the first 3 weeks of life (Fig. 3). Observed mortalities at ages older than 3 weeks were associated with herd movement west into Alaska (Fig. 4). These movements were rapid and on a large scale. Calves could have become separated from their dam in this movement. Accidents (trampling, etc.) could have resulted in the apparent drowning of calf No. 5 while crossing the Firth River.

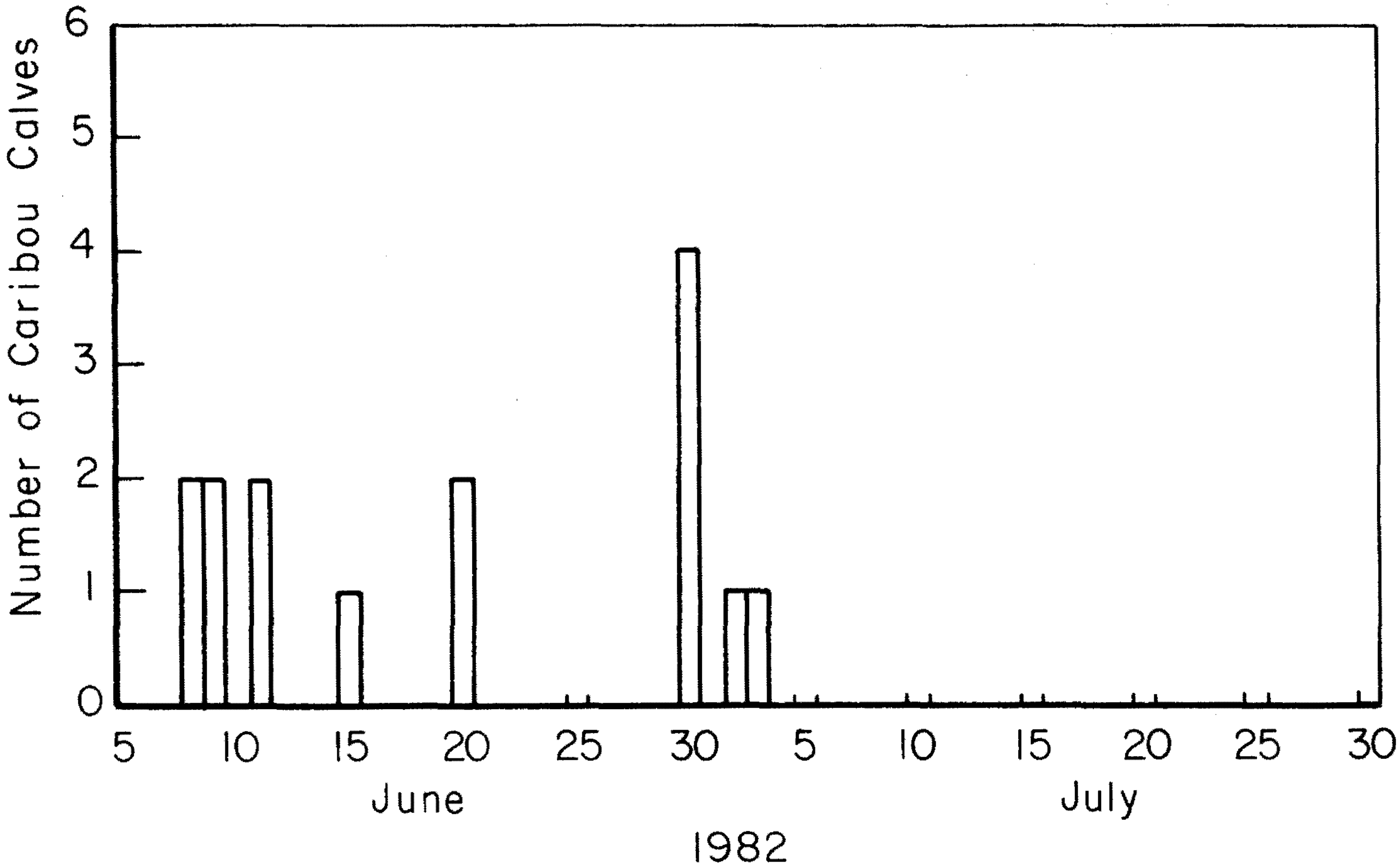

Fig. 2 Temporal distribution of mortality among 12 of 23 radio-collared calves and 3 unmarked caribou calves, June-July 1982.

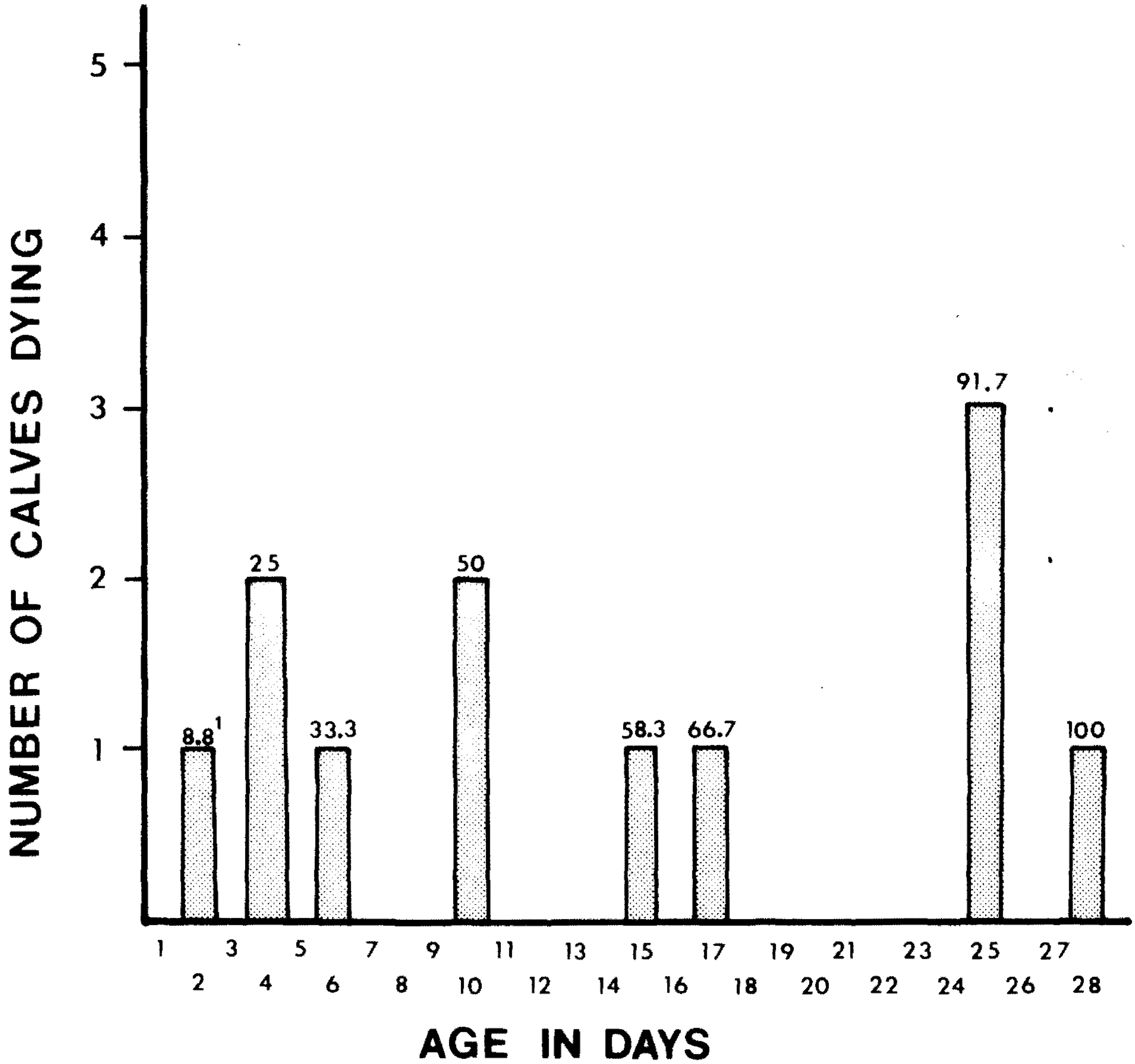

FIG. 3. NUMBER OF CARIBOU CALVES DYING WITHIN ESTIMATED AGE CATEGORIES, 1982.

[1]Cumulative percent of total mortality.

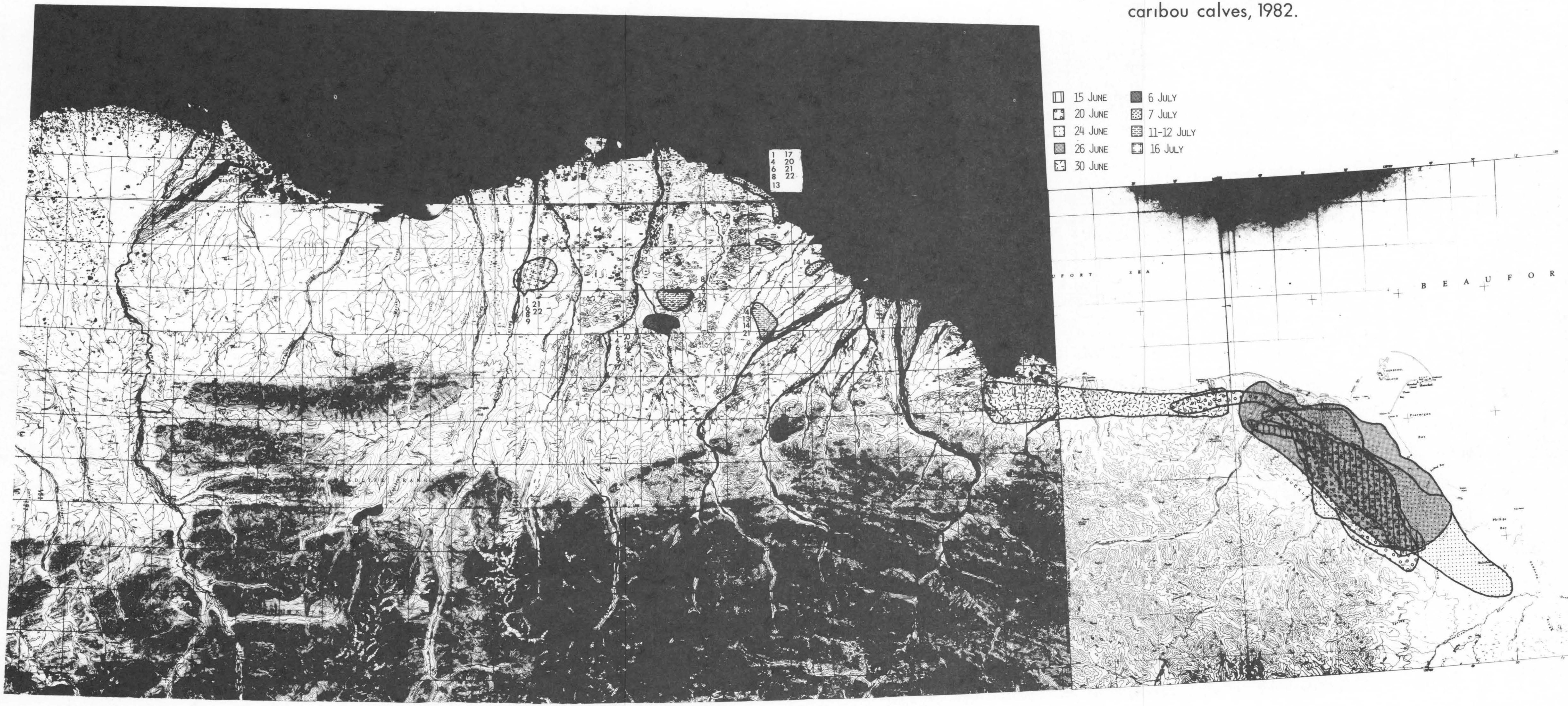

Fig. 4. General movements of radio collared caribou calves, 1982.

Calf Movements

Twenty monitoring surveys were conducted between 8 June and 5 September (Table 4). Collared calves remained in the general calving/capture area until late June (Fig. 4). The size of groups became progressively larger throughout June, and visual checks of individuals was not possible from 26 June to 28 July.

On 30 June radio-collared calves were detected among several large groups (numbering in the 100's - 2,000) located along the coastal plain/foothills from the Turner River in Alaska to Fish Creek in the Yukon Territory (Fig. 4). These groups were moving rapidly westward. From 1-18 July, collared calves remained within large post-calving aggregations which occupied the coastal plain of northeast Alaska and ranged from the Hulahula River on the west to the Clarence River on the east (Fig. 4). By 19 July the large aggregations splintered into several smaller groups and moved southward into the foothills and northern mountains between the Aichilik and Sadlerochit Rivers (Fig. 4). One group was found at the northern base of Mt. Michelson (1500 m elevation). On 28 July study calves were found in the mountains on both sides of the continental divide from the Jago River to the upper Firth River.

Five collared calves were relocated on 19 August approximately 40-60 km northeast of Arctic Village, Alaska. Canadian biologists relocated all but one of the study calves (Calf No. 9) in the general vicinity of the upper Babbage and Blow Rivers during 30 August to 10 September.

Test Collar Observations

On 24 June a sample collar/transmitter system identical to those used on the study calves was placed on a 57 day old female reindeer calf which was held in an enclosure at the University of Alaska, Fairbanks. At the time of installation the reindeer calf had a neck circumference of 31.8 cm. The first expansion fold of the collar was opened to accomodate the larger neck size. After 20 days the collar tightened slightly and the second expansion fold released in 30 days, providing for additional neck growth. The test collar was examined on 12 August (50 days following installation) and no indication of scraping or irritation to the calf's neck was observed. In general the collar appeared to be functioning well, however, the left antenna had broken off at the base where it attached to the transmitter cannister. Examination of the test collar 98 days after installation found that the third expansion stage had released. There was no sign of scraping, irritation or collar constriction.

Logistics

The primary operations base for the study was located at Barter Island, Alaska. Most fixed-wing aircraft and helicopter operations associated with calving distribution surveys and monitoring/relocation surveys originated from Barter Island. Facilities located at the Komakuk Beach Dewline Site, Northern Yukon Territory, (145 km east southeast of Barter Island) were used during the calf capture operation (7-9 June). The calf capture area is located 185 km south southeast of Barter Island and is 41 km east southeast of Komakuk Beach. During the period of 11-26 June, relocation surveys and carcass collections were conducted from Barter Island to the general capture

Table 4. Schedule of aerial relocation surveys of radio-collared caribou calves, 1982.

Survey date	No. frequencies received (live/dead)	No. of visual contacts	General area of relocations
8 June	19/1	0	Coastal Plain Malcolm R. to Spring River
9 June	20/3		Same
11 June	18/2		Same
15 June	17/1	3	Same
20 June	15/2	1	Same
24 June	15/0	4	Same
26 June	13/0	0	Same
30 June	11/3	0	Turner R. to Fish Creek
6 July	11/0	0	Jago R. to Aichilik R.
7 July	10/0	0	Niguauak R. to Beaufort Lagoon
11 July	6/0	0	Jago R. to Aichilik R.
12 July	5/0	0	Same
13 July	11/0	0	Okpilak R. to Beaufort Lagoon
15 July	10/0	0	Same
16 July	10/0	0	Hulahula R to Okpilak R
18 July	3/0	0	Foothills and Mountains Sadlerochit R. to Aichilik R.
22 July		0	Same
28 July	9/0	0	Mountains from Jago to Firth River
19 & 20 Aug.	5/0	1	N.E. of Arctic Village (E. Fk. Chandalar R. to N. Old Crow Flats)
30 Aug.	10/0	?	Upper Babbage & Blow R.
10 Sept.	10/0	?	Upper Babbage & Blow R., Northern Richardson Mtns.

vicinity. Approximately 50% of all aircraft flight time associated with the study during that period was for transit to and from Barter Island. Transit time was greatly reduced during the period of 30 June to 22 July due to the westward movement of the herd.

A total of 34 hr of fixed-wing aircraft flight time was used during calving distribution surveys. Fixed-wing aircraft support for the calf capture operation was 15.8 hr. Calf capture operations required a total of 13.7 hr of helicopter flight time. Only 2.0 hr of helicopter time were used during the actual capture of 23 calves. The remaining 11.7 hr was ferry time and for transit to the capture area from operational bases. Fixed-wing time for monitoring and relocations was 35.3 hr (11 June - 28 July). A total of 15 hr of helicopter time was used for collection of calf carcasses. Approximately 41% of the helicopter total was for ferry and transit to the work area. By 28 July a combined total of 113.8 hr of aircraft flight time costing $25,158 was used during this study. Cost of aircraft operations to locate, select, capture, process, monitor/relocate, and collect caribou calves was $1,094/calf for the period of 29 May to 28 July.

As a result of unanticipated logistical problems (due to eastern calving distributions), data collection efforts were negatively affected. Relocation/mortality monitoring surveys were reduced due to the additional distance required to reach study calves during June. Fuel limitations of some aircraft (Cessna-185) also limited efforts to obtain visual confirmation of radio-collared calves. The frequency and duration of mortality monitoring surveys was less than planned and the timely detection of mortalities was negatively affected. Also, additional distances influenced the ability to reach detected mortality sites in a timely manner. The time interval between mortality detection and carcass collection ranged from 1 to 264 hr ($\bar{X}$ = 98 hr). This delay was detrimental to positive identification of cause of death for 8 of 12 mortalities.

During most years the Porcupine caribou herd calves in concentrations within 50 km of Barter Island (1/3 as distant as encountered in 1982). Thus it is likely this study occurred in a "worst case" scenario and in "normal" years, logistics would be greatly reduced.

Conclusions

The methods and equipment used in this study have favorable potential for acquisition of detailed data regarding neonatal caribou calf mortality. Large numbers of calves can be captured and processed in a timely manner through the use of a helicopter. The elastic, expandable neck collar was easy to install and no problems occurred regarding collar expansion for neck growth. Mortality transmitters functioned well and provided consistent signals with adequate range. The delay period between "alive" signals and "dead" signals should be shortened to 1 hour. The 4 hour delay period caused confusion when a transmitter emitted "alive" signals, when in fact the calf was dead (re. avian scanvengers fed on carcasses and activated the "alive" signal). If the delay period was shortened, the likelihood of missing a "dead" signal would be lessened.

Appropriate handling procedures must include provisions for shielding captured calves from human scents (re. surgical gloves for handlers, and burlap cloth for handling calves). Processing time should be minimized and detailed notes taken on cow behavior during pursuit, processing, and post-processing. Efforts must be made to observe cow/calf reunions. Monitoring surveys must be conducted daily and calf carcasses collected immediately. This effort will require a ground based operation located inland (to avoid coastal fog problems at Barter Island) of both fixed-wing aircraft and helicopter for calf retreival.

The identification of study-induced abandonment/mortality needs further definition. Post-processing observations of cow-calf behavior could confirm reunions, potential abandonment, and possible complications such as agonistic behavior by the maternal female in response to foreign scent or the appearance of the radio-collared calf. Such efforts will facilitate evaluation of techniques and accurate identification of natural mortality factors.

Radio-collared cows and their respective calves can provide data for a group of control animals. However, intensive and systematic efforts must be made to relocate these animals and determine their reproductive status at calving. To determine mortality of control group calves, relocations and observations must be made periodically before post-calving aggregations occur. Also, an intensive effort should be made to relocate and observe these control cows after emigration from the coastal plain in July.

Perhaps the element most essential for obtaining conclusive calf mortality data is logistics. Logistical support was not adequate during portions of this trial study and consequently had negative effects on data collection. It is essential that frequent relocation/mortality monitoring surveys be conducted during the study period and that all detected mortalities are promptly visited in order to collect conclusive evidence on causes for mortality.

Preliminary data gained in this study indicate that most neonatal calf mortality in 1982 occurred during the first month of life. This time period will require intensive effort to accurately determine timing and causes of neonatal calf mortality. In addition, a less intensive monitoring effort would be desirable during emigration from the coastal plain to determine if calf mortality occurs during this period. In the current study, 4 mortalities occurred when caribou moved west across the Firth River in late June. This time period approximates the "normal" post-aggregation period for the Porcupine herd and may represent a potential time period for calf mortality.

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APPENDIX

ANWR Progress Report Number FY83-6

Mortality Case History

Calf No. 2

Sex: Male

Captured: 7 June 1982

Location: 69°23' N 139°20' W

Weight: 6.0 kg

Right hind foot length: 32.2 cm

New hoof length: 10.0 mm

Processing time: 5 min.

Total length: 77.0 cm

Head length: 20.2 cm

Neck circumference: 22.5 cm

Ear length: 6.8 cm

Umbilicus condition: Dry

Hoof condition:

Health status: Appeared healthy at capture.

Reunion observed: Yes. Maternal female remained within 275 m during processing. Calf was observed returning to its mother following processing.

Monitored: 8 June 1982, alive signal received.

Visual relocation:

Mortality detected: 9 June 1982

Location: 69°24' N 139°22' W

Carcass collected: 9 June 1982

Distance from capture site: 2.7 km

Carcass weight: 5.2 kg

Response time: 1 hour

Total length: 70 cm

Right hind foot length: 32 cm

Head length: cm

New hoof length: 6 mm

Neck circumference: 20.5 cm

Carcass condition and disposition: ear and tail chewed off, right rear leg torn open.

Necropsy findings: Puncture wounds on right side of head, slightly below anterior portion of the ear, and on left side of rib cage. Subcutaneous hemorahage around wound. Rumen contained undigested vegetation, milk absent from rumen and intestines. Abdominal fat absent. All internal organs appeared normal.

Mortality category: Hemorrhage from wounds inflicted by an avian predator. Calf was in starvation situation at time of death, which may have predisposed it to predation. Golden eagle predation involved.

Mortality Case History

Calf No. 3
Captured: 7 June 1982

Sex: female
Location: 69°22' N 139°13' W

Weight: 5.9 kg
Right hind foot length: 33.0 cm
New hoof length: 9.5 mm
Processing time: 4 min.

Total length: 79.8 cm
Head length: 21.0 cm
Neck circumference: 21.0 cm
Ear length: cm

Umbilicus condition: Dry.

Hoof condition:

Health status: Scouring at the anus

Reunion observed: Maternal female remained within 180 m during processing. Reunion with mother within 2 minutes following release.

Monitored: 8, 9, 11, 15, 20, 24, and 26 June
Visual relocation: 15 June, cow and calf in group of 200 animals.
Mortality detected: 30 June 1982
Location: 69°14' N 139°04' W
Carcass collected: 2 July 1982
Distance from capture site: 17.2 km
Carcass weight: 1.45 kg
Response time: 51 hours
Total length: cm
Right hind foot length: 34.5 cm
Head length: cm
New hoof length: mm
Neck circumference: cm

Carcass condition and disposition: Scattered over 1 m radius, partially covered with silt on stream bank. 98% flesh removed, limbs seperated from vertebrae,, no evidence of broken bones. Predator sign: Grizzly bear track 1 m from carcass.

Necropsy findings: NA

Mortality category: Predation involved, avian predator/scavenger probable. Golden eagle probable species.

Mortality Case History

Calf No. 5
Captured: 7 June 1982

Sex: female
Location: 69°20' N 139°20' W

Weight: 4.7 kg
Right hind foot length: 31.0 cm
New hoof length: 5.0 mm
Processing time: 5 min.

Total length: 79.0 cm
Head length: 20.0 cm
Neck circumference: 18.0 cm
Ear length: 5.6 cm

Umbilicus condition: Dry.

Hoof condition:

Health status: Vulva inflamed, scouring at anus.

Reunion observed: Reunion with mother not observed. Calf followed capturers after release.

Monitored: June 8, 11, 15, 20, 24, 26
Visual relocation: 24 June at 69°25' N 139°20' W, calf with cow in a group of 4 cows, and 3 calves.
Mortality detected: 30 June
Location: 69°32' N 139°39' W
Carcass collected: 2 July
Distance from capture site: 21.8 km
Carcass weight: 3.0 kg
Response time: 50 hours
Total length: cm
Right hind foot length: 32.0 cm
Head length: cm
New hoof length: 6.0 mm
Neck circumference: cm

Carcass condition and disposition: Lying about 1 m from river, skeleton & skin intact, eye removed, flesh and internal organs decomposed.

Necropsy findings: NA

Mortality category: Predation involved, scavenging by avian species. Probable drowning.

Mortality Case History

Calf No. 7
Captured: 7 June 1982

Sex: female
Location: 69°20' N 139° 23' W

Weight: 6.3 kg
Right hind foot length: 34.0 cm
New hoof length: 8.5 mm
Processing time: 6 min.

Total length: 87.0 cm
Head length: 21.0 cm
Neck circumference: 23.0 cm
Ear length: 7.2 cm

Umbilicus condition: absent.

Hoof condition:

Health status: Scouring at the anus.

Reunion observed: Reunion not observed.

Monitored: June 8, 9, 11, 15
Visual relocation:
Mortality detected: 20 June
Carcass collected: 22 June
Carcass weight: 0.125 kg
Total length: cm
Right hind foot length: cm
New hoof length: mm

Location: 69°19' N 139°23' W
Distance from capture site: 1.7 km
Response time: 48 hrs.
Head length: cm
Neck circumference: cm

Carcass condition and disposition: Few scattered bones splinters and hair over 4.6 m radius. Skull cap 12 m from bone splinters. No sign of a predator found.

Necropsy findings: NA

Mortality category: Predation involved, probable mammalian species. Predator species undetermined.

Mortality Case History

Calf No. 10
Captured: 7 June 1982

Sex: male
Location: 69°21' N 139°21' W

Weight: 7.5 kg
Right hind foot length: 35.0 cm
New hoof length: 11.0 mm
Processing time: 3 min.

Total length: 89.0 cm
Head length: 20.5 cm
Neck circumference: 21.0 cm
Ear length: 7.6 cm

Umbilicus condition: Dry

Hoof condition:

Health status: Appeared healthy at capture.

Reunion observed: Reunion not observed.

Monitored: June 8, 9, 11, 15, 20, 24, 26
Visual relocation: coastal Plain E. of Firth River, W of Spring River.
Mortality detected: 30 June
Location: 69°18' N 139°09' W
Carcass collected: 2 July
Distance from capture site: 11.6 km
Carcass weight: 2.0 kg
Response time: 50 hrs.
Total length: cm
Right hind foot length: 37.4 cm
Head length: cm
New hoof length: mm
Neck circumference: cm

Carcass condition and disposition: Scattered bones and hair (3 m radius), skull, vertebrae and ribs connected. Limbs separated from skeleton. Bones not broken or chewed. Golden Eagle feather found near carcass.

Necropsy findings: NA

Mortality category: Predation involved, avian predator. Golden eagle probable species.

Mortality Case History

Calf No. 11
Captured: 7 June 1982

Sex: female
Location: 69°19 N 140°01' W

Weight: 6.1 kg
Right hind foot length: 31.2 cm
New hoof length: 9.0 mm
Processing time: 2 min.

Total length: 82.0 cm
Head length: 20.5 cm
Neck circumference: 21.2 cm
Ear length: 7.4 cm

Umbilicus condition:

Hoof condition:

Health status: Appeared healthy at capture.

Reunion observed: Calf returned towards cow when released-reunion not observed. Maternal female acted defensively during pursuit and remained about 275 m away during processing of the calf.

Monitored: June 8, 9, 11, 15, 20, 24, 26
Visual relocation: 24 June at 69°32' N 139°50' W In a group of 5 cows and 4 calves.
Mortality detected: 30 June 82.
Location: 69°32' N 139°57' W
Carcass collected: 8 July
Distance from capture site: 2.7 km
Carcass weight: 1.05 kg
Response time: 196 hours
Total length: cm
Right hind foot length: 36.0 cm
Head length: cm
New hoof length: 9.0 mm
Neck circumference: cm

Carcass condition and disposition: Hair, skin, and bones scattered over 2 m radius. Limbs seperated from veretbrae, skull missing, bones not chewed. Golden eagle feather found near carcass. 2 Golden Eagles sighted near carcass on 2 July 82

Necropsy findings: NA

Mortality category: Predation involved, avian predator probable. Golden eagle probable species.

Mortality Case History

Calf No. 12	Sex: Female
Captured: 7 June 1982	Location: 69°30' N 139°50' W
Weight: 4.5 kg	Total length: 69.0 cm
Right hind foot length: 39.0 cm	Head length: 18.0 cm
New hoof length: mm	Neck circumference: 18.0 cm
Processing time: 5 min.	Ear length: cm

Umbilicus condition:

Hoof condition:

Health status: Appeared weak and thin.

Reunion observed: No. Maternal female seen running away from the capture area with small group of adults.

Monitored: 8 June	
Visual relocation:	
Mortality detected: 8 June	Location: 69°30' N 139°50'30" W
Carcass collected: 9	Distance from capture site: 0.8 km
Carcass weight: 4.1 kg	Response time: 29 hrs.
Total length: 70.0 cm	
Right hind foot length: 33.0 cm	Head length: 17.3 cm
New hoof length: 5.0 mm	Neck circumference: 15.2 cm

Carcass condition and disposition: Essentially intact, right eye missing-appears to have been removed by and avian scavenger.

Necropsy findings: Milk absent from rumen and intestines. No abdominal fat present. Undigested vegetative material in rumen. All internal organs appeared normal. There was no evidence of hemorrhage or wounds.

Mortality category: Predation-involved, scavenging by avian species. Other factors involved, starvation (probable abandonment).

Mortality Case History

Calf No. 15	Sex: male
Captured: 7 June 1982	Location: 69°22' N 139°29' W
Weight: 7.2 kg	Total length: 77.0 cm
Right hind foot length: 32.0 cm	Head length: 19.5 cm
New hoof length: mm	Neck circumference: 21.0 cm
Processing time: min.	Ear length: cm

Umbilicus condition:

Hoof condition:

Health status: Appeared healthy at capture.

Reunion observed: Yes. Maternal female remained within 115 m during processing. Mother displayed agonistic behavior (striking calf with her front foot) towards this calf following release. Calf did not appear to be injured from this behavior.

Monitored: June 8 and 9 - "alive" signal received.
Visual relocation:

Mortality detected: 11 June	Location: 69°22'30" N 139°29' W
Carcass collected: 22 June 82	Distance from capture site: 0.9 km.
Carcass weight: 6.1 kg	Response time: 264 hrs.
Total length: 82 cm	
Right hind foot length: 34.2 cm	Head length: 19.5 cm
New hoof length: 7.0 mm	Neck circumference: 17.4 cm

Carcass condition and disposition: Basically intact, right eye and tongue removed (apparently by an avian scavenger). No sign of predation at the carcass site.

Necropsy findings: Milk absent from rumen and intestines. No abdominal fat present. Undigested vegetation material packed in the rumen. All internal organs appeared normal. No evidence of hemorrhage or wounds.

Mortality category: Predation-involved, scavenging by avian species. Other factors involved. Starvation (probable abandonment).

Mortality Case History

Calf No. 16
Captured: 7 June 1982

Sex: female
Location: 69°21' N 139°26' W

Weight: 5.7 kg
Right hind foot length: 32.5 cm
New hoof length: mm
Processing time: min.

Total length: 78.0 cm
Head length: 19.0 cm
Neck circumference: 19.0 cm
Ear length: cm

Umbilicus condition:

Hoof condition:

Health status: Appeared healthy at capture.

Reunion observed: Reunion was not observed. Cow remained about 160 m during processing.

Monitored: June 8 and 9 - "alive" signal received.
Visual relocation:
Mortality detected: 11 June
Carcass collected: 22 June
Carcass weight: 0.8 kg
Total length: cm
Right hind foot length: 32.4 cm
New hoof length: 7.0 mm

Location: 69°20' N 139°17' W
Distance from capture site: 6.8 km.
Response time: 264 hrs.
Head length: cm
Neck circumference: cm

Carcass condition and disposition: Scattered hair and bones over about 3 m radius. Leg bones seperated from vertebrae, skull cap intact. Some bones broken and chewed. Golden Eagle feather near carcass.

Necropsy findings: NA

Mortality category: Predation-involved, avian and mammalian species involved, avian predator probable. Species undetermined.

Mortality Case History

Calf No. 18
Captured: 7 June 1982

Sex: male
Location: 69°22' N 139°24' W

Weight: 5.4 kg
Right hind foot length: 32.0 cm
New hoof length: mm
Processing time: 6 min.

Total length: 78.0 cm
Head length: 20.0 cm
Neck circumference: 18.0 cm
Ear length: cm

Umbilicus condition:

Hoof condition:

Health status: Appeared healthy at capture.

Reunion observed: Reunion with cow not observed.

Monitored: 8 June 82 "alive" signal received
Visual relocation:
Mortality detected: 9 June
Carcass collected: 9 June
Carcass weight: 5.6 kg
Total length: 80 cm
Right hind foot length: 32.4 cm
New hoof length: 7.0 mm

Location: 69°21' lat. 139°11' W
Distance from capture site: 8.3 km.
Response time: 1 hr.

Head length: 19.0 cm
Neck circumference: cm

Carcass condition and disposition: No visible external marks.

Necropsy findings: Milk in rumen and intestines, abdominal fat present. All internal organs appeared normal, however the spleen appeared slightly small. No evidence of hemorrhage or wounds found.

Mortality category: Predation-excluded, probable exposure related death.

Mortality Case History

Calf No. 19
Captured: 7 June 1982

Sex: female
Location: 69°23' N 139°23' W

Weight: 6.3 kg
Right hind foot length: 32.0 cm
New hoof length: mm
Processing time: 4 min.

Total length: 80.0 cm
Head length: 20.0 cm
Neck circumference: 18.0 cm
Ear length: cm

Umbilicus condition:

Hoof condition:

Health status: Appeared healthy at capture.

Reunion observed: Reunion with cow not observed.

Monitored: June 8, 9, 11, 15 - "alive" signal received.
Visual relocation:
Mortality detected: 20 June
Carcass collected: 22 June
Carcass weight: 1.475 kg
Total length: cm
Right hind foot length: 36.0 cm
New hoof length: 8.0 mm

Location: 69°23 N 139°15' W
Distance from capture site: 5.1 km.
Response time: 48 hrs.
Head length: cm
Neck circumference: cm

Carcass condition and disposition: Scattered bones and hair. Skull, vertebrae, pelvic gridle and limbs connected. Flesh nearly entirely removed. Bones not broken or chewed. Avian feces present.

Necropsy findings: NA

Mortality category: Predation-involved, avian predator probable. Golden eagle probable species.

Mortality Case History

Calf No. 23
Captured: 9 June 1982

Sex: Male
Location: $69^{\circ}24'$ N $139^{\circ}21'$ W

Weight: 4.7 kg
Right hind foot length: 32.5 cm
New hoof length: 7.0 mm
Processing time: 5 min.

Total length: 73.0 cm
Head length: 19.5 cm
Neck circumference: 21.0 cm
Ear length: cm

Umbilicus condition:

Hoof condition:

Health status: Appeared healthy at capture.

Reunion observed: Reunion with cow was not observed. Calf attempted to follow handlers after it was released.

Monitored: 11 June - "alive" signal received.
Visual relocation:
Mortality detected: 15 June
Carcass collected: 22 June
Carcass weight: 1.0 kg
Total length: cm
Right hind foot length: 32.0 cm
New hoof length: 8.0 mm

Location: $69^{\circ}25'$ N $139^{\circ}24'$ W
Distance from capture site: 1.9 km.
Response time: 168 hrs.
Head length: cm
Neck circumference: cm

Carcass condition and disposition: Scattered bones and hair, limbs intact and connected. Skull, vertebrae and ribs missing. Lower jaw bone chewed away. No predator sign. Bones not broken or chewed.

Necropsy findings: NA

Mortality category: Predation-involved, avian predator probable. Golden eagle probable species.

Mortality Case History

Calf No. Unmarked No. 1
Sex:
Captured:
Location:

Weight: kg
Right hind foot length: cm
New hoof length: mm
Processing time: min.
Total length: cm
Head length: cm
Neck circumference: cm
Ear length: cm

Umbilicus condition:

Hoof condition:

Health status:

Reunion observed:

Monitored:
Visual relocation:
Mortality detected: 8 June
Location: S. Herschel Island, Yukon Territory
Carcass collected: 8 June
Distance from capture site: NA
Carcass weight: 6.3 kg
Response time:
Total length: 8.75 cm
Right hind foot length: 33.8 cm
New hoof length: 8.0 mm
Head length: cm
Neck circumference: 20.5 cm

Carcass condition and disposition: Caribou survey crew saw brown bear feeding on this calf. Ran the bear off and collected the carcass. Transported it to Komakuk Beach. Carcass intact except face and abdomen. Bruises on loin area and back of neck. Carcass still warm and steaming in cool air. Two main feeding sites: 1) face gone including nose, top dental rows, eyes, brain and brain case, and ears. Lower jaw with tongue intact; 2) Abdominal cavity open, all viscera except heart, lungs, and kidneys gone. Carcass was well fleshed and calf appeared in excellent physical condition.

Necropsy findings: NA

Mortality category: Brown bear predation.

Mortality Case History

Calf No. Unmarked No. 2
Sex: Male
Captured:
Location:

Weight: kg
Right hind foot length: cm
New hoof length: mm
Processing time: min.
Total length: cm
Head length: cm
Neck circumference: cm
Ear length: cm

Umbilicus condition:

Hoof condition:

Health status:

Reunion observed:

Monitored:
Visual relocation:
Mortality detected: 2 July
Location: Coastal plain, ANWR.
Carcass collected: 2 July
Distance from capture site:
Carcass weight: 9.7 kg
Response time:
Total length: 86.5 cm
Right hind foot length: 34.5 cm
Head length: 22.2 cm
New hoof length: 7.5 mm
Neck circumference: 19.7 cm

Carcass condition and disposition: Carcass lying in tundra. Cow standing nearby. No external marks on carcass.

Necropsy findings: Lungs deep red with some hemmoraging. Rumen inflated, nearly empty. Milk curds in abomasun. Intestines empty. No evidence of trauma. Diagnosis - acute pneumonia.

Mortality category: Pneumonia.

Mortality Case History

Calf No. Unmarked No. 3
Captured:

Sex: Male
Location:

Weight: kg
Right hind foot length: cm
New hoof length: mm
Processing time: min.

Total length: cm
Head length: cm
Neck circumference: cm
Ear length: cm

Umbilicus condition:

Hoof condition:

Health status:

Reunion observed:

Monitored:
Visual relocation:
Mortality detected: 3 July
Carcass collected: NA
Carcass weight: kg
Total length: cm
Right hind foot length: cm
New hoof length: mm

Location: Coastal plain, ANWR
Distance from capture site:
Response time:

Head length: cm
Neck circumference: cm

Carcass condition and disposition: Lying in tundra. Viscera were exposed and upper shoulder were fed upon. Talon wounds in mid-loin area on both sides of back bone. Golden eagle sitting on tundra approximately 200 m from carcass. Calf appeared to be in good physical condition.

Necropsy findings: NA

Mortality category: Golden eagle predation.

Table A-1. Summary of weather information collected at Komakuk and Shingle Point DEWLINE sites during June, 1982.

June	Komakuk			Shingle Point		
	Avg. temp (°C)	Avg. wind (kph)	PPT (mm)	Avg. temp (°C)	Avg. wind (kph)	PPT (mm)
1	1.5	14.8	1.0	-1.5	7.9	10.2
2	0.75	21.8	-	0.5	16.2	6.0
3	0.5	18.5	-	0.75	17.6	0.8
4	-1.0	20.4	-	-1.5	12.0	-
5	-0.75	40.7	-	0	16.2	-
6	1.0	44.4	-	2.25	24.0	-
7	3.75	42.6	-	6.75	28.7	-
8	4.0	7.4	-	9.5	23.2	-
9	1.5	14.8	-	4.0	10.5	-
10	0.5	42.6	-	2.0	17.6	-
11	0.75	36.1	-	2.0	17.1	-
12	0.75	20.8	1.0	2.0	16.2	0.4
13	0.25	3.2	-	1.25	9.7	-
14	2.0	12.5	-	2.0	12.5	-
15	3.0	24.5	-	0.75	10.2	11.4
16	0.5	9.7	2.0	0	20.4	6.2
17	0.33	6.5	1.0	0	29.0	5.0
18	0.75	19.4	-	0.25	10.6	-
19	1.25	32.4	-	4.5	10.6	-
20	1.5	22.7	-	2.25	16.7	-
21	3.33	28.2	-	2.0	15.4	-
22	4.66	37.0	-	6.66	11.1	-
23	6.66	27.3	-	10.33	22.2	-
24	6.33	12.2	-	12.0	16.7	-
25	12.0	8.8	-	10.5	6.5	11.8
26	6.75	10.6	-	12.5	8.8	-
27	4.5	13.9	-	15.5	7.4	-
28	18.25	6.5	2.8	21.5	18.5	-
29	18.50	19.0	-	21.0	21.3	-
30	7.5	12.0	-	10.25	11.6	-
	$\overline{X}$ = 3.69	$\overline{X}$ = 21.04	x = 0.26	$\overline{X}$ = 5.12	$\overline{X}$ = 15.81	$\overline{X}$ = 1.96

Table A-2. Assessment of weather factors recorded during June, 1982, at Komakuk Beach DEWLINE site, northern Yukon Territory (after Miller and Broughton 1974).

June	[1]Gross degree day C°	Wind (kph)	[2]Adjusted degree day C°	Precipitation	[3]Net degree day C°
1	1.5	14.8	-13.3	1.0	-23.3
2	0.75	21.8	-21.05	x	-21.05
3	0.5	18.5	-18.0	T	-18.0
4	-1.0	20.4	-21.4	-	-21.4
5	-0.75	40.7	-41.45	-	-41.45
6	1.0	44.4	-43.4	-	-43.4
7	3.75	42.6	-42.1	-	-42.1
8	4.0	7.4	-3.4	T	-3.4
9	1.5	14.8	-13.3	-	-13.3
10	0.5	42.6	-42.1	-	-42.1
11	0.25	36.1	-35.85	*	-35.85
12	0.75	20.8	-20.05	1.0	-30.05
13	0.25	3.2	-2.95	-	-2.95
14	2.0	12.5	-10.5	-	-10.5
15	3.0	24.5	-21.5	T	-21.5
16	0.5	9.7	-9.2	2.0	-29.2
17	0.33	6.5	-6.17	1.0	-16.17
18	0.75	19.4	-18.65	-	-18.65
19	1.25	32.4	-31.15	-	-31.15
20	1.5	22.7	-21.2	-	-21.2
21	3.33	28.2	-24.87	*	-24.87
22	4.66	37.0	-32.34	-	-32.34
23	6.66	27.3	-20.64	-	-20.64
24	6.33	12.2	-5.87	-	-5.87
25	12.0	8.8	+3.2	*	+3.2
26	6.75	10.6	-3.85	-	-3.85
27	4.5	13.9	-9.4	-	-9.4
28	18.25	6.5	+11.75	2.8	-16.25
29	18.50	19.0	-.5	*	-.5
30	7.50	12.0	-4.5		-4.5
TOTALS	103.31		-516.14		-598.44

[1]Gross degree day = avg. daily temp-A threshold of 0C°
[2]Adjusted degree day = GDD-(1°/kph)
[3]Net degree day = ADD -(1°/0.1 mm. ppt.

Table A-3. Assessment of weather factors recorded during June, 1982, at Shingle Point DEWLINE Site, northern Yukon Territory. (after Miller and Broughton 1974).

June	[1]Gross degree day C°	Wing (kph)	[2]Adjusted degree day C°	Precipitation	[3]Net degree day C°
1	-1.5	7.9	-9.4	10.2	-111.4
2	0.5	16.2	-15.7	6.0	-75.7
3	0.75	17.6	-16.8	0.8	-24.8
4	-1.5	12.0	-13.5		-13.5
5	0	16.2	-16.2		-16.2
6	2.25	24.0	-21.8		-21.8
7	6.75	28.7	-21.9		-21.9
8	9.5	23.2	-13.7		-13.7
9	4.0	10.5	-6.5		-6.5
10	2.0	17.6	-15.6		-15.6
11	2.0	17.1	-15.1		-15.1
12	2.0	16.2	-14.2	0.4	-18.2
13	1.25	9.7	-8.5		-8.5
14	2.0	12.5	-10.5		-10.5
15	0.75	16.2	-9.5	11.4	-123.5
16	0	28.4	-28.4	6.2	-90.4
17	0	29.0	-29.0	5.0	-79.0
18	0.75	10.6	-10.4		-10.4
19	4.5	10.6	-6.1		-6.1
20	2.25	16.7	-14.5		-14.5
21	2.0	15.4	-13.5		-13.4
22	6.66	11.1	-4.55		-4.55
23	10.33	22.2	-11.9		-11.9
24	12.0	16.7	-4.7		-4.7
25	10.5	6.5	+4.0	11.8	-114.0
26	12.5	8.8	+3.7		+3.7
27	15.5	7.4	+8.1		+8.1
28	21.5	18.5	+3.0		+3.0
29	21.0	21.3	-0.3		-0.3
30	10.25	11.6	-1.4		-1.4
Totals	159.99		-318.75		-832.84

[1]Gross degree days - Avg. daily temperature - A threshold of 0°C.
[2]Adjusted degree days = GDD - (1°/kph)
[3]Net degree days = ADD - (1°/0.1 mm ppt.)

ANWR Progress Report Number FY83-7

POPULATION SIZE, PRODUCTIVITY, AND DISTRIBUTION OF MUSKOXEN IN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA.

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Key words: muskoxen, population size, productivity, calving grounds, mortality, herd dynamics, distribution, movement, Arctic National Wildlife Refuge

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Population size, productivity, and distribution of muskoxen in the Arctic National Wildlife Refuge, Alaska.

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Abstract: Data on population size and productivity of muskoxen (*Ovibos moschatus*) in the Arctic National Wildlife Refuge were collected during surveys in April and October 1982. The post-calving population was estimated to be between 240 and 257 animals. In October, 38 calves were counted for a ratio of 0.49 calves/cow 2 years and older, and 0.19 calves/animal older than calf. Complete sex and age composition data for all herds are needed before an accurate estimate of productivity can be made. Three adult mortalities were documented in 1982. Distribution and movement of muskoxen were determined by relocating radio-collared animals from mid-April through October. In May, 60-70 muskoxen from both the Sadlerochit area and the Tamayariak area calved in the hills east of Carter Creek. Other animals calved on the bluffs along the Tamayariak River, on a ridge between Arctic Creek and the Kekiktuk River and along the Niguanak River. Some females were observed alone during the birth of their calves. In June after the peak of calving, several animals dispersed into areas not used later in the summer. From July through October muskoxen utilized riparian willow thickets along major river drainages. In mid-April animals were observed on wind-blown ridges above river valleys. Interchange of animals between the Tamayariak and Sadlerochit area was observed. Herds were not stable descrete units throughout the year.

Population size, productivity, and distribution of muskoxen in the Arctic National Wildlife Refuge, Alaska.

Muskoxen (Ovibos moschatus), reintroduced to the Arctic coast in 1969 and 1970, are year-round residents of the Arctic National Wildlife Refuge (ANWR) coastal plain and are susceptible to impending petroleum exploration activities in all seasons. Reproduction and survival in recent years have been high, however, continuing data collection on population size and composition is essential to monitor changes which may occur in the presence and/or absence of potential disturbances. In this population where large herds have become established and may be fracturing, an understanding of herd dynamics is a necessary element for evaluating the role that dispersal, movement, and distribution plays in population dynamics of this species. Seasonal use of specific areas, particularly calving areas, needs to be documented to insure adequate habitat protection.

The objectives of this study were as follows:

1. Determine population size and composition of muskoxen herds on ANWR.
2. Document the distributional patterns and movements of muskoxen herds on ANWR.
3. Locate and define calving grounds of the herds using the coastal plain of ANWR.

Methods and Materials

The study area was located between the Canning and Kongakut Rivers, from the 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).

Between 9 and 13 April muskox herds were located using reconnaissance flights by fixed-wing aircraft over the study area. Overflights were made at 350-1000 m AGL to minimize disturbance to the animals. Aerial photographs were taken using a 6x7 large format SLR (Mamiya RB-67) camera with a 200 mm lens of 2 large herds to determine number of animals in each herd. Sex and age composition counts of small herds were made from the air. Differentiation of sex and age of muskoxen was determined by body size and horn boss development (Smith 1976). Portions of large herds were classified from the ground using a spotting scope and Questar telescope.

Between 13 and 16 April, 15 muskoxen were captured and marked using methods similar to those used by Jonkel et al. (1975). Muskoxen were darted from a helicopter using Cap-Chur equipment (Palmer Chemical Co., Douglasville, GA). Two or 3 animals were separated from the main herd and darted in quick succession. This procedure permitted several animals to be immobilized and collared quickly and insured that individuals would not be alone after recovering from the drug. Muskoxen are highly social animals and undrugged individuals were reluctant to leave muskoxen which were immobilized.

Thirteen of the muskoxen were drugged with 7.5 cc of M-99 (Etorphine, 1 mg/ml, D-M Pharmaceuticals, Rockville,MD) mixed with 0.2 cc Rompun (100 mg/ml injectable Xylazine, Cutter Laboratories, Inc., Shawnee, KN). Induction time

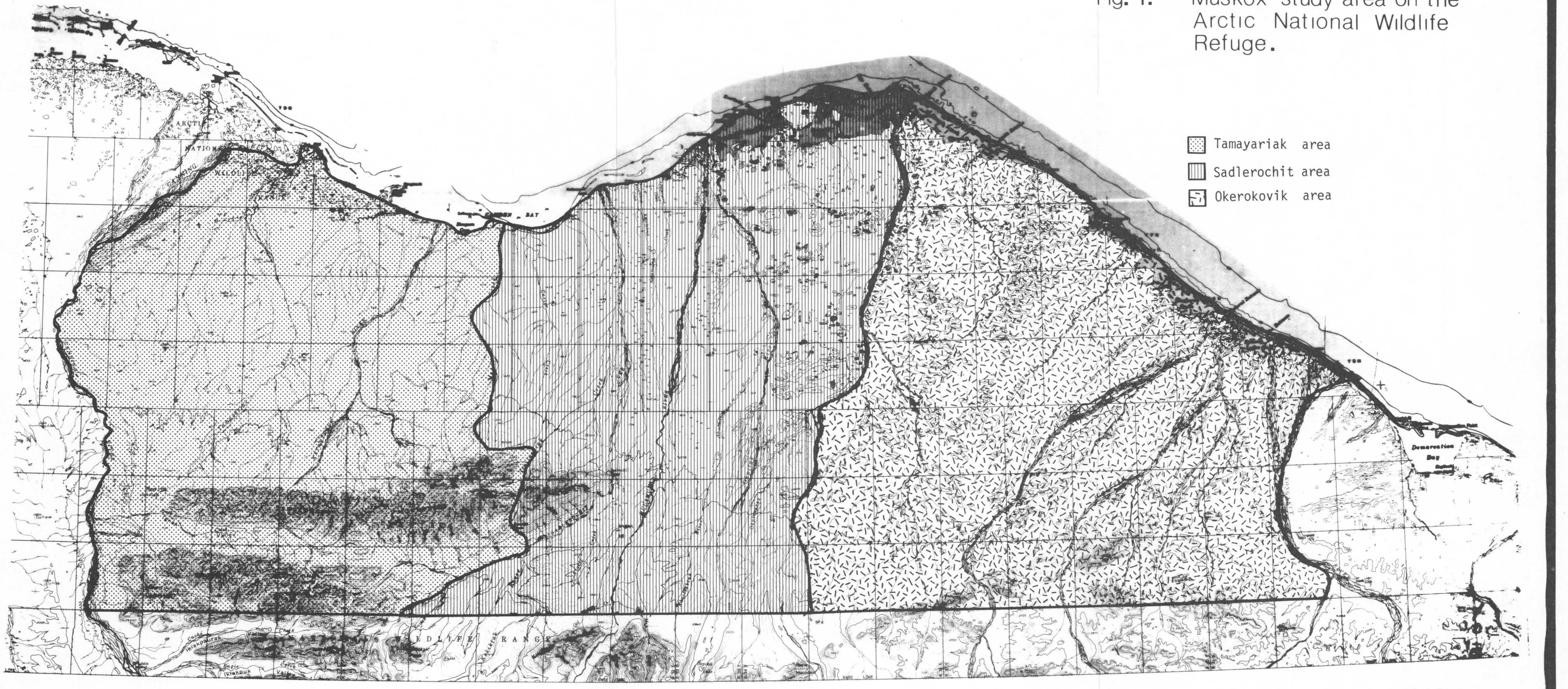

Fig. 1. Muskox study area on the Arctic National Wildlife Refuge.

ranged from 3 to 16 min ($\bar{X}$ = 10 min). Using these dosages, 11 drugged animals were completely immobilized but 2 adult females were slightly alert, removing head and ears. Two 3-year old females were immobilized with 5.0 cc M-99 and 0.2 cc Rompun. Both of these muskoxen were very active while being collared and no body measurements were taken.

All animals recovered after the antidote M-50-50 (Dipremorphine, 0.2 mg/ml, D-M Pharmaceuticals, Rockville, MD) was administered intermuscularly in the rump, at the same dosage as the M-99. Recovery times ranged from 4 to 13 min ($\bar{X}$ = 8 min) for animals which recovered quickly with no apparent affects. One animal was groggy, and 2 animals had difficulty standing and were slow to get up (range 20 to 28 min); 1 of these animals may have been accidently darted twice. She was given an additional 5.0 cc of M-50-50 when she did not get up after the 7.5 cc dose.

Body measurements (See Appendix, Table A-1) were recorded for 11 females and 2 males using methods described by Langvatn (1977). Samples (4 cm^2) of guard hair and underwool were clipped from the right front shoulder of each animal for mineral analysis. A canine tooth was collected from 2 individuals for aging.

Numbered plastic roto-tags (NASCO, Ft. Atkinson, WS) were 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 (See Appendix, Table A-2). Mortality sensing radio-transmitters (Telonics, Mesa, AZ) were attached by neck collars to 14 of the captured muskoxen.

Radio-collared animals were relocated 19 times between mid-April and late October (See Appendix, Table A-3) 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, vegetation type, reaction to aircraft, and elevation of aircraft above ground level were recorded on form sheets. Vegetation was catagorized as tussocks, riparian willow, dry ridge, wet sedge meadow, and other. Reaction to aircraft was recorded as one of 5 classes (See Appendix, Table A-4). After each flight, locations were transferred to a set of master maps, information was entered in a chronological log book, and data for each animal were summarized on maps and form sheets.

In late June, a herd of 26 muskoxen was observed for a continuous 12 h period. Individuals within the herd, which contained 3 radio-collared animals, were classified as to sex and age, and behavior was recorded. In early August major calving areas were examined on the ground; vegetation and topography were described at each location.

From 29 to 31 October a systematic survey was made of the study area. All major drainages between the Canning and Kongakut Rivers were searched using fixed-wing aircraft and all radio-collared muskoxen were located. Most large groups were photographed with a 6x7 cm format camera or a 35 mm camera with 80-200 mm zoom lens. The same methods and procedures of data collection used in radio-relocation flights were used during this survey. Snow cover made sighting animals much easier than in summer. Poor weather conditions precluded landing and determining the composition of large herds, but numbers of calves were counted from the air. Initial overflights were made at 350 m

ACL or greater to prevent animals from aggregating into a defensive formation from which it was difficult to distinguish calves.

For purposes of data analysis, the study area was divided into 3 geographic areas: 1) the Tamayariak area, between the Canning River and Marsh Creek, 2) the Sadlerochit area between Marsh Creek and the Hulahula River, and 3) the Okerokovik area between the Hulahula River and the Kongakut River (Fig. 1). Observational periods were separated into the following categories (Jingfors 1980):

mid-April	late winter
late April-May	calving
June	post calving
July	mid-summer
August- September	rut
October	early winter

Results and Discussion

Population, Size, and Productivity

Total counts of muskoxen observed in the study area were attempted in April and October 1982 (Table 1). The total of 240 animals including 38 calves seen in October represents the minimum post-calving population present in the study area in 1982. In October, fewer animals older than calves were seen than in April. Very likely, this difference was primarily due to overlooking small groups and/or single animals in October; in addition, there were 3 known mortalities. If the 216 animals older than calves which were seen in April survived until fall, and produced the same proportion of calves as did the 202 animals observed in October an alternate population estimate can be derived using the following formula:

$$N = \left(216 \times \frac{38}{240}\right) + 216 = 257$$

Population numbers for 1982 compared with previous years show that population growth was slow in the first 3-4 years after the 1969 and 1970 transplants, and began to increase after 1974, reached a maximum in 1979-1980 (Fig. 2). Rates of population increase varied between geographic areas within the study area (Fig. 2; See Appendix, Table A-5). Recruitment to the population in the Okerokovik area apparently has been lower than the Sadlerochit and Tamayariak areas, where population growth was similar until 1979 (Fig. 2).

In the Sadlerochit area, the greatest increase to the population occurred in 1979-1980 (See Appendix, Table A-5,). Jingfors and Klein (1982) reported high productivity in the largest herd in the Sadlerochit area in June 1979. They reported 0.89 calves/cow of reproductive age (older than 2 years of age), and found at least 2 of 17 calves were born to 2-year old cows with no over-wintering mortality in the calf and yearling cohorts between 1979 and 1980.

Recruitment to the population in the Sadlerochit area was less in 1981 and possibly in 1982, when an increase of only 1 animal was recorded, although 12 to 14 calves were born each year (Fig. 2). This decline may be due to emigration of animals to the Tamayariak area where recruitment between 1981

Table 1. Muskoxen observed in the ANWR study area during spring (9-16 April) and fall (30 October-1 November) surveys in 1982.

Geographic area	Herd Size		
	Spring	Fall	
		Adults	Calves
OKEROKOVIK AREA:			
Jago River to Kongakut River		24	8
	32	10	3
	5	2	-
	6	2	-
Subtotal	43	38 +	11
SADLEROCHIT AREA:			
Sadlerochit River to Hulahula River		15	5
	71	[21	[2
	3	4	6
	5	25]	2]
Subtotal	79	65 +	15
TAMAYARIAK AREA:			
Canning River to Marsh Creek		3	-
	4	2	-
	5	2	-
	-	2	-
	29	35	3
	46	[15	[1
		11]	5]
		16	1
	5	10	2
	8	3	-
Subtotal	97	99 +	12
Total Observed	219	202 +	38

[ ] Groups close together and considered to be a single herd.

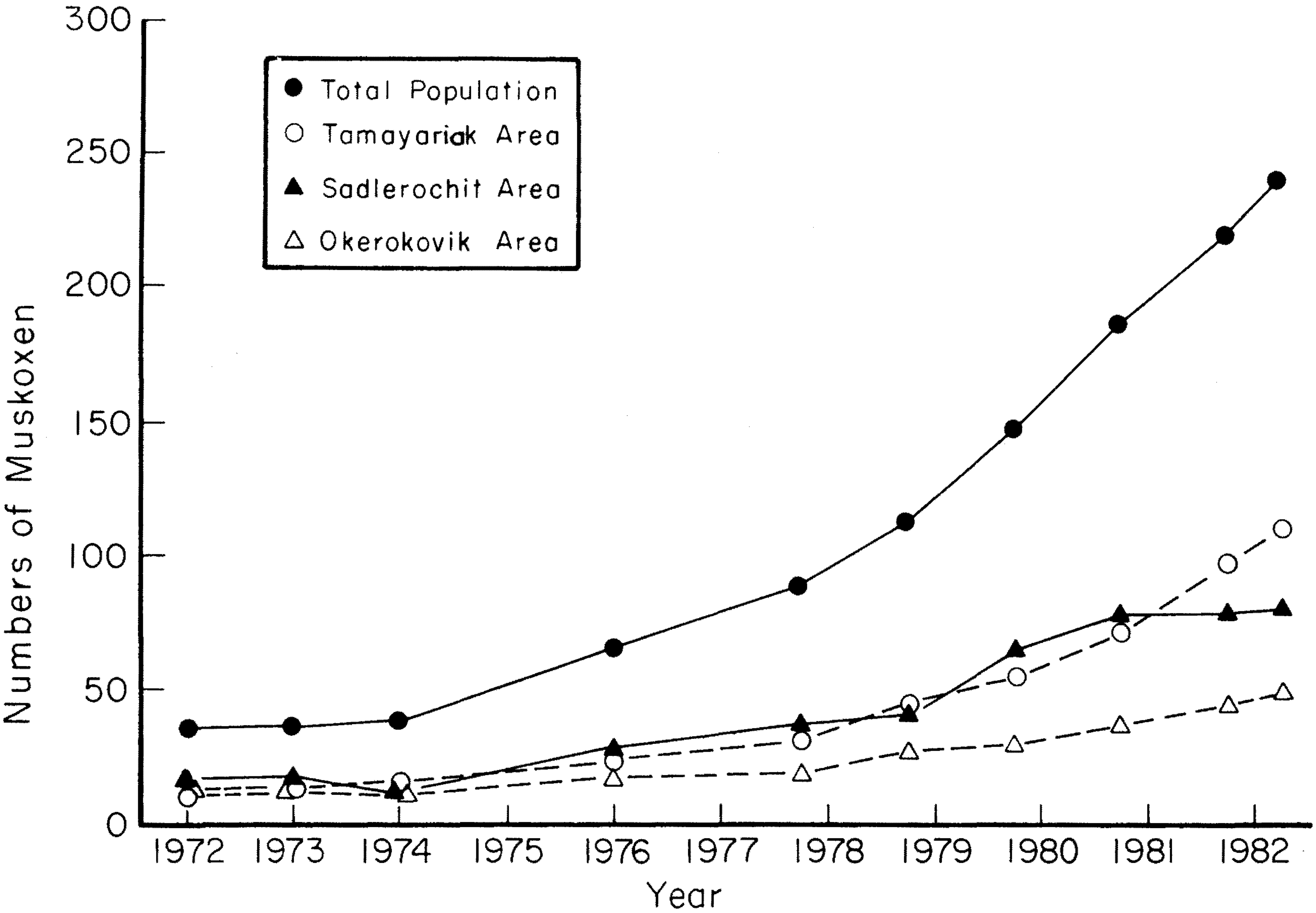

Fig. 2. Estimated numbers of muskoxen in the Arctic National Wildlife Refuge from 1972 to 1982.

Table 2. Composition of muskoxen herds observed in the ANWR study area in April 1982.

Geographic area	Group size	Number classified	Adult M	Adult F	3 years M	3 years F	2 years M	2 years F	Yearlings	Yearlings per cow (3+)	Bulls (2+) per cow (2+)
Okerokovik	32	20	1	4	4	2	4	1	4	0.67	1.29
	5	5	5								
	6	6			1		1		4		
Total	43	31	6	4	5	2	5	1	8	1.30	2.40
%			19.4	12.9	16.1	6.5	16.1	3.2	25.8		
Sadlerochit	71	52	3	14	3	8	7	7	10	0.45	0.31
	3	3	3								
	5	5			1		2		2		
Total	79	60	6	14	4	8	9	7	12	0.54	0.66
%			10.0	23.3	6.7	13.3	15.0	16.7	20.0		
Tamayariak	29	0									
	46	32	5	9	2	5	2	4	5	0.36	0.50
	4	4	4								
	5	5	2				1		2	--	--
	5	5	5								
	8	8	6	2							
Total	97	54	22	11	2	5	3	4	7	0.44	1.35
%			40.7	20.4	3.7	9.3	5.6	7.4	13.0		
Population totals	219	145	34	29	11	15	17	12	27	0.61	1.10
%		100	23	20	8	10	12	8	19		

and 1982 remained high (Fig. 2; See Appendix, Table A-5). A decline in productivity and/or increase in mortality may also have occurred.

In April 1982, 145 of 219 animals observed were classified according to sex and age (Table 2). Of these, 44 (30%) were potentially reproductively active females of at least 3 years of age and 56 (39%) were cows of at least 2 years of age. Assuming that the sample of animals classified was representative of the entire population, the 27 yearlings observed in April 1982 represent a ratio of 0.61 yearlings/cow older than 3 years. If 39% of the 202 animals observed in October were reproductively active females of at least 2 years of age, the 1982 October calf ratio was 0.49 calves/cow and 0.19 calves/animal older than calf. Calves represented 16% of the total numbers of muskoxen observed in October, suggesting the rate of increase for the population may be similar to that observed in 1981 (See Appendix, Table A-5).

The productivity estimate based on calf ratios is biased by an incomplete composition sample and the extrapolation of April data to October. The proportion of calves in the population may also be biased if all animals were not seen in October. Accurate productivity data require more complete sex and age composition surveys.

Data on productivity of radio-collared females is summarized in Table 3. Assuming that both 4F and 8F produced calves and no calves were born after 21 June, the productivity of radio-collared females was 0.45 calves per cow. A herd of 24 muskoxen observed in mid-July on upper Marsh Creek had 4 calves and 12 cows 2 years or older (0.33 calves per cow).

Table 3. Reproductive status of radio-collared cow muskoxen.

Number	Reproductive status	Remarks
1F	No calf 21 June	Seen with 2 calves or yearlings on 14 October.
3F	Calf born about 25 May	Alone with calf 25 May.
4F	Not known	25 June - 5 August
5F	No calf 5 August	
6F	No calf 27 June	
8F	Not known	
9F	Still-born calf 30 April	
10F	Calf 21 June	Alone with calf 21 June, 2-16 July.
11F	No calf 2 July	
14F	Calf 25 June	Observed on ground by Connie O'Brian

Composition of herds varied between geographic areas in 1982 (Table 2). In the Sadlerochit area, 51% of the 60 animals classified were 2 years of age or younger. Jingfors and Klein (1982) also found a large proportion of young age classes in the largest herd in the Sadlerochit area in 1979 and 1980. By contrast, only 26% of the 54 animals classified in the Tamayariak herd were 2 years of age or younger and a higher percentage of adult bulls was observed. Muskoxen classified in the Okerokovik area were characterized by large numbers of males in all age classes, and more yearlings than cows 3 years of age and older were classified, suggesting that at least some yearlings had come from other areas.

Mortality

At least 3 adult mortalities occurred between April and November 1982. A 3 year old cow, captured and radio-collared on 15 April was found dead on 14 May. There was no sign of predation at the time the animal was located. Poor weather conditions delayed examination of the carcass for 2 weeks by which time scavengers had consumed much of the carcass. As a result, cause of death could not be determined. Because it occurred relatively soon after the animal had been handled, this death may have been the result of the capture operation, although the animal had been given a light (5 ml) dosage of M-99 and had been relatively active during the handling procedure. Some complication during the latter stages of pregnancy or parturition may also have occurred. The presence of moderate back fat and white bone marrow suggests that the animal did not die of malnutrition.

In late April an adult male was found dead on Arctic Creek by W. Soplu of Kaktovik. Mr. Soplu had seen a live animal lying down in this location a week earlier. The animal apparently had died from several puncture wounds which appeared to have been inflicted by the horns of another muskox. The wounds appeared to have been badly infected, suggesting that the animal had not died immediately after being injured. This muskoxen was 1 of the original animals transplanted to Barter Island in 1969. It had ADF&G tag 7845 in its right ear and was 15 years old at the time of its death (Sverre Pedersen pers. comm.).

A second radio-collared cow (4F) died between 17 and 30 October 1982. This adult female had been alone since 13 August. From late June until early August she had been accompanied by a smaller muskox (possibly a 2-year old) and a calf. Prior to that time she had been associated with larger groups of animals. On 16 October, she was in a weakened state and lying beneath drifting snow. The frozen carcass was collected and will be autopsied at a future time. Preliminary examination revealed no external wounds; the animal appeared to be emaciated.

A radio-collared female (9F) had a still-born calf on about 30 April 1982. Superficial examination indicated the fetus was at or near full term; cause of death was not obvious (Bartels pers. comm.). The carcass was not collected. Loss of the calf occurred within 15 days after the cow had been drugged and handled.

Herd Dynamics

Flow diagrams of movements and interactions of muskox herds observed in the study area from April through October 1982 show numbers of muskoxen, radio-collared animals, and number of calves associated with each herd (Fig. 3 and 4). Movement of herds through time and space are shown by vertical and horizontal shifts. Observed changes in herd size are indicated by solid lines. Previous studies described 3 different herds occupying distinct geographic locations: 1) the Canning/Tamayariak area, 2) the Sadlerochit area and, 3) the Jago/Okerokovik area (USFWS 1982). Data from radio-collared muskoxen show that in 1982, interchange of animals between the Tamayariak and Sadlerochit areas occurred (Fig. 4). Muskoxen from the Tamayariak area and

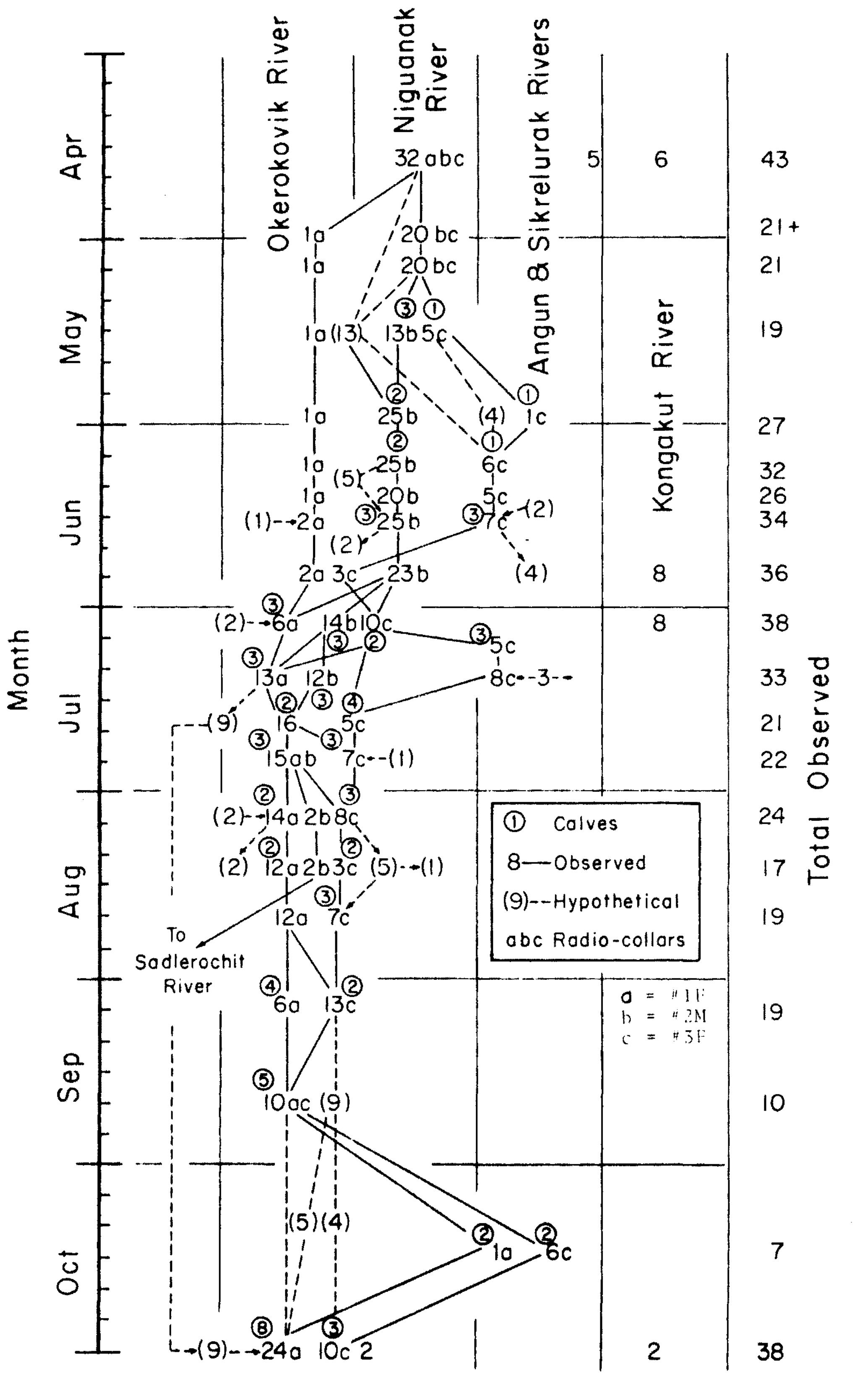

FIG. 3. MOVEMENTS AND INTERACTIONS OF MUSKOX HERDS EAST OF THE JAGO RIVER IN THE OKEROKOVIK AREA, APRIL - OCTOBER 1982.

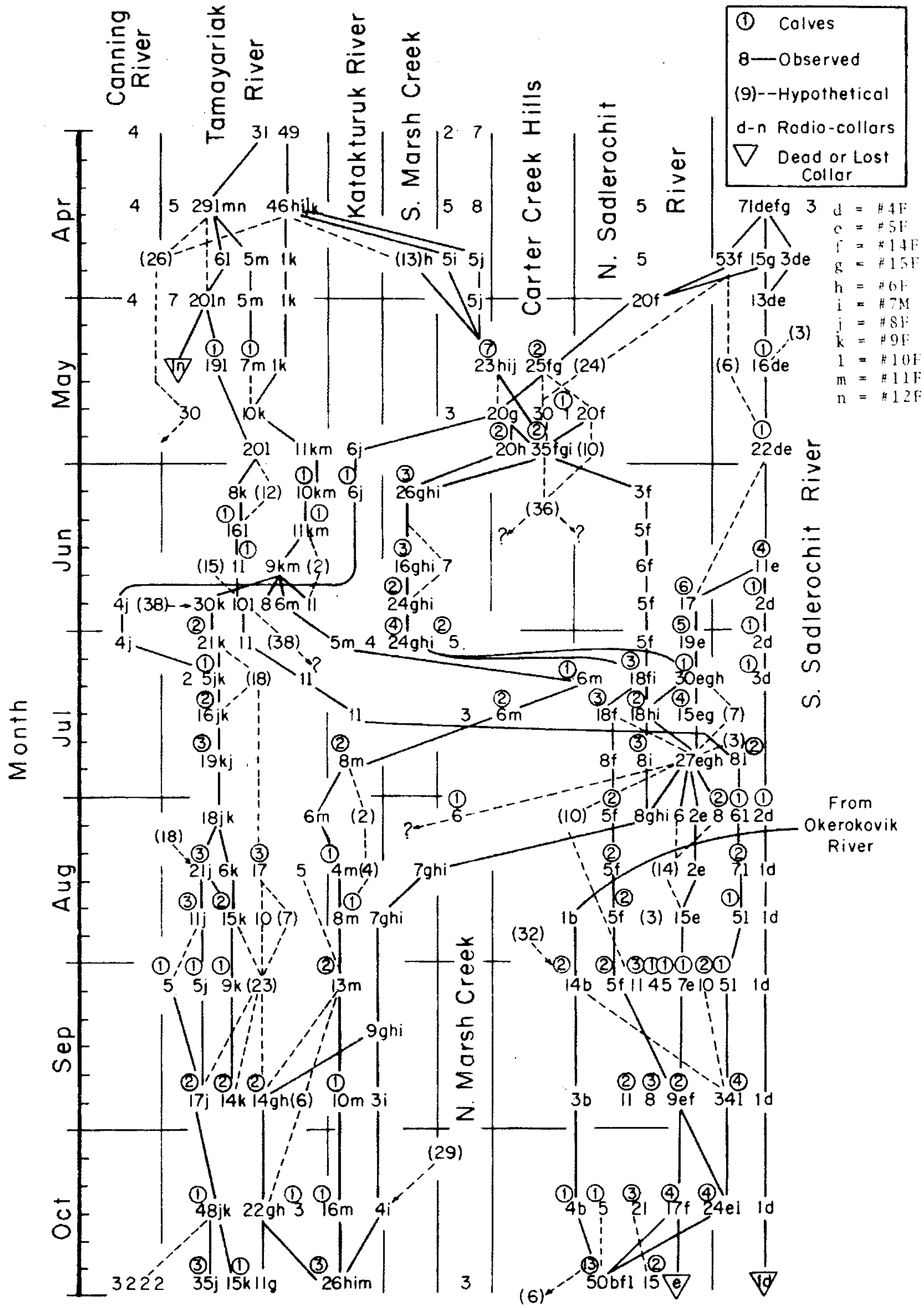

FIG. 4. MOVEMENTS AND INTERACTIONS OF MUSKOX HERDS WEST OF THE HULAHULA RIVER IN THE SADLEROCHIT AND TAMAYARIAK AREAS, APRIL - OCTOBER 1982.

the Sadlerochit area utilized the same calving grounds in the hills east of Carter Creek. On 14 May, 3 radio-collared muskoxen which had been tagged near the Tamayariak River and 2 radio-collared muskoxen tagged near the Sadlerochit River were observed in 2 distinct herds in the Carter Creek hills. Intermixing of these herds occurred by 29 May (Fig. 4).

Interchange between muskoxen from the Tamayariak area and the Sadlerochit area also occurred after calving and in mid-summer (Fig. 4). In early June, a herd of 24 muskoxen containing 2 radio-collared animals from the Tamayariak area and 1 animal from the Sadlerochit area moved from Carter Creek hills to upper Marsh Creek where they remained for a month. In July these animals moved to the Sadlerochit River and intermixed with herds already there. In mid-August these same 3 radio-collared animals moved in a herd of 7 "adults" from the Sadlerochit River to the Tamayariak area where they were observed until late October (Fig. 4).

Two other radio-collared muskoxen from the Tamayariak area also moved to the Sadlerochit area in mid-summer. A group of 5 "adults" traveled from the Katakturuk River about 42 km east to the Sadlerochit River between 2 July and 11 July. Within 5 days this group with an additional cow and calf left the Sadlerochit River and returned to the Katakturuk River (Fig. 4). Another radio-collared female traveled from the Tamayariak area to the Sadlerochit area in late July. Accompanied only by her calf, this animal moved about 13 km east from the Tamayariak River to the Kataturuk River in 5 days and continued approximately 47 km east to the Hulahula River during the following 7 days. She was observed there on 23 July in a group of 8 "adults" and 2 calves. This animal remained in the Sadlerochit area in late October (Fig. 4).

One instance of interchange of animals between the Okerokovik area and Sadlerochit area was observed (Fig. 3). One of 3 radio-collared muskoxen from the Okerokovik area traveled 52 km to the Sadlerochit River between 13 and 22 August. This animal was a 3-year old bull which had apparently been ejected from a harem group during rut.

In addition to herds seen primarily along the Okerokovik, Sadlerochit, and Tamayariak Rivers, a small herd of 6 to 8 animals was observed along the Kongakut River in April, June, and July, but was not seen in the October survey. At least 1 calf was present in this herd in July.

In 1982, muskoxen herds did not remain as identifiable units throughout the year (Fig. 3 and 4). Numbers of animals and radio-collared individuals in a herd would stay the same for several weeks and then change (Table 4). Herds appeared to be more stable during early calving, post-calving, and rut, and less stable in mid-summer and early winter. Gunn (1982) stated that the size and composition of herds varied by season, range condition and the number of bulls in the population; but suggested that herd composition could be relatively stable with the exception of bulls leaving and joining the herd. Gray (1973) described merging and splitting of herds on Bathurst Island and described herds as open systems during most of the year except during rut when closed harem groups are controlled by a single bull. Smith (1976) described intermingling of harem groups during rut on Nunivak Island.

Mean herd size varied with season (Table 4). Largest herds were seen in mid-April and October and smallest herds were seen during rut in August. Gray (1973) found monthly mean herd size changed from a low in July-August to highs

Table 4. Numbers of animals with radio-collared muskoxen from April through October 1982.

Date		Individual radio-collared muskoxen													Herd size
		4F	5F	14F	15F	6F	7M	8F	9F	11F	10F	1F	2M	3F	X ± SD
April	13-16	71	(71)	(71)	(71)	46	(46)	(46)	(46)	29	(29)	32	(32)	(32)	44.5 ± 19.2
	23-26	3	(3)	53	15	--	4	4	1[a]	5	6	1	20	(20)	13.8 ± 17.0
	30	13	(13)	20	(20)	--	--	4	1	5	20	1	20	(20)	13.7 ± 7.6
May	14	16	(16)	25	(25)	23	(23)	(23)	1	7	19	1	13	5	15.4 ± 7.6
	21-25	--		20	--	--	--	--	10	--	--	1	23	1[a]	17.7 ± 6.8
	29	22	(22)	35	(35)	20	(35)	6	11	(11)	15	1	25	6	17.5 ± 10.0
June	4-6	--	--	3	26	(26)	(26)	6	9	(9)	8	--	20	5	11.0 ± 8.6
	10	--	--	5	--	--	--	--	11	(11)	14	2	23	4	9.8 ± 7.9
	21	--	11	6	13	(13)	(13)	--	9	(9)	1[a]	2	23	3	9.6 ± 7.2
	25-26	2	17	5	24	(24)	(24)	4	30	6	10	25	(25)	6	12.9 ± 10.2
July	2	2	19	5	25	(25)	(25)	4	21	5	1[a]	6	14	10	11.1 ± 8.1
	11	3	30	18	(30)	(30)	(18)	5	(5)	6	1[a]	13	12	8	9.3 ± 5.3
	16	--	15	18	(15)	8	(8)	16	(16)	6	1[a]	16	--	5	12.0 ± 5.5
	23	2	27	8	(27)	(27)	8	19	(19)	8	8	15	--	7	11.3 ± 7.7
Aug.	5	2	2	5	8	(8)	(8)	18	(18)	6	6	14	2	8	7.1 ± 5.3
	13	1	2	5	7	(7)	(7)	21	6	4	7	12	2	3	6.9 ± 5.8
	22	1	15	5	7	(7)	(7)	15	15	8	5	12	1	7	9.9 ± 4.3
Sept.	3	1	7	5	9	(9)	(9)	15	9	13	5	6	14	13	9.6 ± 3.8
	23	1	9	9	14	(14)	3	17	14	10	34	10	3	(10)	12.3 ± 8.8
Oct.	16	1	24	17	24	(24)	4	56	(56)	17	(24)	1	4	6	19.0 ± 17.1
	30-31	--	--	50	11	26	(26)	35	15	(26)	15	24	(50)	10	23.2 ± 13.8
Mean Herd Size[b]		13.6	17.8	18.4	21.4	19.8	16.3	17.4	17.8	10.1	14.0	14.0	18.1	9.4	
SD		21.43	16.0	18.8	14.7	10.6	12.2	15.0	13.6	6.8	9.0	8.7	12.0	7.1	

() more than 1 radio-collared animal in the same herd
[a]cow with calf
[b]excluding solitary individuals

in October, February, and April on Bathurst Island. He states: "The seasonal change in herd size from large winter herds to smaller herds corresponds to the situation reported by Tener (1965) for other Canadian muskoxen populations and by Spencer and Lensink (1970) for the muskoxen of Nunivak Island." Miller et al. (1977, as cited in Gunn 1982) also observed a decrease in average herd size from 17.2 in March-April to 10.0 in July-August on Melville Island.

In past years, the large herd on the Sadlerochit River appeared to have been a stable unit, although in 1979 this herd split temporarily several times during rut. In 1979-80 this herd was larger than most herds reported elsewhere and fracture into smaller groups seemed inevitable (Jingfors and Klein 1982). A similar situation may have existed with the other 2 large herds observed in past years (USFWS 1982). In the summer of 1982 no large stable herds were observed in the study area. Some individuals remained together for several weeks in small herds. For example, 6F, 7F and 15F were together in a herd of 24 animals for 4 weeks during June and were together in a herd of 7 animals during August. Herds observed in late October 1982 did not appear to be stable. Numbers of animals and marked individuals associated with herds were different than those observed 2 weeks earlier (Table 4).

Distribution and Movements

The distribution of muskoxen observed in the study area from April through October 1982 (Fig. 5) indicate that muskoxen were concentrated within the same 3 geographic areas summarized in the Initial Report of the Baseline Study (USFWS 1982). Seasonal use of specific areas was apparent during calving, post-calving, rut, and late winter.

Calving. The hills east of Carter Creek were the most important calving area (Fig. 5, Table 5). A herd of 20 animals moved about 40 km from the upper Sadlerochit River to Carter Creek hills during the last week in April (Fig. 4). Radio-collared muskoxen, tagged in the Tamayariak area were seen between Marsh Creek and Carter Creek during the last week of April in herds of 5 animals. On 15 May the same muskoxen were in the Carter Creek hills in a herd of 23 animals. Three herds with an estimated 70 animals were observed in Carter Creek hills on 21 May; 55 muskoxen in 2 herds of 20 and 35 were counted on 29 May. A herd of 6 animals, including 8F, had already left the area on this date. Other herds containing radio-collared muskoxen left Carter Creek hills between 29 May and 4 June (Table 5).

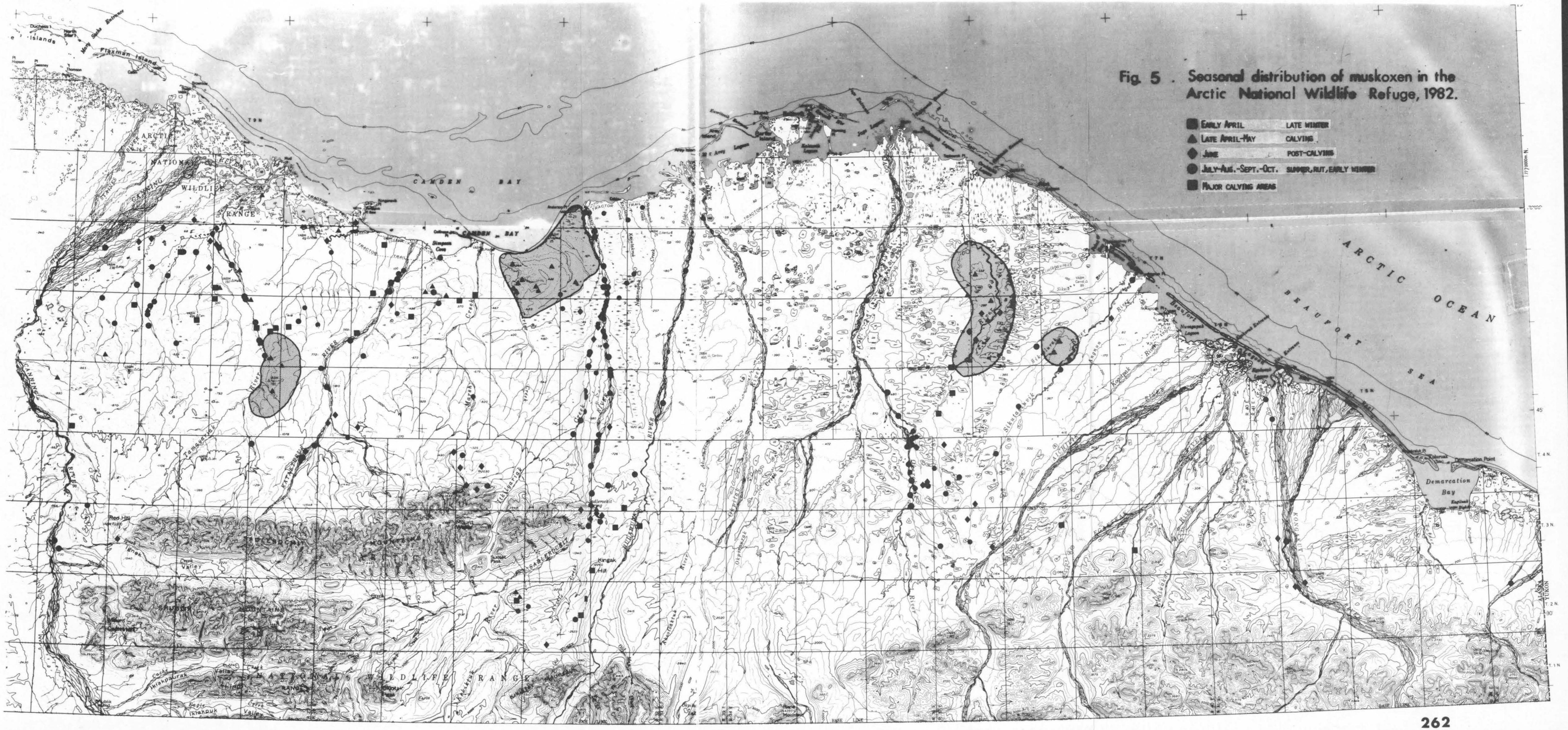

Fig. 5 . Seasonal distribution of muskoxen in the Arctic National Wildlife Refuge, 1982.

Table 5. Calving areas used by muskoxen in 1982.

Location	Approximate Dates: Arrival	Approximate Dates: Departure	Date calves first seen	Estimated numbers	Radio-collared animals present
Carter Creek Hills	30 April to 14 May	4 June	14 May	60-70	6F^{t}, 15F^{s} 7M^{t}, 8F^{t}, 14F^{s}
Tamayariak Bluffs	14 May	29 May	14 May	26	10F^{t}, 11F^{t}
Upper Sadlerochit River	30 April	29 May	14 May	13-22	4F^{s}, 5F^{s}
Niguanak River	---	---	14 May	18-31	2M, 3F

^{t}captured in the Tamayariak area.
^{s}captured in the Sadlerochit area.

Other radio-collared muskoxen in the Tamayariak area calved along bluffs in the central portion of the east fork of the Tamayariak River (Fig. 5, Table 5) On 14 May, 2 herds of 19 and 7 were observed in this area. A radio-collared female (9F) who had given birth to a stillborn calf on about 30 April, was observed in the Tamayariak bluffs with a herd of 10 muskoxen on 21 May. These herds had left the bluff area by 29 May.

At least 13 muskoxen calved near the upper Sadlerochit River on a high ridge between Arctic Creek and the Kekiktuk River (Fig. 5, Table 5). Muskoxen moved into this area between 23 and 30 April, and were in a herd of 16 in the same general location on 15 May. By 29 May, they had left the ridge and had moved about 11 km north to east of Sadlerochit Springs, where they were observed in a herd of 22.

In the Okerokovik area, most animals calved along the Niguanak River (Fig. 5, Table 5). About 31 muskoxen were seen in this area in mid-April and remained there until mid-June. Two herds of 13 and 5 were seen on 14 May. One radio-collared animal (3F) had her calf on about 25 May after moving from the Niguanak River about 10 km east to the Sikrelurak River.

Calving areas were characterized by moderate to high relief with good visability of the surrounding country. Vegetation at all calving sites visited was a Dry Prostrate Shrub-Forb Tundra (USFWS 1982), similar to the Dry Ridge type described by Robus (1981). Dryas intergrifolia was a major species as were grasses, sedges, some forbs, and low-growing willow (Salix sp.). Adjacent river valleys, with the exception of the Niguanak River, had abundant riparian willow thickets (Robus 1981) comprised primarily of Salix alaxensis.

Calves were first observed in all areas on 14 May. Due to poor weather, no radio-relocation flights were made between 30 April and 14 May. In 1979, peak of calving occurred on 15 May in the Sadlerochit herd, however, newborn calves were observed in mid-June (Jingfors 1980).

Some parturient females separated from the herd with which they were associated for a brief period during birth of their calf. On 14 May, 3F was observed with a group of 5 "adults" and 1 calf. On 25 May she was seen alone with a new born calf, and 4 days later she was again with a herd of 6 animals. A solitary unmarked female was observed with a new born calf in Carter Creek hills on 21 May. On 21 June, 10F was observed alone with a calf and within 4 days she was with a group of 10 animals. The radio-collared animal (9F) which had a still-born calf, was alone with the calf on 30 April and remained alone until 21 May.

Post-calving dispersal In late May and early June after the peak of calving, 4 herds containing radio-collared animals moved into snow free areas not generally used during other times of the year (Fig. 5). Three of 5 radio-collared animals calving in Carter Creek hills (6F, 7M, and 15F) moved together in a herd of 24 to the upper Marsh Creek area, about 27 km south, and remained in this area for about a month. These animals were utilizing alpine tundra (USFWS 1982) for feeding and resting on 27 June. Another herd of 4 muskoxen (including 8F) moved about 40 km southwest of Carter Creek hills to the west end of the Sadlerochit Mountains near Red Hill between late May and late June. Two herds (including 9F, 10F and 11F), which calved on the Tamayariak River bluffs, moved about 24 km north to near the coast between the Canning River and the Katakturuk River. At least 2 herds (including 5F and 14F) moved to the lower Sadlerochit River in early June.

Summer - Rut In late June and July after leaves on riparian willows had emerged, willow-covered gravel bars along the lower Sadlerochit River and its main tributary were heavily used by muskoxen (Fig. 5). Robus (1981) described the habitat utilization of this area by muskoxen. In addition to the herds which had been in the area since early June, a herd of 24 moved from upper Marsh Creek to the Sadlerochit River between 2 and 11 July. A herd of 6 moved from the Tamayariak area to the Sadlerochit area during the same time period.

In the Tamayariak area, muskoxen were also concentrated along the forks of the Tamayariak River where willows were abundant. Animals in the Okerokovik area were localized on the Okerokovik River near abundant willow stands.

A similar distribution was observed in August. One animal (10F), accompanied by a calf, moved about 68 km east from the Tamayariak area to the Hulahula River in August. A solitary young male (2M) moved about 51 km from the Okerokovik River to the Sadlerochit River in late August. In late September and early October, muskoxen were stil distributed along major drainages which contained abundant willows (the Sadlerochit, the east and west forks of the Tamayariak, the Katakturuk, and the Okerokovik Rivers). By contrast, in April 1982, animals in the Sadlerochit and Okerokovik areas were observed along wind-blown ridges above the valley floors (Fig 5).

Average daily movements of radio-collared muskoxen, calculated by dividing the distance moved by the number of days between sightings, ranged from 0.0 to 6.7 km/day (Table 6). Almost 70% of the animals had largest movements in July or

August. Movements in late April and early June reflect travel to and from calving areas. Jingfors (1982) reported daily group movement rates ranging from 0.66 + 0.42 km/day to 9.9 + 3.6 km/day for the Sadlerochit herd in 1979. Jingfors (1982) data were based on distances between bedding locations within a 24 hour period and more accurately reflect daily movement of animals. He noted that highest movement rates occurred in mid-summer (11-20 July) and suggested that extensive movements were made to evade insects.

Table 6. Average daily movements made by 13 radio-collared muskoxen between 23 April and 31 October 1982.

ID-sex	Range of average daily movement (km/day)	Maximum distance[a] moved (km)	Month when maximum movement occurred
1F	0.0-2.0	22	July; late Sept.
3F	0.2-4.8	41	Late Sept.
2M	0.1-5.7	52	August
4F	0.1-1.8	9	August
5F	0.1-5.1	30	July
14	0.1-5.5	38	Late April
15	0.1-6.7	32	August
6	0.1-5.4	35	Late April
7M	0.1-5.4	27	Early June; August
8	0.1-3.2	19	Early June; August
9	0.1-4.8	13	October
10	0.6-6.7	29	August
11	0.1-4.8	41	August

[a] straight line distance between 2 sightings.

Numbers of muskoxen observed in 4 geographic areas varied during different seasons of the year (Fig. 6). Highest numbers were observed in April and October and lowest in early June, July, and August. Muskoxen were more visable when snow was present in early and late winter. However, the decreasing numbers of animals observed may also be related to increasing mean daily movements and decreasing herd size during mid-summer and the rut. As herds become smaller, and become more widely dispersed in summer, they are less likely to be seen. Dispersal from calving areas in early- and mid-June may account for the low numbers of muskoxen seen during that time period.

Numbers of muskoxen observed in the Okerokovik area remained relatively stable between April and early September, while numbers observed in the Tamayariak area varied throughout the summer (Fig. 6). Similarly, numbers recorded for the Sadlerochit area also varied in July and August, suggesting that movement between areas was occurring. Data from radio-callers muskoxen verified that interchange was between the Tamayariak and Sadlerochit area occurred.

Summary

Preliminary data on productivity, and movements of radio-collared individuals suggest that several changes have occurred in the muskox population since 1980. The high rate of growth observed in 1979 and 1980, probably resulting from high productivity and low over-winter mortality (Jingfors and Klein 1982)

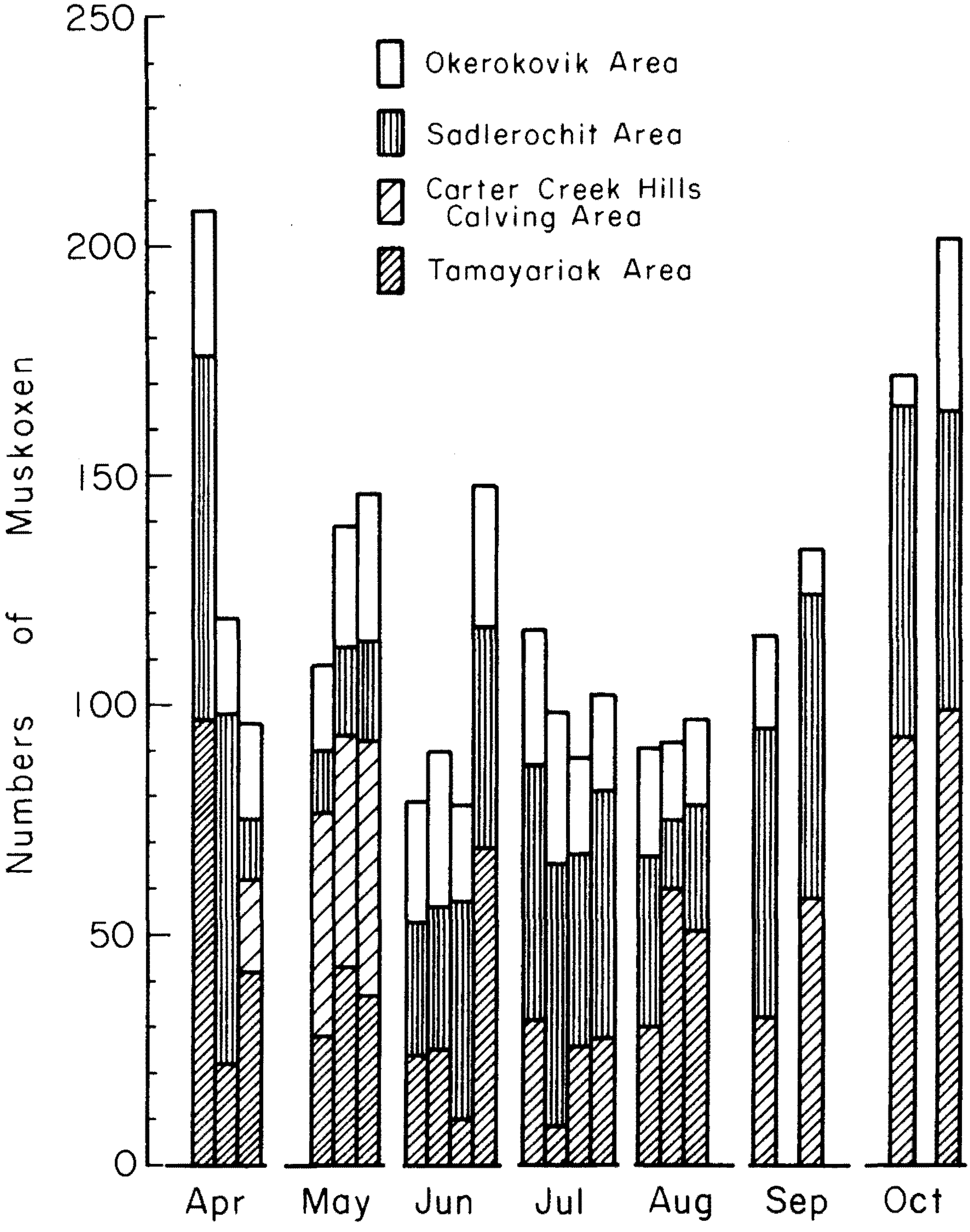

Fig. 6. Numbers of muskoxen observed in 3 geographic areas in the Arctic National Wildlife Refuge, April - October 1982.

slowed, in 1981. Decreasing productivity may have occurred, but more complete sex and age composition of all herds is needed to accurately assess productivity of the population. Mortality of survivors of the 1969-1970 transplants may be increasing as these animals reach old age. As predicted by Jingfors and Klein (1982), the large herds observed in 1979 and 1980 have apparently fragmented. Dispersal of these animals may also be affecting recruitment to the population.

The smaller herds observed during the summer of 1982 appear to be more typical of muskoxen in other areas (Gray 1972, Smith 1976, Gunn 1982). Herd stability may be dependent on the proximity of other herds. In areas of concentration such as the Carter Creek hills during calving, and the Sadlerochit River in July, herds are likely to encounter one another and intermix. During rut, herds are usually small stable harem groups controlled by a single adult bull (Smith 1976).

Movements of radio-collared animals between geographic areas were observed in 1982 but the extent of interchange is undetermined. The high percentage of adult bulls in the Tamayariak area suggest that these animals may have dispersed from the Sadlerochit area.

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APPENDIX

ANWR Progress Report Number FY83-7

Table A-1. Physical characteristics (cm) of muskoxen tagged in the Arctic National Wildlife Refuge, 13-16 April 1982.

ID Sex	Est. Age	Length	Body length	Tail	Ear	Neck	1/2 girth	Shoulder height	Hind leg	Fore leg	Skull width	Skull length	Horn width	Horn length	Horn circumference
1F[a]	14	2100	2140	4	11.0	90.0	72.5	109.0	39.5	33.0	21.0	45.0	43.0	56.8	14.0
3F[a]	14	2121	2115	6	12.5	--	72.0	112.0	41.3	33.3	22.1	51.3	43.5	42.5	15.3
4F	4+	2022	2019	3	14.0	113.0	79.5	117.0	44.0	33.0	25.7	52.0	61.0	43.5	15.9
5F	4	2024	2019	5	13.0	102.0	77.0	120.0	42.5	31.5	21.5	54.5	--	31.5	13.0
6F	4+	2015	2011	4	11.5	98.0	72.5	113.0	39.5	34.8	18.5	47.0	57.5	43.0	14.8
8F	3	2006	2002	4	12.8	88.5	80.0	114.5	43.0	32.0	19.0	44.5	53.0	40.2	--
9F	4+	2014	2008	6	11.5	99.0	75.5	111.0	39.0	36.0	21.0	47.0	61.0	43.0	15.1
10F	4+	2004	2004	5	13.0	107.5	73.5	103.5	38.2	33.0	20.2	49.0	55.5	45.5	13.0
11F	3	1882	1876	6	13.2	80.5	83.5	119.0	42.0	32.3	18.9	47.0	53.0	38.2	16.0
14F[a]	17	2024	2018	6	13.0	114.0	86.0	117.0	41.5	35.0	21.6	55.8	52.0	43.2	13.6
15F	3	2009	2004	5	13.0	87.0	80.0	98.0	38.0	32.0	19.1	53.0	54.0	41.0	15.4
Female															
mean	2020.6	20019.6	4.9	12.6	98.0	77.5	112.1	40.8	33.2	20.8	49.7	53.4	42.6	14.6	
SD	59.9	67.2	1.0	0.9	11.4	4.8	6.7	2.0	1.4	2.1	3.9	6.2	6.0	1.1	
2M	3	2040	2010	10	14.0	93.5	80.0	130.0	44.0	34.4	22.8	54.5	66.0	57.3	24.9
7M	4+	2041	2036	5	13.5	103.5	82.0	129.0	46.0	34.3	24.0	58.0	68.0	65.0	26.0
Male															
mean	2040.5	2023.0	7.5	13.8	98.5	81.0	129.5	45.0	34.4	23.4	56.3	67.0	61.2	25.5	
SD	0.7	18.4	3.5	0.3	7.1	1.4	0.7	1.4	0.1	0.8	2.5	1.4	5.4	0.8	

[a]original transplant animals released at Barter Island in March and April 1969.

Table A-2. Muskoxen captured and marked on the Arctic National Wildlife Refuge, April 1982.

Capture location	ID-sex	Estimated age	Ear tags left	Ear tags right	Visual marks left	Visual marks right
Okerokovik	1 F[a]	14	7676[a]	551	Green	Red
area: Niguanak	2 M	3	552	553	Blue	White
River	3 F[a]	14	7674[a]	7665[a]	Blue	Red
Sadlerochit	4 F	Adult	558	557	Green	Green
area: upper	5 F	Adult	556	555	Blue	Green
Sadlerochit	14 F[a]	17	577	7699[a]	NONE	
River	15 F	3	578	576	NONE	
Tamayariak	6 F	Adult	572	573	Green	Green
area: east side	7 M	Adult	574	575	Red	Red
of Tamayariak	8 F	3	559	560	White	Red
River	9 F	Adult	562	561	Blue	Blue
Tamayariak	10 F	Adult	565	564	Green	Red
area: west side	11 F	3	566	563	Green	Blue
of Tamayariak	12 F	3	569	568	White	White
River	13 F[n]	3	571	570	Green	White

[a]ADF&G ear tags: animals released at Barter Island in March and April 1969.
[n]No radio collar.

Table A-3. Relocation dates for radio-collared muskoxen, ANWR, 1982.

Date	Radio-collared Muskox Id and Sex													
	1F	2M	3F	4F	5F	14F	15F	6F	7M	8F	9F	10F	11F	12F
23-25 April	x	x	x	x	x	x	x		x	x	x	x	x	
30 April	x	x	x	x	x	x	x			x	x	x	x	x
14 May	x	x	x	x	x	x	x	x	x	x	x	x	x	+
21-24 May[a]						x	x	?	?	?	x	?	?	
29-31 May	x	x	x	x	x	x	x	x	x	x	x	x	x	
4-6 June	x	x	x	x	x	x	x	x	x	x	x	x	x	
10 June	x	x	x			x	x	x	x		x	x	x	
17-21 June	x	x	x		x	x	x	x	x		x	x	x	
25-28 June	x	x	x	x	x	x	x	x	x	x	x	x	x	
2 July	x	x	x	x	x	x	x	x	x	x	x	x	x	
10-11 July	x	x	x	x	x	x	x	x	x	x	x	x	x	
16 July			x		x	x	x	x	x	x	x	x	x	
23 July	x	x	x	x	x	x	x	x	x	x	x	x	x	
5-8 August	x	x	x	x	x	x	x	x	x	x	x	x	x	
13 August	x	x	x	x	x	x	x	x	x	x	x	x	x	
22 August	x	x	x	x	x	x	x	x	x	x	x	x	x	
3-5 September	x	x	x	x		x	x			x	x	x	x	
21-23 September	x	x	x	x	x	x	x	x	x	x	x	x	x	
13-16 October	x	x	x	x	x	x	x	x	x	x	x	x	x	
30-31 October	x	x	x	+	+	x	x	x	x	x	x	x	x	

[a]not a regular relocaton flight
+ died or lost collar.

Table A-4. Classes of responses to aircraft (modified from Davis and Valkenburg 1979).

Class 1.	Panic response: muskoxen run into a defensive "circle", then run as a group; may trip and fall; may stop and turn to face aircraft and then run again. Some subjectivity on distinguishing this class from Class 2.
Class 2.	Strong escape response: muskoxen run into a defensive circle, may stop and turn to face aircraft.
Class 3.	Mild escape response: muskoxen move toward each other, group together in a loose formation.
Class 4.	Stop and look (stationary) response: muskoxen stop feeding, rise from resting position, look up at aircraft.
Class 5.	No visible response: muskoxen continue feeding or resting, or if moving, continue moving at the same pace in the same direction.

Table A-5. Estimated numbers of muskoxen in the Arctic National Wildlife Refuge, 1972-1982.

Date	Tamayariak area		Sadlerochit area		Okerokovik area		Total		Data source
	no.	r	no.	r	no.	r	no.	r	
Summer 1972	10	--	14	--	12	--	36	--	Roseneau and Warbelow 1974
Summer 1973	11	0.09	11	--	14	0.14	36	0.08	Roseneau and Warbelow 1974
Summer 1974	14	0.21	12	--	12	--	38	0.05	USFWS 1982
Summer 1976	24	0.21	27	0.28	16	0.25	67	0.22	USFWS 1982
Summer 1977	31	--	40	--	19	--	90	--	USFWS 1982
Spring[a] 1978	32	0.25	36	0.25	18	0.11	86	0.22	Ross 1978-1980
Summer 1978	42	--	46	--	20	--	108	--	Ross 1978-1980
Spring[a] 1979	44	0.27	42	0.14	26	0.23	112	0.23	Ross 1978-1980
Spring[a] 1980	54	0.18	65	0.35	29	0.10	148	0.24	Ross 1978-1980
Spring[a] 1981	72	0.25	78	0.17	36	0.19	186	0.20	Ross 1978-1980
Spring[a] 1982	97	0.26	79	0.01	43	0.16	219	0.15	Current study
Fall 1982	111	--	80	--	49	--	240	--	Current study

r = rate of increase per year

[a] pre-calving survey which represents over-winter survival of the previous year's population.

ANWR Progress Report Number FY83-8

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, range size, Arctic-Beaufort, Arctic National Wildlife Refuge

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30 December 1982

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Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge.

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Abstract: Fifty brown bears (*Ursus arctos*) were captured between 23 June and 3 July 1982 in the coastal plain and adjacent foothills and mountains of the northeastern portion of ANWR. Radio-transmitters were attached to 32 of the 50 bears and these bears were monitored through denning in October and early November. More females were captured in age classes 6.5 year old and less, while males were more abundant in 7.5 year old and older age classes. Survival of immature bears appears good from year to year based on the percentage of captured bears in each age class. No mortality was detected within the immature age classes. Preliminary data interpretation indicate that the coastal plain and foothills habitats may be used more often by younger age classes and females with young than older bear without young. Preliminary calculations of range size indicated that young bears moved over larger areas than adult bears. In all cases, range sizes determined in this study were less than recorded for brown bears in northwest Alaska and northeast Alaska. Brown bears were observed feeding on caribou (*Rangifer tarandus*) carcasses on 6 occasions during the study. These instances were the only recorded interactions between the 2 species, except one unsuccessful chase of a bull caribou by a bear on 23 August. Dens were located for 28 radio-collared bears and dens of 10 unmarked bears were located during aerial surveys for bear dens. Bears moved south into the foothills and mountainous habitats to den, except for 2 radio-collared bears. One brown bear denned in the coastal plain and one denned in the foothills of Marsh Creek. These 2 dens were the only bear dens located within the 1002c study area boundaries.

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Brown bear (<u>Ursus arctos</u>) 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 (<u>Rangifer tarandus</u>), occupying the coastal plain and adjacent foothills and mountains of the northeastern portion of ANWR.
4. Determine the structure, size, status, and reproductive biology of brown bear populations on the northern slope of the eastern Brooks Range.

This project is a cooperative effort between the USFWS and the Alaska Department of Fish and Game (ADF&G), with FWS having primary responsibility for the first 3 objectives and ADF&G being primarily responsible for objective 4.

Methods and Materials

The study area is located between the Canning River and the Canadian border, and extends southward to the Brooks range. A detailed description of the study area was presented in the Initial Report - Baseline Study of the ANWR Coastal Plain (USFWS 1982).

Field work was based at Barter Island and extended from 23 June through 5 November 1982. Bears were captured between 23 June and 3 July using a Bell 206B helicopter. Fixed-wing aircraft were used to locate bears and direct the helicopter with the capture crew to the site. Capture procedures followed standard helicopter immobilization techniques used on brown bears in northern Alaska (Reynolds 1974, 1976). Sernylan (phencyclidine hydrochloride, Bio-Centic Labortories, St. Joseph, MO) and acepromazine maleate (Ayerst Labs, New York) were injected into the rump using Cap-Chur equipment (Palmer Chemical and Equipment Co., Douglasville, GA). Captured animals were measured, weighed, tattooed for permanent identification, ear-tagged, and marked with color-coded visual ear flags (Reynolds 1974). In addition, 32 bears were fitted with collars containing radio-transmitters (Telonics, Inc., Mesa AZ).

The 2 vestigial 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 by radio-collared bears increased intervals between relocations to 2-3 weeks. 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.

Preliminary estimates of range sizes were determined 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 was a 4.83 km square (Reynolds 1980). Radio-relocations were transferred to 1:250,000 scale topographic maps for these determinations. Movement distances between consecutive radio-relocations were 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.

Results and Discussion

A total of 50 brown bears were captured and marked between 23 June and 3 July 1982 (Table 1). Two bears died as a result of capture efforts: bear 1201, a 5 year old female, drowned while under the influence of the drug; bear 1215, a 18.5 year old male, apparently suffocated while recovering from the effects of the drug. Of the 50 captured bears, 32 were equipped with radio-transmitters (Table 1). Distribution of bear captures included 25 (13 males, 12 females) in coastal plain habitats, 13 (9 males, 4 females) in foothills habitats, 10 (4 males, 6 females) in mountainous habitats, and 2 males in river valley habitats in mountainous terrain (Fig. 1).

Average weights of captured adult bears was 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).

Table 1. Physical characteristics of brown bears captured on the Arctic National Wildlife Refuge, Alaska, June-July 1982 (Measurements shown in cm).

Bear number	Sex	Cementum age	Weight lbs./kg.	Total length	Hind leg	Hind foot	Neck	Girth	Head width	Head length	Shoulder height	Upper left canine	Lower left canine	General capture location	Date
1056	M[a]	20.5	365/166	181	129	29	74	126	22.5	35.7	118	3.9	3.2	Old Man Ck.	28 June
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
1183	F	0.5	14/ 6	74	34	18	22	35	9.4	15.6	41	3.4	2.8	Jago R.	23 June
1184	F	0.5	14/ 6	72	35	13	22	36	9.2	16.0	46	-	-	Jago R.	23 June
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
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
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
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
1189	F[a]	5.5	- -	168	94	26	55	99	17.1	32.1	100	3.4	2.8	Kongakut R.	23 June
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
1191	M	0.5	19/ 9	69	42	15	26	43	10.2	15.7	46	-	-	Turner R.	24 June
1192	M	0.5	20/ 9	88	33	14	25	43	9.8	16.5	41	-	-	Turner R.	24 June
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
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
1195	M[a]	4.5	210/ 95	174	83	22	62	-	18.4	32.2	80	3.4	3.2	Kongakut R.	24 June
1196	M[a]	6.5	- -	155	78	25	62	104	17.0	30.3	98	3.0	2.9	Ekalukat R.	24 June
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
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
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
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
1201	F	5e[b]	190/ 86	159	80	28	62	97	18.3	31.1	92	2.8	2.7	Katakturuk R.	25 June
1202	F[a]	16.5	215/ 98	160	97	24	60	109	18.2	31.6	98	3.1	2.8	E. Marsh Cr.	25 June
1203	M	1.5	30/ 14	90	51	16	33	53	11.0	18.6	57	0.6	1.0	Marsh Cr.	25 June
1204	M	1.5	55/ 25	97	64	19	39	75	12.2	21.5	68	1.0	1.2	Marsh Cr.	25 June
1205	M	1.5	46/ 21	101	62	20	39	66	11.2	20.4	61	1.1	1.0	Marsh Cr.	25 June
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
1207	M	5.5	190/ 86	157	104	28	61	93	18.8	32.2	109	3.7	3.5	Hulahula R.	26 June
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
1209	M	3.5	125/ 57	139	85	27	49	81	15.5	29.0	86	3.0	2.9	Hulahula R.	26 June
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
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
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

Table 1. (Continued.)

Bear number	Sex	Cementum Age	Weight lbs./kg.	Total length	Hind leg	Hind foot	Neck	Girth	Head width	Head length	Shoulder height	Upper left canine	Lower left canine	General capture location	Date
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
1214	F	2.5	80/ 36	109	66	22	44	74	14.0	24.6	74	1.2	1.7	Marsh Cr.	28 June
1215	M	18.5	400/181	194	121	33	83	133	22.7	37.3	112	4.3	3.5	Jago R.	28 June
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
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
1218	M	2.5	144/ 65	154	93	29	48	87	14.6	27.7	88	2.3	2.5	Egaksrak R.	29 June
1219	M	4.5	170/ 77	159	89	27	53	87	16.2	29.6	101	3.2	2.9	Jago R.	30 June
1220	F	10.5	230/104	168	100	25	58	110	19.4	29.5	101	2.9	2.6	Jago R.	30 June
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
1222	M	3.5	120/ 54	148	82	25	47	87	15.2	26.2	91	3.0	2.7	Clarence R.	30 June
1223	M	6.5	250/113	176	98	27	66	109	19.1	34.6	109	3.1	2.9	Kongakut R.	30 June
1224	M	3.5	190/ 86	155	99	27	62	96	16.7	31.2	94	3.1	3.1	Beaufort L.	1 July
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
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
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
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
1229	M[a]	4.5	- -	143	92	29	53	102	16.2	30.2	109	4.0	3.5	Kongakut R.	3 July
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

[a]Radio-collared
[b]Estimated age

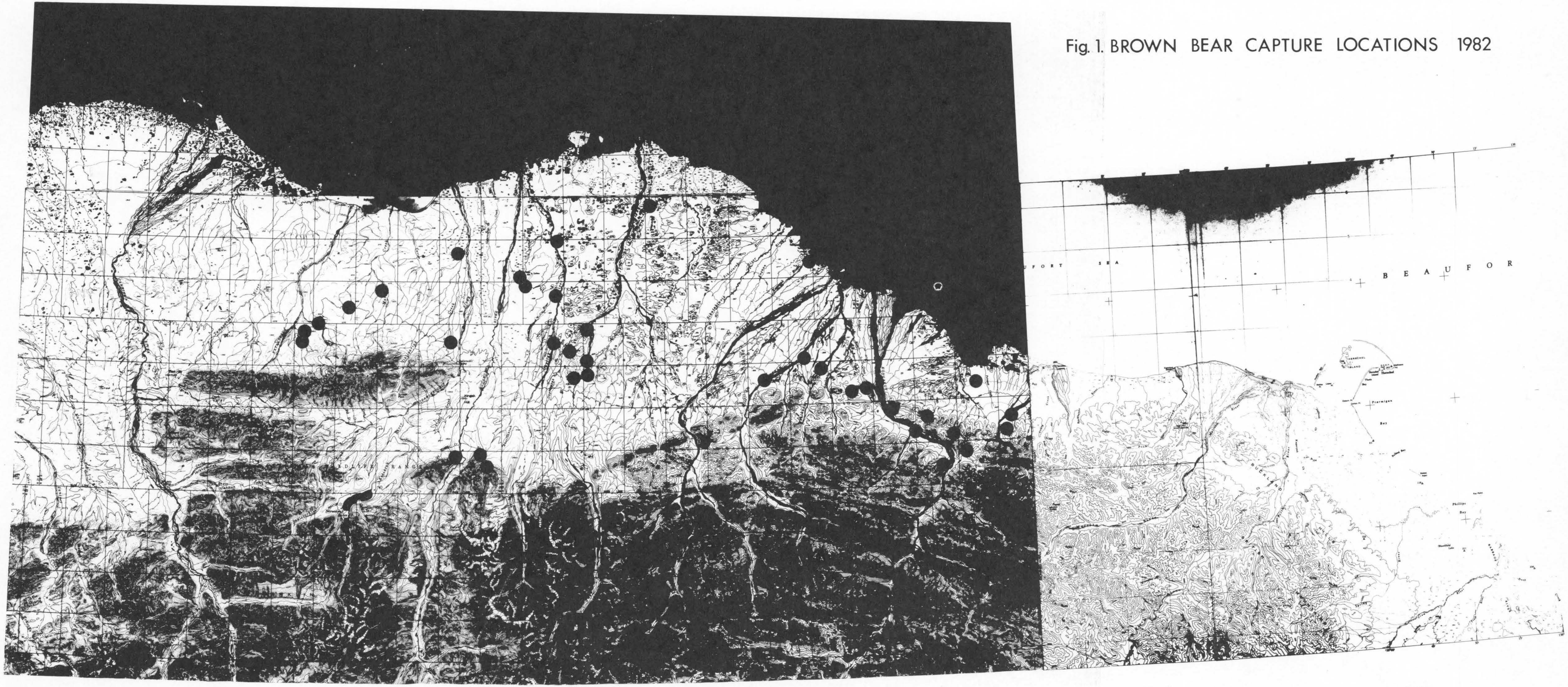


Fig. 1. BROWN BEAR CAPTURE LOCATIONS 1982

Table 2. Average weights (kg) of adult brown bears in northern Alaska and Yukon Territory.

Sex	Sample size	Average weight	Weight range	Location	Reference
Male	40	139	106-240	interior-southern Yukon Territory	Pearson 1975
Female	21	95	74-124	interior-southern Yukon Territory	Pearson 1975
Male	25	169	--	northern Yukon Territory	Pearson 1976
Female	31	111	--	northern Yukon Territory	Pearson 1976
Male	--	180	136-268	Canning R. drainage, northeast Alaska	Reynolds 1976
Female	18	109	88-141	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	10	137	93-181	north slope, ANWR	This study
Female	15	93	75-116	north slope, ANWR	This study

Productivity

Age structure of captured bears (Fig. 2) was predominated by females in age classes 6.5 years or less (22 females versus 8 males), while males predominated age classes older than 6.5 years (14 males versus 6 females). Immature bears (4.5 old or less) comprised 46.6% of captured bears, with cubs, yearlings, 2.5 year olds, 3.5 year old, and 4.5 year olds comprising 10.3%, 8.6%, 10.3%, 8.6%, and 8.6% respectively. Adults comprised 53.4% of captured bears. These data differ from data reported for bears in northeast Alaska along the Canning River (Reynolds 1976); however, the Canning River data were more complete than the current study. 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 uncertain. 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. These data appear to indicate that coastal plain and foothills habitats may be used more heavily by younger age classes and females with young than by adult bears without young.

Age structure for immature bears indicates relatively good survival of young bears through the first 4 years of life. During this study, 9 females were captured that had young (Table 3). All young survived throughout the monitoring period and all young apparently denned with the maternal female, except bear 1221 (Table 3). These data support the age structure data and

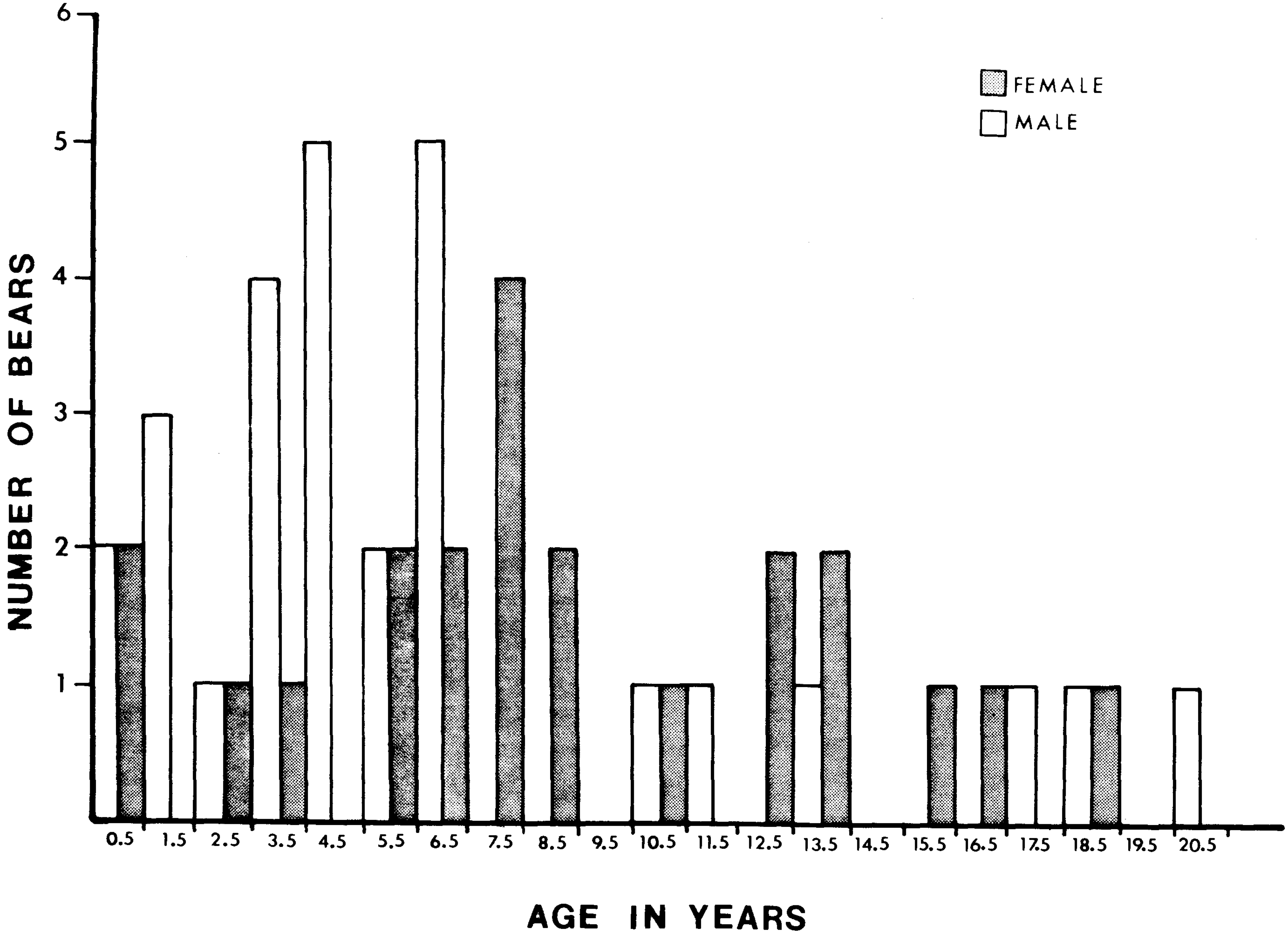


Fig. 2 Age structure of 50 brown bears captured between 23 June and 3 July 1982 in the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge.

indicate a high survival rate for young bears from one year to the next. Average litter size for captured bears with young was 1.89 which is comparable to recorded litter sizes in NPR-A (2.03, Reynolds 1980) and along the Canning River (1.8 Curatolo and Moore 1975, Reynolds 1976).

Table 3. Maternal females captured on the ANWR study area in 1982 and their associated offspring.

Bear Number	Number relocations	Offspring Numbers/age/sex	Time period with female	Offspring marked/bear no.
1182	14	2/cubs/FF	All season	Yes/1183 and 1184
1185	10	2/yearlings or 2 yr. olds	All season	No
1190	10	2/cubs/MM	All season	Yes/1191 and 1192
1197	10	2/yearlings	All season	No
1202	10	3/yearlings/MMM	All season	Yes/1203, 1204, and 1205.
1208	10	2/cubs	All season	No
1213	12	1/2.5 years/F	All season	Yes/1214
1220	9	1/3.5 years/M	Until 23 Aug.	Yes/1221
1227	9	2/2.5 years	All season	No

Breeding season normally extends from May through approximately 10 July, with peak of breeding occurring between 10 and 20 June (Reynolds pers. comm.). Observations of pairs was common during the capture period and through 11 July (Fig. 3). Pairs observed after 11 July were probably short term reassociations of siblings and/or family groups. Sexual maturity in females evidently occurs at 6 years of age. Four of the 9 females with young bred when 6.5 years old (Table 4).

Table 4. Age at breeding for 9 radio-collared female brown bears on the ANWR study area, 1982.

Bear Number	Centum age	Reproductive status	Age at breeding
1182	15.5	2 cubs	14.5
1185	18.5	2 yearlings or 2.5 year olds	15.5-16.5
1190	7.5	2 cubs	6.5
1197	8.5	2 yearlings	6.5
1202	16.5	3 yearlings	14.5
1208	7.5	2 cubs	6.5
1213	12.5	1 2.5 year old	9.5
1220	10.5	1 3.5 year old	6.5
1227	13.5	2 2.5 year olds	10.5

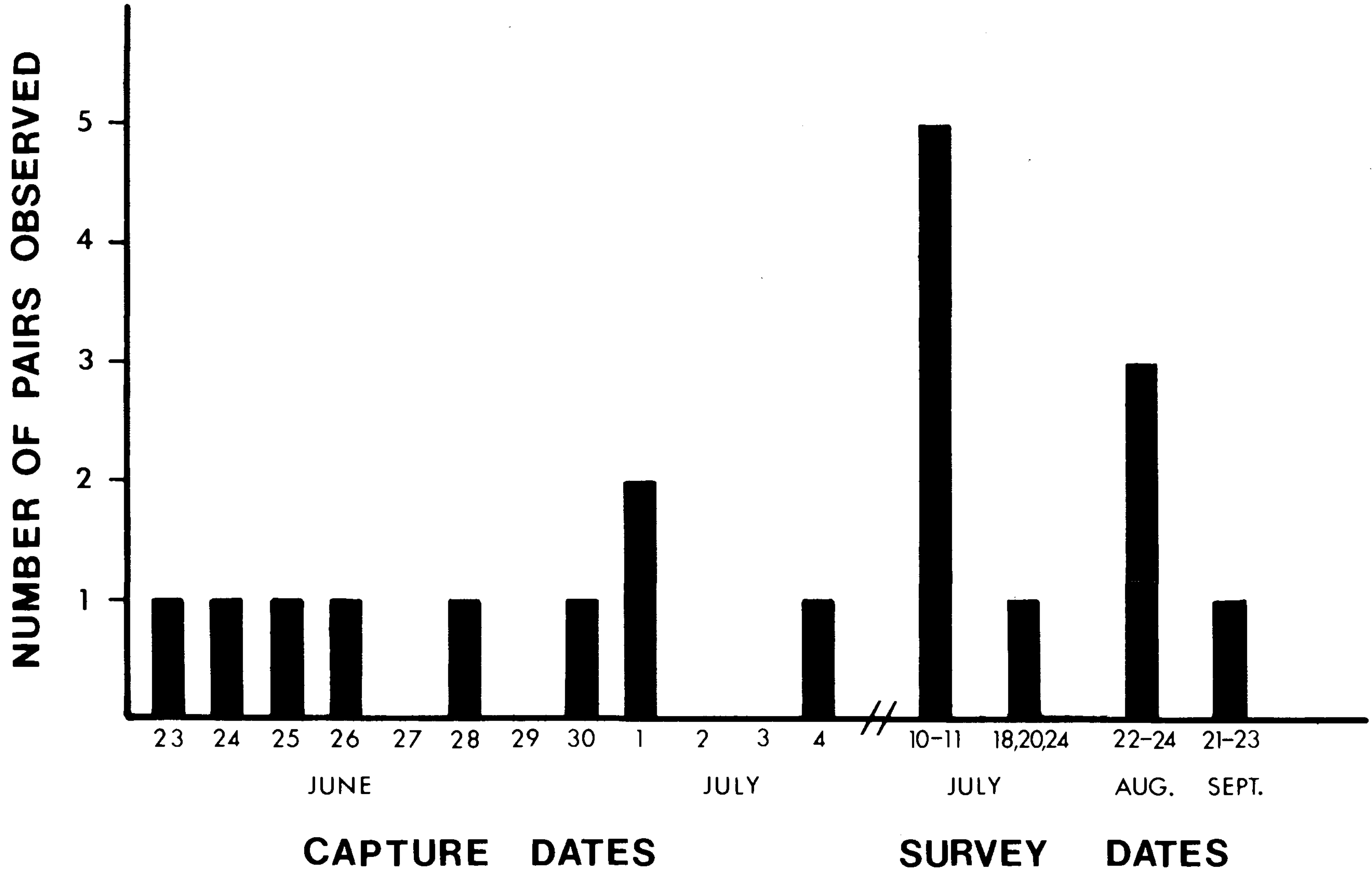


Fig. 3 Chronology of observations of brown bear pairs on the ANWR study area, 1982.

Range Size and Movements

Range size of 9 males and 17 females were approximately equal during 1982 (248 km^2 for males and 246 km^2 for females). Immature bears also had equivalent range sizes (309 km^2 for 3 males and 311 km^2 for 3 females), while 14 adult females had slightly larger range sizes than 6 adult males (232 km^2 and 217 km^2 respectively). These range sizes are smaller than reported annual range size for brown bears in northeast Alaska (702 km^2 for 5 males and 319 km^2 for 8 females, Curatolo and Moore 1975) and northwest Alaska (510 km^2 for 7 males and 269 km^2 for 16 females, Reynolds 1980). However, the limited number of relocations for each bear in the current study (range 5 to 14) probably biased these preliminary determinations. Additional data will be collected in future years to further define range size for brown bears using the ANWR study area.

Range length was variable between radio-collared bears; however, 14 males had larger average range lengths than 17 females (66 km and 38 km respectively). Immature males had range length twice as large as immature females (90 km for 6 males and 45 km for 3 females), while range lengths of adult bears were similar (49 km for 8 males and 37 km for 14 females). Maximum range length was 223 km for an immature made and 126 km for an adult female. These data indicate that immature bears were more mobile than adults and they used larger areas. Average daily movements (distance between 2 consecutive locations divided by the number of days) for 15 males was 1.27 km and 0.95 km for 17 females.

Interactions Between Brown Bears and Other Species.

Brown bears were observed in the vicinity of dall sheep (Ovis dalli) on 1 occasion, moose (Alces alces) on 4 occasions, and muskoxen (Ovibos moschatus) on 5 occasions. No interaction between bears and these species were observed. Caribou were in the vicinity of bears on 30 occasions and interactions were recorded on 7 of these observations. Caribou did not react to nearby brown bear on 23 sightings of the 2 species in close proximity. Bears were observed on 4 caribou carcasses during June and July and were seen on 2 carcasses in August and September. One observation was made of a radio-collared bear (1210, 3.5 year old female) chasing a bull caribou on 23 August. This bear chased the bull for 5 minutes, but was unsuccessful in catching the bull.

The relationship between brown bear and caribou on ANWR was not well defined. Bears were marked after caribou were present in the area, therefore, it was not possible to determine if bears shifted their ranges to include areas frequented by caribou. Bear 1188 (a 4.5 year old male) was observed feeding on 2 different caribou carcasses on 28 June and 2 July. Bear 1190 (a 7.5 year old female with cubs) moved from the Turner River to the Hulahula River during the time period caribou were abundant on the coastal plain. She was observed feeding on 2 different caribou carcasses on 18 July and 24 July. Caribou were present in small numbers in late May and early June, however, the main influx of large numbers occurred in late June and corresponded to the shift from the Turner River to the west by bear 1190. Caribou emigrated from the coastal plain in late July. Data collected in future years will provide information to clarify the relationship between seasonally abundant caribou and brown bear movements.

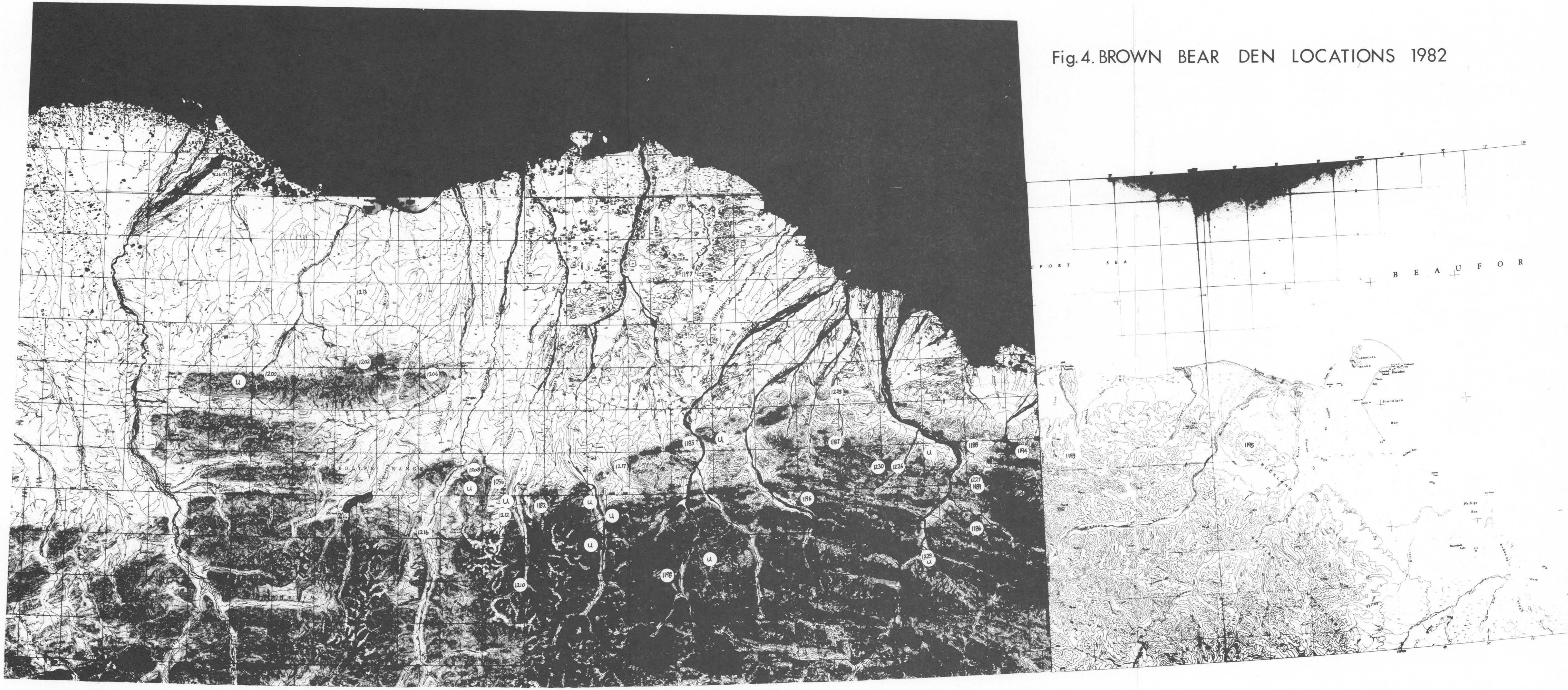
Denning

Dens were located for 28 radio-collared bears and 10 dens of unmarked bear were recorded during den surveys. Distribution of located dens was 1 on the coastal plain, 4 in foothills, and 38 in mountainous terrain (Fig. 2). In general, all radio-collared bears captured on coastal plain or foothills habitats denned south of their capture sites (Figs. 1 and 2) with 2 exceptions. Bear 1197 denned in coastal plain habitat near her capture site and bear 1213 denned in foothills habitat near her capture site. Twenty-five bears were captured in coastal plain habitats, but only 1 bear denned in this habitat type. Only 4 bears denned in foothills habitat, whereas 13 bears were captured in this habitat type. Chronology of denning indicated that 11 bears denned during the first half of October, while 16 bears denned during the last half of October (Table 5). One bear denned in early November. Den sites will be characterized after bear emerge from the dens in the spring of 1983.

Table 5. Denning characteristics of 28 brown bears in the northeastern portion of the Arctic National Wildlife Refuge, 1982.

Bear number	Reproductive status	Terrain	Date of denning
1056	Male	Mountains	16-25 October
1182	Female with 2 cubs	Mountains	13-24 October
1185	Female with 2 yearlings/ 2-2 years olds	Mountains	13-24 October
1186	Male	Mountains	13-24 October
1187	Breeding female	Mountains	5-14 October
1188	Male	Mountains	24-31 October
1189	Non-breeding female	Mountains	14-24 October
1193	Breeding female	Mountains	21 Sept- 14 Oct.
1194	Male	Mountains	14-24 October
1195	Male	Foothills	22 Sept.-14 Oct.
1196	Male	Mountains	14-24 October
1197	Female with 2 yearlings	Coastal plain	21 Sept.-8 Oct.
1198	Male	Mountains	22 Sept.-16 Oct.
1200	Male	Foothills	13-25 October
1202	Female with 3 yearlings	Mountains	23 Sept.-13 Oct.
1206	Breeding female	Mountains	23 Sept.-13 Oct.
1208	Female with 2 cubs	Mountains	15-25 October
1210	Non-breeding female	Mountains	15-25 October
1211	Male	Mountains	8 October
1212	Breeding female	Mountains	5-13 October
1213	Female with 1 2 yr. old	Foothills	13 Oct.-5 Nov.
1216	Breeding female	Mountains	15-25 October
1217	Breeding female	Mountains	13 October
1225	Male	Foothills	31 Oct.-5 Nov.
1226	Male	Mountains	14-24 October
1227	Female with 2 2 yr. olds	Mountains	14-24 October
1229	Male	Mountains	14-24 October
1230	Breeding female	Mountains	5-14 October

Fig. 4. BROWN BEAR DEN LOCATIONS 1982



While conducting aerial surveys to locate dens, the survey crew sighted bears at open den sites on 14 occasions. In 8 of these instances, bears at the densite subsequently moved and established a new den site. It is believed that disturbance by the survey aircraft resulted in this movement. This movement emphasizes the sensitive nature of bears at time of denning.

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AQUATIC STUDIES ON THE NORTH SLOPE OF THE ARCTIC NATIONAL WILDLIFE REFUGE 1981 AND 1982

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ABSTRACT

During 1981 and 1982, the Fairbanks Fishery Resource Station conducted aquatic studies on the coastal plain of the Arctic National Wildlife Refuge. The major emphasis in 1981 was fall and winter movement and overwintering of arctic char and on general species distribution and life history in the Canning River. Char movement and overwintering was again studied on the Canning River in 1982. Fish distribution and life history in several other drainages including the Tamayariak, Katakturuk, Sadlerochit and Aichilik Rivers were also studied in 1982. Physical characteristics of these drainages were examined and related to potential overwintering habitat. The potential for suitable overwintering habitat was thought to be greatest in fourth and fifth order streams where gradient is less than 4% and there is an unbraided channel pattern. During the study period, char movement into the Canning River ranged from mid July through August. The peak movement in numbers of fish appeared to occur around the third week of August. Overwintering pools appear to be limited on the Canning River. Only 13 pools deep enough to provide suitable overwintering habitat were located in a 75 km reach of the mid and lower river. Radio tagged char and fall concentrations of char were also located near these same pools. Radio tagged fish showed considerable movement throughout the winter. One fish moved 17 km downstream during the period October 1, 1981 to January 28, 1982. Another fish moved upstream 6.4 km during March and April, 1982. Fall concentrations of char were observed in late September 1982 through the mid and upper reaches of the Canning drainage. Major spawning areas were located in the Marsh Fork and main river above the Marsh Fork confluence. Char concentrations were also located in the Aichilik River.

Fairbanks Fishery Resources Progress Report No. FY83-1
AQUATIC STUDIES ON THE NORTH SLOPE OF THE ARCTIC NATIONAL WILDLIFE REFUGE, 1981 and 1982

INTRODUCTION

Section 1002c of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980 included provisions for a 5 year assessment of the fish and wildlife resources of the coastal plain of the Arctic National Wildlife Refuge (ANWR). This assessment was to include the following: an assessment of the size range, and distribution of fish and wildlife populations; a determination of the extent, location and carrying capacity of fish and wildlife habitat; an assessment of the impacts of human activities and natural processes on fish and wildlife and their habitat; and an analysis of potential impacts from oil and gas exploration, development, and production. During 1981 and 1982 the Fairbanks Fishery Resource Station conducted aquatic studies in accordance with the fishery portion of this mandate.

The study area established by ANILCA includes most of the coastal plain of the ANWR from the Aichilik River on the east to the Canning River on the west. It covers an area of approximately 630,000 hectares (2520 sq. miles) and includes 135 km of coastline, barrier islands and lagoons along the Beaufort Sea. Eight major drainages and several smaller coastal streams either traverse or are contained within the study area. Relatively few lakes, compared to the western Alaska coastal plain are found in the study area and the majority of these are shallow thaw lakes supporting only a seasonal summer fishery at best.

Very little is known about fish populations and their habitats on the coastal plain of the ANWR. Craig (1977a; 1977b) conducted studies on arctic char life history on the Canning River and Sadlerochit Springs during 1972 and 1973. Previous fish distribution studies have reported only two species, grayling and char, in fresh water on the coastal plain east of the Canning River (Ward and Craig 1974).

This study reports the results of aquatic surveys on the coastal plain during 1981 and 1982. Specific objectives were to: 1) Assess general distribution and life histories of major fish species on those coastal drainages located between the Canning River and Sadlerochit Rivers; 2) Identify and describe char overwintering movements and habitat requirements on the Canning River; 3) Monitor anadromous arctic char migration patterns on the Canning River; 4) Obtain reconnaissance level information on species distribution and habitat condition on the Sadlerochit and Aichilik Rivers.

METHODS

Access into the survey areas consisted of a variety of fixed wing and rotor wing aircraft including: Cessna 185, Super Cub, Helio-courier, and Bell 206 and 205 helicopters. Aircraft type depended on availability and site accessability. Surveys at the sites were conducted on foot or by inflatable Avon and Zodiac rafts.

Fish capture techniques depended on the location and included the following: 125 X 6 ft. monofilament experimental gill nets with five 25 ft panels of 1/2 in. to 2 1/2 in. bar mesh; baited minnow traps; Type X1 Smith-Root backpack electrofisher; beach seines from 30 X 4 ft. to 100 X 8 ft; fyke nets; and hook and line.

Fork length of fish was measured to the nearest millimeter. Weights of fish were determined using Pesola spring scales with ranges of 0 to 250 g, 0 to 500 g and 0 to 2500 g. Coefficient of condition (K) was determined for char, round whitefish and grayling according to the following equation:

$$K = \frac{\text{Weight X } 10^5}{\text{Length}^3}$$

Ages were determined from scale samples taken from grayling and round whitefish during the 1981 study and were read on a Bell and Howell microfiche reader after impressing on acetate slides. Due to difficulty in reading older aged fish, otoliths were used exclusively to age all fish samples during the 1982 study. Otoliths were cleaned, ground on 400 grit wet sanding paper and read under a Bausch and Lomb binocular microscope at 30-40 X magnification.

Numbered Floy FD-67 anchor tags were implanted in fish in the Canning, Tamayariak, Sadlerochit and Aichilik Rivers to gain information on movement patterns. Water chemistry measurements for dissolved oxygen, total alkalinity, total hardness, and pH were made with Hach AL-36B kits. Conductivity was determined with Hach Mini Conductivity Meters.

Depths of pools on the Canning River were measured and recorded by use of a Lowrance LRG 1510-B fathometer mounted on an Avon Redshank rubber raft. Locations of pools were recorded on USGS 1:63,350 scale maps and on U-2 aerial photographs.

USGS, 1:63,350 scale maps were used to determine stream order, total stream network distances, extent of channel braiding and gradient characteristics of the Aichilik, Katakturuk, Sadlerochit, and Tamayariak Rivers. Strahler's (1957) method was used to determine stream order. Stream orders ranged from 1 to 5 with 1st order streams in the headwater reaches. A higher stream order change was affected only when two streams of equal order converge. Terminal streams that were less than 1.0 kilometer did not affect a change from first to second order. After all streams were ordered they were broken down into reaches. An individual reach maintained continuity in gradient and stream order. Gradients were determined using 50 and 100 foot contours. The total drop in feet of the reach was divided by the total reach distance and then converted to percent gradient. Total distance of braided channel for each stream order was determined and later converted into percent.

Four arctic char in the lower Canning River were implanted with radio tags during August 1981. Five additional tags were implanted on October 1, 1981 in char below Shublik Springs. Aerial relocation was attempted on a monthly basis throughout the winter and early spring. Fifteen tags were implanted in char below Shublik Springs during September 1982 and attempts will be made to relocate these fish twice monthly during the winter.

Telonics equipment was utilized for the telemetry study and included: 1) RB-5 transmitters, weight 27g, diameter 1.7 cm, length 5.6 cm; 2) TR-2 Receiver with the TS-1 Scanner/Programmer; and 3) RA-2AK Antennaes. The frequency range selected for the above equipment was 150.000 MHz to 151.999 MHz. Antennaes were mounted during aerial tracking on the wing struts of a Cessna

185 or on specially modified antennae mounts on a Helio-courier. Pulse rate for the transmitters was selected at 55 per minute to extend the operational life of the lithium batteries to 8 months.

Most fish, collected for tagging, were captured by use of a 100 X 8 ft. beach seine in an attempt to reduce stress to the fish. Nine fish out of the total 24 tagged during both years were captured by angling. Fish were anesthetized in MS-222, weighed and measured, tagged and returned to a holding pen for 1 to 4 hours for observation. Tagging was accomplished by sliding the tag through the mouth into the stomach cavity. The 18 in. external antennae on the radio tag was left trailing out of the mouth along the fishes body.

The minimum size of fish in which tags were implanted was determined from autopsy analysis on 5 fish implanted with tags and held for two days in a holding pen. Stomachs were ruptured on two fish, 396 mm and 525 g and 438 mm and 850 g. Fish over 500 mm and 1400 g appeared healthy with no apparent damage to the stomach cavity. Attempts were made to limit the minimum size to 500 mm and 1400 g. During the 1981 project, the minimum size fish tagged was 470 mm and 1300 g due to unavailability of larger fish. In 1982, the size range was 515 mm and 1375 g to 667 mm and 2800 g.

Aerial tracking was accomplished by parallel flights along the river at altitudes of 500-1000 feet above ground level. Specific locations were determined by monitoring pulse volume. Ground checking of one tagged fish near Shublik Springs in April 1982 revealed accuracy to within 50 meters.

RESULTS

CANNING RIVER

Study Area

The Canning River is the western boundary of the 1002c study area and the Arctic National Wildlife Refuge. It drains an area of approximately 5,843km^2 (2340 sq. miles) and has an average annual flow of 33.75 m^3/s. The Canning River originates in the Brooks Range and the main channel extends over 200 km to the Beaufort Sea. The lower 60 km of river are contained within the study area.

Extensive braiding occurs throughout the drainage but is especially common in the middle and lower reaches. The fan-shaped Canning Delta encompasses an area approximately 40 km long and 25 km wide where it enters the Beaufort Sea. Numerous shallow, coastal thaw lakes are found in the delta area, however most lack connections to delta channels (Craig 1977a).

The Canning drainage differs to some degree from other rivers in the study area by the number and magnitude of perennial ground water sources flowing into the river. The cumulative discharge of springs on the Canning River drainage is one of the largest on the North Slope (Childers et. al. 1977). The largest of these is Shublik Springs located on the southwest end of Mount Coplestone in the Shublik Mountains. The discharge from this spring remains fairly constant throughout the year at about 0.72 m^3/s and 5.5° C. Large sheets of ice called aufeis, that form below springs during winter, are extensive on the Canning River. By late winter aufeis fields are almost continuous from the upper Marsh Fork throughout the entire length of the main channel. One of the largest icings in the study area occurs in the Canning River delta.

Water Chemistry

Water chemistry measurements were taken weekly on the lower Canning River during July 18 to August 21, 1981 (Table 1). Dissolved oxygen remained fairly constant near saturation levels during this period. Conductivity ranged from a low of 150 umhos/cm on August 17 to a high of 230 umhos/cm on August 21.

Table 1. Chemical characteristics of the lower Canning River, July-August 1981.

Date	Dissolved Oxygen (mg/l)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Conductivity umhos/cm	pH	Water Temp. (°C)	Air Temp. (°C)
7/18/81	11	102	154	175	8.5	13	20
7/21/81	11	85	136	180	8.5	11	10
7/25/81	10	102	154	200	8.5	14	14
7/30/81	11	136	154	173	8.5	10	16
8/06/81	10	120	171	190	8.5	13	14
8/10/81	12	102	154	185	8.5	8	12
8/17/81	10	120	171	150	8.5	14	3
8/21/81	10	102	188	230	8.5	-	-

Five grayling were collected on August 29, 1981 for heavy metals analysis. Values found in these fish (Table 2) are comparable to metal concentrations found in grayling in other undisturbed Alaska streams and lakes (West, 1982) and show no current natural bioaccumulative problems for the metals analyzed.

Table 2. Heavy metal concentration in arctic grayling in the lower Canning River collected on August 29, 1981.

Fork Length (mm)	Weight (g)	Cadmium (mg/g)	Copper (mg/g)	Zinc (mg/g)	Barium (mg/g)	Chromium (mg/g)	Mercury (mg/g)
305	329	0.04	1.2	25.3	1.1	0.14	0.02
333	385	0.02	1.0	19.5	0.67	0.02	0.02
326	355	0.03	1.2	24.9	1.1	0.03	0.02
309	-	0.03	1.2	24.2	1.3	0.13	0.04
388	650	0.03	0.91	20.6	0.69	0.06	0.02

Fish Distribution and Abundance

The Canning River has the most diverse fish species composition reported from any other drainage in the 1002c study area. Ten species have been reported from the Canning Drainage (Craig 1977a; USFWS 1982). These include arctic char, Savelinus alpinus; grayling, Thymallus arcticus; round whitefish, Prosopium cylindraceum; burbot, Lota lota; lake trout, Savelinus namaycush; ninespine stickleback, Pungitius pungitius; arctic cisco, Coregonus autumnalis; chum salmon, Oncorhynchus keta; pink salmon, O. gorbuscha; and red salmon, O. nerka. Of these only grayling, round whitefish, and char are very abundant. Known distributuion of fish in the Canning River through 1981 was provided in the "Initial Report Baseline Study of the Fish, Wildlife and Their Habitats" (USFWS, 1982). The only additional species to be added to this list was one pink salmon caught in the lower Canning River on August 7, 1982.

Arctic char on the north slope occupy a variety of life history forms and habitat types. All four life history patterns reported by Craig (1977a) are found in the Canning drainage. Adult anadromous char are found all through the system during their annual migration into fresh water and then become concentrated at specific sites for spawning and for overwintering. The distribution of juvenile char between the time of emergence and smolting is not well known. Craig (1977a) reported that fry remained in one spring in the Marsh Fork their first summer and winter. Many age 1 fish left this spring during June and July but returned in September to overwinter. The majority of age 2 and older juveniles leave the spring and disperse through the drainage. In nearby drainages presmolts have been found in small tributaries of the Sagavanirktok River (Yoshihara, 1973) and in a tundra stream in the Shaviovik River (Craig and Poulin, 1975). In the Canning, age 0 through 4 fish were caught in the main channel of the lower river and in coastal tributaries. Distribution of juvenile char appears to be widespread in the Canning drainage.

Arctic grayling are widely distributed in the drainage. They have been reported in the upper Marsh Fork area all through the system to the delta. They occur in a wide variety of habitat types including lakes, springs, coastal tributaries, main channel and the delta area.

Round whitefish are also found throughout the system from the Upper Marsh Fork to the delta. They were found in this study in the main channel near Shublik Springs and in the lower river upstream from the delta. No round whitefish were found in coastal tributaries.

Burbot were caught in the main channel upstream from the delta area. They have also been reported from a lake in the foothills area (Craig 1977a). Ninespine stickleback have been reported from several coastal plain lakes in the drainage (Wilson et. al., 1977). One was caught from the main channel of the Canning River during 1981 and one from a coastal tributary in 1982. One arctic cisco was reported by Craig (1977a) in the delta region. It is unlikely that the Canning River supports any arctic cisco other than for summer feeding in the lower delta. Three salmon species were caught during August sampling upstream from the delta area in 1981 and 1982. In 1981 two chum and one red salmon were caught and in 1982 one chum and one pink salmon were caught. All salmon were in spawning condition. While all three species are relatively rare in Beaufort Sea drainages, red salmon have been reported only once previously, one fish from Simpson Lagoon in 1979 (Craig and Hadorson, 1980).

Relative abundance and mean length of fish collected by gillnet and baited minnow trap in 1981 and 1982 from the main channel above the delta area is shown in Table 3. Char were the most abundant species during the 1982 sampling period with a catch rate of 1.50 fish per hour with 125 foot experimental gill net and .35 fish per hour with baited minnow trap. The sampling period was during the upstream migration of anadromous char to spawning and overwintering areas.

Table 3. Mean length and catch per hour for fish collected in the lower Canning River.

Gear Type	Species	Number of Fish	Total Effort (hrs)	Mean Fork Length(mm)	Length Range(mm)	Catch per Hour
			August 1-15, 1982			
Gill Net*	Arctic Char	250	166.5	449.5	141-628	1.50
	Grayling	77	166.5	315.0	119-414	0.46
	Round Whitefish	42	166.5	366.1	140-462	0.25
	Pink Salmon	1	166.5	472	-	0.006
	Chum Salmon	1	166.7	673	-	0.006
Baited Minnow Trap	Arctic Char	48	136.8	123.8	65-169	0.35
	Burbot	1	136.8	99.0	-	0.007
			July 16-August 26, 1981			
Gill Net*	Arctic Char	474	1530	383.1	125.665	0.31
	Grayling	368	1530	311.2	112-475	0.24
	Round Whitefish	73	1530	310.6	147-459	.05

*Gill nets utilized were 125 foot experimental with 25 ft. panels, mesh size 1/2 in., 1 in., 1 1/2 in., 2 in., 2 1/2 in.

More extensive sampling from July 16 through August 25, 1981 yielded a much lower catch per unit effort. Average catch per hour for the entire period was 0.31. The highest daily catch rate by gill net during this period was on August 19 at 1.6 fish per hour. The lowest during this period was on July 24 when .01 fish per hour were caught. The lower catch rate for char is probably a result of sample site selection and the longer duration of sampling which included the early part of the run.

Two small coastal tributaries to the lower Canning River were sampled in August 1982. Locations of these streams and sample sites are depicted on Figure 1. Discharge ranged from 0.03 m^3/s in tributary 1 to 0.21 m^3/s at site B on tributary 2. Adult grayling, juvenile char and ninespine stickleback were collected at sample site A on tributary 1. Grayling and juvenile char were collected at site B on tributary 1. Grayling fry were observed at both sites and were particularly abundant at site B.

A population estimate and confidence limits (P = 0.05), using the Leslie method (Ricker, 1975), was determined for tributary 2. A 108 meter stretch of

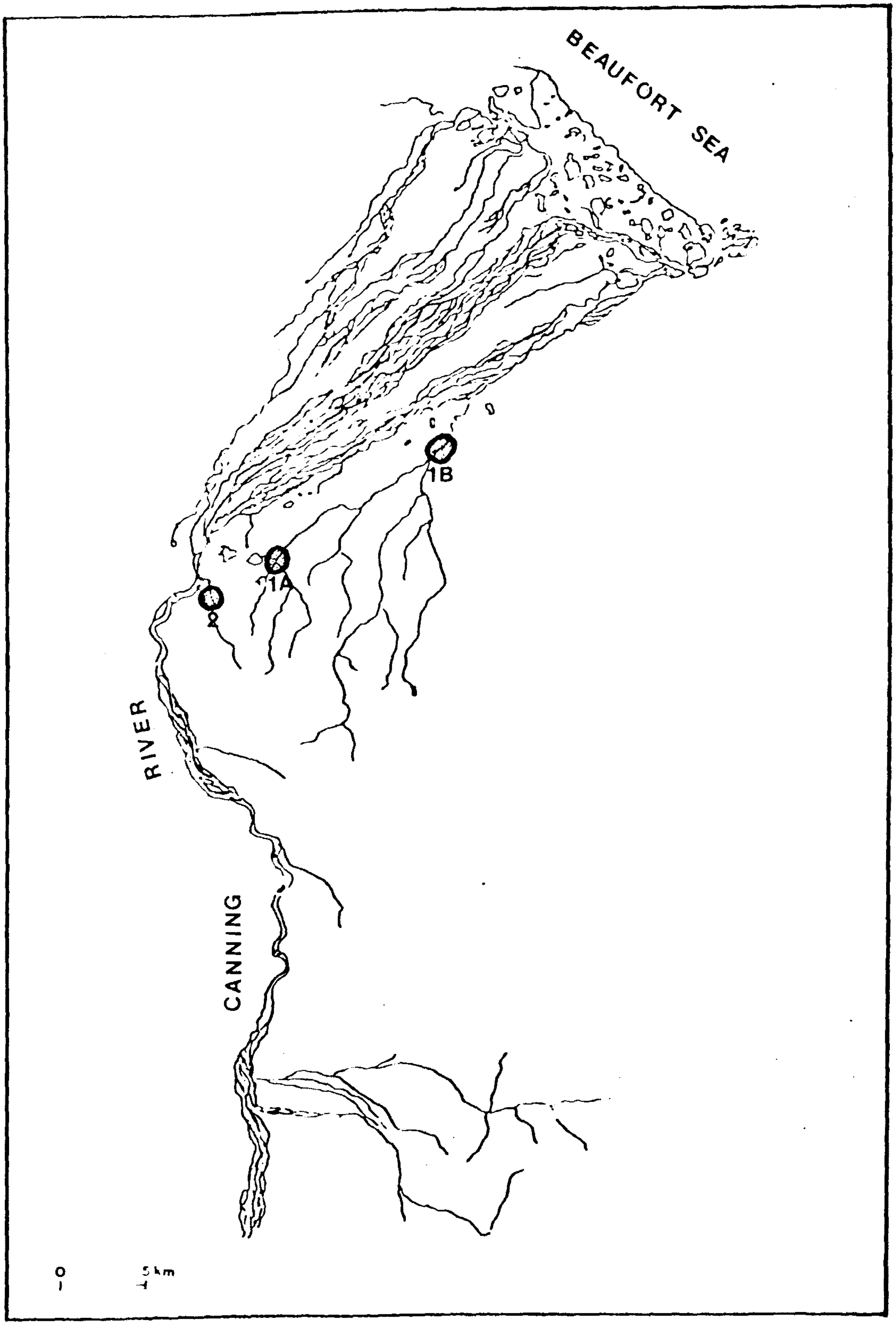

Figure 1. Coastal tributary sampling sites, August 1982.

the stream (average width = 1 meter) was blocked and electrofished for three successive trials. A total of 15 juvenile char, ranging in fork length from 80 to 146 mm, were collected. The extrapolated population estimate was 1420 fish/hectare with a lower confidence limit of 1200 fish/hectare and an upper limit of 1960 fish/hectare. The average weight of char collected was 16.2 grams. The biomass standing crop estimate was 23.0 kg/hectare (confidence limits, P = 0.05, 19.4 to 31.8 kg/h). Ages of fish collected in the two tributaries sampled ranged from 0 to 4 years old.

In the 1982 sample, grayling catch rate was 0.46 fish per hour and round whitefish catch rate was 0.25 fish per hour, compared to 0.24 and 0.05 respectively in the larger 1981 sample.

Length Frequency

Length frequency histograms for arctic char from the 1981 and 1982 sampling periods on the lower Canning are found in Figures 2 and 3. During 1981, 40.7% of the 633 char measured were in the 360 to 459 mm length group. Char collected in 1982 were larger, with most fish occuring in the 420 to 499 mm length range. The 1982 data is similar to Craig's (1977a) study which showed 420 to 519 mm as the predominant length range. A possible explanation for the large number of smaller fish in the 1981 data is the timing and duration of sampling. Sampling in 1981 occurred from July 16 through August 26. Large numbers of smaller immature fish were included in this longer sampling period that may have been missed in the other studies.

Grayling length frequency histograms (Figure 4 and 5) indicate the largest number of fish in the 340-379 mm range. Over 40% of all grayling measured during the 1981 study were in this length group.

The length frequency histogram for round whitefish is in Figure 6. The 380-419 mm length group included 31.6% of all round whitefish caught.

Age and Growth

Age and growth information for grayling and round whitefish from the lower Canning is shown in Table 4. Grayling growth was slow, typical of arctic lotic systems. Average growth was slightly higher in Canning River fish than those collected from the Sadlerochit River. Canning fish averaged 243 mm at age 4 and 359 mm at age 8 while those from the Sadlerochit averaged 234 mm and 312 mm for the same age group. Age groups 0 through 11 were represented in the Canning sample. Age classification for the Canning sample may be inaccurate in older fish due to the use of scales as an ageing technique. Slow growth in older fish makes distinguishing of annuli difficult. Otoliths were used to age all other grayling samples.

Round whitefish age groups 1 through 11 were represented in the total sample of 86 fish from the lower Canning in 1981. Average fork length for age 4 and 8 was 288 mm and 398 mm respectively.

Char were aged from two sampling locations in 1982. Fish taken near Shublik Springs were mostly 5 and 6 year old fish while the predominant age groups in the lower river were 7 and 8. The area below Shublik Springs is used primarily for overwintering by sea run immatures and non-spawners which would account for the lower average age. This data is depicted in Table 5.

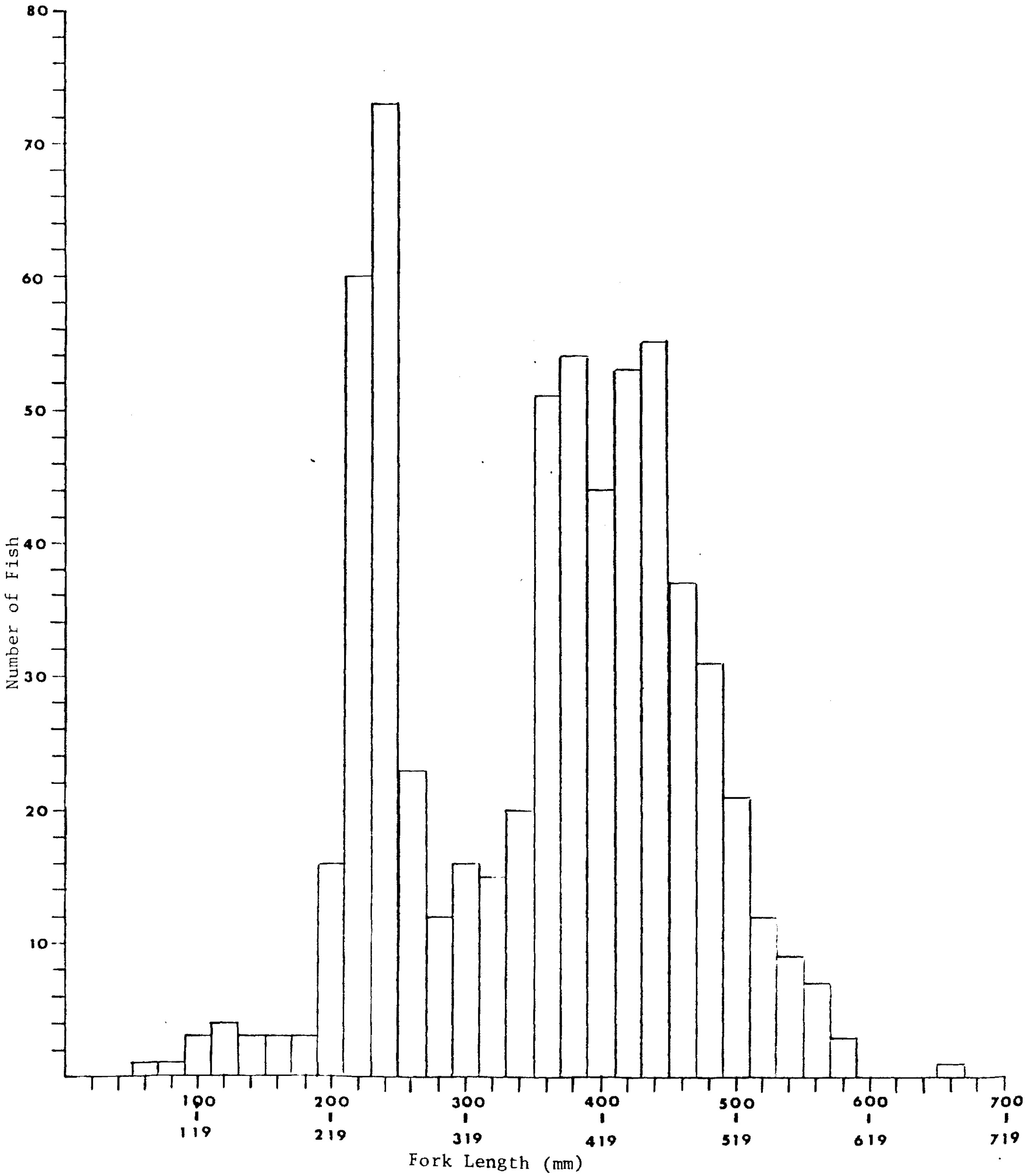

Figure 2. Length frequency of arctic char collected by experimental gill net, fyke net, seine, and angling on the lower Canning River, July 16-August 26, 1981.

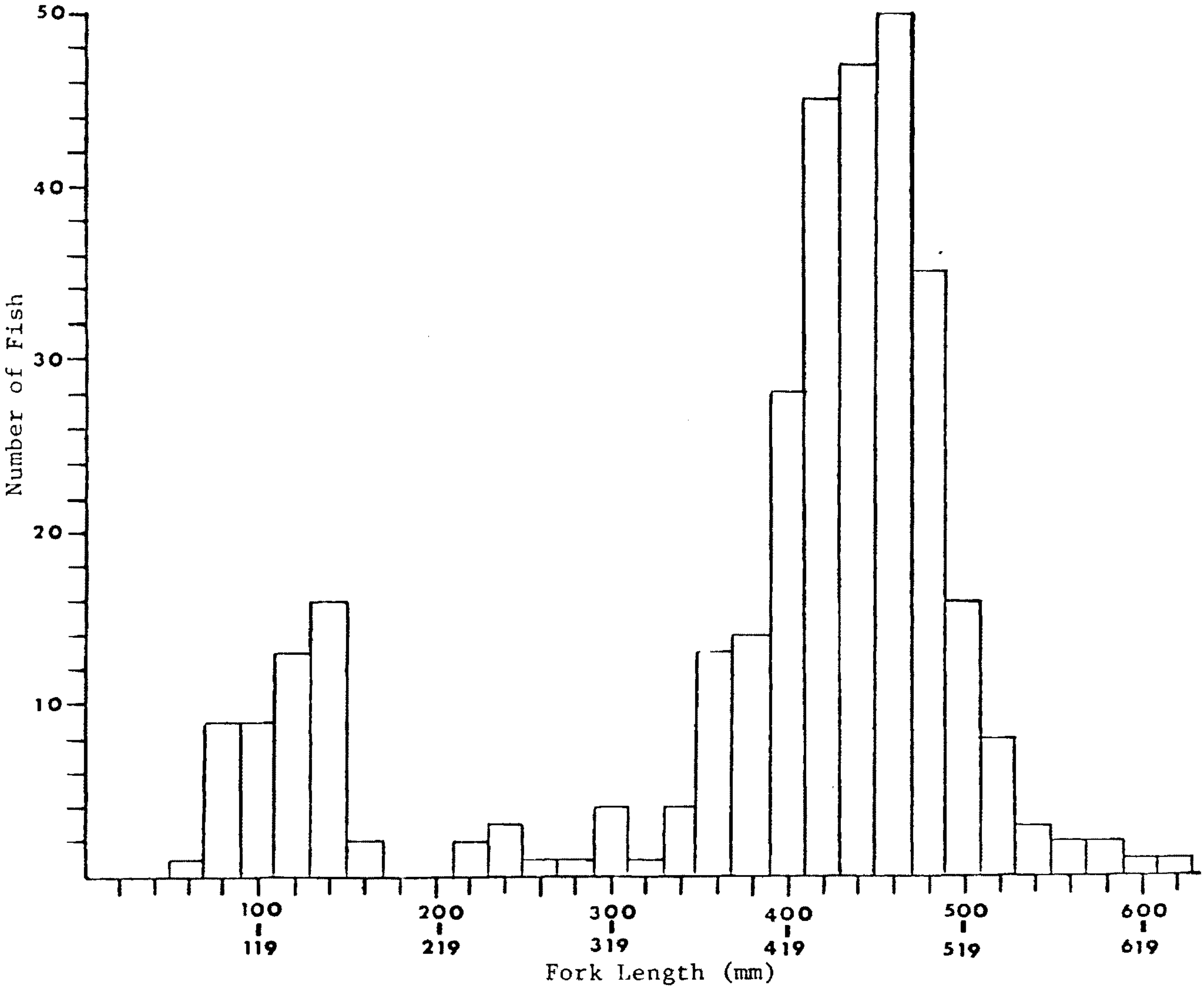

Figure 3. Length frequency of arctic char collected by experimental gill net, angling and baited minnow trap on the lower Canning River, August 1-16, 1982.

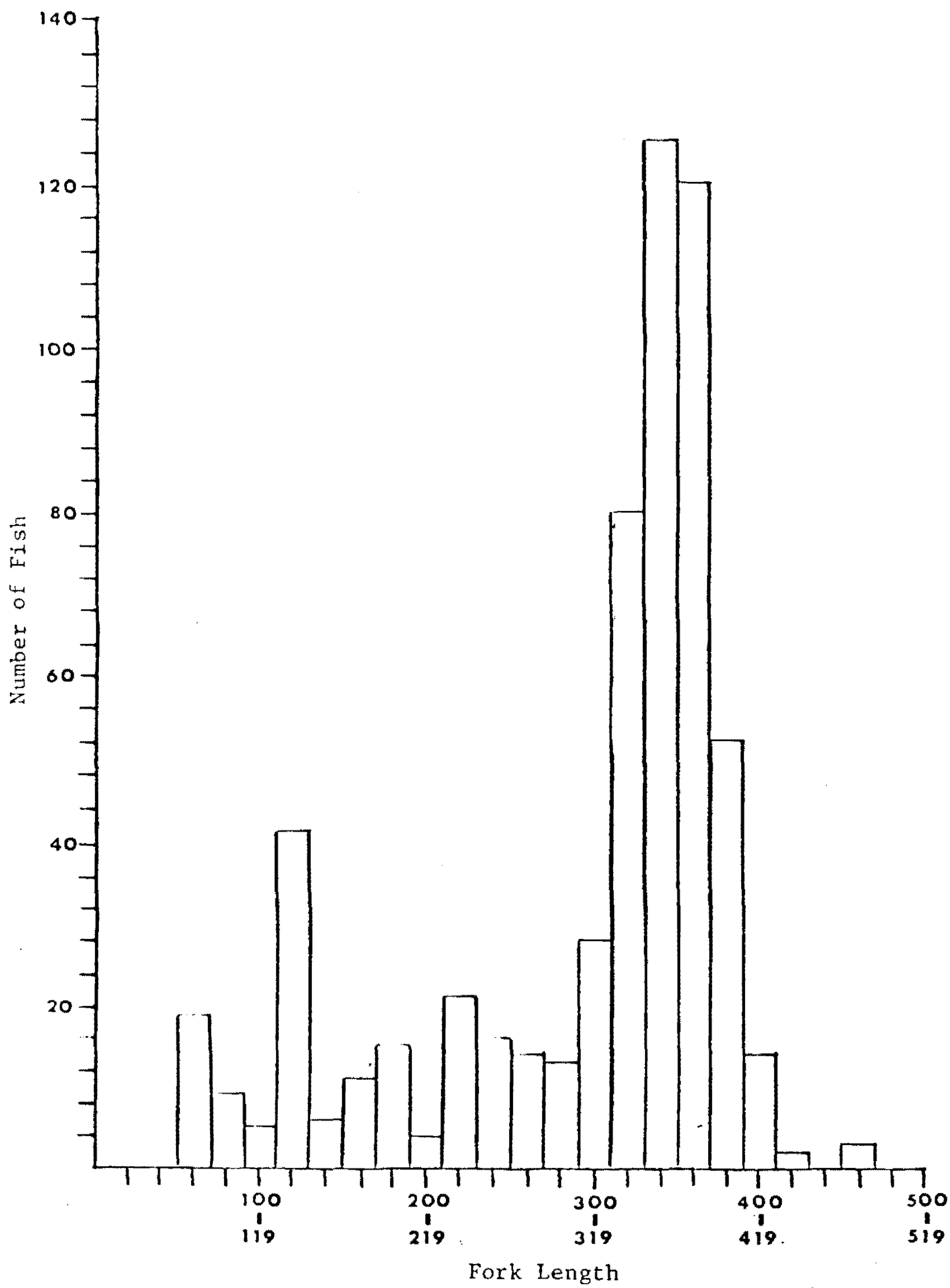

Figure 4. Length frequency of grayling collected by experimental gill net, fyke net, seine and angling on the lower Canning River, July 16-August 26, 1981.

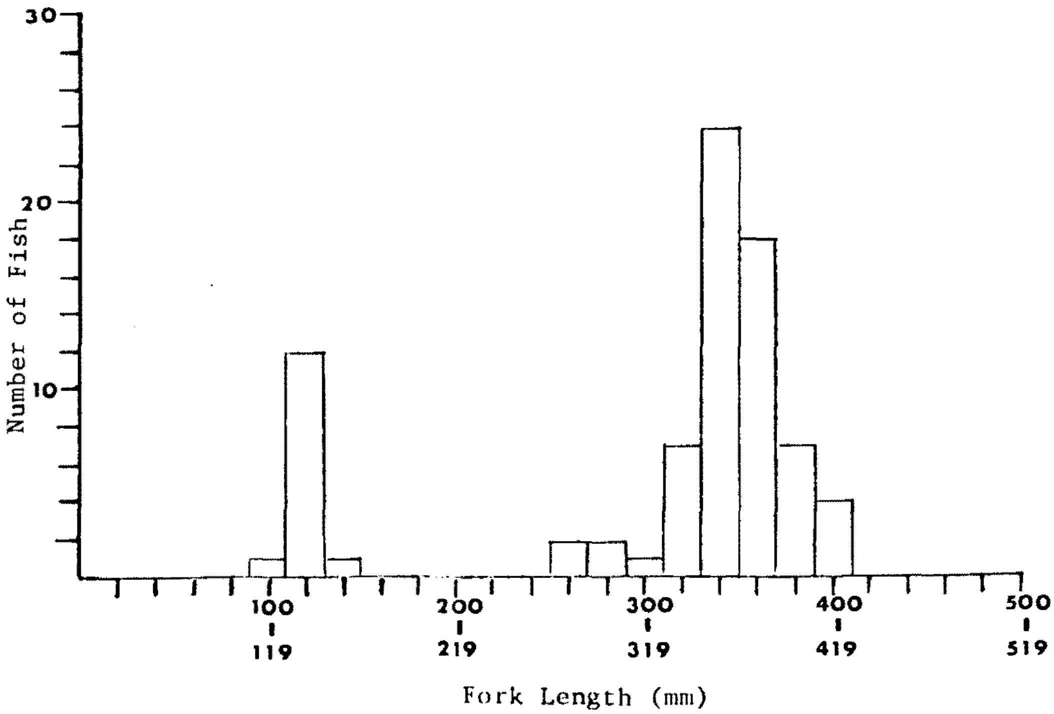

Figure 5. Length frequency of grayling collected by experimental gill net and angling on the lower Canning River, August 1-16, 1982.

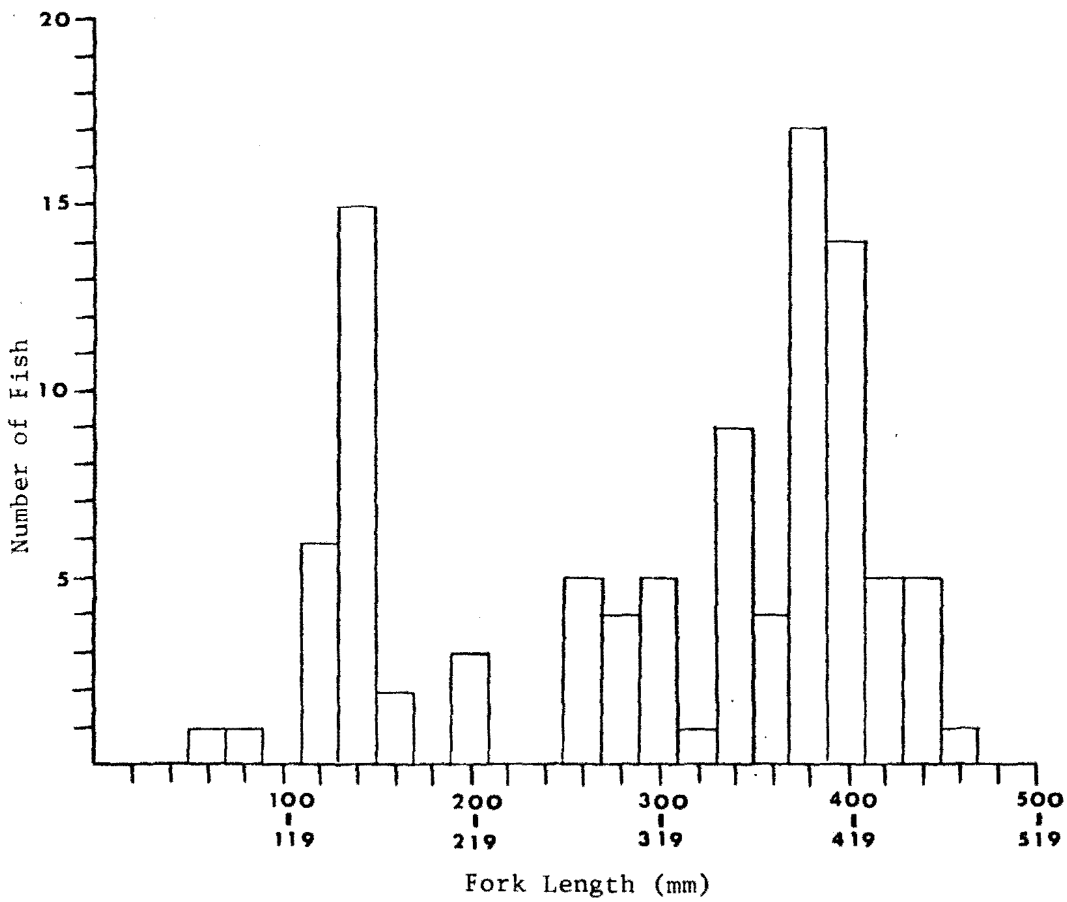

Figure 6. Length frequency of round whitefish collected by experimental gill net and seine on the lower Canning River, July 16- August 26, 1981.

Table 4. Age specific length of grayling and round whitefish from the lower Canning River, July 16-August 26, 1981 (ages determined from scales).

Age	Number	Mean Fork Length	Standard Deviation	Length Range	Percent Composition
		Round Whitefish			
1	2	175.0	39.6	147-203	2.3
2	21	148.3	17.7	127-215	24.4
3	2	242.0	42.2	212-272	2.3
4	4	287.5	19.9	268-315	4.7
5	10	303.0	26.5	268-354	11.6
6	5	357.2	10.4	349-373	5.8
7	14	377.1	23.0	340-422	16.3
8	14	398.0	14.3	384-439	16.3
9	6	414.7	43.5	342-470	6.9
10	4	430.3	17.4	411-449	4.7
11	4	439.0	20.5	414-459	4.7
		Grayling			
0	19	76.0	8.4	63-89	3.9
1	15	102.1	33.4	65-184	3.1
2	54	141.1	23.9	112-195	11.1
3	29	202.5	30.5	135-257	6.0
4	19	243.4	17.7	210-274	3.9
5	31	301.8	36.8	234-365	6.4
6	74	338.3	29.3	243-415	15.3
7	110	356.2	21.0	293-403	22.7
8	101	359.0	20.9	310-412	20.8
9	29	377.3	24.6	337-438	6.0
10	3	359.7	20.8	336-375	.6
11	1	475	-	475	.2

Weight and Condition

The following length-weight relationships were calculated for grayling, round whitefish and char from the lower Canning River collected during July 16 to August 26, 1981.

Grayling (N = 45, r = 0.99, range = 118 to 407 mm):
$\text{Log}_{10}\ W(g) = 3.04\ \text{Log}_{10}\ L(mm) - 5.12$

Round Whitefish (N = 45, r = 0.99, range = 127 to 470 mm):
$\text{Log}_{10}\ W(g) = 2.99\ \text{Log}_{10}\ L(mm) - 5.03$

Anadromous Arctic Char (N = 50, r = 0.99, range = 226 to 590 mm):
$\text{Log}_{10}\ W(g) = 3.03\ \text{Log}_{10}\ L(mm) - 5.07$

Table 5. Age specific length (otolith) of char from the Canning River, 1982.

Age	Number	Mean Fork Length(mm)	Standard Deviation	Length Range(mm)	Percent Composition
		Lower River - August 3-12			
5	5	352	36.3	310-393	13.9
6	4	397	15.6	379-417	11.1
7	13	446	19.4	412-476	36.1
8	7	466	26.0	442-513	19.4
9	3	463	20.8	440-480	8.3
10	2	537	43.8	506-568	5.6
11	-				
12	1	532	-	-	2.8
13					
14					
15	1	583	-	-	2.8
		Main Channel near Shublik Springs - September 20-25			
4	1	335			2.7
5	12	367	34.0	318-419	32.4
6	14	414	30.0	349-462	37.8
7	4	455	32.2	423-499	10.8
8	3	490	24.2	473-518	8.1
9	1	521			2.7
10	1	579			2.7
11	1	620			2.7
		Coastal Tributaries near Lower River - August 1-16			
0	2	63	3.5	60- 65	6.9
1	6	94	11.2	81-106	20.7
2	12	131	16.0	97-151	41.4
3	8	146	12.9	125-163	27.6
4	1	243	-	-	3.4

The following length-weight relationships were calculated for a sample taken from the lower Canning River during August 1-16, 1982.

Grayling (N = 50, r = 0.99, range = 122 to 414 mm):
Log_{10} W(g) = 2.93 Log_{10} L(mm)-4.83

Round Whitefish (N = 41, r = 0.99, range = 140 to 462 mm):
Log_{10} W(g) = 2.68 Log_{10} L(mm)-4.22

Anadromous Arctic char (N = 68, r = 0.99, range = 220 to 670 mm):
$\text{Log}_{10} W(g) = 3.09 \text{Log}_{10} L(mm) - 5.26$

The following length-weight relationship was calculated for non-spawning char collected from the main channel below Shublik Springs during September 18-25, 1982.

Anadromous Arctic Char (N = 40, r = 0.99, range = 229 to 667 mm):
$\text{Log}_{10} W(g) = 3.08 \text{Log}_{10} L(mm) - 5.26$

Coefficient of condition (K) was determined for char, round whitefish and grayling samples from different locations in the Canning River in 1981 and 1982 (Tables 6 and 7).

Table 6. Coefficient of condition (K) for grayling and round whitefish from the Canning River, 1981 and 1982.

	Length Group (mm)	Numbers in Sample	Mean K	Standard Deviation
Grayling; Lower River - July-August 1981	50- 99	5	.98	.14
	100-149	48	.95	.16
	150-199	25	.99	.08
	200-249	22	.95	.06
	250-299	27	.98	.06
	300-349	115	.97	.08
	350-399	176	.97	.08
	400-449	8	1.0	.09
	450-499	2	.88	.03
Grayling, Lower River - August 1982	100-149	4	1.05	.07
	150-199	-	-	-
	200-249	-	-	-
	250-299	4	.09	.04
	300-349	16	.99	.11
	350-399	36	.97	.09
Grayling, Near Shublik Springs - September 1982	300-349	11	.97	.04
	350-399	6	.97	.09
Round Whitefish, Lower River - July-August 1981	100-149	14	.82	.08
	150-199	5	.89	.11
	200-249	3	.95	.05
	250-299	8	.83	.05
	300-349	10	.91	.07
	350-399	23	.97	.08
	400-449	17	.90	.11
	450-499	2	.98	.08

Table 7. Coefficient of condition (K) for arctic char from the Canning River 1981 and 1982.

	Lower River - July-August 1981			Main Channel near Shublik Springs September 1982		
Length Group(mm)	Number	Mean K	Standard Deviation	Number	Mean K	Standard Deviation
100-149	6	.97	.08	-	-	-
150-199	6	.88	.05	-	-	-
200-249	64	.96	.07	4	.90	.10
250-299	49	.96	.08	3	.85	.09
300-349	35	1.00	.06	9	.96	.05
350-399	83	1.02	.09	24	.88	.12
400-449	99	1.04	.10	43	.89	.10
450-499	72	1.05	.09	27	.95	.11
500-549	35	1.07	.11	14	.98	.08
550-599	11	1.03	.10	7	1.0	.08
600-649	1	1.08	-	2	.94	.04
650-699	1	.96	-	1	.94	-

The largest char caught during two years of sampling on the Canning was taken in the main channel below Shublik Springs on September 25, 1982. This fish weighed 2800g and measured 667mm.

Fish Spawning and Overwintering

Spawning habitat requirements and locations for grayling has not been extensively surveyed in the Canning drainages. Fry were most abundant in slow, shallow back water areas of the main river and in coastal tributaries.

Overwintering locations of grayling in the Canning are largely unknown. Suitable habitat is limited to springs, pools, and the brackish delta area. Grayling have been found in the Colville River in water depths under the ice as low as 1.5 meters (Bendock, 1980). Pools deep enough to overwinter fish, are scarce on the Canning River below the confluence with Eagle Creek. Ice can accumulate to 2 meters or more by late winter restricting movement and severely limiting available habitat. A fathometer profile conducted in August 1981 of the Canning River from Eagle Creek to the Staines documented only 13 areas where depths were greater than 2 meters (Figure 7). Grayling were caught by Ward and Craig (1974) in November 1973, through the ice in a location upstream from Nanook Creek where a 4.3 meter pool was recorded during the fathometer study. The few pools available to overwintering fish are probably heavily utilized by several species.

Anadromous char spawning habitat on the north slope is associated with springs and ground water sources that insure an adequate winter water supply for egg and fry survival. Although large numbers of springs supply water to the Canning River throughout the system, spawning appears to be located primarily in the Marsh Fork and the main river above the Marsh Fork confluence. An aerial survey of the Canning drainage was flown by Super Cub on September 26, 1982 in which concentrations of fish were counted and spawning redds were located. The total number estimated in these counts was 39,000 char. Of

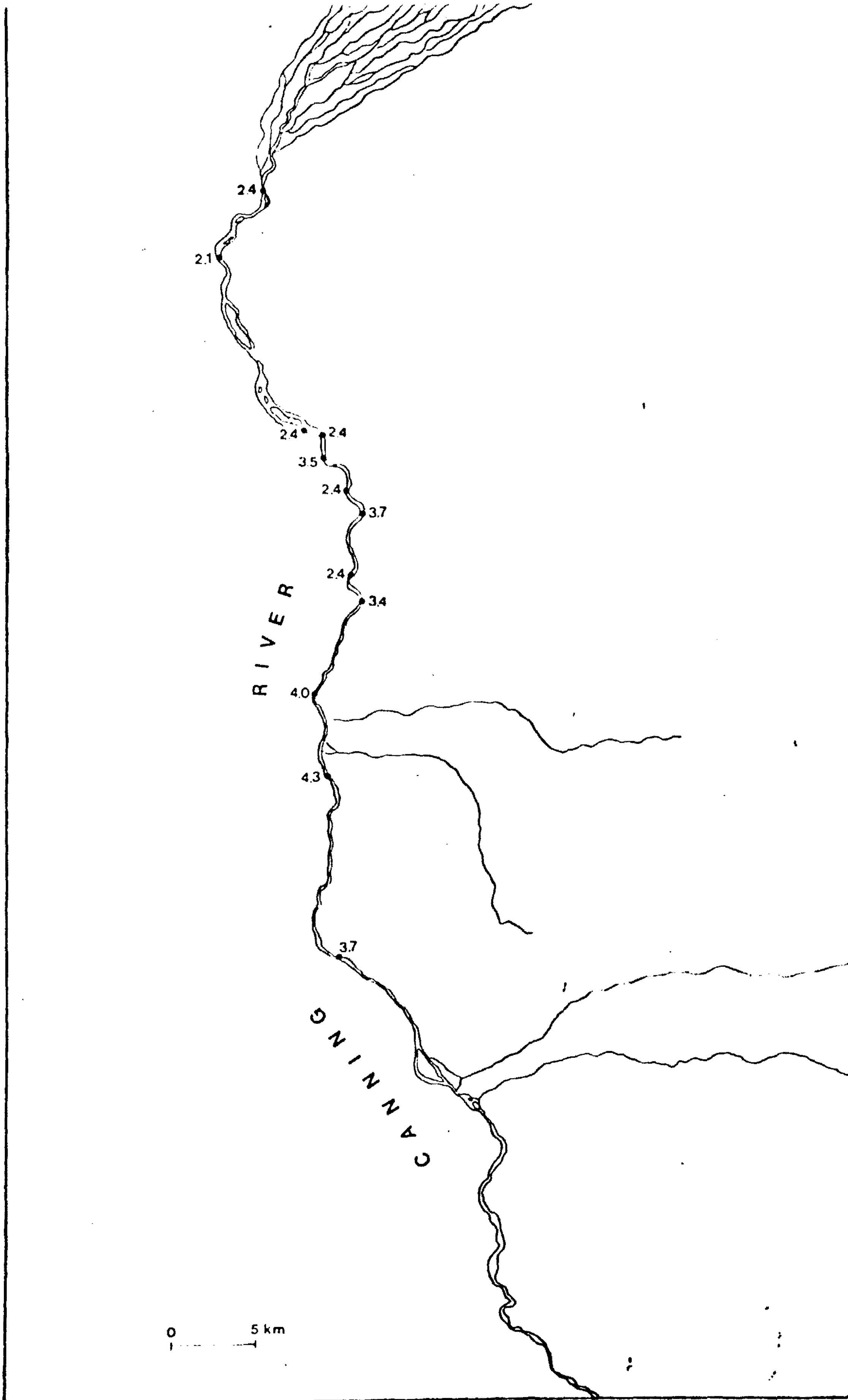

Figure 7. Pool locations and maximum depths (m), in lower Canning River, August, 1981.

these, 7,000 fish were in the Marsh Fork and 13,000 were in the main river above the Marsh Fork confluence. The remaining 19,000 were in the main channel between Ignek Creek and the Marsh Fork (Figure 8). Large concentrations of char were documented in several areas from the confluence of Ignek Creek to the headwaters, however spawning redds were only readily apparent above the Marsh Fork confluence. Most of the concentrations of fish below the Marsh Fork confluence are probably non-spawners and immature located at overwintering areas. A large concentration of char near Shublik Springs were sampled during September 1982 and consisted primarily of non-spawners and immatures. Less than 4% of a sample of 335 char from this location were in spawning condition.

Nine char were implanted with radio tags in the fall of 1981 to attempt to monitor fall and winter movements and to locate overwintering areas. Tag relocations are depicted on Figure 9. The areas in which radio tagged char overwintered are all in the vicinity of deeper pools located by fathometer in 1981 (Figure 7). Char concentrations located during the September aerial survey are also located near these pool areas. Attempts to locate and describe the physical characteristics of these overwintering areas on the ground were unsuccessful. Fish were collected in the open water reach below Shublik Springs on April 30, 1982. Fifteen char were sampled and ranged in fork length from 327 to 450 mm.

One dead, apparently spawned out chum salmon was observed approximately 1 mile below Shublik Springs on September 26, 1982. It is not known to what extent, if any, the Canning River is utilized by salmon for spawning.

Fish Movement

Very little is known about grayling and round whitefish movement in the Canning drainage. There is, generally, thought to be a movement of grayling into smaller tributaries for spawning in spring and early summer and movement away from these areas into the larger river for feeding and overwintering during summer and fall. Two grayling and one round whitefish tagged in the lower river in 1981 were recaptured near Shublik Springs in September 1982. These fish had moved upstream 59.5 km from the original tagging site. Another grayling tagged in the lower river in 1981 was recaptured in the Tamayariak River in 1982. Only one grayling out of 290 tagged in 1981 was recaptured in the same area on the lower river where it was tagged the previous fall.

Char migation into fresh water was monitored in the lower river in 1981 and 1982. Based on catch per unit effort data it appears the peak movement into the river was between August 15 to 25 for these two years (Figures 10 and 11). Four char were implanted with radio tags during August in the lower river. Daily progress was monitored for two of these fish for a period of two weeks and was again checked approximately one month later (Figure 12). Daily movement of these fish varied considerably and the longest distance traveled upstream, during any 24 hour period, was 9.7 km.

Winter movement of char is greatly reduced. Shallow reaches in rivers freeze solid restricting movement of fish. Radio tagged char were monitored throughout the winter of 1981-82. Fall and winter movements of these fish are listed in Table 8. Five fish were tagged below Shublik Springs on October 1, 1981 and relocated periodically throughout the winter. Two other fish tagged in the lower river in August 1981 were also relocated during the winter.

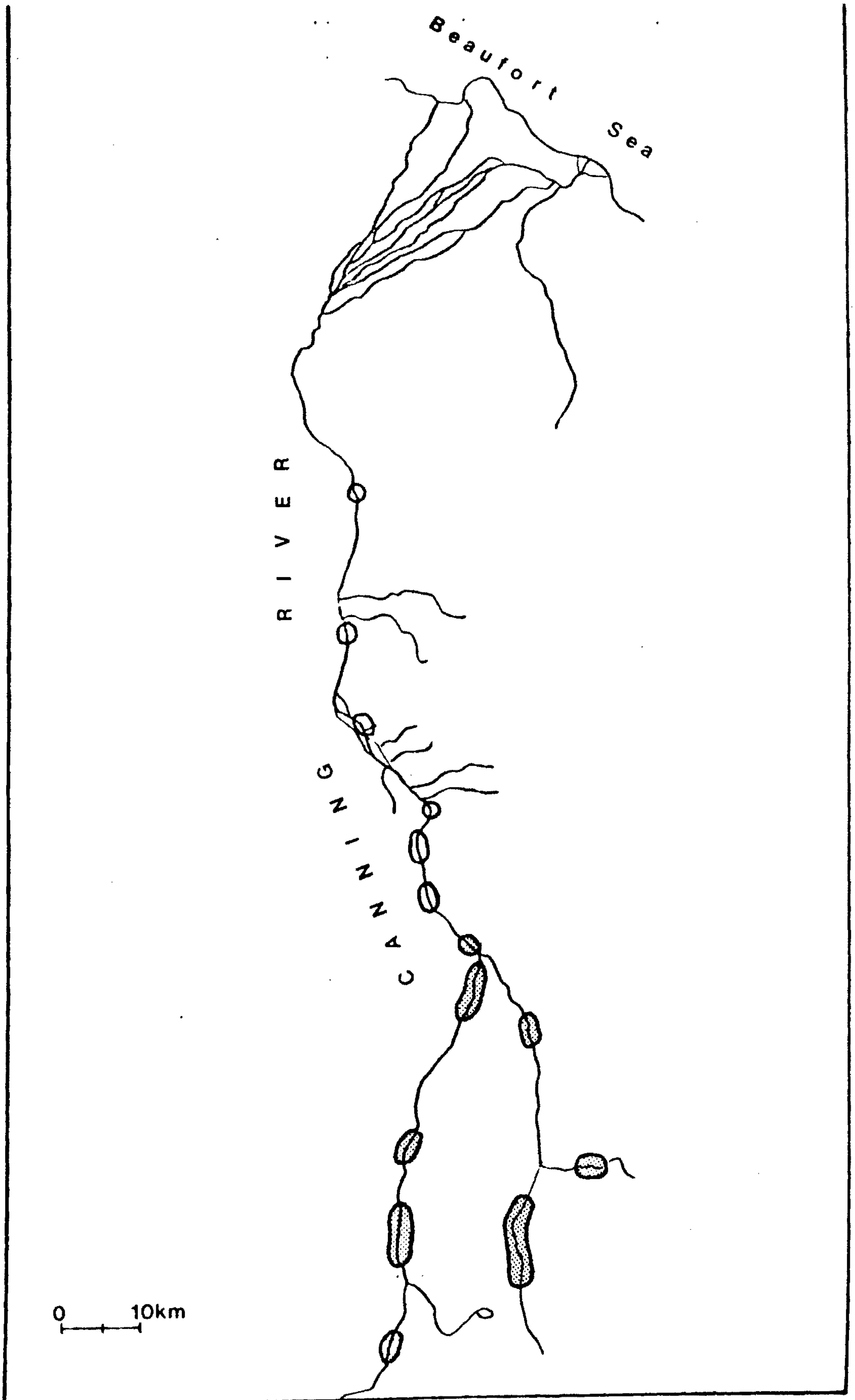

Figure 8. Char concentrations observed by aerial surveys in the Canning River, September 26, 1982. Stippled areas indicated spawning concentrations.

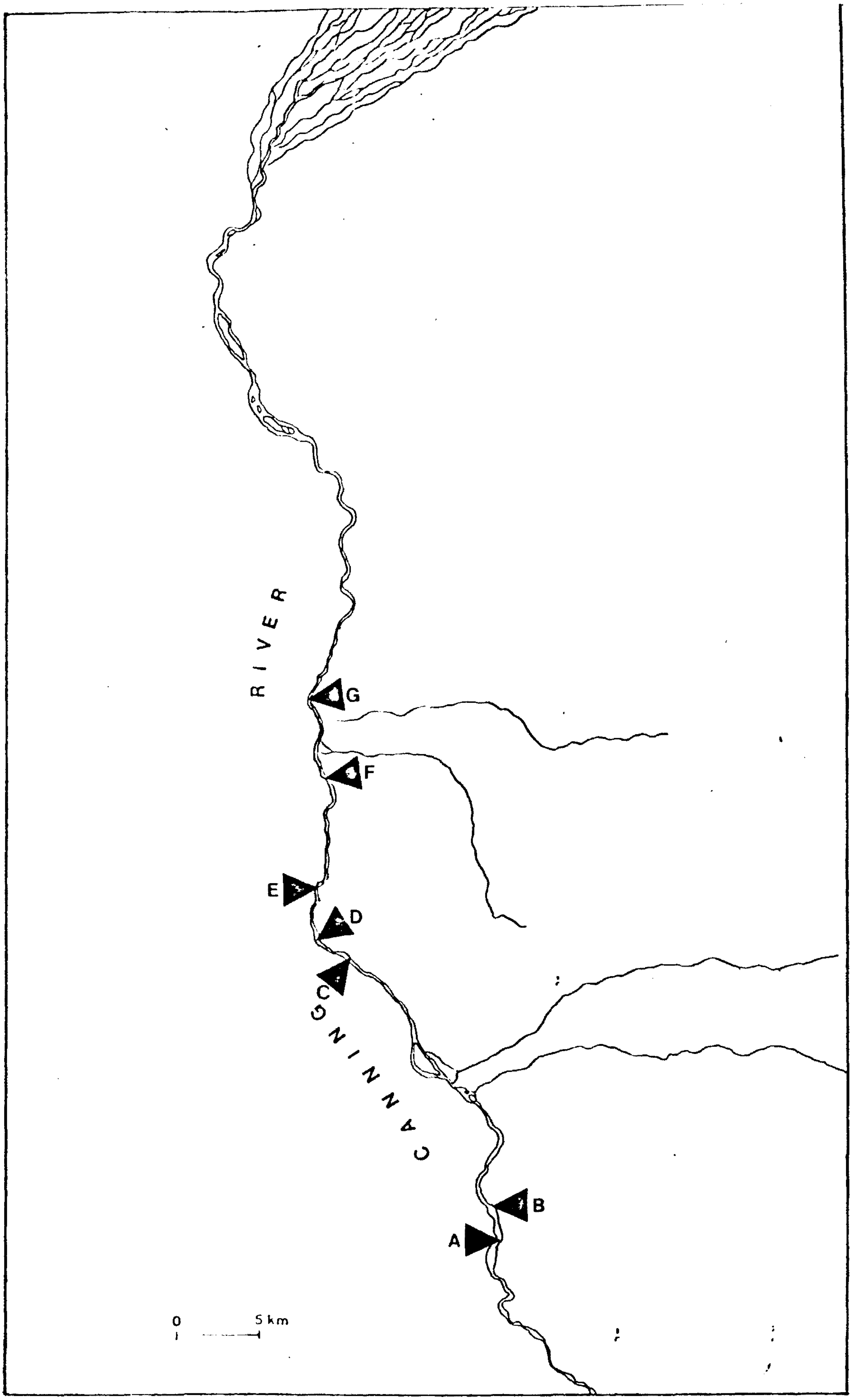

Figure 9. Overwintering locations of radio tagged arctic char in the Canning River, October 1981 - April 1982.

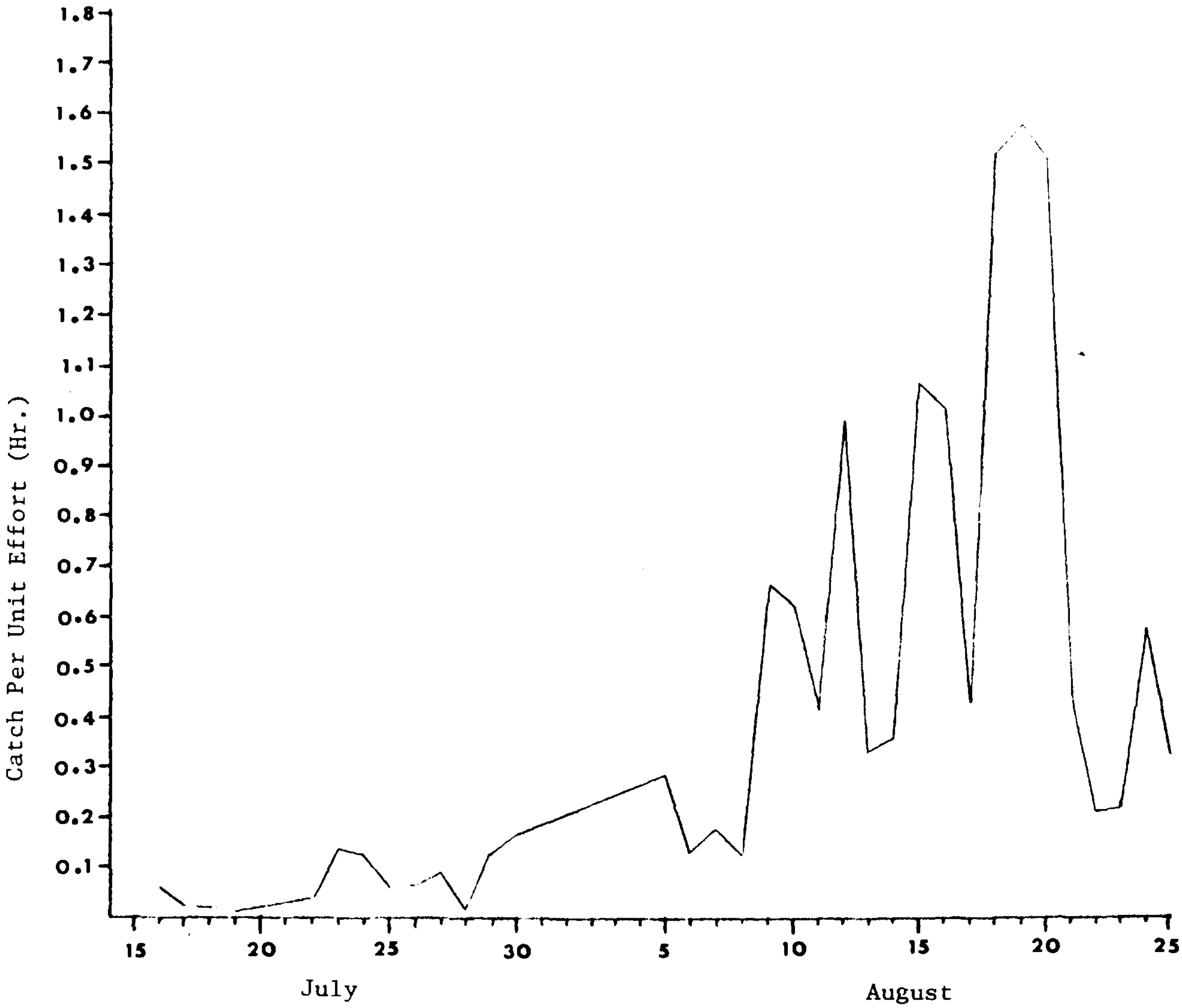

Figure 10. Daily catch rates of anadromous arctic char by experimental gill net in the lower Canning River, 1981.

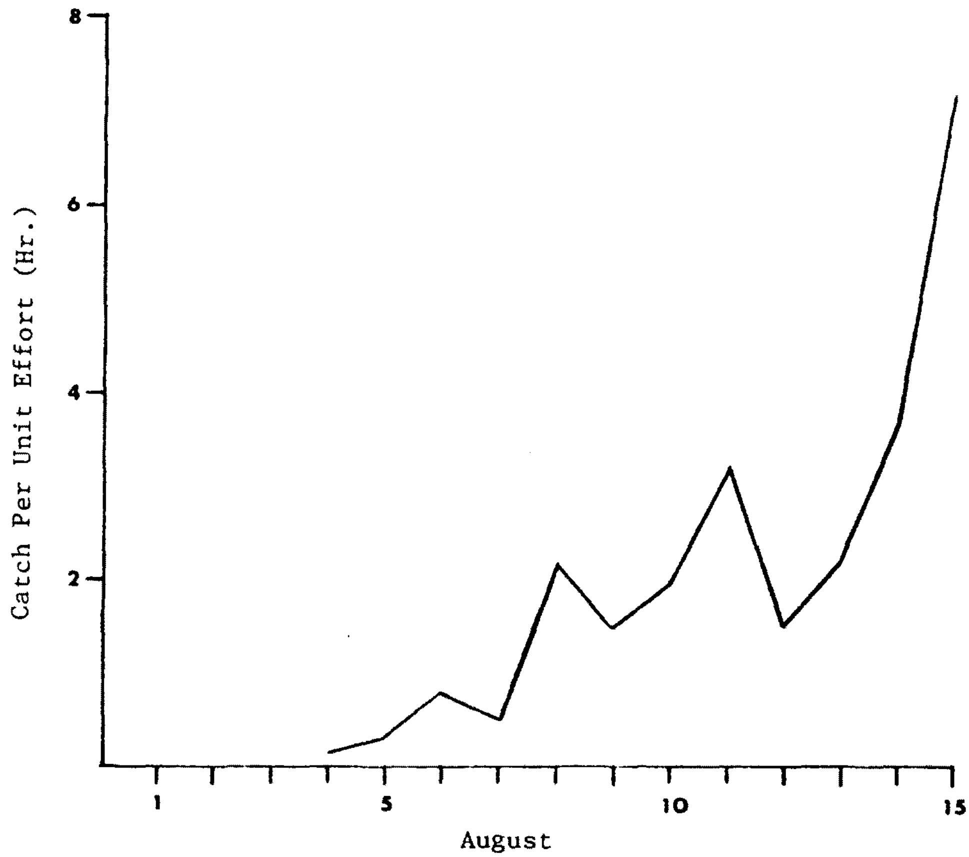

Figure 11. Daily catch rates of anadromous arctic char by experimental gill net in the lower Canning River, 1982.

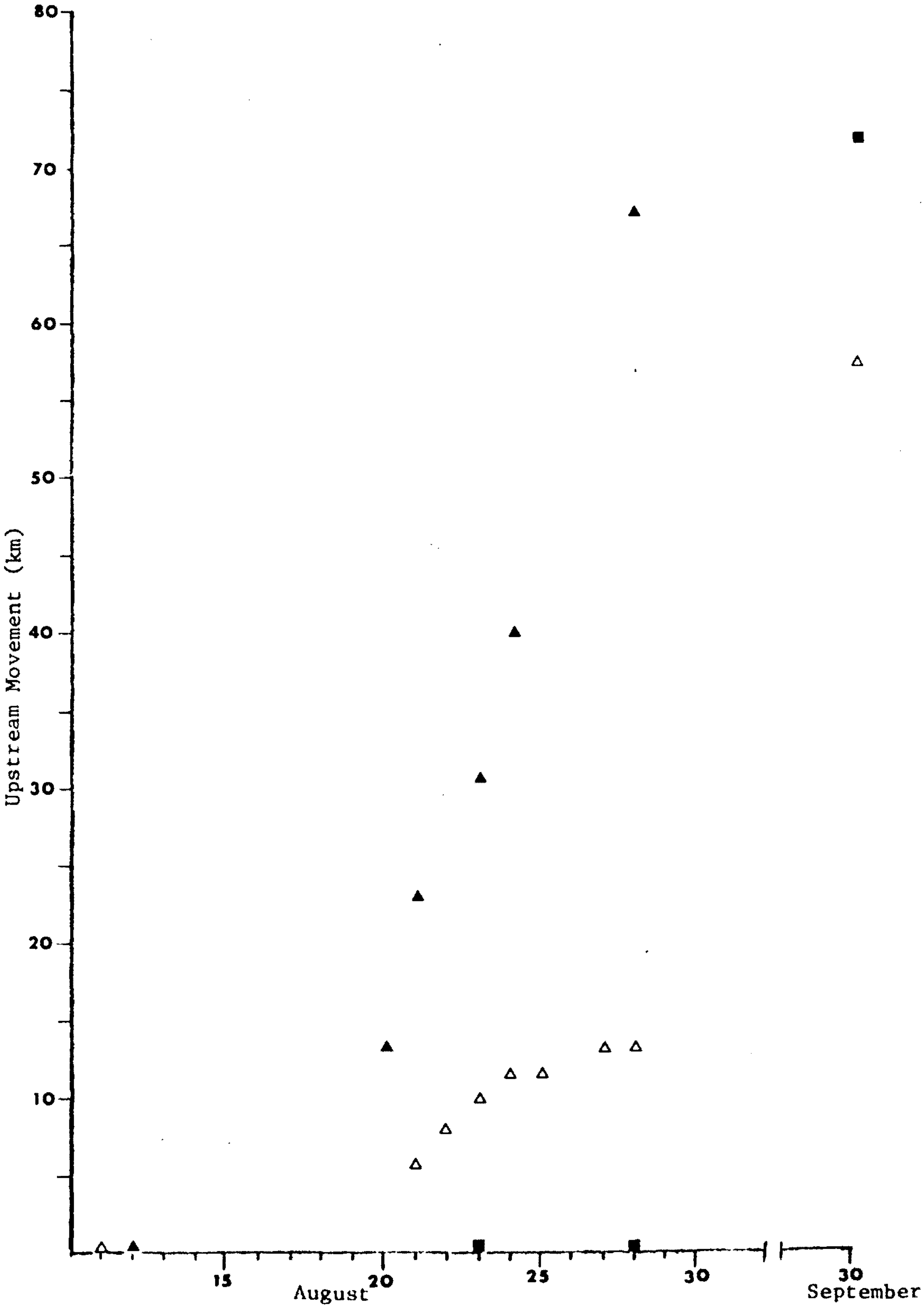

Figure 12. Upstream movement of three radio tagged arctic char in the lower Canning River, 1981.

Total movements of these fish from October to April ranged from 0 to 17 km. Most movement was early from October to January, and in a downstream direction. One fish was located near Shublik Springs on April 28. The same fish was approximately 6.4 km downstream from this location on March 5. The movement of this fish was upstream through one of the largest aufeis fields in the drainage.

Table 8. Winter movement of radio tagged arctic char in the Canning River, October 1981 - April 1982.

Tag Frequency MHz	Fork Length (mm)	Locations* Oct. 1	Oct. 21	Jan. 28	Mar. 5	Apr. 28
151.640	495	C	D (-2.7)	?	E (-3.7)	?
151.660	495	A	A (0)	A (0)	B (-2.3)	?
151.680	565	C	D (-2.7)	?	D (0)	D (0)
151.720	475	C	D (-2.7)	F (-12)	F (0)	F (0)
151.780	495	D	F (-12)	G (-5)	G (0)	?
151.800	570	C	D (-2.7)	?	D (0)	?
151.820	460	C	D (-2.7)	D (0)	E (-3.7)	C (+6.4)

*Locations are depicted on Figure 9. Number in parenthesis indicates movement by km from previous relocation. Upstream movement is indicated by (+) and downstream by (-). Those dates in which fish were not located during a survey are indicated by (?).

TAMAYARIAK

Study Area

The Tamayariak River is located between the Canning River, which forms the western boundary of the Arctic National Wildlife Refuge, and the Katakturuk River. It drains an area of approximately 90,000 hectares (347 sq. miles). The headwaters originate in the western portion of the Sadlerochit Mountains and from there the streams travels 65 kilometers to its confluence with the Canning River, which is located 7 kilometers from the mouth of the Canning River. Red Hill Spring, located at the western end of the Sadlerochit Mountains, is the only spring identified on the Tamayariak River. It is a hot spring with temperatures at the orifice reported to be between 29.3 and 32.9°C (Childers et.al., 1977). The spring has a relatively low discharge of $0.02m^3$/sec. A few small lakes (less than 10 hectares) and one 60 hectare lake are attached to the drainage. Areas sampled on the Tamayariak River, during the period of July 19 to 30, 1982, are depicted in Figure 13.

Physical Characteristics

The Tamayariak River is a fifth order stream at its confluence with the Canning River. River distances by stream order and percent braided channel area are shown in Table 9. Stream distances were taken from U.S.G.S. 1:63,360 scale maps. A total of 582 kilometers of stream drain the Tamayariak basin. Over 50 percent of the stream distance is comprised of first order reaches, approximately 25 percent by second order, and third, fourth and fifth order sreams contributing to the remainder of the stream network. Braided channel

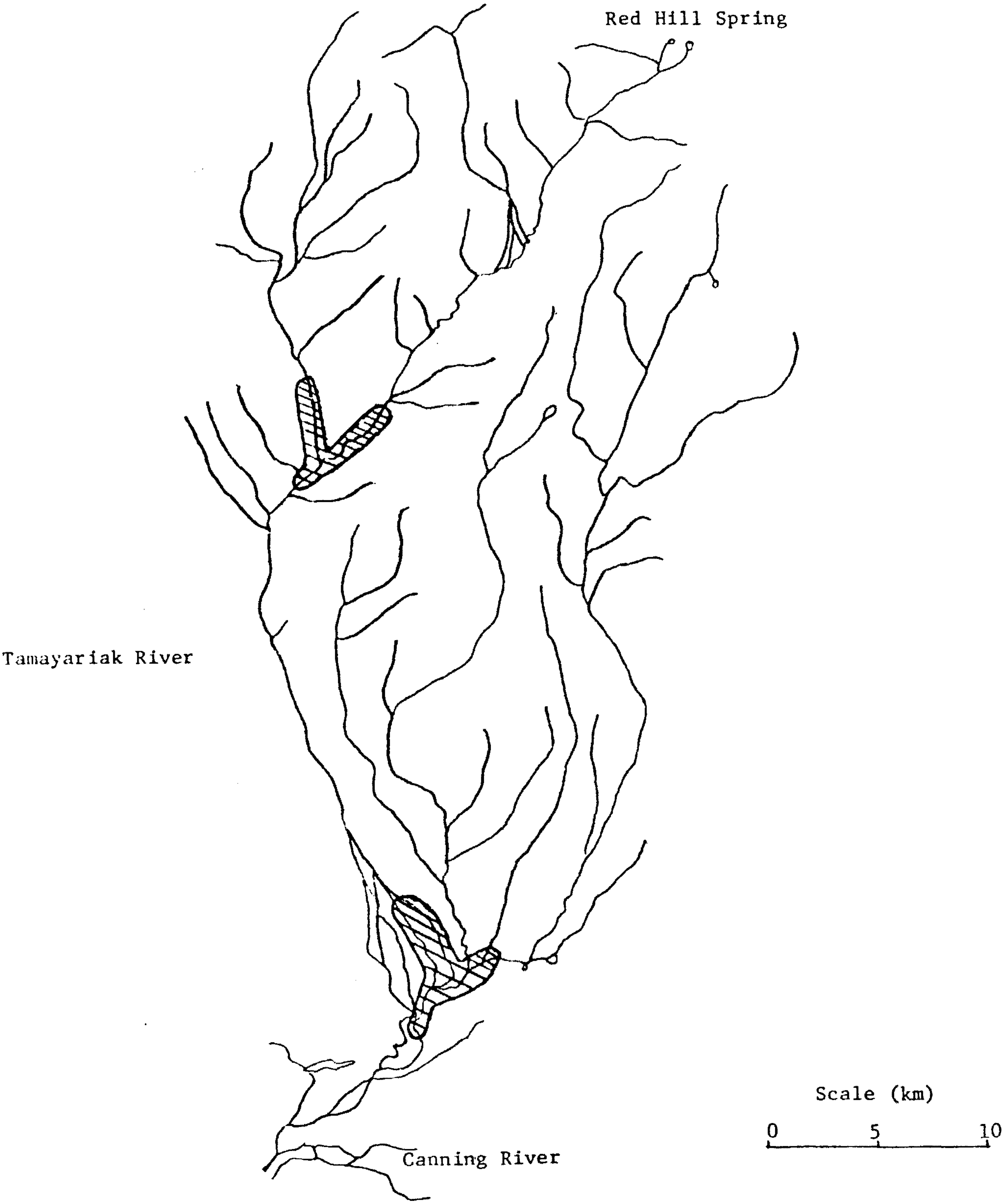

Figure 13. Upper and lower sampling areas on the Tamayariak River, July 19-30, 1982.

sections comprise 5.6 percent of the total river distance, with channel braiding primarily occuring in fourth order stream reaches.

Table 9. River kilometers and percent composition by stream order and percent braided channel for the Tamayariak River.

Stream Order	Kilometers	Percent Composition	Braided Channel Kilometers	Braided Channel Percent Composition
1	316	54.2	0.0	0.0
2	143.5	24.8	4.3	3.0
3	70.5	12.1	1.8	2.6
4	41.7	7.2	26.5	63.1
5	10.2	1.7	0.0	0.0
	581.9		32.6	*5.6

*Percent of total river distance.

Gradient (percent) was determined using U.S.G.S. 1:63,360 scale maps. Figure 14 depicts gradient characteristics of the Tamayariak River, stratified by stream order and by gradient composition of the total network. Approximately 26 percent of the total river distance had gradients between 0.5 and 1.0 percent (5 to 10m/km). Percent composition of gradient groups between 1.0 (10m/km) and 6.0 percent (60m/km) were evenly distributed. Sections of channel with gradients greater than 6.0 percent comprised 9.8 percent of the total network distance. First order reaches had gradients primarily between 1.5 and 6.0 percent. Second order reaches were primarily distributed between the 0.5 and 4.0 percent gradient range. Gradient of third and fourth order stream sections primarily ranged from 0.5 to 1.0 percent. Fifth order stream gradient was less than 0.5 percent.

Figures 15 and 16 show specific sampling areas on the Tamayariak River. Physical characteristics of the channel for these areas are shown in Table 10. In general, discharge, percent pool area, channel width and depth of pools was greater in the lower river reaches. The upper river reaches had steeper gradients and consequently faster water velocity, larger substrate, and much more riffle area. First and second order streams, sampled in the upper Tamayariak, were either dry or had less than 0.01 m^3/sec. discharge.

Water Chemistry

Water chemistry for sample areas on the Tamayariak are shown in Table 11. Little difference existed between the upper and lower sampling areas. Dissolved oxygen was usually at or near saturation. Total alkalinity ranged from 120 to 137 mg/l. Conductivity ranged from 235 to 305 umhos/cm and pH ranged from 7.7 to 8.3.

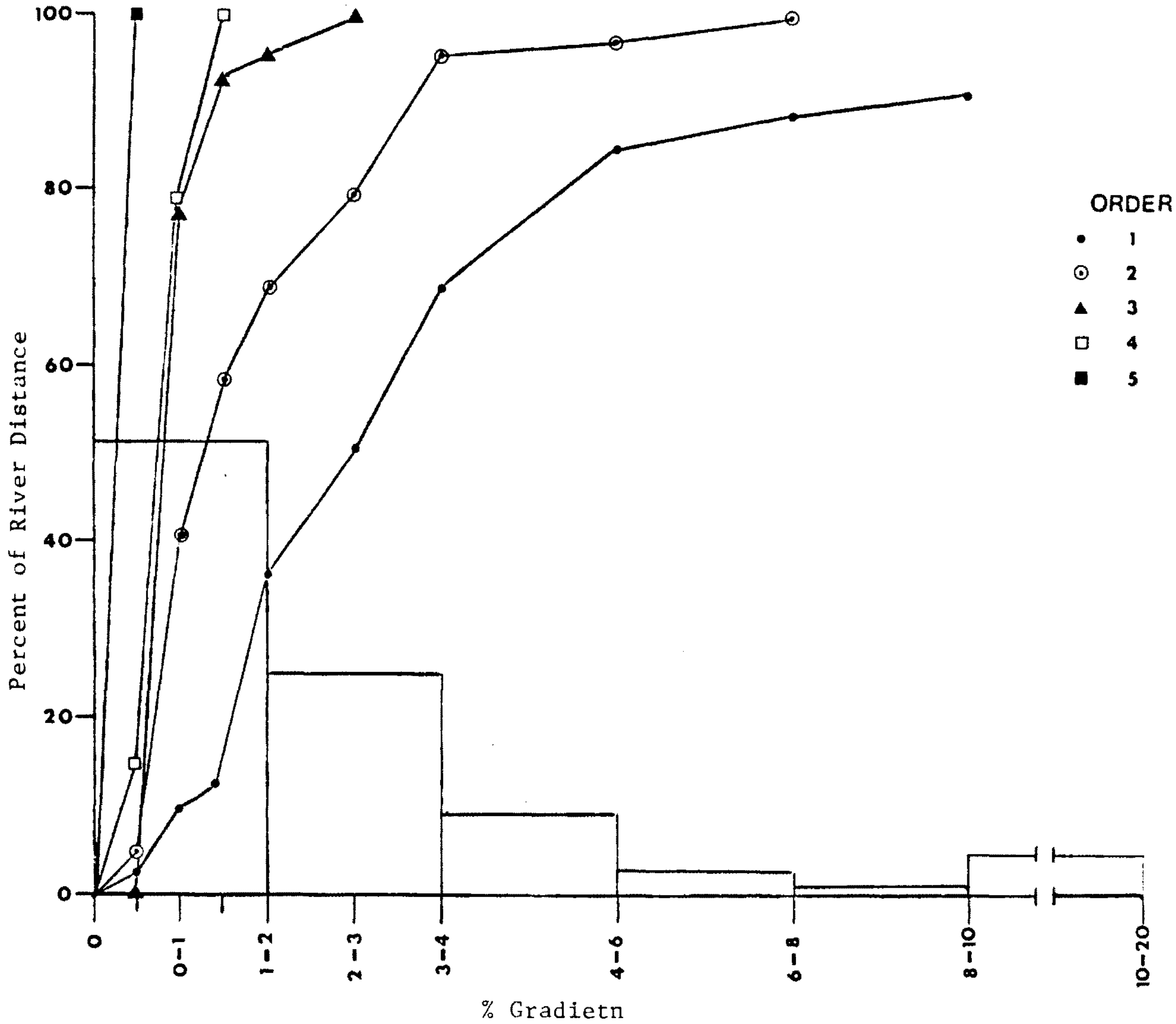

Figure 14. Gradient characterization of Tamayariak River (lines represent gradient composition by stream order and boxes represent composition of all reaches combined).

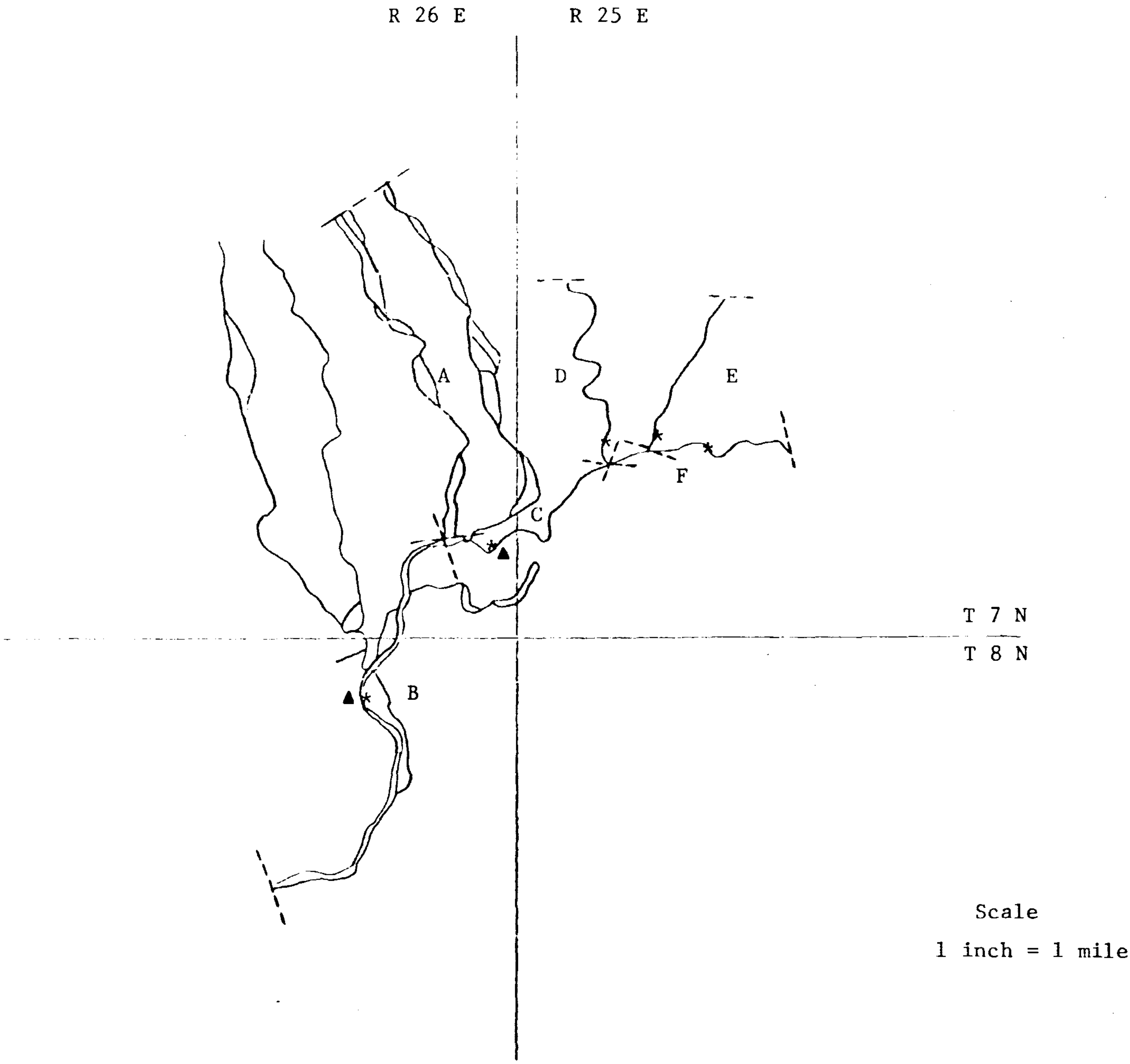

Figure 15. Reaches sampled on the lower Tamayariak River, July 19-30, 1982. ((---) reach boundaries, (*) discharge measurements, (▲) water chemistry.)

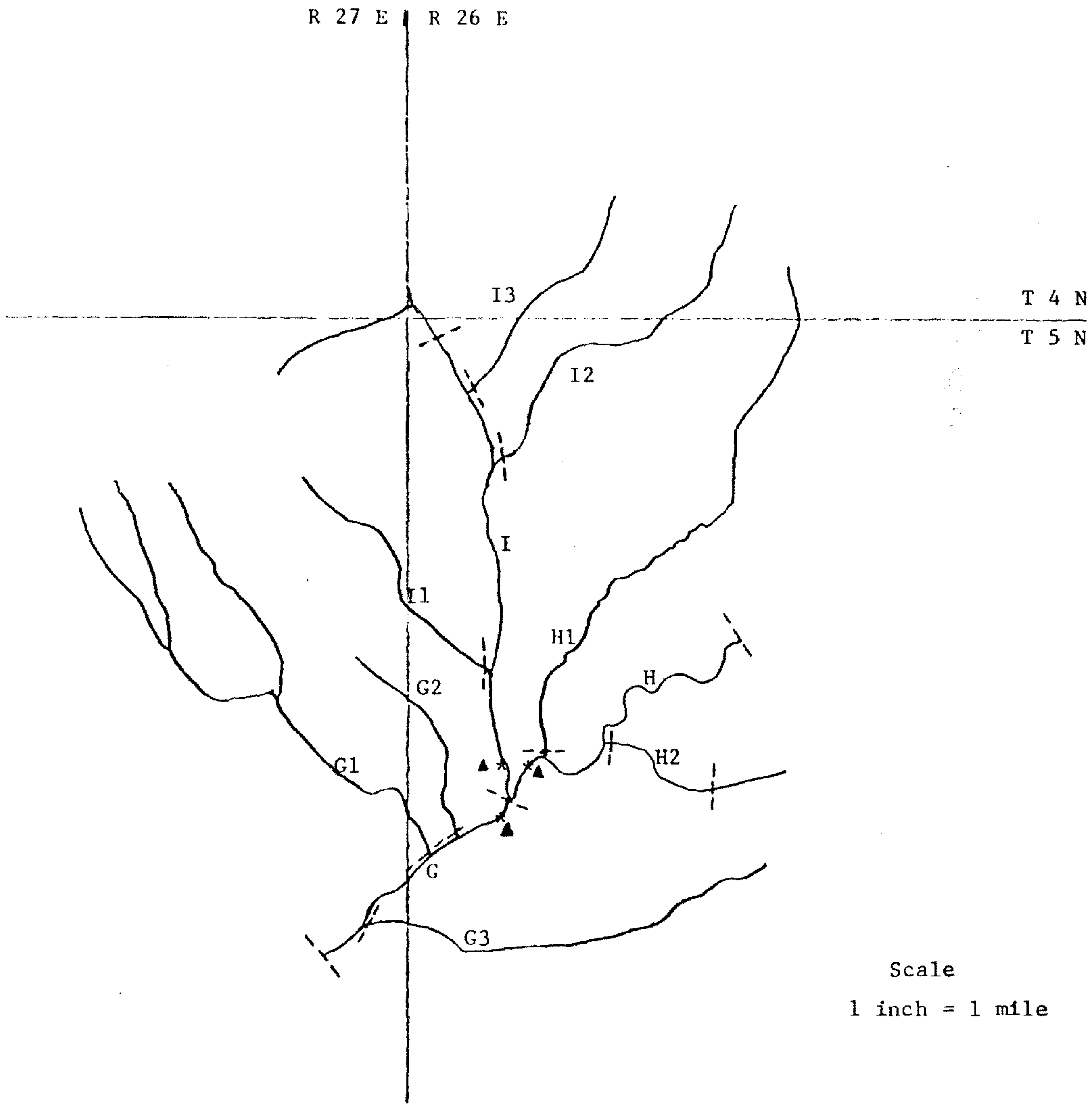

Figure 16. Reaches sampled on the upper Tamayariak River, July 19-30, 1982. ((---) reach boundaries, (*) discharge measurements, (▲) water chemistry.)

Table 10. Physical characteristics of the sample areas on the Tamayariak River, July 1982.

	Stream Order	Gradient (%)	Channel Configuration	Wetted Perimeter	Channel Width Meters	Average Depth (m)	Pool Depth (m)	Discharge (cms)	Average Velocity (m/sec)	% Pool Area	% Refuge Area	% Flow Shallow Area	Predominant Substrate
Lower River													
A	4	0.47	Braided	-	-	0.2	-		-	0.0	60.0	40.0	Large and Small Gravel
B	5	0.28	Irregular	15-50	60-125	0.3	1.5-2.5	2.65	0.34	25.0	55.0	20.0	Large and Small Gravel
C	4	0.90	Irregular	10-20	-	0.5	1.2-1.9	0.79	0.12	60.0	10.0	30.0	Large and Small Gravel
D	4	0.31	Meandering	6-10	10- 15	0.3	0.5-1.5	0.20	0.08	50.0	30.0	20.0	Large and Small Gravel
E	2	0.47	Straight	1- 5	1- 5	0.1	0.2-0.4	0.02	0.05	60.0	10.0	30.0	Large and Small Gravel
F	3	0.34	Irregular	8-15	20- 50	0.3	0.3-1.0	0.55	0.15	20.0	30.0	50.0	Large and Small Gravel
Upper River													
G*	4	0.79	Irregular	15-25	30- 60	0.3	0.3-1.5	4.26 1.5-1.75*	0.62	15.0	80.0	5.0	Rubble Cobble
H*	3	0.75	Irregular	15-25	30- 80	0.4	0.3-1.2	3.20 1.0-1.3**	0.62	10.0	70.0	20.0	Rubble Cobble
I*	4	0.95	Straight	10-15	25- 40	0.24	0.3-0.6	1.00 0.15-.45*	0.36	5.0	90.0	5.0	Rubble Large Gravel
G1	2	3.10	Irregular	1- 3	1- 5	-	-	0.1	-	-	-	-	-
G2,G3,I1-3, H1,H2	1	1.60-5.20	Straight	1- 3	1- 5	-	-	0.00-0.01	-	-	-	-	-

*Sampled at above normal summer flow.
**Estimated discharge for normal summer flow.

Table 11. Chemical characteristics of sample areas on the Tamayariak River, July 1982.

	Dissolved Oxygen (mg/1)	Total Alkalinity (mg/1)	Total Hardness (mg/1)	Conductivity (umhos/cm)	pH
Lower River					
Reach					
B	10	124	205	260	7.7
C	10	120	154	225	8.3
Upper River					
Reach					
G	10	137	-	260	7.8
H	11	120	-	305	8.0
I	9	137	-	279	7.7

Fish Distribution and Abundance

Adults and Juveniles: A total of 146 grayling and one ninespine sticklebackwere captured during the sampling period of July 19 to 30, 1982. Angling and experimental gill nets were used to collect fish.

In the lower river reaches grayling were collected in greatest abundance in reaches B and C (Figure 15). Grayling adults were also collected in or observed in reaches D and F. No fish were observed in reach A (braided section) and reach E. In the upper sampling area, adults and juvenile grayling were found only in reaches G and H (Figure 16).

Figure 17 depicts grayling length frequencies for the upper and lower river sampling aeas. Mean length and catch-per-unit-effort are shown in Table 12. The length frequency distribution (Figure 17) indicates that grayling collected in the upper river section were much smaller than those collected from the lower river. Mean fork length of grayling collected at the downstream sites was 374.8 mm and 279.9 mm (Table 12) for grayling collected at the upper river sites. Gill net catch per hour (Table 12) was greater in the lower river section (1.39 fish/hr. - lower river, 0.65 fish/hr. - upper river). Angling catch rates were around 3.4 fish/hr. for both upper and lower river sections.

Fry: Observations were used to record abundance and distribution of grayling fry. Fry (15 to 20 mm) were first observed on July 21 in the lower river sampling area. During the next few days, small groups of 5 to 25 fry were observed in reaches B, C, and F (Figure 15) of the lower river sampling area. In the upper section of the Tamayariak, fry were observed in greatest abundance in reach G (Figure 16), but were also dispersed throughout reaches H and I. Fry observed between July 26 and 29 at the upper river section, averaged 25 to 30 mm in length. They were observed much more frequently than in the lower river sampling area. Incubation time for grayling was reported by Scott Crossman (1973) to be between 13 to 18 days and that fry were 8 mm

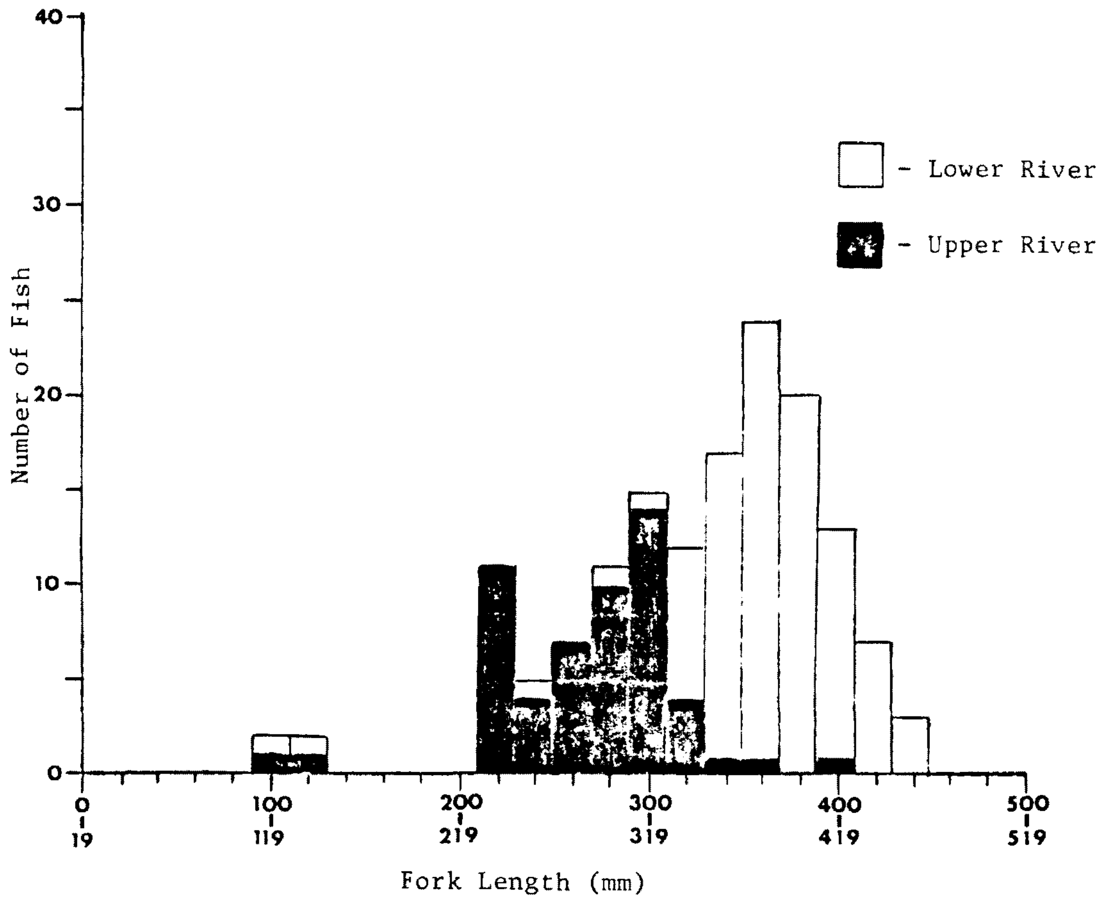

Figure 17. Length frequency of grayling collected by experimental gill nets and angling on the Tamayariak River, July 19-30, 1982.

long at hatching. Grayling fry in the Tamayariak River probably hatched during the last two weeks of June. Craig and Poulin (1974) estimated time of emergence for a nearby drainage to be between the last week of June and first week of July.

Table 12. Mean length and catch per hour of grayling collected by gillnets and angling on the Tamayariak River, July 19-30, 1982.

Total Number	Total Effort of Fish	Mean Fork (Hrs.)	Length Length (mm)	Catch Per Range (mm)	Hour
Gillnet					
Lower River	32	23.0	369.0	314-435	1.39
Upper River	25	38.2	265.1	117-402	0.65
Angling					
Lower River	59	17.4	379.8	328-444	3.40
Upper River	30	8.6	292.3	224-333	3.48
Combined					
Lower River	91	-	374.8	314-444	-
Upper River	55	-	279.9	117-402	-

Grayling Age and Maturity

Otoliths were used to determine age of grayling. Age and maturity of grayling on the Tamayariak River is shown in Table 13. Lengths reported for various age groups include the growth past the period of last annulus formation. Age 1 and age 3 fish were not sampled and it is suspected that the scarcity of them could be related to gear selectivity. One grayling captured was 20 years old and had a fork length of 433 mm. The majority of fish captured were between 4 and 8 years of age. Combined length frequency (Figure 17) and age-length information indicate that grayling in the upper river were primarily between the ages of 4 and 5 and grayling in the lower river were 7 years and older. All grayling were mature by age 6. Gonadal development had just begun in three of four grayling in the five year old age group, and it appears that they would spawn during their sixth year of growth.

Grayling Weight and Condition

The length weight regression (r=0.98) for 62 grayling (range 115 to 444 mm fork length) collected from the Tamayariak River was:

$$\log_{10} W = 3.048 \log_{10} L - 5.113$$

W = Weight in grams
L = Fork length in millimeters

Table 13. Age (otolith) and maturity of grayling collected in the Tamayariak River, July 19-30, 1982.

Age	Number	Mean Fork Length(mm)	Length Range(mm)	Standard Deviation	Mature Male	Mature Female	Combined %
1	0						
2	2	128	117-139	15.5	0	0	0.0
3	0						
4	9	233	227-239	4.6	0	0	0.0
5	4	265	245-280	15.0	0	3	75.0
6	6	301	284-314	11.3	5	1	100.0
7	1	320	-	-	1	0	100.0
8	8	359	326-380	23.1	6	2	100.0
9	3	389	380-396	8.1	1	2	100.0
10	4	384	363-402	18.0	2	1	100.0
11	1	406	367-444	54.4	1	1	100.0
12	1	402	-	-	0	1	100.0
13	0						
14	1	431	-	-	1	0	100.0
15	1	415	-	-	1	0	100.0
16							
17							
18							
19							
20	1	433	-	-	1	0	100.0

Condition factors (K) for grayling, by size groups are reported in the following table.

Table 14. Coefficient of condition (K) for grayling collected on the Tamayariak River, July 19-30, 1982.

Length Group (mm)	Number in Sample	Mean K	Standard Deviation
100-149	4	0.73	0.121
150-199	-	-	-
200-249	12	1.06	0.092
250-299	19	1.04	0.098
300-349	31	1.03	0.088
350-399	29	0.99	0.076
400-449	18	0.92	0.091

Fish Movement

It is suspected that the larger older grayling found in the lower river sampling area have recently returned from spawning areas upstream. The greater abundance of fry in the upstream sampling area indicates that this area is used heavily for spawning. Some recently mature fish were collected here but the majority of fish collected were juveniles. It is suspected that juvenile and adult grayling moved upstream from lower river overwintering areas, during spring highwater periods. Adults spawned and returned downstream during late June and early July with juvenile and recently matured grayling returning downstream sometime between August and October. Craig and Poulin (1974) report similar patterns of grayling movement in Weir Creek, a tributary of the Kavik River.

Overwintering habitat for the Tamayariak has not been documented but, shallow water depth in the upper reaches would preclude these areas from overwintering use. Some of the deeper pools examined in the lower river sampling area may support moderate numbers of fish through the winter. It is suspected that reach B (Figure 15) of the lower sampling area is the upstream boundary of overwintering habitat on the Tamayariak River.

During 1981, 319 grayling were tagged on the Canning River. One of those grayling, captured 40 kilometers upstream of the Canning River mouth on August 21, was recaptured from the Tamayariak River approximately 5 kilometers upstream from its confluence with the Canning River, on July 19, 1982. The fish had grown 1 mm between the time of capture and recapture (373 in 8/81 to 374 in 7/82). During 1982, 84 grayling on the Tamayariak were tagged with Floy anchor tags.

KATAKTURUK RIVER

Physical Characteristics

The Katakturuk River originates in the Sadlerochit and Shublik Mountains, from where it travels 70 kilometers to its mouth in Camden Bay of the Beaufort Sea. The Katakturk River has an extensively braided channel and drains an area of approximately 75,000 hectares (290 sq. miles). Six spring areas have been identified in the Katakturk drainage and are shown in Figure 18 and Table 15. All of the springs are located south of latitude 69°45'00". Discharge, for two of the springs, was 0.121 m^3/sec at one site and 0.247 m^3/sec. at the other.

The Katakturuk River is a fifth order stream at its mouth. The total river network distance is 530 km of which 58.3 percent is first order, 18.1 percent second order, 11.5 percent third order and the remaining comprised of fourth and fifth order reaches (Table 16). Over 23 percent of the total network distance exhibits a braided channel pattern. All fourth and fifth order stream channel is braided and about 58 percent of the third order reaches are braided.

Gradient composition of the Katakturuk River is shown in Figure 19. First and second order streams exhibit relatively steep gradients with much of their total distance exceeding a slope of 8.0 percent (80 m/km). Thirty to fifty percent of their distance had gradients less than 4.0 percent (40 m/km). Third, fourth and fifth order sream gradients were generally less than 2.0 percent (20 m/km).

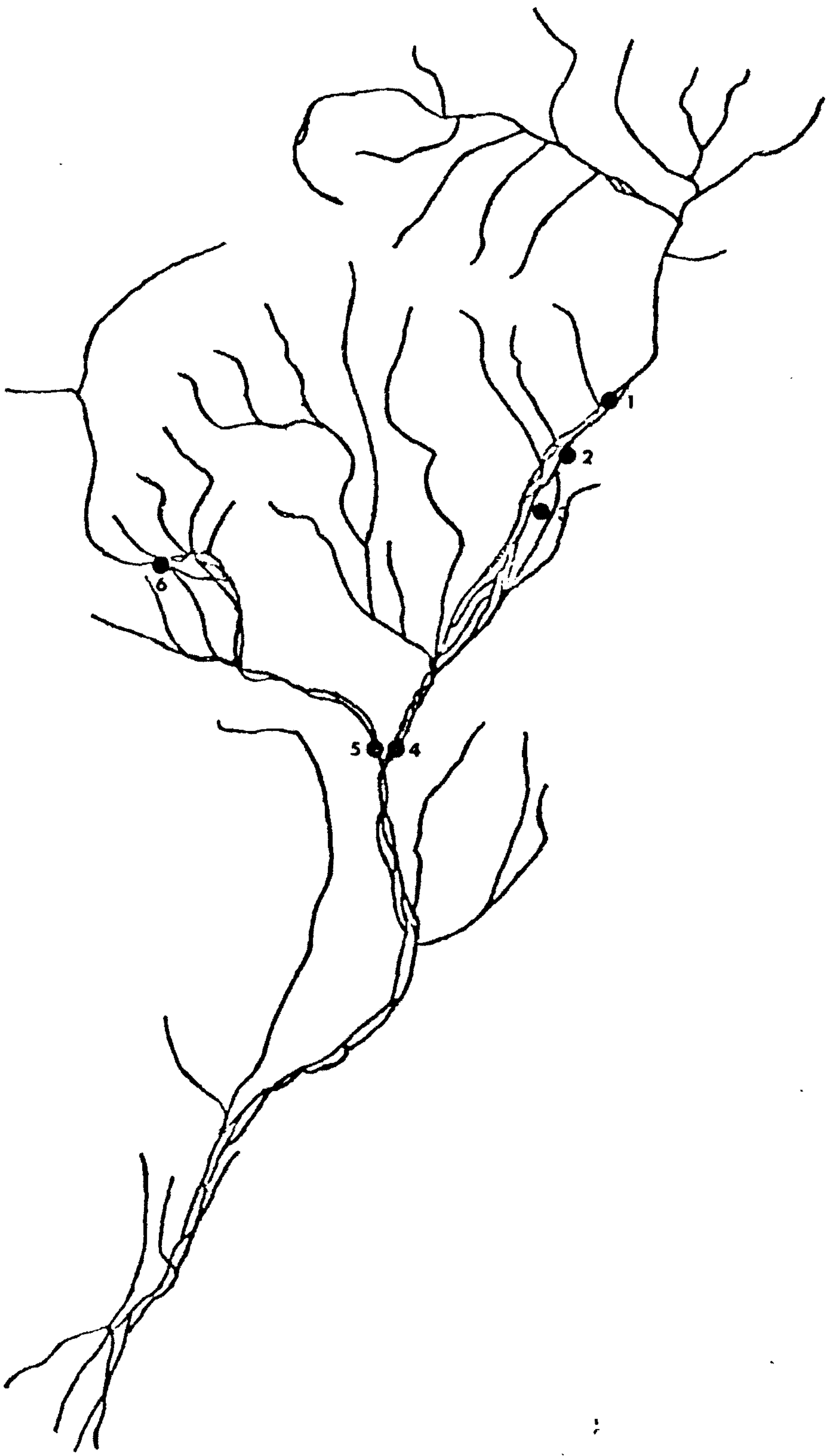

Figure 18. Spring locations in the Katakturuk Drainage.

Table 15. Locations, discharge, temperature for springs in the Katakturuk River Drainage.

Spring	Latitude	Longitude	Discharge (m^3sec)	Temperature (°C)	Information Source
	69°39'00"	145°31'45"	-	-	Wilson et. al. 1977
	69°39'45"	145°30'15"	*0.247	9.0	USFWS, Fishery Resources, Fairbanks, 1982
	69°41'45"	145°26'30"	-	-	USFWS, Fishery Resources, Fairbanks, 1982
	69°45'30"	145°20'30"	-	4.5	Wilson et.al. 1977, Ward and Craig 1974
	69°45'30"	145°19'15"	-	-	Wilson et.al. 1977
	69°41'45"	145°06'30"	0.121	1.0	Childers et. al. 1977

*Cumulative value for five small springs that enter the Katakturuk at this location. Individual spring discharges ranged from 0.035 to 0.080 m^3/sec.

Table 16. River kilometers, percent composition by stream order and percent braided channel for the Katakturuk River.

Stream Order	Kilometers	Percent Composition	Braided Channel Kilometers	Braided Channel Percent Composition
1	309	58.3	6.6	2.1
2	96	18.1	16.9	17.6
3	61	11.5	35.6	58.4
4	31	5.8	31.0	100.0
5	33	6.2	33.0	100.0
	530		123.1	*23.2

*Percent of total river distance.

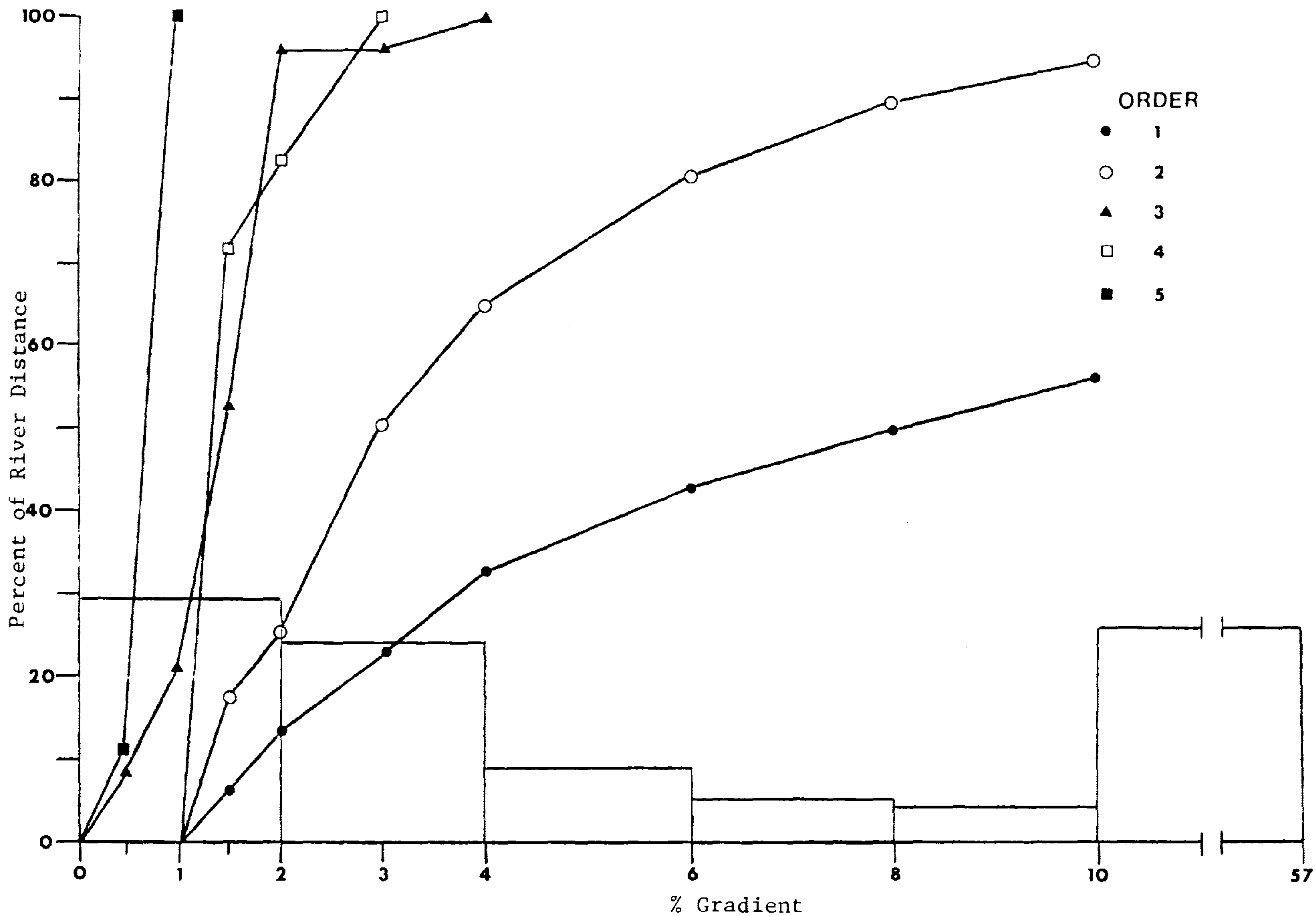

Figure 19. Gradient characteristics of the Katakturuk River (lines represent gradient composition by stream order and boxes represent composition of all reaches combined).

Observations of physical characteristics of the channel were recorded for the lower river, approximately 10 km from the mouth, and for the upper river, about 6 km upstream from the confluence of the two main branches. Both of these locations had braided channels. Mean depth in the lower river was between 0.15 and 0.25 meters. Mean pool depth was between 0.25 to 1.25 meters and, in a 4 km section that was surveyed, the deepest pool located was 1.75 meters. Approximately 5 to 10% of the area surveyed was classified as pool habitat. Substrate was primarily comprised of rubble and cobble. The upper river exhibited similar characteristics however pools were slightly shallower. Discharge, measured at the lower river sampling area, on July 21, 1982, was 5.64 m^3/sec.

Water Chemistry

Water chemistry was measured at both the upper and lower river sampling areas. Conductivity ranged from 220 umhos/cm at the lower river site to 280 umhos/cm at the upper river site. Total alkalinity (12 mg/l), total hardness (190 mg/l) and pH (7.8) were the same at both sites. Dissolved oxygen concentration was near saturation at both locations.

Fish Distribution

Fishery survey locations on the Katakturuk River are shown in Figure 20. Locations A and C were sampled by USFWS personnel during July 19-27, 1982. Ward and Craig (1974) sampled location B in July, 1972.

A total of 69 hours effort with baited minnow traps and 93 hours of experimental gillnet effort were used to sample fish at location A. Results of this effort produced no fish. Ward and Craig (1974) sampled location B with gillnets and angling. They also did not capture any fish. At location C, one anadromous char (250 mm fork length) and one ninespine stickleback were captured in 26 hours of gillnet effort and 199 hours of effort with baited minnow traps. Ward and Craig (1974) flew several aerial surveys over the Katakturuk between July and November, 1972, but fish were not observed.

SADLEROCHIT RIVER

Study Area

The Sadlerochit Headwaters are approximately located at 69°15'N latitude, 145°30'W longitude, in the Franklin Mountains. From there it flows approximately 115 kilometers to its mouth at Camden Bay of the Beaufort Sea. The drainage area of the Sadlerochit River is approximately 180,000 hectares (700 sq. miles). Its principle water sources, with the exception of one spring, are from snowmelt and rainfall. Sadlerochit Spring is located at the eastern end of the Sadlerochit Mountains and drains into the Itkilyariak River. A large aufeis field is located 5 kilometers downstream from the spring. It is approximately 30 kilometers from the spring orifice to the confluence of the Itkilyariak and Sadlerochit River. Childers et.al. (1977) determined that the discharge was 1.05 m^3/sec (37 cfs) and reported a water temperature of 13°C at the main orifice. Two large lakes are found in the drainage area, Lake Peters (775 hectares) and Lake Schrader (1450 hectares). They are drained by the Kekiktuk River which joins the Sadlerochit River near the southeast end of the Sadlerochit Mountains.

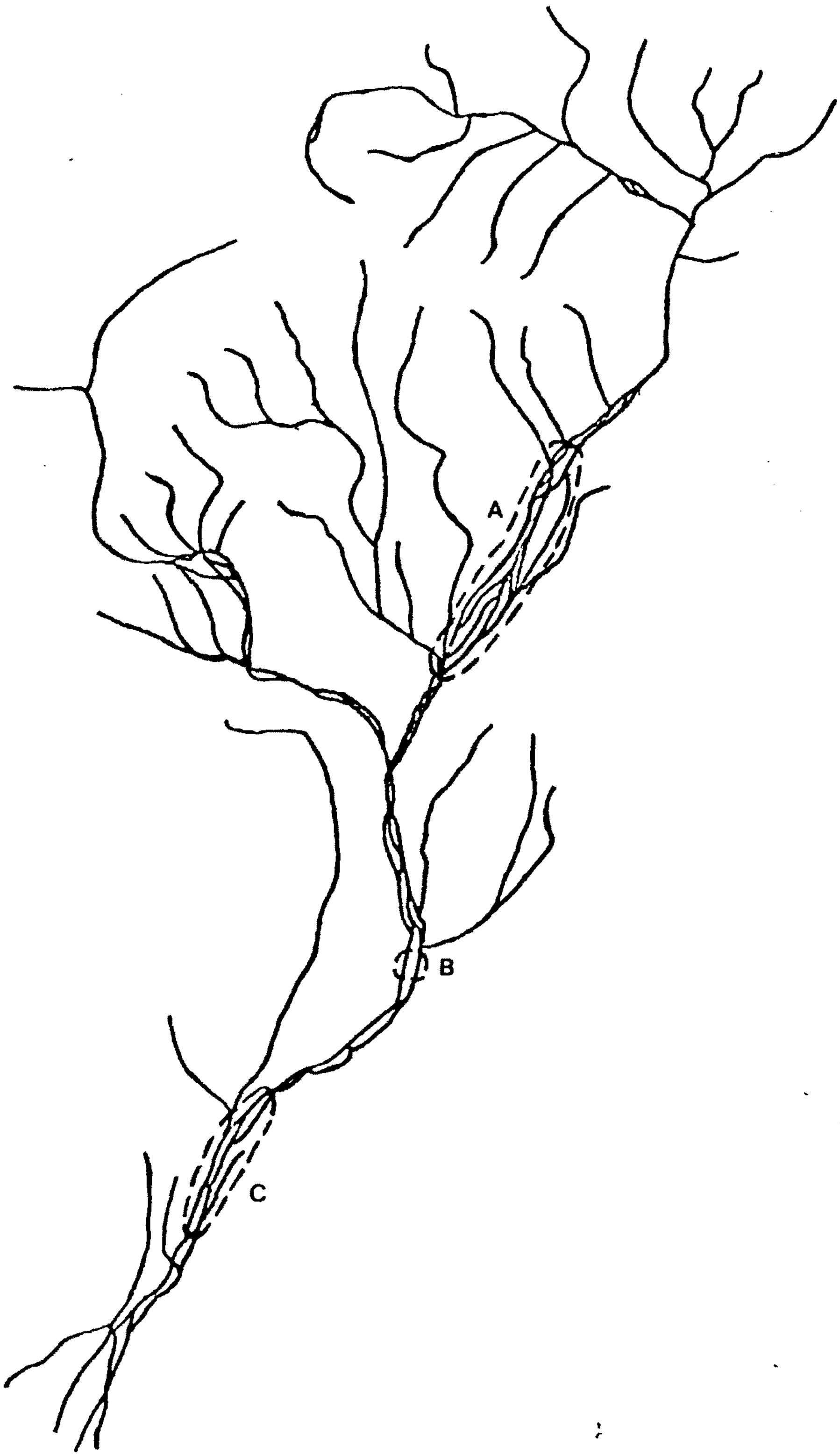

Figure 20. Fish sampling areas on the Katakturuk River.

Physical Characteristics

The Sadlerochit River is a fifth order stream. River distances by stream order and percent braided channel area are shown in Table 17. Stream distance was taken from U.S.G.S. 1:63,360 scale maps. A total of 1326 kilometers of stream drain the Sadlerochit basin. First and second order streams comprise approximately 78% of the total stream distances. Braided channel areas accounted for 19.9% (264 km) of the total stream distance. Channel braiding primarily occured in third, fourth, and fifth order stream sections.

Table 17. River kilometers and percent composition by stream order and percent braided channel area for the Sadlerochit Drainage.

Stream Order	Kilometers	Percent Composition	Braided Channel Kilometers	Braided Channel Percent Composition
1	791	59.7	20	2.5
2	244	18.4	34	13.9
3	159	12.0	88	55.3
4	48	3.6	38	79.2
5	84	6.3	84	100.0
	1326		264	*19.9

*Percent of total river distance.

Gradient characteristics of the Sadlerochit drainage are shown in Figure 21. Approximately 44% of the stream distance had gradients of less than 2.0% (20 m/km). Less than 20% of the total river distance had gradients ranging between 2.0 and 4.0% (20 to 40 m/km). Reaches with gradients greater than 10.0% (100 m/km) accounted for 13% of the total river distance. Percent composition of gradient groups in first order streams was evenly distributed between 0.5 and 10% gradient. Second order streams had primarily gradient of less than 4.0 percent. Gradient of third order stream reaches was less than 3.0 percent with the majority being less than 1.5 percent. Fourth and fifth order stream reaches had gradients generally less than 1.0 (10 m/km).

Physical characteristics of reaches sampled during 1982 (Figure 22) are shown in Table 18. The Sadlerochit main channel (reach S-1) is a low gradient fifth order stream. The channel is extremely braided and has a relatively shallow average depth. It was estimated that approximately 30 percent of this section was pool area with depths ranging from 0.5 to 2.0 meters. Discharge for this section was measured at 13.4 m^3/sec. Reaches S-2 and S-3 are first order streams with gradients of 0.5 and 0.7% respectively. Their channels exhibited a meandering pattern, were shallow, narrow, and had discharges of 0.01 m^3/sec. Itkilyariak Creek (Reach I-1) is a fourth order stream and exhibits a partially braided channel pattern. Slow shallow area was abundant in this reach. Pools were between 0.5 and 2.0 meter deep and accounted for 10% of the area. Discharge in Reach I-1 was 1.85 m^3/sec. The source of most of this water is from Sadlerochit Springs, approximately 25 to 30 km upstream. Itkilyariak tributary I-3 is a narrow first order stream with alternating small pools (1.0 meters day) and riffles. The discharge of reach I-3 was 0.01 m^3/sec.

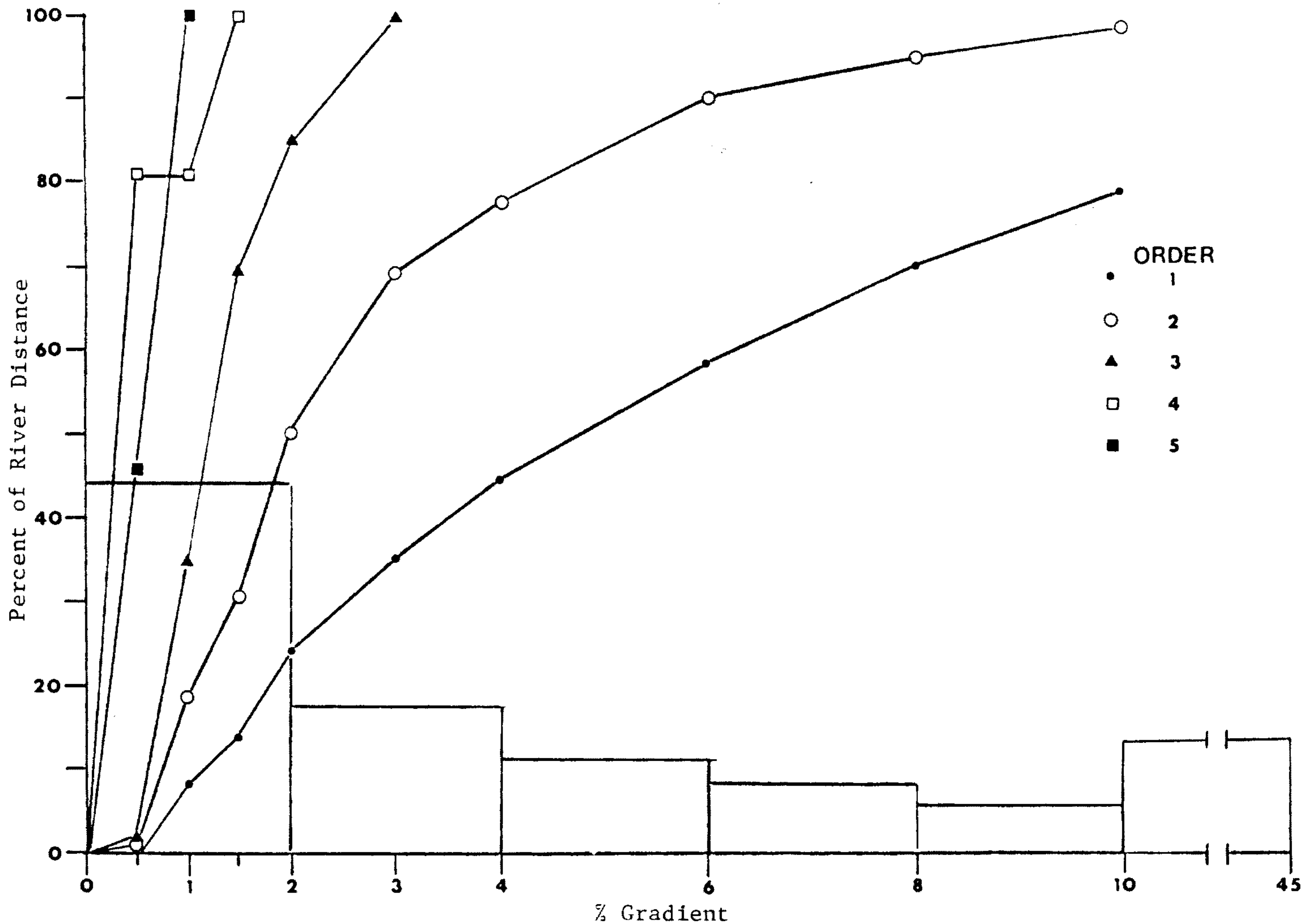

Figure 21. Gradient characterization of the Sadlerochit River (lines represent composition by stream order and boxes represent composition of all reaches combined).

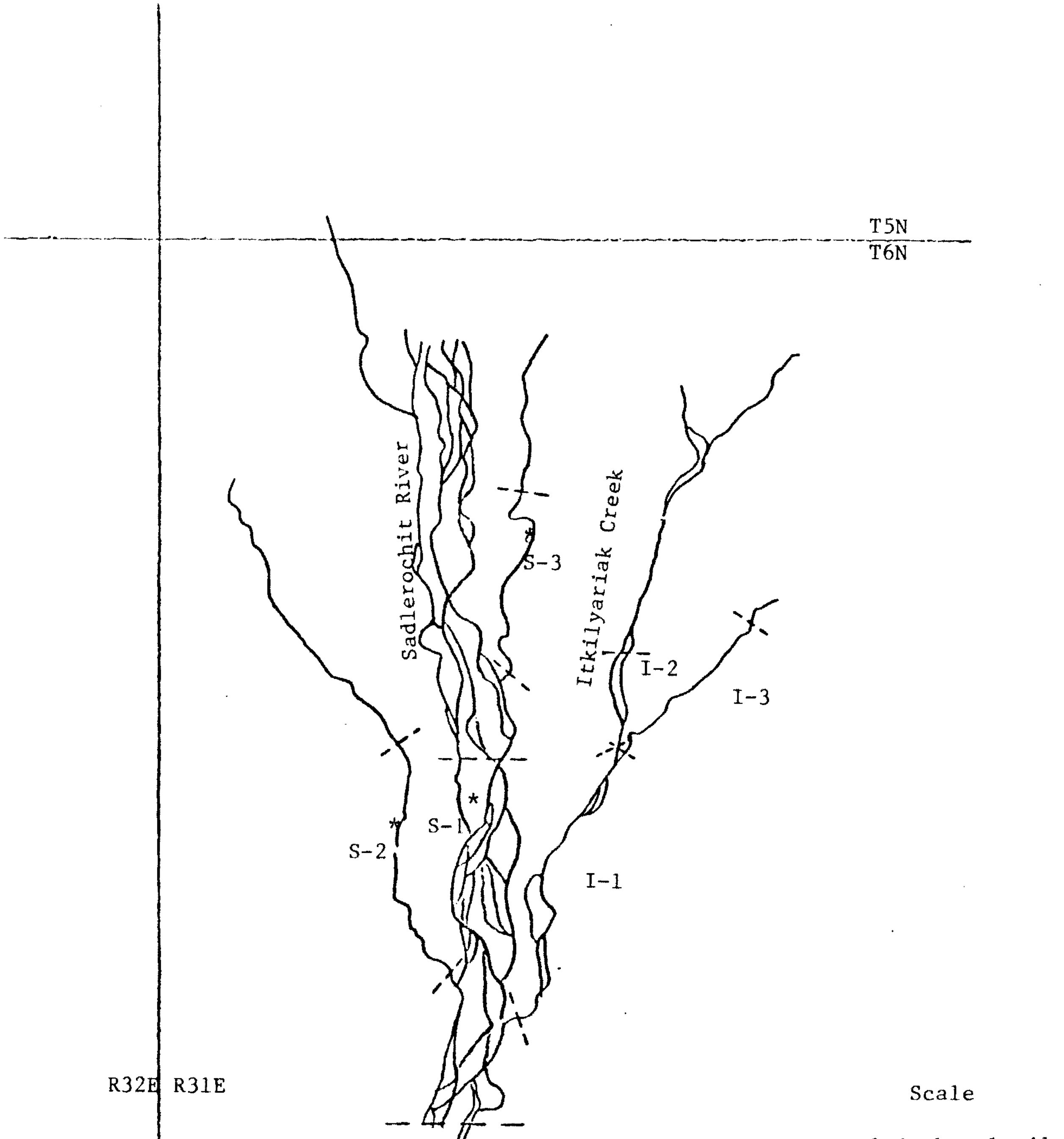

Figure 22. Reaches sampled on the Sadlerochit River during August, 1982. ((---) indicates reach boundaries, (*) indicates discharge sampling sites.)

Talbe 18. Physical characteristics of areas sampled on the Sadlerochit River and Itkilyariak Creek during August 1982.

	Stream Order	Gradient %	Channel Configuration (m)	Wetted Perimeter Width	Channel Width(m)	Ave. Depth(m)	Pool Depth(m)	Discharge (m^3/sec)	Ave. Velocity (m/sec)	% Pool Area	% Riffle Area	% Slow Shallow Area	Predominant Substrate
Sadlerochit													
S-1	5	0.3	Braided		100	0.23	0.5-2.0	13.40	0.68	30.0	40.0	30.0	Rubble, Cobble
S-2	1	0.5	Meandering	1	3- 6	0.13	1.0	0.01	0.09	20.0	5.0	75.0	Silt, Small Gravel, Rubble
S-3	1	0.7	Meandering	3- 8	10-30	0.28	1.0	0.01	0.02	5.0	35.0	60.0	Sand, Small Gravel Rubble
Itkilyariak													
I-1	4	0.4	Irregular Braided	10-30	30-50	0.30	0.5-2.0	1.85	0.4	10.0	35.0	55.0	Large Gravel, Rubble
I-2	4	0.4	-	-	-	-	-	-	-	-	-	-	-
I-3	3	0.5	Irregular	1- 2	1- 2	0.09	1.0	0.01	0.09	40.0	40.0	20.0	Small Gravel

Water Chemistry

Water chemistry for areas sampled on the Sadlerochit River and Itkilyariak Creek is found in Table 19. Total alkalinity and total hardness were lowest at Reach S-1 (85 and 137 mg/l, respectively) and highest at Reach S-3 (171 and 221 mg/l, respectively). Conductivity ranged from 240 umhos/cm at Reach S-1, to 395 umhos/cm at Reach I-1.

Table 19. Chemical characteristics of sample areas on the Sadlerochit River and Itkilyariak Creek.

Reach	Dissolved Oxygen (mg/l)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Conductivity (umhos/cm)	pH
Sadlerochit					
S-1	7	85	137	240	7.8
S-2	10	154	154	255	8.0
S-3	8	171	221	310	8.0
Itkilyariak					
I-1	7	120	205	395	7.8
I-2	10	137	138	250	7.8

Fish Distribution and Abundance

Fish sampling locations and fish species distribution are found in Figure 23 and Table 20. Arctic char, grayling, lake trout, ninespine stickleback and pink salmon have been collected in the Sadlerochit drainage.

Lake resident arctic char, along with grayling and lake trout, are found in Peters-Schrader Lakes. A dwarf stream resident form of arctic char is present in the Sadlerochit Springs area (Craig 1977). Arctic char were also collected from the Ikilyariak and Sadlerochit in the area of their confluence. It is suspected that these fish are either downstream migrants from Peters-Schrader lake or downstream migrants from the Sadlerochit Springs area. Anadromous char have not been positively identified in the drainage, however, one specimen (285 mm fork length), collected in the Itkilyariak lacked parr marks and had the silvery appearance exhibited by sea run char. This may be an immature anadromous char that has wandered from its natal stream area. Craig (1977b) stated that the lack of an adequate supply of ground water in the mainstream makes this drainage unsuitable for char overwinter survival.

Grayling are widely distributed throughout the drainage. They were collected in almost all of the areas sampled. Grayling fry have been found approximately 17 km above the Itkilyariak-Sadlerochit confluence, in a tributary to the Itkilyariak and in the Itkilyariak near its confluence. Adult grayling summer distribution is patchy throughout the main channel of the Sadlerochit River. The majority of those collected were associated with the small amounts of pool area found in the long braided section of the

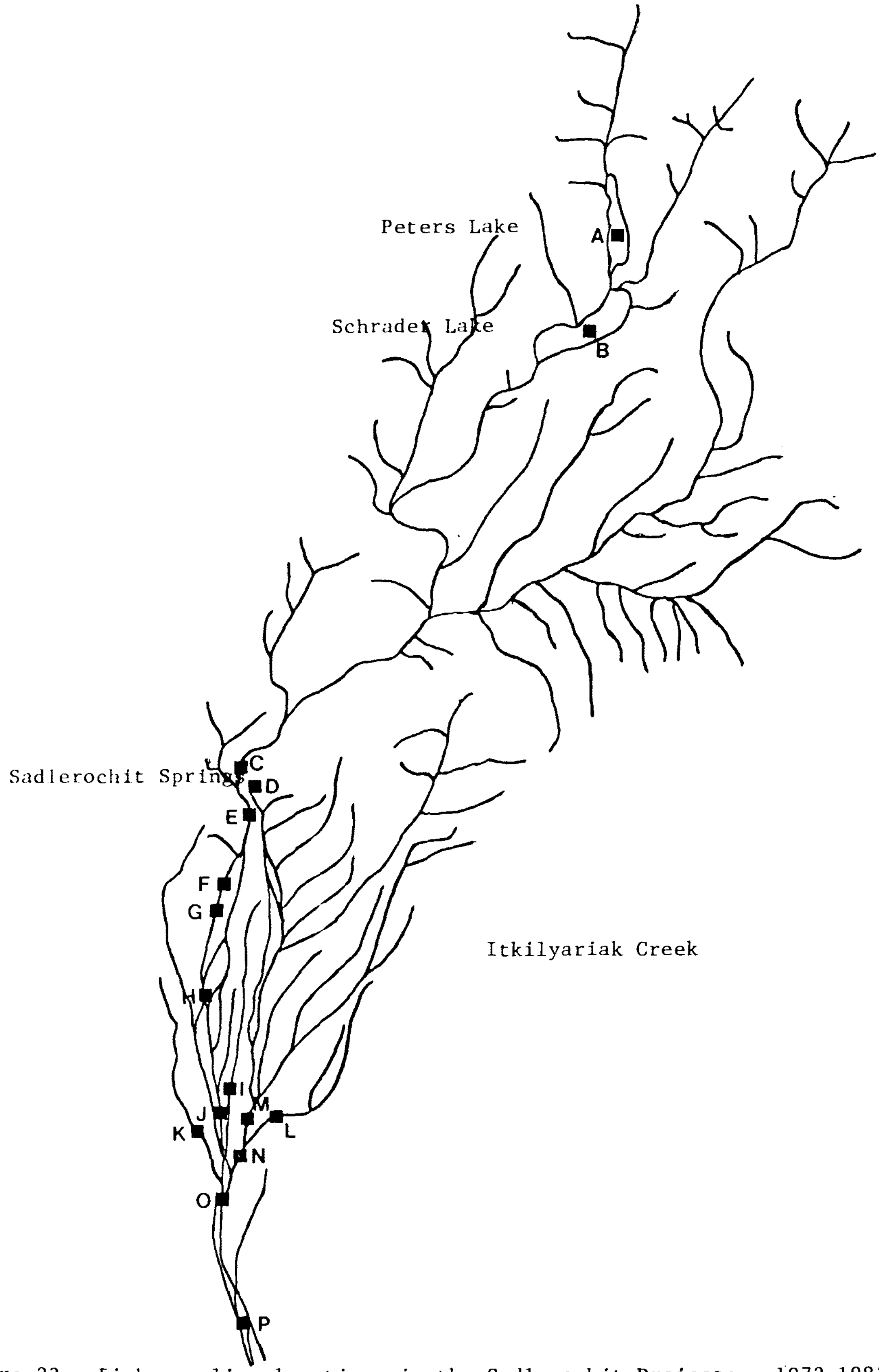

Figure 23. Fish sampling locations in the Sadlerochit Drainage. 1972-1982.

Table 20. Fish distribution in the Sadlerochit Drainage.

Sample Area	Sample Date	Fish Species	Life Stage	Investigators
A (Peters Lake)	8-76, 8-79, 8-80	GR	ALL	Fishery Resources, USFWS, Fairbanks (unpublished field data)
B (Schrader Lake)	1978-80	GR	ALL	Fishery Resources, USFWS, Fairbanks (unpublished field data)
C (Sadlerochit River)	6-23-81	GR	A	Fishery Resources, USFWS, Fairbanks
D (Sadlerochit Sp.)	5-72, 8-72 6-73, 7-74, 9-75	AC(SR) GR	ALL A,J	Craig (1977b)
E (Sadlerochit River)	6-22-81	GR	A	Fishery Resources, USFWS, Fairbanks
F (Sadlerochit River)	7-23-74	GR	J,F	Ward and Craig (1974)
G (Sadlerochit River)	6-24-81	GR	A	Fishery Resources, USFWS, Fairbanks
H (Sadlerochit River)	6-25-81	GR	A	Fishery Resources, USFWS, Fairbanks
I (Trib. to Sadlerochit)	8-13-82	GR	F	Fishery Resources, USFWS, Fairbanks
J (Sadlerochit R.)	6-26-81 8-82	GR GR PS AC	A A,J A J	Fishery Resources, USFWS, Fairbanks
K (Trib. to Sadlerochit)	8-13-82	No fish collected		Fishery Resources, USFWS, Fairbanks
L (Trib. to Itkilyariak	8-7-82	GR AC	J,F J	Fishery Resources, USFWS, Fairbanks
M (Itkilyariak Creek)	8-82	GR NSB	A	Fishery Resources, USFWS, Fairbanks
N (Itkilyariak Creek)	8-82	GR AC AC(SR)	A,F J A	Fishery Resources, USFWS, Fairbanks
O (Sadlerochit River)	8-82	GR	A,J	Fishery Resources, USFWS, Fairbanks
P (Sadlerochit River)	6-27-81	GR	A	Fishery Resources, USFWS, Fairbanks

PS - Pink Salmon
GR - Grayling
AC - Arctic Char LR - Lake Resident SR - Stream Resident
LT - Lake Trout
NSB - Ninespine Stickleback
A - Adult J - Juvenille F - Fry

mainstem. One ninespine stickleback was collected in Itkilyariak Creek just above its confluence with the Sadlerochit River. One pink salmon was collected in the Sadlerochit River near the Itkilyariak confluence.

Relative abundance and mean length of fish collected in the Sadlerochit and Itkilyariak rivers during August 1-15, 1982 is shown in Table 21. Grayling were abundant in the sampling area. Gillnet catch rates were 0.40 fish per hour on the Sadlerochit River and 0.88 fish per hour on Itkilyariak Creek. Angling catch rates were much greater, 3.83 fish/hr. for the Sadlerochit River and 5.10 fish/hr. on Itkilyariak Creek. Arctic char were not very abundant in the sample area. A total of 20 char were captured by gillnet, with catch rates of 0.09 fish/hr. in the Sadlerochit river and 0.02 fish/hr. in Itkilyariak Creek. Baited minnow trap sampling in Itkilyariak Creek resulted in a catch rate 0.13 char/hr.

Table 21. Mean length and catch-per-hour of grayling and arctic char collected by gillnets*, angling, and baited minnow traps in the Sadlerochit Drainage, August 1-15, 1982.

	Species	Total No. of Fish	Total Effort (Hrs.)	Mean Fork Length(mm)	Length Range(mm)	Catch per Hour
Sadlerochit R.						
Gillnet	Grayling	68	170.5	313	221-488	0.40
	Arctic Char	16	170.5	125	106-233	0.09
Angling	Grayling	44	11.5	318	279-378	3.83
Itkilyariak Cr.						
Gillnet	Grayling	155	175.8	325	115-385	0.88
	Arctic Char	4	175.8	184	114-285	0.02
Angling	Grayling	59	11.5	330	268-390	5.10
Baited Minnow Trap	Arctic Char	20	150.0	122	111-149	0.13 +

*Experimental gillnet, 5-25 feet panels of 1/2, 1, 1 1/2, 2, 2 1/2 inch bar mesh size.

Length Frequency

Length frequency histograms for grayling and arctic char in the Sadlerochit Itkilyariak sampling area are presented in Figure 24 and 25. At both sample areas, grayling were predominantly within the 300 to 359 mm length group. Length frequencies of grayling at both the Itkilyariak and Sadlerochit River were very similar with the exception of a few fish under 220 mm fork length being sampled from Itkilyariak Creek.

Length frequency of char was combined for both sample areas. Approximately 90 percent of the char sampled were between 100 and 139 mm fork length.

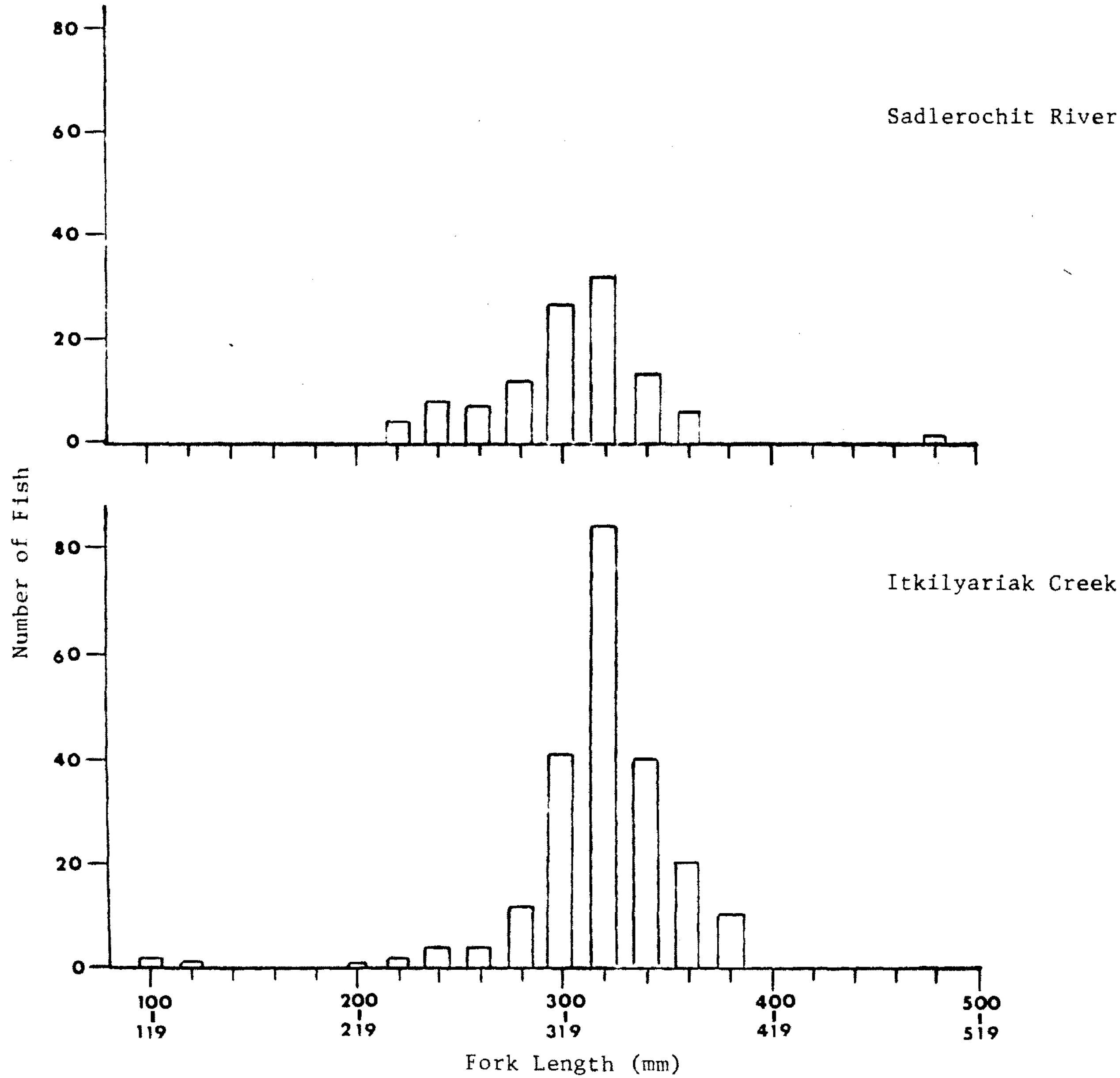

Figure 24. Length frequency of grayling collected in the Sadlerochit River and Itkilyariak Creek, August 1-15, 1982.

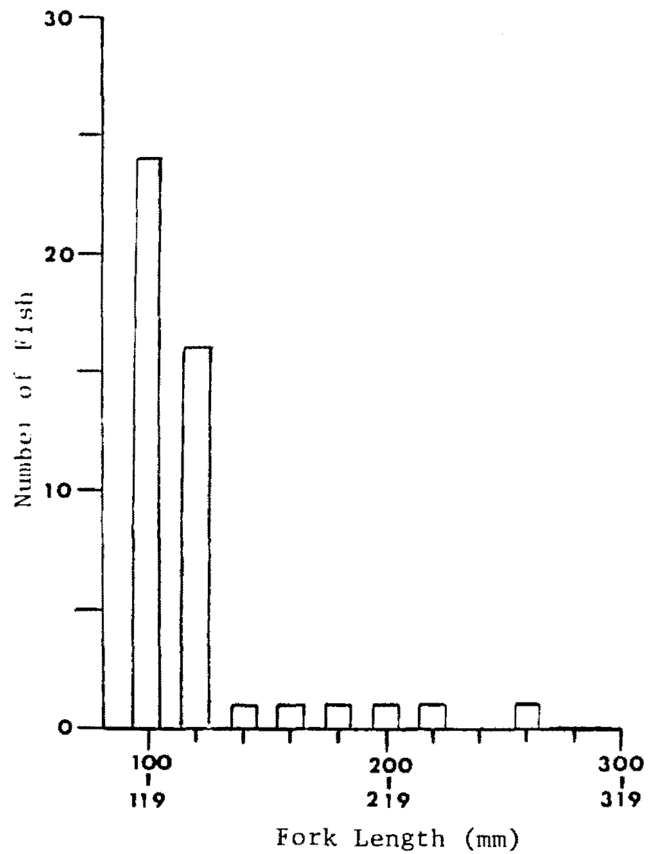

Figure 25. Combined length frequency of arctic char collected in the Sadlerochit - Itkilyariak sampling area, August 1-15, 1982.

Age and Growth

Age and growth information for grayling and arctic char are shown in Table 22. Grayling age groups 4 through 6 and 7 through 13 were represented. Grayling growth was relatively slow with four year old fish averaging 234 mm and eight year old fish averaging 312 mm fork length. Arctic char age groups 2, 3, and 5 were sampled. Growth of these char was slow with two year old fish averaging 113 mm, three year old fish averaging 121 mm and five year old fish averaging 166 mm. These growth rates fall within the ranges given by Craig (1977) for char collected in the Sadlerochit Spring area (Figure 26).

Table 22. Age-specific length (otolith) of grayling and arctic char collected from the Sadlerochit and Itkilyariak Rivers, August 1-15, 1982.

Age	Number	Mean Fork Length (mm)	Standard Deviation	Length Range (mm)
		Grayling		
1	0	-	-	-
2	0	-	-	-
3	0	-	-	-
4	1	234	-	-
5	5	239	18.0	221-259
6	4	283	18.3	262-301
7	0	-	-	-
8	2	312	7.1	307-317
9	6	328	11.7	309-341
10	6	324	16.0	295-342
11	3	338	8.7	328-344
12	4	353	11.7	343-369
13	1	364	-	-
		Arctic Char		
1	0	-	-	-
2	5	113	7.7	104-125
3	5	121	5.2	111-127
4	0	-	-	-
5	3	166	16.1	149-181

Weight and Condition

A length-weight regression for grayling was calculated from the combined Itkilyariak-Sadlerochit sample. The regression included 75 fish, with a length range of 115 to 390 mm fork length.

$$\log_{10}W = 3.01 \log_{10}L - 4.99 \quad r=0.99$$

W = weight in grams
L = fork length in millimeters

Grayling condition (K) was also determined using combined data and was stratified by 50 mm length groups (Table 23).

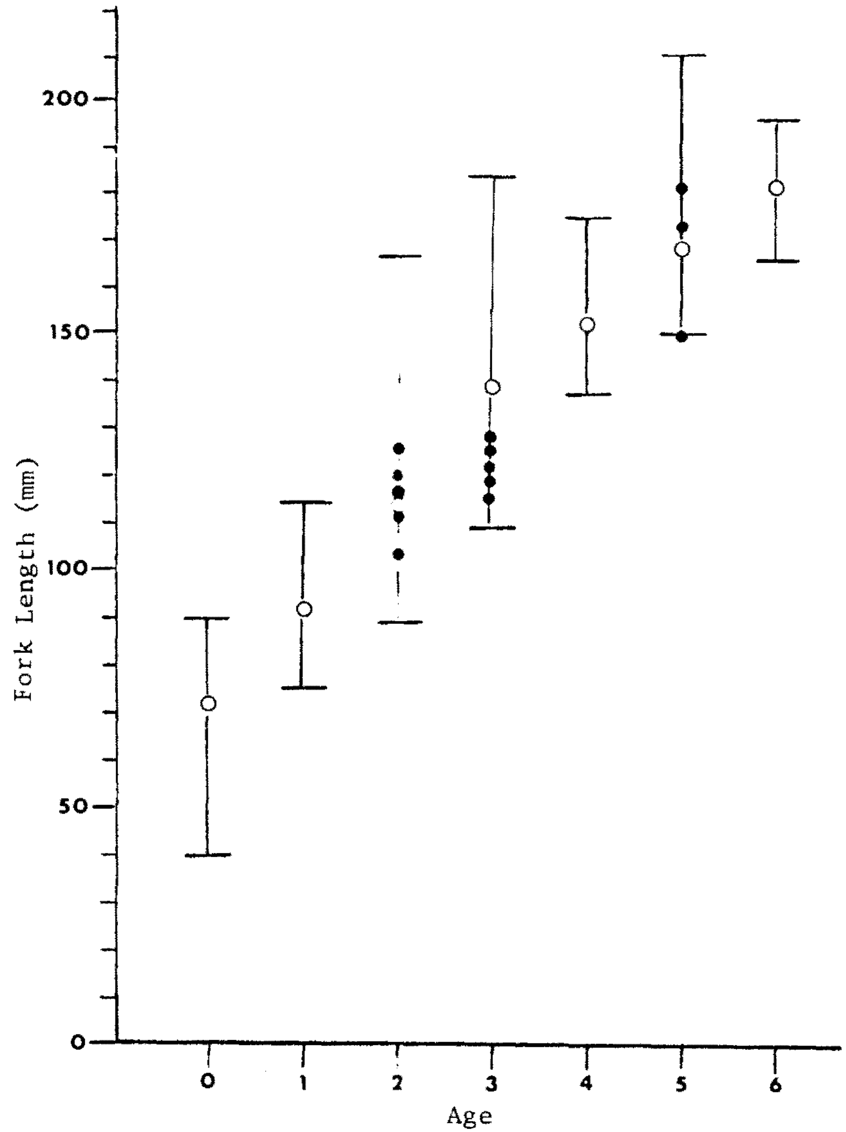

Figure 26. Age-specific mean length and range for arctic char from Sadlerochit Springs (○) (Craig, 1977) and age-specific length for arctic char collected in the Sadlerochit - Itkilyariak confluence area (●) between August 1 and 15, 1982.

Table 23. Coefficient of condition (K) for grayling collected in the Sadlerochit-Itkilyariak sampling area, August 1-15, 1982.

Length Group (mm)	Number in Sample	Mean K	Standard Deviation
100-149	3	0.92	0.026
150-199	0	-	-
200-249	10	1.12	0.026
250-299	20	1.14	0.056
300-349	40	1.07	0.068
350-399	10	0.93	0.080

Fish Spawning and Overwintering

Grayling: Grayling are widely distributed throughout the Sadlerochit drainage.Greatest numbers have been collected in the Peters-Schrader Lakes area and at the Sadlerochit-Itkiyariak confluence area. Spawning areas have been located in tundra stream tributaries to the Itkilyariak and Sadlerochit near their confluence and approximately 15 km upstream from the confluence. It is also assumed that spawning takes place in tributaries and the outlet to Peters-Schrader Lake. USFWS biologists surveyed a 1000 meter section of river below the outlet to Schrader Lake and found adult and juvenile grayling in moderate abundance (Crateau, 1976).

With the exception of Peter-Schrader Lake and Sadlerochit Springs very little overwintering habitat is available. Very few grayling were found in Sadlerochit Springs and is most likely not of much importance as overwintering habitat for grayling. In the main channel of the Sadlerochit River, only few suitable pools have been identified, downstream from the channel in the area adjacent to Sadlerochit Springs. In this general area, Ward and Craig (1977) found that the channel was frozen solid in November. The area upstream from this point has not been investigated throughly, however, aerial photographs indicate that channel braiding is less extensive and consequently more pool area may be available.

Arctic Char: The dwarf population of char identified by Craig (1977) at Sadlerochit Springs spawn and overwinter in the spring channel upstream from the large aufeis field. Char found in Peter-Schrader Lakes are of a much larger variety (fish of over 600 mm have been collected by Paul Fischer, USFWS, unpublished field data). It is assumed that they spawn in the lakes or their nearby tributaries and outlets. Paul Fischer (personal communication) indicated that large concentration of mature arctic char were found near the outlet of Schrader Lake during late August. Char collected in the Sadlerochit-Itkilyariak confluence area were primarily juveniles and little is known about their origin and overwintering area.

Fish Movement

Very little is known about fish movement in the Sadlerochit drainage. During 1979 and 1980 a total of 257 grayling and 177 arctic char from Peters-Schrader Lake were tagged with numbered floy dart tags. None of these fish were captured during subsequent sampling. During 1982 an additional 291 grayling were tagged with numbered floy dart tags in the Sadlerochit- Itkilyariak confluence area.

ACHILIK RIVER

Fishery investigations on the Aichilik River were initiated during June of 1982 and again in September. Previous work was accomplished by Aquatic Environments Limited - Calgary, Alberta. They sampled at two locations along a proposed route of the gas pipeline that traversed the Arctic Coastal Plain.

Study Area

The Aichilik River is a primarily braided stream that flows 115 km from its headwaters, in the Romanzof Mountains, to its mouth at the Beaufort Lagoon. The Aichilik River drains an approximate area of 190,000 hectares (733 $mi.^2$). Two spring areas have been identified on the Aichilik River. Childers, et. al. (1977) determined discharge (0.042 m^3/sec) and temperature (3.6°C) for the spring located at 69°31' N latitude and 143°02' W longitude. Another spring is located upstream approximately 20 km upstream at 69°22' N latitude and 143°05' W longitude. Discharge and temperature information is not available at this site. There are only two small lakes (25 hectares) connected to the drainage.

Physical-Chemical Characteristics

The Aichilik River, at its mouth is a fifth order stream of which 62% is first order and 19.5% second order (Table 24). Braided channel area was primarily found in fourth and fifth order reaches and comprised 10.6% of the total river network distance (1416 km).

Table 24. River kilometers, percent composition by stream order and percent braided channel for the Aichilik River.

Stream Order	Kilometers	Percent Composition	BRAIDED CHANNEL Kilometers	BRAIDED CHANNEL Percent Composition
1	874	61.8	0	0.0
2	276	19.5	5	1.8
3	87	6.1	9	10.3
4	84	5.9	41	48.8
5	95	6.7	95	100.0
	1416		150	*10.6

*Percent of total river distance.

The Aichilik is a moderately steep gradient river. A large portion of its terminal drainage area is in the mountains resulting in steep gradients for first and second order reaches (Figure 27). Over 50 percent of the entire drainage network has gradients ranging from 10 to 50 percent. The majority of

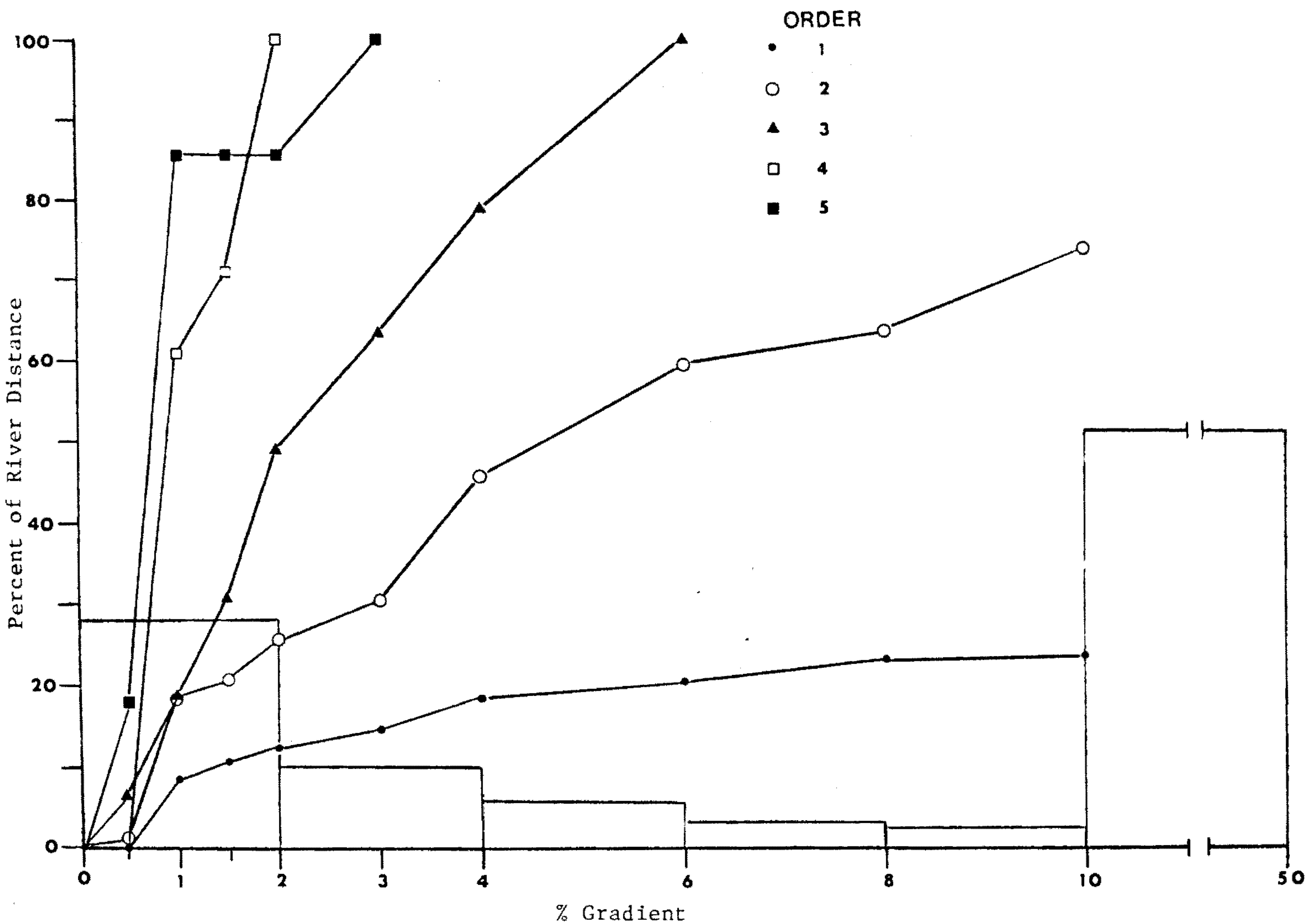

Figure 27. Gradient characterization of the Aichilik River (lines represent gradient composition by stream order and boxes represent composition of all reaches combined).

these reaches probably exhibit intermittent flow. Reaches with gradients less than 2.0 percent account for 28 percent of the total river network distance. These channel sections are primarily third, fourth, and fifth order and, with the exception of extremely braided areas, offer more suitable habitat for fish populations.

Discharge was determined for the east and west forks of the Aichilik River in T1N, R37E on September 23, 1982. Discharge for the East Fork was 1.16 m^3/sec. The channel was 9.8 meters wide and average depth was 0.35 meters. The west fork was 19.5 meters wide and had a average depth of 0.25 meters and discharge of 1.63 m^3/sec. Water chemistry sampling was done in the area immediately downstream from the confluence of the east and west forks. Water temperature was 4°C, pH was 8.0, conductivity was 340 umhos/cm, total alkalinity was 136 mg/l and total hardness was 272 mg/l.

Fish Distribution and Abundance

Figure 28 shows sample sites where fisheries information was collected. The two known spring areas are also found in Figure 28. Fish distribution for the various sampling locations are shown in Table 25.

Table 25. Fish distribution in the Aichilik River.

Sample Area	Latitude	Longitude	Fish Species	Life Stage(s)	Comments
A	69°23'09"	143°04'	AC	A	Aerial survey, USFWS Fishery Resources, Fairbanks. 9/26/82
B	69°26'11"	143°02'	AC-An,R GR	ALL A,J	USFWS, Fishery Resources, Fairbanks. 9/82
C	69°29'28"	142°46'	AC-An,R GR	ALL A,J	USFWS, Fishery Resources, Fairbanks. 6/82, 9/82
D	69°35'50"	142°57'	GR	A	USFWS, Fishery Resources, Fairbanks. 6/82
E	69°41'00"	142°46'	GR AC-R	J J	Ward and Craig (1974) 7/74
F	69°40'53"	142°35'	No fish were collected in 7/74. Channel frozen to bottom in 9/74.		Ward and Craig (1974)
G	69°50'09"	142°09'	GR AC-An	A A	USFWS, Fishery Resources, Fairbanks. 6/82

AC - Arctic Char A - Adult An - Anadromous
GR - Grayling J - Juvenile R - Anadromous presmolts and residuals

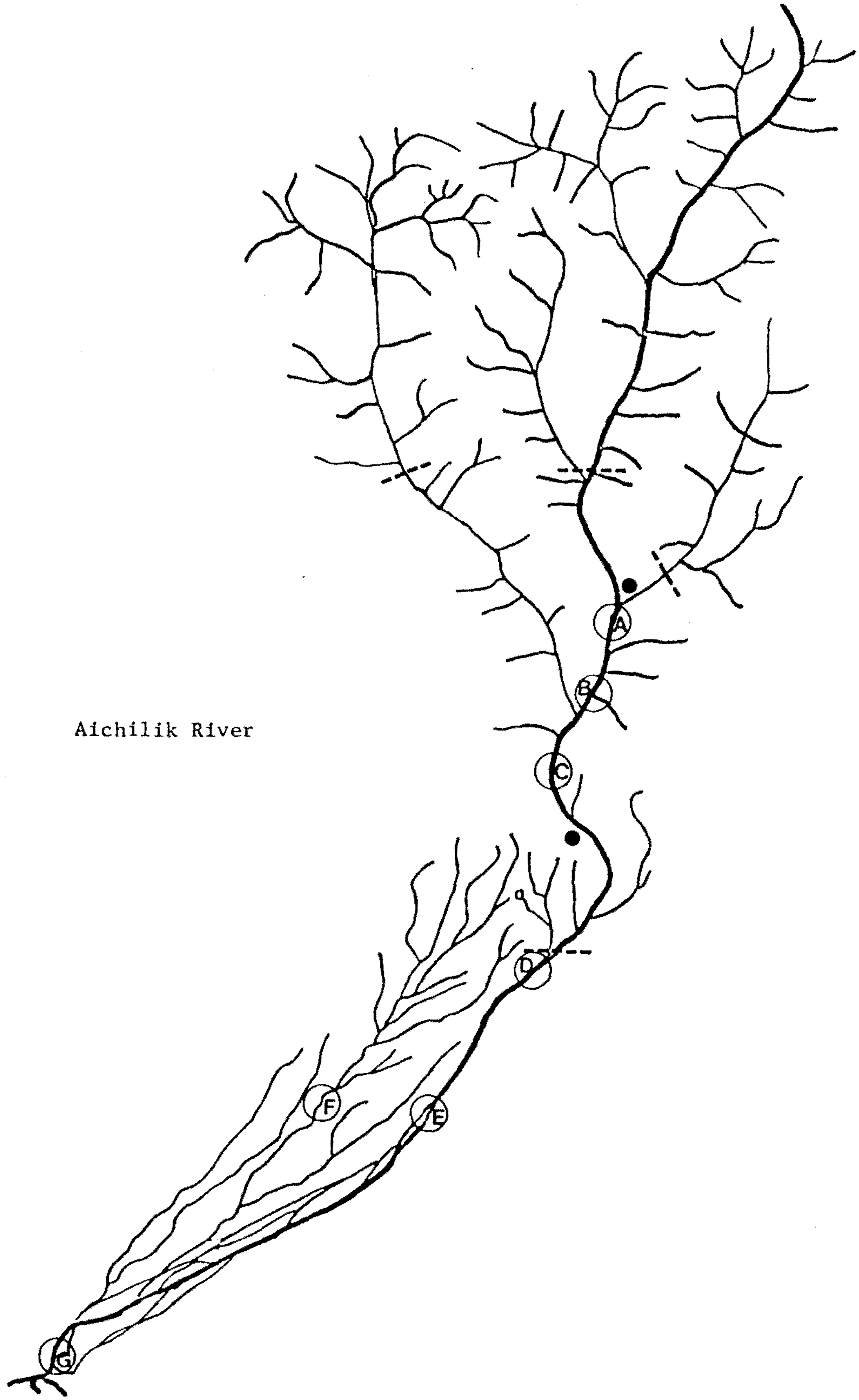

Figure 28. Fish sampling locations, spring locations (●) and aerial census boundaries (--) for the Aichilik River.

Arctic Char: Arctic char were collected in almost all sample areas with the exception of sample sites D and F. All of the char in the Aichilik River are from anadromous stock, however a portion of the population never migrate to the sea. These fish are called residuals and are generally much smaller in size, retain their parr marks after maturity, and are predominantly male fish. In the Aichilik River discussion, these residuals are included with anadromous presmolts and are refered to as resident char.

An aerial survey of the Aichilik River (channel sections indicated in Figure 28) on September 26, 1982 showed a large concentration of arctic char (2000-4000) in location A, which is immediately downstream from a spring. A few other fish were spotted downstream in location B. No other fish were observed during the aerial survey. Mean length and catch/hour of arctic char are found in Table 26. Location C was sampled by experimental gillnet in June, 1982. Gillnets and angling were used to sample locations B and C in September 1982. Gillnet catch-rate of anadromous char was greater during June at location C than in September. Angling catch-rates for both anadromous and resident char was much greater at location B in September. Gillnet catch-rates did not reflect this difference. Arctic char fry and juveniles were much more abundant in the location B sampling area than in the location C area, as determined from observations during the September 1982 survey. Juvenile char were collected at location E in July, 1974 by Ward and Craig (1974) and one adult anadromous char was collected near the Aichilik mouth (Location G) in June 1982.

Table 26. Mean length and catch/hour of arctic char in the Aichilik River.

Date	Sample Location	Total No. Of Fish Collected	Total Effort (hrs)	Mean Fork Length (mm)	Length Range (mm)	Catch/Hr.
			Experimental Gillnet - Resident Char			
9/82	B	7	61.25	241	113-402	0.11
9/82	C	15	60.75	234	120-270	0.25
			Experimental Gillnet - Anadromous Char			
9/82	B	4	61.25	513	460-600	0.06
9/82	C	2	60.75	346	262-429	0.03
6/82	C	2	5.75	433	380-485	0.35
6/82	D	0	5.75	-	-	0.00
6/82	G	1	5.50	435	-	0.19
			Angling - Resident Char			
9/82	B	29	18.50	234	98-320	1.56
9/82	C	5	7.00	250	234-275	0.71
			Angling - Anadromous Char			
9/82	B	22	18.50	474	318-629	1.19
9/82	C	1	7.00	431	-	0.14

Grayling: Grayling were collected at all locations sampled, with the exception of Location F. During the September 1982 sampling period, grayling were collected less frequently than char at location B (Table 26 and 27). Catch per unit effort of char and grayling was nearly equal for angling effort at location C during the September sampling period, however char were caught more frequently in the gillnets. Catch-rate of grayling at location C, in June 1982 was much greater than the catch-rate at that location in September. During June 1982, the largest concentration of grayling were found at location G, near the mouth of Aichilik.

Table 27. Mean length and catch/hour of grayling in the Aichilik River.

Date	Sample Location	Total Numbers of Fish Collected	Total Effort Hrs.	Mean Fork Length (mm)	Length Range (mm)	Catch/ Hr.
			Experimental Gillnet			
9/82	B	2	61.25	284	225-343	0.03
9/82	C	5	60.75	304	102-380	0.08
6/82	C	7	5.75	280	265-310	1.22
6/82	D	5	11.75	352	330-380	0.42
6/82	G	32	5.5	365	335-385	5.80
			Angling			
9/82	B	21	18.5	320	119-395	1.14
9/82	C	10	7.0	274	108-376	1.43

Age and Growth

Age specific lengths, determined by otoliths, for grayling and arctic char collected from the Aichilik River during September 18-23, 1982 are found in Tables 28 and 29. This information only presents a general idea of age-length relationships, because of the small sample size.

Combined age-length and length frequency information (Figure 29) show that grayling age frequency was comprised of primarily fish 4 to 6 years old and fish 10 to 14 years old in the areas sampled in September 1982. A wide range of size classes of arctic char were present in the sampling area (Table 29). Resident char (anadromous presmolts and residents) ranged from 70 to 320 mm fork length. The majority of the resident char were age 5 to 7. The oldest resident char collected was a 9 year old residual male, 320 mm long. Anadromous char ranged from 315 to 629 mm in fork length and were represented by age classes from 5 to 13. The majority of the fish were between ages 6 and 9.

From a sample of 25 anadromous char it was determined that 16% were immature, 40% were mature nonspawners and, 44% were spawners of which 20% were spawned out.

Table 28. Age specific length (otolith) of grayling collected from the Aichilik River, September 18-23, 1982.

Age	Number	Mean Fork Length (mm)	Standard Deviation	Length Range (mm)
1				
2	1	108	-	-
3	1	117	-	-
4	1	210	-	-
5	3	224	3.39	219-227
6	1	223	-	-
7				
8				
9				
10	1	315	-	-
11	3	353	16.67	336-369
12	3	364	11.78	352-380
13	1	363	-	-
14	1	380	-	-

Table 29. Age specific length (otolith) of resident* and anadromous arctic char collected in the Aichilik River, September 18-23, 1982.

		Resident		
Age	Number	Mean Fork Length (mm)	Standard Deviation	Length Range (mm)
1	3	74.6	3.39	70- 78
2	4	106.8	3.56	103-112
3	2	126.5	4.50	122-131
4	2	194.0	4.00	190-198
5	12	251.0	17.55	227-277
6	6	259.6	8.88	245-270
7	1	245.0	-	-
8				
9	1	320.0	-	-

		Anadromous		
Age	Number	Mean Fork Length (mm)	Standard Deviation	Length Range (mm)
5	2	332.5	17.50	315-350
6	1	429.0	-	-
7	5	449.6	14.00	432-468
8	2	456.0	4.00	452-460
9	3	495.3	13.69	479-506
10	2	568.5	36.50	532-605
11	1	600.0	-	-
12				
13	1	629.0	-	-

*Resident includes anadromous presmolts and residual char.

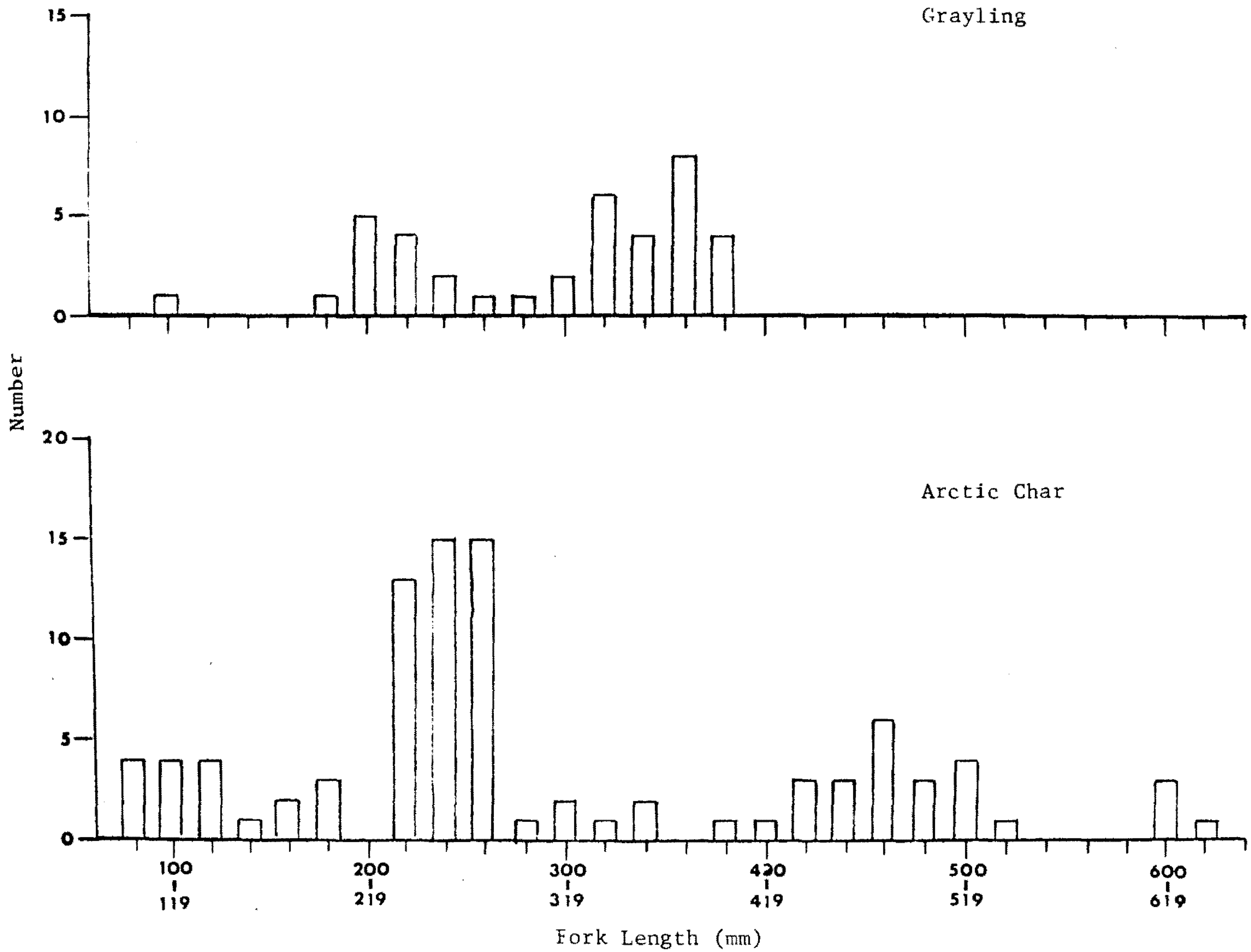

Figure 29. Length frequency of grayling and arctic char collected in the Aichilik River, September 18-23, 1982. (Arctic char length frequency includes both resident and anadromous fish.)

Weight and Condition

The following length-weight relationships were calculated for arctic char and grayling collected during the September 18-23 sampling period.

Grayling (N=39, r=0.992, range - 108 to 380 mm):

$$\text{Log}_{10} W(g) = 2.933 \text{ Log}_{10} L(mm) - 4.898$$

Resident Arctic char (N=60, r=0.994, range - 70 to 320 mm):

$$\text{Log}_{10} W(g) = 3.149 \text{ Log}_{10} L(mm) - 5.420$$

Anadromous Arctic char (N=28, r=0.950, range - 350 to 629 mm):

$$\text{Log}_{10} W(g) = 3.075 \text{ Log}_{10} L(mm) - 5.269$$

Coefficient of condition (K) was calculated for grayling and char collected during September 18-23, 1982 (Tables 30 and 31). These values are also subject to errors associated with small sample size.

Table 30. Coefficient of condition (K) for grayling collected from the Aichilik River, September 18-23, 1982.

Length Group (mm)	Numbers in Sample	Mean K	Standard Deviation
100-149	1	0.71	-
150-199	1	0.89	-
200-249	9	0.92	0.03
250-299	3	0.94	0.11
300-349	10	0.89	0.09
350-400	14	0.81	0.06

Table 31. Coefficient of condition (K) for arctic char collected from the Aichilik River, September 18-23, 1982.

	Resident						Anadromous								
Length Group	Pre-smolts and Residuals			Immature			Non Spawners			Spawners			Spawned Out		
(mm)	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.
100-149	7	0.79	0.09												
150-199	6	0.85	0.02												
200-249	20	0.85	0.09												
250-299	23	0.89	0.08												
300-349				2	0.88	0.02									
350-399				2	0.85	0.01	1	1.02	-						
400-449							2	0.92	0.02	1	0.96	-	1	0.68	-
450-499							3	0.96	0.10	3	0.90	0.02	1	0.65	-
500-549							2	1.03	0.13	2	0.86	0.03	1	0.74	-
550-599															
600-649							2	0.96	0.03				2	0.74	0.06

Mean "K" for grayling (Table 30) ranged between 0.71 for the 100-140 mm size class to 0.94 for the 250-299 mm size class. Most of the "K" values for grayling ranged between 0.81 and 0.94. Arctic char "K" values were separated by resident and anadromous fish. Resident char "K" values ranged between 0.79 to 0.89. Anadromous char mature nonspawners exhibited the highest "K" values (0.92 to 1.03). Mature spawners had "K" values ranging from 0.90 to 0.96. The coefficient of condition for spawned out char was much lower (0.68 to 0.74).

Spawning and Overwintering

Overwintering habitat in the Aichilik appears to be limited. Pool habitat is primarily associated with the two spring areas, location B (Figure 2) and possibly near the mouth of the Aichilik River. Some pools (up to 2 meters deep) were found in upper river, braided, channel sections, however they were not very common.

The large numbers of arctic char observed at the upstream spring, during the late September aerial survey, and observations of large numbers of juveniles and fry, in an area about 3 km downstream indicate that this may be the primary spawning and overwintering areas for char. Although char were collected at locations B and C, no spawning activity was observed. Char were not observed at the downstream spring during the aerial survey, however they may use this area.

Little is known about grayling spawning and overwintering habitat in the Aichilik River. The area near the mouth of the Aichilik may provide overwintering habitat. During late June a large number of adult grayling were collected in this area.

Fish Movement

Anadromous char probably enter the Aichilik during late July to early August and proceed to the upper spring areas to spawn. By late September, it appeared that most fish had arrived on the spawning grounds and a few, collected several kilometers downstream, had already spawned. Spring outmigration is assumed to occur immediately after breakup with most char out of the river by mid June. One anadromous char was collected a few miles upsteam from the mouth on June 26, 1982. Another anadromous char was collected at location C on June 23, 1982.

During the June survey 36 grayling were tagged with numbered floy anchor tags.

DISCUSSION

Spawning and Overwintering Habitat

Overwintering habitat is probably the single most important variable affecting fish populations in arctic rivers. With the exception of perennial groundwater sources, winter flow is generally immeasurable (Murphy and Greenwood, 1971, Arnborg et. al., 1966, McCart et.al., 1972). During this period overwintering areas are limited to spring areas, deep isolated pools, deeper lakes, and brackish river delta areas (Wilson et. al. 1977). A more detailed literature review on arctic overwintering habitat is included in the "Initial Report Baseline Study of the Fish, Wildlife and Their Habitats" (USFWS, 1982).

Several physical characteristics of streams, affecting the amount of overwintering habitat (pools) include channel width, depth, velocity, discharge, channel pattern, gradient, bank stability and substrate. The amount of pool habitat in a river channel is a result of the complex interrelationships between these variables.

Stream order, gradient, and channel pattern were examined for some ANWR streams during 1982. These variables incorporate several morphometric parameters previously listed. Stream order is representative of channel width, discharge, and to a lesser degree, substrate and gradient. With increasing stream order, channel width and discharge tend to increase and gradient and substrate particle size tend to decrease. Channel pattern is related to gradient, depth, width, bed resistance, and bank stability. The greatest amount of pool area is generally found in meandering channels where the stream bed offers less resistance to the erosive action of water than the stream banks, consequently the depth increases. Braided channels are found where the banks erode much faster than the stream bed. The majority of the streams scouring and erosive action occurs during spring floods. Meandering channels concentrate the water into narrower channels and enhance the scouring action. In braided channels, this action is moderated by the dissolution of the streams energy as it spreads across a wide channel. In mountainous sections of the study area, braided channels are often confined or constricted in narrower canyons. These areas generally have more pool area than other braided sections.

Table 32 compares physical parameters for four streams located in the study area. Most deeper pools located were found in fourth and fifth order channel sections that were not extensively braided. Third order channel sections may also provide some pool area deep enough for fish overwintering, particularly in lower gradient meandering streams. These stream sections comprised a small percentage of the total stream distance. Comparisons between gradient and fish distribution, from data collected during 1981 and 1982 and from previously known distribution information, show that grayling and arctic char are seldom found in channel sections with gradients greater than 4.0 percent (the majority are found in areas with gradients less than 2.0 percent). All fourth and fifth order stream sections had gradients less than 4.0 percent. Much of the Aichilik and Katakturuk Rivers had gradients exceeding 4 percent. This was due to the large proportion of lower order streams draining mountainous areas. Channel braiding occurred most frequently in fourth and fifth order channel sections. Degree of channel braiding was greatest in the Katakturuk River and lowest in the Tamayariak River.

Stream distance with potential for overwintering habitat was determined by including only those channel sections with gradients less than 4.0 percent, stream orders greater than 4 and those areas that were not braided (this excludes the influence of springs on available overwintering habitat). Results shown in Table 32 indicate that the potential for overwintering habitat was greatest in the Aichilik and Tamayariak Rivers and lowest in the Katakturuk. This corresponds well with fishery investigations, which showed established fish populations in all of the rivers except the Katakturuk. This index is probably more useful in evaluation of grayling distribution, which do not depend on perennial ground water sources for overwintering and spawning as much as char do. The index also indicates that very small portions of the total stream networks are suitable for development of pools, that would be deep enough to provide overwintering habitat. On the Canning River a

Table 32. Comparison of physical parameters for the Aichilik, Katakturuk, Sadlerochit and Tamyariak Rivers in the Arctic National Wildlife Refuge.

	Total Stream Distance (km)	Total Distance (km) for 4th and 5th Order Channel	Percent of Stream With Gradient Less than 4.0%	Braided Channel (%) Order		*Kilometers of Stream with Potential Overwintering Habitat Order	
				4th	5th	4th	5th
Aichilik River	1416	179	38.0	49.0	100.0	42	0
Katakturuk River	530	64	52.0	100.0	100.0	0	0
Sadlerochit River	1326	132	62.0	79.0	100.0	10	0
Tamayariak River	582	52	76.0	63.0	0.0	16	10

*Potential for suitable overwintering habitat includes channel sections with gradients less than 4.0%, stream order greater than 4 and with an unbraided channel pattern. This excludes the influence of springs.

recording fathometer was used to determine the number of suitable overwintering pools. Only 13 pools, greater than 2 meters in depth, were found in a section of the river between Eagle Creek and the main channel just above the delta area.

Springs are common in headwater areas of ANWR streams and extremely important to spawning and overwinter survival of arctic char. Arctic char distribution in the ANWR, excluding lake resident forms, is entirely dependent on the presence of perennial ground water sources. Many spring areas have been located in the study area (Wilson, 1977; USFWS, 1982). Spawning and overwintering of char has been identified at several of these locations. The Katakturuk River has several springs that appear to have sufficient flow to support small overwintering fish populations, however, no fish are found in this river. This may be due to the lack of adequate pool area below the springs. A similar situation exists at Sadlerochit Springs, which does have a resident population of char but no anadromous char are known to use this drainage for spawning and overwintering. Craig (1977b) suggested that during dry years, the channel between the mainstream and aufeis area below the springs may present a barrier to migration of anadromous char.

Movement and Distribution

Radio telemetry, aerial census and on the ground surveys were used during 1981 and 1982 to determine distribution and movement of arctic char in the Canning River. Aerial surveys during late September 1982 revealed concentrations of anadromous char at mid and upper river sections of the mainstem, however no redds were observed in the mid river reaches. On-the-ground surveys at Shublik Springs (mid river) during late September 1982 showed that 97.6 percent of the sample (N = 335) were nonspawners and immature anadromous char. This area was also sampled during April 1982. All fish collected were nonspawners and immature. Overwintering segregation of spawners and nonspawners was also reported for the Sagavanirktok River by McCart et al. (1972), Yoshihara (1973) and `urniss (1975).

Anadromous char spawning migrations in the Canning River generally begins in mid July and early August with most fish reaching spawning and overwintering areas by mid September. The peak of the migration in the lower river was in mid August during 1981 and 1982. Aerial and on the ground surveys on the Aichilik River indicate that the char migration was nearly over in late September and spawning was in progress. A few spawned out char were collected several kilometers downstream from the main spawning area at this time.

Movement of char was monitored during winter. All locations of radio tagged fish and of fish concentrations below Shublik Springs corresponded with pool locations observed by fathometer. Several char showed movement throughout the monitoring period (October to April). Most movement was downstream and the maximum distance moved was 17 km. Between March and April, 1981, one fish had moved upstream through a large aufeis field back into the spring area where it was originally tagged. This indicates that pools downstream from the large aufeis field, below Shublik Springs, may not be as isolated as previously thought.

Seaward migrations of anadromous char, generally begin immediately after breakup, with most fish leaving the rivers by late June and early July. One anadromous char was collected near the mouth of the Aichilik on June 28, 1982.

Resident char, presmolts and residuals, were found in greatest abundance, in the vicinity of spring areas. Some of these fish leave spring areas after breakup and return in the fall (Craig 1978). Resident char ages 0 to 4 were collected in two small, tundra stream tributaries to the Canning River in 1982. Some of these fish were as much as 20 kilometers from the nearest known overwintering area (Shublik Springs area), in August 1982. One of these tributaries enters the Canning in the delta area and it is more likely that these fish overwinter somwhere in the lower river area. Juvenile arctic char were also reported to use a small tundra stream tributary of the Kavik River (Craig and Poulin, 1974).

Grayling are widely distributed throughout streams studied during 1981 and 1982, with the exception of the Katakturuk River. Spawning areas, determined from fry observations in July, were found in several mainstream and tributary areas in foothill sections of the drainages. Very little is known about grayling overwintering habitat in the study area. In November, Ward and Craig (1974) found grayling in pools downstream from Shublik Springs in the Canning River. Bendock (1981) sampled eleven pools in the Colville River during the winter. Mean oxygen concentration was 2.3 mg/l and mean water depth was 8.6 feet. Grayling were captured at all eleven sites. Bendock concluded that nonmigratory fish use all areas of free standing water under ice as overwintering habitat.

Round whitefish, burbot, ninespine stickleback, red salmon, pink salmon and chum salmon were collected in the study area during 1981 and 1982. With the exception of round whitefish all of the other species were relatively rare.

CONCLUSIONS

Stream channels in the study area exhibit a high degree of braiding and have relatively steep gradients. Pools suitable for supporting overwintering populations of fish are rare. This is especially apparent for the Katakturuk River which is devoid of established fish populations.

Perennial groundwater sources are found on all of the rivers sampled during 1981 and 1982. They are most abundant in the Canning River drainage. Both the Canning and Aichilik Rivers support populations of anadromous char and the spring areas are critical for their spawning and overwintering. The suitability of a spring area to anadromous char depends on access to and from the area and the amount and quality of the area that is suitable for overwintering (ie discharge, depth, etc.) Radio tagged char in the Canning River near Shublik Springs exhibited greater movement during winter than was previously thought possible. Maximum downstream movement from October to April was 17 km. One fish moved upstream through a large aufeis field during March and April.

Aerial surveys on the Canning River found large concentrations of char from Ignek Creek to the headwaters. Most concentrations in the mid river were located in the vicinity of pools documented earlier. Radio tagged fish were found to overwinter in these same pools.

Grayling were widely distributed in all rivers studied except for the Katakturuk River. They were generally collected in greatest abundance in lower and mid sections of the rivers surveyed.

Round whitefish were only collected in the Canning River, from Marsh Fork to the mouth. Their distribution was similar to grayling except they have not been found in tributary streams.

Three species of salmon were collected in the study area. One pink salmon, one red salmon and several chum salmon were collected in the Canning River. Another pink salmon was collected in the Sadlerochit River.

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Fall, Winter, and Spring Distribution of the Porcupine Caribou Herd, 1981-82

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BACKGROUND

The Porcupine Caribou Herd (PH) uses 3 main routes during fall and spring migrations (Fig. 1). These routes are diffuse corridors, and the same passes, valleys, and river crossing sites are not used every year (Roseneau and Stern 1974, Roseneau et al. 1984, Roseneau et al. 1975). The Richardson Route follows the Richardson Mountains along the Yukon/Northwest Territories border to the Peel River Basin. The Old Crow Route traverses Old Crow Flats or the adjacent highlands and continues across the Porcupine River into the Ogilvie Mountains. The Chandalar Route leads westward along the southern foothills of the Brooks Range into the Coleen, Sheenjek, and Chandalar drainages. In some years, caribou follow the Old Crow Route as far as the Porcupine River and then turn northwestward to follow the Chandalar Route.

The PH has wintered primarily in 3 areas during the past 20-30 years: 1) the Richardson Mountains in the Yukon and Northwest Territories (via the Richardson Route); 2) the Ogilvie Mountains, mostly in the Yukon Territory, but also including the upper Black, Kandik, and Nation River valleys in Alaska (via the Old Crow Route); and 3) in Alaska between the Brooks Range and the Yukon River and from the Chandalar River drainage eastward (via the Chandalar Route). The wintering grounds are extensive areas and use within each varies greatly from year to year (Roseneau et al. 1975).

During the winter, PH caribou may move on to new localities, but they usually remain within the same wintering area. Use of specific winter ranges has been linked to snow conditions (Martell pers. commun.), but may also be a function of the migration route taken in the fall.

Other migration routes and/or wintering areas have been used by small portions of the herd in some years. PH caribou have occasionally wintered in the Mackenzie River Delta, along the Arctic coast, or on the northern slopes of the Brooks Range. Passes between the North Slope summer ranges and the Chandalar wintering area have been used during both fall and spring migrations (Roseneau et al. 1975).

Canadian biologists have been radio-collaring PH caribou since 1978. Numbered neck bands (no transmitters) were used in fall 1978 and 1979. Resightings of collared caribou have yielded much data on wintering areas and migration routes. Most collared caribou were captured along the Old Crow Migration Route. Caribou captured in fall at the Porcupine River crossing spent the winter in the Ogilvie Mountains, but in subsequent years some used other wintering regions. Likewise, caribou captured during spring did not always return to the Oglivie Mountains area the next year. Comparisons of the number of caribou using the main wintering areas in different years also indicate that caribou have no strong fidelity to a specific winter range.

Nevertheless, many questions remain about use of migration routes and wintering areas. A few individuals with strong fidelity to specific ranges may maintain a tradition of using those areas. Alternatively, a combination of terrain, vegetation, and weather patterns may tend to direct caribou movements along certain corridors toward the wintering areas without the individual caribou having specific knowledge of their destination. Hopefully, long-term studies of marked caribou will better explain use of migration routes and winter ranges.

Recent observations of winter range use have been focused in the Yukon Territory. The current study is a cooperative effort between the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game to locate concentrations of PH caribou migrating to and wintering in Alaska; to monitor movements and distribution of Canadian-collared caribou wintering in Alaska; and to radio-collar additional caribou to enlarge the sample size for studying midwinter and spring movements. Complementary data are being collected in Canada by the Yukon Department of Renewable Resources.

METHODS

Fixed-wing aircraft were used during early October to search for caribou along traditionally used portions of the Old Crow and Chandalar Migration Routes in Alaska. Reports by local residents of large numbers of caribou crossing the Yukon River in Alaska near the Canadian border were confirmed in mid-October. Backtracking trails into the Ogilivie Mountains in Canada and monitoring of Canadian radio collar frequencies verified that these were PH caribou.

Twenty-five caribou were radio-collared in Alaska during winter 1981-82 to aid studies of midwinter movements and spring migration. South of the Yukon River, radio collars also helped assess the degree of mixing and interchange between PH caribou and caribou of the resident Fortymile Herd. Nine caribou were captured near Arctic Village on 23 October; 3 near Eagle Summit on 12 December; 5 near Central on 1 March; 3 near Slate Creek Mine on 8 April; and 5 on upper Birch Creek on 20 April. Caribou were captured using a helicopter and Cap-Chur dart gun. M99 (Etorphine; 5 mg dosage) was used for immobilization and M50-50 (Diprenorphine; 10 mg dosage) was administered for recovery. Telonics (Mesa, Arizona) radio collars and tracking receivers were used.

Wintering areas located during October were surveyed by fixed-wing aircraft 1 or more times monthly from November through May. All Alaskan and Canadian radio-collared caribou were monitored during these survey flights. Snow cover facilitated location of caribou during all surveys, since trails and feeding craters were visible even from high altitudes (1,500-2,000 m AGL).

Data on PH distribution and movements in Canada were obtained from the Yukon Renewable Resources Department. Biologists from the Yukon Territory also assisted in monitoring radio-collared caribou south of the Yukon River in Alaska. Brief summaries of PH distribution in Canada are included in this report so that the distribution in Alaska may be considered in the context of the dynamics of the entire herd.

RESULTS AND DISCUSSION

Fall Migration

Richardson Route

An undetermined number of caribou used the Richardson Route and reached the Dempster Highway area by about 10 October. The specific route of travel was not monitored.

Old Crow Route

Numerous caribou crossed the Porcupine River near Old Crow between late August and 3 October. Fall harvest of caribou by Old Crow villagers was larger than normal (≥1,000 caribou). By mid-October most of the caribou using the Old Crow route were in the Ogilvie Mountains near the upper Tatonduk River.

Several hundred caribou were located in the Kandik River valley just west of the international border on 10 October. Extensive trail systems, visible in several day-old snow, indicated that caribou had migrated through all major valleys in the Black River drainage upstream toward Canada. Number and size of trails suggested that thousands or even tens-of-thousands of caribou passed through the area. These caribou could have moved directly south from the Coleen-Old Crow divide, or they may have been part of the group that crossed the Porcupine River at Old Crow. Apparently, they were near the headwaters of the Salmon Trout River when the snow fell, and we could not backtrack trails any farther to determine where they had crossed the Porcupine River. In any event, the trails in Alaska apparently led to the large concentration of caribou in the Ogilvie Mountains.

On about 15 October, roughly 20,000 caribou moved from the Ogilvie Mountains down the Tatonduk and Kandik Rivers and crossed the Yukon River in Alaska. After reaching the Yukon, a few thousand caribou turned back and returned to the Ogilvie Basin in Canada. Others continued to the Seventymile, Fortymile, Charley, Salcha, Chena, Birch Creek, and Preacher Creek drainages in Alaska (Fig. 2). As recently as 1978-79, many PH caribou wintered in the Kandik, Nation, lower Tatonduk, and upper Black River valleys. Overwintering in this area is infrequent, but has been reported periodically. Movement across the Yukon River, however, has not been reported since the 1930's, when movements of the PH were confused by the proximity of the then huge Fortymile Herd (possibly 500,000 head) (Skoog 1968).

Chandalar Route

On 10 October, about 1,000 caribou were observed in small, scattered groups along the southern foothills of the Brooks Range between the Sheenjek and East Fork Chandalar Rivers. One group of 15 caribou was on the lower Coleen River; no caribou tracks were noted in the upper Coleen or Bilwaddy Creek areas.

Around 20 October, approximately 20,000 caribou moved through the Arctic Village area from the east. These caribou were most likely east of the border in the Old Crow Flats area during early October. Some caribou traveled only as far as Old John Lake or Arctic Village, while others proceeded as far as the lower Middle Fork of the Chandalar River.

Winter Distribution

Richardson Area

Biologists from the Yukon Territory surveyed for caribou in the Richardson Mountains and Peel River Basin during March. Perhaps 16,000 caribou used the area; 1,500 were harvested by NWT residents along the Dempster Highway. Most of this harvest occurred on the Yukon side of the border. No radio-collared caribou were detected.

Ogilvie Basin-Tanana Hills

Yukon Territory biologists estimated that about 40,000 caribou spent the entire winter in the Ogilvie Basin area. Most remained in the western Ogilvie Mountains, but about 5,000 moved as far east as the Hart River area.

Caribou which had moved from the Ogilvie Mountains in mid-October and crossed the Yukon River in Alaska were mostly along the Yukon River or in the Seventymile valley on 22 October, but some had already moved farther south into the Fortymile drainage. By 1 November, caribou had reached at least as far west as the mouth of Copper Creek on the Charley River. On 19 November, several thousand caribou were in the upper and middle Salcha River valley, and most of the Charley and Seventymile valleys no longer had caribou. By about 1 December, residents of Central, Alaska reported caribou entering the Birch Creek drainage. On 9 December, hundreds to thousands of caribou were in the Birch Creek valley and as far west as Eagle Summit on the Steese Highway.

The presence of 3 radio-collared caribou, all originally marked on traditional PH ranges and all of which had spent the summer on PH range, confirmed that the crossing of the Yukon River in October was by PH caribou (see Appendix A for sighting dates and location of radio-collared PH caribou in Alaska, October 1981 through May 1982). Additionally, about twice as many caribou were involved in the crossing as were known to exist in the resident Fortymile Herd. One collared caribou returned to the upper Tatonduk River by December. One caribou crossed into Alaska, but was never again located after 22 October, presumably due to transmitter battery failure. The third collared caribou was on Copper Creek on 1 November and in the upper Salcha valley from 19 November until at least 29 January.

During the winter, additional radio collars were placed on animals from both the Porcupine and Fortymile Herds to determine if mixing of these herds occurred. Three adult females were collared near Eagle Summit on 12 December. One was killed by wolves in late January; 1 stayed near the capture site until about 1 May; and 1 moved west to Preacher Creek and remained there until early May. Four adult females and 1 young male were collared during March just west of Central, Alaska. One female died as a result of capture, and the others remained within about 25 km of the capture site until 1 May. All of those caribou were thought to be from the PH since they were in an area to which PH caribou had been tracked after the crossing of the Yukon River in October.

On 8 April, 2 adult females and a young male were captured near Slate Creek mine in the Middle Fork Fortymile drainage. Fortymile Herd caribou had used this area during fall and early winter (D. Kelleyhouse, pers. commun.), but the small body size of those captured suggested that they may have been PH caribou (see Appendix B). Three known Fortymile caribou (i.e., radio-collared 18 months previously and having calved on the Fortymile calving grounds in 1981) moved into the upper Salcha and Birch Creek areas by mid-February. Four female and 1 male caribou were collared on upper Birch Creek near 1 of the collared Fortymile caribou on 20 April. Large body size suggested that all were indeed Fortymile caribou. Unfortunately, 1 female died due to unknown, but probably capture-related, causes. Several thousand presumed PH caribou, including those collared in December and March, were still within 40-100 km when these caribou were collared on Birch Creek.

Residents at Eagle, Alaska reported that several hundred caribou remained in the vicinity of Eagle on the Yukon and Seventymile Rivers all winter. Trails and feeding craters were present in newly fallen snow in the area on 19 November, after the main body of PH caribou had moved south and west, or back up the Tatonduk River into Canada.

Chandalar Area

Five female and 4 male caribou were radio-collared near Arctic Village on 23 October. During the tagging operation and on subsequent tracking trips, about 20,000 caribou were estimated to be in this area. By mid-December, some caribou (including 2 collared bulls) had advanced as far as the Middle Fork of the Chandalar River west of Thazzik Mountain. Most caribou moved no farther south and west than the Wind River drainage, however, and many remained within 50 km of Arctic Village all winter. From about late February through late April, caribou moved slowly northeastward through the immediate Arctic Village area. During the course of the winter, 3 caribou collared 1 or more years previously in Canada were located in the Arctic Village region. One transmitter apparently failed, however, and 1 male caribou either died or shed its collar. Of the caribou collared in Alaska, 1 female was reportedly shot in Arctic Village, and another was killed by wolves north of Arctic Village, both during April.

Several hundred additional caribou wintered in the mountains between the Kongakut, Firth, and Coleen Rivers in Alaska. They were widely separated from the caribou near Arctic Village.

Spring Migration

Richardson Route

Caribou which overwintered in the Richardson Mountains began moving northward during early April, but were not monitored during spring migration on the calving grounds.

Old Crow Route

Yukon biologists reported caribou moving north from the Ogilvie Mountains in early April. Trails led across the border into Alaska, suggesting that they crossed the Porcupine River west of the international border. No caribou crossed the Porcupine River near Old Crow until the end of May and early June, and relatively few came through the immediate Old Crow area.

PH caribou wintering south of the Yukon River began moving north during the first week of May. For the most part, these caribou moved directly toward the calving grounds and did not retrace their circuitous fall migration route (Fig. 3). On 6 May, most had already crossed the Yukon and many were north of the Black River. Numerous well-traveled trails crossed the Yukon River from just east of Fort Yukon upstream to Eagle. Four of the caribou collared in the Eagle Summit and Central areas were between Fort Yukon and Chalkyitsik villages, while 1 remained near Eagle Summit, and 1 was not located. All of the suspected Fortymile caribou collared in Birch Creek remained in that area, although they had moved a short distance to the east. Trails in the snow led directly from these Fortymile caribou northward across the Yukon.

Subsequent radio-tracking showed that all of the original Fortymile collared caribou, all of the surviving collared animals on Birch Creek, and 1 from Central (the individual remaining behind on 6 May) remained in the Fortymile Herd range. Five of 6 collared at Eagle Summit or Central went north, as did all those collared at Slate Creek. These data, along with the observations of trails leading northward from sedentary caribou groups, indicate considerable mixing of Porcupine and Fortymile Herd caribou (Fig. 3). However, it appears there was little or no interchange of individuals. No unexpected changes in population size of either herd (i.e., not explainable by normal recruitment and/or mortality) were detected. Furthermore, no late-born calves were observed in the Fortymile Herd, nor early calves in the PH. Calving dates are about 2 weeks earlier in the Fortymile Herd, and such observations should have been commonplace if interchange had occurred.

The migration route north of the Black River remains uncertain. On 1 June, an extensive trail system was observed in the highlands between the Coleen River and Old Crow Flats. Radio-collared caribou from the Eagle Summit, Central, and Slate Creek areas were located at the northern end of these trails. It seems probable that the spring migration paths of caribou wintering south of the Yukon and in the Ogilvie Mountains converged north of the Porcupine River on the Alaska side of the border.

Chandalar Route

Deep, soft snow persisted in the mountains north of Arctic Village until mid-May. Caribou encountering snow-filled valleys retreated to windswept ridges and did not continue northeastward until traveling conditions in the valleys improved with rapid snowmelt in late May (L. Duquette and D. Miller, pers. commun.). At the crest of the Brooks Range, most turned east rather than continuing due north to traditional calving grounds in Alaska. Most caribou apparently crossed through Mancha Creek or the upper Coleen River to the Firth River area, where they joined the Old Crow Migration Route. Interestingly, caribou which wintered south of the Yukon encountered much easier travel conditions and arrived on the coastal calving grounds earlier than those which wintered near Arctic Village.

SUMMARY

Fall migration and early winter distribution of the PH followed traditional patterns. All 3 main migration routes and wintering areas were used. During October a major variation occurred, as about 20,000 caribou left the Ogilvie Mountains and continued south and west into traditional ranges of the Fortymile Herd. Past interchange between these herds has been widely speculated (Skoog 1968), but has never been documented (Davis et al. 1978). The most recent suspected interchange was in 1964 when Fortymile caribou supposedly invaded the PH range. Since caribou do not live 17 years, the current mixing of the Porcupine and Fortymile Herds cannot be explained by tradition or learned behavior. Spring migration for many PH caribou in 1982 followed routes which had not been used by any caribou for at least 42 years. These observations suggest that weather and terrain features, along with an innate tendency to move in a given direction during certain times of the year, accounted for last year's unusual PH distribution. Use of range and migration routes not occupied for many decades may also indicate that the PH population is expanding.

Late snowmelt slowed the spring migration of many PH caribou. Adverse conditions on traditional migration routes through the Brooks Range and on the coastal plain in Alaska directed PH movements and calving east into Canada. Unlike the unusual winter distribution, however, this pattern of spring range use has been noted several times previously (Roseneau et al. 1975).

Estimates of numbers of caribou using the various migration routes and wintering areas in 1981-82 (Richardson = 16,000; Old Crow = 40,000 in Ogilvie Basin plus 20,000 south of Yukon; Chandalar = 20,000; other areas in Yukon Territory = 6,000; Total = 102,000) approximate the estimated herd total of 110,000 plus (Whitten and Cameron 1980). Most likely, some or all of the winter range estimates were slightly low and there were probably no large groups of wintering caribou unaccounted for.

ACKNOWLEDGMENTS

Without the help of numerous other agencies and biologists this study would not have been possible. D. Ross of the U. S. Fish and Wildlife Service flew many hours of survey and radio-tracking and participated in collaring operations. P. Valkenburg, R. Boertje, and D. Kelleyhouse of the Alaska Department of Fish and Game (ADF&G) also assisted in tagging and tracking, as did B. Durtsche and J. Schreier of the Bureau of Land Management (BLM). Sport Fish Division of ADF&G offered a plane and pilot G. Pearse when we were unable to obtain a Game Division plane in November. L. Duquette of the University of Alaska and pilot D. Miller assisted in radio-tracking during May. D. Russell and R. Farnell of the Yukon Territory Department of Renewable Resources provided data on Porcupine Herd distribution in Canada. This study was funded primarily by contract with the Arctic National Wildlife Refuge, U.S. Fish and Wildlife Service; additional support was obtained through Federal Aid in Wildlife Restoration Project No. W-21-2, Job No. IIIB-3.23R. Much of the collaring and tracking south of the Yukon River was conducted through a cooperative project administered by BLM.

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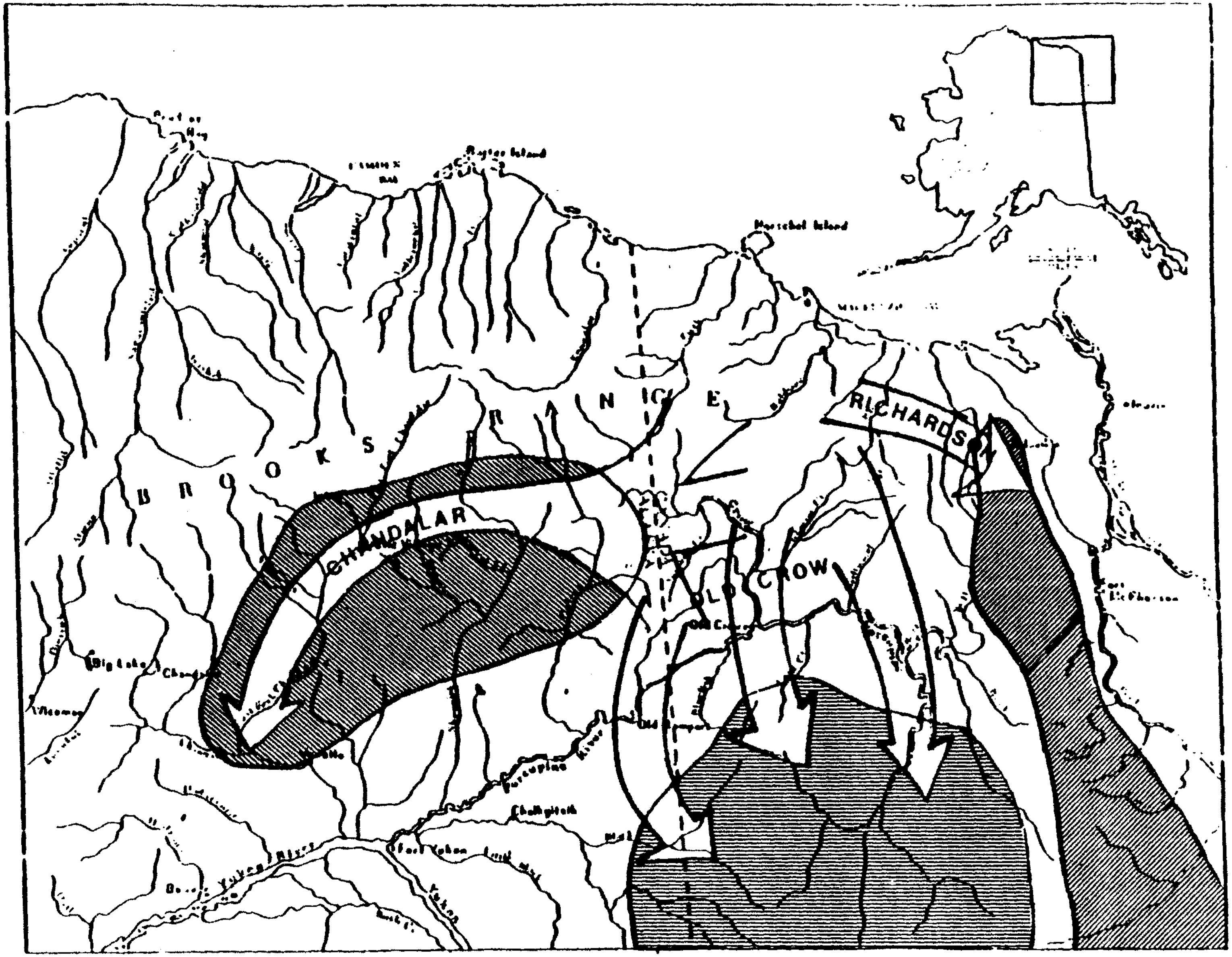

Fig. 1. Major fall migration routes and wintering areas of the Porcupine Herd.

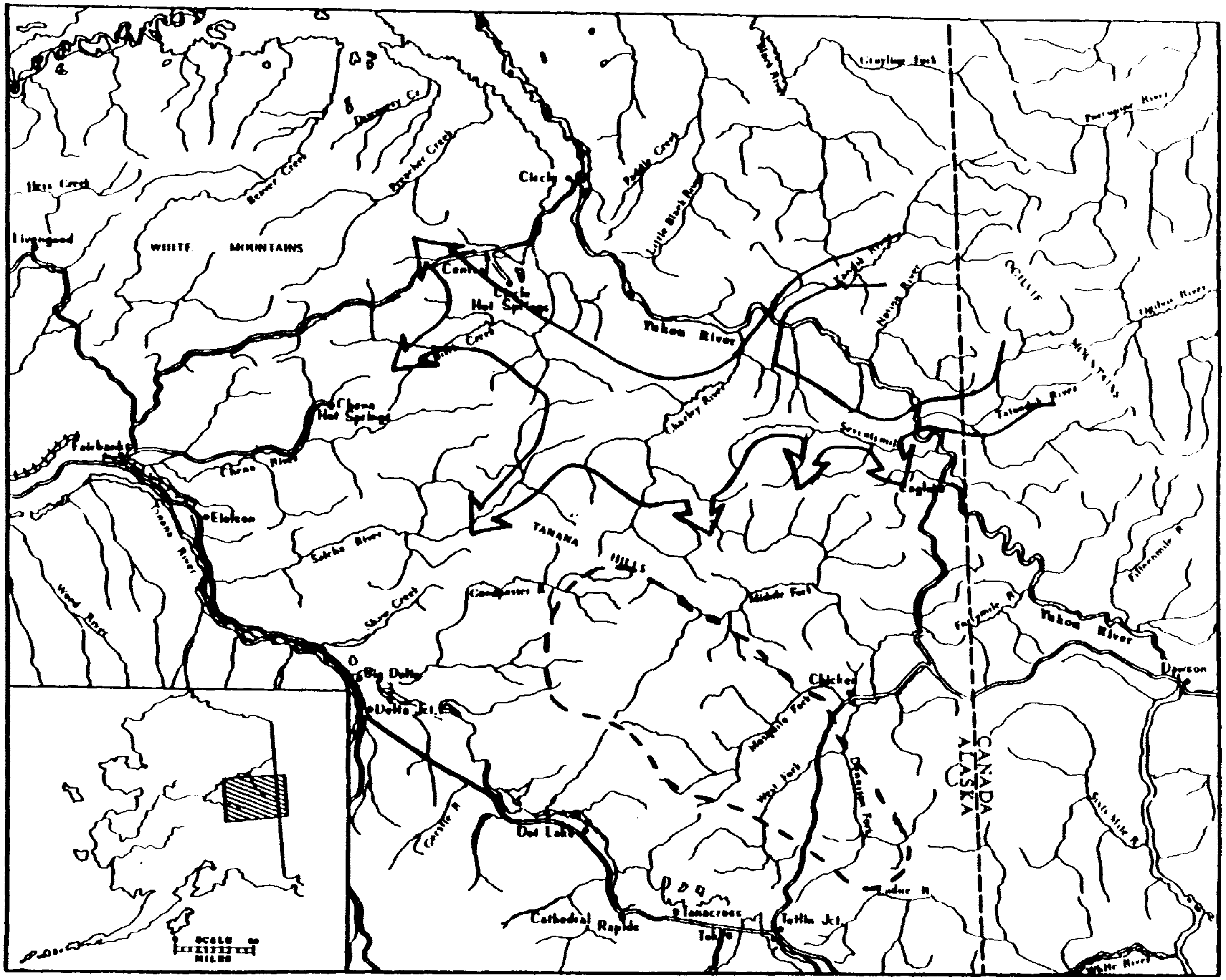

Fig. 2. Dispersal of the Porcupine Herd south of the Yukon River, October through December 1982 (solid lines), and early winter distribution of the Fortymile Herd (broken lines).

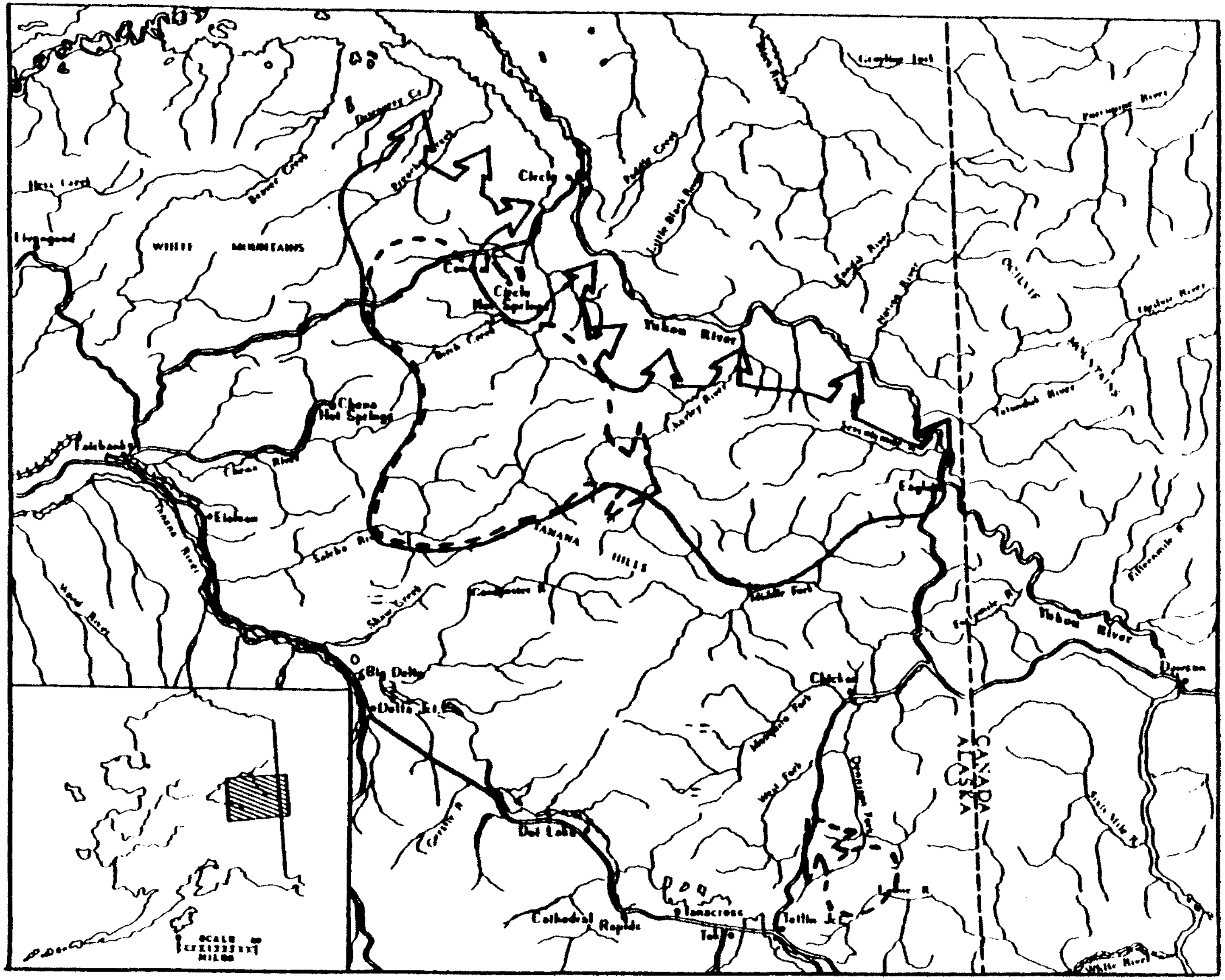

Fig. 3. Late winter distribution and spring 1982 movements of the Porcupine Herd (solid lines) and Fortymile Herd (broken lines) south of the Yukon River.

APPENDIX A. Locations of radio-collared Porcupine Herd Caribou in Alaska, October 1981 through May 1982.

Collar No.	Date	Location	Collar No.	Date	Location
GY26	10/23/81	68°13' x 146°13'	GY12	10/23/81	68°01' x 145°30'
150.830	03/04/82	67°29' x 147°48'	151.390	12/22/81	67°33' x 146°45'[1]
	04/12/82	67°27' x 148°05'		01/28/82	67°25' x 146°40'[1]
	04/30/82	67°25' x 148°00'		03/04/82	67°16' x 147°50'
	05/08/82	67°27' x 147°50'[1]		03/15/82	67°11' x 147°57'[1]
				04/12/82	67°13' x 148°05'
GY24	10/23/81	68°01' x 145°30'		04/30/82	67°12' x 148°05'
150.850	12/22/81	67°38' x 146°00'[1]		05/08/82	67°12' x 148°05'[1]
	03/04/82	68°09' x 145°23'			
	03/15/82	68°03' x 145°42'[1]	GY22	10/23/81	68°06' x 146°15'
	04/09/82	68°06' x 145°07'[1]	151.750	12/22/81	68°07' x 146°20'[1]
	04/12/82	68°10' x 145°10'		03/04/82	68°10' x 145°37'
	04/30/82	68°18' x 145°18'[2]		03/15/82	68°09' x 145°37'[1]
					(reportedly shot)
GY25	10/23/81	68°13' x 146°13'			
150.920	12/22/81	68°06' x 146°50'	GY2-	10/23/81	68°06' x 146°15'
	01/28/82	68°05' x 146°35'[1]	151.770	12/22/81	68°06' x 146°50'
	03/04/82	68°10' x 145°25'		01/28/82	68°05' x 146°35'[1]
	03/15/82	68°03' x 145°38'[1]		03/04/82	68°25' x 146°50'[1]
	04/09/82	68°06' x 145°21'[1]		03/15/82	68°17' x 145°06'[1]
	04/12/82	68°15' x 145°25'		04/12/82	68°12' x 144°55'
	04/30/82	68°27' x 145°10'[1]		04/30/82	68°11' x 144°50'
	05/03/82	68°28' x 145°08'		05/03/82	68°11' x 144°51'
	05/05/82	68°26' x 145°08'		05/05/82	68°11' x 144°49'
	05/07/82	68°27' x 145°08'		05/07/82	68°12' x 144°44'
GY27	10/23/81	68°13' x 146°13'	GYXX	10/23/82	68°06' x 146°15'
151.060	12/22/81	68°00' x 147°00'	151.800	12/22/82	68°14' x 146°21'[1]
	01/28/82	67°58' x 146°30'[1]		03/04/82	68°24' x 145°33'
	03/04/82	67°47' x 146°05'		03/15/82	68°09' x 145°28'[1]
	03/15/82	67°30' x 147°20'[1]		04/09/82	68°02' x 145°42'[1]
	04/12/82	68°13' x 145°05'		04/12/82	68°11' x 145°06'
	04/30/82	68°11' x 144°48'		04/30/82	68°14' x 145°00'
	05/03/82	68°12' x 144°49'		05/03/82	68°15' x 144°59'
	05/05/82	68°12' x 144°53'		05/05/82	68°15' x 144°58'
	05/07/82	68°12' x 144°49'		05/07/82	68°15' x 144°57'
GY23	10/23/81	68°13' x 146°13'	C-92	12/22/81	68°06' x 146°50'
151.340	03/04/82	68°26' x 146°00'	151.314		
	03/15/82	68°05' x 145°35'[1]			
	04/12/82	68°11' x 145°05'	I-53	12/22/81	68°12' x 146°08'[1]
	04/30/82	68°12' x 144°54'	150.543	03/04/81	68°09' x 146°05'[2]
	05/05/82	68°10' x 144°54'			
	05/07/82	68°10' x 144°53'			

APPENDIX A. Continued

Collar No.	Date	Location
I-58	12/22/81	67°30' x 146°30'
150.543	03/05/82	67°22' x 146°47'
	03/15/82	67°21' x 146°40'[1]
	04/12/82	67°29' x 146°30'
	04/30/82	67°29' x 146°30'
	05/08/82	67°29' x 146°30'
I-50	10/22/81	64°52' x 141°45'
150.462	11/01/81	64°52' x 143°30'
	11/19-20/81	64°57' x 144°25'
	12/09/82	64°51' x 144°42'
	01/29/82	64°47' x 144°36'
I-52	10/22/81	65°02' x 141°19'
150.481	(returned to Canada)	
D-03	10/22/82	65°21' x 142°05'
150.890	(apparent transmitter failure)	
BKY4	03/01/82	65°35' x 145°30'
150.240	03/05/82	65°35' x 145°30'[1]
	03/27/82	65°38' x 144°55'
	04/12/82	65°38' x 144°45'
	04/19/82	65°40' x 144°50'[1]
	05/06/82	66°45' x 143°45'
BKY26		
150.280	03/01/82	65°36' x 145°00'
	03/04/82	65°36' x 145°00'[1]
	03/27/82	65°35' x 145°24'
	04/12/82	65°35' x 145°24'
	04/19/82	65°35' x 145°24'[1]
RY29	03/01/82	65°36' x 145°00'
150.310	03/05/82	65°36' x 145°00'[1]
	03/27/82	65°37' x 145°27'
	04/12/82	65°34' x 145°34'
	04/19/82	65°34' x 145°34'[1]
	05/06/82	66°39' x 143°41'
BKY47	12/12/81	65°30' x 145°10'
150.300	01/29/82	65°34' x 145°15'[2]
BKY41	12/12/81	65°30' x 145°10'
150.420	01/29/82	65°30' x 145°00'
	02/24/82	65°30' x 145°08'
	03/05/82	65°30' x 145°08'[1]
	03/27/82	65°30' x 145°09'
	04/12/82	65°32' x 145°02'
	04/19/82	65°30' x 145°08'
	05/06/82	66°18' x 143°50'
BKY42	12/12/81	65°30' x 145°25'
150.430	02/24/82	65°48' x 145°55'
	03/05/82	65°48' x 145°55'
	03/27/82	65°49' x 145°50'
	04/12/82	65°52' x 145°50'
	05/06/82	66°27' x 145°05'
RY86	03/01/82	68°37' x 145°13'
150.802	03/04/82	68°37' x 145°13'
	03/27/82	68°37' x 145°13'[2]
BY1	04/08/82	64°30' x 142°40'
151.150		
BY3	04/08/82	64°30' x 142°40'
151.250		
BY2	04/08/82	64°30' x 142°40'
151.260		

[1]approximate location only

[2]dead

APPENDIX B. Body measurements of collared caribou from the Porcupine and Fortymile Herds.

Collar No.	Tagging Frequency	Tagging Location	Date	Sex	Body Measurements (cm) Head	Neck Girth	Length	Metatarsal	Hind Foot
		------PORCUPINE CARIBOU------							
BKY4	150.240	Central	03/01/82	M	35	43	174	40	58
BKY26	150.280	Central	03/01/82	F	38	47	192	39	58
RY29	150.310	Central	03/01/82	F	40	48	192	40	58
BKY47[1]	150.300	Eagle Summit	02/12/81	F	--	--	---	--	--
BKY41	150.420	Eagle Summit	02/12/81	F	--	--	---	--	--
BKY42	150.430	Eagle Summit	02/12/81	F	--	--	---	--	--
RY86[1]	150.802	Central	03/01/81	F	--	--	---	--	--
GY26	150.830	Arctic Village	10/23/81	M	34	72	201	42	61
GY24	150.850	Arctic Village	10/23/81	F	33	52	191	37	56
GY25	150.920	Arctic Village	10/23/81	F	32	54	181	40	57
GY27	151.060	Arctic Village	10/23/81	F	33	55	179	38	56
GY23	151.340	Arctic Village	10/23/81	M	32	44	181	42	59
GY12	151.390	Arctic Village	10/23/81	M	37	68	210	42	64
GY22	151.750	Arctic Village	10/23/81	F	34	47	182	40	58
GY2-	151.770	Arctic Village	10/23/81	M	33	59	197	41	59
GYXX	151.800	Arctic Village	10/23/81	F	32	55	183	41	56
BY1	151.150	Slate Creek	04/08/82	F	36	44	183	40	57
BY2	151.250	Slate Creek	04/08/82	F	36	42	173	39	56
BY3	151.260	Slate Creek	04/08/82	M	39	45	191	42	58.5
		------FORTYMILE CARIBOU------							
BKY53	150.180	W. Frk. Dennison	10/15/80	F	46	49	192	43.5	60
BKY52	150.140	W. Frk. Dennison	10/15/80	F	45	52	188	38	60
BKY50	150.180	W. Frk. Dennison	10/15/80	F	47	50	191	43	59
BKY51	150.185	W. Frk. Dennison	10/15/80	F	48	57	195	42	59
BKY56	150.340	Central	03/01/82	F	42	48	175	41	56
BY4[1]	151.290	Birch Creek	04/20/82	F	38	42	194	42	57
BY6	151.575	Birch Creek	04/20/82	M	--	--	---	44	63
BY5	151.720	Birch Creek	04/20/82	F	41	45	201	42	61
BY7	151.770	Birch Creek	04/20/82	F	43	47	203	41	60
BY8	151.780	Birch Creek	04/20/82	F	37	43	189	40	60
		---------MEAN VALUES---------							
Porcupine Herd Females					34.9	49.3	184.0	39.3	56.9
Fortymile Herd Females					43.0	48.1	192.0	41.4	59.1

[1]Died before spring migration. Herd identity assumed, not confirmed.