ARCTIC NATIONAL WILDLIFE REFUGE COASTAL PLAIN
RESOURCE ASSESSMENT

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

Volume II
Section 1002C
Alaska National Interest Lands Conservation Act

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

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Edited by
Gerald W. Garner and Patricia E. Reynolds

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CONVERSION TABLE

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

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

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Appendix III MAMMALS

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ANWR Progress Report Number FY86-21

FALL AND WINTER MOVEMENTS, DISTRIBUTION, AND ANNUAL MORTALITY PATTERNS OF THE PORCUPINE CARIBOU HERD, 1984-1985

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Key Words: Porcupine caribou herd, movement, mortality, predation, wintering areas, Arctic-Beaufort.

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Fall and winter movements, distribution, and annual mortality patterns of the Porcupine caribou herd, 1984-1985.

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Abstract: Weather conditions appeared to influence the 1984 fall movements of the Porcupine caribou (*Rangifer tarandus*) herd. Snow storms during late August stimulated strong southeasterly movements of caribou from Alaska, however, caribou drifted back north during mild weather in September. Some caribou returned to Alaska during late fall (October) movements. At the onset of winter conditions (November), large numbers of caribou were located in the northern Richardson Mountains in Canada where they remained during the winter of 1984-1985. Based on proportions of radio-collared caribou found, it is estimated that about 50,000 caribou wintered on traditional ranges in Alaska and about 90,000 caribou wintered in the northern Richardson Mountains and Yukon north slope in Canada. First year mortality (based on survival rates of radio-collared calves) was estimated at 38% for 1984-1985. Male calves had a higher first year mortality rate (53%) than female calves (23%). Annual mortality of (1-3 year old) radio-collared caribou (5%) was significantly lower than that for adults older than 3 years (32%). Following a brief period of higher mortality immediately after parturition, calves survived well until fall, when detected mortality again increased. Overwinter mortality of radio-collared calves was low. This pattern was similar to that identified for the 1983 calf cohort.

Fall and winter movements and distribution, and annual mortality patterns of the Porcupine caribou herd, 1984-1985.

Intensive studies of the ecology of the Porcupine caribou herd are currently being conducted cooperatively by the U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, Yukon Territory Government, and the Canadian Wildlife Service. Primary emphasis has been on calving distribution, initial productivity, and neonatal calf survival in relation to petroleum exploration and potential development in the Arctic National Wildlife Refuge (ANWR). Numerous calf and adult caribou have been radio-collared in conjunction with these studies, providing a large sample of individually recognizable caribou. Relocating these marked caribou throughout the year yields valuable information on winter movements and annual mortality rates which can otherwise be gathered only with great expense and/or difficulty using conventional aerial survey and collection techniques. This report summarizes the results of radio-tracking surveys in Alaska during winter 1984-1985.

Methods and Materials

Radio-collared caribou were relocated using fixed-wing aircraft and standard techniques and equipment from July 1984 through May 1985. Surveys in Alaska were flown once in August, September, and November 1984 and February and April 1985, and twice in May 1985. In Canada surveys were flown numerous days in July and once in August, September, November, and December 1984, and May 1985. Movements and distribution were determined primarily from locations of radio-collared caribou, although observations of other caribou seen during tracking flights were also considered in making general conclusions.

Numbers of caribou involved in late summer and fall movements and numbers wintering in Alaska and Canada were determined through a combination of visual estimates of caribou and sign (tracks, trails, and cratering) and estimation based on distribution of collared animals. There were about 135 collared caribou in July 1984, when the population was estimated at approximately 150,000 (Whitten 1987 this volume). Loss of collared caribou through the winter was assumed to be proportional to overall herd mortality and the distribution of collared caribou was assumed to reflect the distribution of the herd with each collar representing about 1000 caribou. Thus numbers of caribou were generalized estimates, not precise figures.

Radio collars were equipped with motion-sensing mortality switches (Whitten et al. 1984). Suspected mortalities were investigated on the ground, using helicopters for easy access. Mortality rate calculations include data from summer studies (Whitten et al. 1985a) and from tracking flights and field necropsies conducted in Canada (Russell and Nixon 1986). Differences in distribution and mortality patterns among various subsections of the Porcupine herd were compared using chi-square contingency tables (Conover 1971).

Results and Discussions

Fall and Winter Movements and Distribution

Southward migration of Porcupine herd caribou through the Brooks Range occurred earlier in 1984 than in most previous years. Approximately 40,000 caribou moved southward through the Aichilik and upper Kongakut River valleys and crossed the continental divide into the upper Coleen River valley during the first week of July. By 6 July, they had continued down the Sheenjek River valley and were tightly aggregated in the vicinity of Lobo Lake. About 100,000 caribou aggregated in the British Mountains in the northern Yukon in early July (Russell and Nixon 1986). During mid-July, most of these caribou moved southwestward from the Firth River and joined the caribou in Alaska. Many caribou then moved westward across the southern foothills of the Brooks Range and reached the Arctic Village area between 15 and 20 July. By the end of the month, well over 100,000 caribou, including at least 104 with radio collars, were scattered across the foothills and mountains between Arctic Village and the Coleen River (Fig. 1). Only about 8,000 remained in the Yukon in the northern Richardson Mountains (Russell and Nixon 1986).

By late August, most of the caribou in Alaska had moved east into Canada, north of Old Crow (Russell and Nixon 1986). A major storm which deposited snow throughout eastern Alaska in late August stimulated a rapid southeasterly movement of caribou. Significant numbers of caribou crossed the Porcupine River near the international border. At the end August 33 radio collars remained in Alaska, mostly in the foothills between the Sheenjek River and the Canadian border (Fig. 2).

Eastward movements continued, and by mid-September essentially all of the Porcupine Herd (including all radio-collars) was in Canada (Fig. 3). Relatively mild weather prevailed during September and at the end of the month, caribou were moving northwestward. The head of the movement reached the Alaska border in the upper Firth River drainage about 26 September.

By mid-November, Porcupine herd caribou were distributed throughout the hills and mountains in Alaska from the Middle Fork of the Chandalar River to the Canadian border, but primarily west of the Sheenjek River (Fig. 4). About 50,000 Porcupine herd caribou, including at least 47 radio collars, remained in Alaska throughout the winter. The remainder of the herd wintered primarily in the northern Richardson Mountains in the Yukon and Northwest Territories (Russell and Nixon 1986). Some caribou also wintered on the Eagle Plains, east of Old Crow, and in the Ogilvie Basin.

Spring migration was underway by mid-April (Fig. 5). Long lines of caribou moved up the Sheenjek River and then east along either side of the crest of the Brooks Range though the upper Kongakut and Coleen Rivers. A few caribou remained southwest of Arctic Village until early May, and some moved eastward across the southern foothills of the Brooks Range before heading north along the Coleen and/or Firth River drainages (Fig. 6). Spring migration was not monitored in Canada, but presumably proceeded through the Richardson Mountains, around the Old Crow Flats, and along the north slope.

Winter distribution was determined for 108 radio collared caribou, including 37 calves and 71 adults. More collared caribou wintered in Canada (56%) than in Alaska (44%). Calves and adult cows were distributed similarly between the two areas (x^2=1.92, df=1, P 0.05). All radio-collared adult males (6) started the mid-winter period in Canada, although only 2 were still transmitting by spring. Two yearling males wintered in Alaska. These data indicate that proportions of maternal versus barren cows were similar between the 2 broad wintering areas, but that the majority of males possibly wintered in Canada. The sample size of radio collared males was too small to be conclusive; however, extensive surveys during radio-tracking and collaring in Alaska in April 1985 suggested that there were, in fact, few adult males in

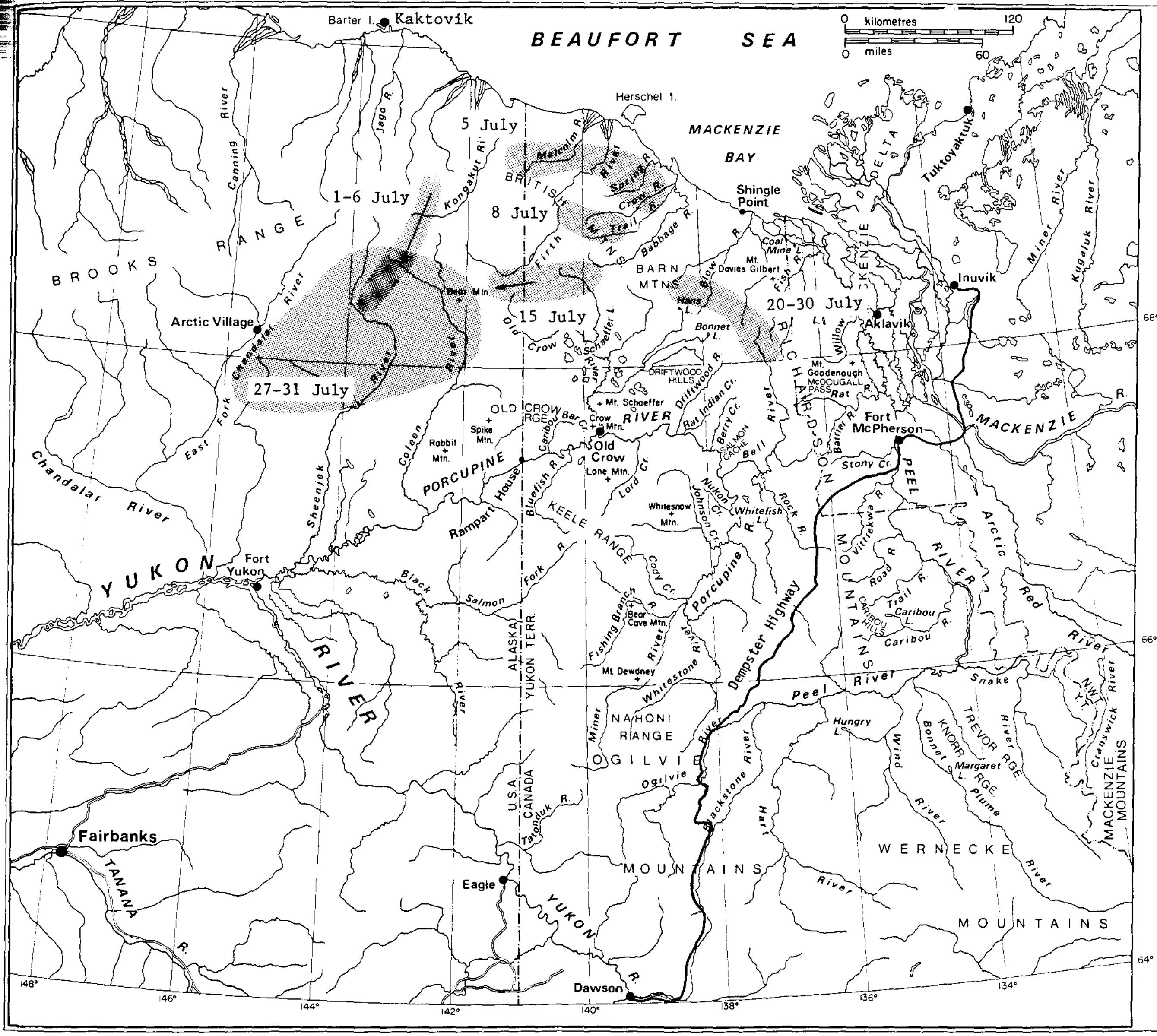

Fig. 1. Porcupine caribou herd distribution 1-31 July, 1984.

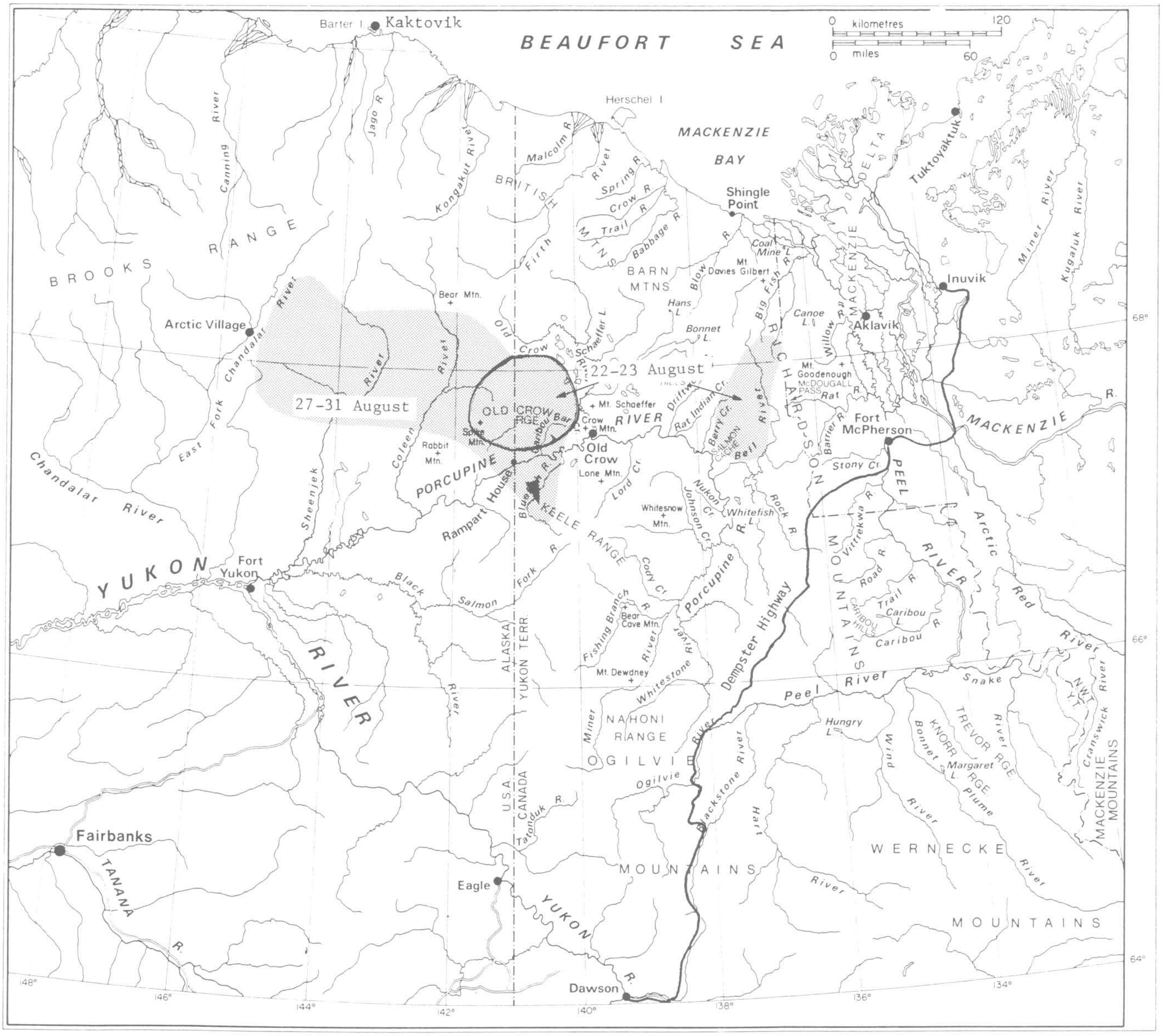

Fig. 2. Porcupine caribou herd distribution 22-31 August, 1984.

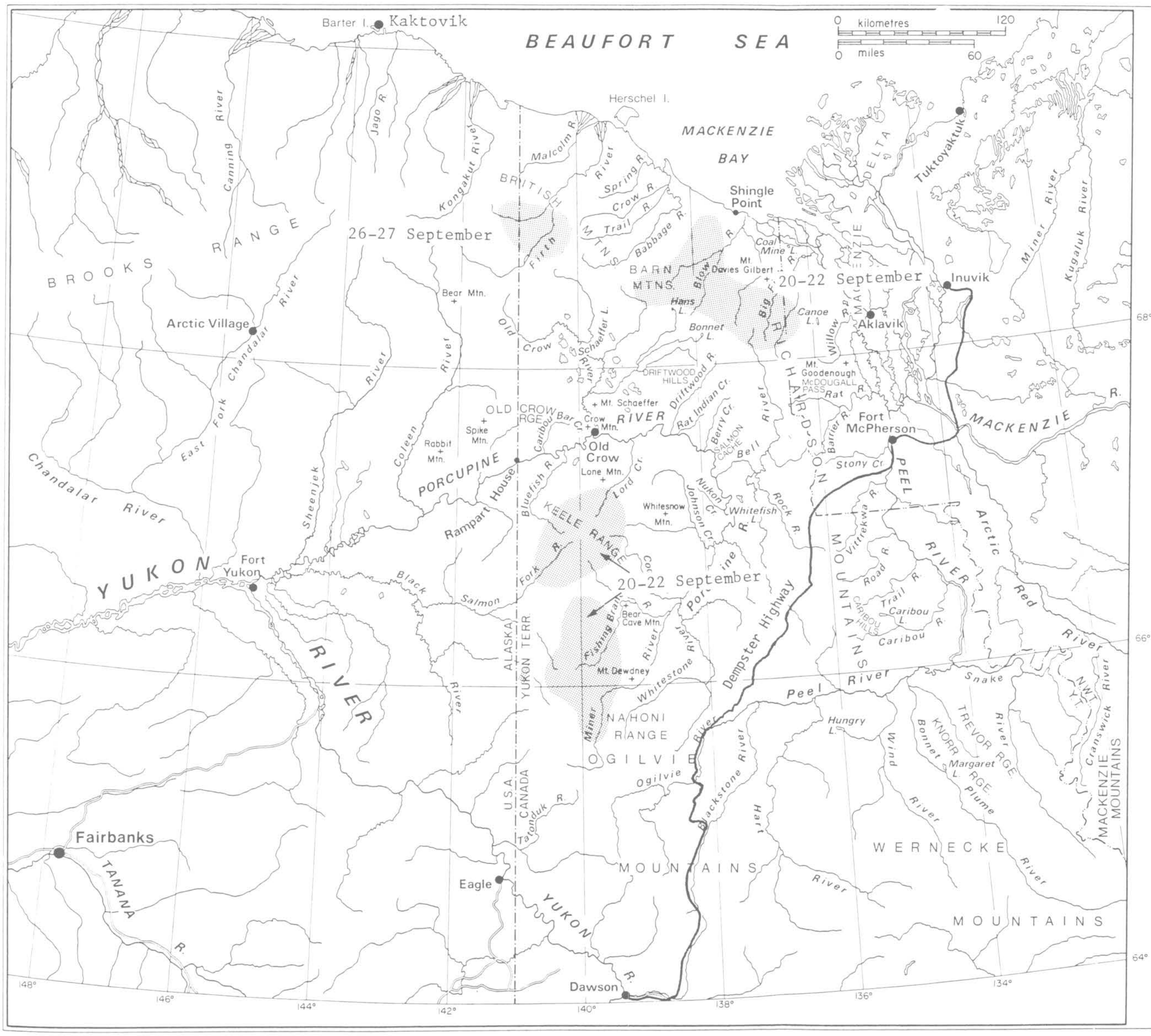

Fig. 3. Porcupine caribou herd distribution 20-27 September, 1984.

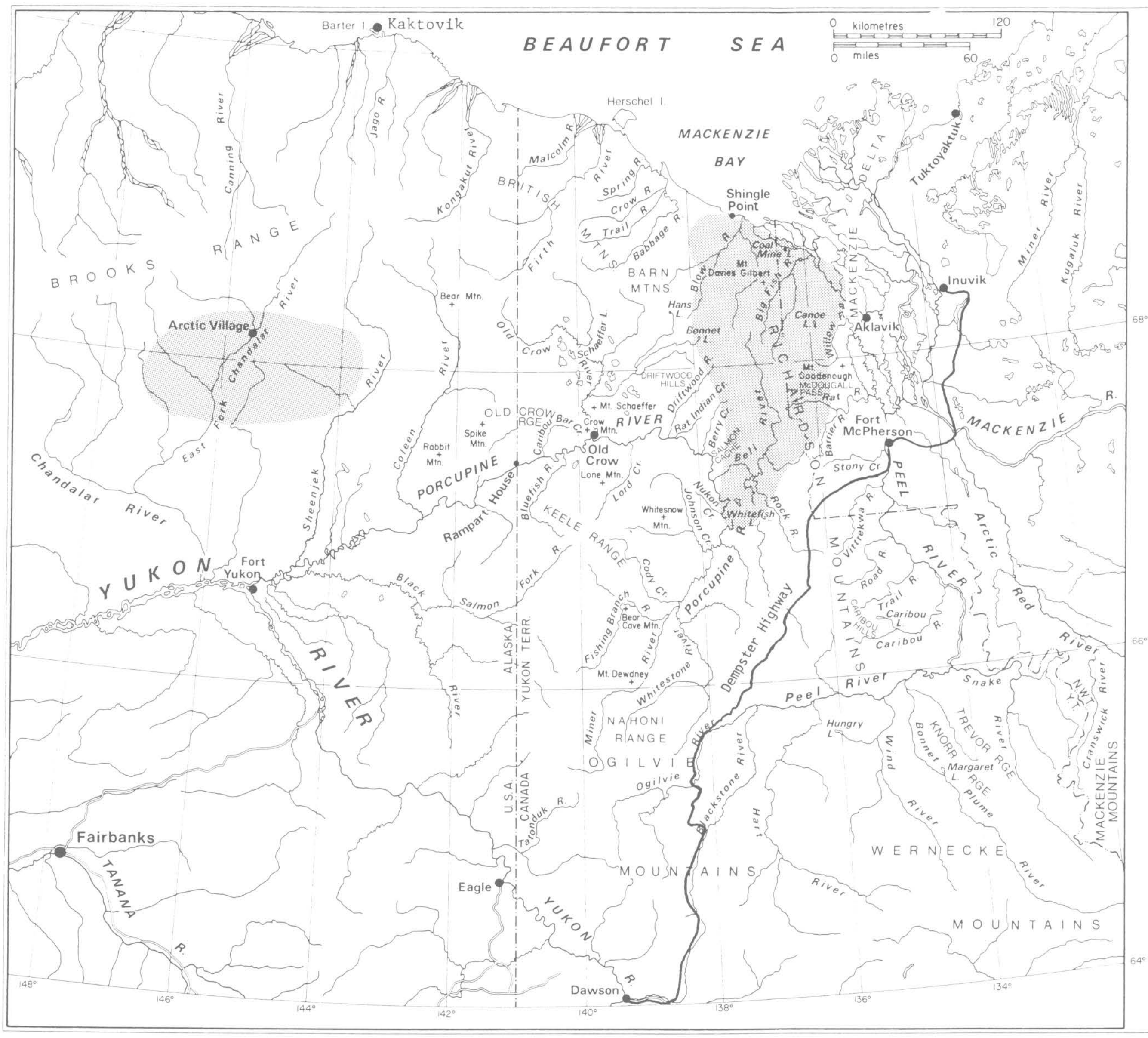

Fig. 4. Porcupine caribou herd distribution 13-17 November, 1984.

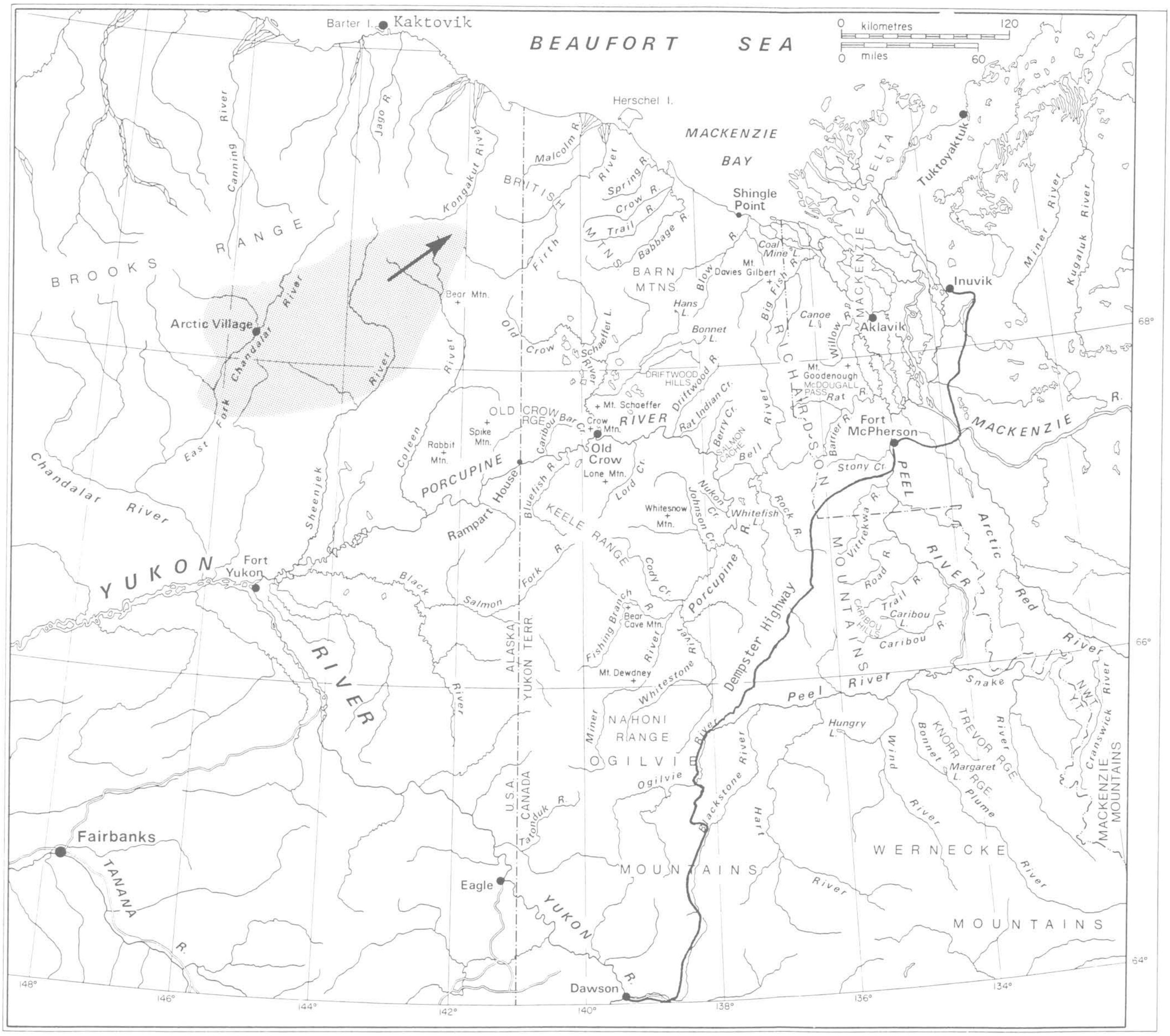

Fig. 5. Porcupine caribou herd distrubtion 13-15 April, 1985 (Alaska only).

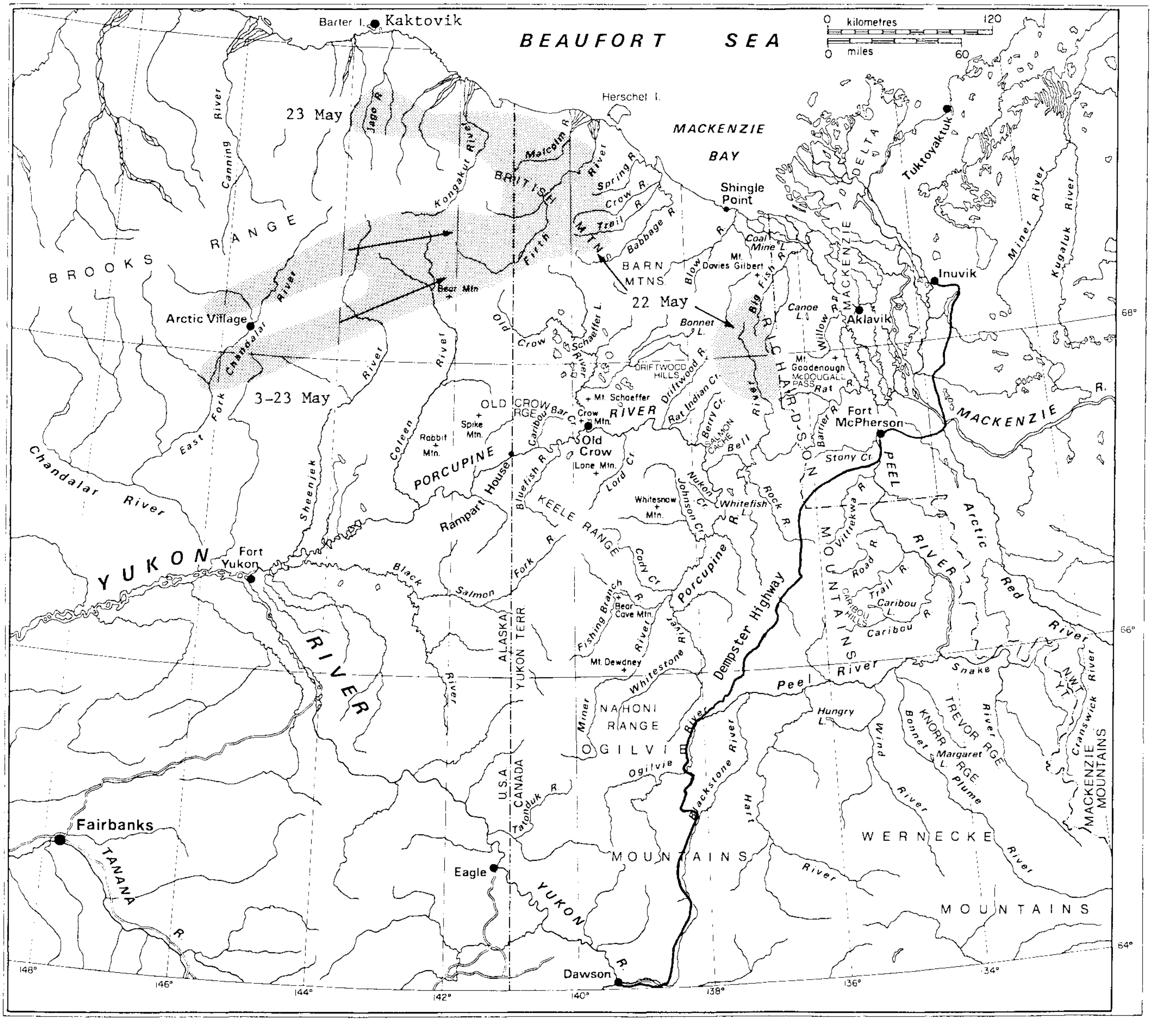

Fig. 6. Porcupine caribou herd distribution 3-23 May, 1985.

Alaska. A similar situation was noted during winter 1983-1984 (Whitten et al. 1985b). Most females wintering in Alaska presumably bred in the British Mountains or along the border before moving on to their final winter ranges. Eight additional adult males were collared in Alaska in April 1985, and 13 males from the 1984 calf cohort were recollared with longer lasting (3.3 year) transmitters. This increased sample size of collared males in future years will provide additional data to more accurately describe the overwinter distribution of males.

Mortality Patterns

The redesigned calf radio collars used in 1984 functioned considerably better than those used in 1983 (Whitten et al. 1985b). Reflector antennas still tended to break, but sender antennas remained intact, providing adequate range for tracking. Only 2 calf collars failed, or at least were never heard after September. Four more collared calves were never located during the winter, but were found alive and well with functioning collars on summer range in 1985. Thus the fate of 58 of 60 collared calves (97%) was known for first year mortality calculations. This was in contrast to the 43 of 63 collared calves (68%) in the 1983 cohort whose fate during the first year of life was definitely known, the remainder presumably having failed collars (Whitten et al. 1985b). Eleven of 81 adult radio collars (14%) apparently failed during the winter of 1984-1985; 3 of these functioned for 3.1 years and the other 8 for 2.4-2.6 years of a projected 3.3 year battery life.

Annual mortality was 40% among the 58 calves whose fates were known. One calf was killed by a wolverine within 24 h of being recollared in April, however, and its death may have been attributable to capture. Thus natural calf mortality may have been only 38%. Mortality was significantly lower (11%; x^2=13.77, df=1, $P < 0.01$) among the 70 collared caribou older than calves which were tracked throughout the entire winter. Calf mortality was particularly high during summer and fall (Table 1), a pattern which also occurred in 1983 (Whitten et al. 1985b). During mid-winter and spring, calf and adult mortality did not differ significantly (x^2=1.44, df=1, $P > 0.05$).

Table 1. Chronology of mortality among radio-collared calves and adults 1984-1985.

	Percent of annual mortality (N)				
Category	Summer (June-Jul)1984	Fall (Aug-Oct)1984	Winter (Nov-Mar)1984	Spring (Apr-May)1985	Total
Calves	23(5)	55(12)	9(2)	14(3)	38 (22)
Adults	22(2)	22(2)	56(5)	0(0)	13 (09)

Among those collared caribou older than calves, mortality was lower among young animals. Combined mortality among 1-, 2-, and 3-year olds (5%) was significantly lower than among adults older than 3 years (32%; x^2=6.07, df=1, $P < 0.05$). Cementum annuli ages of adults older than 3 years are not yet available. However, most were adults when captured, and many have been collared 2 or 3 years. Thus it is likely that many are 6-10 years old and past their prime, and as such would be expected to undergo higher mortality than younger adults.

First year mortality was significantly higher among male calves (53%) than among females (23%; x^2=4.86, df=1, $P < 0.05$). Too few males were tracked through the winter to determine whether adult mortality also differed between sexes.

Causes of calf mortality through November 1984 were reported previously (Whitten et al. 1985a). With the exception of the wolverine kill in April which was possibly capture-related, mortalities during the rest of the winter were not investigated quickly enough to determine cause of death. Predation/scavenging was involved in all cases, however, and wolves were the suspected predator.

Two adult cows were apparently killed by brown bears during summer, as were a yearling male and an adult female that died during fall migration. During mid-winter, 2 adult female mortality sites showed signs that predation/scavenging was involved (likely wolves), 2 other sites could not be investigated, and 1 cow was shot near Arctic Village.

Predation/scavenging was thus the major cause of mortality of both calves and adults on a year round basis. Hunting accounted for 11% of the adult mortality, but only 1% of the adults. Two percent of the calves were shot, accounting for 5% of the calf mortality.

The relatively high calf survival and yearling recruitment, combined with low to moderate adult mortality and low hunting pressure, strongly indicate the Porcupine caribou herd is growing.

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ANWR Progress Report Number FY86-6

CALVING DISTRIBUTION, INITIAL PRODUCTIVITY, AND NEONATAL MORTALITY OF THE PORCUPINE CARIBOU HERD, 1985

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Key words: Caribou, Porcupine herd, calving distribution, productivity, neonatal mortality, predation, post-calving movements, Arctic-Beaufort, north slope

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Calving distribution, initial productivity, and neonatal mortality of the Porcupine caribou herd, 1985.

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Abstract: This report presents information collected during the third year of a 3 year study by the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service of the Porcupine caribou herd's calving distribution, initial productivity, and neonatal mortality. Calving distribution and areas of concentrated calving activity were determined by relocation of 57 radio-collared adult (3+ years old) female caribou (Rangifer tarandus) and by aerial reconnaisance surveys during late spring migration and calving seasons. Distributions of calving caribou extended across the arctic coastal plain and foothills from the Hulahula River in Alaska to approximately the Babbage River in Canada. A major concentration of calving activity occurred on the coastal plain and foothills from the Hulahula River to the Ekaluakat River. A second concentration area occurred on the coastal plain south of Stokes Point in Canada. The peak of calving occurred on 31 May - 1 June which was slightly earlier than previous years. Thirty-eight of 56 (68%) radio-collared females 3 years old or older produced calves, and initial productivity appeared to be similar to that of recent years. During 2-5 June, 66 calves were captured in the Jago River - Aichilik River calving concentration area, and fitted with mortality sensing radio-transmitters. Radio frequencies were monitored at least daily and visual checks were made every 48h during 2 June - 1 July. Monitoring was less intense during the remainder of July and continued on a monthly basis through 1984. Thirty-eight productive radio-collared females were monitored as a control group on 1-3 day intervals during 27 May-27 June. During 2 June-3 September, 14 study calves died. Four calves died as a result of study-induced abandonment. Two radio-transmitters apparently failed soon after installation. The natural mortality rate of the remaining calves was 16.8%. Categories of natural mortality included: mammalian predation (brown bear, Ursus arctos and wolf Canis lupus), 30%; avian predation (golden eagle, Aquila chrysaetos), 30%; undetermined predation, 10%; natural starvation, 10%; disease, 10%, and undetermined causes, 10%. The geographic distribution of mortality of study calves as well as that of unmarked adults and calves was primarily oriented towards the eastern and southern coastal plain/foothlls areas in Alaska, and may be attributed to generally higher concentrations of predators in that region. Increased incidence of mortality among study calves was measured during fall migration in regions south of the Brooks Range and British Mountains, but were not investigated prior to this report.

Calving distribution, initial productivity, and neonatal mortality of the Porcupine caribou herd, 1985.

Much of the coastal plain portion of the Arctic National Wildlife Refuge (ANWR) was opened to a limited oil and gas exploration program by the Alaska National Interest Lands Conservation Act (ANILCA) of 1980. If significant potential for petroleum resources are indicated, Congress may pass additional legislation to open ANWR to further exploration, leasing, and development. Caribou from both the Porcupine and Central Arctic herds utilize portions of the coastal plain of ANWR for calving, post-calving aggregations, and insect relief activities during the spring and summer (U.S. Fish and Wildife Service 1982). Parturient female caribou and post-parturient females with young calves are sensitive to disturbances associated with human activity (de Vos 1960, Lent 1964, Bergerud 1974, Cameron et al. 1979, Davis and Valkenburg 1979). Studies conducted annually since 1974 have shown that female caribou with young calves avoid the Prudhoe Bay oil field and adjacent Trans-Alaska Pipeline corridor (Cameron and Whitten 1976, Whitten and Cameron 1985). 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 need to be assessed to make predictions regarding calf survival and herd productivity if traditional calving habitats are further explored and developed for petroleum production. Consequences of displacement from traditional insect relief areas and preferred forage areas, and the overall impacts of human/industrial disturbances also need to be evaluated. ANILCA requires the evaluation of potential adverse effects that oil and gas exploration, production, and development on ANWR might have upon the Porcupine caribou herd. In addition, if petroleum development on ANWR is allowed, more information on caribou distribution and habitat use during the calving and post-calving periods is needed to formulate recommendations for leasing schedules, placement of facilities, and other mitigative measures. In particular, causes and patterns of calf mortality need to be examined with emphasis on differences between areas or habitat types, in order to assess the the possible effects of displacement from development sites. This study focuses on determining annual calving distribution, initial productivity, and neonatal caribou calf mortality on the calving grounds and post-calving areas of the Porcupine caribou herd and was initiated in 1983 as a joint project between the U.S. Fish and Wildlife Service (USFWS and the Alaska Department of Fish and Game (ADF&G).

Objectives for this study were:

A. Primary

1. Delineate calving distribution of the Porcupine caribou herd and identify annual consistencies in calving distribution and/or common characteristics among separate calving areas.

2. Determine initial calf production and extent, causes, and chronology

of mortality among neonatal calves (i.e., 4-6 weeks postpartum).

3. Measure variation in calf mortality and calf mortality factors between core and peripheral areas and/or between different habitat types or localities.

B. Secondary

1. Provide productivity data for analysis of herd status.

2. Identify characteristics (i.e., habitat, snow ablation patterns, topography, etc.) of core and peripheral calving areas and/or calving areas in different habitat types or localities.

3. Provide additional collared caribou for concurrent studies of over-winter calf survival and seasonal movements.

4. Provide incidental observations of other species as part of the overall ANWR baseline studies, including casual or incidental locations of radio-collared muskoxen, brown bears, and wolves.

This study was conducted concurrently with studies of the status (population size and trend), over-winter calf mortality, and winter distribution of the Porcupine caribou herd. Adult caribou collared in conjunction with those studies aid in the conduct of this investigation. Collectively, this study is part of a comprehensive environmental inventory and assessment of the potential petroleum development area of ANWR. This report presents preliminary findings of the 1985 field season.

Methods and Materials

Study Area

The study area was located on the north slope of ANWR extending east to the Blow River in Canada and south to the southern slopes of the Brooks Range, depending on annual variation in caribou distributions. In 1985, the study area extended from the Sadelrochit River on the west, to the Babbage River in Canada on the east, and from the Beaufort Sea coastline on the north, to the southern slopes of the Brooks Range on the south.

Most study activities occurred on the coastal plain and foothills portions of the area described above. Descriptions of the physical environment, climate, geology, vegetation, and other wildlife resources of the study area are found in U.S. Fish and Wildlife Service (1982). Logistical operations were based at Kaktovik, Alaska.

Calving Distribution and Initial Productivity

General calving distribution was determined primarily by locating all radio collared adult female caribou in the Porcupine herd during late May and early

June. All radio-tracking was conducted from aircraft equipped with standard tracking equipment (Telonics, Mesa, AZ). Radio-tracking flights during calving distribution surveys were usually at altitudes greater than 1,000 m AGL. Low altitude (20-100 m AGL) aerial searches were also conducted to identify calving caribou.

Low-level transects across the calving grounds between the Aichilik River and Barter Island were flown using fixed-wing aircraft on 30 and 31 May. All caribou within approximately 300 m of the flight line were counted and classified as either newborn calves or adults.

High altitude radio-tracking flights over the northern part of the winter range, and over the mountains and coastal plain east of the calving areas were conducted to determine the distribution of bulls and yearlings during calving.

Neonatal Mortality

Caribou calves were captured from 2 areas with higher densities of calving females. The first capture area was located about 20 - 50 km inland from the coast on either side of the Jago River and coincided with the historic "core" calving region of the Porcupine herd. This area included flat, wet coastal plain in the north, and rolling hills and tussock tundra in the south. The second capture area was along both sides of the Aichilik River where it emerges from the Brooks Range mountains. Most of this area was rolling hills with tussock tundra, but it also included some riparian habitat within the higher mountains (Fig. 1). This capture area is sometimes considered a peripheral calving area for the Porcupine herd.

Caribou groups were approached by helicopter (Bell Jet Ranger 206B) with a capture crew of 3 persons aboard. The helicopter landed approximately 200 m from the caribou and 1 person took a sitting position on the right skid. The helicopter then proceeded towards the group and a calf was selected for capture. Selection from groups was standardized (calf on extreme left) to minimize sampling bias for slower, younger, and/or weaker calves.

The selected calf was pursued by flying approximately 1 m above the ground. When the helicopter was within 2-3 m of the running calf, the person on the skid stepped off to the side, ran, and grasped the calf. Sterile surgical gloves were worn by personnel handling captured calves and new gloves were used for each handling. When a calf was captured, the helicopter landed and the remaining members of the capture crew assisted in processing the calf.

Captured calves were sexed, weighed, and measured for total body length, right hind foot length, and new hoof length (Haugen and Speake 1958). Characteristics of the umbilicus (moist, dry, absent) and hooves (degree of wear) were noted as described by Miller and Broughton (1974). Each calf was examined for abnormalities, and fecal samples were collected from those calves with scours.

An expandable elastic collar supporting a mortality sensing transmitter (Telonics Inc., Mesa, AZ) weighing approximately 114 g was installed around the neck of each calf. Mortality mode for transmitter units was doubling of normal pulse rate following a 1 h motion free period. Estimated battery life was 15 months. Each collar was constructed from a 3.75 cm wide elastic band.

The initial collar size (25 cm circumference) was achieved by sewing the left and right ends of the elastic collar band together. Three separate expansion folds per collar were sewn with incremental amounts of cotton thread stitching. Each expansion fold provided an additional 7 cm of collar circumference. Maximum expansion circumference of each collar was 53 cm. Collars were constructed to break away after the last expansion fold was used. Collars were dyed brown as in 1984. All collars were stored in plastic bags with local soil and vegetation for 24 hours prior to placement on calves (Garner et. al 1985b).

Aircraft (PA-18) equipped with standard radio tracking equipment were used to monitor instrumented calves, locate mortalities, and determine calf locations and movements. The capture crew in the helicopter occasionally observed an immediate reunion of the calf with its dam, however, aerial relocation and visual checks of all marked calves were made at 1-3 h time intervals following release to determine if the dam rejected the calf. All calf radio frequencies were monitored for mortality signals at least once daily and visual locations or location to caribou group were made for each calf every other day from 2 June through 7 July 1985. Relocation surveys were conducted on a monthly basis from July through December 1985. Visual and group locations were plotted on 1:250,000 and 1:63,360 scale topographic maps.

All mortalities were investigated as soon as possible using a helicopter for access. Each carcass and mortality site was examined for information on the cause of death. Photographs were taken to document mortality sites. Evidence of predators/scavengers at the carcass site was noted and collected. Each carcass was placed in a plastic bag, labeled, and transported to Barter Island. Necropsies were performed on carcasses when sufficient remains were present. In cases where only hair and bones remained, measurements of weight, right hind foot length, and new hoof length were recorded whenever possible. The locations of retrieved carcasses were plotted on 1:63,360 scale topographic maps. Criteria for determining the category (Cook et al. 1971) and the cause of each mortality (Table 1) were developed from descriptions of predator kills and feeding characteristics in the literature (Murie 1948, Thompson 1949, Johnson 1951, Borg 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).

Carcasses of unmarked calves encountered during this and other field studies were also examined as opportunity allowed. The locations of predators observed on the calving grounds were noted and observations of interactions between caribou and predators were recorded. Concurrent field studies of brown bear, wolf, and golden eagle ecology on the coastal plain on ANWR also provided additional information relative to this study (Garner et al. 1987, Weiler et al. 1987, Mauer 1987).

Initial productivity and subsequent mortality of calves from 57 3+ year-old cows and 8 2-year-old radio-collared control cows were compared with data from the radio-collared study calves. The control females were radio-tracked in late May and early June 1985 as they arrived on the calving grounds and their locations were plotted on 1:250,000 scale topographic maps. Parturition status was determined by low-level aerial observations of the presence/absence of young, antler shedding (Lent 1965, Epsmark 1971), and udder distention (Bergerud 1964). Following parturition, productive members of the control group were monitored on a 24-72 h basis until approximately 27 June.

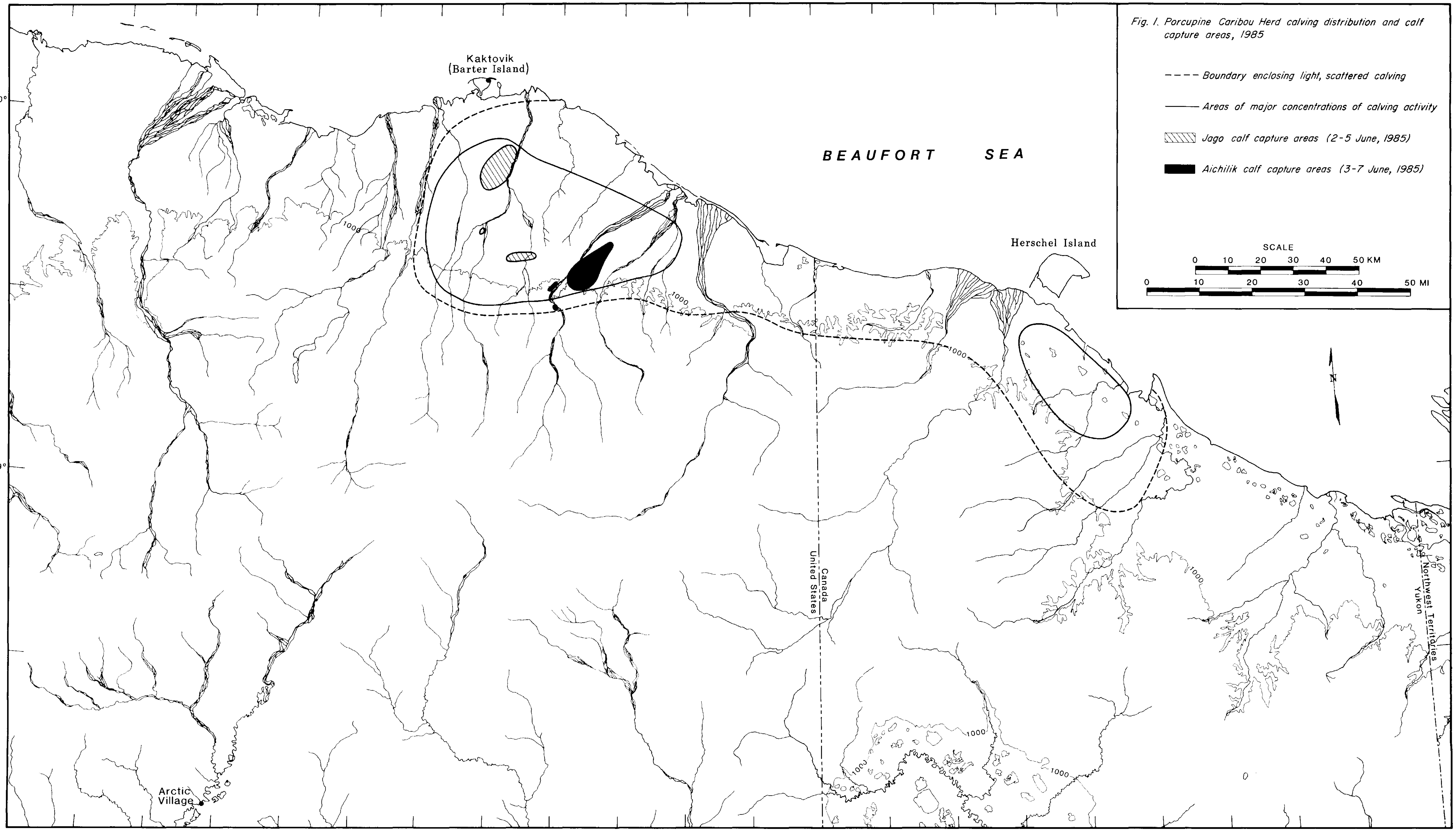

Fig. 1. Porcupine Caribou Herd calving distribution and calf capture areas, 1985
Boundary enclosing light, scattered calving
Areas of major concentrations of calving activity
Jago calf capture areas (2-5 June, 1985)
Aichilik calf capture areas (3-7 June, 1985)
SCALE
0 10 20 30 40 50 KM
0 10 20 30 40 50 MI
BEAUFORT SEA
Kaktovik
(Barter Island)
Herschel Island
Arctic Village
Canada
United States
Northwest Territories
Yukon
1000
70°
69°
146°
145°
144°
143°
142°
141°
140°
139°
138°
137°
N

Table 1. Criteria used for determining category of observed mortalities of neonatal caribou calves in northeast Alaska.

Criterion	Category
I. Carcass lacks sign of being bitten, chewed or disturbed by predators.	I. Predation-excluded
1. Milk curds absent in abomasum and intestinal tract. Lack of mesentary and subcutaneous fat. Rumen may be packed with vegetation.	1. Starvation
a. No reunion with dam observed following release and subsequently observed unattended by dam prior to death.	a. Probable study-induced abandonment
b. Reunion with dam observed following release, but later observed unattended by dam prior to death.	b. Probable natural abandonment
2. Milk curds present or absent from abomasum or intestinal tract. Mesentary and subcutaneous fat present. Absence of any signs of starvation.	2. Exposure/accident
a. Physical trauma present	
i. Broken bones, bruises, etc.	a. Accident
ii. Gun shot wounds	b. Hunter kill
b. No physical trauma present. Carcass in river or stream. Water in lungs, rumenoreticulum, or abomasum.	c. Drowning
c. No physical trauma or evidence of drowning.	d. Exposure
3. Disease syndrome present, or disease syndrome noted at capture.	3. Disease
4. None of the above.	4. Undetermined
II. Carcass bitten, chewed, and/or partially eaten.	II. Predation/scavenging involved.
A. Lack of blood in wounds, lack of frothy blood in nares and trachea, no bruises surrounding tooth marks, or no subcutaneous hemorrhages present.	A. Scavenging
1. Bones gnawed and chewed, feeding pattern generally not restricted to the upper portion of carcass.	1. Mammalian scavenger (return to I.1 to determine cause of death)
2. Bones not chewed, feeding limited to upper portions of carcass.	2. Avian scavenger (return to I.1 to determine cause of death)
3. Neither of the above, or some characteristics from both.	3. Undetermined

Table 1. (Continued).

Criterion	Category
B. Blood in wounds, frothy blood in nares and trachea, bruises surrounding wounds and subcutaneous hemorrhages present.	B. Predation
1. Debilitating 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 bones 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
i. Extensive trauma to carcass. Large portions of carcass missing. Bones broken or crushed. Skull crushed. In older calves, rumen not consumed. Carcass often covered with debris.	i. Brown bear
ii. Extensive trauma to carcass. Bones broken. Carcass not covered with debris. Skin at kill area often not punctured.	ii. Wolf
iii. Extensive trauma to carcass. Evidence not conclusive for any species or conflicting evidence.	iii. Undetermined mammal
c. None of the above.	c. Undetermined predator

Results and Discussion

Calving Distribution and Initial Productivity

In spite of deep snow on the Alaskan winter ranges and on the southern slope of the Brooks Range, spring migration of the Porcupine herd followed traditional routes with no noticeable delays. Caribou from the Chandalar wintering area moved north and east through the Sheenjek and Coleen drainages into the Firth River valley. Many first crossed the Continental Divide into the upper Kongakut River valley, but most of those left the Kongakut River where it turns north and crossed into the Firth River valley before heading toward the coastal plain. A few moved directly north from the Kongakut River and down the Aichilik River to the calving grounds. The latter movement is essentially the reverse of the mid-summer southward movement taken by as much as 1/3 of the herd in recent years. For most caribou, however, spring migration does not retrace the route taken in fall. Fall movements often entail abrupt reversals of direction followed by staging in various areas before finally heading toward winter range. The spring migration tends to be more directed, though there may be pauses, especially when deep snow areas temporarily inhibit travel. Thus, even though most sections of the spring routes may also be traveled in the fall, the routes used by caribou to reach the wintering areas and those followed north to the calving grounds are different.

Many caribou had reached the Continental Divide by about 20 April, while some radio-collared females remained far south on winter range until May. Once caribou reached the windswept valleys north of the crest of the Brooks Range and in the British Mountains, they had easy access to the coastal calving areas. Many cows were already on the traditional high-density calving area near the Jago River by 28 May, although others remained scattered eastwards across the coastal plain and foothills to the British Mountains. As in previous years (Whitten et al. 1984, 1985a), pregnant cows toward the rear of the migration kept moving north and westward during the first week of June. Thus the distribution of collared cow calving sites was skewed much farther west than the distribution of parturient cows at the onset of the calving period (Fig. 2 and 3).

Some cows did not follow the westward shift toward the Jago River during spring migration and calving, but instead moved toward the low, rolling hills south of Herschel Island and near Stokes Point in the Yukon Territory. Thus this region became an area of relatively high calving density that was isolated from the high density calving areas farther west (Fig. 1). A similar pattern occurred in 1984 (Whitten et al. 1985a) and in previous years (U.S. Fish and Wildlife Service 1982). Non-pregnant females and yearlings stayed mainly at the rear of the calving migration in the east and south; males were mostly on the south side of the British Mountains.

Peak of calving among radio-collared cows was between 30 May and 1 June (Fig. 4). Transects flown across the high density calving areas near the Jago River indicated 25% calves among 76 caribou on 30 May and 17% among a sample of 192 on 31 May. Surveys at the same time in earlier years found about 20 - 25 % calves, and the peak of calving in both 1983 and 1984 was between 2 and 6 June. The relatively advanced age of calves captured on 2 and 3 June 1985 compared with those captured on 3, 4, and 5 June in 1983 and 1984 (Whitten et al. 1984, 1985a) suggests that the peak of calving was earlier in 1985.

Among radio-collared cows, 15 of 25 (60%) 3-year olds and 23 of 31 (74%) aged 4 years or older gave birth to calves in 1985. These rates did not differ significantly (x^2=0.89, df=1, P > 0.05). One of 8 (13%) 2-year olds gave birth, but lost its calf within 24 h. In previous years, no 2-year olds produced calves, (Whitten et al. 1984,1985a) and the present data also indicate that 2-year olds do not contribute significantly to herd productivity, at least under current and recent conditions. Initial productivity among collared cows 3-years old or older has not differed significantly over the past 4 years (67%, 78%, 74%, and 67% in 1982 -1985, respectively; X^2=1.52, df=3, P > 0.05).

Calf Capture

On 2 June, 30 calves were captured and fitted with radio-collars in the core calving concentration area along the Jago River, (15 on thaw-lake plains between the Jago and Okpilak Rivers, and 15 on uplands between the Jago and Okerokovik Rivers). An additional 29 calves were captured on the eastern periphery of the core calving concentration along the Aichilik River on 3 June (Fig.1). Seven calves were subsequently captured (2 on the Jago uplands, 5 on the Aichilik foothills) during 5 to 7 June to replace those lost to early mortality.

Cumulative time required for capture operations to search, capture, process and release 66 calves was 5 h 55 min. Average search/capture/procesing time was 5.38 min with processing time averaging 1.65 min. and search/capture averaging 3.73 min. Monitoring techniques using fixed-wing aircraft were used to document reunions and/or cases of study-induced mortality.

The average weight for all calves captured (Table 2) was 7.75 kg. Males were heavier, 7.89 kg vs. 7.59 kg for females. The average estimated age of captured calves was 2.47 days old. There were 36 males and 30 females (1.2 males:1 female).

Calf Mortality

A total of 14 study calf mortalities were detected and investigated between 4 June and 3 September 1985 (Table 3). An additional 8 mortality signals were detected from September 1985 through January 1986, however, investigations of their status was completed prior to this report. Case histories for each investigated mortality are included in Appendix I.

Four of 66 calves captured may have died due to abandonment after capture (Table 3). Study-induced mortality (abandonment by the dam or predisposition of calf to predation, etc.) is inherent using radio-transmitter study techniques. Transfer of foreign scent (human on calf) appears to increase study-induced

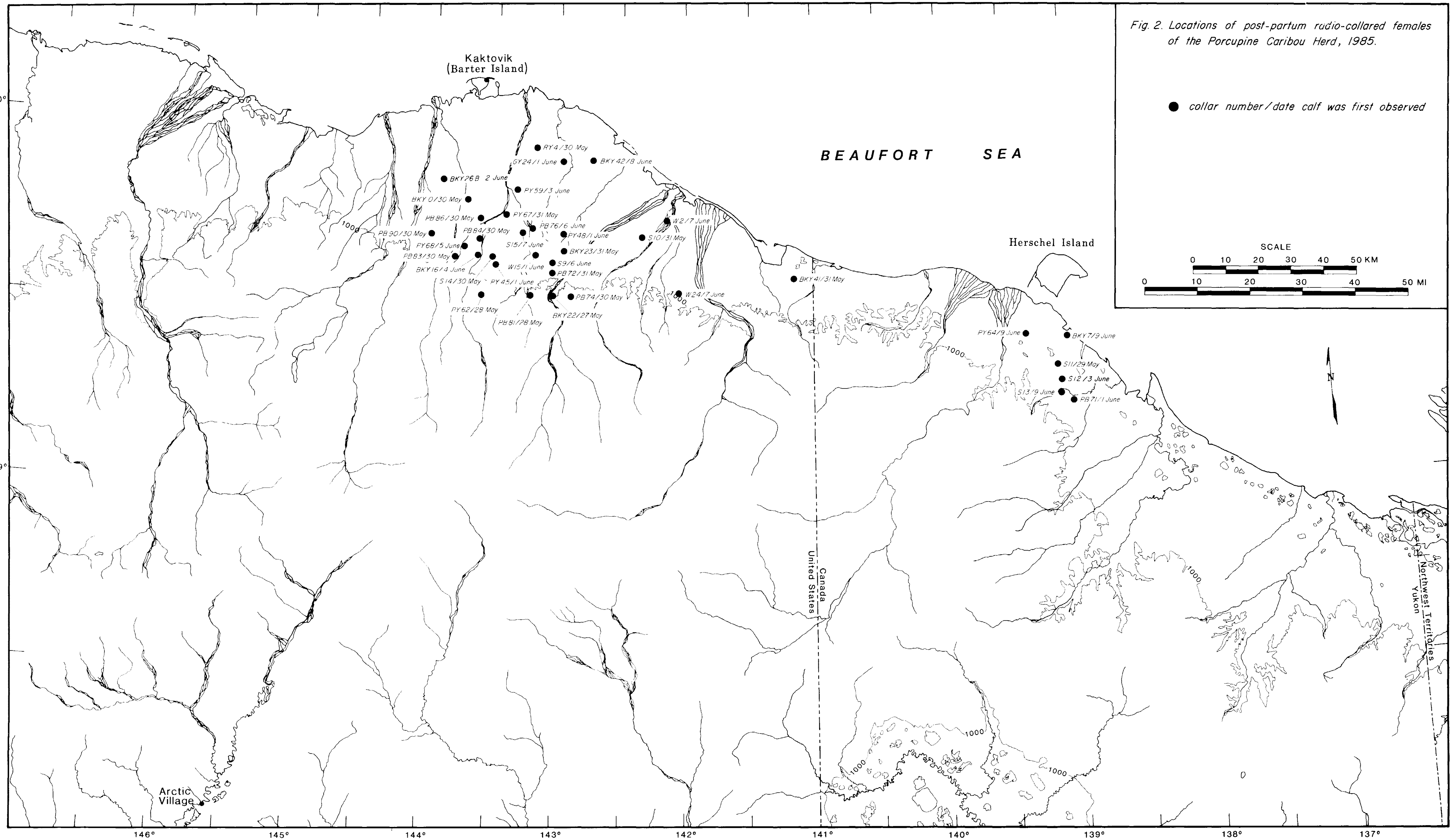

Fig. 2. Locations of post-partum radio-collared females of the Porcupine Caribou Herd, 1985.

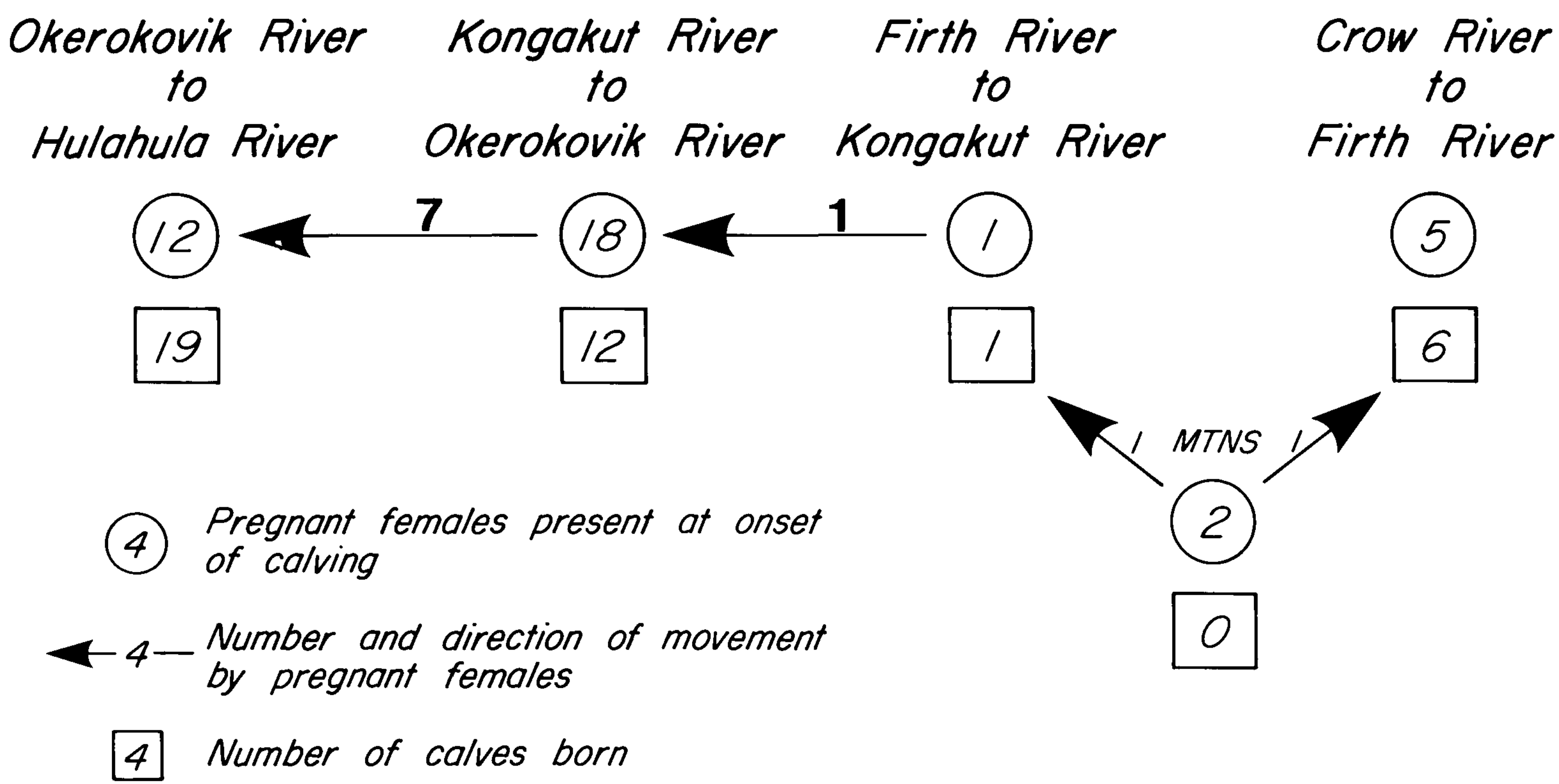

Fig. 3. Schematic representation of movements by pregnant radio-collared female caribou during the 1985 calving season.

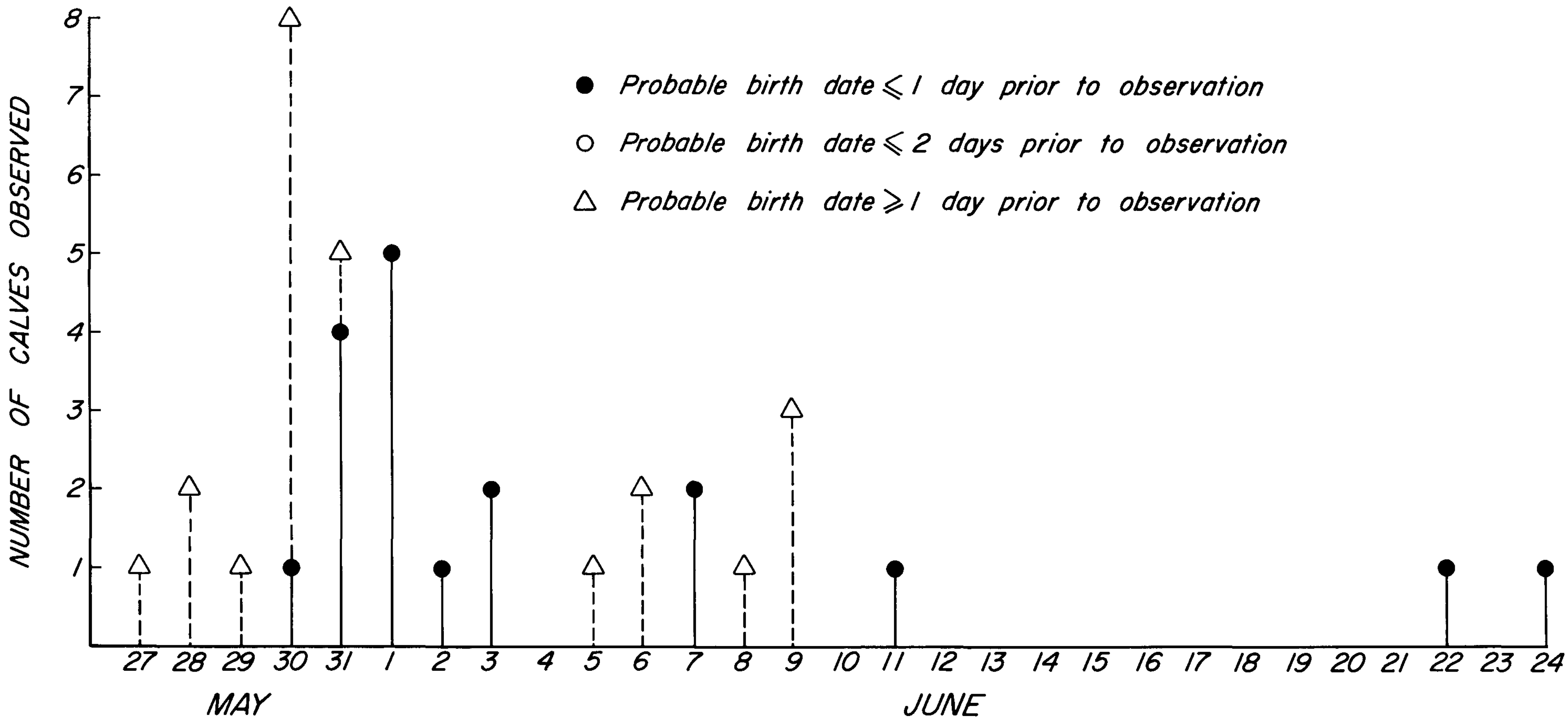

Fig. 4. Dates when newborn calves of 37 radio-collared cows were first observed, Porcupine caribou herd, 1985.

Table 2. Physical characteristics and survival related observations of radio-collared caribou calves, Arctic National Wildlife Refuge, 1985.

Calf no.	Capture date	Location	Sex	Weight (kg)	Length (cm)	Hind foot length(cm)	New hoof length(mm)	Umbilicus condition	Hoof condition[a]	Estimated age[b]	Handling time(min)	Status Jan 1986
1	3 June 85	Aichilik Fths.	M	7.4	93	33.0	7.2	Dry	H/W	2	1.75	Dead (19 June)
2	3 June 85	Aichilik Fths.	M	8.4	79	34.0	7.7	Absent	H/W	3	1.52	Alive
3	3 June 85	Aichilik Fths.	M	7.6	83	33.0	7.2	Dry	H/W	2	1.30	Dead*(October)
4	3 June 85	Aichilik Fths.	M	7.6	92	34.5	7.2	Absent	H/W	3	1.17	Alive
5	3 June 85	Aichilik Fths.	F	7.0	90	33.0	7.3	Dry	H/W	2	1.26	Alive
6	3 June 85	Aichilik Fths.	M	8.9	97	36.5	7.5	Dry	H/W	2	1.32	Dead*(October)
7	3 June 85	Aichilik Fths.	F	7.6	89	34.0	7.4	Absent	H/W	3	N/A	Dead*(September)
8	3 June 85	Aichilik Fths.	F	9.1	97	36.0	7.6	Dry	H/W	2	5.10	Alive
9	3 June 85	Aichilik Fths.	M	8.0	85	34.5	7.6	Absent	H/W	3	2.10	Alive
10	3 June 85	Aichilik Fths.	F	10.1	102	37.5	8.7	Dry	H/W	4	1.42	Alive
11	3 June 85	Aichilik Fths.	M	6.8	79	34.0	7.9	Moist	PH/W	2	1.18	Alive
12	5 June 85	Aichilik Fths.	M	6.2	78	32.0	8.3	Moist	PH/W	2	N/A	Dead (8 June)
13	3 June 85	Aichilik Fths.	F	5.9	79	32.0	6.0	Dry	PH/W	2	1.32	Alive
14	3 June 85	Aichilik Fths.	F	7.6	84	34.0	7.3	Dry	H/W	2	2.35	Alive
15	3 June 85	Aichilik Fths.	M	8.8	92	36.0	8.0	Absent	H/W	4	N/A	Alive
16	3 June 85	Aichilik Fths.	M	7.6	89	35.0	7.3	Absent	H/W	3	1.57	Alive
17	3 June 85	Aichilik Fths.	M	6.5	78	33.0	8.1	Moist	PH/W	2		1.05Alive
18	3 June 85	Aichilik Fths.	F	7.5	86	35.5	8.6	Dry	PH/W	3	1.15	Alive
19	3 June 85	Aichilik Fths.	M	6.8	87	34.5	7.4	Moist	PH/W	1	1.34	Alive
20	3 June 85	Aichilik Fths.	M	9.4	91	37.0	8.0	Dry	H/W	2	1.56	Dead (5 June)
21	3 June 85	Aichilik Fths.	M	8.6	87	36.0	8.2	Dry	H/W	3	1.15	Alive
22	3 June 85	Aichilik Fths.	F	6.9	85	33.0	7.4	Absent	PH/W	2	1.09	Dead*(January)
23	3 June 85	Aichilik Mtns.	F	8.5	89	34.0	9.1	Dry	H/W	4	1.36	Dead (5 June)
24	3 June 85	Aichilik Mtns.	F	9.2	92	34.5	8.0	Dry	H/W	3	1.18	Dead (5 June)
25	3 June 85	Aichilik Fths.	F	8.9	90	37.0	7.2	Dry	H/W	2	N/A	Alive
26	3 June 85	Aichilik Fths.	M	11.9	101	36.0	9.1	Absent	H/W	4	1.40	Alive
27	3 June 85	Aichilik Fths.	M	9.0	94	35.5	8.3	Dry	H/W	3	1.20	Dead (5 June)
28	3 June 85	Aichilik Fths.	F	7.5	87	32.0	7.7	Dry	H/W	2	1.45	Alive
29	3 June 85	Aichilik Fths.	F	6.8	83	35.0	8.6	Bloody	PH/SW	1	N/A	Alive
30	3 June 85	Aichilik Fths.	M	8.0	88	36.0	7.8	Dry	H/W	2	N/A	Alive
31	2 June 85	Jago C.P.	F	7.4	82	31.0	7.7	Absent	H/W	3	5.00	Alive
32	2 June 85	Jago C.P.	M	7.5	84	34.0	7.8	Moist	PH/W	2	2.02	Alive
33	2 June 85	Jago C.P.	M	6.9	82	32.0	8.2	Dry	PH/W	3	2.09	Dead (5 June)
34	2 June 85	Jago C.P.	M	7.9	84	34.5	8.4	Moist	PH/W	2	1.50	Alive
35	2 June 85	Jago C.P.	F	8.2	88	34.5	8.7	Dry	H/W	4	1.46	Alive
36	2 June 85	Jago C.P.	F	7.5	79	34.0	7.4	Dry	PH/W	2	1.32	Dead (24 June)
37	2 June 85	Jago C.P.	F	7.7	84	34.0	7.5	Dry	H/W	2	1.49	Dead*(October)
38	2 June 85	Jago C.P.	F	8.4	88	35.5	8.4	Dry	H/W	3	1.27	Alive

Table 2. (Continued)

Calf no.	Capture date	Location	Sex	Weight (kg)	Length (cm)	Hind foot length(cm)	New hoof length(mm)	Umbilicus condition	Hoof condition[a]	Estimated age[b]	Handling time(min)	Status Jan. 1986
39	2 June 85	Jago C.P.	M	7.6	88	34.5	8.0	Dry	PH/W	2	1.35	Alive
40	2 June 85	Jago C.P.	M	7.4	82	34.5	7.4	Dry	PH/W	2	1.41	Dead (20 June)
41	2 June 85	Jago C.P.	M	7.1	76	33.5	8.5	Bloody	PH/W	1	1.35	Alive
42	2 June 85	Jago C.P.	M	7.7	82	35.0	8.5	Dry	H/W	3	N/A	Alive
43	2 June 85	Jago C.P.	F	6.7	80	32.5	8.2	Dry	H/W	3	1.31	Alive
44	2 June 85	Jago C.P.	M	8.0	84	36.0	7.6	Moist	H/W	2	1.35	Alive
45	2 June 85	Jago C.P.	F	6.9	82	34.0	9.0	Dry	H/W	4	2.10	Alive
46	2 June 85	Jago Fths.	F	8.1	92	35.5	7.4	Absent	H/W	3	1.48	Alive
47	2 June 85	Jago Fths.	M	6.6	81	33.5	7.1	Moist	PH/W	1	2.22	Alive
48	2 June 85	Jago Fths.	F	6.6	85	33.5	7.3	Absent	PH/W	3	1.30	Alive
49	2 June 85	Jago Fths.	F	9.1	91	37.0	7.7	Absent	PH/W	3	1.54	Alive
50	2 June 85	Jago Fths.	M	8.3	90	35.0	7.8	Absent	H/W	3	1.57	Dead (5 June)
51	2 June 85	Jago Fths.	F	5.5	77	32.0	6.8	Dry	PH/W	2	1.36	Alive
52	2 June 85	Jago Fths.	M	8.4	87	37.0	7.6	Absent	H/W	3	1.45	Alive
53	2 June 85	Jago Fths.	F	6.9	81	33.0	7.2	Dry	H/W	2	2.06	Alive
54	2 June 85	Jago Fths.	M	7.6	87	34.5	8.2	Moist	PH/W	2	1.49	Alive
55	2 June 85	Jago Fths.	F	8.2	98	35.0	7.3	Dry	H/W	2	2.11	Dead*(December)
56	2 June 85	Jago Fths.	M	6.4	87	33.0	6.7	Bloody	PH/W	1	1.42	Dead (24 June)
57	2 June 85	Jago Fths.	M	7.8	88	34.5	7.7	Absent	H/W	3	1.43	Alive
58	2 June 85	Jago Fths.	M	7.4	89	33.5	8.3	Moist	N/A	2	2.45	Dead*(December)
59	2 June 85	Jago Fths.	F	8.0	84	33.5	7.9	Moist	PH/SW	2	2.50	Alive
60	2 June 85	Jago Fths.	M	7.6	78	34.0	7.1	Absent	H/W	3	N/A	Dead (24 June)
61	5 June 85	Jago Fths.	M	8.4	83	34.0	7.7	Absent	H/W	3	N/A	Alive
62	5 June 85	Jago Fths.	M	7.6	84	36.0	7.4	Dry	H/W	2	1.40	Alive
63	5 June 85	Aichilik Fths.	M	10.5	94	35.5	8.0	Absent	H/W	3	1.55	Alive
64	5 June 85	Aichilik Fths.	F	7.1	84	34.0	7.5	Absent	PH/W	3	1.45	Dead*(October)
65	6 June 85	Aichilik Fths.	F	6.8	79	34.0	7.4	Dry	H/W	2	1.35	Dead (31 August)
66	7 June 85	Aichilik Fths.	F	6.1	83	33.0	7.3	Dry	H/W	2	2.15	Dead (15 June)
		Male Averages		7.89	86.2	34.6	7.80			2.39		
		Female averages		7.59	86.	34.1	7.72			2.57		
		Overall averages		7.75	86.25	34.4	7.76			2.47	1.65	

[a] H=hardened; PH=partially hardened; S=soft; W=hooves worn; SW=slightly worn.

[b] Age rounded to nearest whole day.

*Mortality detected but not confirmed by ground investigation.

mortality rates (Whitten et al. 1984). The use of sterile latex gloves, holding captured calves away from contact with the capture crew, and scenting the collars with natural moss and soil (Dickinson et al. 1980) and dying collars brown prior to deployment or redeployment on calves helped to minimize foreign sight and scents. Study-induced mortalities in 1985 were low compared to earlier years of this study (Whitten et al. 1984 and 1985a). Any further studies of caribou calf mortality using radio-collaring techniques should also employ the same capture and handling procedures to minimize study-induced mortality.

Table 3. Probable causes of mortality for 14 of 66 radio-collared caribou calves between 4 June and 3 September 1985.

Category	Number or Calves	% Total Mortality
I. Predation - excluded mortality		
1. Starvation		
a. probable study-induced abandonment	2	14.3
b. probable natural starvation	1	7.1
2. Disease (congenital)	1	7.1
3. Undetermined cause	1	7.1
II. Predation and/or scavenging involved		
1. Predation		
a. Predator kill and other factors		
1. Mammal predator/study-induced abandonment	2	14.3
b. Predator kill		
1. Golden eagle kill	3	21.4
2. Mammalian predator, probable wolf	2	14.3
3. Mammalian predator, undetermined	1	7.1
4. Undetermined predator (brown bear/golden eagle)	1	7.1
TOTALS	14	99.8%

Two calf transmitters failed during June, leaving 60 calves for which natural mortality rate could be calculated; 10 (16.8%) died between 3 June and 3 September, 1985 (Table 4). Nine calves (15%) died on the calving and post-calving areas, and 1 died during late summer south of the continental divide. Previous levels of natural mortality among radio-collared neonates on the calving and post-calving habitats were 15.4% in 1983 and 6.6% in 1984 (Whitten et al. 1984, 1985a).

Predation was the cause for 70% of the natural mortality in 1985. Other natural causes (starvation and disease) each accounted for 10% of mortality and the probable cause of mortality could not be determined 10%. Predation by mammalian

Table 4. Proportions of observed natural mortalities occurring among radio-collared caribou calves during 4 June to 3 September 1985.

Mortality category	Number of calves	Proportion (%) of sample calves	Proportion of natural mortality
Mammalian predation	3	5.0	30.0
Golden eagle predation	3	5.0	30.0
Undetermined predation	1	1.7	10.0
Natural starvation	1	1.7	10.0
Disease (congenital)	1	1.7	10.0
Undetermined	1	1.7	10.0
TOTALS	10	16	100%

predators (brown bears and wolves) accounted for 3 of 7 predation - related mortalities. In 2 of these, wolves were suspected as the probable cause. The remaining case of mammalian predation could not be differentiated between brown bear or wolf. There was also one case in which differientiation between brown bear and golden eagle as primary predator could not be established. Brown bears were relatively common on the calving grounds during the calving season. The movements of radio-collared brown bears to the calving grounds generally coincided with arrival of the cows at calving time (Garner et al. 1987). In spite of 12 known wolf mortalities from a minimum 1984 fall population of 34 adult wolves associated with the northern portion of ANWR, the incidence of wolf observations on the calving/post-calving habitats of the PCH did not decline sharply over those of 1984 (Weiler et al. 1987). Three radio-collared calves were killed by golden eagles. The abundance of golden eagles appeared to be similar to that recorded in previous years (Whitten et al. 1984, Mauer 1985, 1987).

Natural starvation was the probable cause of death of 1 radio-collared calf. This calf apparently became temporarily separated from the dam, was unable to suckle or was not allowed to suckle. One radio-collared calf apparently died because of congenital defects (abnormal heart) and pneumonia complications. This is the first such case documented in 235 radio-collared calves over the past 4 years. In one case the mortality could not be determined, but was due to natural causes.

The chronology of natural mortality of radio-collared calves followed a pattern similar to that of the 2 previous years (Fig 5.) (Whitten et al. 1984, 1985a). Natural mortality was high during the first month of life (n=9), then decreased sharply during summer (n=1) and increased during fall (n=8).

Twenty-five carcasses of unmarked calves were collected from areas utilized by calving and post-calving caribou between 30 May and 30 June 1985. Several additional carcasses were observed from fixed-wing aircraft, but could not be retrieved due to a lack of ground access. Necropsy examinations revealed that 10 (40%) were killed by golden eagles; 6 (24%) died of starvation/pneumonia; 3 (12%) died of undetermined disease; 1 (4%) died of exposure; 2 (8%) were probably killed by wolves; 1 (4%) was apparently trampled by an adult caribou; 1 (4%) had

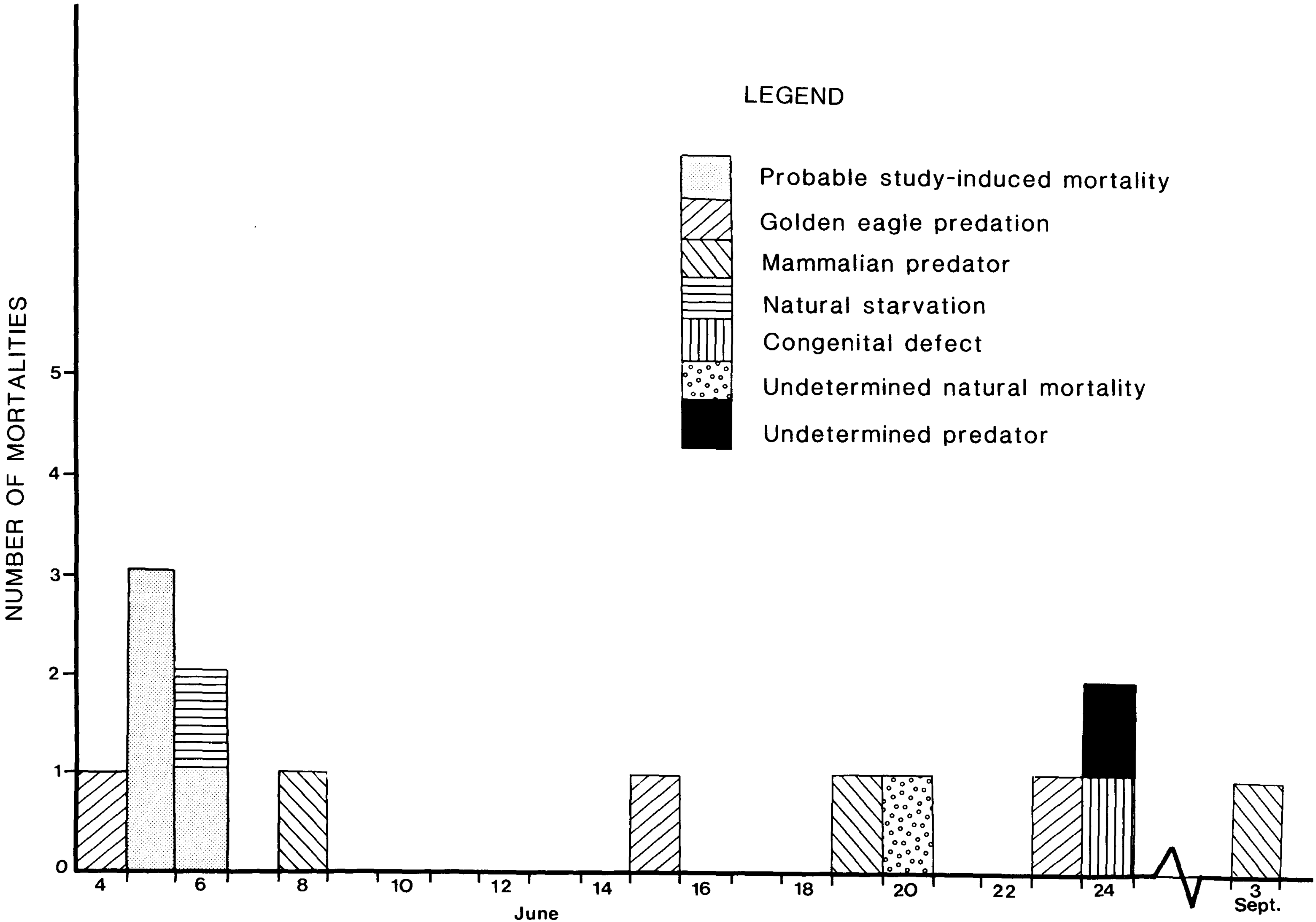

Fig. 5. Chronology of observed mortalities among 14 radio-collared calves, Porcupine caribou herd, 1985.

an abnormally low birth weight (weak/non-viable); and the cause of 1 mortality could not be determined.

Eighty percent of the natural mortality among radio-collared calves occurred in foothills and mountainous terrain located in the eastern and southern portions of the calving/post-calving habitats during the intensive study period (Fig 6). The distribution of mortality sites of unmarked calves and adults found during field operations was also greater in these areas (Fig 6). This geographic relationship is consistent with results from the previous 2 years (Whitten et al. 1984, 1985a), which also indicated a preponderance of mortality occurring in the southern and eastern foothills/mountains. Field studies of brown bears (Garner et al. 1984, 1985, 1987), wolves (Weiler et al. 1985, 1987), and golden eagles (Mauer 1985, 1987) indicate a greater abundance of these predators in the foothill/mountain zone.

Natural mortality of radio-collared calves during the calving/post-calving period (2 June - 1 July) was 15.0%. Calves born to radio-collared females aged 3 years or older had a higher mortality rate, (24.3%) for the same period. The calf mortality rate measured by control cows includes still-born calves, a factor of mortality not measured using the radio-collared calf technique. Excluding still-born mortality, the control rate (17.1%) did not differ significantly from the mortality rate among collared calves (X^2=0.07, df=1, $P > 0.05$). A similar pattern for radio-collared calves and control calves (17.5% vs, 27.8%), respectively, was recorded in 1983 when calving distribution (Jago River foothills) was similar to that of 1985 (Whitten et al. 1984). In 1984, mortality of both radio-collared calves (7%) and control calves (4.4%) was lower (Whitten et al. 1985a). Calving distributions in 1984 differed in that a major concentration occurred along the Niguanak River (approximately 10-15 km north of foothills calving areas), and in the Aichilik River foothills. Movement of nursery groups following calving in 1983 and 1985 during the immediate post-calving period (10 - 20 June) was southward towards the foothills and mountains (Whitten et al. 1984). In contrast, the 1984 Aichilik calving distribution shifted northwesterly onto the coastal plain and merged there with the Niguanak distribution (Whitten et al. 1985a). These observations further support the observation that habitats more distant or northerly from the southern/southeastern foothills and mountains zone may afford greater advantages to calf survival.

Movements

Marked calves in both the Jago and Aichilik capture areas, remained near capture sites during the first 48-72 hours after capture. Both upland tussock meadows and riverine habitats were used by radio-collared calves and their dams. Calves of the Jago area gradually moved in southerly, westerly and northwesterly directions, while the Aichilik calves moved primarily southwest and west. A unified movement to higher elevations to the south and southwest by the Jago group occurred during and immediately following a snowfall on 10 June. The Aichilik group also shifted more toward the southwest. By 18 June members of the Jago group extended as far west as the Sadlerochit River and the Aichilik group extended west to the Okpilak River Riparian areas along the Salderochit River were used extensively at this time. On 19 June nearly all members of both

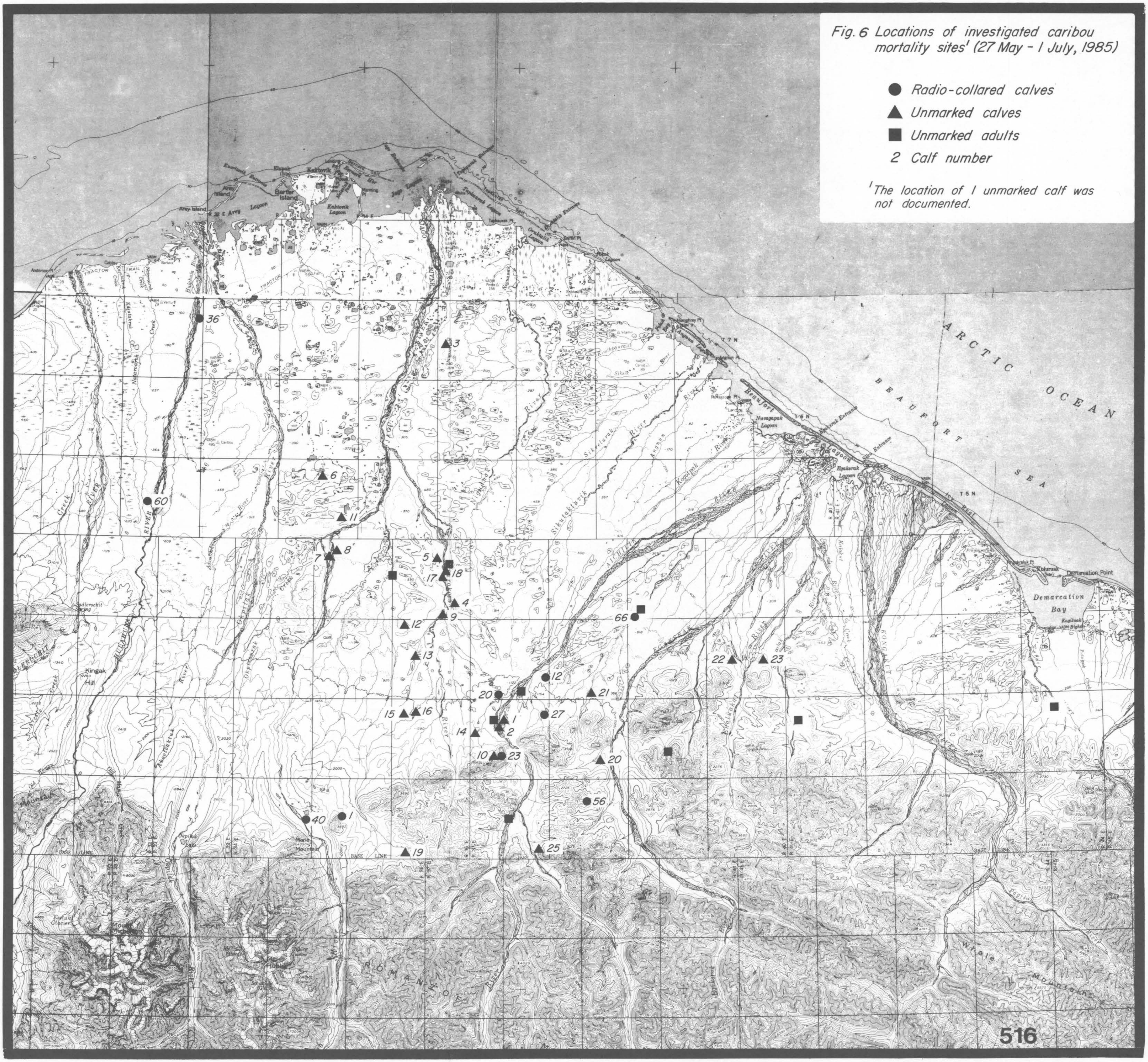

Fig. 6 Locations of investigated caribou mortality sites[1] (27 May - 1 July, 1985)

[1] The location of 1 unmarked calf was not documented.

groups reversed direction and increased their movement rate several fold (Figs. 7, 8, 9). Scattered caribou groups near the coastline also demonstrated a similar directional movement towards the east. This synchronous shift by essentially the entire Porcupine calving group in Alaska coincided with emmergence of mosquitos reported at several locations within the study area.

The eastward movement occurred in a broad band across the central and southern coastal plain region and in concentrated corridors within east-west valleys of the foothills and mountains (Fig. 8). Movements through the foothills shifted northeastward prior to reaching the Kongakut River on 24 June. Calving caribou located east of the Firth River in Canada initiated a swift, nearly simultaneous, westward movement during 20-22 June. These caribou merged with juvenile, barren female and bull groups in the foothills west of the Firth River that were also moving west. Essentially all segments of the Porcupine caribou herd converged on the coastal plain and foothills south of Demarcation Bay on 26 June.

A large scattered distribution of caribou extended from the Kongakut River on the west to Fish Creek in Canada. By 28 June, 2 major movements had developed from this loose aggregation. Approximately 60% of the herd moved southeastward into Canada, while about 40% moved southward up the Kongakut River to Whale Mountain before turning west. Scattered residual groups numbering perhaps a few thousand persisted on the Alaska coastal plain and foothills near Schrader Lake through August. By 30 June the west moving group had reached the Aichilik River where most of them moved rapidly southeast into the valley of the Leffingwell Fork of the Aichilik River. The group splintered several times during southern movements across the continental divide of the Brooks Range. By 4 July, many caribou had arrived in the upper Kongakut and upper Coleen River drainages. Most of these groups moved southwesterly and reunited in the vicinity of Table Mountain by 12 July. These groups continued southwesterly to the vicinity of Old John Lake before breaking into smaller groups and dispersing eastward during late summer.

The southward movement of large portions of the Porcupine caribou herd through the mountain valleys of the Aichilik, Egaksrak, and Kongakut Rivers during late June - early July has been observed each year since 1982. This movement pattern was not observed during earlier intensive caribou studies in the mid-1970's (Roseneau per. comm.). The presence of numerous old trail systems visible in moist soil areas and on talus/scree slopes of this area, suggest similar movements have occurred in the past.

Acknowledgements

Appreciation is extended to members of the Arctic National Wildlife Refuge staff and the Alaska Dept. of Fish and Game, Fairbanks Regional Office, who assisted this study in various ways. Pilots D. Miller, R. Kaye, M. Clark and K. Butters provided safe air support for the project and their efforts are greatly appreciated. D. Russell and W. Nixon, Canadian Wildlife Service assisted by conducting radio-tracking surveys in Canada.

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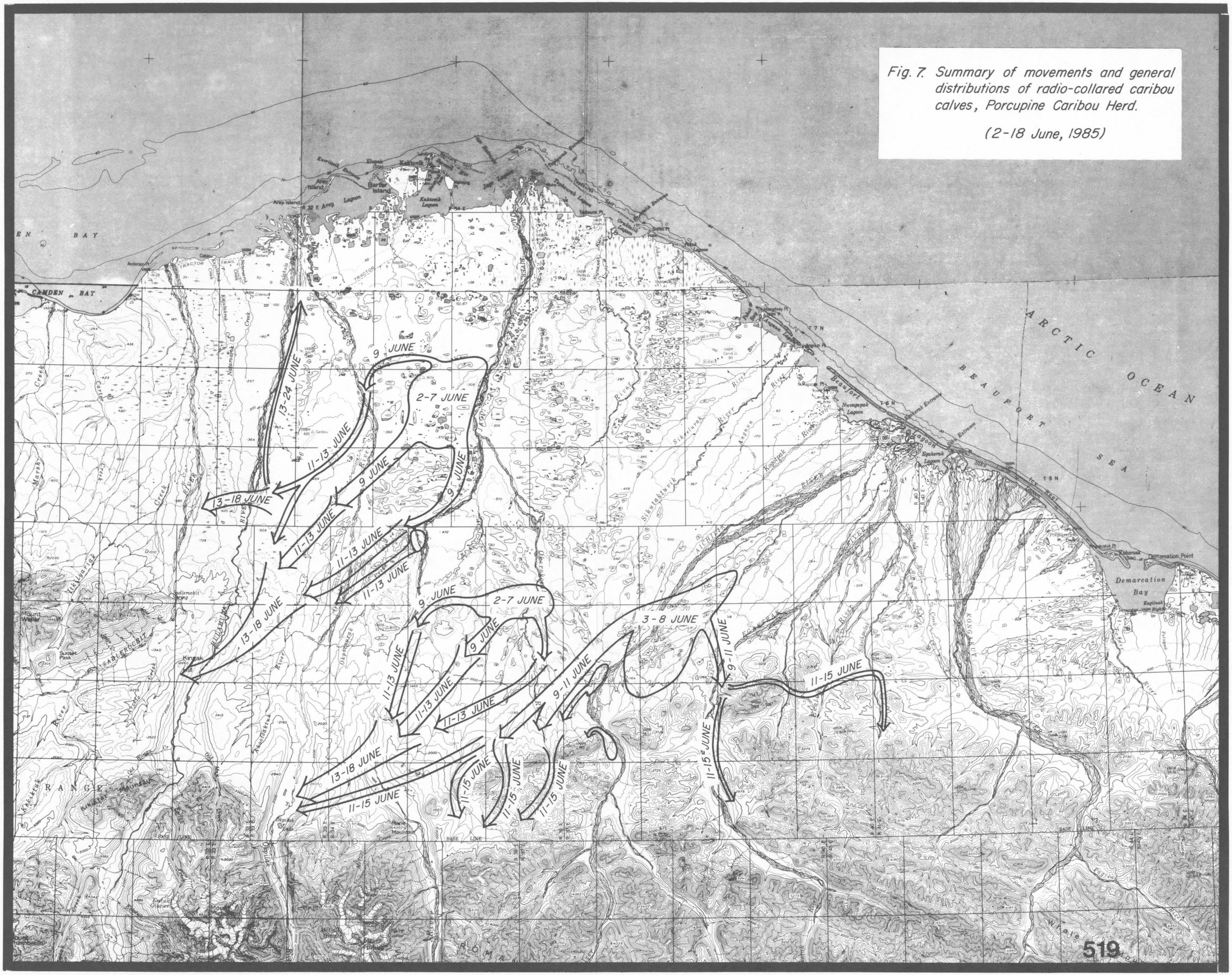

Fig. 7. Summary of movements and general distributions of radio-collared caribou calves, Porcupine Caribou Herd.

(2-18 June, 1985)

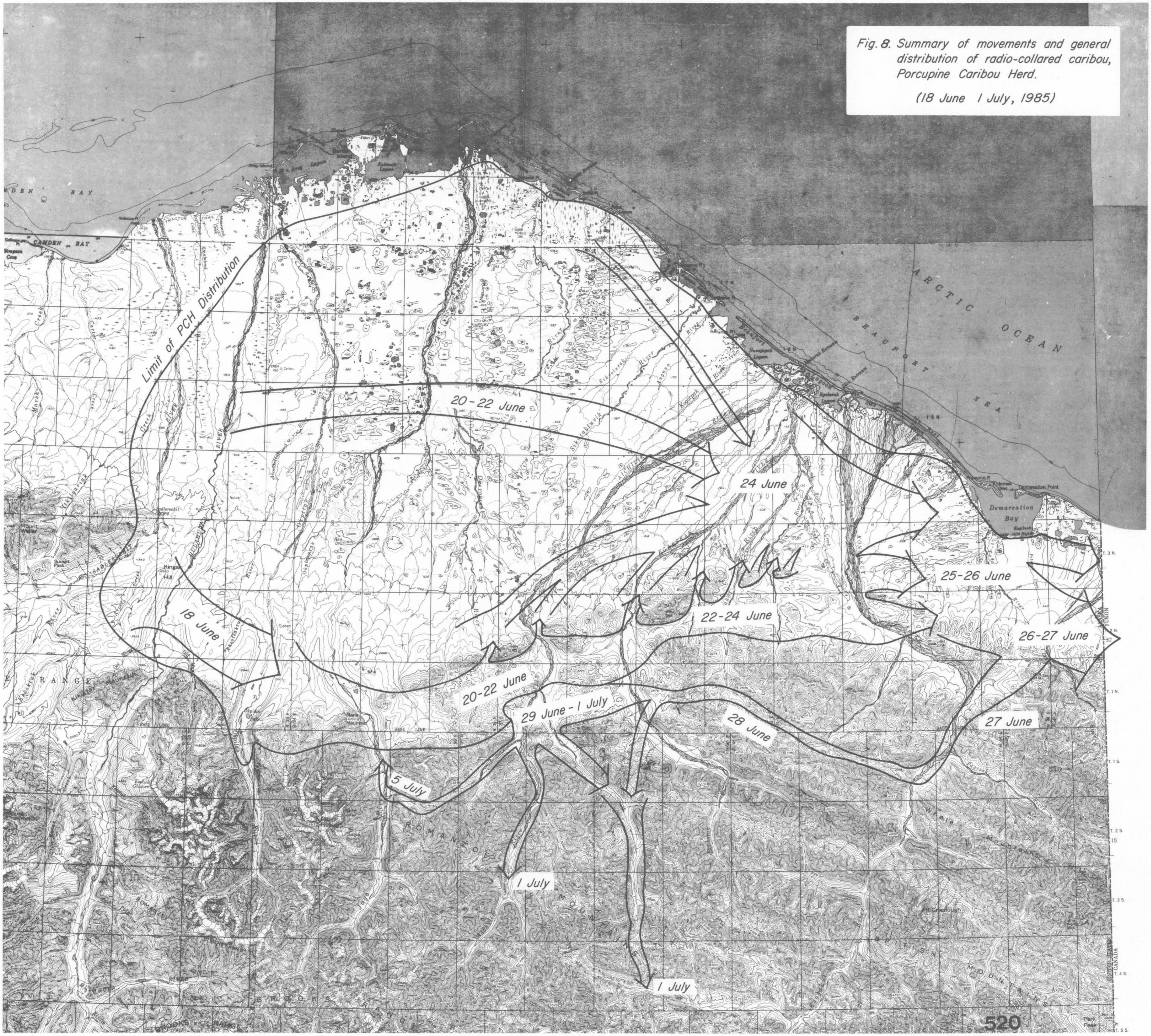

Fig. 8. Summary of movements and general distribution of radio-collared caribou, Porcupine Caribou Herd.

(18 June 1 July, 1985)

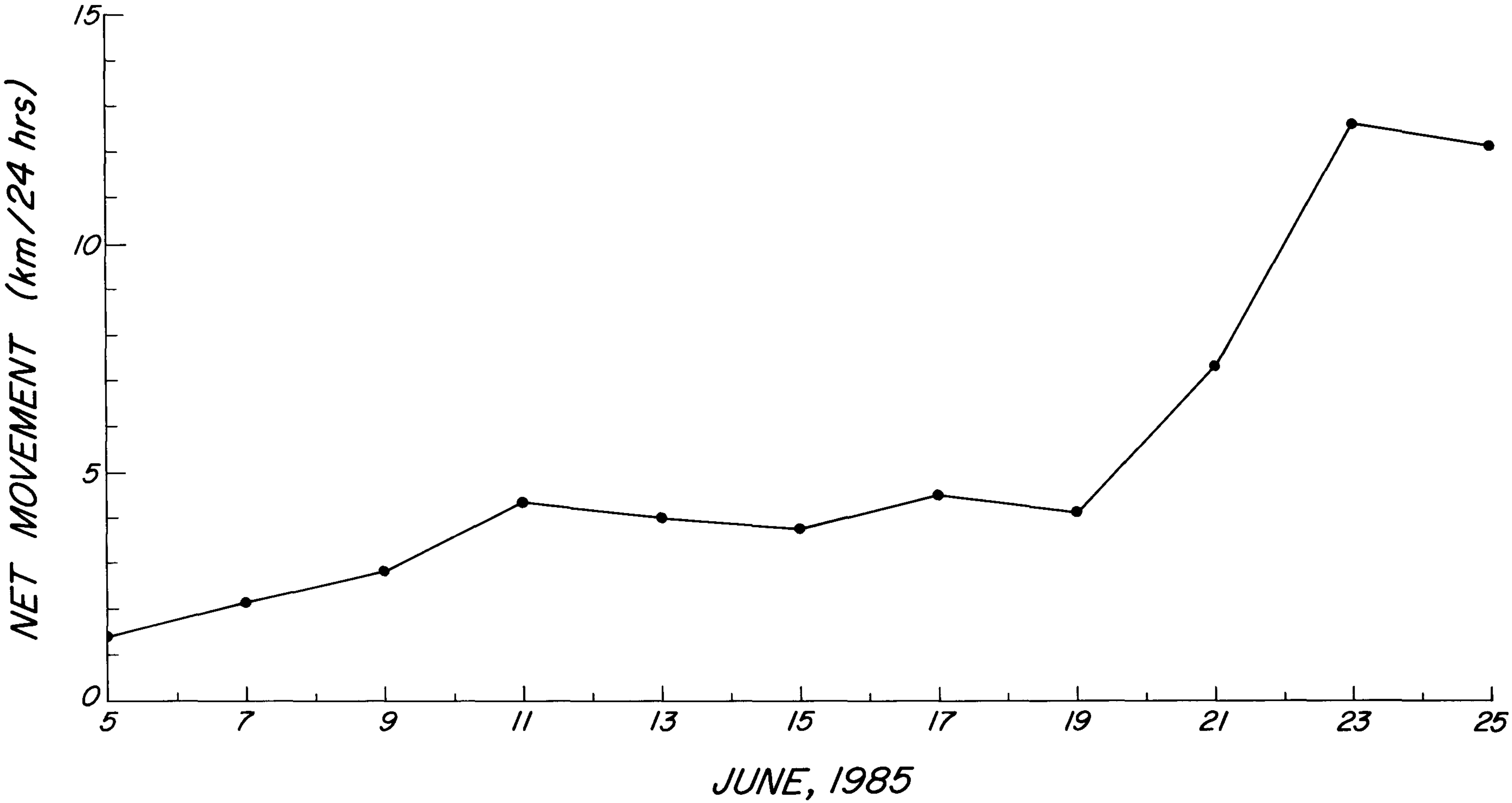

Fig. 9. Net movement rates for radio-collared caribou calves (5-25 June, 1985).

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APPENDIX

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Appendix Table 1. Chronology of calving, calf mortality, udder distension, and antler retention of radio-collared cows in the Porcupine caribou herd, 1985a

Cow #			May																	June												
and Status	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
4+ years old																																
S8:																																
calf				N	N	N		N						N							N									N		
udder				N	N	N		N						U							U									U		
antlers (#)				0	0	0		0						0							0									0		
S9:																																
calf				N	N	N	N	N			Y		Y		Y		Y			N	N				Y	Y		N		N		
udder				U	Y	Y	Y	Y			U		U		U		U			U	Y				U	U		U		U		
antlers (#)				2	2	2	2	2			2		2		2		2			0	0				0	0		0		0		
BKY26B:																																
calf				N	N	N	N	N		N		N			N	Y	Y				Y		Y		Y		Y		Y		Y	
udder				Y	Y	Y	Y	Y		Y		Y			Y	U	U				U		U		U		U		U		U	
antlers (#)				0	0	0	0	0		0		0			0	0	0				0		0		0		0		0		0	
S10:																																
calf			N	N	Y	Y	Y	Y				Y		Y		Y				Y		Y		Y		Y		Y		Y		
udder			U	U	U	U	U	U				U		U		U				U		U		U		U		U		U		
antlers (#)			2	2	2	2	2	2				0		0		0				0		0		0		0		0		0		
S11:																																
calf			Y		N	N		N						N			N								N			N				
udder			U		U	Y		Y						N			N								U			U				
antlers (#)			2		2	2		0						0			0								0			0				
BKY41:																																
calf			N		Y		Y	Y				Y		Y		Y		Y														
udder			U		U		U	U				U		U		U		U		DIED												
antlers (#)			2		2		2	2				0		0		0		0														
BKY42:																																
calf			N	N		N	N	N		N			Y			Y		Y		Y		Y			Y		Y		Y			
udder			U	Y		Y	Y	Y		Y			U			U		U		U		U			U		U		U			
antlers (#)			2	2		2	2	2		2			2			0		0		0		0			0		0		0			

Appendix Table 1.Continued.

Cow #	May					June																										
and Status	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
BKY16:																																
calf				N		N	Y		Y			Y		Y		Y				Y		Y			Y		Y		Y		Y	
udder				U		Y	U		U			U		U		U				U		U			U		U		U		U	
antlers (#)				2		2	2		2			0		0		0				0		0			0		0		0		0	
S12:																																
calf					N	N		Y						N							N				N			N				
udder					N	U		U						Y							U				N			U				
antlers (#)					2	2		2						2							1				0			0				
BKY22:																																
calf	Y			Y		Y	Y			Y		Y				Y		Y				Y		Y		Y		Y		Y		
udder	U			U		U	U			U		U				U		U				U		U		U		U		U		
antlers (#)	2			2		0	0			0		0				0		0				0		0		0		0		0		
BKY7:																																
calf												Y					Y				Y				Y			Y				Y
udder												U					U				U				U			U				U
antlers (#)												0					0				0				0			0				0
BKY23:																																
calf			N	N	Y		Y				Y		Y		Y		Y			Y		Y		Y		Y		Y		Y		Y
udder			U	U	U		U				U		U		U		U			U		U		U		U		U		U		U
antlers (#)			2	2	2		2				0		0		0		0			0		0		0		0		0		0		0
S13:																																
calf					N	N		N						Y			Y								Y			Y				Y
udder					N	N		N						U			U								U			U				U
antlers (#)					2	2		2						0			0								0			0				0
S14:																																
calf				Y	Y		Y	Y		Y		Y		Y		Y		Y		Y		Y			Y			Y		Y		Y
udder				U	U		U	U		U		U		U		U		U		U		U			U			U		U		U
antlers (#)				2	2		2	2		2		0		0		0		0		0		0			0			0		0		0
GY24:																																
calf			N	N		Y	Y			Y		Y		Y		Y		Y			Y		Y			Y			Y		Y	
udder			U	Y		U	U			U		U		U		U		U			U		U			U			U		U	
antlers (#)			2	2		2	2			0		0		0		0		0			0		0			0			0		0	

Appendix Table 1.Continued.

Cow #	May					June																										
and Status	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
GY25:																																
calf			N																													
udder			U																													
antlers (#)			0																													
BKY0:																																
calf				Y	Y		Y			Y		Y				Y						Y		Y			Y		Y		Y	
udder				U	U		U			U		U				U						U		U			U		U		U	
antlers (#)				2	2		2			0		0				O						0		0			0		0		0	
BKY1:																																
calf					N																											
udder					U																											
antlers (#)					0																											
BKY5:																																
calf				N	N					N		N								N												
udder				N	N					N		N								N												
antlers (#)				0	0					0		0								0												
RY4:																																
calf			N	Y														N		DIED												
udder			U	U														N														
antlers (#)			2	2														0														
W2:																																
calf					N	N	N	N	N			Y	Y			Y					Y					Y			Y			Y
udder					U	U	Y	Y	Y			Y	U			U					U					U			U			U
antlers (#)					2	2	2	2	2			2	2			2					2					0			0			0
W7:																																
calf		N		N		N		N			N						N			N					N	N	N	N		N		N
udder		Y		Y		Y		Y			Y						Y			Y					Y	Y	Y	Y		U		U
antlers (#)		0		0		0		0			0						0			0					0	0	0	0		0		0
W9:																																
calf					N																				N							
udder					N																				N							
antlers (#)					0																				0							

Appendix Table 1.Continued.

Cow #	May					June																										
and Status	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
W11:																																
calf						N																										
udder						N																										
antlers (#)						0																										
W13:																																
calf					N																											
udder					N																											
antlers (#)					0																											
S15:																																
calf				N	N	N	N	N		N	N	Y			Y																	
udder				Y	Y	Y	Y	Y		Y	Y	Y			U			DIED														
antlers (#)				2	2	2	2	2		2	2	2			2																	
W15:																																
calf				N	N	Y	N																									
udder				U	N	U	U																									
antlers (#)				2	2	2	2																									
PY49:																																
4 years old																																
calf													N								N										N	
udder													Y								U										U	
antlers (#)													2								2										2	
RY67:																																
calf			N	N	Y	Y	N	N																								
udder			U	U	U	U	U	U																								
antlers (#)			2	2	2	2	2	2																								
PB86:																																
calf				Y		Y	Y			Y		Y		Y		Y		Y	Y			Y		Y		Y		Y				
udder				U		U	U			U		U		U		U		U	U			U		U		U		U				
antlers (#)				2		2	1			0		0		O		0		0	0			0		0		0		0				
PB87:																																
calf				N	N	N	N	N		N		N				N			N			N				N						
udder				U	Y	Y	Y	Y		U		Y				Y			Y			U				U						
antlers (#)				0	0	0	0	0		0		0				0			0			0				0						

Appendix Table 1.Continued.

Cow #	May					June																										
and Status	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
3 years old																																
PY45:																																
calf				N	N	Y	Y	Y	Y			Y		Y		N																
udder				U	Y	U	U	U	U			U		U		U																
antlers (#)				2	2	2	2	2	2			0		0		0																
PY47:																																
calf					N																											
udder					N																											
antlers (#)					0																											
PY48:																																
calf				N		Y	Y					Y				Y	Y				Y		Y		Y				Y			Y
udder				Y		U	U					U				U	U				U		U		U				U			U
antlers (#)				2		2	2					2				U	1				0		0		0				0			0
PY51:																																
calf			N																											N		
udder			U																											U		
antlers (#)			0																											0		
PY52:																																
calf			N	N	N	N	N	N			N	N		N		N	N	N				N	N		N		N		Y	N		N
udder			U	U	Y	Y	Y	Y			Y	Y		Y		Y	Y	U				Y	Y		U		U		U	U		U
antlers (#)			1	1	1	1	1	1			1	1		1		1	1	1				1	1		1		1		U	U		0
PY53:																																
calf					N	N		N						N																N		
udder					Y	Y		Y						Y																U		
antlers (#)					2	2		1						0																0		
PY56:																																
calf			N		N																									N		
udder			U		N																									U		
antlers (#)			0		0																									0		
PY57:																																
calf			N		N																									N		
udder			U		N																									U		
antlers (#)			0		0																									0		

Appendix Table 1.Continued.

Cow #	May					June																										
and Status	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
PY59:																																
calf				N	N	N	N	Y				Y		Y		Y		Y				Y		Y	Y		Y		Y		Y	
udder				U	Y	Y	Y	U				Y		U		U		U				U		U	U		U		U		U	
antlers (#)				2	2	2	2	2				2		2		1		0				0		0	0		0		0		0	
PY62:																																
calf		Y		Y		Y	Y				Y		Y		Y				Y			Y		Y		Y			Y		Y	
udder		U		U		U	U				U		U		U				U			U		U		U			U		U	
antlers (#)		0		0		0	0				0		0		0				0			0		0		0			0		0	
PY64:																																
calf						N		N						Y							Y				Y			Y				Y
udder						N		N						U							U				U			U				U
antlers (#)						2		2						2							0				0			0				0
PY68:																																
calf		N		N	N	N	N	N		Y		Y											Y		Y		Y		Y		Y	
udder		U		U	N	Y	Y	Y		U		U											U		U		U		U		U	
antlers (#)		2		2	2	2	2	2		2		2											0		0		0		0		0	
PY71:																																
calf					N	Y		Y						Y			Y								Y		Y					Y
udder					Y	U		U						U			U								U		U					U
antlers (#)					1	1		0						0			0								0		0					0
PB72:																																
calf					Y								Y		Y				Y			Y			Y		Y		Y			Y
udder					U								U		U				U			U			U		U		U			U
antlers (#)					2								0		0				0			0			0		0		0			0
PB74:																																
calf				Y		Y	Y	Y					Y											Y		Y		Y		Y		
udder				U		U	U	U					U											U		U		U		U		
antlers (#)				2		2	2	1					0											0		0		0		0		
PB76:																																
calf				N	N	N	N	N			Y		N			Y		Y								Y		Y		Y		
udder				U	Y	Y	Y	Y			U		Y			U		U								U		U		U		
antlers (#)				2	2	2	2	1			2		0			0		0								0		0		0		

Appendix Table 1.Continued.

Cow #	May					June																										
and Status	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
PB78:																																
calf					N	N	N	N	N			N	N			N	N	N							N			N				
udder					N	N	N	N	N			N	N			Y	U	Y							U			U				
antlers (#)					0	0	0	0	0			0	0			0	0	0							0			0				
PB81:																																
calf		Y		Y		Y	Y	Y				Y		Y					Y			Y		Y			Y		Y			Y
udder		U		U		U	U	U				U		U					U			U		U			U		U			U
antlers (#)		2		2		2	2	2				0		0					0			0		0			0		0			0
PB82:																																
calf				N		N	N	N		N		N	N	N	N	N		N	N			N			N							
udder				Y		Y	Y	Y		Y		Y	Y	Y	Y	Y		Y	Y			Y			U							
antlers (#)				1		1	1	1		1		1	1	1	1	1		1	1			1			U							
PB83:																																
calf				Y		Y	Y				Y		Y		Y						Y		Y		Y		Y		Y			Y
udder				U		U	U				U		Y		Y						U		U		U		U		U			U
antlers (#)				2		2	2				0		0		0						0		0		0		0		0			0
PB84:																																
calf				Y		Y	Y			Y		Y		Y		Y		Y			Y		Y		Y		Y		Y			
udder				U		U	U			U		U		U		U		U			U		U		U		U		U			
antlers (#)				2		2	2			2		0		0		0		0			0		0		0		0		0			
PB89:																																
calf			N		N																											
udder			U		N																											
antlers (#)			0		0																											
PB90:																																
calf				Y		Y	Y	Y			Y		Y		Y									Y			Y			Y		Y
udder				U		U	U	U			U		U		U									U			U			U		U
antlers (#)				2		2	1	1			0		0		0									0			0			0		0
PB91:																																
calf			N																						N							
udder			U																						U							
antlers (#)			0																						0							

Appendix Table 1.Continued.

Cow #	May					June																										
and Status	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
2 years old																																
W18:																																
calf			N		N																											
udder			U		N																											
antlers (#)			0		0																											
W6:																																
calf				N																												
udder				U																												
antlers (#)				0																												
W21:																																
calf					N																				N							
udder					N																				U							
antlers (#)					0																				0							
W22:																																
calf			N		N																											
udder			U		N																											
antlers (#)			0		0																											
W23:																																
calf					N																											
udder					N																											
antlers (#)					0																											
W16:																																
calf					N																											
udder					N																											
antlers (#)					0																											
W24:																																
calf				N	N	N	N	N	N			Y		N		N																
udder				U	Y	Y	Y	Y	Y			U		Y		Y																
antlers (#)				2	2	2	2	2	2			2		2		2																
W17:																																
calf																																
udder																																
antlers (#)																																

[a] N=no, Y=yes, U=undertermined

Mortality Case History

Calf No: 1

Sex: Male

Captured: 3 June 1985

Location: Aichilik River foothills

Weight: 7.4 kg

Total length: 93 cm

Umbilicus condition: dry

Right hind foot length: 33.0 cm

Hoof condition: hard/worn

New hoof length: 7.2 mm

Health status: appeared healthy at capture

Processing time: 1.44 min.

Estimated age at capture: 2 days old

Cow-calf reunion: Capture crew did not observe reunion. Observed with dam 9 hrs. after release.

Signal monitored: 14 times/ 16 day period

Number of visual relocations: 5

Mortality detected: 19 June 1985

Location: Jago River foothills

Carcass collected: 19 June 1985

Distance from capture site: 33 km

Carcass weight: 0.8 kg

Response time:

Total length: N/A cm

Right hind foot length: N/A cm

New hoof length: N/A mm

Carcass condition and disposition: Bone fragments chewed and scattered: partial vertebrae, skull fragments, distal portion of forelimb, skin and hair fragments. Golden eagle perched approximately 200 m from carcass, radio-collared wolf approximately 1.5 km from carcass.

Necropsy findings: N/A

Mortality category: Predation/scavenging involved, mammalian predator, probable golden eagle scavenging.

Mortality Case History

Calf No: 12
Captured: 5 June 1985

Sex: Male
Location: Aichilik River foothills

Weight: 6.2 kg
Umbilicus condition: moist
Hoof condition: partially hard/worn
Health status: appeared healthy at capture
Processing time: 2 min.

Total length: 78 cm
Right hind foot length: 32 cm
New hoof length: 8.3 mm

Estimated age at capture: 2 days old

Cow-calf reunion: Capture crew did not observe reunions. Observed with dam 48 hrs. after capture.

Signal monitored: 2 times/ 3 day period
Mortality detected: 1354 8 June 1985
Carcass collected: 1225 9 June 1985
Carcass weight: N/A kg
Total length: N/A cm
Right hind foot length: N/A cm
New hoof length: N/A mm

Number of visual relocations: 2
Location: Aichilik River foothills
Distance from capture site: 2 km
Response time: 22.5 hrs.

Carcass condition and disposition: Cow with two antlers, distended udder within 50 m of carcass on 8 June 1985. Scattered bone fragments, skull cap, lower jaw bone and lower portions of hind legs and one front leg present at site of retrieved radio-collar. No skin/hide present. Radio-collar torn, multiple punctures in transmitter cannister, antennae chewed.

Necropsy findings: N/A

Mortality category: Predation included, mammalian predator (probable wolf).

Mortality Case History

Calf No: 20
Captured: 3 June 1985

Sex: Male
Location: Aichilik River foothills

Weight: 9.4 kg
Umbilicus condition: dry
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: 1.5 min.

Total length: 91 cm
Right hind foot length: 37 cm
New hoof length: 8.0 mm

Estimated age at capture: 2 days old

Cow-calf reunion: Capture crew did not observe reunion. Unattended by dam approximately 3.0 hrs. after capture.

Signal monitored: 4 times/ 4 day period
Mortality detected: 6 June 1985
Carcass collected: 6 June 1985
Carcass weight: 5.0 kg
Total length: N/A cm
Right hind foot length: 36 cm
New hoof length: 7.8 mm

Number of visual relocations: 2
Location: Aichilik River foothills
Distance from capture site: 3.4 km
Response time:

Carcass condition and disposition: Found in two portions separated at the sacrum. Flesh removed from right foreleg, neck, vertebrae, right hip area, abdominal cavity opened, internal organs not present. Skull cap broken, bone fragment pushed into brain, left and right zygomatic arches broken. No puncture of scalp adjacent to skull fractures. No other puncture wounds found in remainder of skin. Golden eagle observed at carcass prior to collection.

Necropsy findings:

Mortality category: Predation involved, mammalian predator, probable wolf, golden eagle and gull scavenging, possible predisposition due to study-induced abandonment.

Mortality Case History

Calf No: 23
Captured: 3 June 1985

Sex: Female
Location: Aichilik River foothills

Weight: 8.5 kg
Umbilicus condition: dry
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: 1.5 min.

Total length: 89 cm
Right hind foot length: 34 cm
New hoof length: 9.1 mm

Estimated age at capture: 4 days old

Cow-calf reunion: Capture crew did not observe reunion. Observed with dam approximately 4 hrs. after capture.

Signal monitored: 3 times/ 2 day period
Mortality detected: 1637 4 June 1985
Carcass collected: 5 June 1985
Carcass weight: 8.1 kg
Total length: 89 cm
Right hind foot length: 32.5 cm
New hoof length: 7.6 mm

Number of visual relocations: 3
Location: Aichilik River foothills
Distance from capture site: 2.3 km
Response time: N/A

Carcass condition and disposition: Intact, no external indication of trauma. Female caribou observed near carcass when mortality was detected. Golden eagle flushed approximately 50 m from carcass when collected.

Necropsy findings: Multiple round puncture wounds (3-6 mm.diameter) on skin of right thorax and abdomen with corresponding massive hemorrhage. Liver punctured at several locations, extensive internal hemorrhage. Stomach full with milk curds.

Mortality category: Predation included, golden eagle kill.

Mortality Case History

Calf No: 24
Captured: 3 June 1985

Sex: Female
Location: Aichilik River foothills

Weight: 9.2 kg
Umbilicus condition: partially intact
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: 1 min.

Total length: 92 cm
Right hind foot length: 34.5 cm
New hoof length: 8.0 mm
Estimated age at capture: 3 days old

Cow-calf reunion: Capture crew did not observe reunion. Observed with dam approximately 4 hrs. after capture. Observed unattended approximately 20 hrs. after capture.

Signal monitored: 3 times/ 2 day period
Mortality detected: 5 June 1985
Carcass collected: 5 June 1985
Carcass weight: 5.9 kg
Total length: N/A cm
Right hind foot length: 34.5 cm
New hoof length: 7.6 mm

Number of visual relocations: 3
Location: Aichilik River foothills
Distance from capture site: less than 1.0 km
Response time: N/A

Carcass condition and disposition: Carcass partially fed upon, flesh removed from right shoulder, thorax and hip areas. Right side of skull fractured, right zygomatic arch and right orbit removed. Skin torn on left ear, round puncture wound posterior to left ear.

Necropsy findings: Portions of heart, left lung intestines and stomach remain. Stomach packed with vegetation, green solution in intestines.

Mortality category: Predation involved, mammalian predator/scavenger, probable predisposed due to study-induced abandonment.

Mortality Case History

Calf No: 27
Captured: 3 June 1985

Sex: Male
Location: Aichilik River foothills

Weight: 9.0 kg
Umbilicus condition: dry
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: 1.3 min.

Total length: 94 cm
Right hind foot length: 35.5 cm
New hoof length: 8.3 mm
Estimated age at capture: 3 days old

Cow-calf reunion: Capture crew observed reunion within 0.5 min. after release. Observed with dam approximately 4 hrs. after capture.

Signal monitored: 3 times/ 3 day period
Mortality detected: 1306 6 June 1985
Carcass collected: 6 June 1985
Carcass weight: 8.3 kg
Total length: 87 cm
Right hind foot length: 35.5 cm
New hoof length: 7.7 mm

Number of visual relocations: 2
Location: Aichilik River foothills
Distance from capture site: 1.6 km
Response time: N/A

Carcass condition and disposition: Female caribou at carcass when mortality was detected and when carcass was collected. Intact, left eye removed, tongue partially removed. No external indications of trauma.

Necropsy findings: Carcass skinned - no wounds, hemorrhage or indication of trauma. Stomach packed with soil and vegetation, absent of milk.

Mortality category: Predation excluded, avian scavenging, probable natural starvation.

Mortality Case History

Calf No: 33
Sex: Male
Captured: 2 June 1985
Location: coastal plain west of Jago River

Weight: 6.9 kg
Total length: 82 cm
Umbilicus condition: dry
Right hind foot length: 32 cm
Hoof condition: partially hard/worn
New hoof length: 8.2 mm
Health status: appeared healthy at capture
Processing time: 2 min.
Estimated age at capture: 3 days old
Cow-calf reunion: Capture crew did not observe reunion. Observed with female caribou displaying agonistic behavior towards calf approximately 3 hrs. after release by capture crew. Observed unattended approximately 24, and 48 hrs. after capture.

Signal monitored: 4 times/ 3 day period
Number of visual relocations: 3
Mortality detected: 5 June 1985
Location: coastal plain west of Jago River
Carcass collected: 5 June 1985
Distance from capture site: 1.2 km
Carcass weight: 5.3 kg
Response time: N/A
Total length: 82 cm
Right hind foot length: 7.2 mm
New hoof length:

Carcass condition and disposition: Intact, no evidence of trauma.

Necropsy findings: Stomach packed with vegetation, absence of milk.

Mortality category: Predation excluded, starvation/study induced abandonment.

Mortality Case History

Calf No: 36
Sex: Female
Captured: 2 June 1985
Location: Jago River coastal plain

Weight: 7.5 kg
Total length: 79 cm
Umbilicus condition: dry
Right hind foot length: 34.0 cm
Hoof condition: partially hard/worn
New hoof length: 7.4 mm
Health status: appeared healthy at capture
Processing time: 1.32 min.
Estimated age at capture: 2 days old
Cow-calf reunion: Capture crew did not observe reunion. Observed with dam approximately 5 hrs. after release.

Signal monitored: 19 times/ 22 day period
Number of visual relocations: 8
Mortality detected: 2000 23 June 1985
Location: Hulahula River coastal plain
Carcass collected: 1220 24 June 1985
Distance from capture site: 19 km
Carcass weight: 6.4 kg
Response time: 16.3 hrs.
Total length: N/A cm
Right hind foot length: N/A cm
New hoof length: N/A mm

Carcass condition and disposition: Lying on left side, approximately 70% consumed. Golden eagle observed at carcass at 2000 h on 23 June 1985. Two golden eagles and one glaucous gull observed at carcass when collected.

Necropsy findings: Round puncture wounds with subcutaneous hemorrhage on right shoulder and rib cage. Left zygomatic arch broken. Flesh removed from right side of carcass. Viscera removed.

Mortality category: Predation/scavenging involved, golden eagle kill.

Mortality Case History

Calf No: 40
Captured: 2 June 1985

Sex: Male
Location: Jago River coastal plain

Weight: 7.4 kg
Umbilicus condition: dry
Hoof condition: partially hard/worn
Health status: appeared healthy at capture
Processing time: 1.41 min.

Total length: 82 cm
Right hind foot length: 34.5 cm
New hoof length: 7.4 mm
Estimated age at capture: 2 days old

Cow-calf reunion: Capture crew did not observe reunion. Observed with dam approximately 5 hrs. after release.

Signal monitored: 17 times/ 18 day period
Mortality detected: 1435 20 June 1985
Carcass collected: 20 June 1985
Carcass weight: 9.8 kg
Total length: 93 cm
Right hind foot length: 38.5 cm
New hoof length: 22.8 mm

Number of visual relocations: 6
Location: Jago River foothills
Distance from capture site: 52 km
Response time: N/A

Carcass condition and disposition: Intact, no indication of injury or trauma, carcass found near river.

Necropsy findings: No internal wounds or hemorrhage, vegetation in rumen, milk curds absent, internal body fat absent.

Mortality category: Predation excluded, natural mortality, cause undetermined.

Mortality Case History

Calf No: 50
Captured: 2 June 1985

Sex: Male
Location: coastal plain east of Jago River

Weight: 8.3 kg
Umbilicus condition: absent
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: 1.5 min.

Total length: 90 cm
Right hind foot length: 35 cm
New hoof length: 7.8 mm
Estimated age at capture: 3 days old

Cow-calf reunion: Capture crew did not observe reunion. Observed with female caribou exhibiting agonistic behavior towards calf approximately 4 hrs. and 20 hrs. after release by capture crew.

Signal monitored: 4 times/ 3 day period
Mortality detected: 5 June 1985
Carcass collected: 5 June 1985
Carcass weight: 6.5 kg
Total length: 91 cm
Right hind foot length: 36 cm
New hoof length: 7.6 mm

Number of visual relocations: 3
Location: coastal plain east of Jago River
Distance from capture site: 0.2 km
Response time: N/A

Carcass condition and disposition: Intact, no evidence of trauma.

Necropsy findings: Stomach packed with vegetation, absence of milk.

Mortality category: Predation excluded, starvation/study induced abandonment.

Mortality Case History

Calf No: 56
Sex: Male
Captured: 2 June 1985
Location: Jago River foothills

Weight: 6.4 kg
Total length: 87 cm
Umbilicus condition: bloody
Right hind foot length: 33.0 cm
Hoof condition: partially hard/worn
New hoof length: 6.7 mm
Health status: appeared healthy at capture
Processing time: 1.42 min.
Estimated age at capture: 1 day old
Cow-calf reunion: Capture crew did not observe reunion. Observed with dam approximately 3 hrs. after release.

Signal monitored: 19 times/ 22 day period
Number of visual relocations: 4
Mortality detected: 1900 24 June 1985
Location: Egaksrak River foothills
Carcass collected: 2215 24 June 1985
Distance from capture site: 29 km
Carcass weight: N/A kg
Response time: 3.25 hrs.
Total length: N/A cm
Right hind foot length: N/A cm
New hoof length: N/A mm

Carcass condition and disposition: Small scattered, chewed bone fragments and hair. Tooth marks on transmitter cannister. Adult female brown bear with two yearling cubs present at carcass when collected. Golden eagle feathers also at carcass site.

Necropsy findings: N/A

Mortality category: Predation/scavenging involved - brown bear and golden eagle.

Mortality Case History

Calf No: 60
Captured: 2 June 1985

Sex: Male
Location: Jago River foothills

Weight: 7.6 kg
Umbilicus condition: absent
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: N/A min.

Total length: 78 cm
Right hind foot length: 34.0 cm
New hoof length: 7.1 mm

Estimated age at capture: 3 days old

Cow-calf reunion: Capture crew did not observe reunion. Observed with dam approximately 2 hrs. after release.

Signal monitored: 20 times/ 22 day period
Mortality detected: 1240 24 June 1985
Carcass collected: 1245 24 June 1985
Carcass weight: 22 kg
Total length: N/A cm
Right hind foot length: N/A cm
New hoof length: N/A mm

Number of visual relocations: 55
Location: Hulahula River coastal plain
Distance from capture site: 23 km
Response time: 5 min.

Carcass condition and disposition: Intact, cow with distended udder standing near calf. No external evidence of injury or trauma.

Necropsy findings: No internal injury or trauma. Lungs appeared cloudy and were partially fused to the pericardium, right lung was hard-rubbery. Heart abnormally shaped. Internal fat deposits absent. Milk curds and vegetative material present in abomasum, vegetative material in rumen and reticulum.

Mortality category: Predation excluded, natural mortality, congenital defects/pneumonia.

Mortality Case History

Calf No: 65
Captured: 6 June 1985

Sex: Female
Location: Aichilik River foothills

Weight: 6.8 kg
Umbilicus condition: dry
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: 1.35 min.

Total length: 79 cm
Right hind foot length: 34.0 cm
New hoof length: 7.4 mm
Estimated age at capture: 2 days old

Cow-calf reunion: Capture crew did not observe reunion. Observed with dam during the day following release.

Signal monitored: 27 times/ 85 day period
Mortality detected: 31 August 1985
Carcass collected: 3 September 1985
Carcass weight: N/A kg
Total length: N/A cm
Right hind foot length: N/A cm
New hoof length: N/A mm

Number of visual relocations: 3
Location: Coleen River
Distance from capture site: 225 km
Response time: 3 days

Carcass condition and disposition: Fractured skull bones, mandibles, and hair found near retrieved collar. Site was located along a game trail in dense willow shrubs. Fresh bear scats containing blueberries nearby.

Necropsy findings:

Mortality category: Predation/scavenging involved, mammalian predator/scavenger.

Mortality Case History

Calf No: 66
Captured: 7 June 1985

Sex: Female
Location: Aichilik River foothills

Weight: 6.1 kg
Umbilicus condition: dry
Hoof condition: hard/worn
Health status: appeared healthy at capture
Processing time: 2.15 min.

Total length: 83 cm
Right hind foot length: 33 cm
New hoof length: 7.3 mm

Estimated age at capture: 2 days old

Cow-calf reunion: Capture crew did not observe reunion. Observed with dam the following day.

Signal monitored: 6 times/ 7 day period
Mortality detected: 1137 15 June 1985
Carcass collected: 1530 15 June 1985
Carcass weight: 3.6 kg
Total length: N/A cm
Right hind foot length: 35.7 cm
New hoof length: N/A mm

Number of visual relocations: 3
Location: Aichilak River foothills
Distance from capture site: 5.2 km
Response time: 4 hrs.

Carcass condition and disposition: Sixty percent consumed, internal organs removed/consumed, flesh removed from legs, shoulders and back, ribs removed, remainder of skeleton attached by skin and tendons. Neck and head intact, eyes, ears and tongue present. Dead cow lying 30 m away. golden eagle observed feeding on calf. Neck and left jaw of cow fed upon, left rear leg disarticulated, fed upon left shoulder and ribs also fed upon.

Necropsy findings: No evidence of trauma to head and neck.

Mortality category: Predation/scavenging involved, probable golden eagle kill, predisposed to predation by death of cow.

Mortality Case History

Calf No: Unmarked 01

Sex: Female
Location: Aichilik River aufeis field

Carcass collected: 5 June 1985
Carcass weight: 4.8 kg
Total length: N/A cm
Right hind foot length: N/A cm
New hoof length: 7.9 mm

Carcass condition and disposition: Forty percent consumed, eyes and tongue removed, flesh removed from right shoulder and hip, internal organs removed. Skull crushed, rostrum fractured from skull, right mandible and right foreleg broken off. Wolf observed in area of carcass.

Necropsy findings:

Mortality category: Predation/scavenging involved - probable wolf, avian scavenging.

Mortality Case History

Calf No: Unmarked 02

Sex: Male
Location: Aichilik River aufeis field

Carcass collected: 5 June 1985
Carcass weight: 4.0 kg
Total length: 88.5 cm
Right hind foot length: 34.0 cm
New hoof length: 7.4 mm

Carcass condition and disposition: Fifty-five percent consumed, right eye, and ear removed, flesh removed from rear quarters and ribs, six right ribs severed (snapped), internal organs removed. Posterior of skull crushed with corresponding subcutaneous hemorrhage. Wolf observed in area of carcass.

Necropsy findings:

Mortality category: Predation/scavenging involved probable wolf kill, avian scavenger.

Mortality Case History

Calf No: Unmarked 03

Sex: Female
Location: coastal plain east of Jago River

Carcass collected: 30 May 1985
Carcass weight: 8.3 kg
Total length: 92 cm
Right hind foot length: 35.5 cm
New hoof length: 8.4 mm

Carcass condition and disposition: Calf of radio-collared adult female (#RY4) which was observed standing near carcass. Found in water (flooded tundra), hooves soft and not worn, placenta still attached to calf. Intact, no evidence of external injuries or trauma.

Necropsy findings: Lungs inflated/normal, all other internal organs appeared normal, stomach and intestines empty.

Mortality category: Predation excluded, exposure.

Mortality Case History

Calf No: Unmarked 04

Sex: Male
Location: Okerokovik River foothills

Carcass collected: 2 June 1985
Carcass weight: 4.6 kg
Total length: 83.5 cm
Right hind foot length: 32.0 cm
New hoof length: 7.3 mm

Carcass condition and disposition: Intact, radio-collared adult female (#W15) observed at carcass. Umbilicus bloody, hooves partially hardened and worn. Cow observed previous day without calf. No evidence of external injury/trauma. Appeared thin.

Necropsy findings: Lungs spotted/cloudy, internal fat absent, organs otherwise normal. Small amount of vegetative material in abomasum, milk absent, intestines empty.

Mortality category: Predation excluded, starvation/pneumonia.

Mortality Case History

Calf No: Unmarked 05

Sex: Female
Location: Okerokovik River foothills

Carcass collected: 2 June 1985
Carcass weight: 4.9 kg
Total length: 86 cm
Right hind foot length: 31 cm
New hoof length: 6.8 mm

Carcass condition and disposition: Right eye removed, no other evidence of external injury or trauma.

Necropsy findings: Lungs clouded, absence of internal fat deposits, abomasum empty, absent of milk.

Mortality category: Scavenging involved, avian scavenger, starvation/pneumonia.

Mortality Case History

Calf No: Unmarked 06

Sex: Male
Location: Jago River coastal plain

Carcass collected: 4 June 1985
Carcass weight: 6.5 kg
Total length: 92 cm
Right hind foot length: 35 cm
New hoof length: 7.4 mm

Carcass condition and disposition: Intact, no evidence of external injury/trauma. Umbilicus dry, hooves partially hard/worn. Carcass appeared thin.

Necropsy findings: Lungs spotted and cloudy, absence of internal fat deposits, hair and vegetative material in abomasum, absence of milk curds.

Mortality category: Predation excluded, starvation/pneumonia.

Mortality Case History

Calf No: Unmarked 07

Sex: N/A
Location: Jago River foothills

Carcass collected: 5 June 1985
Carcass weight: 7.5 kg
Total length: 95 cm
Right hind foot length: 35 cm
New hoof length: 8.1 mm

Carcass condition and disposition: Carcass lying on right side, flesh removed from left side, rib cage intact, left eye and tongue removed, heart, stomach and lungs consumed, liver partially consumed.

Necropsy findings: No evidence of injury or trauma on head and neck.

Mortality category: Predation/scavenging involved, avian scavenger.

Mortality Case History

Calf No: Unmarked 08

Sex: Male
Location: coastal plain west of Jago River

Carcass collected: 5 June 1985
Carcass weight: 5.8 kg
Total length: 85 cm
Right hind foot length: 35 cm
New hoof length: 7.2 mm

Carcass condition and disposition: Carcass lying on left side, gulls were feeding on it at time of collection. Right eye and tongue removed, flesh removed from right abdominal area, intestines and stomach consumed. Hooves soft, little wear.

Necropsy findings: No evidence of wounds, lungs red and bloody.

Mortality category: Predation/scavenging involved, avian scavengers - gulls, probable pneumonia.

Mortality Case History

Calf No: Unmarked 09

Sex: Female
Location: coastal plain east of Jago River

Carcass collected: 5 June 1985
Carcass weight: 6.5 kg
Total length: 83 cm
Right hind foot length: 33.5 cm
New hoof length: 8.1 mm

Carcass condition and disposition: Intact, hemorrhage at mouth, scours around anus.

Necropsy findings: Bruise on right rib cage with corresponding gelatinous hemorrhage, abdominal hemorrhage, ruptured liver. No corresponding puncture of skin adjacent to bruise. Heart, lungs and spleen normal, milk curds present in stomach.

Mortality category: Predation excluded, probable trampling accident.

Mortality Case History

Calf No: Unmarked 10

Sex: N/A

Location: Aichilik River mountains

Carcass collected: 5 June 1985

Distance from capture site:

Carcass weight: 3.1 kg
Total length: N/A cm
Right hind foot length: N/A cm
New hoof length: 7.5 mm

Carcass condition and disposition: Sixty percent consumed, only anterior portion remaining. Right eye removed, flesh partially removed from neck. No evidence of injury to the head. Golden eagle at carcass site when collected.

Necropsy findings: N/A

Mortality category: Predation/scavenging involved, golden eagle.

Mortality Case History

Calf No: Unmarked 11

Sex: Female
Location: Jago River coastal plain

Carcass collected: 7 June 1985
Carcass weight: 5.5 kg
Total length: 87 cm
Right hind foot length: 34 cm
New hoof length: 7.5 mm

Carcass condition and disposition: Intact, cow standing at carcass. Appears thin. Umbilicus dry, hooves hard/worn.

Necropsy findings: No evidence of wounds/trauma. Internal organs normal. Internal fat deposits absent, small amount of milk in abomasum. Muscle behind left eye soft, gelatinous.

Mortality category: Predation excluded, disease related, natural mortality.

Mortality Case History

Calf No: Unmarked 12

Sex: Female
Location: Okerokovik River foothills

Carcass collected: 9 June 198
Carcass weight: 4.6 kg
Total length: 71 cm
Right hind foot length: 32 cm
New hoof length: 7.6 mm

Carcass condition and disposition: Partially consumed, jaegers observed feeding on carcass. Tongue and right eye removed, flesh removed from left abdomen. Hooves partially hard, slight wear. Cow with distended udder standing near carcass site.

Necropsy findings: Liver, kidneys and stomach removed, heart normal, internal fat absent, lungs dark and gelatinous.

Mortality category: Scavenging involved, jaegers, disease related natural mortality, probable weak calf at birth (non-viable).

Mortality Case History

Calf No: Unmarked 13

Sex: Male
Location: Okerokovik River foothills

Carcass collected: 9 June 1985
Carcass weight: 5.1 kg
Total length: N/A cm
Right hind foot length: 36 cm
New hoof length: 8.9 mm

Carcass condition and disposition: Thirty percent consumed, right eye removed, all internal organs removed, puncture wounds on head, broken skull. Flesh from left femur removed. Several ribs severed at base. Three gulls feeding at carcass when collected.

Necropsy findings: Puncture wounds on dorsal surface of skull 30.4 mm apart (5.5 mm and 8.1 mm diameter). Puncture of skull above left ear 13.2 mm diameter.

Mortality category: Predation/scavenging involved, golden eagle - predator, glaucous gull - scavenger.

Mortality Case History

Calf No: Unmarked 14

Sex: Female
Location: Aichilik River foothills

Carcass collected: 9 June 1985
Carcass weight: 5.5 kg
Total length: N/A cm
Right hind foot length: 35.1 cm
New hoof length: 8.4 mm

Carcass condition and disposition: Lying on right side, immature golden eagle at carcass site. Flesh removed from exposed ribs and hip area, eyes, ears and tongue removed. Zygomatic arches fractured, lower jaw broken off.

Necropsy findings: Heart, lungs normal.

Mortality category: Predation/scavenging involved, golden eagle-predator.

Mortality Case History

Calf No: Unmarked 15

Sex: Female
Location: Okerokovik River foothills

Carcass collected: 11 June 1985
Carcass weight: 5.3 kg
Total length: 82 cm
Right hind foot length: 33 cm
New hoof length: 7.4 mm

Carcass condition and disposition: Intact, lying on left side. Radio-collared adult female (#PY45) standing at carcass site. No evidence of external wounds/trauma.

Necropsy findings: Internal organs normal, lack internal fat deposits. Vegetation and milk curds in abomasum and rumen.

Mortality category: Predation excluded, disease related natural mortality.

Mortality Case History

Calf No: Unmarked 16

Sex: N/A
Location: Okerokovik River foothills

Carcass collected: 11 June 1985
Carcass weight: 4.8 kg
Total length: 85 cm
Right hind foot length: 35 cm
New hoof length: 8.4 mm

Carcass condition and disposition: Fifty percent consumed, gulls observed feeding at carcass, eagle feathers present. Tongue partially removed, no broken or chewed bones, legs, shoulders intact, puncture wounds dorsal surface of neck, hemorrhage associated with wounds.

Necropsy findings: Internal organs removed. Talon punctures left and right side of skull and neck with corresponding hemorrhage.

Mortality category: Predation/scavenging involved, golden eagle - predator, glaucous gulls - scavengers.

Mortality Case History

Calf No: Unmarked 17

Sex: Male

Location: Okerokovik River coastal plain

Carcass collected: 12 June 1985
Carcass weight: 5.0 kg
Total length: 76.5 cm
Right hind foot length: 33.5 cm
New hoof length: 6.5 mm

Carcass condition and disposition: Lying on right side, gulls feeding on carcass. Tongue and left eye removed. Flesh removed from left side, internal organs consumed. Skin punctured above right ear, with blood stain.

Necropsy findings: Skull punctured (5.3 mm and 9.3 mm diameter) approximately 10 mm apart.

Mortality category: Predation involved, golden eagle.

Mortality Case History

Calf No: Unmarked 18

Sex: N/A
Location: Okerokovik River coastal plain

Carcass collected: 13 June 1985
Carcass weight: 2.5 kg
Total length: N/A cm
Right hind foot length: 35 cm
New hoof length: 12.2 mm

Carcass condition and disposition: Sixty percent consumed, brown bear observed feeding on carcass. Carcass of collared adult female (#S15) nearby. Eyes and tongue removed, wounds appear old and dried relative to fresh evidence of bear feeding. Internal organs removed, flesh removed from upper hind legs, shoulder and under neck.

Necropsy findings: Skull punctured on right (7.0 mm diameter), with corresponding hemorrhage and on the left (above the eye) 15.4 mm diameter puncture wound with no associated hemorrhage.

Mortality category: Predation/scavenging involved. Golden eagle - predator, brown bear - scavenger.

Mortality Case History

Calf No: Unmarked 19

Sex: N/A
Location: Okerokovik River mountains

Carcass collected: 21 June 1985
Carcass weight: 8.7 kg
Total length: 92 cm
Right hind foot length: 37 cm
New hoof length: N/A mm

Carcass condition and disposition: Intact, lying on right side. Bird peck hole on left hip. No other external evidence of injury or trauma.

Necropsy findings: No internal evidence of injury or trauma. Internal organs normal, no internal fat deposits, vegetation packed in stomach, milk curds absent.

Mortality category: Scavenging involved, avian scavenger, starvation.

Mortality Case History

Calf No: Unmarked 20

Sex: N/A
Location: Egaksrak River foothills

Carcass collected: 24 June 1985
Carcass weight: N/A kg
Total length: N/A cm
Right hind foot length: N/A cm
New hoof length: N/A mm

Carcass condition and disposition: Eighty-five percent consumed, two immature golden eagles were feeding at the carcass. Skin stained with blood, numerous talon puncture wounds. Flesh and internal organs consumed.

Necropsy findings:

Mortality category: Predation involved, golden eagle.

Mortality Case History

Calf No: Unmarked 21

Sex: Female
Location:

Carcass collected: 24 June 1985
Carcass weight: 15 kg
Total length: 37.5 cm
Right hind foot length: N/A cm
New hoof length: 12.1 mm

Carcass condition and disposition: Found live, seriously disabled by wounds and hemorrhage on right rear of abdomen and hip area. Adult female was standing near disabled calf. Calf was dispatched and carcass collected for necropsy investigations. Wolf observed approximately 3.2 km from injured calf.

Necropsy findings: Puncture wounds (12.4 mm) and (20.6 mm) diameter, 10.2 mm deep on upper right hip with extensive hemorrhage. Puncture wound on left flank and left shoulder. Internal organs normal, fat deposits present, vegetation preset in rumen, milk curds present in abomasum.

Mortality category: Predation involved, probable golden eagle.

Mortality Case History

Calf No: Unmarked 22

Sex:
Location:

Carcass collected: 29 June 1985
Carcass weight: kg
Total length: cm
Right hind foot length: cm
New hoof length: mm

Carcass condition and disposition:

Necropsy findings:

Mortality category:

Mortality Case History

Calf No: Unmarked 23

Sex: Female
Location: Ekaluakat River foothills

Carcass collected: 29 June 1985
Carcass weight: 5.4 kg
Total length: cm
Right hind foot length: 31.5 cm
New hoof length: 8.5 mm

Carcass condition and disposition: Carcass was intact. Adult female standing at carcass, immature golden eagle approximately 30 m from carcass, brown bear approximately 200 m from carcass. Hooves partially hard and worn, dried umbilicus. Hemorrhage from mouth and puncture wounds on right rib cage (50.4 mm diameter).

Necropsy findings: Extensive hemorrhage. Small puncture wounds in right abdominal area. Milk curds present in abomasum.

Mortality category: Predation involved, probable golden eagle.

Mortality Case History

Calf No: Unmarked 24

Sex: Male
Location:

Carcass collected: 1985
Carcass weight: 10.9 kg
Total length: cm
Right hind foot length: 37.5 cm
New hoof length: 9.5 mm

Carcass condition and disposition: Carcass was intact with dried umbilicus. Adult female without antlers standing at carcass site.

Necropsy findings: Lungs clouded, internal fat deposits absent, milk curds absent in abomasum and intestinal tract, moss and soil material in rumen.

Mortality category: Predation excluded, starvation/pneumonia.

Mortality Case History

Calf No: Unmarked 25

Sex: Male
Location: Aichilik River mountains

Carcass Collected: 30 June 1985
Carcass weight: 13.8 kg
Total length: cm
Right hind foot length: 42. cm
New hoof length: mm

Carcass condition and disposition: Carcass was 50% consumed. Radio-collared wolf observed at carcass, immature golden eagle near carcass. Internal organs removed/consumed, ribs partially removed, skull fractured into four parts, brain partially consumed, mandibles broken, flesh removed, ears, tongue and eyes consumed, left foreleg broken/chewed at joint.

Necropsy findings: Puncture wounds in mid back (4.9 mm and 6.5 mm) with corresponding hemorrhage.

Mortality category: Predation involved, golden eagle - predator, wolf - scavenger.

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ECOLOGY OF MUSKOXEN IN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1982-1985

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Key words: Muskoxen, population size, composition, productivity, mortality, herd dynamics, distribution, movements, habitat use, Arctic National Wildlife Refuge.

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Ecology of muskoxen in the Arctic National Wildlife Refuge, Alaska, 1982-1985.

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Abstract: Muskoxen (*Ovibos moschatus*), transplanted to the Arctic National Wildlife Refuge in northeast Alaska in 1969 and 1970, were studied from April 1982 to April 1986 with the use of radio-telemetry. Forty-five animals were captured, measured, and marked, and 43 were radio-collared. In April 1985, the pre-calving population was estimated to be 352 muskoxen. In November 1985, 476 muskoxen were counted. This transplanted population rapidy expanded since 1976, increasing at a mean annual rate of 22% from 1978-1985. An estimated 111 calves were added to the population between late April and late June 1985. Most calves were born in mid- to late May, but the birth of calves in late June suggested that some cows came into a second estrus. Radio-collared cows calved both annually and in alternate years. A mean reproductive interval of 1.6 years was calculated for 15 radio-collared muskoxen observed for 2 or 3 consecutive years. In early July 1985, 75 calves:100 cows (3+) were counted among 419 muskox classified. The bull(3+):100 cows (3+) ratio was 65 in 1985. Survival rates of calves and yearlings were high in 1983-1985. Annual loss (mortality and dispersal), including an annual harvest of 4-5 adult bulls, was estimated to be approximately 7-12% in 1983-1986. Muskoxen were most frequently seen in moderately sized mixed-sex herds of 10 to 30 animals, although herds as large as 118 muskoxen were seen. The largest mixed-sex herds were seen in precalving, fall and winter seasons, and mean herd size decreased during the rut. Bulls also occurred in groups of 2-10 and as solitary animals, but small groups of cows or solitary cows were seen only infrequently. Many marked adult bulls did not remain with a herd for long periods of time, but moved from herd to herd. Seasonal use of specific areas was documented and dispersal into new areas also occurred in 1982-1985. Muskoxen were most frequently associated with river and creek drainages except in winter and spring when ridges and hillsides blown free of snow were used by some animals. Use of vegetation types followed a phenological progression with muskox using tussock and low vegetation uplands in May and June, early blooming forbs on river bars in early June, and riparian willow bars after their emergence in late June.

Ecology of muskoxen in Arctic National Wildlife Refuge, Alaska, 1982-1985.

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

Muskoxen were re-introduced on the Arctic National Wildlife Refuge (ANWR) coastal plain study area when animals brought from Nunivak Island off the western Alaska coast were released at Barter Island in 1969 and at Kavik in 1970. Now year-round residents of the ANWR coastal plain, muskoxen are susceptible to impending petroleum exploration activities in all seasons. Reproduction and survival in recent years have been high; however, continuing data collection on population size and composition is essential to monitor changes which may occur in the presence or absence of potential disturbances. In this population where large herds have become established and are dispersing, an understanding of herd dynamics is a necessary element for evaluating the role that dispersal, movement, and distribution play in population dynamics of this species. Seasonal use of specific areas, particularly calving and over-wintering areas, needs to be documented to insure adequate habitat protection. This report summarizes data collected from April 1982 through April 1986.

The objectives of this study were:

1. Determine population size, composition and dynamics of muskox herds on ANWR.

2. Document seasonal distribution patterns, movements, and habitat use of muskox herds on ANWR.

Methods and Materials

The study area was located in northeastern Alaska between the Canning River and the Canadian border, from the arctic coast south to 69°30'N latitude (Fig. 1). A detailed description of this area was presented in U.S. Fish and Wildlife Service (1982). Muskoxen were also present west of the Canning River between the Kavik River and Sagavanirktok River, and in northwestern Canada. For purposes of this study, the study area was subdivided into the Tamayariak area, the Sadlerochit area, and the Okerokovik area (Fig. 1).

For purposes of analysis, the year was divided into 6 seasons, relative to life cycle activities of the muskoxen (Table 1).

Table 1. Seasons of the year relevant to muskox life cycle activity.

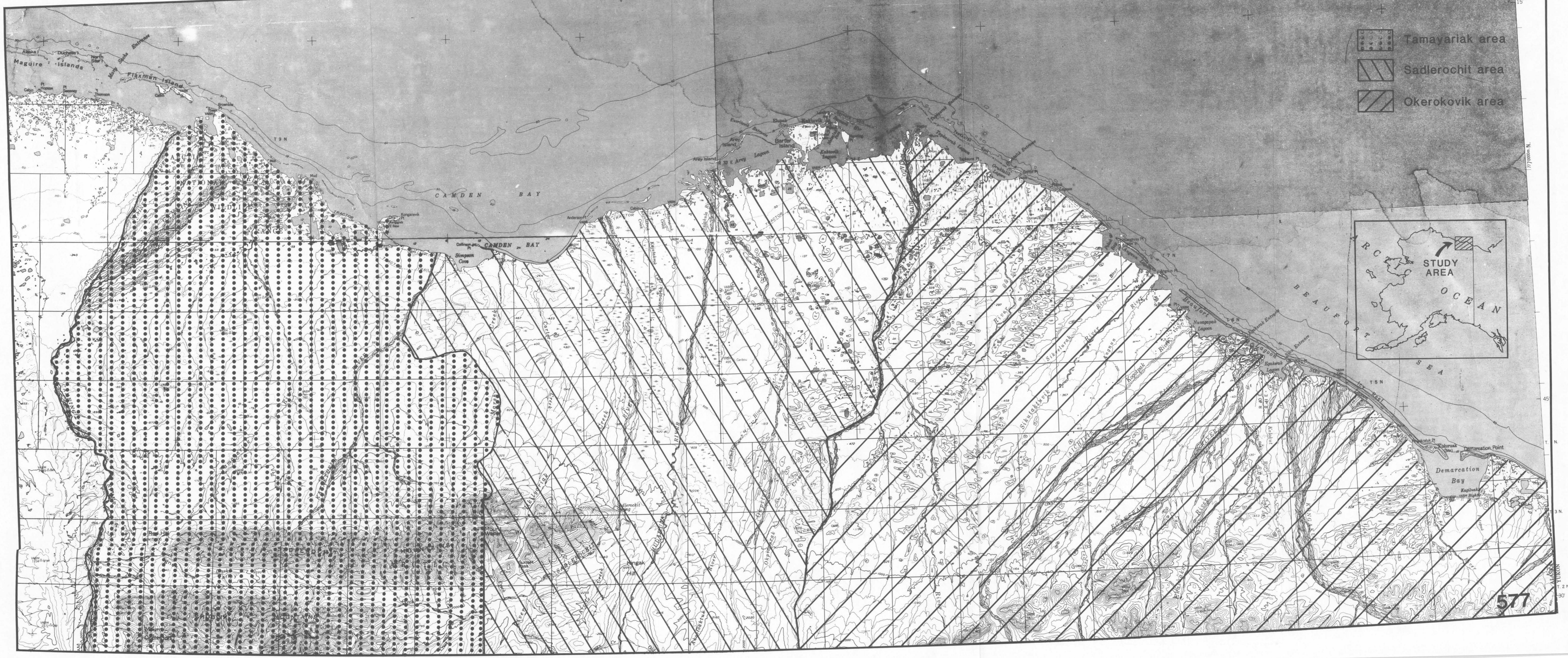
Name of season	Dates of season
Winter	mid-November to early March
Pre-calving	mid-March to mid-April
Calving	late April to mid-June
Summer	late June through July
Rut	August to mid-September
Fall	late September to early November

Forty-five different muskoxen were captured in the ANWR between April 1982 and July 1985. All muskoxen were darted from a Jet Ranger helicopter using a Cap-Chur rifle, 3-10 cc syringes, 3.8 cm barbed needles and low power charges (Palmer Chemical Company, Douglasville, Ga). Herds were first overflown at low level to select which animals would be darted. A small group containing the selected animals was separated from the main herd and 1-4 animals were darted in quick succession. Drugging more than 1 individual at a time permitted several animals to be immobilized quickly, reduced the number of passes over a herd, and insured that drugged muskoxen would not be alone after recovering from the drug.

Body measurements, including length of body, tail, ear, foreleg, hindleg; horn width, length, and circumference; skull width and length; 1/2 girth, shoulder height, and neck circumference, were made using methods described by Langvatn (1977). In 1982, samples (4 cm^2) of guard hair and underwool were clipped from the right front shoulder of each animal and a tooth was collected from 2 individuals for aging by Alaska Department of Fish and Game (ADF&G). Blood was collected from 1 3-year old cow in 1983 for analysis by ADF&G and University of Alaska (UAF). Captured muskoxen were individually identified by numbered plastic roto-tags or metal ear tags (Nasco, Ft. Atkinson, WS) placed in each ear. Visual markers, consisting of streamers of colored safety flagging (Safety Flag Co. of America, Pawtucket, RI), were attached to horns with hose clamps (Jonkel et al. 1975).

Between April 1982 and July 1985, 43 of the captured muskoxen were radio-collared using transmitters made by Telonics (Mesa, Arizona). An experimental satellite collar provided by Telonics was put on 1 cow in August 1984. Radio-collared muskoxen were relocated 19, 25, 26, and 25 times in 1982 through 1985, respectively. Most observations were made between late March and late October. Animals were relocated using fixed-wing aircraft outfitted with wing-mounted "H" antennas, and a scanner-receiver (Telonics, Mesa, AZ). Radio-locations and miscelleanous observation of muskoxen were plotted on 1:63,360 scale USGS topographic maps. Herd size, number of calves, habitat type, reaction to aircraft, and elevation of aircraft above ground level (AGL) were recorded on form sheets. After each flight, locations were transferred to a set of master maps, information was entered in a chronological log book, and data for each animal were summarized on maps and form sheets. Information was also entered into data base computer files. Locations were digitized and entered into a graphic information system: Map Overlay Statistical System (MOSS).

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



Pre-calving surveys were conducted from fixed-wing aircraft in mid-April 1982 and late March 1983, 1984, 1985 and 1986. In 1982, muskox herds were located during reconnaissance flights over the study area between the Canning River and Kongakut River. In 1983-1986 all major drainages between the Kavik River and the Canadian border (Clarance River) were overflown and all radio-collared muskoxen were located. Overflights were made at 350-1000 m AGL to minimize disturbance to the animals. Aerial photographs were taken using a 35 mm camera (Nikon F-2) with 80 to 200 mm zoom or 500 mm lens. Composition counts were made in mid-June and late August 1983, and late June - early July 1984 and 1985. Animals were classified from the ground with the aid of a Questar telescope. Composition of small herds (less than 10 animals) were made from the air. Differentiation of sex and age of muskoxen was determined by body size and horn boss development (Smith 1976). Fall surveys were made in late October and early November in 1982-1985. Major drainages between the Canning River and the Kongakut River were searched using fixed-wing aircraft and all radio-collared muskoxen were located. In 1983, 1984 and 1985 the survey was expanded to include the Kavik River west of the Canning River and the Turner River and Clarence River between the Kongakut River and the Canadian border. Numbers of calves were estimated from the air during fall surveys. Initial overflights were made at 350 m AGL or greater to prevent animals from aggregating into a defensive formation from which it was difficult to distinguish calves. Ground observations of rutting behavior, activity patterns, and habitat use of muskox herds were made in August 1984 and July and August 1985. Population estimates from surveys conducted in 1982-1985 were compared with estimates made in 1972-1981 (Roseneau and Warbelow 1974; Ross 1978, 1979, 1980, 1981). Population estimates prior to 1982 were based on limited surveys or casual observations and represent minimum numbers of muskoxen present in the study area.

Results and Discussion

Capture and Marking Procedures

Between April 1982 and July 1985, a total of 45 muskoxen, including 19 bulls and 26 cows, were captured and marked in ANWR (Table 2). All animals were 3 years of age or older. Muskoxen were drugged with M-99 (Etorphine, 1 mg/ml, D-M Pharmaceuticals, Rockville, MD) (Table 3). All recovered after injection of the antidote M-50-50 (Dipremorphine, 0.2 mg/ml, D-M Pharmaceuticals, Rockville, MD) administered intermuscularly in the rump. Drug dosages required for adequate immobilization varied from year to year (Reynolds and Garner 1983, Reynolds et al. 1984 and 1985). In 1984, more than half the animals handled were immobilized with single injections of M-99: 7cc for cows and 10cc for bulls. However, an adult bull, captured in July 1984 required 26cc before it could be handled. Another adult male captured 3 weeks earlier was completely immobilized in 10 min with 4cc M-99 or less. In 1985, all animals captured required 10-15 cc dosages. Variability in reaction to drugs may be due to variations in drug strength or other factors as well as weight, sex, and condition of the animal. In 1985, induction time of 7 animals immobilized with 1 or 2 concurrent injection ranged from 1 to 13 min ($X = 9.1 \pm 4.8$). Recovery times for 9 animals immobilized in 1985 ranged from 4 to 10 min ($X = 6.8 + 2.2$ SD). These values were similar to induction and recovery times observed during muskox capture operations conducted in 1982, 1983, and 1984 (Reynolds et. al. 1984, 1985). Body measurements were made on 22 cows and 16 bulls between April 1982 and July 1985 (Tables 4 and 5).

Table 2. Sex and age of muskoxen captured and marked in the Arctic National Wildlife Refuge, 1982 - 1985.

Year	Date	Adult bull		3-year bull	Adult cow		3-year cow	Totals		
		New	Recap.	New	New	Recap.	New	New	Recap.	Total
1982	13-16 Apr	1	8	1	5[a]	15		15		
1983	2-3 Apr	3		2	4	1	2	11	1	12
1983	1-2 Nov	3[a]						3		3
1984	31 Mar-2 Apr	4	2	1	3	5		8	7	15
1984	30 Jun	1			1			2		2
1984	16 Jul		1			1			2	2
1984	24 Aug				1			1		1
1985	5-7 Apr	3	2		1		1	5	2	7
1985	9 Jul		1			1			2	2
Totals		15	6	4	18	8	8	45	14	59

[a] marked but not radio-collared

Table 3. Drug dosages used to immobilize muskoxen in the Arctic National Wildlife Refuge, 1982 - 1985.

Amount of M-99 used (cc)	Number of muskoxen drugged 1982		1983		1984		1985		Total	
	M	F	M	F	M	F	M	F	M	F
4.0 - 5.0		2								2
7.0 - 8.0	2	10	1[a]	3[b]	1	7		2	4	22
10.0 - 13.0		1	4[a]	4[b]	7	4	2	2[c]	13	11
14.0 - 18.0			3		1		4	1	8	1
26.0					1				1	
Total	2	13	8	7	10	11	6	5	26	36

[a] All animals drugged with M-99 + 0.2cc Rompun.
[b] All but one animal drugged with M-99 + 0.2cc Rompun.
[c] Dose included 1.0 cc acepromazine maleate.

Table 4. Body measurements (cm) of female muskoxen captured on the Arctic National Wildlife Refuge, 1982 - 1985.

Capture date	ID#	Est. age	Total length	Body length	Tail	Ear	Neck	Half girth	Shoulder height	Hind leg	Fore leg	Skull width	Skull length	Max. horn width	Inside horn length	Horn circumference 1/4	1/2	3/4	Boss width
13 Apr 82	1[a]	14	214.0	210.0	4.0	11.0	90.0	72.5	109.0	39.5	33.0	21.0	45.0	43.0	56.8	--	--	14.0	--
13 Apr 82	3[a]	14	217.5	211.5	6.0	12.5	--	72.0	112.0	41.3	33.3	22.1	51.3	43.5	42.5	--	--	15.3	--
13 Apr 82	4	4+	204.9	201.9	3.0	14.0	113.0	79.5	117.0	44.0	33.0	25.7	52.0	61.0	43.5	--	--	15.9	--
13 Apr 82	5	4	206.9	201.9	5.0	13.0	102.0	77.0	120.0	42.5	31.5	21.5	54.5	--	31.5	--	--	13.0	--
15 Apr 82	6	4+	205.1	201.1	4.0	11.5	98.0	72.5	113.0	39.5	34.8	18.5	47.0	57.5	43.0	--	--	14.8	--
15 Apr 82	8	3	204.2	200.2	4.0	12.8	88.5	80.0	114.5	43.0	32.0	19.0	44.5	53.0	40.2	--	--	--	--
15 Apr 82	9	4+	206.8	200.8	6.0	11.5	99.0	75.5	111.0	39.0	36.0	21.0	47.0	61.0	43.0	--	--	15.1	--
15 Apr 82	10	4+	205.4	200.4	5.0	13.0	107.5	73.5	103.5	38.2	33.0	20.2	49.0	55.5	45.5	--	--	13.0	--
15 Apr 82	11	3	193.6	187.6	6.0	13.2	80.5	83.5	119.0	42.0	32.3	18.9	47.0	53.0	38.2	--	--	16.0	--
16 Apr 82	14[a]	16	207.8	201.8	6.0	13.0	114.0	86.0	117.0	41.5	35.0	21.6	55.8	52.0	43.2	--	--	13.6	--
16 Apr 82	15	3	205.4	200.4	5.0	13.0	87.0	80.0	98.0	38.0	32.0	19.1	53.0	54.0	41.0	--	--	15.4	--
2 Apr 83	16	4+	209.3	202.3	7.0	11.5	91.5	71.0	107.0	39.5	--	20.5	47.5	53.5	40.0	7.6	12.5	16.0	--
2 Apr 83	17	4+	216.0	208.0	8.0	12.0	107.0	77.0	103.0	40.5	--	20.6	44.0	61.0	44.5	6.7	11.0	15.2	--
3 Apr 83	25	4+	224.0	216.5	7.5	11.5	98.0	72.5	96.5	39.0	28.0	19.5	54.0	57.0	46.0	7.0	12.0	14.0	--
3 Apr 83	23	4+	214.0	204.0	10.0	11.5	89.0	75.4	106.0	33.1	24.5	18.0	50.2	48.5	41.0	8.5	11.6	12.1	--
3 Apr 83	21	3	219.0	210.5	8.5	12.0	82.5	75.0	118.0	28.0	22.0	21.0	55.5	53.0	44.0	7.0	10.0	14.0	--
3 Apr 83	22	3	224.5	216.0	8.5	12.5	109.2	76.0	109.0	26.0	36.0	18.5	50.0	53.0	40.0	6.5	10.0	13.0	--
1 Apr 84	32	4+	244.0	235.0	9.0	12.0	92.0	85.0	124.0	40.0	33.0	30.0	52.0	55.0	44.5	6.5	12.0	14.0	12.0
1 Apr 84	33	4+	217.0	208.0	9.0	12.0	82.0	76.0	110.0	38.0	30.0	22.0	45.0	52.0	45.0	8.5	10.5	14.0	10.0
2 Apr 84	36	4	223.0	215.0	8.0	13.0	91.0	76.0	111.0	35.0	30.0	32.0	48.0	50.0	44.0	7.0	12.5	13.0	11.0
30 Jun 84	38	4+	213.0	202.0	11.0	13.0	--	72.0	109.0	43.0	33.0	27.0	47.0	64.0	46.0	9.0	12.5	16.0	--
29 Aug 84	40	4+	215.0	207.0	8.0	14.5	94.0	84.0	105.0	42.0	32.0	26.0	48.5	48.5	40.0	7.0	10.0	13.0	10.0
5 Apr 85	41	3	189.0	182.0	7.0	14.0	81.0	85.0	109.0	33.0	31.0	17.0	44.0	56.0	44.0	8.0	13.0	16.0	10.0
6 Apr 85	43	4+	193.0	184.0	9.0	9.0	82.0	72.0	116.0	40.0	40.0	20.0	41.0	53.0	40.0	6.0	12.0	20.0	12.0
Female X			211.3	204.5	6.9	12.4	94.4	76.6	110.7	38.6	32.1	21.7	48.9	53.8	42.8	7.3	11.5	14.6	10.8
SD			11.6	11.4	2.1	1.2	10.6	4.6	6.8	4.6	3.8	3.8	4.0	5.2	4.3	0.9	1.1	1.7	1.0

[a] Original transplant animals

Table 5. Body measurements (cm) of bull muskoxen captured on the Arctic National Wildlife Refuge, 1982 - 1985.

Capture date	ID#	Est. age	Total length	Body length	Tail	Ear	Neck	Half girth	Shoulder height	Hind leg	Fore leg	Skull width	Skull length	Max. horn width	Inside horn length	Horn circumference 1/4	Horn circumference 1/2	Horn circumference 3/4	Boss width
13 Apr 82	2	3	211.0	201.0	10.0	14.0	93.5	80.0	130.0	44.0	34.4	22.8	54.5	66.0	57.3	--	--	24.9	--
14 Apr 82	7	4+	208.6	203.6	5.0	13.5	103.5	82.0	129.0	46.0	34.3	24.0	58.0	68.0	65.0	--	--	26.0	--
2 Apr 83	18	4+	240.0	235.5	6.5	--	99.0	88.0	114.5	42.0	38.0	27.1	67.0	74.0	59.0	14.1	19.0	25.1	--
2 Apr 83	19	4+	242.6	237.0	5.6	11.0	122.5	86.0	116.0	--	36.5	28.7	62.8	78.0	60.0	11.5	18.5	22.4	--
2 Apr 83	20	4+	250.8	245.0	5.8	12.0	139.5	92.0	112.0	--	39.0	27.7	64.5	78.5	58.0	10.0	16.5	20.5	--
3 Apr 83	24	3	220.5	212.0	8.5	11.0	92.0	75.0	102.0	32.0	28.0	--	54.8	68.0	54.0	9.5	20.0	25.0	--
3 Apr 83	26	3	222.8	214.3	8.5	13.5	88.0	82.0	96.5	29.8	34.0	23.0	46.5	59.0	51.0	10.0	15.0	23.0	--
1 Nov 83	27	4+	--	--	5.0	--	--	80.0	106.0	39.0	32.0	28.0	64.0	69.0	62.0	9.5	17.0	25.0	--
1 Nov 83	28	4+	244.0	239.0	5.0	18.0	112.0	87.0	104.0	36.0	32.0	32.0	57.0	74.0	62.0	9.0	17.0	22.8	--
1 Nov 83	29	4+	--	--	8.0	12.0	127.0	88.0	112.0	41.0	34.0	28.0	62.5	71.0	66.0	11.0	16.0	21.0	--
31 Mar 84	30	5	248.0	239.0	9.0	12.0	106.0	84.0	122.5	44.0	31.0	25.5	61.5	67.0	62.5	8.5	19.0	24.0	29.5
1 Apr 84	31	3	243.5	237.0	6.5	13.5	91.0	78.0	123.0	32.0	32.0	32.5	53.5	63.0	58.0	10.0	18.0	23.0	20.0
1 Apr 84	34	4+	264.5	256.0	8.5	11.0	121.0	82.0	123.0	38.0	35.0	42.0	63.0	76.0	--	9.0	16.5	27.0	32.0
2 Apr 84	35	4+	236.0	228.0	8.0	12.0	89.0	85.0	110.0	42.0	32.0	37.5	58.0	67.0	58.0	9.5	18.0	23.0	27.0
2 Apr 84	37	4+	258.0	247.0	11.0	13.0	102.0	83.0	106.0	33.0	32.0	43.0	58.0	70.0	63.0	10.0	17.0	20.0	27.0
30 Jun 84	39	4+	263.0	254.0	9.0	13.5	103.5	90.0	121.0	41.0	33.0	41.5	60.5	72.0	65.5	11.0	17.0	23.0	30.0
6 Apr 85	42	4+	239.0	230.0	9.0	13.0	92.5	81.0	125.0	35.0	35.0	27.0	49.0	74.0	63.0	8.0	16.0	25.0	26.0
6 Apr 85	44	4+	242.0	234.0	8.0	14.0	99.0	90.0	137.0	48.0	36.0	29.0	51.0	74.0	63.0	9.0	15.0	22.0	31.0
7 Apr 85	45	4+	243.0	234.0	9.0	16.0	109.0	81.0	130.0	51.0	42.0	28.5	60.5	70.0	64.0	9.0	15.0	24.0	29.0
Male X			239.8	232.1	7.7	13.1	105.0	83.9	116.8	39.6	34.2	30.4	58.2	70.4	60.6	9.9	17.1	23.5	27.9
SD			15.7	15.6	1.7	1.8	14.1	4.4	10.8	5.9	3.1	6.2	5.4	4.9	3.9	1.4	1.4	1.8	3.4

[a] Original transplant animals

Radio-collars did not remain functional on bull muskoxen as long as on cow muskoxen (Table 6). At least 7 of 25 radio-collars put on bulls malfunctioned within 2 to 14 months. Nine bulls shed their collars and at least 6 of these collars were torn in half. Only 5 bull collars still functioned after 14 months post-deployment. Collars remained on bulls for an average of 16.0 ± 9.9 months (N=21, range = 2-40). Bull collars probably malfunctioned during antagonistic clashes prior to and during the rut. Most malfunctions and collar losses occurred between July and September. In contrast, only 2 of 34 collars placed on cow muskox malfunctioned prior to 14 months post-deployment (Table 6). One cow lost a collar and 19 collars still functioned after 19 to 31 months. Collars remained on cows an average of 26.5 ± 11.6 months (N=30, range=6-56).

Some problems occurred by attaching collars too loosely. At least 7 collars were loose enough to slip over the boss, in some cases covering part of the face. At least 1 cow lost her collar in this manner. Bulls whose collars were ripped off probably became entangled with another bull's horn during dominance fights during the rut.

Population Size and Productivity

Reintroduction. Muskoxen were reintroduced to the ANWR coastal plain in 1969 when 51 muskoxen (27 males and 24 females) from Nunivak Island were brought to Barter Island (Griffin 1969, Hout 1969, Jennings 1970a). The animals were released in 4 small groups in late March and early April (Table 7). Over half the animals were less than 2 years old (Jennings 1970a). A total of 38 muskoxen were seen in small groups south of Barter Island 2 days after the last group was released (Griffin 1969), but initial mortality was apparently high. At least 9 animals died by mid-April and 6 apparently moved east into Canada, where 3 to 5 were reportedly shot (Neiland 1969, Thayer 1969a and 1969b, Lent 1971, Jennings and Burris 1971). Another bull was shotnear Arctic Village on the south side of the Brooks Range in October 1969 (Hinman 1969, Thayer 1969a). Therefore survivors of the initial transplant on the ANWR coastal plain probably did not exceed 35 muskoxen.

Sightings of muskoxen in the first few months following the initial transplant suggest that dispersal and mortality may have further decimated numbers of animals on the ANWR coastal plain. Only 10 different individuals were seen between June and August 1969 (Thayer 1969c). Knutson (1969), in an extensive survey to locate muskoxen, observed only 17 muskoxen in early September 1969. Thayer (1970) reported seeing 18 individuals in February 1970. Mortality of another bull was documented in August 1970 (Jennings 1970b).

In June 1970, 13 additional muskoxen (Table 8) were released at the Kavik River airstrip, about 145 km southwest of Barter Island and 26 km west of ANWR's western boundary. Nothing is known about initial mortality of the Kavik transplant.

In spite of initial mortality and reported long range dispersal of some animals following the Barter Island transplant, enough muskoxen survived to form the nucleus of breeding populations on the ANWR coastal plain. A maximum of 48

Table 6. Longevity of radio-collars on bull and cow muskoxen in the Arctic National Wildlife Refuge, 1982 - 1986.

Sex	Number of muskoxen collared and/or re-collared	Number of collars: Functioning after 14-31 months	Number of collars: Malfunctioning within 2-14 month	Number of collars: shed by muskox
Bulls	25	5	7	9
Cows	34	19	2	1

Table 7. Number and composition of muskoxen released at Barter Island in northeast Alaska, March and April 1969. (Source: Griffin 1969, Jennings 1970a).

Date	47+ mo M	47+ mo F	35-47 mo M	35-47 mo F	23 mo M	23 mo F	11 mo M	11 mo F	Total
6 Mar			2	2[a]	1[b]	1	5[c]	5	16
29 Mar	1		3[d]	2		1	1		8
4 Apr			3[e]	3	1		5[f]	12	
14 Apr			5		1[g]		5[h]	4	15
Total	1		13	7	3	2	11	14	51
Percent	2		25	14	6	4	22	27	100

a 1 recaptured 4/82, Sadlerochit River
b 1 dead 6/74, Okerokovik area, Angun Point
c 1 dead 6/80, Okerokovik area, Jago River
d 1 dead 3/82, upper Sadlerochit River
e 1 killed 8/69 Arctic Village
f 2 recaptured 4/82 Okerokovik
g 1 washed ashore 8/70 Flaxman Island
h 1 dead 3/81 upper Sadlerochit River

Table 8. Numbers and composition of muskoxen released at Kavik River, in northeastern Alaska, June 25, 1970 (Source: Jennings and Burris 1971).

	2 years olds (25 mo) M	2 years olds (25 mo) F	Yearlings (13 mo) M	Yearlings (13 mo) F	Total
Number	2	7	1	3	13
Percent	15	54	8	23	100

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

Population size. The ANWR muskox population has expanded rapidly (Fig. 2). Population growth closely approximates (R^2=.98) an exponential curve. The population has doubled every 3 to 4 years since 1976, and annual rates of increase have ranged from 0.16 to 0.32 (X=0.22±.07 SD) for pre-calving population estimates since 1978 (Table 9). Jingfors and Klein (1982) calculated an apparent rate of increase of 0.24 in the ANWR muskox population between 1977 and 1980. Although differences in census methods and areas of coverage before 1983 influenced the number of muskoxen counted, rapid growth was a characteristic of this transplanted population. The post-calving (fall) population of muskoxen in and adjacent to the ANWR was an estimated 240, 311, and 384 animals in 1982, 1983 and 1984 respectively (Table 9). During the pre-calving census in early April 1985, 352 muskoxen were counted between the Kavik River and the Canadian border; in November 1985, 476 muskoxen including an estimated 90 calves were counted during the census of the same area. The Tamayariak-area contained the largest number of muskoxen (Table 10).

Population Composition. In early July 1985, 419 muskoxen including 98 calves were classified between the Tamayariak and Kongakut Rivers (Table 10). Composition data were collected on about 88% of the estimated post-calving population in 1985.

Composition data collected in July 1985 were compared with composition data obtained in August 1983 and July 1984 (Table 11). The percentage of adults bulls classified was higher in 1984 and 1985 than in 1983. Adult bulls radio-collared in the fall of 1983 and the spring of 1984 and 1985 were used to locate bull groups during 1984 and 1985 composition counts. Some bulls were probably missed during composition counts in 1983 when fewer bulls were radio-collared. Also, bulls may be more dispersed in August as a result of the rut.

In 1985, the bull:cow ratio was 65 bulls:100 cows for animals three years or older, compared with a ratio of 53 and 92 seen in 1983 and 1984, respectively. Variability in bull:cow ratios is likely related to bulls movements and changing group association. Gray (1973) found an equal ratio of bulls to cows on Bathurst Island after a stressful winter. In other areas, more cows were seen (Tener 1965, Hubert 1977, Miller et al. 1977, all as cited in Gunn 1982). In areas where conditions were favorable and muskox populations were expanding, more bulls than cows were observed according to Tener (1965) and Spencer and Lensink (1970).

In 1984 and 1985, the composition counts were made in early July to insure that all calves had been born. In 1983, differences in numbers of calves observed in early June and late August suggested that some calves were born after the June 1983 composition counts (Reynolds et al. 1984). Four calves were seen in July 1984 and 2 calves were seen in July 1985 which appeared to be less than one week old. These calves were considerably smaller and darker in color than calves born in late April and May and had difficulty keeping up with the herd when the animals were walking rapidly.

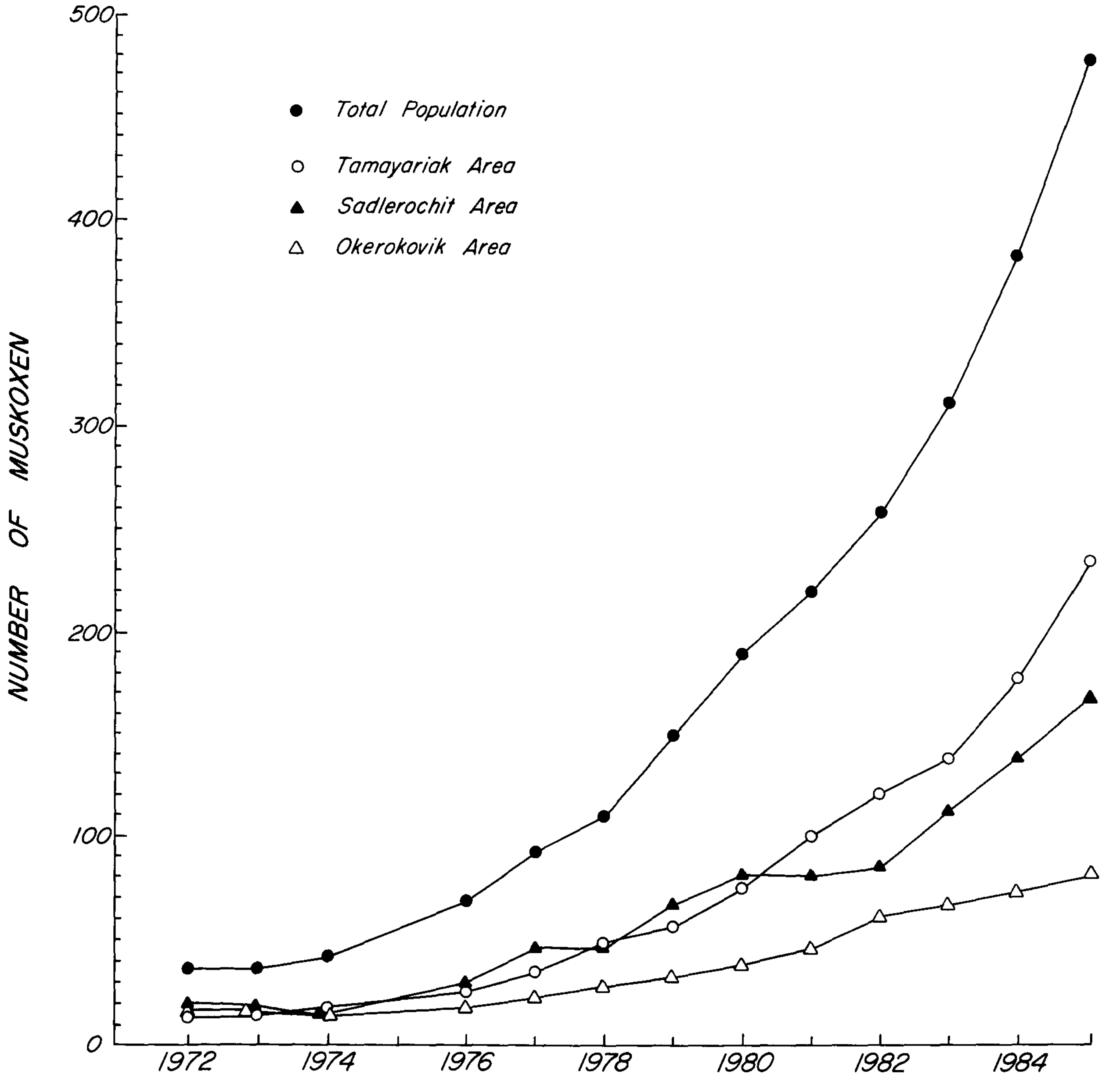


Fig. 2. Estimated number of muskoxen in post-calving populations in the Arctic National Wildlife Refuge, 1972-1985.

Table 9. Numbers of muskoxen observed in the Arctic National Wildlife Refuge during spring, summer and/or fall, 1972-1986.

	Spring (pre-calving)		Summer		Fall	
Year	Total number	Annual rate of increase	Total number	Number of calves	Total number	Source
1972	--	--	36	7	--	a
1973	--	--	43	6	--	a
1974	--	--	38	--	--	b
1976	--	--	67	15	--	b
1977	--	--	90	18	--	b
1978	86	--	108	28	--	c
1979	112	0.30	--	--	--	d
1980	148	0.32	--	--	--	e
1981	186	0.26	--	--	--	f
1982	219	0.18	--	--	240	g
1983	257	0.17	211	46	311	g
1984	301	0.17	341	72	384	g
1985	352	0.17	419	98	476	g
1986	408	0.16	--	--	--	g

[a] Roseneau and Warbelow 1974
[b] U.S. Fish and Wildlife Service 1982
[c] Ross (1978)
[d] Ross (1979)
[e] Ross (1980)
[f] Ross (1981)
[g] current study, Reynolds et al. (1983, 1984, 1985)

Table 10. Numbers of muskoxen observed in different areas of the Arctic National Wildlife Refuge during spring census, summer composition counts, and fall census in 1985.

Geographic area	Spring census 3-5 Apr 1985	Summer composition 3-6 Jul 1985	Fall census 31 Oct-5 Nov 1985
Tamayariak[a]			
Older than calves	175	150	187
Calves	0	47	45[b]
Total	175	197	232
Sadlerochit			
Older than calves	119	107	132
Calves	0	31	34[b]
Total	119	138	166
Okerokovik			
Older than calves	58	64	67
Calves	0	20	11[b]
Total	58	84	78
Study area total			
Older than calves	352	321	386
Calves	0	98	90[b]
Total	352	419	476

[a] including Kavik River
[b] estimated from the air

Table 11. Observed composition of muskox groups on the Arctic National Wildlife Refuge in 1983 and 1984.

Age-sex class		Tamayariak area[a]			Sadlerochit area			Okerokovik area[b]			Totals		
		Aug 1983	July 1984	July 1985	Aug 1983	July 1984	July 1985	Aug 1983	July 1984	July 1985	Aug 1983	July 1984	July 1985
Adult bulls	#	15	22	35	8	24	20	4	20	16	27	66	71
	%	15	16	18	11	18	14	12	27	19	13	19	17
Adult cows	#	24	27	43	18	29	32	6	13	17	48	69	92
	%	24	20	22	24	22	23	18	18	20	23	20	22
3-yr. bulls	#	6	10	8	2	10	4	2	2	2	10	22	14
	%	6	7	4	3	8	3	6	3	2	5	7	3
3-yr. cows	#	10	13	17	8	10	13	4	4	9	22	27	39
	%	10	10	9	11	8	9	12	5	11	10	8	9
2-yr. bulls	#	8	4	10	7	6	4	4	5	4	19	15	18
	%	8	3	5	9	5	3	11	7	5	9	5	4
2-yr. cows	#	5	9	13	4	8	7	2	4	4	11	21	24
	%	5	7	7	5	3	5	6	5	5	5	6	6
Yearlings	#	12	19	24	12	18	27	4	12	12	28	49	63
	%	12	14	12	16	14	20	12	16	14	13	14	15
Calves	#	21	33	47	17	26	31	8	13	20	46	72	98
	%	21	24	24	22	20	22	24	18	24	22	21	23
Totals		101	137	197	76	131	138	34	73	84	211	341	419

[a] includes herds on the Kavik and Katakturuk Rivers.
[b] includes bull groups between the Aichilik and Kongakut Rivers.

Productivity. In this study, calf:cow ratios were calculated assuming that productive cows were 3 years of age and older (3+), although some 2-year old cows were observed with calves on the Sadlerochit River in the highly productive year of 1979 (Jingfors and Klein 1982). In 1985, a ratio of 75 calves:100 cows (3+), was calculated for the entire ANWR study area (Table 12). Productivity was high in all areas.

Table 12. Calf:cow ratios observed in muskox herds in the Artic National Wildlife Refuge in mid-summer 1983, 1984 and 1985.

	Number of calves:100 cows (3+)			
Year	Tamayariak area	Sadlerochit area	Okerokorik area	Total
1983	62	65	80	66
1984	83	67	76	75
1985	78	67	77	75

The total number of calves produced in 1985 was estimated by multiplying the estimated number of calves per cow (0.75, Table 12) by the estimated total number of cows in the population. As the percentage of adult and 3-year old cows in the population was 31% (Table 11), and the total number of animals in the fall population was 476 (Table 10), the total number of cows in the population was estimated to be 148 the total number of calves produced in 1985 was estimated to be 111. During the fall census in early November 1985, 90 calves were observed from the air (Table 10), indicating a relatively low mortality rate for calves during their first summer.

Numbers of calves observed in the ANWR muskox population from 1972-1985, suggest that productivity has been relatively high during most of the past 13 years (Table 13). From 21-23% of all animals seen in post-calving surveys in 1983-1985 were calves, and ratios of calves/older animals ranged from 0.27 to 0.30 ($X=0.28\pm0.02SD$). Productivity for the entire study area ranged from 66 calves:100 cows in 1983 to 75 calves:100 cows in 1984 and 1985, for cows 3 years and older (3+) (Table 13).

Calf production was reported as high as 89 calves:100 cows (2 years +) in the ANWR Sadlerochit area in 1979 (Jingfors and Klein 1982). In other areas, muskox calf production has ranged from 27 to 85 calves:100 cows (Hubert 1974, Smith 1976, Lent 1978, Lassen 1984). The high productivity observed in ANWR was similar to muskox productivity recorded for transplanted populations and populations exploiting new habitat in Greenland (Lassen 1984, Thing et al. 1984), Canada (Gunn et al. 1984) and Nunivak Island (Smith 1984), but contrasts with low productivity and reproductive failures of muskoxen documented in the Canadian high arctic (Tener 1965, Gray 1973, Gunn 1984).

Miller and Gunn (1979) observed cows breeding in 3 successive years in the high arctic. Gunn (1982) stated that the age of breeding and the breeding interval may depend on the condition of the animal and possibly on social factors. Productivity of radio-collared cows was compared in 1982, 1983, 1984 and 1985 (Table 14). Cows were considered to have a calf if they were seen alone with a calf or in a herd with equal number of cows and calves, if they were followed

Table 13. Measures of muskoxen productivity, early to mid summer, in the Arctic National Wildlife Refuge, 1972-1985.

	Year							
	1972[a]	1973[a]	1976[b]	1977[b]	1978[b]	1983	1984	1985
Calves classified	7	6	15	18	28	46	72	98
Calves/total	0.19	0.14	0.22	0.20	0.26	0.22	0.21	0.23
Calves/older animal	0.24	0.16	0.29	0.25	0.33	0.28	0.27	0.31
Calves:100 adult cows (3+)						66	75	75
Estimated total number of calves[c]						68	81	111

[a] Source: Roseneau and Warbelow 1974

[b] Source: Ross 1978, 1979, 1980, 1981.

[c] Calculated by: calf/cow ratio x estimated total number of cows.

closely by a calf, or if maternal behavior such as licking or nursing was observed. Cows in herds without calves were assumed to be barren. Some cows may reproduce at age 2 (Jingfors and Klein 1982), but most cows reproduce at age 3 or older.

Nine (60%) of 15 radio-collared cows produced calves yearly for 2 or more years and 4 (27%) had calves every other year (Table 15). Of the 2 cows which produced calves only once in 3 years, 1 was an old cow (16 years in 1985). The other cow produced a calf at age 6, but did not calve at age 4 or 5.

Summarized reproductive data (Table 15) were used to calculate an estimated mean reproductive interval using the following formula:

$$\text{Mean reproductive interval} = \frac{(n_i)*(y_i)}{N}$$

Where n_i = number of cows reproducing at a given interval

y_i = interval in years

N = total number of cows

Using data from 15 radio collared cows, the mean reproductive interval was 1.6 years. If cow #1, a 16 year old animal who had only one calf in 4 years is eliminated from the data set, the mean reproductive interval was 1.3 years.

In 1985, the percentage of observed radio-collared cows with calves was similar to calf:cow ratios calculated for the entire population (Table 16). Numbers of radio-collared cows accompanied by calves increased from 1982 to 1984, following similar trend as calf:cow ratios for the the total population.

In 1985, 17 muskox calves were seen on 29 April, 31 calves were seen on 22 May, 65 calves were seen on 30 May. The peak of calving was probably in mid-May as was described by Jingfors (1980). During composition counts in early July 1984 and 1985, 2-4 calves estimated to be less than one week old were observed, indicating that calves were also born 6 to 8 weeks after the peak of calving.

Table 14. Reproductive status of radio-collared muskox cows in the Arctic National Wildlife Refuge, 1982-1984.

Animal number	Est age	Year collared	Accompanied by calf 1982	1983	1984	1985	Apparent reproductive (interval years/calf)
1 a	16	1982	No	Yes	No	No	4.0
3 b	16	1982	Yes	Yes	Yes[a]	a	1.0
4 c	4+	1982	?	a			
5 d	4+	1982	No	a			
6 e	4+	1982	?	Yes	Yes	Yes	1.0
8 f	4+	1982	?	Yes	Yes	Yes	1.0
9 g	4+	1982	Yes[b]	Yes	Yes	Yes	1.3
10 h	4+	1982	Yes	?	Yes	?	1.0
11 i	6	1982	No	No	Yes	?	3.0
14 j	19	1982	Yes	No	Yes	a	1.5
15 k	6	1982	?	a			
16 l	4+	1983		?	Yes	Yes	1.0
17 m	4+	1983		Yes	Yes	Yes	1.0
21 n	5	1983		?	Yes	Yes	1.0
22 o	5	1983		?	?	No	0.0
23 p	4+	1983		?	No	Yes	2.0
25 q	5	1983		?	Yes	No	2.0
32 r	4+	1984			No	Yes	2.0
33 s	4+	1984			Yes	Yes[c]	1.0
36 t	4+	1984			Yes	Yes	1.0
38 u	4+	1984			No	a	0.0
40 v	4+	1984			?	Yes	1.0

[a] cow died or lost collar.
[b] calf died.
[c] small calf.
? not observed.

Table 15. Summary of productivity of radio-collared cow muskoxen in the Arctic National Wildlife Refuge, 1982-1985.

Number of consecutive years observed	Number of cows producing calves: Yearly	Alternate years	2+ years	Totals
2	3	3	0	6
3	5	1	1	7
4	1[a]	0	1	2
Totals	9	4	2	15

[a] Calf stillborn the first year.

Jingfors (1980) reported 2 calves born on the Sadlerochit between 12-16 June 1979. A new born calf was observed 20 June on Nunivak Island (Smith 1976).

Table 16. Productivity of radio-collared cow muskoxen compared with productivity of the total muskox population, 1982-1985.

Year	No. of radio-collared cows observed	No. of radio-collared cows with calves	Calves:100 cows (radio-collared)	Calves:100 cows (total population)
1982	7	4	57	63
1983	8	5	63	66
1984	17	13	76	75
1985	14	11	79	75

Assuming a gestation of 35 to 36 weeks (Palmer and Rouse 1936; Alendal 1971, as cited in Smith 1976), most conceptions probably occur in mid- August. Calves born in late June must be conceived in late September. Some muskox cows may enter a subsequent estrus if they fail to conceive in August. White-tailed deer that do not become pregnant at their first estrus will come into estrus again 28 days later (Marchinton and Hirth 1984). Rowell and Betteridge (1984) found evidence of repeated estrus cycling in 2 cow muskoxen collected in October.

Mortality. In the past 4 years, the deaths of 29 individuals have been documented, accounting for a minimum annual mortality rate of 1.7 - 2.5% for the population (Table 17). Twenty (69%) of these animals were adult bulls. A limited hunting season established by the State of Alaska in 1983 resulted in a total harvest of 13 bull muskoxen. Two bulls were killed or scavenged by a radio-collared brown bear in late summer 1983 and 2 young-aged cows were also killed or scavenged by brown bears during the late winter of 1984-1985. Three radio-collared cows, which died in 1984 and 1985, were old-aged animals originally brought to the refuge from Nunivak Island. When released at Barter Island in March 1969, they were 11 or 36 months old and died at ages 16, 17 and 19 years (X=17.3+1.5 SD). Assuming no animals immigrated into this transplanted population between November 1983 and April 1985, and calves were the only source of recruitment, annual losses (mortality and dispersal) of 7-12% to the population were calculated for 1983-1985 (Table 18).

Mortality during the first years of life is often high in ungulate populations (McCullough 1984). High survival of muskox calves and yearlings appeared to occur in the ANWR population between 1983 and 1985 (Fig. 3). In 1983-1985, numbers of individuals in each cohort were estimated by multiplying the age class

percentage (Table 11) by fall population counts (Table 9) except in 1982. The ratio of calves/total animals (38/240=0.150) observed from the air during the 1982 fall census was multiplied by the number of animals in the 1983 spring census (257), resulting in a minimum estimate of 41 calves in 1982. Average survival rates (Downing 1980) were 85% for calves and 92% for yearlings between 1983 and 1985. Jingfors and Klein (1982) documented 100% survival of calves and yearlings in a muskox herd on the Sadlerochit River during 1979-1980.

Table 17. Muskox mortalities observed in the Arctic National Wildlife Refuge, 1982-1985.

Cause of mortality	Number of mortalities observed 1982	1983	1984	1985	Total
Hunting:					
M		4	5	4	13
F					
calf					
Fighting:					
M	1				1
F					
calf					
Predation/scavenging:					
M		2			2
F				2	2
calf			1		1
Old-age/malnutrition:					
M					
F	1		1	2	4
calf					
Unknown:					
M	2	1	1		4
F	1				1
calf	1				1
Total mortalities	6	7	8	8	29
Size of fall population	240	311	384	476	
% mortality	2.5	2.3	2.1	1.7	

Table 18. Annual loss (mortality and dispersal) to the pre-calving muskox population in the Arctic National Wildlife Refuge, 1983-1985.

Time interval	Pre-calving population[a]	Estimated number calves[b]	Population 1 year later	Annual loss	Percent loss
t, t+1	P_t	C_t	P_{t+1}	$L_t=(P_t+C_t)-P_{t+1}$	$L_t/(P_t+C_t)$
1983-1984	257	68	301	24	7.4
1984-1985	301	81	352	30	7.9
1985-1986	352	111	408	55	11.9

[a] from Table 9
[b] from Table 13

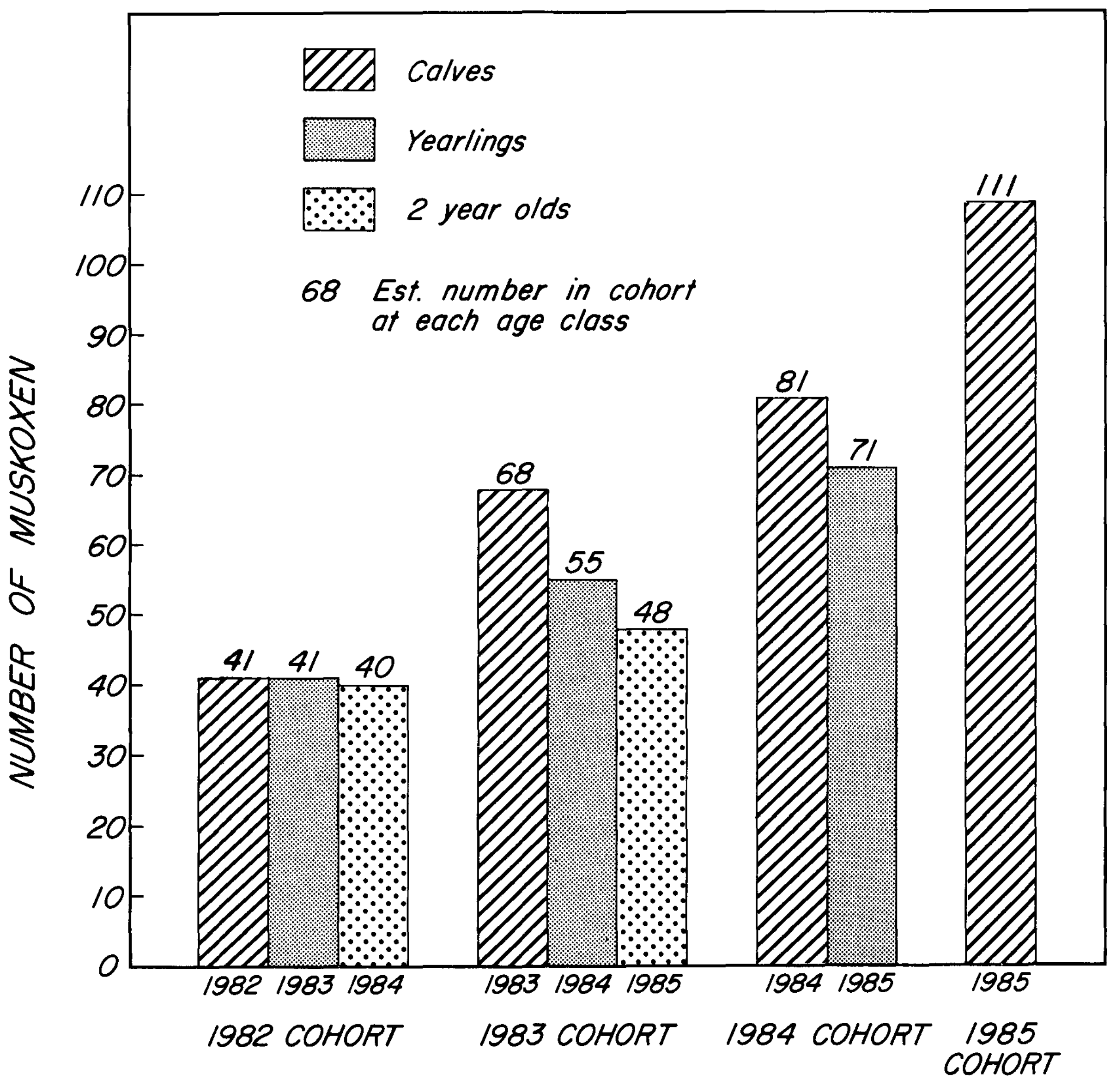


Fig. **3**. Production and survival of calf and yearling muskoxen in the Arctic National Wildlife Refuge, 1982-1985.

Herd Dynamics

Prior to 1982, most muskoxen in ANWR were thought to be associated with 1 of 3 large mixed sex groups or herds, each of which showed an affinity for a specific geographic area (U.S. Fish and Wildlife Service 1982). In 1979, muskoxen observed by Jingfors (1980) along the Sadlerochit River remained in 1 large herd of about 60 muskoxen from March to November with only infrequent temporary fracturing into smaller groups, primarily during the rut. However, Jingfors and Klein (1982) predicted that this large herd would eventually fracture into smaller units. During 1982-1985 the existence of numerous muskox herds on the ANWR coastal plain was documented with the use of radio-collared muskoxen.

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

Mixed-Sex Herds and Cow Groups. Over 76% of all observations were of mixed sex or cow groups (N=1700). Herd size calculations were based on observations made during radio-relocation flights and spring and fall surveys. Mixed-sex herds ranged in size from 2 animals (a bull and a cow) to 118 animals. Almost 80% of 1306 mixed-sex herds observed between 1982 and 1985 contained between 5 and 30 individuals. Herds of 11-21 animals were most frequently seen (Fig. 4). Smith (1976) seldom saw mixed-sex herds smaller than 5 animals on Nunivak Island.

Mean herd size of mixed-sex herds including cow groups ranged from 13.6 ± 11.2 SD in 1982 to 21.5 ± 17.5 SD in 1984 (Fig. 5). Seasonal differences ($F = 8.5$, $P < 0.001$) in herd size, possibly related to social behavior, were also observed. The largest mixed-sex herds were seen in pre-calving, winter and fall seasons, when mean herd size for all years ranged from 21.7 ± 15.9 SD to 27.2 ± 22 SD muskoxen per mixed-sex herd. The smallest herds were seen during the rut ($\bar{X}=12.2 \pm 8.5$ SD). This trend was observed all 4 years of the study (Fig 6). On Bathurst Island, Gray (1973) found monthly mean herd size changed from highs in February, April and October to lows in July and August. On Melville Island (Miller et al. 1977, as cited in Gunn 1982) also observed a decrease in average herd size from 17.2 in March-April to 10.0 in July-August.

Most mixed-sex herds observed during radio-relocation flights on ANWR were small to moderately sized throughout the year. But the number of herds containing fewer than 10 animals gradually increased and reached maximum during the rut in August and early September as herds fragmented into harems. During the same season, herds larger than 30 animals reached a minimum (Fig. 7). Smith (1976) described a harem as a temporary social unit which existed only during the rut between a single bull and a group of cows, but suggested that a basic social structure independent of bulls may exist.

Maximum mixed-sex herd size observed ranged from 53 in 1982 to 118 in 1985 and was larger each year as the population increased, suggesting that the upper limit to herd size may not yet have been reached. Mean mixed-sex herd size during the rut ranged from 9.5 to 14.3 animals in 1982-1985, suggesting that most breeding harems may be within this range.

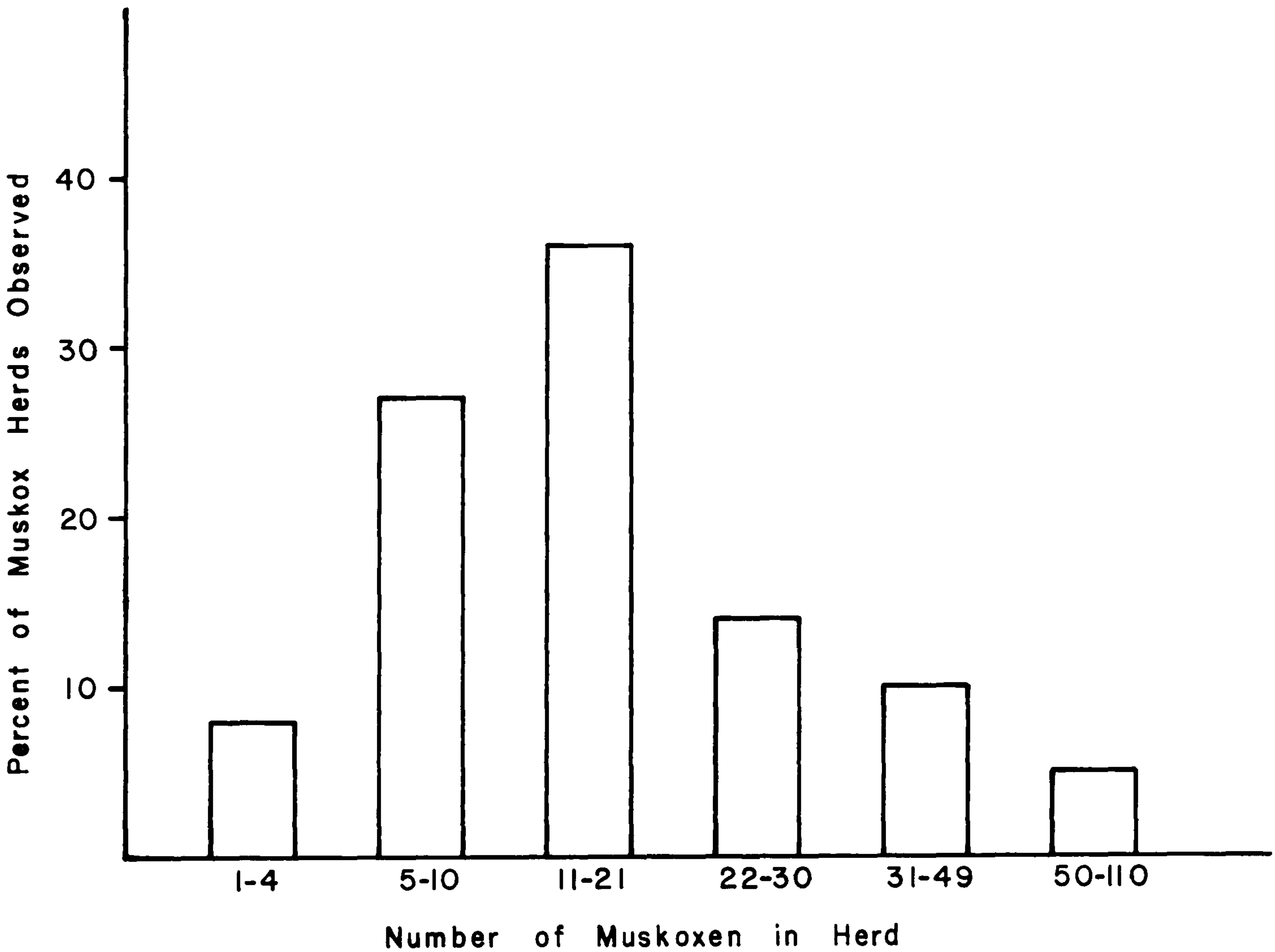


Fig. 4. Frequency distribution of mixed-sex muskox herd size in the Arctic National Wildlife Refuge, 1982-1985.

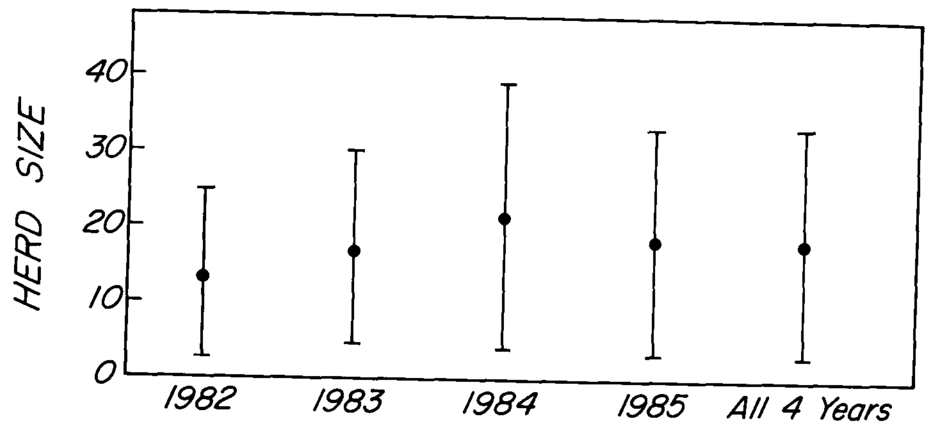


Fig. 5. Mean size of mixed-sex muskox herds (including cow groups) in the Arctic National Wildlife Refuge, 1982-1985.

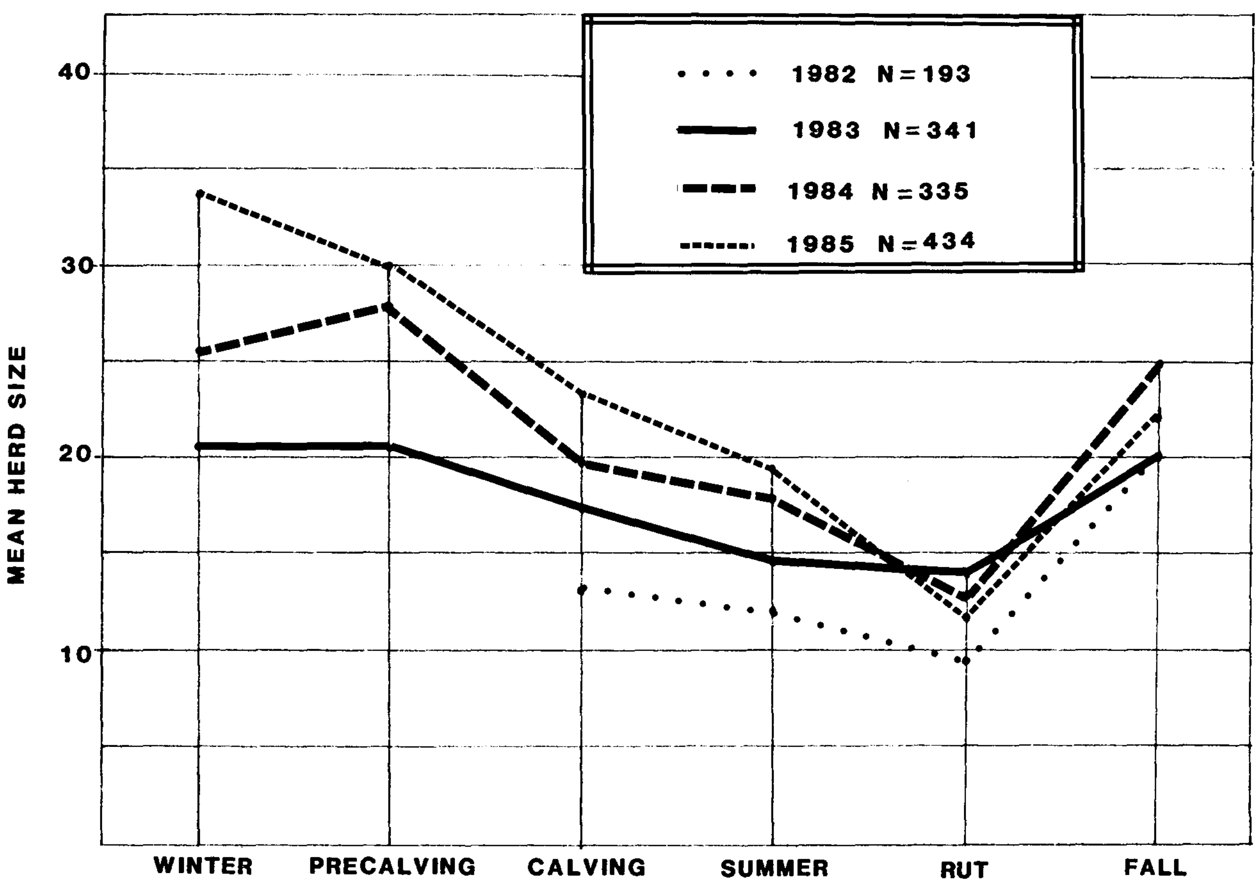


Fig. 6. Seasonal variation in the mean size of mixed-sex muskox herds in the Arctic National Wildlife Refuge, 1982-1985.

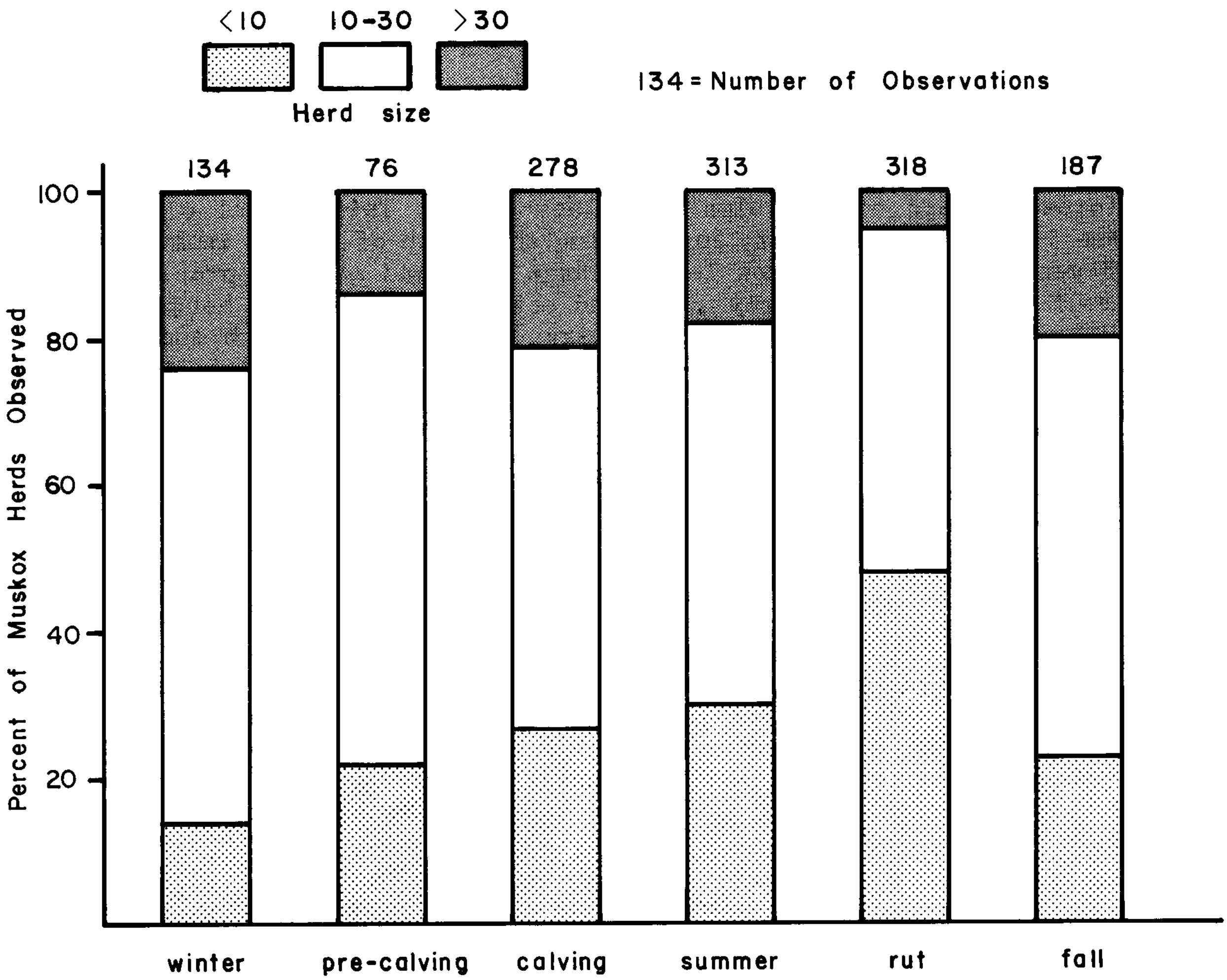


Fig. 7. Seasonal variation in frequency distributions of mixed-sex herd size in the Arctic National Wildlife Refuge, 1982-1985.

Since 1982, mixed-sex muskox herds in ANWR have not been stable units over long periods of time. Total numbers and marked individuals within a herd remained the same in some instances for several weeks, then changed as herds encountered one another and intermixed (Fig. 8 and 9; Reynolds et al. 1985). Some years intermixing occurred when herds came together during pre-calving and calving seasons. Intermixing of herds also frequently occurred when animals congregated on major rivers after leaf emergence of willows in late June and after the rut in late September.

Single cows and small groups of cows ranging in size from 2 to 10 individuals were seen infrequently. Only 4% of over 1300 observations of muskox groups containing cows were single cows or cow groups. Mean size of known cow groups was 4.4 ± 2.2SD during 1982-1985.

Smith (1976) seldom saw cows alone and suggested that animals which become separated quickly tried to rejoin the herd. Gunn (1982) speculated that parturient cows would be unlikely to leave the protection of the herd to give birth. But marked old aged cows were seen alone or with a calf or young cow on several occasions. A 16-year female accompanied by a 3-year old female, split away from a herd of 23 muskoxen and moved about 30 km southwest. A calf was born to this 3-year old cow in early May, and the 3 animals rejoined a mixed-sex herd in mid June. Another 16-year old female left a herd of 24 muskoxen in late April 1984 and remained alone until after it gave birth to a calf in late May or early June. It joined a herd of 10 animals in late June. This animal also was observed alone in late May and early June during the birth of calves in 1982 and 1983. An 18-year old female muskox left a large herd and moved approximately 30 km had a calf in late May or early June, and rejoined a mixed-sex herd in mid June. In 1985, this same cow again left a large herd in late March and moved about 20 km with a 3 year old cow. It remained on this ridge until it died in May 1985 at the age of 19. A radio-collared cow was observed alone with a calf between late June and early July 1982, but was associated with mixed-sex herds at other times. A small calf observed in late June 1984 could not keep pace with a herd of walking animals and eventually fell behind. The mother ran to the herd, but then returned to the calf. These observations suggest that solitary cows are animals unable to keep up with a moving group due to birth of a calf, old age, or injuries.

Bull Groups and Single Bulls. Bull groups in the ANWR study area ranged in size from 2 to 10 animals. Mean bull group size (excluding single bulls) calculated from observations made during radio-relocation flights and seasonal surveys, ranged from 4.6±2.0 SD bulls per group during the pre-calving season to 2.6±0.6 SD bulls per group during the rut (N=34). Observations of single bulls comprised 15% of all bull observations during the pre-calving period, but increased to 78% during the rut.

In contrast to cow muskoxen, many marked bulls did not remain with mixed-sex herds for long periods of time, but moved from herd to herd (Fig. 8 and 9, Reynolds et al. 1985). All marked males were associated with bull groups or were observed alone during at least part of the year during 1982-1985.

FIG 8. DYNAMICS OF MUSKOX HERDS IN THE OKEKROKOVIK AREA, 1985.

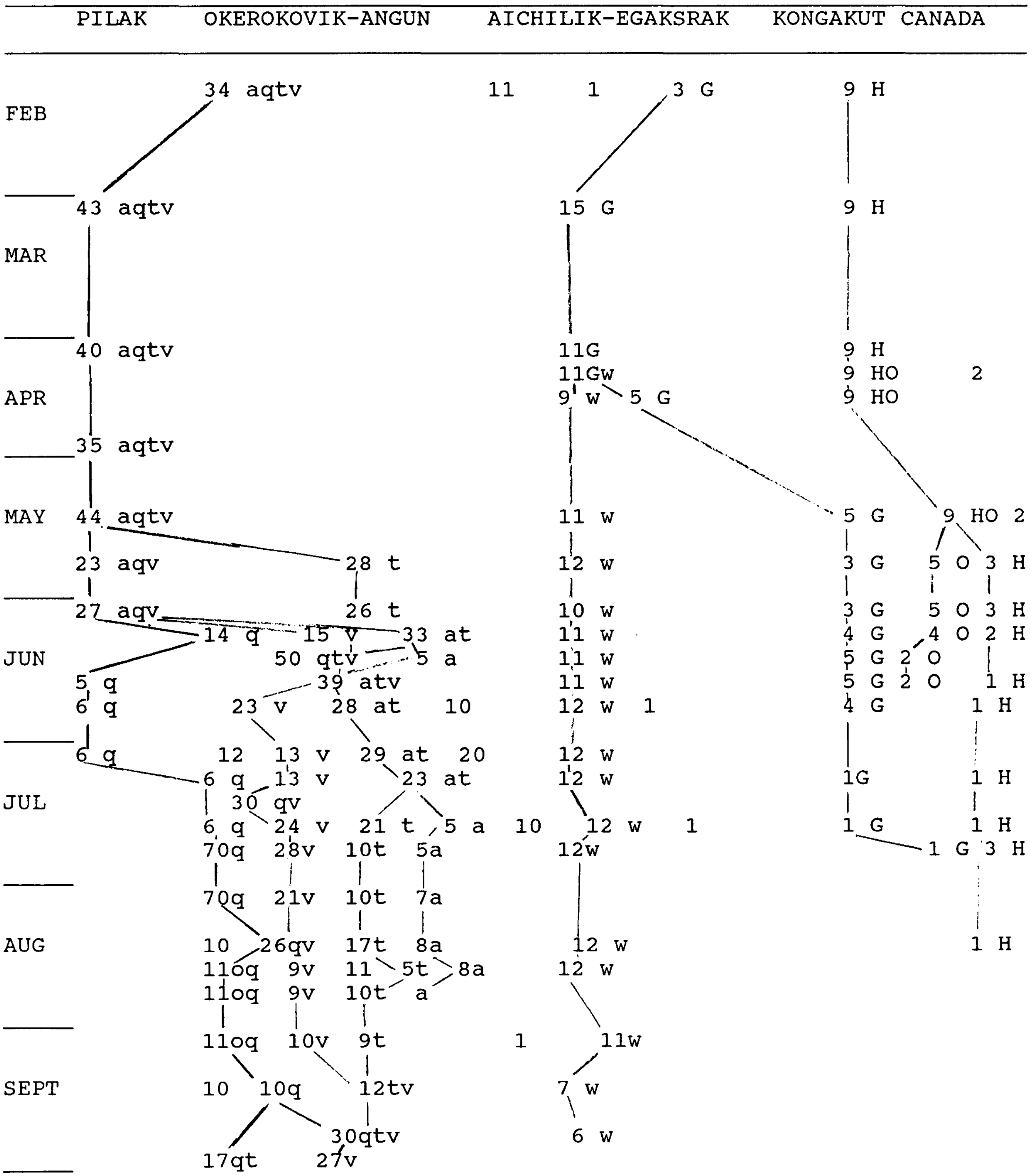
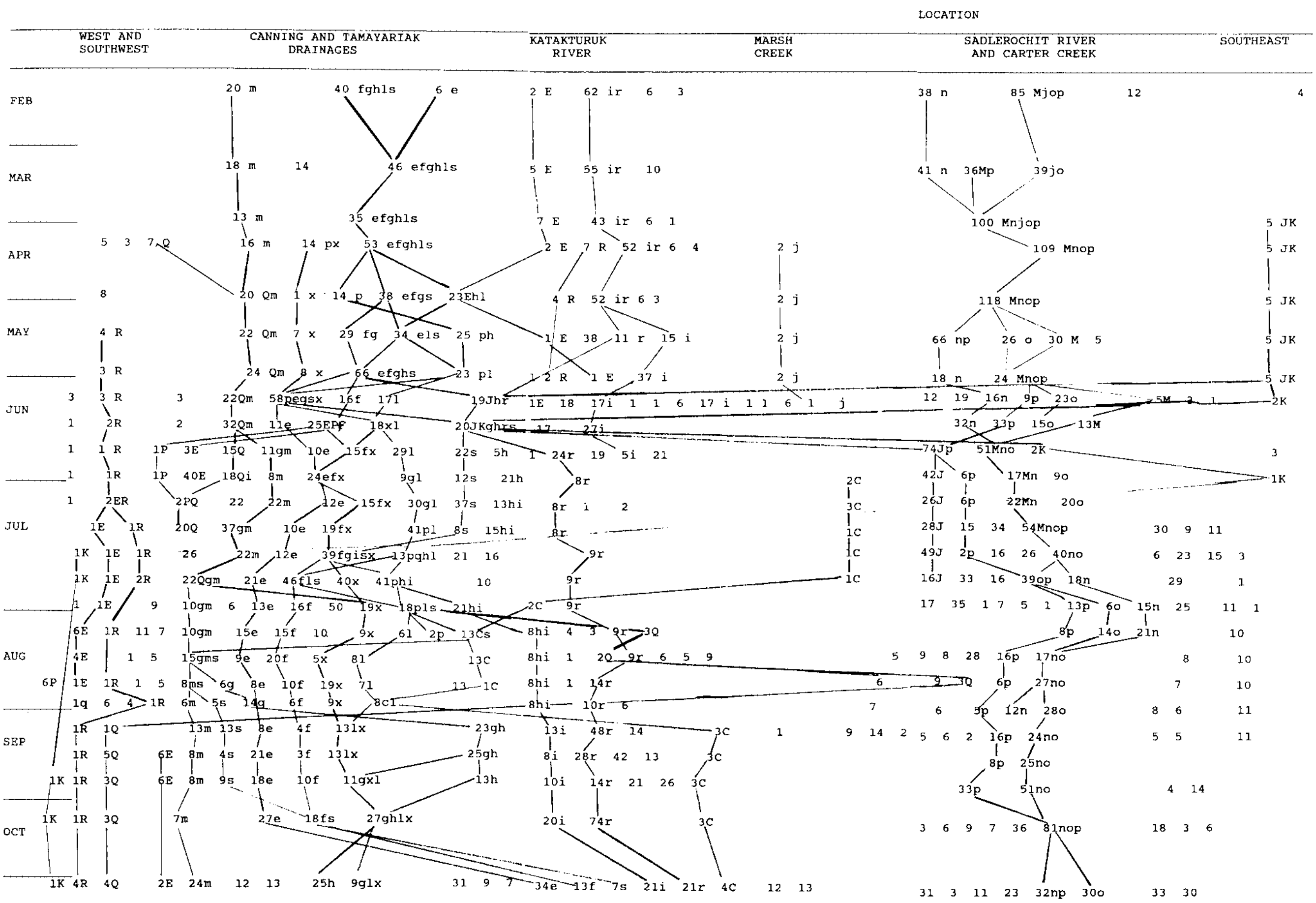


FIG. 9. DYNAMICS OF MUSKOX HERDS IN THE SADLEROCHIT AND TAMAYARIAK AREAS IN NORTHEASTERN ALASKA, 1985.



Distribution and Movements

General Distribution. Muskoxen observed in the ANWR study area from 1982 to 1985 were concentrated in distinct geographic locations between the Canning River and the Katakturuk River, along the Sadlerochit River, and between the Jago River and the Aichilik River (Fig. 10). These areas have been used by muskoxen since shortly after the animals were released at Barter Island in 1969 and at Kavik River in 1970 (Fig. 11). Animals transplanted at Barter Island were released in 4 different groups ranging in size from 8 to 16 animals (Table 7). Of the total, 49% were short yearlings (11 months old), 33% were males older than calves, and 18% were females older than calves. Along the Sadlerochit River, 5-9 muskoxen were seen between April 1969 and March 1970 (Lent 1971); 11-14 animals including at least 8 adults were seen in 1972 and 1973 (Roseneau and Warbelow 1974); and 36-74 muskoxen were observed between 1978 and 1981 (U.S.Fish and Wildlife Service 1982). Jingfors (1984) described the home range affinity of muskoxen along the Sadlerochit River in 1979. In the Okerokovik area, 11-13 muskoxen, including 9 adults, were observed in 1972 and 1973 (Roseneau and Warbelow 1974). From 1978 to 1981, 14-23 muskoxen were seen along the Okerokovik, Niguanak, and Angun Rivers (U.S. Fish and Wildlife Service 1982).

Three cows captured during tagging operations in April 1982, had been previously marked and released at Barter Island (Table 7). One animal, estimated to be 3 to 4 years old at the time of its release on March 26, 1969, was captured on the Sadlerochit River. Two other cows, released together as short yearlings on April 14, 1969, were captured in the same mixed-sex herd on the Okerokovik River. Several bulls released at Barter Island have been found as mortalities: 2 bulls were found dead on the upper Sadlerochit River, and 2 were found dead in the Okerokovik area, one near Angun Point and the other on the Jago River (Table 7). These recaptures and mortalities as well as sightings of muskoxen in the Sadlerochit area and Okerokovik area from 1978 to 1981 (Fig.11) indicate that soon after their release, survivors of the Barter Island transplant formed 2 mixed-sex herds: 1 herd moved southwest to the Sadlerochit River and the other moved southeast to the Okerokovik and adjacent rivers. Other bulls, released at Barter Island, moved longer distances; one was shot south of the Brooks Range near Arctic Village, and others moved east into Canada.

Muskoxen have been observed in the Tamayariak area since at least 1972 (Fig. 11). These animals were probably survivors of the 13 muskoxen released at Kavik in June 1970 which included 3 bulls (23%) and 10 cows (77%), all 1 to 2 years of age (Table 8). Ten to 11 animals, including 8 adults, were seen between the Kavik River and the Katakturuk River in 1972 and 1973 (Roseneau and Warbelow 1974), and 32 to 66 muskoxen were observed along the forks of the Tamayariak River from 1978 to 1981 (U.S.Fish and Wildlife Service 1982).

Dispersal. Muskoxen utilized these same 3 geographic areas during 1982-1985, when extensive data on summer distributions and movements of marked animals were collected (Fig. 10). Distributions expanded each year of the study, in part because additional marked animals were added each year (Fig. 12). However, dispersal of mixed-sex herds into new areas also occurred between 1982 and 1985.

Mixed-sex herds expanded their range into the upper Katakturuk River in 1982 and 1983. Small bull groups and solitary bulls had been seen along the Katakturuk River since 1979 (U.S.Fish and Wildlife Service 1982). However, no long term use by mixed-sex herds was observed until August 1982, when a mixed-sex herd of

6 muskoxen, which had moved between the Tamayariak area to the Sadlerochit area in June and July, moved to the upper Katakturuk River. This herd, joined by other animals and a second herd in 1983, remained between the upper Katakturuk River and Nularvik River during winter, pre-calving, and calving seasons. These animals summered on the forks of the Tamayariak River, the creeks south of Camden Bay, and the lower Katakturuk River during 1983-1985. At least some of these muskoxen moved back to the Tamayariak River in June 1984 and 1985. In the fall of 1985, 137 muskoxen were located along the upper Katakturuk River. Numbers of animals in the Tamayariak area, including the Katakturuk River, increased from 11 in the summer of 1973 to 232 in the fall of 1985. This has been the fastest growing segment of the ANWR muskox population in recent years (Fig. 2). Increasing use of the Katakturak River by animals from the Tamayariak area suggests population pressure may have caused this range expansion.

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

In addition to dispersal within the study area, muskox bulls have dispersed or made temporary movements east, west, and south of the ANWR study area (Fig. 13). Some animals moved long distances soon after the Barter Island transplant. In August 1969, within 5 months of being released at Barter Island, 3-5 muskoxen were shot in Canada as far east as the Mackenzie River delta (300 km east of Barter Island) and another bull muskox was shot north of Arctic Village, 240 km south of Barter Island (Lent 1971). Solitary bulls and small groups of animals have been observed in northwestern Yukon Territory, Canada, almost every year since 1972 (Roseneau and Warbelow 1974, K. Jingfors pers. comm., J. Russell pers. comm.). Between 1982 and 1985, as many as 5 bulls were seen between the Canadian border and the Babbage River. These included radio-collared bulls which moved between Canada and the Kongakut River.

Muskoxen have also been sighted west of the ANWR, since 1970 (Fig. 13). Solitary bulls and at least 1 mixed-sex herd of 9-19 animals have been seen several times along the Sagavanirktok River and adjacent drainages from Prudhoe Bay to Toolik Lake between 1970 and 1983. Radio-collared bulls moved between the Tamayariak area and Prudhoe Bay in 1985 and 1 radio collared bull moved at least 100 km west to the Ivishak River in 1985. Muskox bulls have also been seen 190 km west of the study area on the Colville River near Nuiqsuit, and 300 km southwest along the Killik River. In 1984 and 1985, single bulls were seen 50 km south of the ANWR study area in the Romanzof Mountains, and up to 200 km south of the ANWR study area along the middle fork of the Chandalar River, the upper east fork of the Chandalar, and on the Sheenjek River, all of which are south of the Brooks Range divide.

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

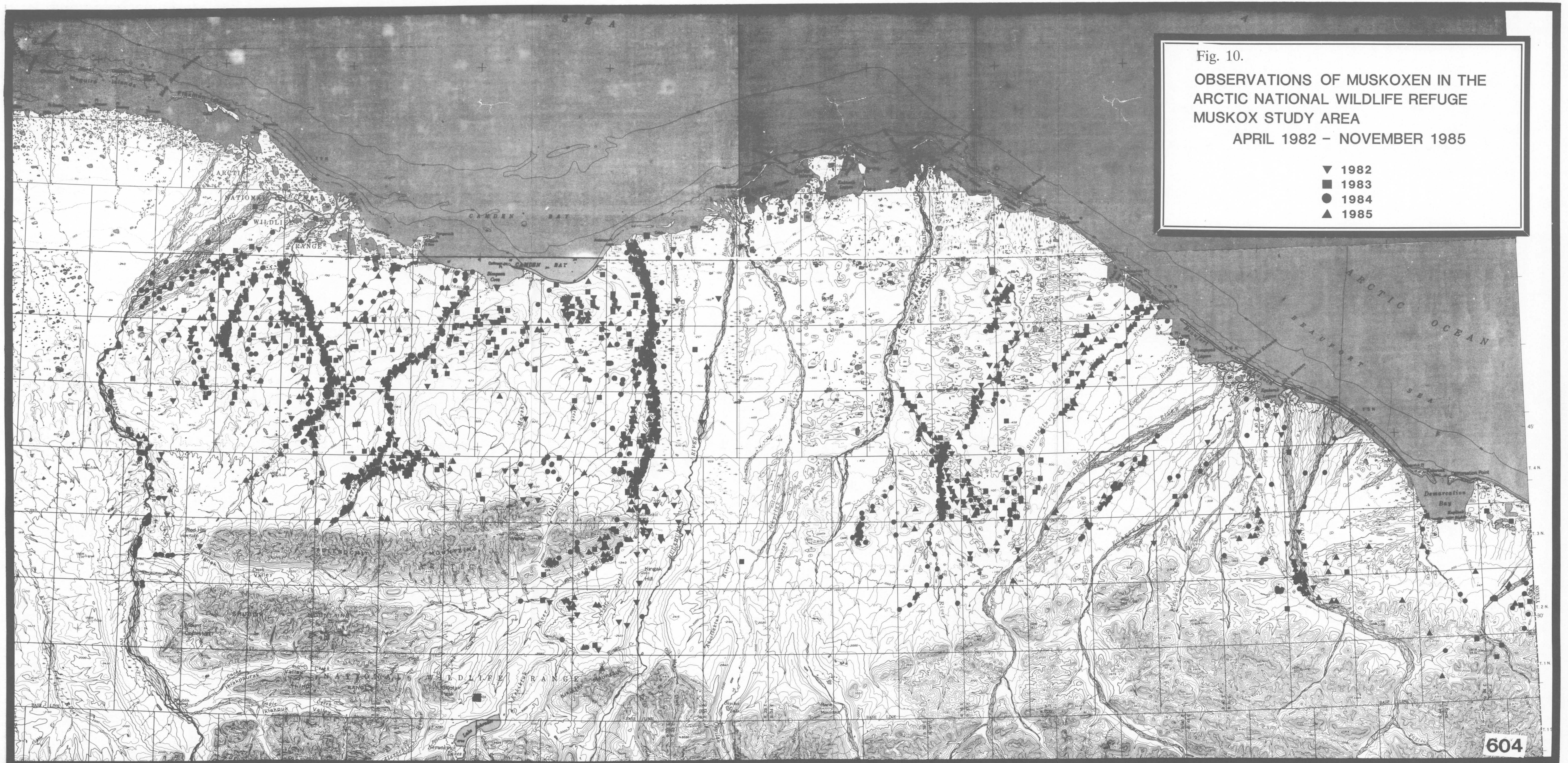


Fig. 10.

OBSERVATIONS OF MUSKOXEN IN THE ARCTIC NATIONAL WILDLIFE REFUGE MUSKOX STUDY AREA

APRIL 1982 - NOVEMBER 1985

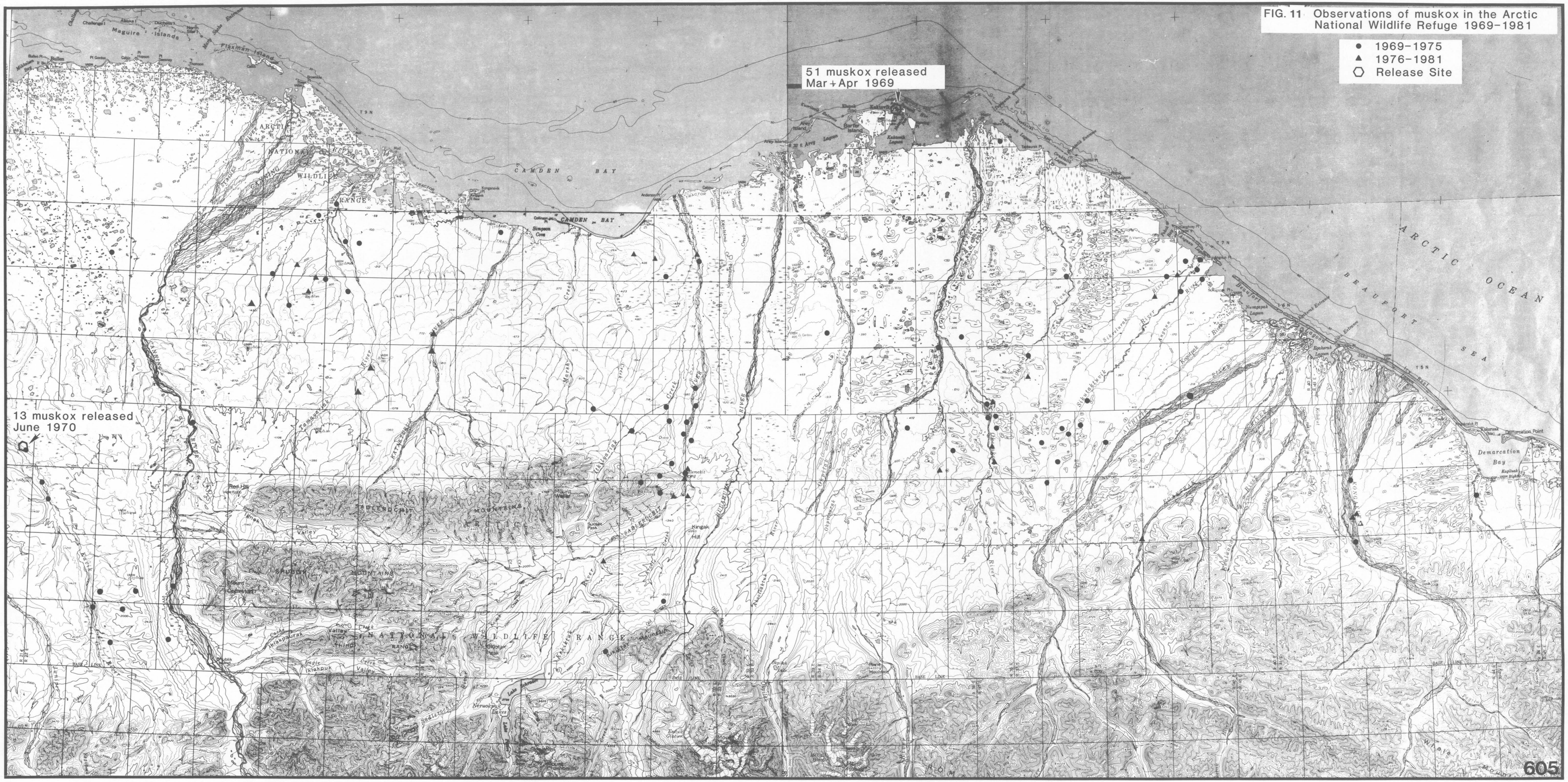


FIG. 11 Observations of muskox in the Arctic National Wildlife Refuge 1969–1981

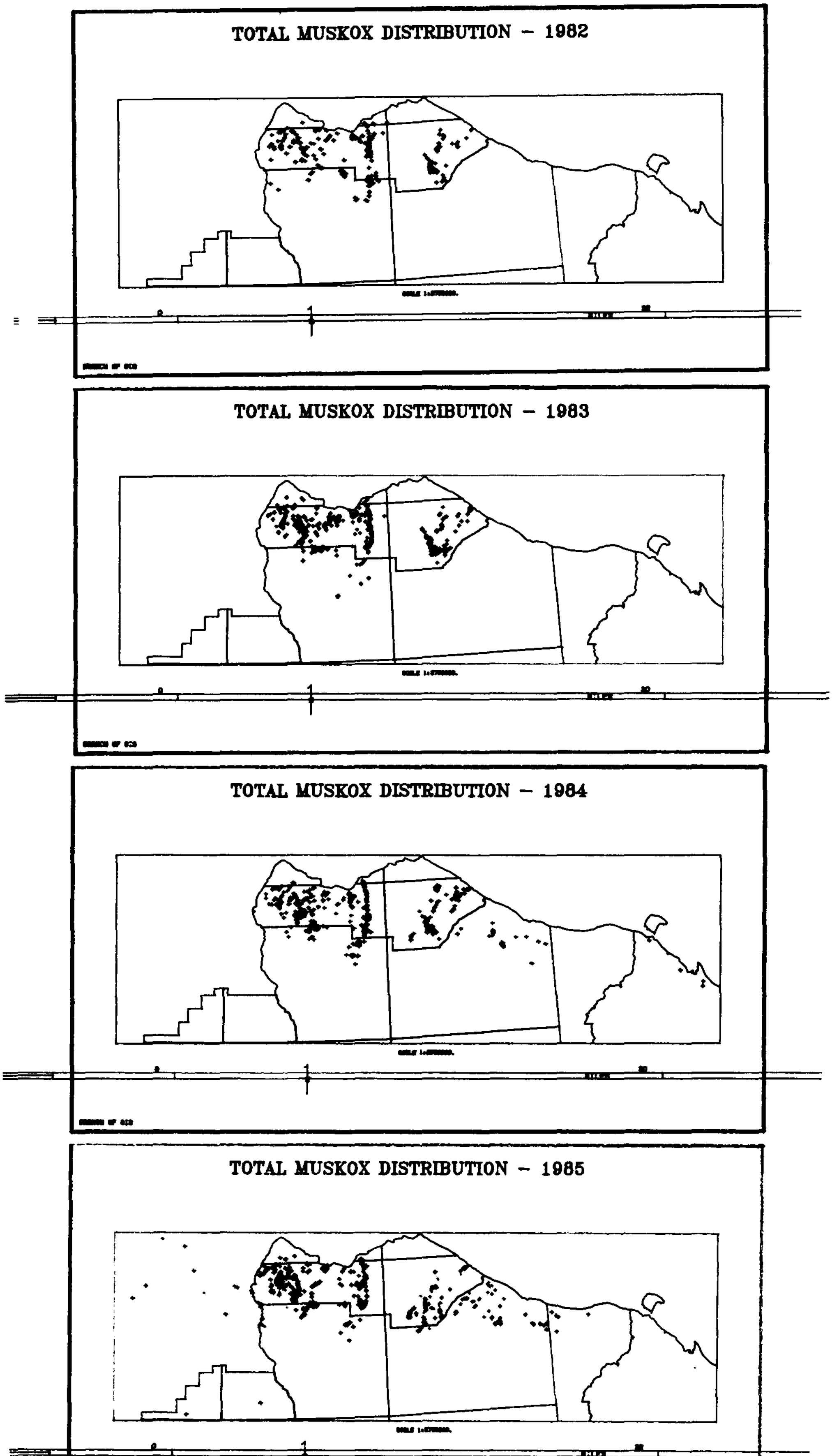


Fig. 12. Changing distribution of muskoxen in and near the Arctic National Wildlife Refuge, 1982-1985.

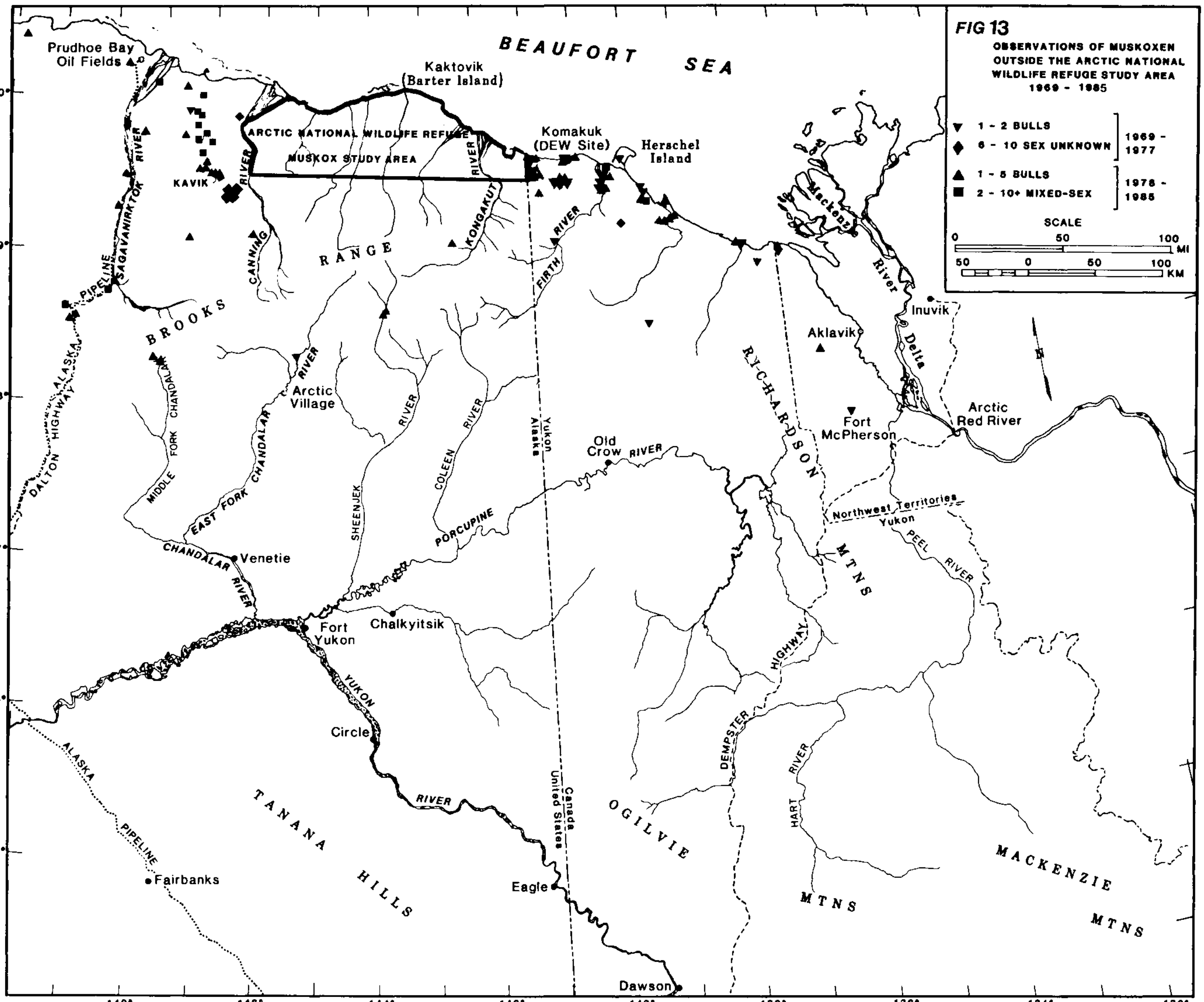


FIG 13
OBSERVATIONS OF MUSKOXEN OUTSIDE THE ARCTIC NATIONAL WILDLIFE REFUGE STUDY AREA 1969 - 1985
1 - 2 BULLS
6 - 10 SEX UNKNOWN
1969 - 1977
1 - 5 BULLS
2 - 10+ MIXED-SEX
1978 - 1985
SCALE
0 50 100 MI
50 0 50 100 KM
BEAUFORT SEA
Prudhoe Bay Oil Fields
Kaktovik (Barter Island)
ARCTIC NATIONAL WILDLIFE REFUGE
MUSKOX STUDY AREA
Komakuk (DEW Site)
Herschel Island
KAVIK
SAGAVANIRKTOK RIVER
CANNING RIVER
KONGAKUT RIVER
FIRTH RIVER
BROOKS RANGE
PIPELINE
ALASKA
DALTON HIGHWAY
Arctic Village
MIDDLE FORK CHANDALAR
EAST FORK CHANDALAR RIVER
CHANDALAR RIVER
Venetie
SHEENJEK RIVER
COLEEN RIVER
PORCUPINE
Old Crow RIVER
Yukon Alaska
Fort Yukon
Chalkyitsik
YUKON RIVER
Circle
TANANA HILLS
ALASKA PIPELINE
Fairbanks
Eagle
Dawson
Canada United States
OGILVIE MTNS
DEMPSTER HIGHWAY
HART RIVER
RICHARDSON MTNS
Aklavik
Inuvik
Mackenzie River Delta
Arctic Red River
Fort McPherson
Northwest Territories
Yukon
PEEL RIVER
MACKENZIE MTNS
N
70°
69°
68°
67°
66°
65°
148°
146°
144°
142°
140°
138°
136°
134°
132°

Mixed-sex Herds

Winter and Pre-Calving Distribution. Distribution of mixed-sex muskox herds observed from 1982-1985 showed seasonal trends in the use of specific geographic areas. In winter (Fig. 14), in the Tamayariak area, herds were found along creeks south of Konganevik Point, the upper Tamayariak near VABM Yari, and in the uplands near VABM Tam. During the month of April, 1983-1985, most herds in the Tamayariak River were in the vicinity of VABM Yari. Some animals moved to the west fork of the Tamayariak River in early April and remained there until mid-May.

Most mixed-sex muskoxen herds wintering in the Sadlerochit area remained along the river during late winter 1983-1985 (Fig. 14). During 1982 and 1983, muskoxen were found on the ridges south of the upper Sadlerochit River in late March and early April. In mid-March 1984 and late February 1985, most animals had congregated into 1 large herd and moved to the hills east of Carter Creek, where in previous years they had calved.

Muskoxen in the Okerokovik area were found along the lower Sikrelurak and Angun Rivers and along the Niguanak River in January through March 1984. In 1983 and 1985, mixed-sex herds also overwintered along these rivers, as well as on the Okerokovik River. In March 1985, the animals joined 1 large herd which moved to bluffs between the Okerokovik and the Jago Rivers near VABM Pilak (Fig. 14).

Calving and Post-calving Distribution. By May, during the peak of calving, mixed-sex muskox herds along the main fork of the Tamayariak River moved downstream toward VABM Mala and other animals remained on the west fork of the Tamayariak River (Fig. 15). In early June, muskoxen from both areas moved west to the Canning River delta. In 1982, some animals from the Tamayariak area also calved in the Carter Creek hills with muskoxen from the Sadlerochit River drainage.

Mixed-sex herds which overwintered in the upper Katakturuk River also calved in this area (Fig. 15). Two different mixed-sex herds were present in 1984, but most of these animals joined into a single large herd during calving in 1985.

In 1984 and 1985, muskoxen that moved to the Carter Creek hills in March and February calved along or adjacent to upper Carter Creek (Fig. 15). In 1982 and 1983, movements to the Carter Creek hills occurred in late April. Most Sadlerochit muskoxen calved in the Carter Hills in 1982 and in the adjacent Marsh Creek hills in 1983 (Fig. 15). Some animals remained on the ridges of the upper Sadlerochit to calve in May 1982 and 1983. Only 1 old-age cow calved here alone in 1984.

During 1982-1984, most mixed-sex muskox herds overwintering along the Angun and the Sikrelurak Rivers remained on these rivers until late April when they moved to the Niguanak River to calve (Fig. 15). In 1985, Okerokovik animals, which had moved to Pilak bluffs east of the Jago River in early March, remained in this area until early June when they moved to the Okerokovik River (Reynolds 1986). This same area had been used during calving and post-calving seasons in 1984 by an old-aged cow accompanied by a 3-year old cow, which gave birth to a calf. A 16-year old cow calved alone on the Angun River in 1984, but joined a herd on the upper Angun River in early June. In all 4 years, mixed-sex herds calving on the Niguanak River, the Angun River, or Pilak bluffs, moved to the Okerokovik River by June.

The mixed-sex herd of 14 animals which apparently dispersed east in 1984, calved on tributaries of the Ekaluakat River and Siksikpalak River in 1984 and near the mouth of the Ekaluakat River in 1985 (Fig. 15). In June 1985 they moved east to near the Kongakut River.

Changes in the use of areas during the peak of calving in mid-May occurred between 1982 and 1985, but most variation was a shift in distribution to adjacent areas or dispersal of some animals into new areas (Table 19). Radio-collared cows showed some yearly variation in the use of calving areas between 1982 and 1984 (Table 20). In all 3 years, 42% of the animals used the same calving location (i.e. moved less than 10 km). Each year, 2-4 cows used totally

Table 19. Use of calving areas during mid-May by muskoxen in the Arctic National Wildlife Refuge, 1982-1985.

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

[a] On the Niguanak River until late May.
[b] No calves in herd by late June.
[c] Including muskoxen from both Tamayariak and Sadlerochit areas.
[d] 21 muskoxen moved to Niguanak River via the Okerkovik River between 29 April and 22 May.

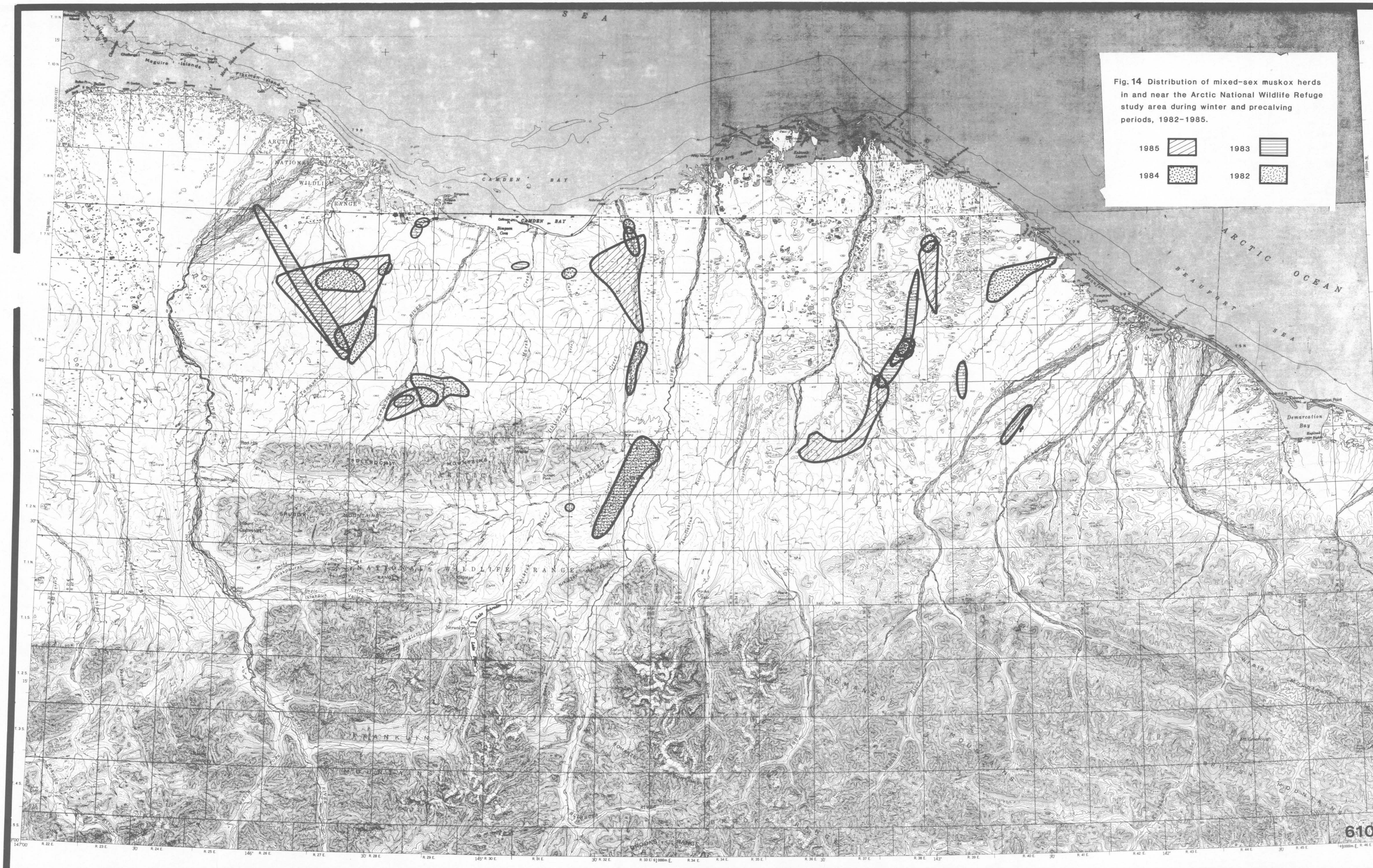


Fig. 14 Distribution of mixed-sex muskox herds in and near the Arctic National Wildlife Refuge study area during winter and precalving periods, 1982-1985.

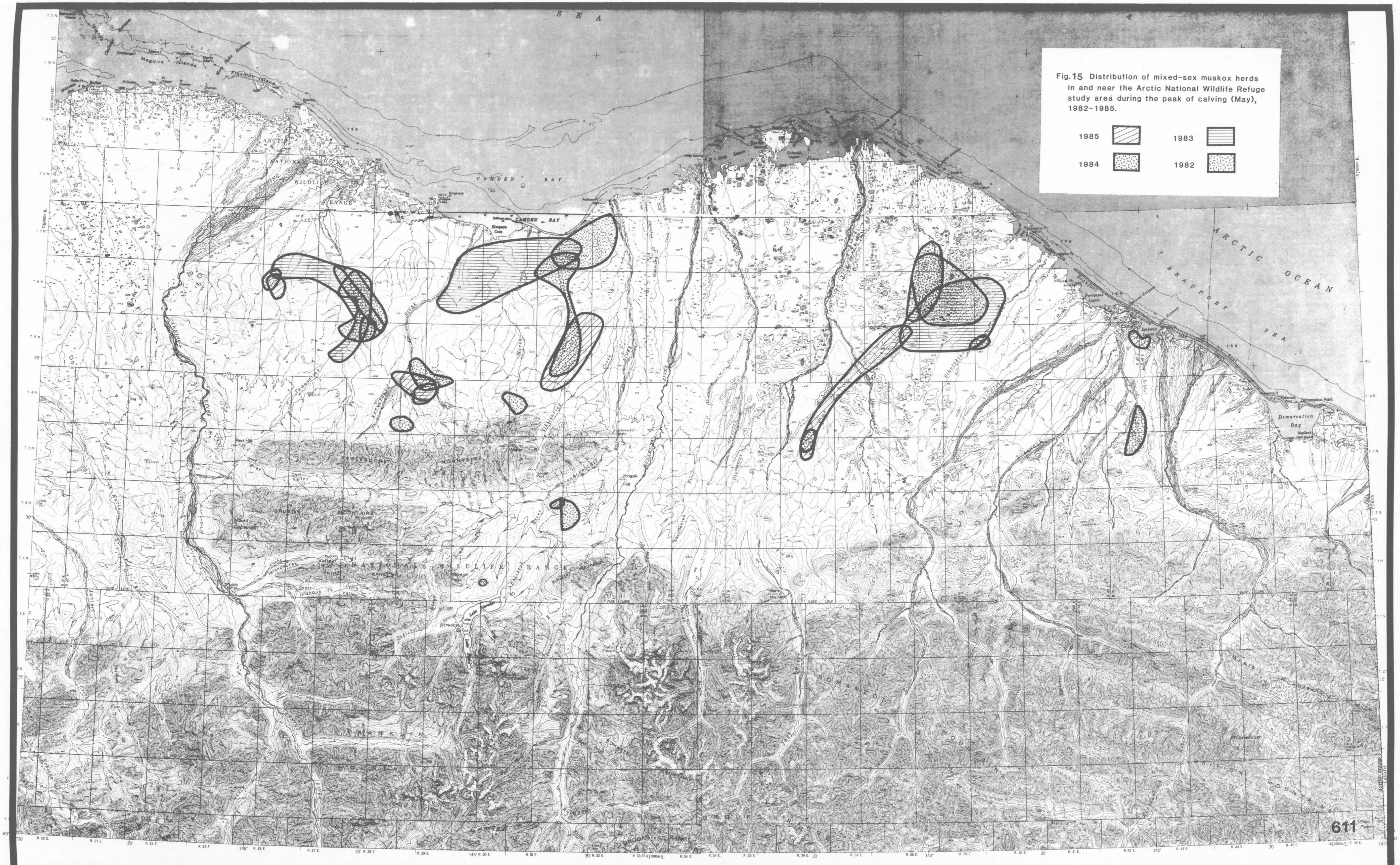


Fig. 15 Distribution of mixed-sex muskox herds in and near the Arctic National Wildlife Refuge study area during the peak of calving (May), 1982-1985.

Table 20. Yearly variation in calving area use by radio-collared muskox cows in the Arctic National Wildlife Refuge, 1982-1984.

Muskox ID	Distance between locations(km) 1982+1983	1983+1984	1984+1985
1a	7	15	0
3b	8	13	--
25q	--	4	42
36t	--	--	42
14j	12	42	--
15k	40	--	--
23p	--	10	6
21n	--	19	6
22o	--	19	6
6e	40	5	16
8f	40	16	0
9g	10	4	0
10h	47	47	16
16l	--	3	16
17m	--	13	4
11i	13	1	0
32r	---	---	4
33s	---	---	32

different areas, located at least 40 km from locations used the previous year. But the majority of cows during calving used areas in relatively close proximity (10-16 km) to areas used the previous year. No radio-collared cow observed for 3 consecutive years calved in the same location during all 3 years, suggesting that the same areas are not used for calving every year.

Summer, Rut, and Fall Distribution. Throughout the summer, rut, and fall, mixed-sex muskox herds showed similar patterns during 1982-1985 (Fig. 16). Animals congregated along major rivers during the latter half of June after leaf emergence of riparian willows. Throughout July and August, as herds dispersed into small rutting groups, distribution was more widespread, but remained along or adjacent to rivers and creeks. After the rut, animals again congregated in large herds along major rivers in late September.

Muskoxen in the Tamayariak area were concentrated primarily along the west and main forks of the Tamayariak River, and in the uplands south of Konganevik Point (Fig. 16). In late September 1984 and 1985, many moved west to the Canning River delta. By late October, all had again congregated along the main fork of the Tamayariak River during 1982-1984. In early November 1985, almost all mixed-sex herds in the Tamayariak area were located along the Katakturuk River. Mixed-sex herds along the Katakturuk River spent the summer and rut along the lower Katakturuk River and the uplands south of Konganevik Point, between the Katakturuk River and the Tamayariak River (Fig. 16).

In the Sadlerochit area, mixed-sex muskox herds were found along the Sadlerochit River from Sadlerochit Springs to the mouth of the river throughout the summer

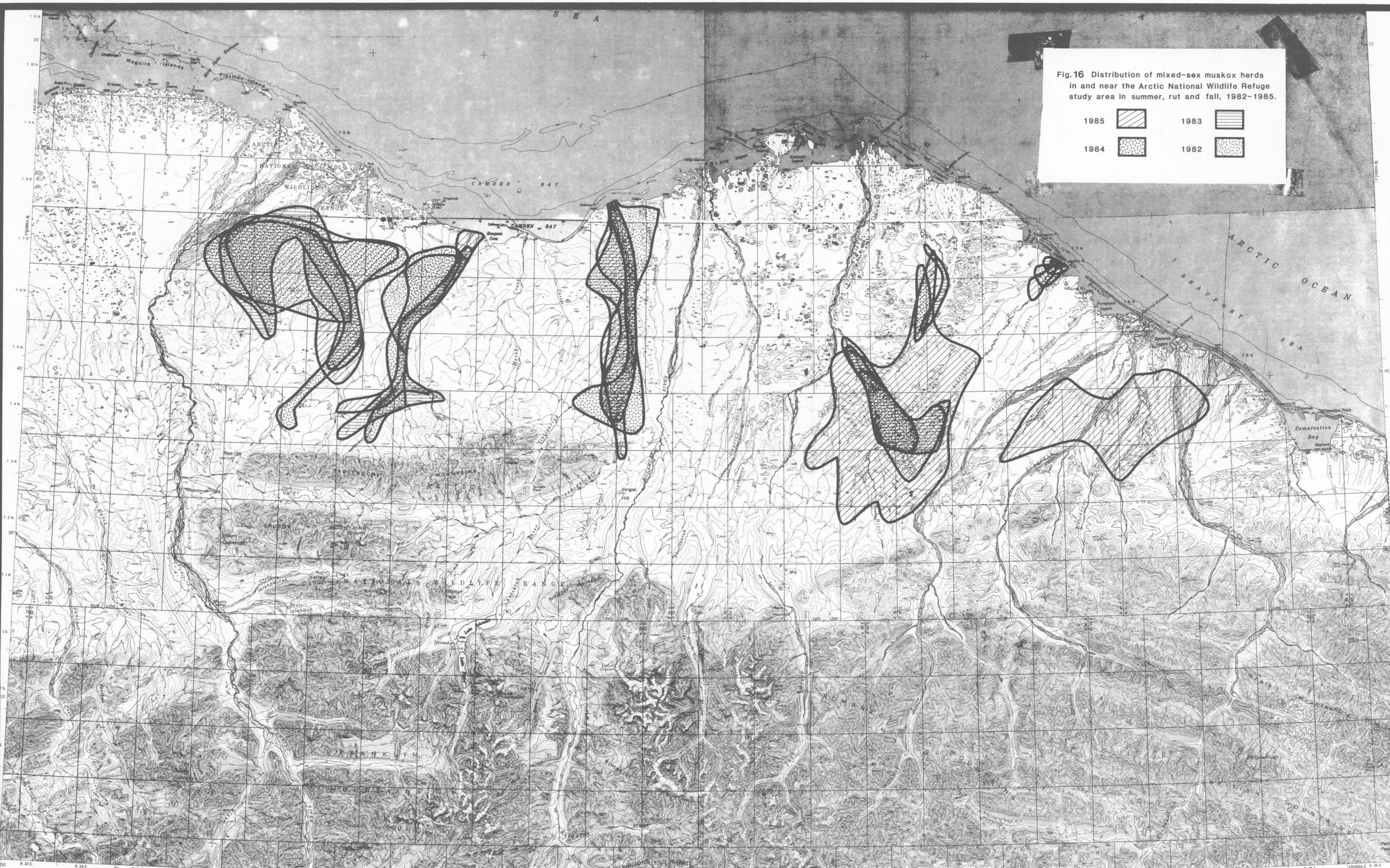


Fig. 16 Distribution of mixed-sex muskox herds in and near the Arctic National Wildlife Refuge study area in summer, rut and fall, 1982-1985.

and fall (Fig. 16). Herd distribution was most extended in August and September during the rut when animals dispersed onto adjacent uplands and into adjacent drainages.

In the Okerokovik area, mixed-sex herds were observed along the Okerokovik River and adjacent hills in July and August. Some animals moved along the Niguanak River in August and several moved to the mouth of the Angun River in late October 1984 and 1985 (Fig. 16). One herd of about 12 muskoxen ranged between the Aichilik and Kongakut Rivers during the summer, rut and fall of 1985.

Movements. Observation of radio-collared cows showed that most cows had a high fidelity to a specific geographic area during 1982-1985. Cows captured in 1982 and 1983 in the Tamayariak and Sadlerochit areas usually remained within relatively small areas during all years they were observed from 1982-1985 (Fig. 17 and 18). Cows captured in the Okerokovik area consistently used the area between the Okerokovik and Angun Rivers (Fig. 19). Jingfors (1984) described range fidelity of animals along the Sadlerochit River area.

Long distance movements of radio-collared cows between geographic areas were infrequently seen, but in 1982 and 1983, 3 radio-collared cows, traveling alone or in different groups, moved from the Tamayariak area to the Sadlerochit area after calving or during summer. One of these cows returned to the Tamayariak area within a few weeks with a group which included a radio-collared cow from the Sadlerochit area and a radio-collared bull originally captured in the Tamayariak area. Another cow over wintered in the Sadlerochit area and returned to the Tamayariak area in the following summer. The third cow moved to the Katakturuk River, where it remained for the next 3 years. These movements may have been related to the fracturing of large herds and the dispersal of herds into new areas. Data from detailed movements of a satellite-collared cow showed that movements of muskoxen can be defined as local movements which occur during the course of feeding activities over 1 or several days, or long movements in which animals travel relatively rapidly from 1 use area to another (Reynolds 1987).

Mean rates of movement for all marked cows observed at 1 to 3 day intervals during all seasons in 1982-1985 were 2.0 $\pm$ 2.0 SD km/day (N=241). Jingfors (1984) recorded average movement rates of 9.9 km/day on the Sadlerochit River and reported the highest rates of movement occurred during periods of severe insect harrassment in summer (N=4).

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

Bull Groups and Single Bulls

Seasonal Distribution. Bull groups and solitary bulls observed during 1982-1985 were often spatially segregated from mixed-sex herds (Fig. 20). Bulls occurred near the Canning River on the west side of the ANWR study area in all 4 years. Bull use of the upper Katakturuk River was documented in 1979 and 1981 (Ross 1979, Ross 1981). Radio-collared bulls used the upper Katakturuk primarily from mid-March to mid-June during 1982-1984 (Fig. 20). Small bull groups overwintered on the south slopes of the eastern end of the Sadlerochit Mountains during 1983-1985. These bulls remained on the mountain slopes until mid-June, when the groups dispersed and solitary animals moved to the lower Sadlerochit River to join mixed-sex herds. Bulls have been observed along the Kongakut River on the eastern edge of the Okerokovik area since 1973 (Roseneau and Warbelow 1974). From 1982-1985, bulls were seen along the Kongakut River throughout the year, and radio-collared bulls were often present in this area (Fig. 20).

Movements. Marked bulls made long movements between the Sadlerochit and Tamayariak areas, particularly in July and August (Fig. 21). Marked bulls also moved between the Tamayariak area and the Kavik and Sagavanirktok Rivers in 1985. One radio-collared bull moved 100 km west to the Ivishak River and apparently did not return.

Marked bulls in the Okerokovik area ranged between the Okerokovik River on the west and the Firth River in northeast Canada (Fig. 22). At least 1 male moved 140 km east to the Babbage River in Canada and apparently did not return. Two bulls moved between the Okerokovik area and the Sadlerochit area. In August 1982, a 3-year old bull, left a mixed-sex herd on the Okerokovik River and moved to the Sadlerochit area where it remained through 1984. In July 1984, a radio-collared bull (27H) estimated to be older than 5-years, moved from the Sadlerochit River to the Kongakut River and then east into Canada (Fig. 22). Two other radio-collared bulls including a 4-year old male, disappeared from the Sadlerochit River in July 1984. Their radio-collars may have failed or they may have made long distance movements into new areas. A solitary bull was seen in the Romanzof mountains near the upper Kongakut River in July 1984. One 4-year old bull left a mixed-sex herd on the Niguanak River in late September 1984 and was observed on a tributary of the Aichilik River in groups of 2-4 bulls in late October and late November.

Many long range movements by bulls were observed prior to and during the rut. Dispersal of young-aged (3-4 year old) males from mixed-sex herds may also occur during this time of year. Such movements may be related to agonistic clashes between bulls during the defense of harem groups. Mean movement rates, calculated from observations of radio-collared bulls, in 1982-1985 at 1-3 day intervals were 1.9 ± 2.0 km/day (N=79).

Habitat Use

Habitat occupied by muskoxen was documented by recording terrain features and land cover categories in which muskox herds were observed during radio-relocation flights and seasonal surveys. Terrain features were combined into 3 categories: 1) rivers and creeks included gravel bars, channels, and beaches lying within the flood plain of rivers and creek bottoms; 2) slopes and tops of hills and mountains included hillsides, hilltops, bluffs, mountain slopes, and summits; and 3) flat tundra included areas of low relief not associated with categories

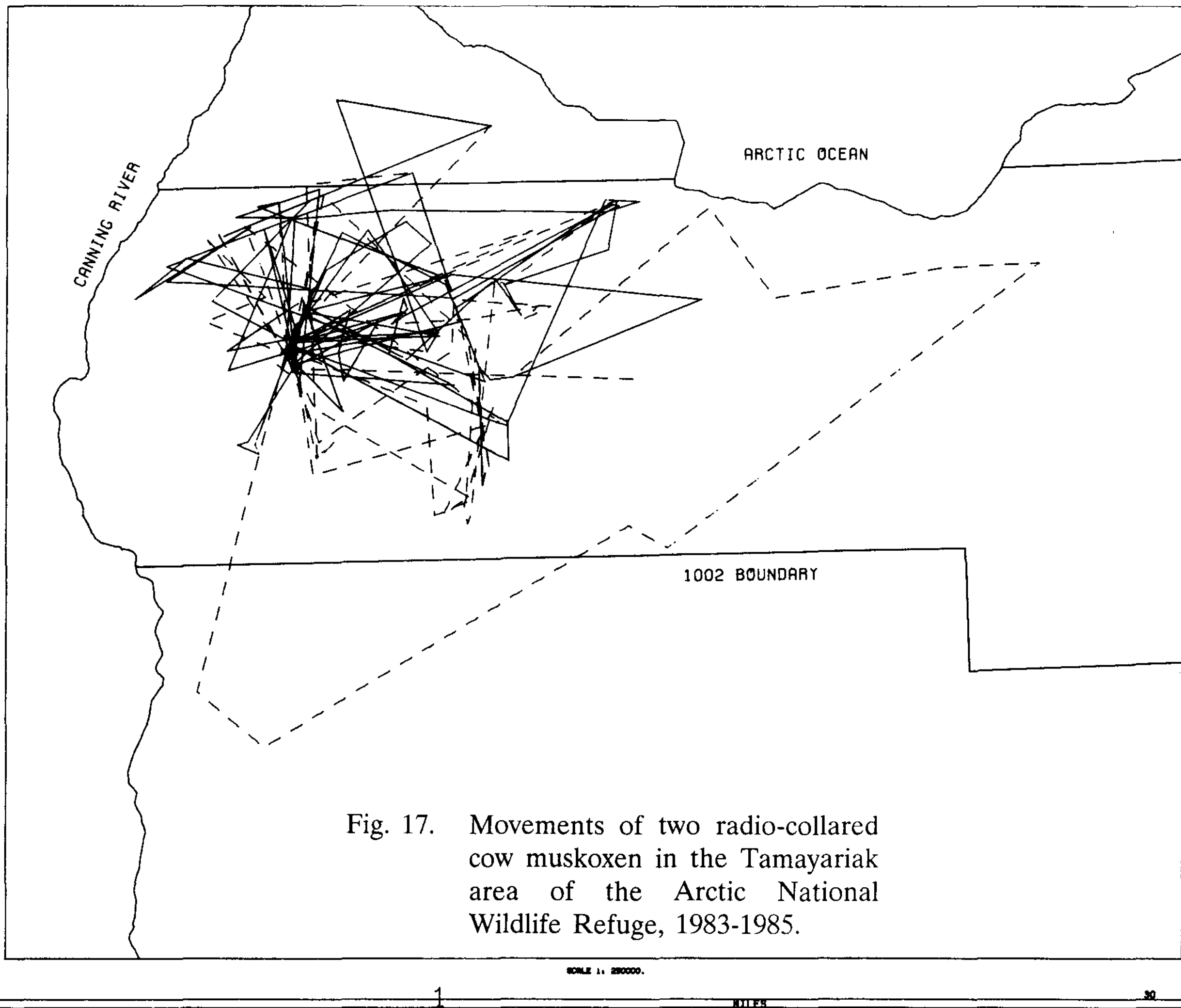


Fig. 17. Movements of two radio-collared cow muskoxen in the Tamayariak area of the Arctic National Wildlife Refuge, 1983-1985.

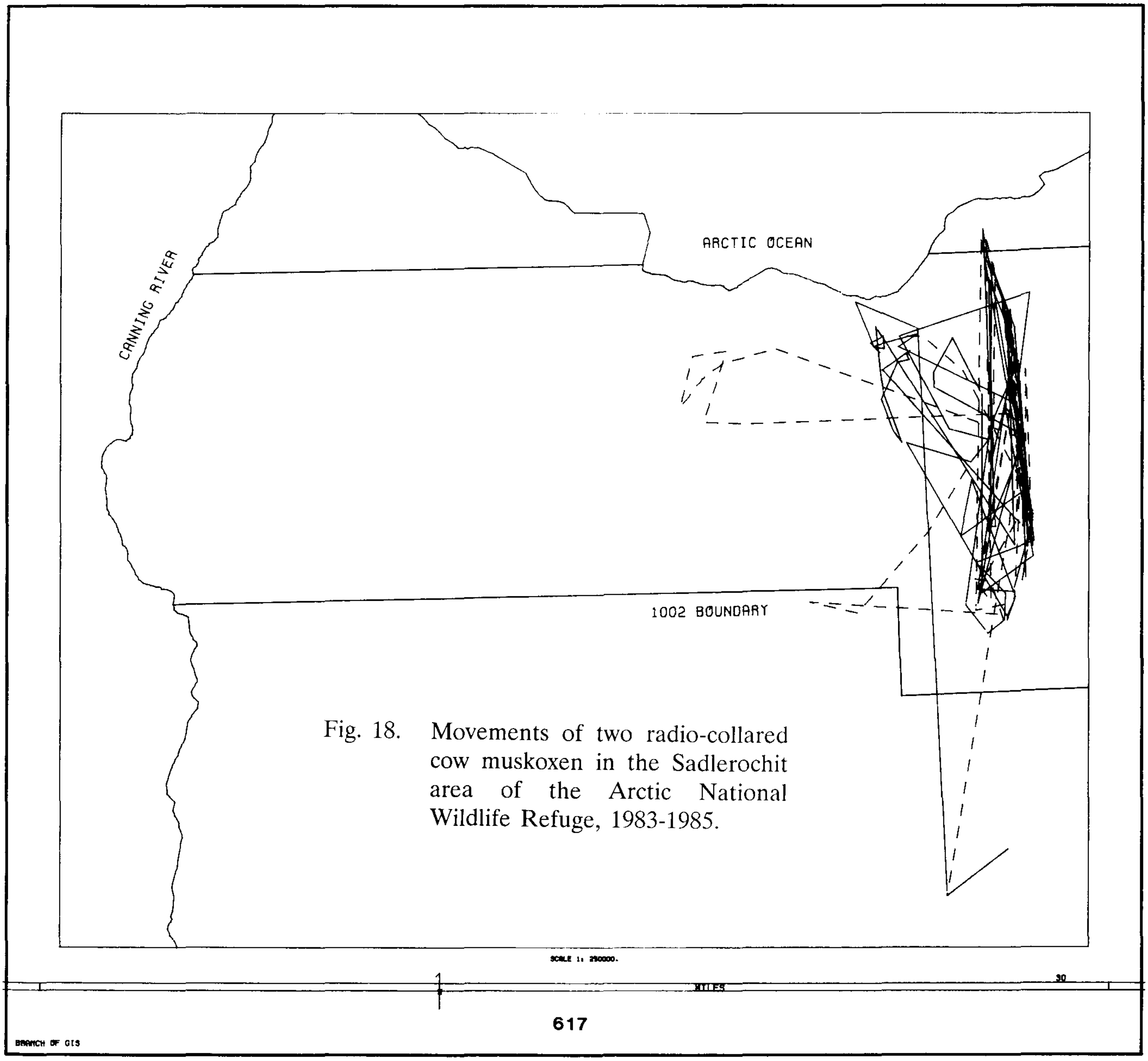


Fig. 18. Movements of two radio-collared cow muskoxen in the Sadlerochit area of the Arctic National Wildlife Refuge, 1983-1985.

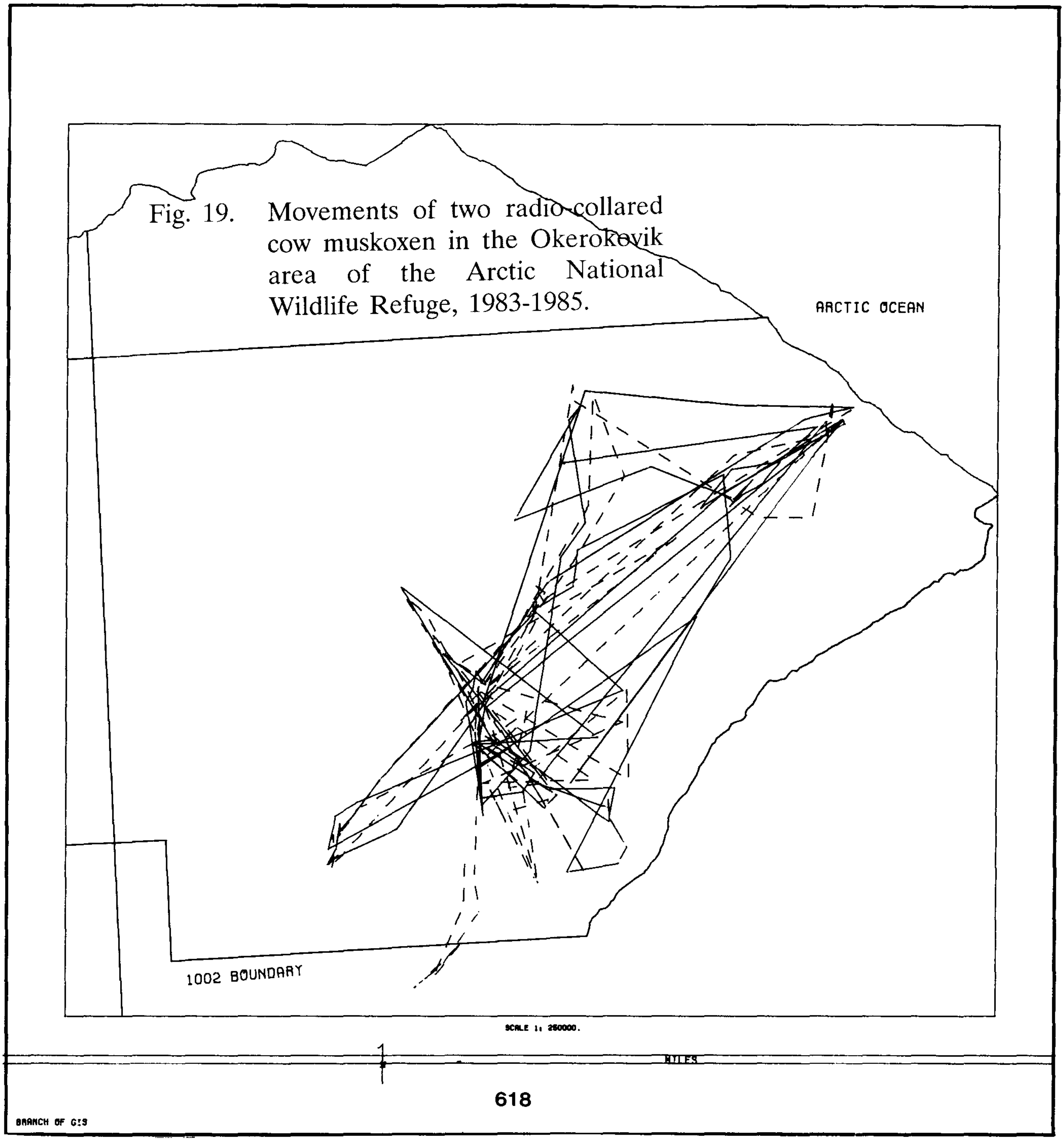


Fig. 19. Movements of two radio-collared cow muskoxen in the Okerokovik area of the Arctic National Wildlife Refuge, 1983-1985.

1 and 2. Seasonal occupancy of different terrain features was apparent during 1982-1985. River and creek drainages were most frequently occupied by muskoxen throughout the year, except during the pre-calving season (Fig. 23). Major river drainages were occupied in winter, summer, and fall. During the rut, muskoxen were often associated with small creek drainages rather than large rivers. Ridges, plateaus, and bluffs, that often blow partly free of snow, were occupied by some muskoxen during winter, pre-calving, and calving seasons. Occurrence of muskoxen on this terrain type reached a maximum during the pre-calving season in all 4 years. By April on the north slope of Alaska, temperature inversions can result in temperatures 10°C higher on ridges than in the surrounding drainages and snow ablation is accelerated in upland areas. Lent and Knutson (1971) found that muskoxen tended to congregate where snow was absent or present in relatively shallow depths (10-30 cm). Gunn (1982) stated that muskoxen appeared to feed more intensively where snow cover was absent.

Land cover categories (snow, wet sedge, tussocks, tall shrub, low shrub/forb, and bare) were identified on the basis of features recognizable from the air. Each category with the exception of snow, included 1 or more vegetation categories used in Landsat mapping of ANWR and described by Walker et al. (1982) (Table 21). Muskox observations in the bare category, which included sightings on unvegetated gravel bars as well as outcrops or talus slopes on ridge tops or mountain sides, were combined with observations in the low shrubs/forb category, as these 2 categories occur adjacently or as complexes that were not always distinguishable (Table 21). The low shrub/forb category encompassed a wide variety of communities including moist dwarf and low shrub tundra in non-riparian areas; dry tundra on ridges and mountain slopes, and dryas terraces, forb-rich river bars, and open riparian shrubland along river flood plains.

Table 21. Vegetation categorites in land cover classes identified from the air and occupied by mixed-sex muskox herds during radio-relocation flights and seasonal surveys in 1982-1985.

Land cover category	Vegetation categories from Walker et al. (1982)
Snow	none
Wet sedge	11b, 11c, 111a, 111b
Tussock	Vb, V1a, V11a, V1c,
Tall shrub	V111c
Low shrub/forb	1Va, Va, Vc, Vd, Ve[a], V11b, VIIc, V111a, V111b, 1Xb, 1Xc[a], 1Xa, 1Xd, 1Xa
Bare	Xa, Xc, Xd

[a] may also be classed as "Bare"

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

Seasonal differences in muskox occupancy of land cover categories, occurred during 1982-1985. Snow, present in all seasons, comprised 37%-95% of all land

Fig. 20 Areas in or near the Arctic National Wildlife Refuge study area used primarily by bull groups or single bull muskoxen, 1982–1985.

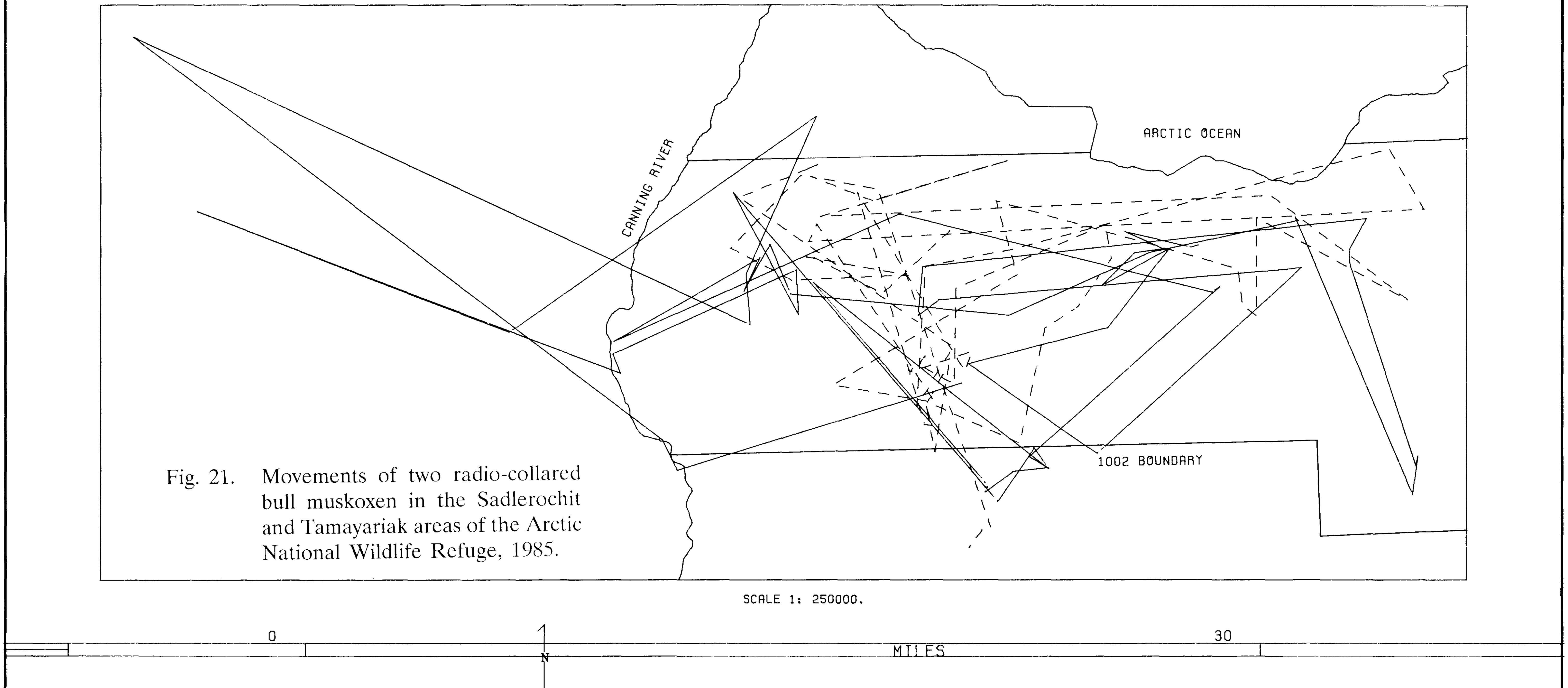


Fig. 21. Movements of two radio-collared bull muskoxen in the Sadlerochit and Tamayariak areas of the Arctic National Wildlife Refuge, 1985.

BRANCH OF GIS

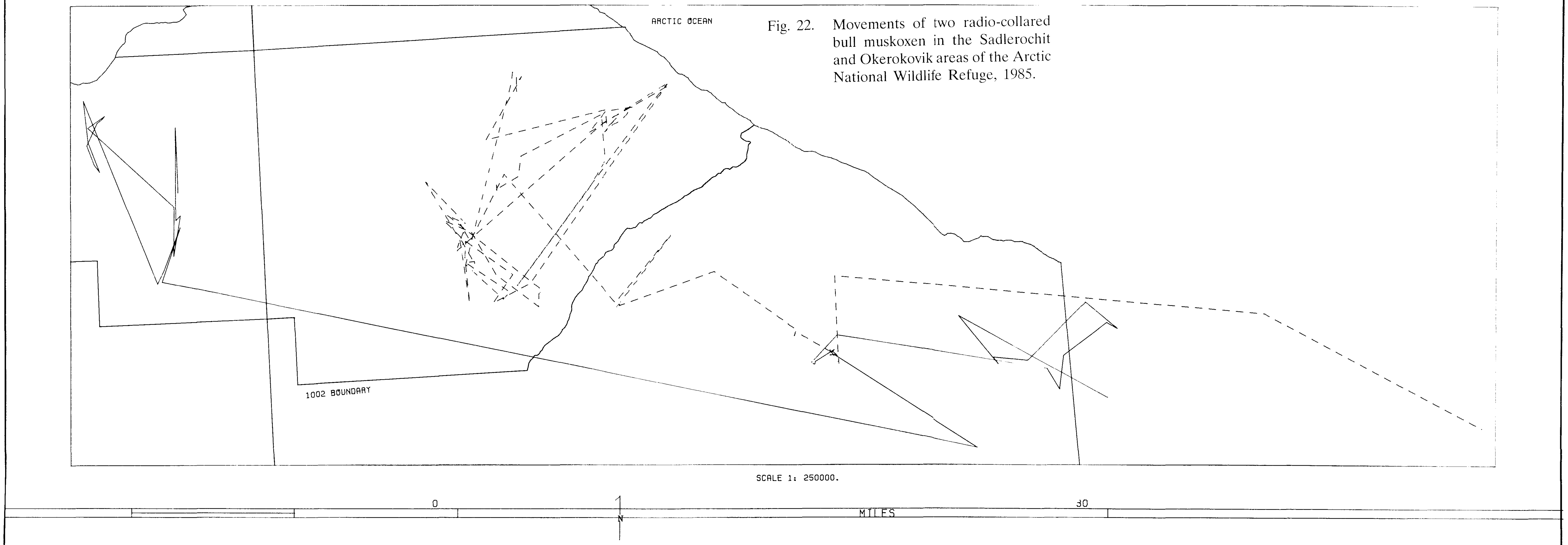


Fig. 22. Movements of two radio-collared bull muskoxen in the Sadlerochit and Okerokovik areas of the Arctic National Wildlife Refuge, 1985.

BRANCH OF GIS

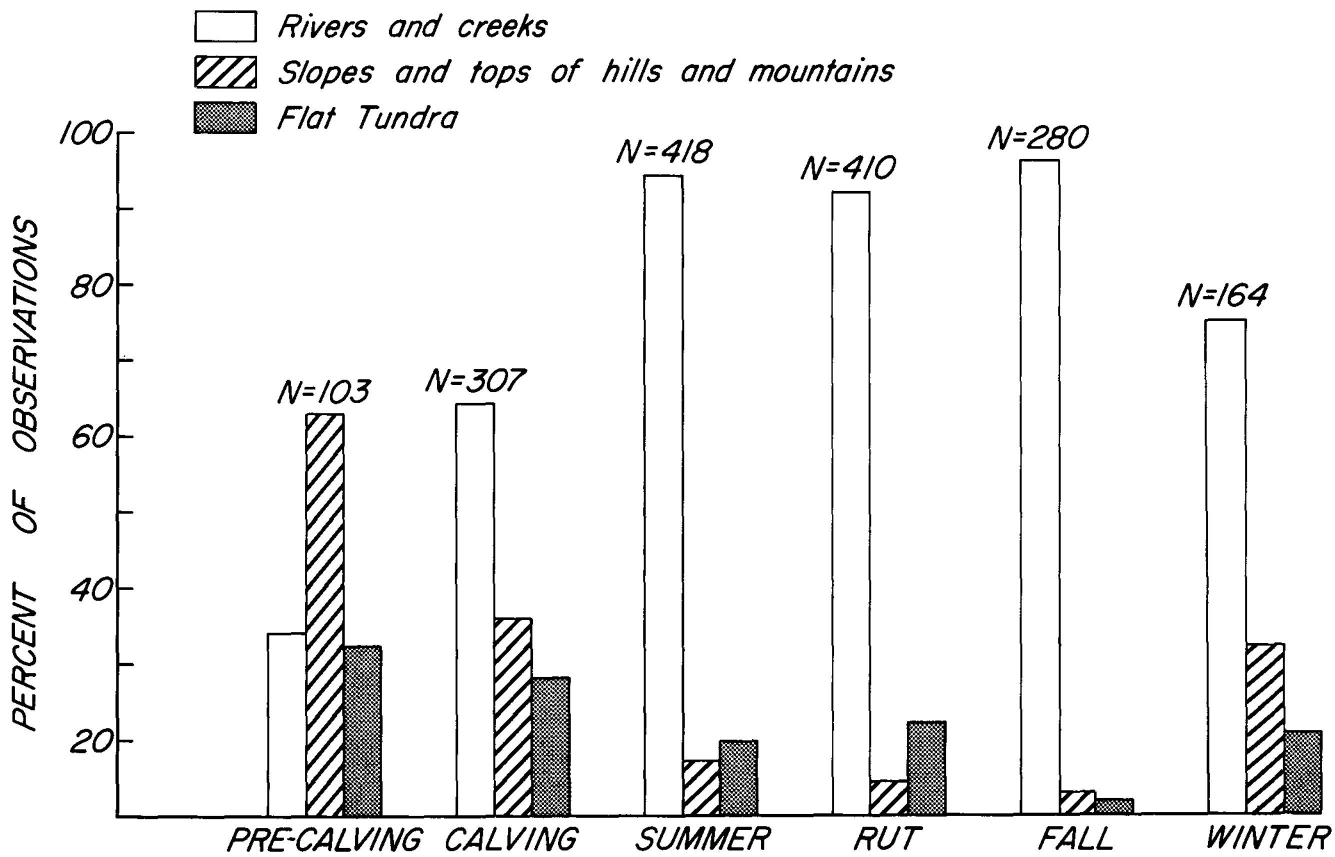


Fig. 23. Seasonal association of mixed-sex muskox herds with terrain features, observed during radio-relocation and seasonal surveys in the Arctic National Wildlife Refuge, 1982-1985.

cover observations from fall through calving (Fig. 24A). Low shrub-forb communities were occupied most frequently throughout the year (Fig. 24B). Association of muskoxen with vegetation followed a phenological progression. In late May or early June during the calving period, as the snow melted first on bluffs and ridges, muskoxen were often found in upland areas of low shrub-forb communities or tussock communities. Robus (1984) found that the tussock-forming sedge Eriorphorum vaginatum was a preferred food item for muskoxen using the Sadlerochit area in late May. In late June and early July, as willows emerged, muskoxen moved back into major river drainages during all 4 years. Occupancy of tall shrub (willow) and adjacent communities of low shrub/forb or bare gravel bars continued through summer and rut. Robus (1981, 1984) found that as riparian willows initiated growth they became important food items for muskoxen along the Sadlerochit River in summer and that willows were selected throughout most of the growing season. Tall shrub communitites along gravel bars were occupied in September and October as animals congregated on major river drainages (Fig. 24B). Snow covered the vegetation except for tall riparian willows by early October 1982, early November 1983 and 1985, and mid-October 1984 (Fig. 24A).

Major components of habitat occupied by muskoxen on the ANWR coastal plain are river systems with diverse low shrub-forb and tall willow communities, situated near uplands, hillsides, plateaus, or bluffs where low snow cover can be found in winter, pre-calving, and calving seasons.

Availability of highly nutritious and abundant forage species may have contributed to the high productivity seen in the ANWR muskox populations. Robus (1981) found that production of the willow Salix alexensis, a preferred muskoxen forage species, peaked in early August at 82.4 g/m^2 along the Sadlerochit River. In contrast, a peak biomass value for Salix arctica of 18.6 g/m^2 was recorded on Bathurst Island in the Canadian high arctic, an area where productivity of muskoxen (numbers of calves/cow) was lower than that observed on the Sadlerochit River (Jingfors 1980). Gunn (1984) suggested that the muskox breeding cycle is related to the quality of summer forage. Snow cover is also apparently a factor controlling muskox populations in Greenland (Vibe 1958 and 1967, as cited by Thing et al. 1984) and high arctic Canada (Parker et al. 1975; Parker 1978, as cited by Thing et al. 1984).

Population growth has been slower on the Okerokovik area than in the Sadlerochit and Tanayariak areas (Fig. 2). Differences in terrain features, vegetation communities, and snow cover may account for this slower rate of population growth. The Okerokovik area is generally flatter and wetter than the Sadlerochit and Tanayariak areas. Muskoxen were rarely seen in the area between the Hulahula River and Jago River (Fig. 10), which is characterized by a lack of major topographic features. Snow cover may also be greater in this area (Felix et al. 1987).

Discussion

The transplanted muskox population on the coastal plain of ANWR has expanded rapidly during the past decade. This rapid growth was the result of high productivity, high survival of calves and yearling, and low mortality of all age classes. Similar population increases were documented in a transplanted muskox population in West Greenland (Thing et al. 1984) and in muskox populations in the northwest Territories, Canada (Gunn 1984). As population numbers increased, expanding distributions and dispersal into new areas occurred. Quantitative

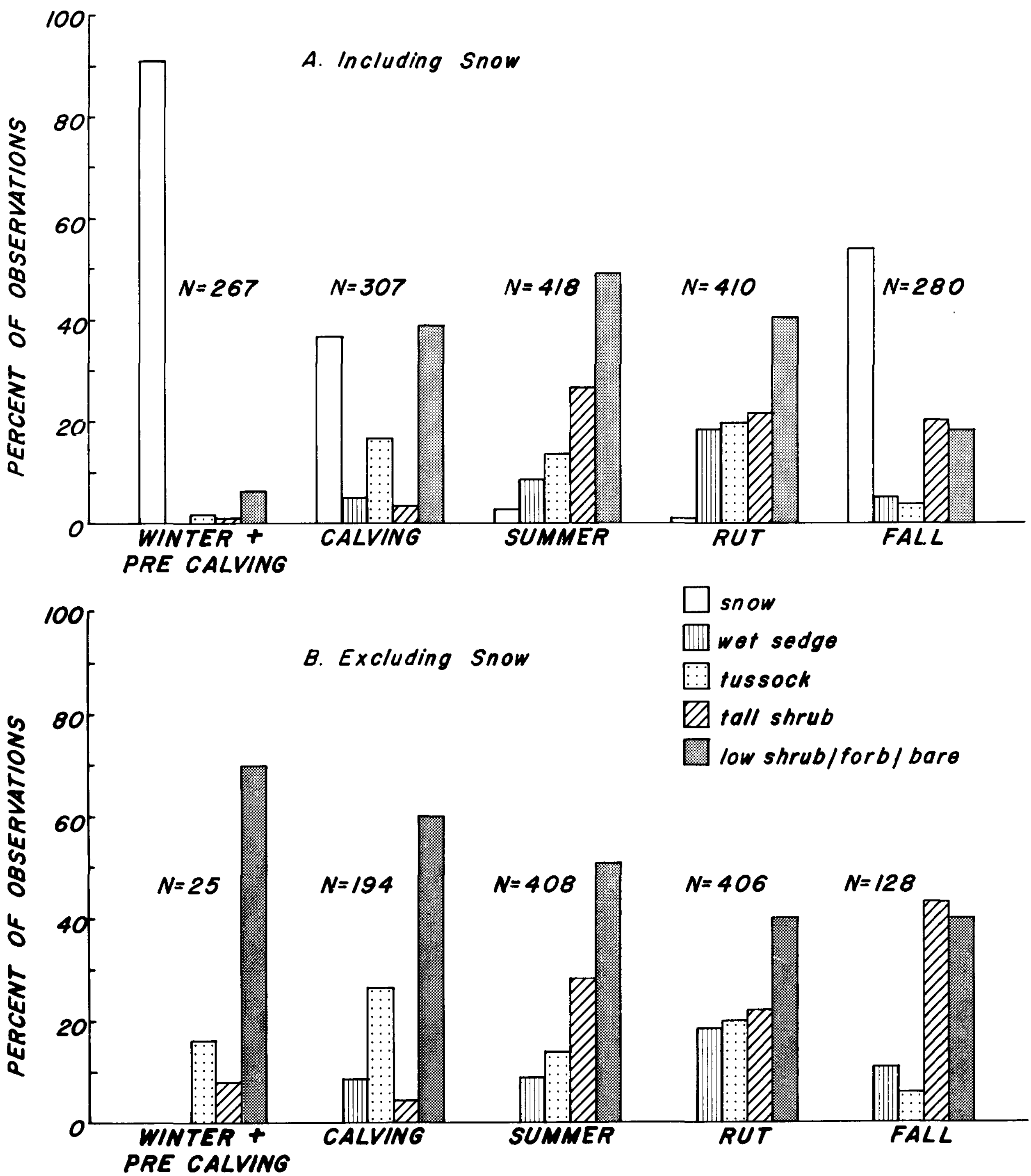


Fig. **24.** Seasonal association of mixed-sex muskox herds with land cover categories observed during radio-relocation and seasonal surveys in the Arctic National Wildlife Refuge, 1982-1985.

measurements are needed to determine the interrelationships between habitat and this expanding population.

Acknowledgements

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MOVEMENTS AND ACTIVITY PATTERNS OF A SATELLITE-COLLARED MUSKOX IN THE ARCTIC NATIONAL WILDLIFE REFUGE, 1984-1985

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Key Words: muskox, satellite-collar, locations, activity patterns, temperature, seasonal distribution, movements, Arctic National Wildlife Refuge

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Movements and activity patterns of a satellite-collared muskox in the Arctic National Wildlife Refuge, 1984-1985.

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Abstract: An experiment satellite collar was tested on a captive bull muskox for 4 weeks and a wild cow muskox for over 12 months. The collar provided frequent locations, data on activity, and internal temperature of the collar canister. During a 12 month period, 329 locations were obtained from the wild cow muskox with a location error ranging from 0.28 km to 2.46 km. Fewer locations were obtained in winter than summer, but amounts of data from activity and temperature sensors were relatively consistent year-round. Seasonal differences in movements, activity patterns and the size of use areas were documented. The animal showed a decline in activity throughout the winter, reaching a low in March. Activity increased throughout the spring and summer reaching a peak in July. Similarly, mean rates of movement were higher in June through September and lower in October through May. These seasonal differences may be a strategy for conserving energy in late winter, a time when muskoxen may be most vulnerable to disturbance.

ANWR Progress Report No. 86-5

Movements and activity patterns of a satellite-collared muskox in the Arctic National Wildlife Refuge, 1984-1985.

Muskoxen (Ovibos moschatus) are one of the few species which remain on the arctic coastal plain of the Arctic National Wildlife Refuge (ANWR) throughout the winter. Since 1982, a study of muskox ecology has been conducted on the ANWR coastal plain study area (Reynolds et al. 1983, 1984, 1985, 1987). Efforts to obtain information on winter distribution, movements, and activity patterns have been hindered by environmental conditioned in winter: a lack of light, cold temperatures, blowing snow, and other adverse weather conditions. Satellite telemetry is one technique which could provide frequent location and activity data on a year-round basis.

In 1984, Telonics (Mesa, AZ) developed a prototype experimental satellite collar which they wished to test on large northern species, such as caribou and muskoxen. Data collection opportunities were expected to be maximum at northern latitudes due to the polar orbits of satellites receiving data from the collars. As a result, an estimated mean of 22 satellite passes per day were predicted at the latitude of Alaska's arctic coastal plain compared to 9-11 passes per day at latitudes in the southern United States. Also a wide range of environmental extremes exist at northern latitudes which provided a rigorous test for the experimental devises.

Three experimental satellite collars were placed on caribou (Pank et al. 1985) and 1 collar was put on a cow muskox in the Arctic National Wildlife Refuge. Objectives of the muskox collaring effort were:

1. Document any problems with the physical configuration of the collar carried by the muskox.

2. Assess the accuracy of location and activity data and compare it to information collected using conventional radio-telemetry and ground observations.

3. Determine any seasonal differences in distribution, movement, activity patterns, and temperature.

Methods and Materials

Description of the satellite system

Three major components comprise the Argos satellite-based data collection and platform location system: satellites which receive signals from the collar, and transmit data, a data collection and processing system, and the signal transmitting unit on the collar, called a platform terminal transmitter (PTT). The Argos system is a cooperative project between the Centre National d'Edudes Spatiales (CNES, France), the National Aeronautics and Space Administration (NASA, USA) and the National Oceanic and Atmospheric Administration (NOAA, USA).

At least 2 operational orbiting satellites comprised the space segment of the system at any one time. These Tyros-N satellites launched by NASA and maintained by NOAA have several functions in addition to collecting information for the Argos system, including the collection of visible and infrared picture data for short term weather and long term climatic interpretation. The satellite orbits were circular, polar, (at 98 degrees inclination), and sun-synchronous (the angle of the orbital plane of each satellite and the sun direction is constant). Each satellite circled the earth in about 102 min. A 5000 km swath was covered per orbit with total coverage of the earth every 24 hours as a result of the earth's rotation. The number of passes per 24 h was greater at polar regions than equatorial regions (Pank et al. 1985).

On each satellite, an onboard data collection system (DCS) was equipped with receivers that picked up messages from transmitting platforms within the satellite's coverage. The DCS recorded the date and time, measured the carrier frequency, and demodulated the platform identification number and sensor data. The data was stored by onboard tape recorders until the satellite passed over 1 of 3 telemetry ground stations at which time the information was transmitted to the ground (Pank et al. 1985). Received data was transmitted to the National Environmental Satellite Service (NESS) Center at Suitland, Maryland where Argos system data was separated from other satellite transmissions and transmitted to the Argos Data Processing Center in Toulouse, France. Data was processed and available to users within 4 h of when it was first picked by the satellite. In Fairbanks, data files were directly accessed from France via computer on each day that the PTT was transmitting. Printed copies of data files were also received twice a month from France.

The experimental satellite collar was equipped with a platform transmitter terminal (PTT) which provided the link between the collar and the satellite. Most PTTs in use today are used for the collection of meteorological and oceanographic data. All PTTs transmit for 160 millisec on the same carrier frequency at regular (40-200 sec) intervals. The apparent frequency of a transmitting PTT is higher as the satellite first comes into view and moves rapidly toward the PTT. As the satellite moves away from the PTT after passing over it, the apparent frequency is lower. This Doppler Shift is the basis for determining location measurements. The satellite must receive messages from the PTT several times during a single overpass in order to calculate location. The main sources of locational errors are apparently related to the accuracy with which the altitude of the PTT is known and the stability of the PTT oscillator (crystal transmitting the frequency) (Pank et al. 1985).

Description of the experimental satellite collar

The experimental collar consisted of 2 units mounted on butyl over butyl collar material used for conventional muskox radio-collars. The PTT, batteries and activity sensors were contained in a canister which weighed approximately 1400 gms and hung at the bottom of the neck. A standard radio-transmitter (beacon-transmitter) and batteries, used as a ground tracking unit, was encased in urethane and mounted on the side of the collar.

A mercury tip switch, mounted inside the canister, closed when the collar moved. One register ("30 min counter) recorded the number of switch closures at 1 min intervals for a total of 30 min. A second counter ("the 6 hr counter") summed the 30 min counts over the 6 h period preceding a transmitting period. Another sensor measured internal temperature of the collar canister.

To extend the battery life over the course of a year, the satellite-portion of the collar was programmed to switch on and off at given intervals. The collar was programmed to function 3 days each week for a total of 6 h each day. The collar was initially turned on at 10 am so that data was transmitted between 10 am and 4 pm, local standard time.

From 30 April 1984 until 29 May, 1984, the experimental satellite collar was placed on a 2 year old bull muskox kept in a 40 acre enclosure at the University of Alaska Large Animal Research Facility. The animal was observed for more than 62 hr during times when the collar was turned on. Behavior, head orientation, and location in the pen were recorded at 30 sec intervals for 30 min periods in which satellite overpasses were predicted to occur.

The study area was located on the coastal plain of the Arctic National Wildlife Refuge in the eastern portion of the 1002 area described by U.S. Fish and Wildlife Service (1982). On 30 June 1984, the experimental satellite collar was placed on a free-roaming cow muskox near the Okerokovik River. The collar malfunctioned within a week and was removed. After being refurbished by Telonics it was replaced on another cow muskox in the same area on 29 August 1984. This time the satellite collar functioned for 12.5 months until mid September 1985. It was removed from the animal in July 1986.

The satellite-collared muskox was relocated from the air using the transmitter attached to the satellite collar during relocation flights of other radio-collared muskoxen. In addition, an effort was made to relocate the animal whenever flights were made in the general area in which it was located.

In July and August 1985, 31 hr of ground observation were made of the satellite-collared muskox and the groups with which it was associated. Information on location, behavior, activity patterns, group composition and habitat use were collected. Distances between satellite locations and visual locations obtained within a 5 min period were calculated. Behavior was categorized as either active (feed head down, feed head up, rub, walk-feed, walk, run, fight) or resting (sprawl, lie, stand) and percent time active per 30 min was correlated with counts from the 30 min activity counter. Mean counts were calculated for those 30 min periods in which active or resting behavior comprised at least 25 min of the 30 min sample. For each day that data was obtained from the wild cow, an index of relative activity was calculated by summing measurements from the 30 min counter and the 6 h counter and dividing by the total minutes during which activity data had been collected that day. Monthly means were calculated from these daily indices of relative activity.

Results

Observations of the captive bull muskox at the University of Alaska and the free-roaming wild muskox in ANWR indicated the collar had no physical effects on the study animals. The muskoxen had no difficulty carrying the collar in its present configuration. When the collar was removed from the wild muskox in July 1986, the animal showed no effects of having carried it for almost 2 years.

It did not appear to have affected normal behavior. The animal gave birth and successfully raised a calf in 1985 and appeared to be in good condition in 1986.

A total of 329 locations were obtained from the satellite collar from late August 1984 until mid-September 1985. During the same time period, the animal was visually relocated 55 times from the air or on the ground (Fig. 1).

Ten of the visual observations were made within 5 min of a satellite fix. The linear distance (km) between observed locations and locations determined by the satellite ranged from 0.3 to 2.4 km with a mean of 1.31 $\pm$ 0.78 SD. Pank et al. (1985) found locational errors ranged from 0.16 to 6.5 km when experimental satellite collars of this same type were stationary at 3 known locations. Locational accuracy of the satellite collar is reportedly influenced by temperature (Argos 1984), and possibly orientation and activity of the animal and terrain features, but stability of the transmitting crystal was probably the biggest factor affecting locational accuracy in this experimental collar.

Distribution and movement

Locational information from the satellite-collared muskox indicated that seasonal differences in distribution and the size of use areas existed (Fig. 2). From June through October during summer, rut and fall the animal utilized 2 major areas: an area of 409 km^2 along the Niguanak and Okerokovik Rivers and a area of 139 km^2 along the Sikreluriak and Angun Rivers. During winter (November to February) distribution was restricted to smaller areas in the upper Niguanak (66 km^2) and Okerokovik Rivers (34 km^2). Between early February and early March the satellite - collared animal and the mixed-sex herd with which it was associated moved to Pilak bluffs on the east side of the Jago River where it remained in a 81 km^2 area throughout the pre-calving and calving periods in April and May 1985.

Locational information obtained from the satellite-collared muskox showed distinctive patterns of local and longer range movements (Fig. 3). During the 12 days following its capture in August 1984, the animal made several long movements between the Niguanak, Okerokovik and Angun Rivers. From September 12 to November 2, it made short local movements remaining in a relatively small area on the Angun River. On November 2 to 4, it made a long movement of to the upper Niguanak where it remained until December. Between 6-18 December, it made another long movement to the Okerokovik River where it remained until at least early February. In early March it moved west to Pilak bluffs where it remained for the next 3 months. In late May and early June, long movements were made back to the Okerokovik River and between the Niguanak and lower Angun Rivers. In June and July short local movements along the Okerokovik and Angun Rivers were observed. In August and early September, it made several long movements from the Angun River to the Niguanak River and back to the Okerokovik River.

These patterns indicate that muskoxen often remain in a localized area, defined as a high use area, for several days or even weeks, moving short distances each day. The animals then make a relatively rapid long distance movement into another high use area..

The satellite-collared muskox showed a high fidelity to specific areas throughout the course of the year. This fidelity had been documented through the use of conventional radio-telemetry in this and other areas used by muskoxen in the ANWR

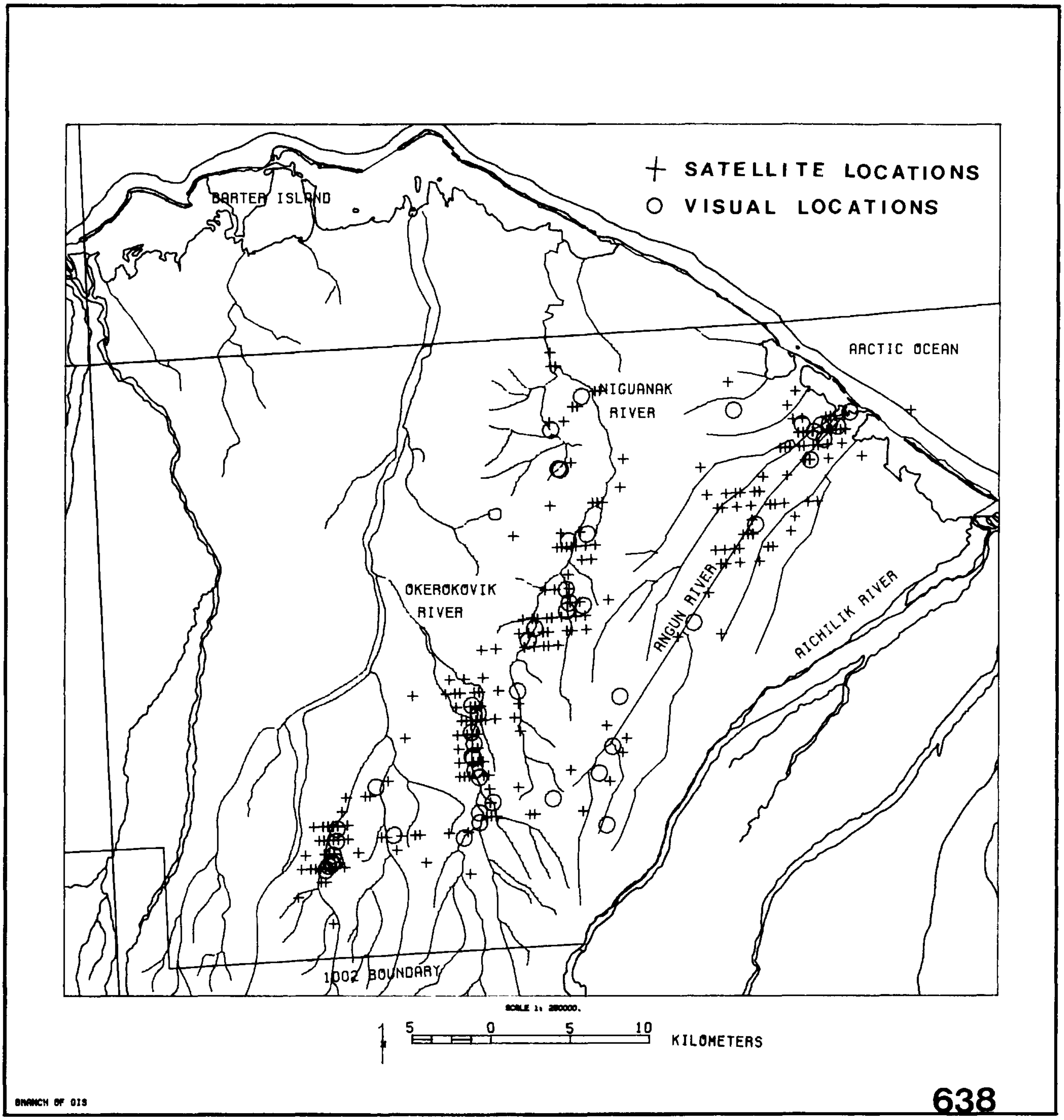

FIG. 1. LOCATIONS OF SATELLITE-COLLARED COW MUSKOX, NORTHEAST ALASKA, SEPT. 1984 - SEPT. 1985.

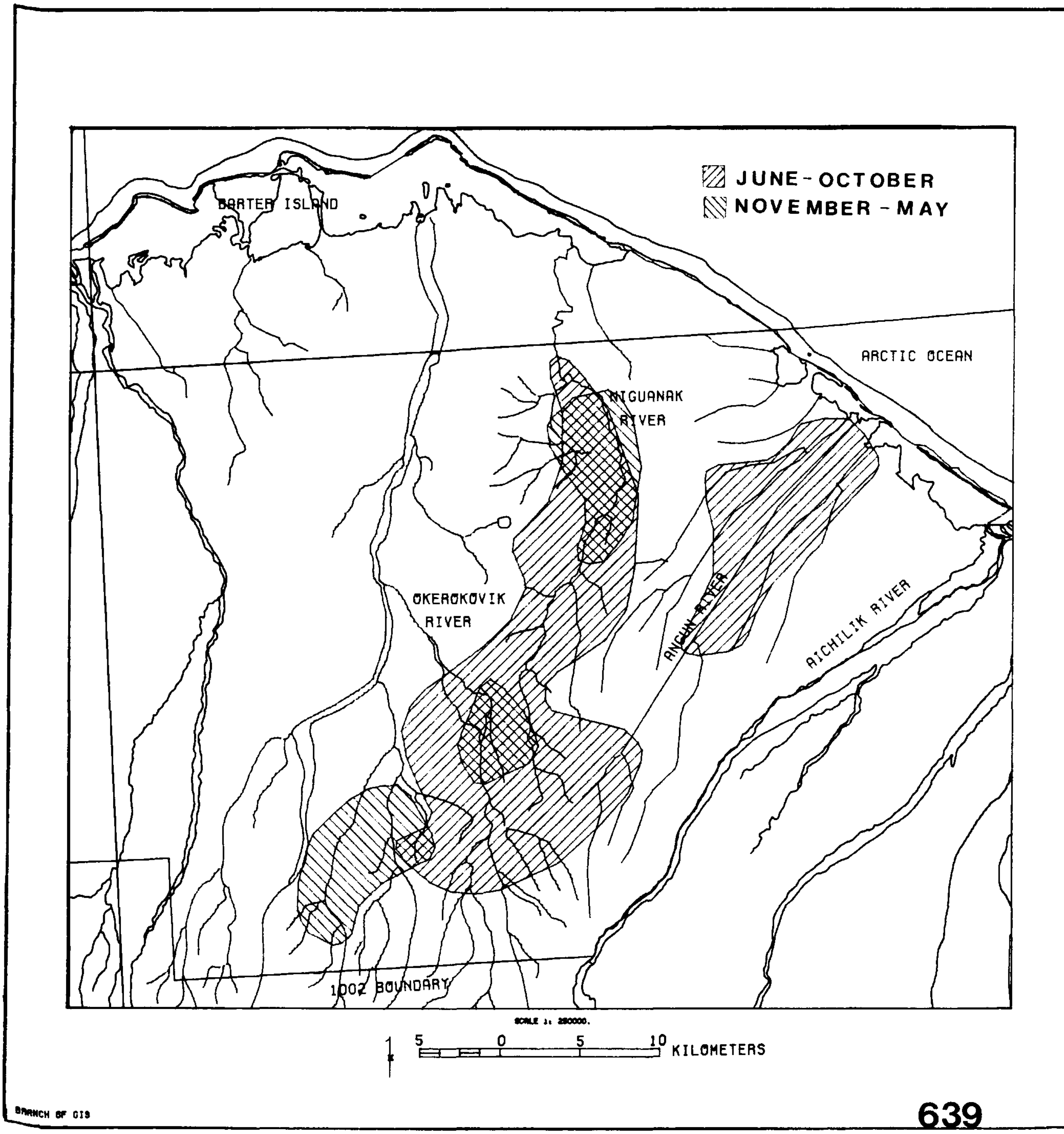

FIG.2. SEASONAL DISTRIBUTION OF A SATELLITE-COLLARED COW MUSKOX IN NORTHEASTERN ALASKA, SEPTEMBER 1984-SEPTEMBER 1985

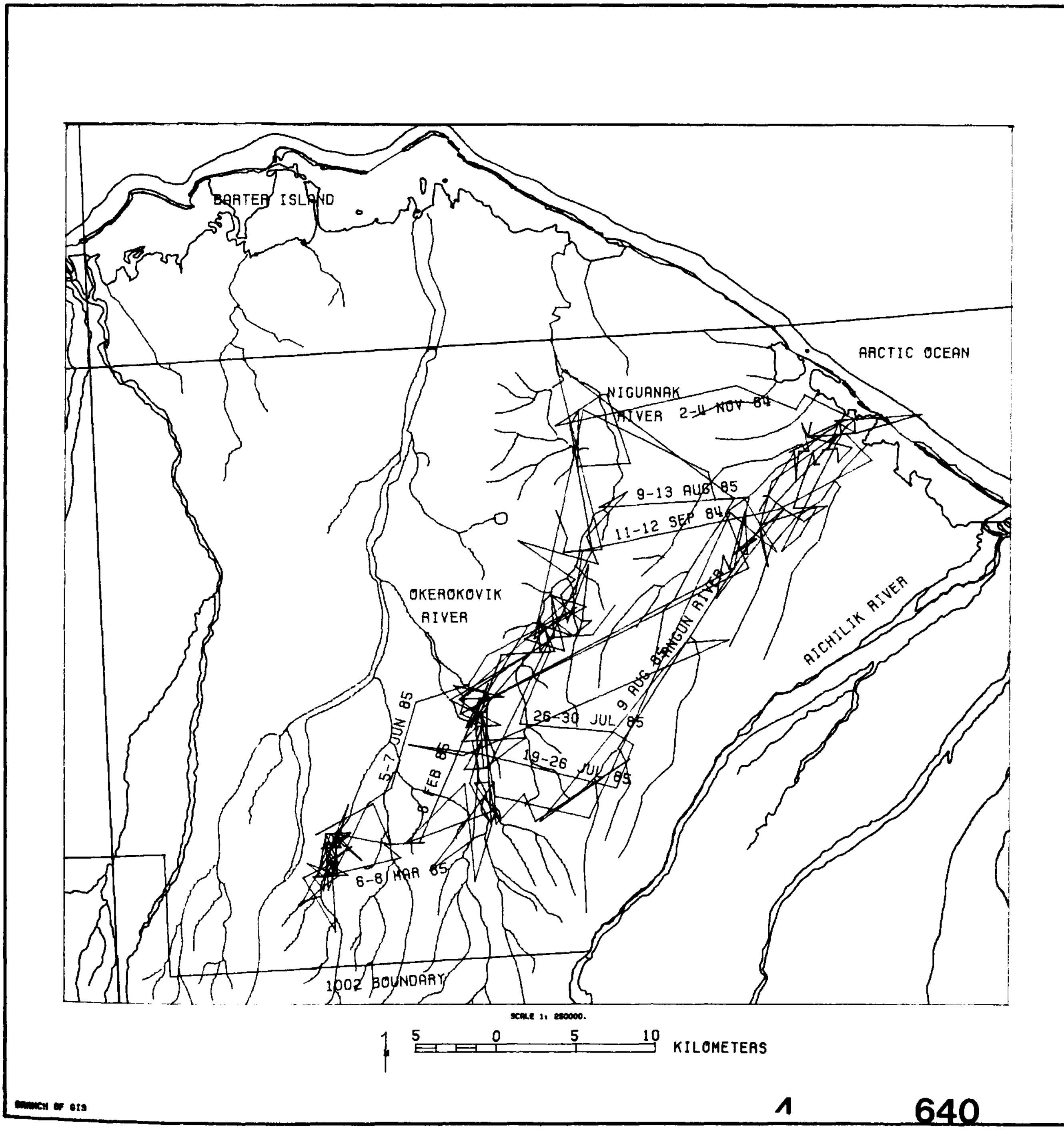

FIG. 3 . MOVEMENTS OF A SATELLITE-COLLARED MUSKOX, NORTHEAST ALASKA, SEPT. 1984 - SEPT. 1985.

study area (Reynolds et al. 1987) and was observed by Jingfors (1984) along the Sadlerochit River in 1979. Satellite telemetry provided detailed information about the extent and intensity of use of specific areas within the home range of muskoxen in the eastern part of the ANWR 1002 study area.

As the distance between observed locations was dependent on the time between observations, only movements made within a specific time period were compared. Movements which occurred within less than 9 h ranged from 0 to 11 km with a mean of 1.9 ± 1.9 SD (N=208). By contrast, movements occurring within a 16 to 28 hr period ranged from 0 to 18 km, with a mean of 3.6 ± 4.1 SD (N=39). Movement rates (km/day) calculated for movements within a 16 to 28 hr period ranged from 0.0 km/day to 20.0 km/day, with a mean of 4.2 + 4.7 SD (N=39). Mean rates of movement varied seasonally (Fig. 4). In summer (June - September) mean rates of movements were 6.9 ± 5.9 km/day (N=18), more variable and significantly higher (F=13.79, dF=38, P<0.01) than in winter (October - May) when mean rates of movements were 2.0 ± 1.3 km/day (N=21).

Activity Patterns

Observations of a captive muskox wearing the experimental satellite collar showed that resting and active behavior could be differentiated on the basis of counts from the 30 min counter. Percent time active was positively correlated (R^2=0.69, P<0.001, N=47) with counts/30 min obtained from the satellite collar. During 30 min periods in which the animal was resting for at least 27 min, activity counts from the satellite collar ranged from 2 to 20 with a mean of 8.5 ± 4.8 SD, N=16. By contrast, when the animal was active for at least 28 min of a 30 min period, activity counts ranged from 21 to 30 with a mean of 26.4 ± 4.2 SD, (N=14) (Fig. 5).

Similar results were seen during observations of the wild free-roaming cow muskox. Percent time active was positively correlated (R^2=.77, P<0.001, N=17) with counts/30 min obtained from the satellite collar. During 30 min periods in which the animal was resting for at least 25 min, activity counts ranged from 4-13 min with a mean of 7.4 ± 4.4 SD, N=5. During 30 min periods when the animal was active for at least 28 min, activity counts ranged from 20 to 30 with a mean of 28.0 ± 3.7, N=7 (Fig.5). These results indicate that the 30 min counter on the satellite collar was a useful measure of the animal's activity.

Seasonal differences in activity were apparent. Mean activity scores calculated for each month declined throughout winter and reached a low during the pre-calving period in March, then increased during spring and summer, and reached a high in July (Fig. 6). Mean activity scores were significantly higher (F=114.18, P<0.0001) in summer (June - September) (X=.74 ± .13, N=56) compared with winter (October-May) (X=.51 ± .13, N=105). The percentage of high counts (indicating active behavior) and low counts (indicating resting behavior) also changed seasonally (Fig. 7). In February, March and April, 57 to 70% of all counts from the 30 min counter were 0 to 10 counts/30 min, indicating the animal was spending a high percent of its time resting. By contrast in July, less than 7 percent of the counts were 0 to 10 counts/30 min and more than 82% of the counts were 20 to 30 counts/30 min, indicating the animal was active a high percent of the time.

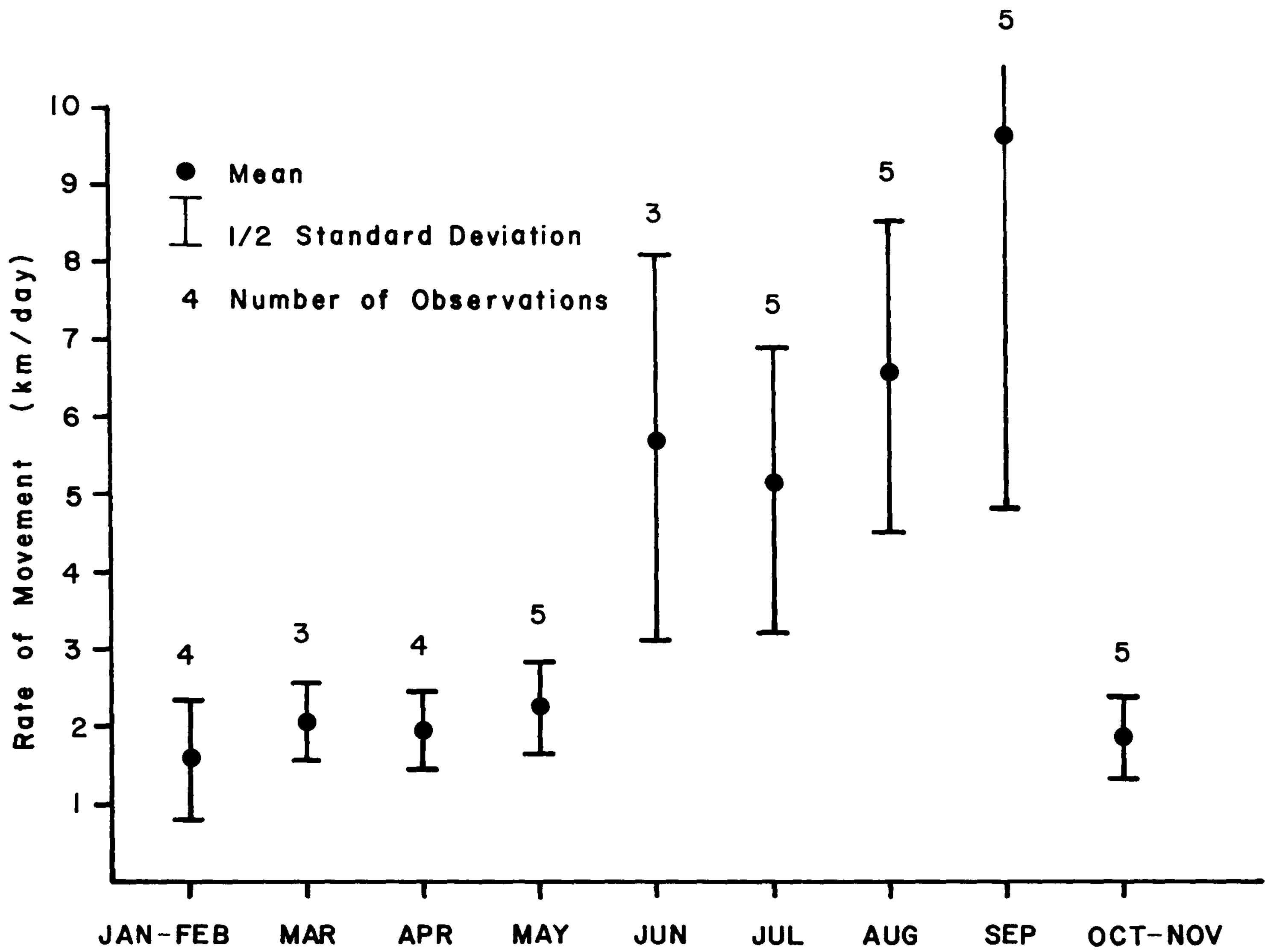

Fig. 4. Seasonal variation in rates of movement, within a 16-28 hr period, if a satellite-collared cow muskox in northeastern Alaska, September 1984 - September 1985.

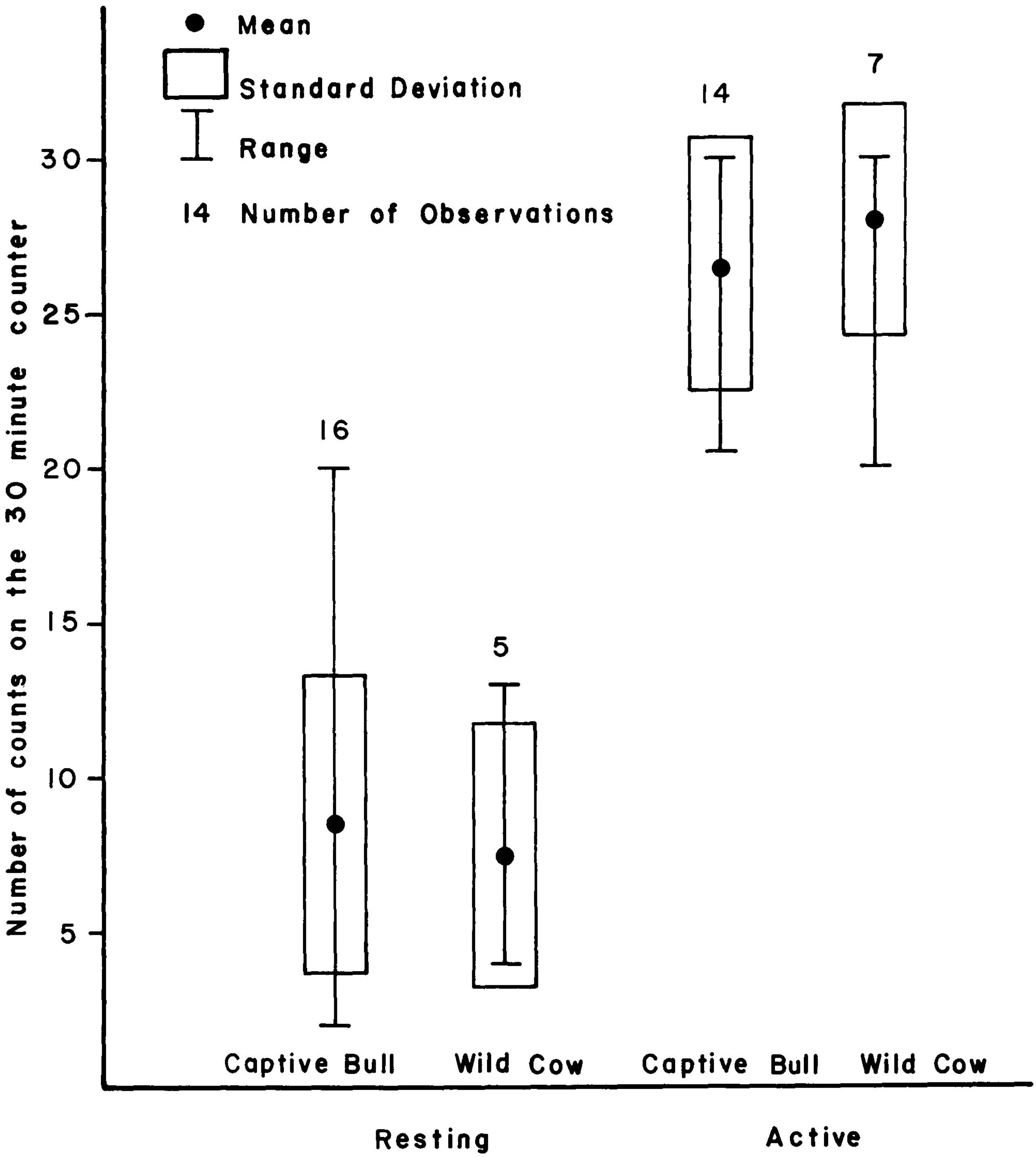

Fig. 5. Counts from a 30 min activity counter on satellite-collared muskoxen associated with active and resting periods of 25-30 min duration.

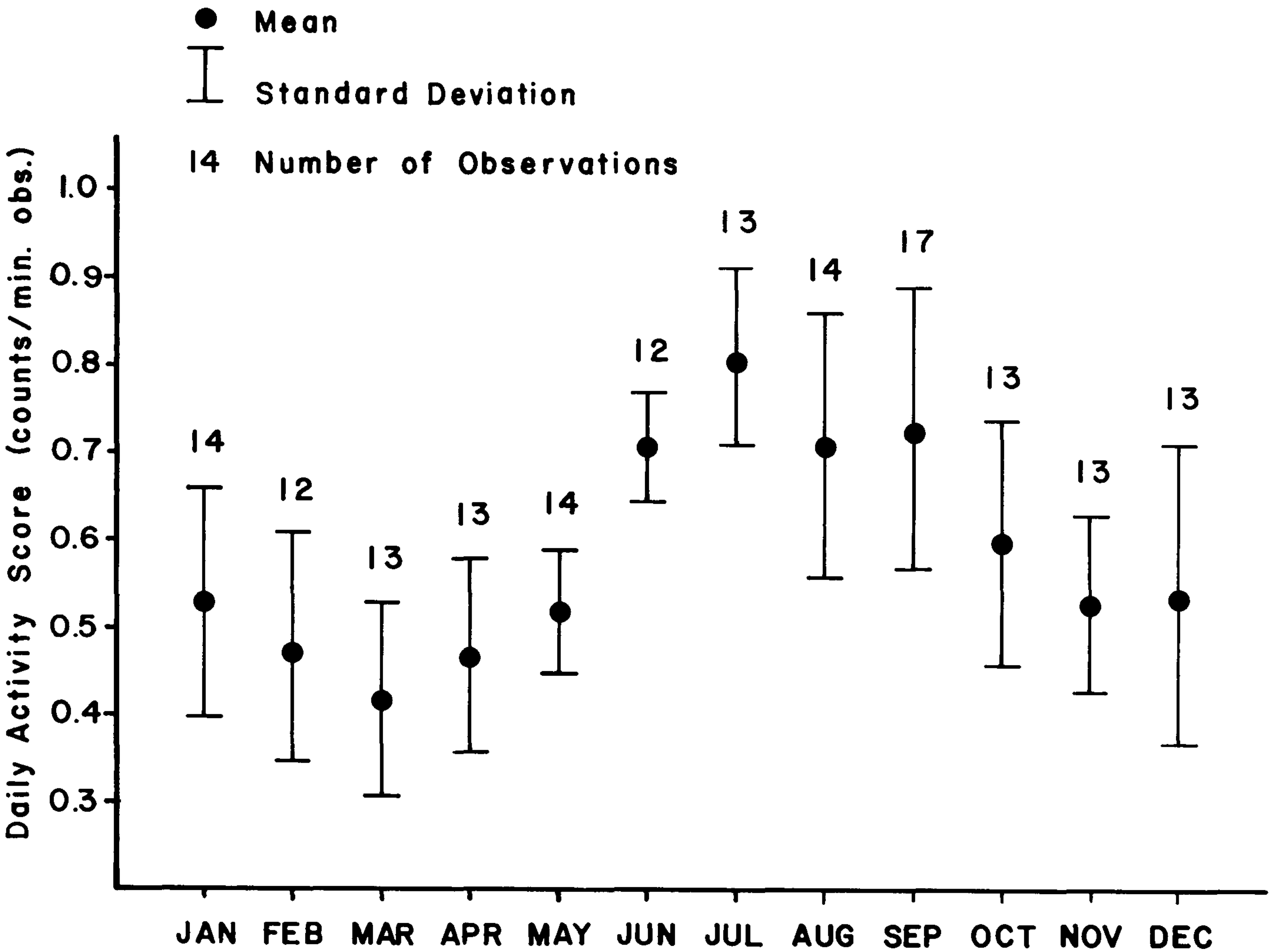

Fig. 6. Seasonal variability in mean activity scores obtained from a satellite-collared cow muskox in northeastern Alaska, 1984 - 1985.

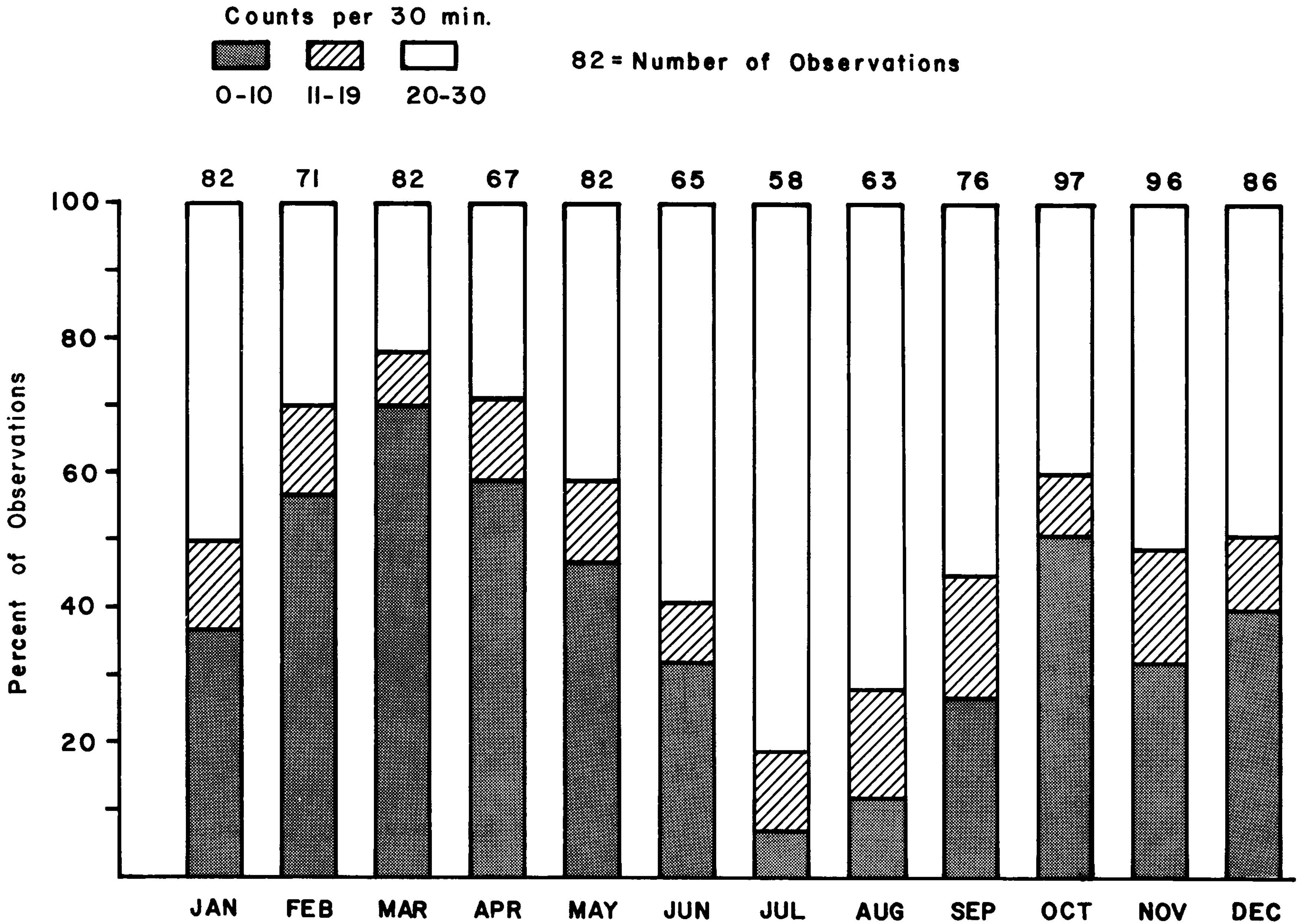

Fig. 7. Seasonal variability in high and low activity counts from a satellite-collared cow muskox in northeastern Alaska, 1984-1985.

Temperature

Monthly mean temperatures from the satellite collar on the wild muskox were highly correlated (corr. coeff = .8885, df=10, R^2=.92) with monthly mean ambient air temperatures at Barter Island (Fig. 8). The proximity of the collar to the insulating fur of the muskox probably contributed to the higher collar temperatures seen throughout the year. This effect may have been greatest in winter and spring when the animal was resting more frequently, and the collar was less exposed to the ambient air temperature. Also inland air temperatures at the locations where the muskxo was located may have been actually higher than those at Barter Island, particularly in summer. Temperatures recorded by the satellite collar ranged from -31.6 degrees C to +30.0 degrees C.

Discussion

Information collected from the satellite-collared muskox provided details about distribution and movements which would have been difficult and extremely costly to duplicate using conventional radio-collars. Of particular interest was information collected in winter. Low light and adverse weather conditions make observations very difficult to obtain from late November through mid-February, using conventional radio-telemetry. The information from this experimental satellite collar resulted in detailed winter data about muskox distribution, movement and activity patterns in the eastern part of the ANWR study area.

Information collected from the wild satellite-collared muskox suggests that in winter the animal reduced both movements and activity and the size of its activity area. This may be a strategy for conserving energy in winter. Most species leave the arctic slope before winter begins or spend the winter hibernating. Muskoxen remain in the area year-round and are subjected to the rigors of the arctic winter from November until April. Their compact bodies and highly insulative coats are adaptations for cold weather living. By reducing activity and movement in late winter, they reduce their need for food. White et al. (1984) found that voluntary food intake in captive muskoxen varied seasonally with maintenance energy requirements (MER) 28% lower in winter than in summer. Physical, physiological and behavioral adaptations all contribute to the ability of this species to survive year-round on the arctic coastal plain.

Repeated disturbance to muskoxen in late winter from human activities may reduce the animals ability to withstand the rigors of winter. If animals are forced to spend less time resting or more time moving because of disturbance, the metabolic cost may result in lower productivity, or higher over-winter mortality.

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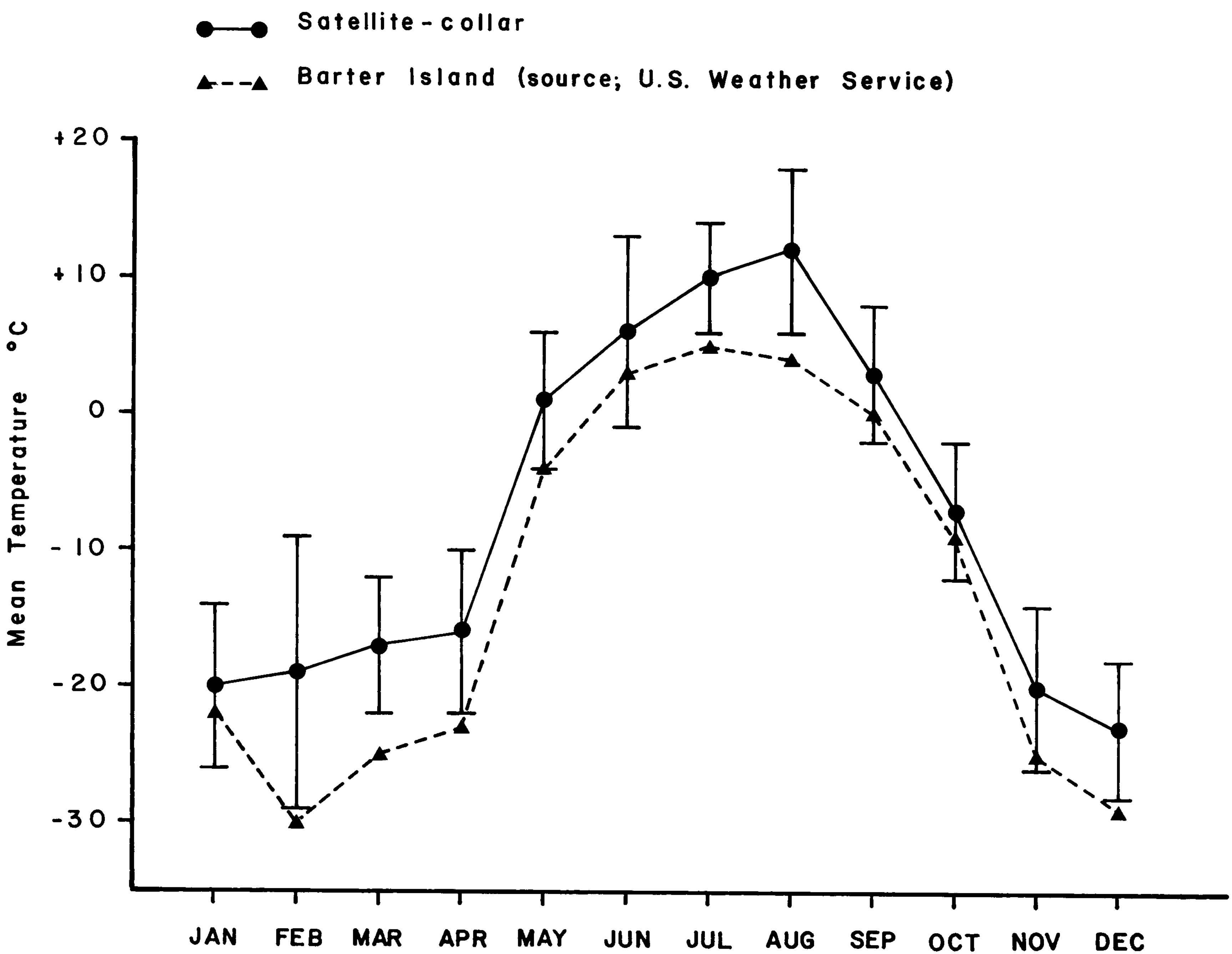

Fig. 8. Seasonal variability in mean temperatures (C degrees) obtained from a satellite-collared cow muskox in northeastern Alaska compared with mean ambient air temperatures collected at Barter Island, Alaska, 1984-

Pank, L.F., W.L. Regelin, D. Beaty, J.A. Curatolo. 1985. Performance of a prototype satellite tracking system for caribou. Pages 97-118 in R.W. Weeks, F.M. Long eds. Proc. Fifth Int. Conf. on Wildl. Biotelemetry, Chicago, IL.

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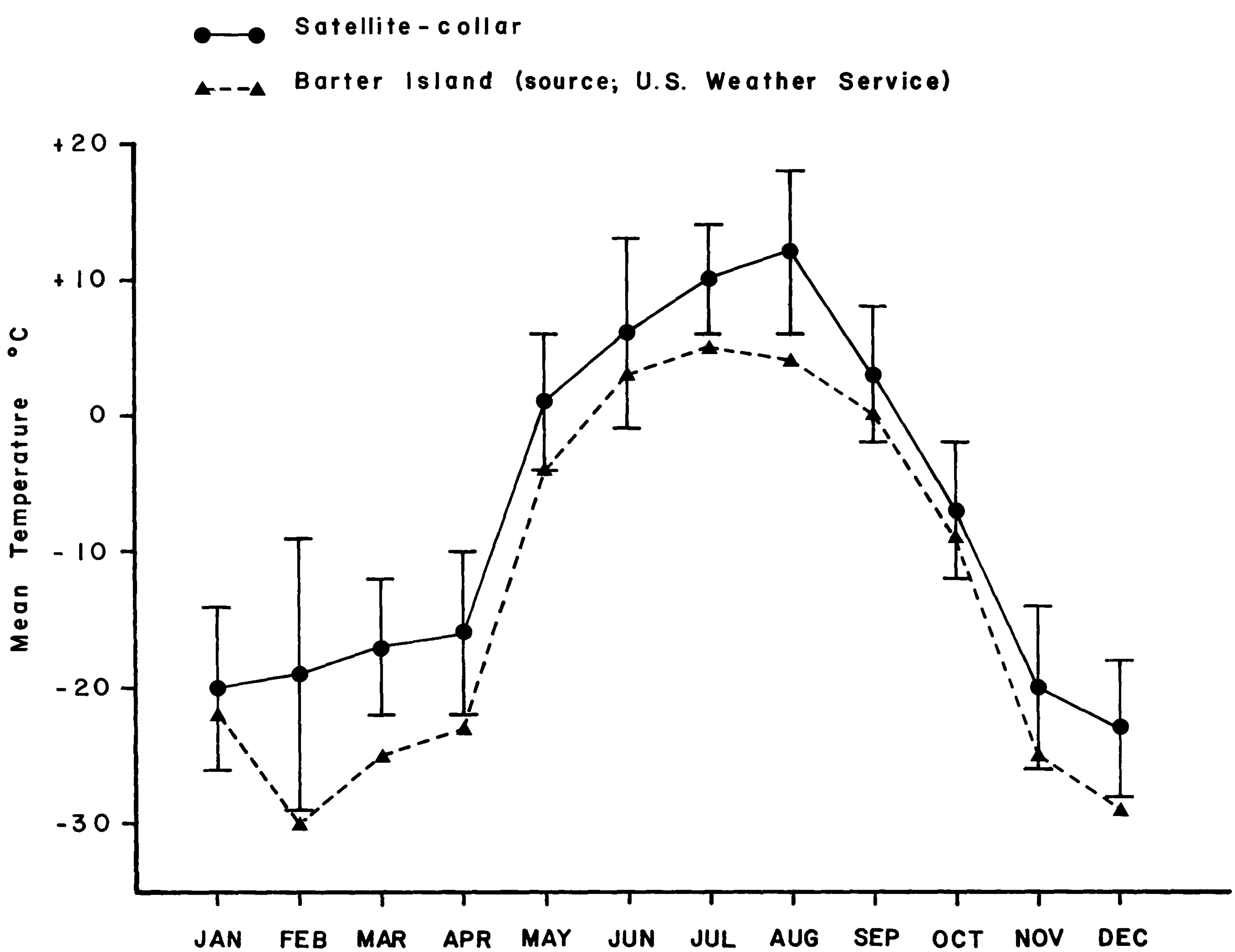

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ANWR Progress Report Number FY86-9

POPULATION SIZE, COMPOSITION, AND DISTRIBUTION OF MOOSE ALONG THE CANNING AND KONGAKUT RIVERS WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, SPRING AND FALL 1985

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Keywords: Moose, population, composition, distribution, Arctic-Beaufort, north slope

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18 April 1986

Population size, composition, and distribution of moose along the Canning and Kongakut Rivers within the Arctic National Wildlife Refuge, Alaska, spring and fall 1985.

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Abstract: Population size, composition, and distribution of moose (Alces alces) along the Canning and Kongakut River drainages were studied using aerial surveys. Data were compared to previous years to determine population trends within the river drainages. Number of moose observed during the 1985 spring survey increased over the 1980 and 1984 spring surveys. In the 1980 spring survey of the Canning drainage 147 moose were observed, 149 were seen in 1984, and 159 were seen in 1985. The 1980 spring survey of the Kongakut drainage, showed 123 moose, 134 in 1984, and 205 in 1985. The 1985 fall survey of the Canning drainage showed an increase: 149 moose were observed in 1983, 158 in 1984, and 192 in 1985. During the 1985 fall survey of the Kongakut drainage 194 moose were tallied, 239 in 1984, and 158 in 1983 This large fluctuation in the population may be due to immigration from surrounding river drainages, which has been a factor in previous years. The Marsh Fork of the Canning River and the Kavik River drainage were included in the survey. The data gathered, along with previous surveys and observations, seem to indicate a high degree of movement between these two drainages and the main Canning drainage.

Population size, composition, and distribution of moose along the Canning and Kongakut Rivers within the Arctic National Wildlife Refuge, Alaska, spring and fall 1985

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

Aerial moose surveys were first conducted along the Canning and Kongakut Rivers in 1972 (Roseneau and Stern 1974). Surveys were conducted again in 1973-1974 (Lenarz et al. 1974), and ANWR staff conducted surveys from 1976-1978. The Kongakut River was not surveyed in 1974 or 1976. During spring 1980, surveys were conducted in both drainages by refuge staff[1]. Timing of these earlier aerial surveys (March-April or September-October), and survey coverage and intensity have varied between years (Appendix Table 1); therefore, direct comparisons of the resultant data sets are difficult. During the 1980 survey, standardized survey areas were established for the Canning and Kongakut Rivers (Appendix Figs. 1 and 2).

Objectives of aerial moose surveys within ANWR are as follows:

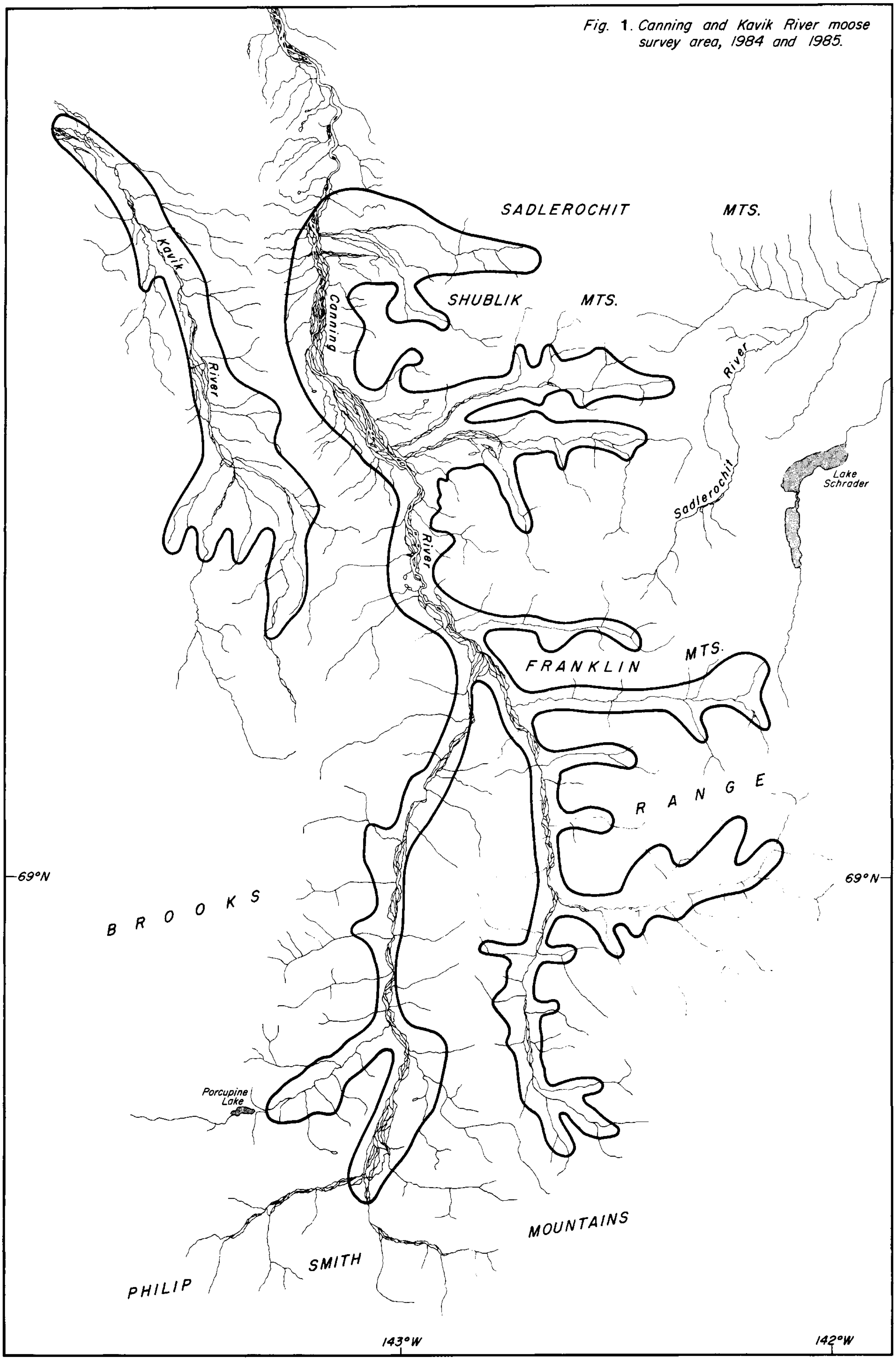
1) determine the population size, composition and distribution of moose within the Canning and Kongakut River drainages;
2) determine productivity of the 2 moose herds;
3) determine over-winter calf survival.

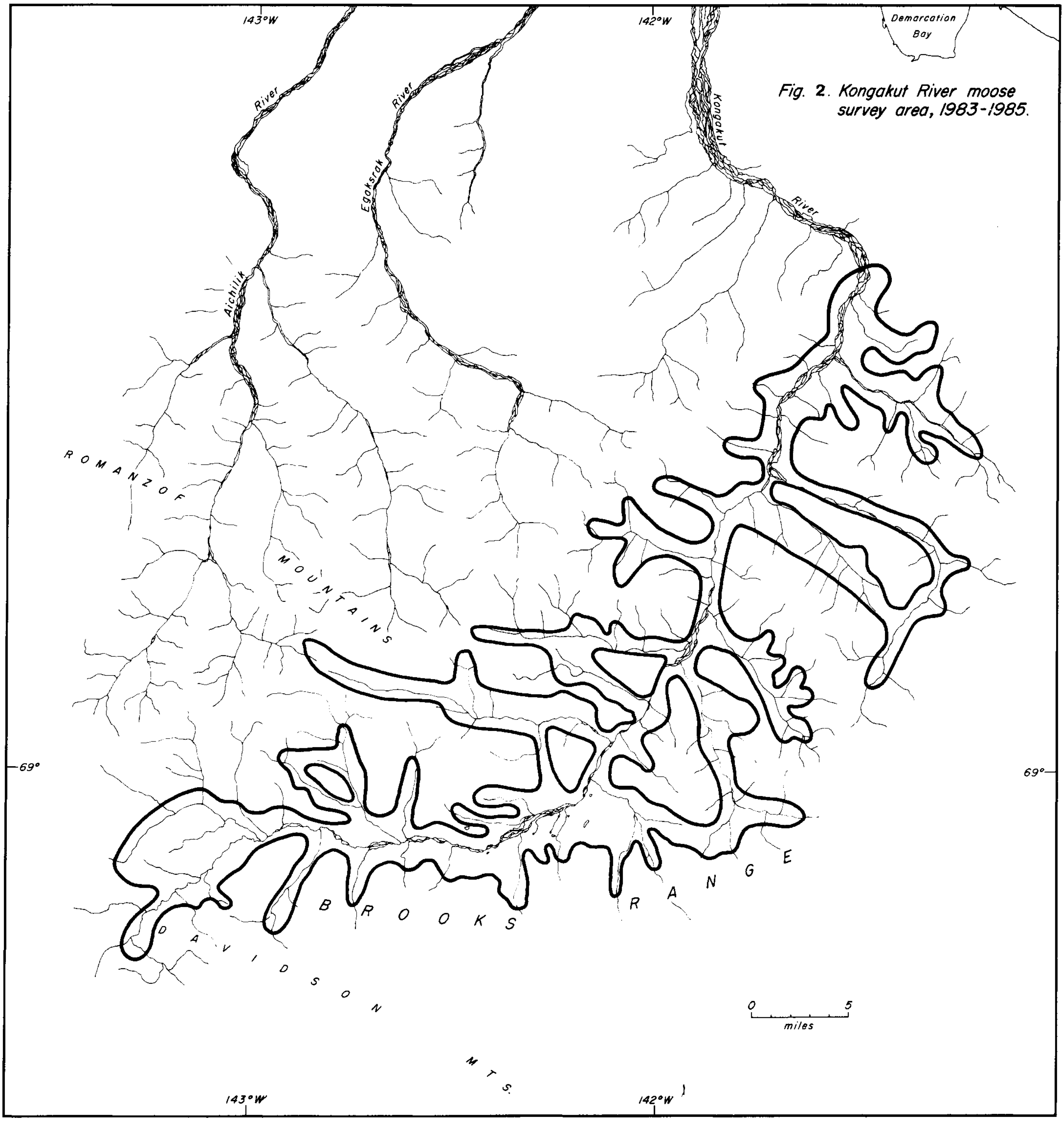
Material and Methods

Standardized survey areas for the Canning and Kongakut River drainages were flown in 1983, 1984, and 1985, and will be used in future surveys of the 2 drainages. The Kavik River and the Marsh Fork of the Canning River were also surveyed during spring 1984 and 1985, and fall 1985 surveys (Fig. 1 and 2). Survey routes were flown at 100-200 m above ground level (AGL) at an indicated airspeed between 112-144 kph. A total of 7.5 h flight time was used for the spring survey of the Canning River, while 9.2 h of flight time was used for the fall survey of this river. The Kongakut River required 7.2 h flight time for the spring survey and 5.7 h flight time for the fall survey. The Canning River has approximately 935 km of survey route and the Kongakut River has approximately 730 km of survey route.

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

Fig. 1. Canning and Kavik River moose survey area, 1984 and 1985.




143°W
142°W
Demarcation Bay
Fig. 2. Kongakut River moose survey area, 1983-1985.
Aichilik River
Egaksrak River
Kongakut River
ROMANZOF MOUNTAINS
BROOKS RANGE
DAVIDSON MTS.
69°
0 5 miles

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

Results and Discussion

For the purpose of this report, only the 1980, 1983, 1984, and 1985 surveys are used for direct comparisons. Surveys in previous years did not cover comparable areas. Three comparisons are discussed: 1) spring surveys conducted during 1980, 1984, and 1985: to assess annual variation in numbers of moose using the 2 drainages in the spring, 2) fall surveys conducted during 1983, 1984, and 1985; to evaluate annual variation in numbers of moose using the 2 drainages in the fall, 3) The surveys in fall 1984 and spring 1985: to assess over-winter survival of calves for each river system. Future inclusion of the Marsh Fork on the Canning River drainage survey is also examined.

Canning River Drainage

Spring Survey. A total of 159 moose were counted during the 26 April 1985 survey (Table 1). Of this total, 43.4% (69) were located within the Cache/Eagle Creeks portion of the drainage. This proportion of moose in Cache/Eagle Creeks is in contrast to 56.4% (84 of 149) in April 1984, and 75.5% (111 of 147) in 1980 (Appendix Table 1). Visibility was good throughout the 1985 survey, with 90-100% snowcover. Moose were easily seen during the survey, and it is believed few were missed.

Table 1.Number and composition of moose observed during aerial surveys of the Canning River during spring 1980, 1984, and 1985, and fall 1983, 1984, and 1985.

	Age and Sex Category				
Survey period	Adult bulls #(%)	Yearling bulls #(%)	Cows #(%)	Calves #(%)	Total
Spring					
Canning only					
April 1980	-	-	-	14(9.5)	147
April 1984	-	-	-	17(11.4)	149
April 1985	-	-	-	23(14.5)	159
Canning and Marsh Fork					
April 1984	-	-	-	20(12.7)	158
April 1985	-	-	-	36(17.7)	203
Fall					
Canning only					
Oct 1983	44(29.5)	7(4.7)	73(49.0)	25(16.8)	149
Nov 1984	47(29.7)	10(6.3)	77(48.7)	24(15.2)	158
Oct 1985	51(26.6)	19(9.9)	90(46.9)	32(16.7)	192
Canning and Marsh Fork					
Oct 1985	55(27.4)	21(10.4)	92(45.8)	33(16.4)	201

Source: Martin and Garner 1984, 1985

Numbers of moose recorded during the 1980 and 1984 spring surveys of the Canning River were comparable, while a slight increase was recorded in 1985 (Table 1). The proportion of calves in the population showed a gradual increase from 1980 through 1985. These data indicate that the Canning River moose population has been relatively stable or increasing slowly between 1980 and 1985.

Fall Survey. During the October 1985 survey, a total of 192 moose were tallied (Table 1). Of this total, 80.2% (154) were located within the Cache/Eagle Creek portion of the drainage (Appendix Table 1). This proportion is similar for October 1983 (87.3%, 130 of 149) and November 1984 (92.4%, 146 of 158). Visibility was good throughout the 1985 survey, with 100% snow cover. Sightability of moose was estimated at 95%.

The number of moose recorded during the fall surveys has been increasing each year since 1983. The annual increase for 1984 was 6.0%, while the annual increase for 1985 was 21.5%. Sex and age composition of the herd has remained relatively stable (Table 1).

Over-winter Calf Survival. The number of calves observed within the Canning River drainage remained stable from November 1984 to April 1985, with the apparent loss of only 1 animal (Table 1). During the winter of 1983-1984, 8 calves disappeared from the Canning River drainage (Martin and Garner 1985). The spring Canning River moose population appears stable since spring of 1980, when moose numbers and composition were comparable to spring of 1985.

Marsh Fork of the Canning River. During the spring 1984 and 1985, and fall 1985 surveys, the Marsh Fork of the upper Canning River was flown as an addition to the Canning survey area. In April 1984, 9 additional moose were recorded along this portion of the Canning drainage, and accounted for 5.7% of the moose within the entire drainage. In April 1985, 44 additional moose were recorded along the Marsh Fork and represented 21.7% of the moose within the entire Canning drainage. In October 1985, only 9 moose were recorded along the Marsh Fork and represented 4.5% of the moose within the entire Canning River drainage. Apparently an influx of approximately 40 moose entered the Canning River drainage through the Marsh Fork in spring 1985. These moose evidently remained in the Canning drainage, but had moved out of the Marsh Fork by fall 1985. The source of the additional moose is unknown, however, these data indicate that the Marsh Fork should be included in future surveys of the Canning River drainage to detect sources of major increases in moose abundance. The seasonal north/south movements along the drainage described by Lenarz et al. (1974) may function as the method for integrating influxes of moose from surrounding drainages into the Canning moose population.

Kongakut River Drainage

Spring Survey. A total of 205 moose were recorded during the April 1985 survey. The visibility was good throughout the survey with 95% snow cover. The 1985 survey showed a 53% increase (71 moose) over the 1984 spring survey. The adult:calf ratio remained relatively constant between these two surveys (Table 2). The 1985 survey was an increase of 66.7% (82 moose) over the 1980 survey. In contrast, the proportion of calves in the spring population has apparently declined steadily from 1980 through 1985, with the total number of calves being relatively constant at 20-25 calves. Therefore, the increase in moose numbers in the Kongakut River drainages is apparently due to immigration from surrounding drainages.

Table 2. Number and composition of moose observed during aerial surveys of the Kongakut River during spring 1980, 1984, and 1985, and the fall 1983, 1984, and 1985.

	Age and Sex Category				
Survey period	Adult bulls #(%)	Yearling bulls #(%)	Cows #(%)	Calves #(%)	Total
Spring					
April 1980	-	-	-	25(20.3)	123
April 1984	-	-	-	19(14.2)	134
April 1985	-	-	-	23(11.2)	205
Fall					
Oct 1983	59(37.3)	16(10.1)	62(39.2)	21(13.3)	158
Nov 1984	83(34.7)	16(6.7)	102(42.7)	38(15.9)	239
Oct 1985	64(33.0)	12(6.2)	87(44.8)	31(16.0)	194

Source: Martin and Garner 1984, 1985

Fall Survey. A total of 194 moose were recorded during the October 1985 survey (Table 2). The average visibility was good throughout the survey, with 100% snow cover. The number of moose detected in the 1985 survey was 18.8% less than the 1984 fall survey, and 5.4% less than the spring 1985 survey. However, the 1985 survey shows an increase of 22.8% over 1983. The proportion of calves remained relatively stable for these 3 years (Table 2). During the fall 1984 survey, 239 moose were tallied in the Kongakut drainage. This large increase in moose apparently occurred between April and November 1984 and was the result of an influx of moose into the Kongakut drainage. Origin of this immigration may have been the Sheenjek River drainage to the south and/or the Firth River/Mancha Creek drainage to the east (Roseneau and Stern 1974). Moose have also been observed moving between Joe Creek and the Kongakut River. These data support the belief that population increase was due to seasonal influxes of moose from surrounding drainages and not reproduction.

Over-winter Calf Survival. Number of calves observed along the Kongakut River drainage decreased 39.5% (15) between November 1984 and April 1985. The total population decreased 14.2% (34 moose) during the same time period. The proportion of calves in the population declined from 15.9% in fall 1984 to 11.2% in spring 1985 (Table 2). These data indicate a higher over-winter loss of calves than adults. Emigration may have accounted for the majority of these losses, however, it is reasonable to assume that some of the losses could be attributed to over-winter mortality. Predation or severe winter conditions are the probable causes of this over-winter calf mortality.

Canning River and Kongakut River Moose Composition

Bulls (yearlings and adults) were slightly more prevalent during fall surveys in the Kongakut River drainage than within the Canning River drainage. The 983 survey showed that bulls comprised 13.2% more of the Kongakut population than the Canning population. This prevalence declined by the 1985 fall survey to a 1.4% difference (Tables 1 and 2). Apparently, a disproportionate number of cows immigrated into the Kongakut River drainage during 1984 and 1985.

Relative sizes of bulls were recorded during fall surveys: bulls with antler spreads greater than 127cm were classified as large, and bulls with antler spreads greater than 76 cm but less than 127 cm were classified as medium. Yearlings were bulls with antler spreads less than 76 cm. Approximately 50% of the Canning River bulls were large in the 3 years observed (Fig. 3), while in the Kongakut River drainage percentage of large bulls increased from 23% in 1983 to over 60% in 1985. Both populations are lightly harvested as evidenced by the high proportion of bulls classified as large. Kongakut River bulls appear to be increasing in size structure with a corresponding decline in medium and yearling size bulls as the proportion of large bulls increases (Fig. 3). State hunting records indicate very low harvest in the Kongakut River with low hunt rates (2-5 animals) in the Canning River drainage.

In order to estimate the number of indistinguishable yearling females in both drainages, an adjustment was applied to the fall data as described by Gasaway et al. (1983). Cows less than 30 months of age in the fall survey are estimated by subtracting the number of yearling males observed from the total number of cows observed (Table 3). Yearling males are assumed to equal yearling females in number. Adjusted adult (greater than 30 months of age) sex ratios indicate that the bull/cow ratio within the Kongakut River drainage for fall 1985 was slightly higher than the same ratio for the Canning River drainage (Table 3). These ratios represent a substantial shift from fall 1983, when the Kongakut bull/cow ratio was nearly double the bull/cow ratio for the Canning drainage.

Table 3. Adjusted composition of moose occurring within the Kongakut River and Canning River drainages during fall surveys, 1983, 1984, and 1985. (Source: Martin and Garner 1984, 1985)

Sex/Age class	Kongakut River			Canning River		
	1983	1984	1985	1983	1984	1985
	#(%)	#(%)	#(%)	#(%)	#(%)	#(%)
Bulls > 30 mo.	59(37.3)	83(34.7)	64(33.0)	44(29.5)	47(29.8)	55(27.4)
Bulls < 30 mo.	16(10.1)	16(6.7)	12(6.2)	7(4.7)	10(6.3)	21(10.4)
Cows > 30 mo.	46(29.1)	86(36.0)	75(38.7)	66(44.3)	67(42.4)	71(35.3)
Cows < 30 mo.	16(10.1)	16(6.7)	12(6.2)	7(4.7)	10(6.3)	21(10.4)
Calves	21(13.3)	38(15.9)	31(16.0)	25(16.8)	24(15.2)	33(16.4)
Total	158	239	194	149	158	201
Ratios:						
Bulls[a] 100 Cows[a]	128/100	96/100	85/100	67/100	70/100	77/100
Calves/ 100 Cows[a]	46/100	44/100	41/100	38/100	36/100	46/100

[a] older than 30 months

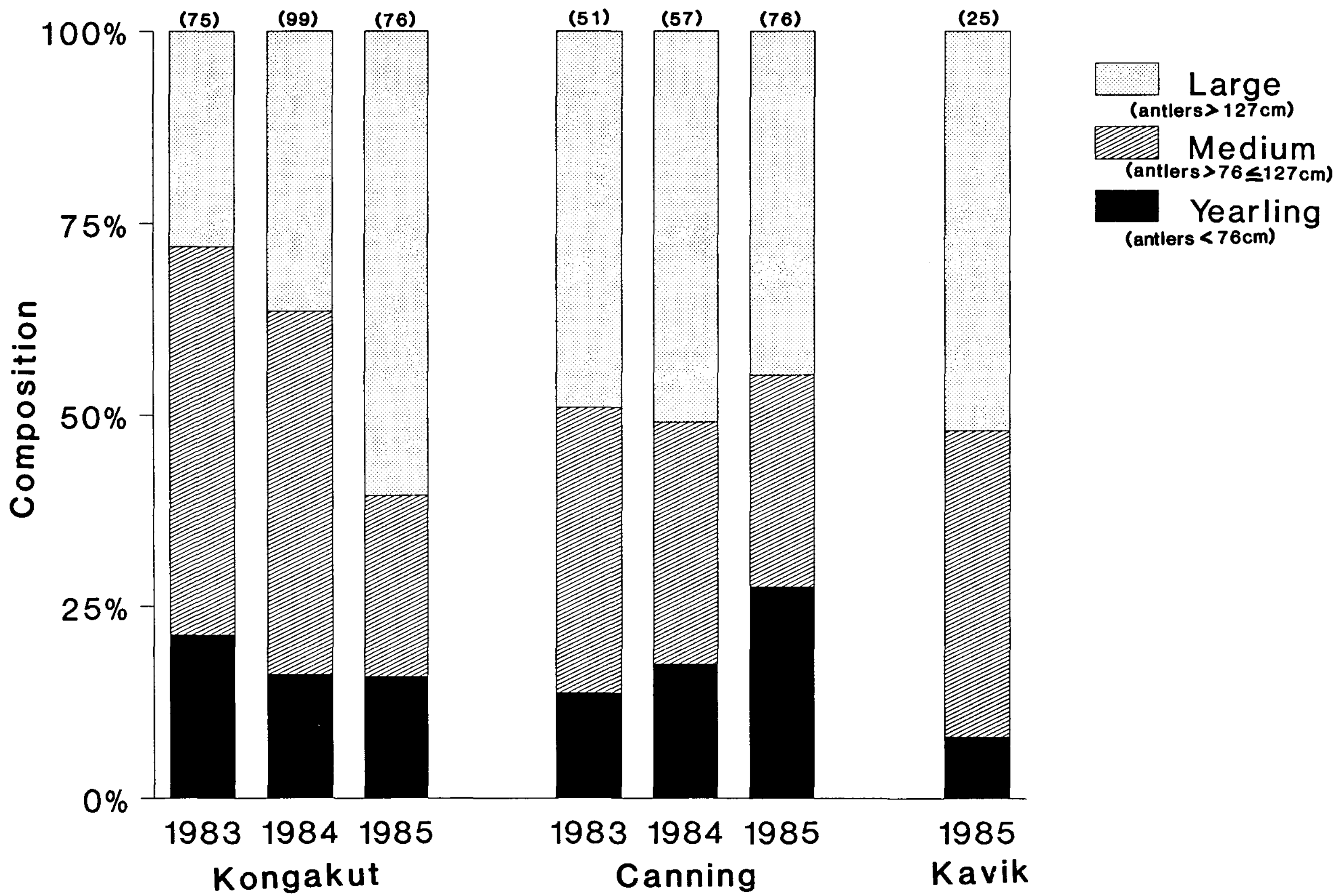


Fig. 3. Size composition of bull moose observed during fall surveys of the Kongakut, Canning, and Kavik river drainages in northeastern Alaska, 1983–1985. (Numbers in parentheses indicate sample size).

Small changes in productivity of the 2 moose populations were noted between 1983 and 1985. The calves/100 adult females ratio decreased 5% for the Kongakut River population and increased 8% for the Canning River population. Due to the lack of movement data for moose within these 2 drainages, accurate explanations for these changes are not possible.

Kavik River Drainage

The Kavik River drainage was flown in conjunction with the Canning River during spring 1984 and 1985, and fall 1985 surveys (Fig. 1). The proximity of the Kavik River to the Canning River, and observed movement of moose between the drainages (Lenarz et al. 1974), indicates the moose occurring in the 2 drainages probably compose a single population.

Spring Survey. During the 16 April 1985 survey, 96 moose were tallied in the Kavik River drainage (Table 4). The number of moose recorded in April 1985 represents an increase of 20 animals over the April 1984 survey. The Cache/Eagle Creek concentration of moose on the Canning River showed a decrease of 15 animals during the same period (Appendix Table 1). The major concentration of moose on the Kavik River is approximately 11 km west of the confluence of Cache and Eagle Creeks. Movements of moose between the Canning and Kavik drainage probably occurred.

Table 4. Number and composition of moose observed during aerial surveys of the Kavik River during the spring of 1984 and 1985, and the fall of 1985.

	Category				
Survey period	Adult bulls #(%)	Yearling bulls #(%)	Cows #(%)	Calves #(%)	Totals
April 1984	-	-	-	18(23.7)	76
April 1985	-	-	-	17(17.7)	96
October 1985	23(29.1)	2(2.5)	36(45.6)	18(22.8)	79

Fall Survey. The 23 October 1985 survey recorded 79 animals along the Kavik River drainage (Table 4). No previous fall survey data are available for comparison. Sex and age composition of the Kavik population (Table 4) is similar to the fall 1985 Canning River population (Table 1). Yearling bulls accounted for 2.5% of the total, slightly lower than the 9.9% represented in the Canning drainage for the same survey. As in the Canning River large bulls comprised over 50% of the bulls observed during the fall 1985 survey (Fig. 3).

The proportion of calves in the Kavik drainage was higher than in the Canning population during all 3 surveys. The April 1984 survey showed the Kavik drainage having double the percentage of calves, 23.7% versus 11.4%. However, the spring and fall 1985 surveys reflected only a 3.2% and 6.1% difference in the calf proportions. These data are insufficient to conclude a higher productivity for the Kavik population.

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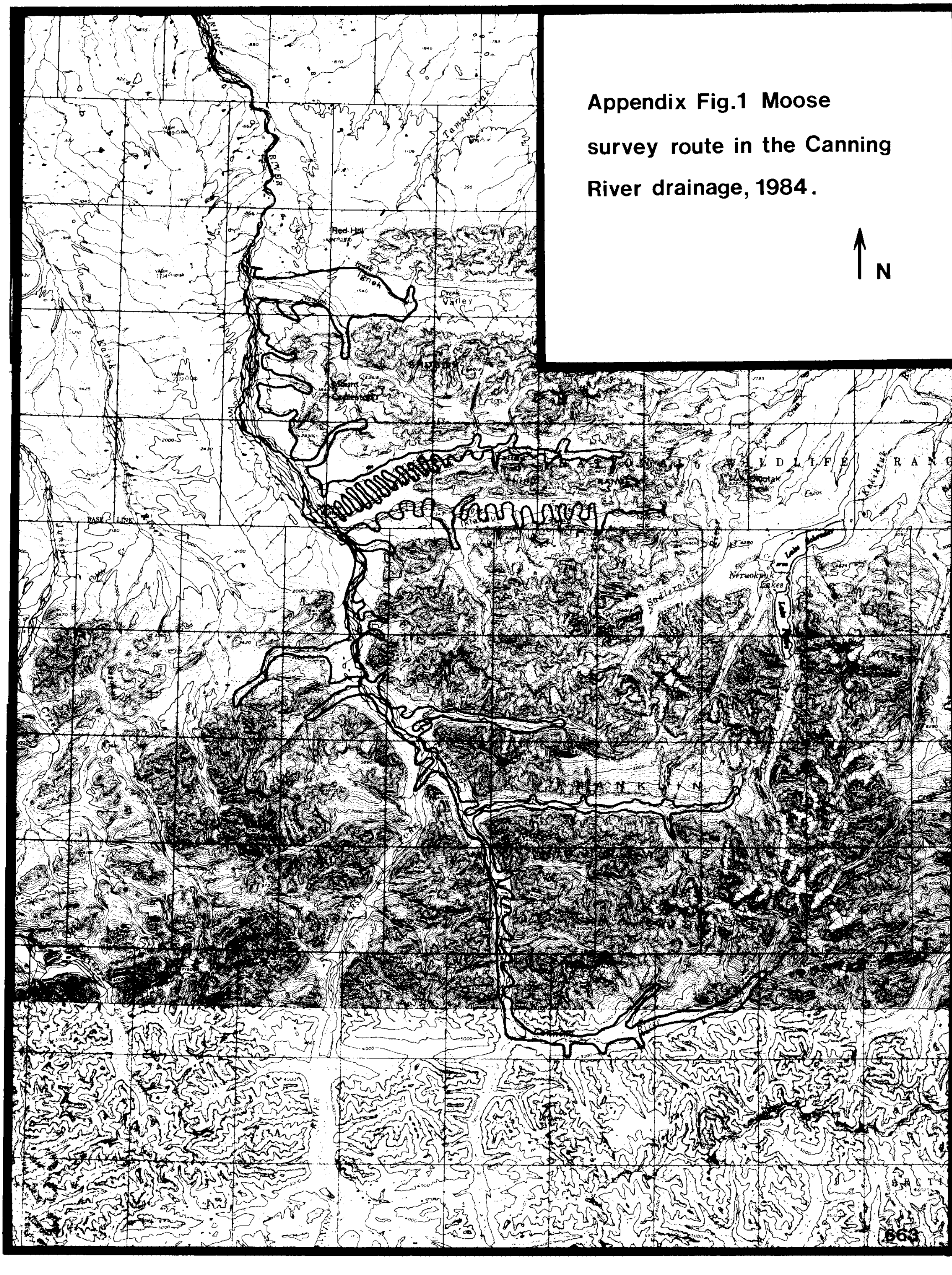
APPENDIX

ANWR Progress Report Number FY86-9

Appendix Table 1. Numbers of moose observed during aerial surveys of the Canning and Kongakut Rivers on the Arctic National Wildlife Refuge, 1972 - 1985.

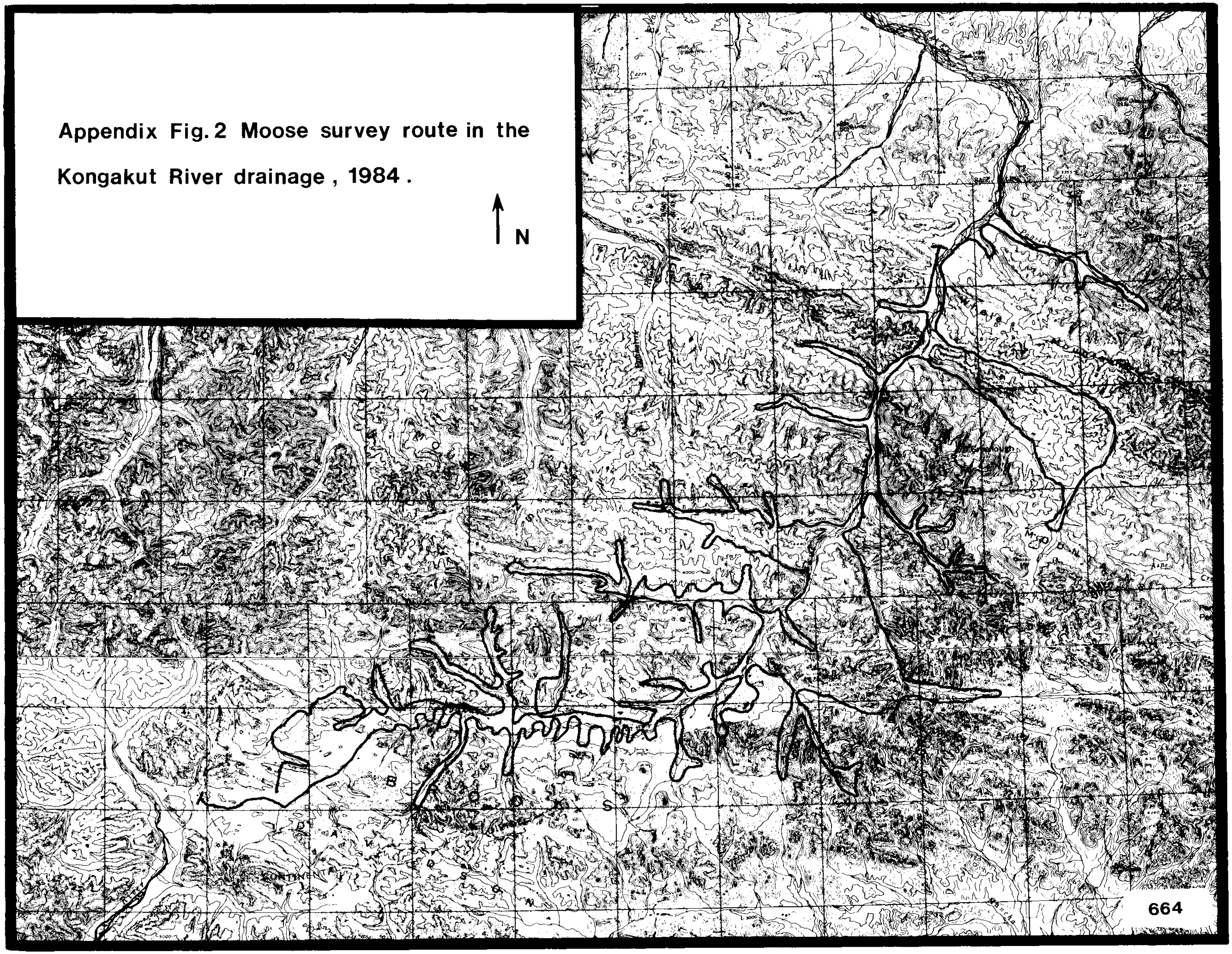
Kongakut Month - Year	Canning River[h] excluding Marsh Fork	including Marsh Fork	Cache/Eagle Creeks	Kongakut River
March-April 1972	33	48	16	21
September-October 1972[a]	4	7	2	8
March-April 1973[b]	43	64	16	NS
May 1973[b]	40	45	25	NS
October 1973[b]	66	60	64	68
March 1974[b]	NA[d]	42	37	NS
September 1976[e]	NS[c]	NS	42	NS
April 1977[e]	48	48	NA	54
April 1978[e]	43	43	NA	58
April 1980[e]	147	NS	111	123
September 1983[f]	79	NS	42	NS
October 1983[f]	149	NS	130	158
April 1984[f]	149	158	84	134
October-November 1984[f]	158	NS	146	239
April 1985[g]	159	203	69	205
October 1985[g]	192	201	154	194

[a] Roseneau and Stern 1974
[b] Lenarz et al. 1974
[c] NS = not surveyed
[d] NA = data not available
[e] Arctic National Wildlife Refuge Files
[f] Martin and Garner 1985
[g] this study
[h] includes moose seen in Cache/Eagle creeks



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

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



ANWR Progress Report Number FY86-12

ECOLOGY OF BROWN BEARS INHABITING THE COASTAL PLAIN AND ADJACENT FOOTHILLS AND MOUNTAINS OF THE NORTHEASTERN PORTION OF THE ARCTIC NATIONAL WILDLIFE REFUGE

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Key Words: brown bear, denning, movements, reproduction, populations, Arctic-Beaufort, Arctic National Wildlife Refuge.

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Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge.

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Abstract: A total of 145 brown bears (*Ursus arctos*) were captured and marked in May, June, and July 1982-1985 on the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge (ANWR). Radio-transmitters were attached to a total of 113 different bears during this time period and these bears were monitored through denning (October-November) each year. More males were captured in age classes 5.5 years of age or less, while females were more abundant in age classes 6.5 years old and older. No natural mortalities occurred among sample bears in 1982, however, 10 apparent mortalities occurred among 17 young bears (cubs and yearlings) in 1983. In 1984, 13 of 24 young bears were apparent mortalities, and in 1985, 18 of 40 young bears were apparent mortalities. Reasons for these high mortality rates in 1983 (58.9%), 1984 (54.2%), and 1985 (45.0%) among young bears is unknown. Four mortalities were recorded during 1985. An adult female (19.5-year old) and an adult male (20.5-year old) died over winter of exposure and drowning, repectively. Two bears (a 13.5-year old female and a 3.5-year old male) were shot by hunters. Brown bears were observed feeding on caribou (*Rangifer tarandus*) carcasses (adults and calves) on 6 occasions in 1982, on 15 occasions in 1983, on 20 occasions in 1984, and on 31 occasions in 1985. Preliminary analysis of radio-relocation data indicate that brown bears appear to shift habitat use patterns to coastal areas in June and early July to coincide with occupancy of those habitats by calving and post-calving caribou. Emerged from winter dens occurred in late occurred in late April and throughout May in 1983 and 1985, but was confined to late April through mid-May in 1984, with early emergence of males and non-parturient females and later emergence of females with cubs of the year. Elevations of den sites averaged 816 ± 61m(SE) in 1983, 966 ± 46m(SE) in 1984, and 964 ± 64m(SE) in 1985. Aspects of den sites were predominantly southeast facing slopes (mean aspect, 1983 = 145°±20°SE; 1984 = 150°±18°SE; 1985 = 146°±± 18°SE). Slope of den sites averaged 54± 4%SE in 1983, 56± 2%SE in 1984, and 58± 3%SE in 1985. In October and November, bears moved south into foothill and mountainous habitats to den. Only two bears in each year denned on the coastal plain and foothill habitats in the 1002c study area in 1983, 1984 and 1985.

Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge.

Brown bears (Ursus arctos) are year-round residents of the Arctic National Wildlife Refuge (ANWR) and use the coastal plain of ANWR during portions of their life cycle. Knowledge specific to ecology of brown bears using the coastal plain of ANWR are limited (U.S. Fish & Wildlife Service 1982). Impending petroleum exploration of the coastal plain and the potential impacts of this activity upon brown bears using the coastal plain requires expanded knowledge of brown bear ecology in the area. Of specific concern is the potential for disturbance during denning, which is postulated to have adverse effects of brown bear populations (Watson et al. 1973, Harding 1976). A study of brown bear ecology was initiated in 1982. The objectives of this study were as follows:

1. Determine location of denning and ecology of denning for brown bears using the coastal plain of ANWR.

2. Determine seasonal habitat use patterns of brown bear using the coastal plain of ANWR.

3. Determine seasonal interrelationships between brown bears and other wildlife species, especially caribou (Rangifer tarandus), occupying the coastal plain and adjacent foothills and mountains of the northeastern portion of ANWR.

4. Determine the structure, size, status, and reproductive biology of brown bear populations on the northern slope of the eastern Brooks Range.

This project is a cooperative effort between the U.S. Fish and Wildlife Service (USFWS) and the Alaska Department of Fish and Game (ADFG).

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 (U.S. Fish and Wildlife Service 1982).

Field work was based at Barter Island and extended from 19 April through 7 November 1985. Bears were captured between 21 May and 15 June using a Bell 205B Jet Ranger helicopter. Fixed-wing aircraft were used to locate bears and direct the helicopter and capture crew to the site. Capture procedures followed standard helicopter immobilization techniques used on brown bears in northern Alaska (Reynolds 1974, 1976). M-99 (Etorphine, lmg/ml, D-M Pharmaceutical) was injected into the rump using Cap-Chur equipment (Palmer Chemical and Equipment Co., Douglasville, GA). Bears recovered after the antidote (M50-50, Dipremorphine, 0.2 mg/ml, D-M Pharmaceutical, Rockville, MD) was administered intravenously (same dosage as M-99) and intramuscularly in the rump at 1/2 the dosage M-99. Certain bears (large males, etc.) were immobilized with the sernylan (phencyclidine hydrochloride, Bio-Centic Laboratories, St. Joseph, MO) and acepromazine maleate (Ayerst Labs, New York) using the Cap-Chur equipment. Young bear (cubs) were captured by hand and were injected with sernylan and acepromazine for handling and processing. Captured animals were measured, weighed, tattooed for permanent identification, ear-tagged, and marked with color-coded visual ear flags (Reynolds 1974). In addition, certain bears were fitted with collars containing radio-transmitters (Telonics, Inc., Mesa AZ). Young age animals were fitted with expandable breakaway collars. These animals will be recaptured annually and the collars replaced. Also, young bears (3-4 years) of radio-collared females were captured and collared in late May to document disruption and dispersal of the family unit during the breeding season.

The two 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 serological study by ADFG personnel.

Movements and range size were determined by aerial surveys using fixed-wing aircraft to relocate radio-collared bears. Radio-relocations were attempted on a weekly basis; however, inclement weather and extensive movements of radio-collared bears increased intervals between relocations to 7-10 days. Attempts were made to visually observe each bear during a relocation; however, terrain, cover, and weather conditions did not always permit visual observation. Therefore, when visual relocations were not possible, radio-fixes were determined by triangulation or by abrupt changes in radio-signal strength. Radio-relocations and fixes were recorded in 1:36,360 scale topographic maps and other relevant information was recorded on form sheets.

Radio-relocations will be digitized and computer graphic techniques will be used to analyze home range and species interrelationships. Movement distances between consecutive radio-relocations will be measured using computer Geographic Information System techniques. Winter dens were located by relocating radio-collared bears throughout October and early November. During these den surveys. dens of non-radio-collared bears were often sighted and their locations were recorded on 1:63,360 scale topographic maps.

Movement and home range data will be used to determine seasonal shifts in range use and an attempt will be made to relate these shifts to food availability. Concurrent observations of other species (especially caribou) will be used to evaluate the interrelationship between brown bear and their potential prey species. Upon completion of an extensive vegetation mapping effort in the study area (Walker et al. 1982, U.S. Fish and Wildlife Service 1982) the locational information for brown bear will be integrated into the digital data base of vegetation/land cover types. These integrated data sets will be examined statistically to determine habitat correlates. These data will be used to evaluate the suitability of using Landsat-derived land cover maps for identifying and assessing brown bear habitat in arctic Alaska. Movement, range size and habitat use data analyses are ongoing and will be presented in a final report.

Data on various parameters of den sites were recorded at the time of denning (October-November) and at the time of emergence in the spring (April-May). Each den site was visited in mid-summer (July) and the vegetation and soil characteristics of the site were documented. Variables measured during the 3 den sample periods were based on den site studies of arctic fox (Chesmore 1969), brown bear (Craighead and Craighead 1972), Harding 1976, Reynolds et al. 1976, Vroom et al. 1980) and black bear (Johnson and Pelton 1980, Tietje and Ruff 1980).

At each den site, two 30.5-m bisecting lines were established, with 1 line along the axis of the slope (up-slope line) and the other line (cross-slope line) perpendicular to the first. The den site was located at the midpoint of each line (the bisection point) in the manner described by Reichelt (1973). A sharpened surveyor's pin was lowered vertically to ground line at 30.5 cm intervals along each line and the point contact and the plant nearest to the pin at ground level was recorded at each point (200 total points per den site). Species composition data will be analyzed using analysis of variance and linear correlations analysis. Analysis of vegetational data is ongoing and will be presented in a final report.

Spring snow depths at each den site were recorded. Soil samples were taken at all ample locations to determine soil texture (Brady 1974). Regression analyses will be used to determine interrelationships between snow depth, soil texture, permafrost depths, and aspects. These data will be useful in more clearly defining denning habitat in the study area.

Results and Discussion

A total of 50 brown bears were captured and marked between 23 June and 3 July 1982 and 30 bears were captured and marked between 28 May and 16 June 1983. In addition, 11 bears captured in 1982 were recaptured in 1983 and refitted with new radio-collars (Table 1). Between 21 May and 15 June 1984, 23 new bears were captured and marked and 34 previously collared bears were recaptured and refitted with new radio-collars (Table 1). Between 13 June and 10 July 1985, 42 new bears were captured and marked and 25 previously collared bears were recaptured (Table 1). A total of 113 different bears were fitted with radio-collars during 1982-1985. Distribution of capture locations for the 76 bears captured in 1985 are depicted in Fig. 1.

Average weights of captured adult bears from 1982-1985 were comparable to weights of adult bears 9in the interior of the southern Yukon Territory (Table 2). It should be noted that weights recorded in other studies were for bears captured throughout the year, and included fall captured bears which are considerably heavier than bears captured in the spring (Pearson 1976). Bear captured in the current study were limited to spring and early summer capture periods.

Productivity

Age structure of 115 captured bears and 23 associated unmarked young (Fig. 2) that were theoretically alive in late winter 1985 indicated a preponderance of males in age classes 5.5 years or less (32 males versus 15 females, plus 23 unidentified bears), while females predominated in age classes 6.5 years and older (39 females versus 29 males). Immature bears (4.5-years old or less) comprised 46.4% of the theoretical population in the late winter of 1984, with cubs, yearlings, 2.5-year old, 3.5-year old, and 4.5-year old comprising 18.8%, 10.1%, 4.3%, 5.8%, and 7.2% respectively. Adults comprised 53.6% of the

Table 1. Physical characteristics of brown bears captured on the Arctic National Wildlife Refuge, Alaska, May, June and July 1982-1985. (Measurements shown in cm, except as noted).

Bear number	Sex	Cementum age	Weight (lbs./kg)	Total length	Body length	Hind foot	Neck	Girth	Head width	Head length	Shoulder height	Upper left canine	Lower left canine	General capture location	Date
1056	M[a]	20.5	365/166	181	129	29	74	126	22.5	35.7	118	3.9	3.2	Old Man Cr.	28 June 1982
1056	M[a]	22.5	350/159	-	-	-	68	130	22.6	35.6	-	-	-	Niguanak R.	10 June 1984
1072	M[a]	12.5	270/123	187	-	-	72	116	21.7	34.5	-	-	-	Jago R.	18 June 1985
1182	F[a]	15.5	170/77	170	92	27	57	92	18.3	34.0	104	3.0	2.7	Jago R.	23 June 1982
1182	F[a]	17.5	200/91	-	-	-	56	-	19.9	33.3	-	-	-	Jago R.	13 June 1984
1183	F	0.5	14/6	74	34	18	22	35	9.4	15.6	41	0.3	0.3	Jago R.	23 June 1982
1184	F	0.5	14/6	72	35	13	22	36	9.2	16.0	46	-	-	Jago R.	23 June 1982
1185	F[a]	18.5	215/98	163	99	27	57	99	19.5	31.0	103	2.8	2.8	Aichilik R.	23 June 1982
1185	F[a]	20.5	220e/100	-	-	-	57	95	19.6	31.5	-	-	-	Aichilik R.	21 May 1984
1186	M[a]	6.5	205/93	155	99	28	57	102	17.9	32.2	97	3.3	3.0	Siksikpalak R.	23 June 1982
1186	M[a]	7.5	250e/113	174	102	31	63	104	18.6	31.6	113	3.4	3.1	Kongakut R.	10 June 1983
1187	F[a]	6.5	168/76	147	93	24	52	99	17.0	29.8	98	3.1	2.9	Egaksrak R.	23 June 1982
1187	F[a]	7.5	180e/82	158	96	28	56	102	17.0	27.6	107	3.0	2.8	Siksikpalak R.	10 June 1983
1188	M[a]	4.5	285/129	201	95	22	67	110	19.5	36.0	102	1.5	1.5	Kongakut R.	23 June 1983
1188	M[a]	6.5	350e/159	-	-	-	68	121	20.5	36.4	-	-	-	Kongakut R.	13 June 1984
1189	F[a]	5.5	- -	168	94	26	55	99	17.1	32.1	100	3.4	2.8	Kongakut R.	23 June 1982
1189	F[a]	6.5	230/104	170	40	28	57	101	17.7	33.1	107	3.0	3.0	Turner R.	13 June 1983
1189	F[a]	7.5	185/84	-	-	-	-	-	-	-	-	-	-	Turner R.	21 May 1984
1189	F[a]	7.5	- -	-	-	-	-	-	-	-	-	-	-	Turner R.	9 June 1984
1190	F[a]	7.5	220/100	171	109	24	58	102	18.1	31.9	97	3.1	2.8	Turner R.	24 June 1982
1190	F	9.5	- -	-	-	-	-	-	-	-	-	-	-	Clarence R.	10 June 1984
1191	M	0.5	19/9	69	42	15	26	43	10.2	15.7	46	-	-	Turner R.	24 June 1982
1192	M	0.5	20/9	88	33	14	25	43	9.8	16.5	41	-	-	Turner R.	24 June 1982
1193	F[a]	8.5	190/86	177	90	19	63	114	21.0	32.5	68	2.8	2.8	Clarence R.	24 June 1982
1194	M[a]	11.5	305/138	191	99	23	74	116	21.0	37.0	41	3.8	3.3	Clarence R.	24 June 1982
1194	M[a]	13.5	380/172	-	-	-	83	122	21.7	37.7	-	-	-	Turner R.	9 June 1984
1195	M[a]	4.5	210/95	174	83	22	62	-	18.4	32.2	80	3.4	3.2	Kongakut R.	24 June 1982
1196	M[a]	6.5	- -	155	78	25	62	104	17.0	30.3	98	3.0	2.9	Ekaluakat R.	24 June 1982
1196	M[a]	7.5	220e/100	175	86	25	66	99	18.0	31.2	104	3.1	3.1	Siksikpalak R.	11 June 1983
1197	F[a]	8.5	190/86	163	92	27	57	100	19.2	30.9	96	2.9	3.0	Jago R.	24 June 1982
1197	F[a]	10.5	200/91	-	-	-	58	103	19.5	31.5	-	-	-	Aichilik R.	9 June 1984
1198	M[a]	5.5	205/93	167	89	29	60	107	16.9	33.0	94	3.5	3.1	Sadlerochit R.	25 June 1982
1198	M[a]	6.5	245/111	184	118	30	65	108	19.1	33.5	111	3.6	3.3	Akootoaktuk R.	10 June 1983
1199	M[a]	6.5	220/100	175	86	30	61	100	18.8	33.0	103	3.2	3.3	Katakturuk R.	25 June 1982
1200	M[a]	13.5	335/152	189	90	32	76	120	22.5	35.5	108	3.4	3.2	Katakturuk R.	25 June 1982
1200	M[a]	15.5	380/173	-	-	-	71	-	22.8	35.6	-	-	-	Marsh Cr.	12 June 1984
1201	F	5.5e[b]	190/86	159	80	28	62	97	18.3	31.1	92	2.8	2.7	Katakturuk R.	25 June 1982
1202	F[a]	16.5	215/98	160	97	24	60	109	18.2	31.6	98	3.1	2.8	Marsh Cr.	25 June 1982
1202	F[a]	18.5	- -	-	-	-	-	-	-	-	-	-	-	Nularvik R.	21 May 1984
1203	M	1.5	30/14	90	51	16	33	53	11.0	18.6	57	0.6	1.0	Marsh Cr.	25 June 1982
1203	M[a]	3.5	- -	-	-	-	-	-	-	-	-	-	-	Nularvik R.	21 May 1984
1204	M	1.5	55/25	97	64	19	39	75	12.2	21.5	68	1.0	1.2	Marsh Cr.	25 June 1982
1204	M[a]	3.5	- -	-	-	-	-	-	-	-	-	-	-	Nularvik R.	21 May 1984

Table 1 (Continued.)

Bear number	Sex	Cementum age	Weight (lbs./kg)	Total length	Body length	Hind foot	Neck	Girth	Head width	Head length	Shoulder height	Upper left canine	Lower left canine	General capture location	Date
1205	M	1.5	46/21	101	62	20	39	66	11.2	20.4	61	1.1	1.0	Marsh Cr.	25 June 1982
1205	M[a]	3.5	- -	-	-	-	-	-	-	-	-	-	-	Nularvik R.	21 May 1984
1205	M[a]	4.5	195/89	165	-	-	53	96	16.6	30.6	-	-	-	Tamayariak R.	18 June 1985
1206	F[a]	7.5	165/75	161	78	25	54	100	17.6	29.3	95	2.6	2.2	Hulahula R.	26 June 1982
1206	F[a]	8.5	190e/86	-	-	-	-	-	17.9	29.7	-	-	-	Itkilyariak Cr.	10 June 1983
1206	F[a]	10.5	185/84	157	-	-	51	96	18.0	29.4	-	-	-	Okpilak R.	4 July 1985
1207	M	5.5	190/86	157	104	28	61	93	18.8	32.2	109	3.7	3.5	Hulahula R.	26 June 1982
1208	F[a]	7.5	180/82	160	105	28	58	102	17.7	31.7	93	2.9	2.8	Old Man Cr.	26 June 1982
1208	F[a]	9.5	205/93	-	-	-	58	95	19.5	32.1	-	-	-	Hulahula R.	12 June 1984
1209	M	3.5	125/57	139	85	27	49	81	15.5	29.0	86	3.0	2.9	Hulahula R.	26 June 1982
1210	F[a]	3.5	151/69	154	83	23	53	94	16.7	29.3	91	2.6	2.6	Okpilak.R.	27 June 1982
1210	F[a]	4.5	175/79	156	90	26	55	92	18.0	30.0	99	2.7	2.6	Jago R.	10 June 1983
1210	F[a]	5.5	- -	-	-	-	58	92	18.1	31.1	-	-	-	Okerokovik R.	9 June 1984
1210	F[a]	6.5	215/98	166	-	-	55	123	19.0	31.3	-	-	-	Okerokovik R.	20 June 1985
1211	M[a]	4.5	152/69	143	81	27	53	91	15.8	28.0	84	3.0	2.9	Okpilak R.	27 June 1982
1212	F[a]	13.5	235/107	166	98	25	58	103	21.0	31.7	99	3.0	2.4	Old Man Cr.	28 June 1982
1212	F[a]	15.5	220/100	-	-	-	54	98	21.0	31.7	-	-	-	Okpirourak Cr.	13 June 1984
1213	F[a]	12.5	210/95	170	103	27	61	105	19.7	31.9	92	3.2	2.8	Marsh Cr.	28 June 1982
1213	F[a]	14.5	200/91	-	-	-	67	92	18.1	30.9	-	-	-	Katakturuk R.	7 June 1984
1214	F	2.5	80/36	109	66	22	44	74	14.0	24.6	74	1.2	1.7	Marsh Cr.	28 June 1982
1214	F[a]	3.5	115/52	143	77	26	45	76	14.8	27.7	86	2.3	2.6	Marsh Cr.	28 May 1983
1214	F[a]	4.5	175/79	-	-	-	51	84	17.2	30.6	-	-	-	Carter Cr.	12 June 1984
1214	F[a]	5.5	210/95	166	-	-	57	89	18.1	31.7	-	-	-	Sadlerochit R.	16 June 1985
1215	M	18.5	400/181	194	121	33	83	133	22.7	37.3	112	4.3	3.5	Jago R.	28 June 1982
1216	F[a]	5.5	195/88	163	102	26	65	107	17.5	28.9	100	2.6	2.7	Jago R.	28 June 1982
1216	F[a]	7.5	190/86	-	-	-	53	105	18.1	31.5	-	-	-	Hulahula R.	12 June 1984
1217	F[a]	12.5	250/113	150	107	30	58	98	18.8	29.9	103	2.7	2.5	Jago R.	29 June 1982
1217	F[a]	14.5	225/102	-	-	-	63	101	-	-	-	-	-	Okerokovik R.	6 June 1984
1218	M	2.5	144/65	154	93	29	48	87	14.6	27.7	88	2.3	2.5	Egaksrak R.	29 June 1982
1219	M	4.5	170/77	159	89	27	53	87	16.2	29.6	101	3.2	2.9	Jago R.	30 June 1982
1220	F	10.5	230/104	168	100	25	58	110	19.4	29.5	101	2.9	2.6	Jago R.	30 June 1982
1220	F[a]	11.5	235/107	163	88	26	66	102	20.3	30.9	109	3.0	2.6	Jago R.	8 June 1983
1220	F[a]	13.5	205/93	171	-	-	57	96	20.4	31.7	-	-	-	Jago R.	18 June 1985
1221	M[a]	3.5	150/68	145	80	26	50	96	15.8	27.3	88	2.8	2.9	Jago R.	30 June 1982
1222	M	3.5	120/54	148	82	25	47	87	15.2	26.2	91	3.0	2.7	Clarence R.	30 June 1982
1223	M	6.5	250/113	176	98	27	66	109	19.1	34.6	109	3.1	2.9	Kongakut R.	30 June 1982
1223	M[a]	7.5	245/111	182	97	28	63	99	19.2	33.5	108	3.0	2.7	Jago R.	10 June 1983
1223	M[a]	8.5	210/95	-	-	-	63	104	19.6	34.6	-	-	-	Okerokovik R.	6 June 1984
1223	M[a]	9.5	305/138	175	-	-	60	112	20.3	34.6	-	-	-	Aichilik R.	15 June 1985
1224	M	3.5	190/86	155	99	27	62	96	16.7	31.2	94	3.1	3.1	Beaufort L.	1 July 1982
1224	M[a]	6.5	320/145	196	-	-	66	109	20.3	35.2	-	-	-	Jago R.	15 June 1985
1225	M[a]	17.5	310/141	185	114	28	72	117	22.3	34.2	114	3.7	3.5	Sadlerochit R.	1 July 1982
1225	M[a]	19.5	390/177	-	-	-	67	119	22.4	34.1	-	-	-	Egaksrak R.	14 June 1984
1226	M[a]	10.5	385/175	203	116	28	78	135	22.9	36.8	123	4.1	3.3	Kongakut R.	2 July 1982
1226	M[a]	12.5	400/181	-	-	-	76	126	23.3	37.1	-	-	-	Kongakut R.	14 June 1984

Table 1 (Continued.)

Bear number	Sex	Cementum age	Weight (lbs./kg)	Total length	Body length	Hind foot	Neck	Girth	Head width	Head length	Shoulder height	Upper left canine	Lower left canine	General capture location	Date
1227	F[a]	13.5	255/116	176	120	33	61	113	20.3	32.9	97	3.4	3.0	Kongakut R.	2 July 1982
1227	F[a]	16.5	225/102	-	-	-	59	98	28e	38.0	-	-	-	Kongakut R.	13 June 1985
1228	M[a]	6.5	230/104	167	99	26	59	97	18.7	31.4	95	3.1	2.8	Okpilak R.	3 July 1982
1228	M[a]	9.5	275/125	178	-	-	63	101	20.6	32.8	-	-	-	Canning R.	16 June 1985
1229	M[a]	4.5	- -	143	92	29	53	102	16.2	30.2	109	4.0	3.5	Kongakut R.	3 July 1982
1229	M[a]	5.5	190/86	165	94	31	57	90	16.9	32.0	105	3.8	3.5	Turner R.	13 June 1983
1230	F[a]	7.5	170/77	163	93	25	54	96	17.9	30.3	99	2.9	2.6	Kongakut R.	3 July 1982
1230	F[a]	9.5	150/68	-	-	-	49	94	17.5	30.5	-	-	-	Kongakut R.	14 June 1984
1231	F[a]	2.5	75/34	129	65	23	45	67	14.1	25.6	75	2.6	2.8	Aichilik R.	28 May 1983
1231	F[a]	3.5	145/66	-	-	-	49	84	16.1	29.1	-	-	-	Angun R.	8 June 1984
1232	M[a]	2.5	85/39	136	75	24	47	69	14.4	26.8	90	2.1	2.4	Aichilik R.	28 May 1983
1232	M[a]	3.5	150/68	-	-	-	53	87	16.2	29.6	-	-	-	Angun R.	8 June 1984
1232	M[a]	4.5	220/100	168	-	-	58	100	16.6	32.0	-	-	-	Niguanak R.	19 June 1985
1233	M[a]	12.5	375e/170	186	104	32	63	110	22.4	33.4	109	3.8	3.2	Sadlerochit R.	28 May 1983
1234	F[a]	2.5	90/41	136	75	25	46	79	14.7	26.4	84	2.7	2.8	Turner R.	29 May 1983
1234	F	3.5	140/63	-	-	-	-	-	-	-	-	-	-	Turner R.	8 June 1984
1235	F[a]	2.5	95/43	138	74	24	43	69	14.6	27.4	85	2.7	2.8	Turner R.	29 May 1983
1235	F[a]	3.5	140/63	-	-	-	46	85	15.8	29.4	-	-	-	Kongakut R.	14 June 1984
1235	F[a]	4.5	155/70	153	-	-	50	102	16.8	30.3	-	-	-	Kongakut R.	19 June 1985
1236	F[a]	8.5	195/88	167	97	23	54	110	18.5	31.1	107	2.9	2.5	Okpilak R.	8 June 1983
1236	F[a]	10.5	235/107	175	-	-	60	108	18.6	31.5	-	-	-	Jago R.	8 June 1985
1237	F[a]	2.5	110/50	136	82	20	49	87	15.4	24.7	79	2.8	2.6	Okpilak R.	8 June 1983
1237	F[a]	4.5	180/82	158	-	-	56	100	17.5	27.7	-	-	-	Okpirourak R.	24 June 1985
1238	F	2.5	95/43	127	63	21	47	86	143.	23.8	76	2.6	2.6	Okpilak R.	8 June 1983
1239	F[a]	8.5	230e/104	167	83	27	60	116	19.1	32.5	105	3.2	2.6	Jago R.	8 June 1983
1239	F[a]	10.5	210e/95	-	-	-	63	98	27.0	37.0	-	-	-	Okerokovik R.	13 June 1985
1240	M[a]	6.5	228/103	165	103	30	59	102	18.3	32.9	108	3.7	3.1	Okpilak R.	9 June 1983
1241	M[a]	18.5	355/161	185	106	25	70	123	23.0	35.7	120	3.8	3.2	Okpilak R.	9 June 1983
1242	F[a]	5.5	160/73	163	88	24	53	111	16.2	29.5	101	3.1	3.0	Okerokovik R.	9 June 1983
1243	F[a]	11.5	235/107	170	92	28	59	109	18.4	32.4	110	3.0	2.8	Okerokovik R.	9 June 1983
1244	M[a]	11.5	310/141	194	115	25	73	117	21.0	33.0	105	3.2	2.7	Okerokovik R.	9 June 1983
1245	F[a]	14.5	215/98	168	94	28	58	99	19.1	33.4	109	2.9	2.6	Itkilyariak R.	10 June 1983
1245	F[a]	16.5	235/107	186	-	-	58	126	18.9	33.7	-	-	-	Sadlerochit R.	17 June 1985
1246	M[a]	10.5	340/154	190	107	31	70	113	21.1	35.8	126	3.6	3.1	Itkilyariak R.	10 June 1983
1246	M[a]	12.5	330/150	185	-	-	67	115	21.9	36.3	-	-	-	Limit Cr.	16 June 1985
1247	F[a]	18.5	220/100	174	100	27	61	109	19.4	31.4	110	3.0	2.3	Katakturuk R.	10 June 1983
1247	F[a]	20.5	215/98	170	-	-	55	97	19.0	31.3	-	-	-	Tamayariak R.	16 June 1985
1248	F[a]	10.5	180/82	158	88	25	55	93	19.1	30.7	92	-	-	Kongakut R.	12 June 1983
1248	F[a]	11.5	- -	-	-	-	59	89	18.6	30.6	-	-	-	Kongakut R.	11 June 1984
1248	F[a]	12.5	200/91	142	-	-	55	96	19.0	32.5	-	-	-	Kongakut R.	5 July 1985
1249	F	3.5	110/50	122	74	22	53	86	15.2	28.1	83	-	-	Kongakut R.	12 June 1983
1249	F[a]	4.5	130/59	-	-	-	48	84	16.0	28.5	-	-	-	Kongakut R.	10 June 1984
1250	M[a]	20.5	405/184	197	114	28	80	131	23.0	36.0	124	3.5	2.8	Turner R.	12 June 1983
1251	M[a]	19.5	330/150	182	111	29	77	114	23.9	35.9	113	2.9	3.2	Turner R.	12 June 1983
1251	M[a]	21.5	305/138	181	-	-	64	109	23.9	35.7	-	-	-	Okerokovik R.	19 June 1985

Table 1 (Continued.)

Bear number	Sex	Cementum age	Weight (lbs./kg)	Total length	Body length	Hind foot	Neck	Girth	Head width	Head length	Shoulder height	Upper left canine	Lower left canine	General capture location	Date
1252	F[a]	7.5	195/88	160	98	28	61	99	18.9	31.5	97	2.8	2.7	Kongakut R.	13 June 1983
1252	F[a]	8.5	205/93	-	-	-	57	93	19.2	30.7	-	-	-	Kongakut R.	15 June 1984
1253	M	1.5e	62/28	109	58	-	42	61	12.7	23.1	67	-	-	Kongakut R.	13 June 1983
1254	M	12.5	255e/116	174	104	27	66	93	21.8	34.0	111	3.4	2.8	Old Man Cr.	14 June 1983
1254	M[a]	14.5	275/125	172	-	-	61	115	22.3	33.2	-	-	-	Akootoaktuk R.	21 June 1985
1255	M[a]	1.5	48/22	107	62	19	32	52	12.2	21.2	68	0.9	0.5	Old Man Cr.	14 June 1983
1256	M[a]	4.5	220/100	172	98	30	56	94	18.1	32.8	111	3.7	3.3	Jago R.	15 June 1983
1257	F[a]	8.5	160/73	163	101	27	54	86	18.5	31.3	98	3.0	2.8	Okpilak R.	15 June 1983
1257	F[a]	9.5	190/86	-	-	-	53	89	18.8	31.8	-	-	-	Okpilak R.	13 June 1984
1258	F[a]	9.5	195/88	195	163	26	57	98	17.6	30.8	93	3.1	2.9	Akootoaktuk R.	15 June 1983
1258	F[a]	11.5	215/98	178	-	-	59	103	18.9	30.5	-	-	-	Okpilak R.	21 June 1985
1259	F[a]	23.5	215/98	153	103	25	58	102	19.3	31.4	106	3.4	3.1	Hulahula R.	15 June 1983
1259	F[a]	24.5	195/88	-	-	-	60	94	19.6	32.1	-	-	-	Itkilyariak R.	13 June 1984
1260	F[a]	10.5	220/100	166	107	28	59	108	19.8	32.1	107	3.2	2.9	Egaksrak R.	16 June 1983
1260	F[a]	11.5	255/16	-	-	-	58	110	19.5	32.4	-	-	-	Egaksrak R.	10 June 1984
1261	F[a]	7.5	190e/86	-	-	-	52	89	18.0	31.2	-	-	-	Aichilik R.	21 May 1984
1262	M[a]	10.5	395/179	-	-	-	82	-	24.0	35.9	-	-	-	Okerokovik R.	6 June 1984
1263	M[a]	11.5	300/136	-	-	-	71	108	21.5	36.6	-	-	-	Katakturuk R.	7 June 1984
1263	M[a]	12.5	400e/182	-	-	-	-	-	-	-	-	-	-	Canning R.	16 June 1985
1264	M[a]	11.5	445/202	-	-	-	79	129	24.1	38.2	-	-	-	Aichilik R.	8 June 1984
1265	M	0.5	22/10	-	-	-	26	43	10.7	16.5	-	-	-	Aichilik R.	9 June 1984
1266	M	0.5	17/8	-	-	-	25	40	10.1	15.0	-	-	-	Aichilik R.	9 June 1984
1267	F[a]	10.5	220e/100	-	-	-	63	103	19.3	30.4	-	-	-	Jago R.	9 June 1984
1268	M[a]	3.5	145/66	-	-	-	51	80	15.4	28.1	-	-	-	Egaksrak R.	10 June 1984
1269	F[a]	10.5	175/79	-	-	-	49	79	17.9	31.1	-	-	-	Itkilyariak R.	11 June 1984
1270	M	0.5	14/6	-	-	-	21	39	9.7	15.1	-	-	-	Clarence R.	11 June 1984
1271	M	0.5	15/7	-	-	-	23	37	9.7	15.6	-	-	-	Kongakut R.	11 June 1984
1272	F	0.5	17/8	-	-	-	25	41	9.9	15.0	-	-	-	Kongakut R.	11 June 1984
1273	M[a]	7.5	205/93	-	-	-	56	93	17.9	32.6	-	-	-	Jago R.	13 June 1984
1274	M[a]	4.5	165/75	-	-	-	51	93	15.9	27.3	-	-	-	Niguanak R.	13 June 1984
1275	M[a]	12.5	385/175	-	-	-	63	113	20.7	33.6	-	-	-	Aichilik R.	14 June 1984
1276	F	0.5	15/7	-	-	-	21	36	9.1	15.2	-	-	-	Kongakut R.	14 June 1984
1277	M	0.5	16/7	-	-	-	21	35	10.1	15.8	-	-	-	Kongakut R.	14 June 1984
1278	F[a]	8.5	185/84	-	-	-	50	99	18.5	31.0	-	-	-	Paulaluk R.	15 June 1984
1279	M	0.5	10/5	-	-	-	19	32	9.0	14.3	-	-	-	Paulaluk R.	15 June 1984
1280	M	0.5	14/6	-	-	-	22	37	10.3	15.0	-	-	-	Paulaluk R.	15 June 1984
1281	M[a]	6.5	260/118	-	-	-	61	106	19.9	33.9	-	-	-	Aichilik R.	15 June 1984
1281	M[a]	7.5	280/127	185	-	-	65	102	20.0	36.4	-	-	-	Okerokovik R.	15 June 1985
1282	F[a]	6.5	205/93	-	-	-	53	90	18.2	31.4	-	-	-	Niguanak R.	15 June 1984
1283	M[a]	4.5	195/88	-	-	-	56	90	14.0	30.0	-	-	-	Niguanak R.	15 June 1984
1283	M[a]	5.5	-	-	-	-	59	104	22.0e	35.0e	-	-	-	Niguanak R.	13 June 1985
1284	M[a]	7.5	255/116	176	-	-	60	96	20.2	34.0	-	-	-	Ekaluakat R.	15 June 1985
1285	M	0.5	19/9	78	-	-	24	37	9.9	16.7	-	-	-	Tamayariak R.	16 June 1985
1286	F	0.5	19/9	78	-	-	23	37	9.7	16.1	-	-	-	Tamayariak R.	16 June 1985
1287	F[a]	8.5	215/98	84	-	-	54	92	17.6	34.3	-	-	-	Tamayariak R.	17 June 1985

Table 1 (Continued.)

Bear number	Sex	Cementum age	Weight (lbs./kg)	Total length	Body length	Hind foot	Neck	Girth	Head width	Head length	Shoulder height	Upper left canine	Lower left canine	General capture location	Date
1288	F	2.5	106/48	143	-	-	46	80	14.8	25.8	-	-	-	Jago R.	18 June 1985
1289	F	2.5	105/48	147	-	-	45	87	15.1	25.8	-	-	-	Jago R.	18 June 1985
1290	M[a]	5.5	205/93	177	-	-	54	102	17.5	33.3	-	-	-	Sadlerochit R.	18 June 1985
1291	M[a]	19.5	305/138	200	-	-	63	105	20.6	34.6	-	-	-	Okerokovik R.	20 June 1985
1292	F[a]	6.5	230/104	165	-	-	67	103	26.9	32.6	-	-	-	Aichilik R.	20 June 1985
1293	M	3.5	175/79	151	-	-	51	102	16.5	30.0	-	-	-	Jago R.	21 June 1985
1294	F[a]	14.5	210/95	172	-	-	55	104	19.4	32.6	-	-	-	Jago R.	21 June 1985
1295	M	0.5	29/13	82	-	-	27	48	10.5	17.2	-	-	-	Jago R.	21 June 1985
1296	M	0.5	27/12	85	-	-	29	46	10.2	17.4	-	-	-	Jago R.	21 June 1985
1297	F[a]	7.5	185/84	162	-	-	54	99	18.7	30.6	-	-	-	Okerokovik R.	23 June 1985
1298	F[a]	10.5	200/91	170	-	-	60	107	20.8	31.6	-	-	-	Aichilik R.	23 June 1985
1299	M	0.5	20/9	73	-	-	27	47	9.5	16.3	-	-	-	Aichilik R.	23 June 1985
1300	F	0.5	23/10	83	-	-	27	51	9.9	16.6	-	-	-	Aichilik R.	23 June 1985
1301	F	19.5	205/93	141	-	-	60	113	18.7	29.7	-	-	-	Tamayariak R.	24 June 1985
1302	M[a]	5.5	255/166	177	-	-	62	104	20.0	34.9	-	-	-	Marsh Cr.	24 June 1985
1303	M	4.5	145/66	149	-	-	48	84	15.4	28.0	-	-	-	Aichilik R.	24 June 1985
1304	M[a]	7.5	265/120	175	-	-	62	109	20.1	35.6	-	-	-	Egaksrak R.	25 June 1985
1305	M[a]	12.5	320/145	165	-	-	72	113	21.7	32.6	-	-	-	Egaksrak R.	25 June 1985
1306	M[a]	5.5	195/89	164	-	-	61	97	19.9	34.4	-	-	-	Ekaluakat R.	26 June 1985
1307	F[a]	10.5	190e/86	162	-	-	60	113	20.5	32.6	-	-	-	Egaksrak R.	26 June 1985
1308	M	2.5	85/39	109	-	-	47	81	14.8	25.5	-	-	-	Egaksrak R.	26 June 1985
1309	F	2.5	62/28	99	-	-	38	68	13.6	23.3	-	-	-	Egaksrak R.	26 June 1985
1310	F[a]	8.5	215/98	140	-	-	62	105	20.7	32.1	-	-	-	Aichilik R.	26 June 1985
1311	M	2.5	74/34	119	-	-	41	66	14.6	24.3	-	-	-	Aichilik R.	26 June 1985
1312	F	2.5	97/44	121	-	-	47	67	15.3	26.8	-	-	-	Ekaluakat R.	27 June 1985
1313B	M[a]	14.5	305/138	200	-	-	65	124	23.4	38.0	-	-	-	Turner R.	27 June 1985
1313A	M[a]	4.5	210/95	160	-	-	59	95	19.3	32.7	-	-	-	Turner R.	27 June 1985
1314	M	3.5	110/50	145	-	-	51	75	15.2	28.1	-	-	-	Kongakut R.	27 June 1985
1315	M[a]	7.5	255/116	180	-	-	60	108	20.8	33.9	-	-	-	Ekaluakat R.	27 June 1985
1316	M	0.5	24/11	80	-	-	26	44	9.8	17.0	-	-	-	Jago R.	4 July 1985
1317	M	0.5	21/10	80	-	-	26	47	10.1	16.6	-	-	-	Jago R.	4 July 1985
1318	F	0.5	22/10	73	-	-	27	46	10.3	16.4	-	-	-	Jago R.	4 July 1985
1319	F[a]	6.5	235/107	171	-	-	59	103	19.0	31.7	-	-	-	Tamayariak R.	10 July 1985
1320	F[a]	20.5	280/127	186	-	-	60	114	19.0	32.6	-	-	-	Sikutaktuvik R.	10 July 1985
1321	M	0.5	33/15	86	-	-	29	48	11.3	18.7	-	-	-	Sikutaktuvik R.	10 July 1985
1322	M	0.5	32/15	85	-	-	27	51	12.2	17.6	-	-	-	Sikutaktuvik R.	10 July 1985
1323	F[a]	4.5	175/79	163	-	-	53	87	17.3	30.2	-	-	-	Sikutaktuvik R.	10 July 1985
1324	M[a]	8.5	300/136	177	-	-	63	114	20.0	34.4	-	-	-	Angun R.	10 July 1985

[a] Radio-collared
[b] e=estimated

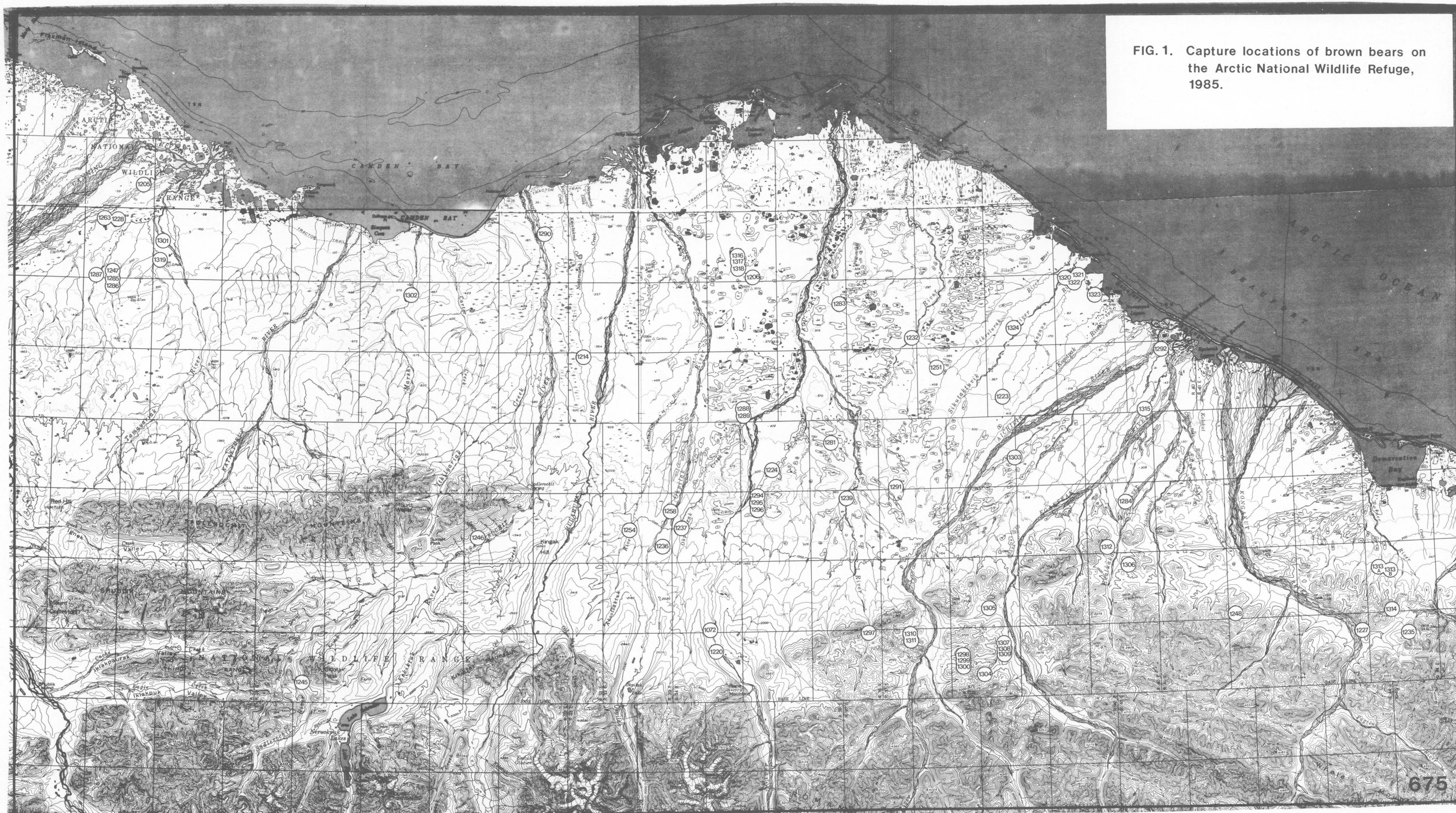

FIG. 1. Capture locations of brown bears on the Arctic National Wildlife Refuge, 1985.

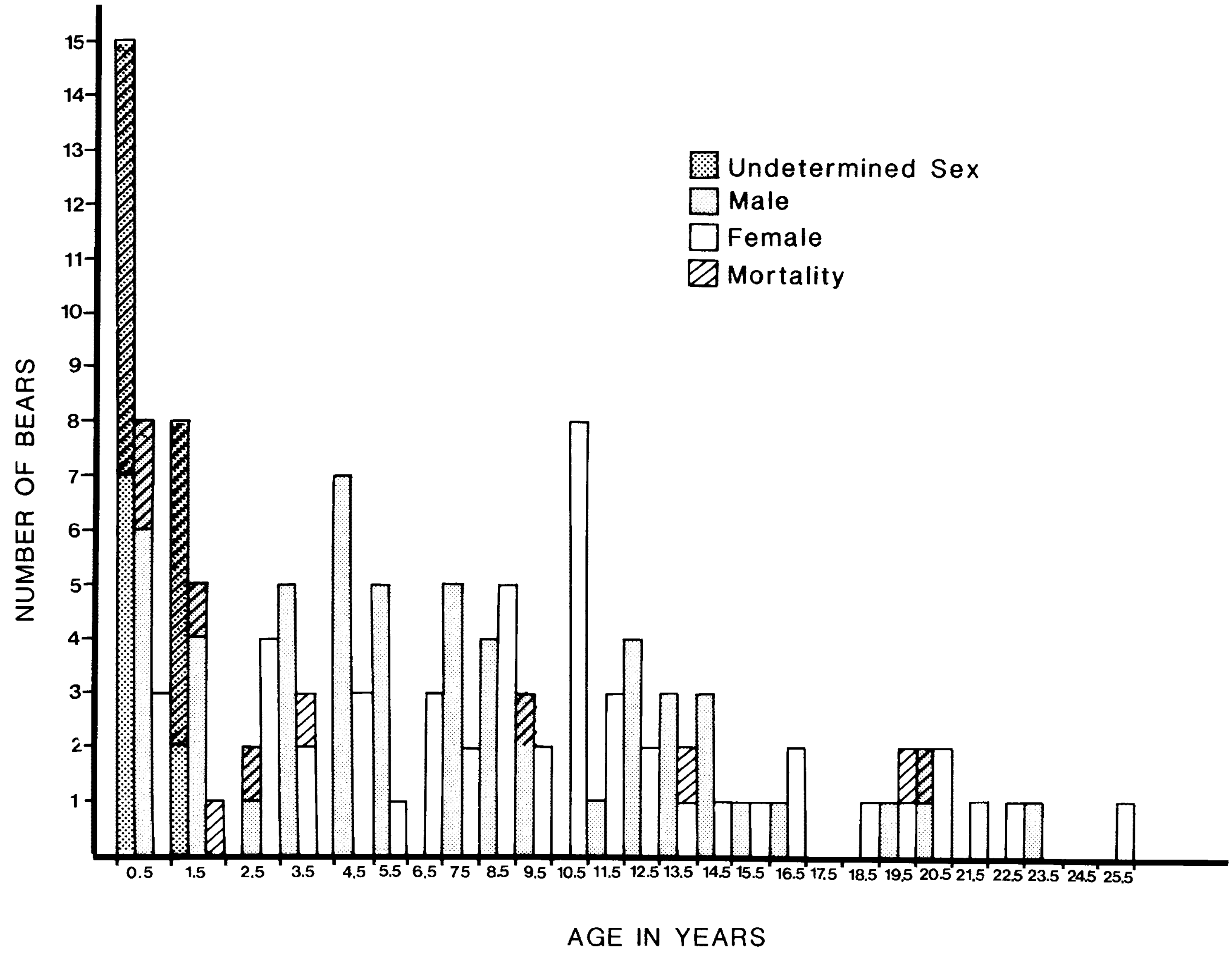

Fig. 2. Age structure of 114 captured bears and 23 associated unmarked young based upon known denning in fall 1984 and subsequent capture of ne individuals in June and July 1985 in the northeastern portion of the Arctic National Wildlife Refuge, Alaska.

theoretical population, while the sex ratio for the 115 captured bears was 61 males and 54 females.

Table 2. Average weights (kg) of adult brown bears in northern Alaska and Yukon Territory.

Sex	Sample Size	Weight Average	Weight Range	Location	Reference
Male	40	139	106-240	interior-southern Yukon Territory	Pearson 1975
Female	21	95	74-12	interior-southern Yukon Territory	Pearson 1975
Male	25	169	-	norther Yukon Territory	Pearson 1976
Female	31	111	-	northern Yukon Territory	Pearson 1976
Male	-	180	136-268	Canning R. drainage, northeast Alaska	Reynolds 1976
Female	18	109	88-41	Canning R. drainage, northeast Alaska	Reynolds 1976
Male	19	167	107-218	northwestern Alaska, NPR-A	Reynolds 1980
Female	24	111	84-177	northwestern Alaska, NPR-A	Reynolds 1980
Male	53	139	93-202	north slope, ANWR	This study 1982-1985
Female	65	94	68-127	north slope, ANWR	This study 1982-1985

This age structure differs from that presented for bears in northeast Alaska along the Canning River (Reynolds 1976). On the coastal plain and adjacent foothills and mountains of ANWR, 60 (65.2%) bears were captured that aged 3.5-11.5 years old, while 32 (34.8%) bears captured aged 12.5 years and older. In contrast to the ANWR data, Reynolds (1976) captured a larger proportion of older age class bears (12.5+ years, n=43, 59.7%) than younger age classes 3.5-11.5 years old, n=29, 40.3%) in the Canning River drainage. Assuming the age structure of captured bears is representative of the population, these data indicate that the declining population status identified by Reynolds (1976) for the Canning River area does not apply to the coastal plain of ANWR. The ANWR populations would have a status of stable or increasing. It should be noted that search and capture efforts during the current study were focused on the coastal plain and adjacent foothills, and intensive search efforts were not conducted in mountainous terrain. Therefore, these data are biased towards bears using the coastal plain and foothill habitats.

Age structure for immature bears in 1982 indicated relatively good survival of young bears through the first 4 years of life (Table 3). During 1982, nine females were captured that had young. All young survived throughout the 1982 monitoring period and all young apparently denned with the maternal female, except bear 1221 (Garner et al. 1983). In 1982, mortalities were recorded for only 2 study related deaths and those data indicated a high survival rate for young bears from 1 year to the next (Garner et al. 1983). The 1983 survival data were not consistent with the 1982 data (Table 3). During 1983, 9 of 17 young brown bears (cubs and yearlings), either died or disappeared from the maternal

Table 3. Maternal female brown bears captured on the Arctic National Wildlife Refuge, their associated offspring, and the fate of those offspring, 1982-1985.

	Offspring				Time period with female			
	1982	1983	1984	1985				
Bear#	No./Age/Sex	No./Age/Sex	No./Age/Sex	No./Age/Sex	1982	1983	1984	1985
1182	2/cubs/FF	2/yrlg/FF	no young	no young	all season	2 disappear 9 June	--	--
1185	2/yrlg	2/2.5yr/FM	2/3.5yr/FM	sow dead 15 Oct 1984	all season	all season	2 separated 5 June	sow dead 15 Oct.1984
1189	--	--	--	1/cub	--	--	--	1 dissapear 19 June
1190	2/cubs/MM	2/yrlg/MM	3/cubs	--	all season	1 emerge den 1 disappear 9 June	sow died at capture	--
1193	--	2/cubs	radio failed 1983	--	--	through 7 Aug (radio failed)	--	--
1197	2/yrlg	2/2.5yr	2/cubs	2/cubs	all season	2 disappear 27 June	2 disappear 23 June	all season
1202	3/yrlg/MMM	3/2.5yr/MMM	3/3.5yr/MMM	sow dead 4 June 1985	all season	all season	1 separated 8 June 2 separated 13 June	sow dead 4 June 1985
1206	--	--	1/cub	3/cubs/MMF	--	--	1 disappear 1 June	all season
1208	2/cubs	2/yrlg	no young	no young	all season	1 disappear 9 June 1 disappear 15 June	--	--
1212	--	1/cub	no young emerge den	3/cubs	--	all season	--	3 disappear 19 June 1985
1213	1/2.5yr/F	1/3.5/F	1/4.5/F	sow dead 18 Sept 1984	all season	all season	1 separated 27 May	sow dead 18 Sept 1984
1217	--	1/cub	2/cubs	2/cubs	--	1 disappear 8 May	2 disappear 16 May	all season
1220	1/3.5yr/M	no data	2/cubs	1/yrlg	until 23 Aug	no data	1 disappear 19 July 1 all season	1 disappear 1 June
1227	2/yrlg	2/2.5yr/FF	collar failed 1983	3/yrlg	all season	1 separated 30 May 1 separated 9 June	collar failed 1983	all season
1230	--	--	2/cubs/FM	1/yrlg	--	--	all season	1 disappear 18 June
1236	--	2/2.5yr/FF	no young	no young	--	2 separated 9 June	--	--
1239	--	2/yrlg	2/2.5yr	2/3.5yr	--	all season	all season	2 separated 28 May
1245	--	2/yrlg	1/2.5yr	3/cubs	--	1 disappear 5 Sept 1 all season	1 disappear 15 May	all season
1247	--	--	2/cubs	2/cubs/MF	--	--	2 disappear 1 June	all season
1248	--	1/3.5yr/F	2/cubs+1 cub	2/yrlg	--	1 separated 17 June	1 disappear 25 June 2 with sow 28 July; collar failed	all season
1252	--	1/yrlg/M	1/2.5yr/M	1/cub	--	all season	1 disappear 5 June	1 disappear 9 June
1257	--	1/yrlg	no young	no young	--	1 disappear - date?	--	--
1260	--	--	1/cub	3/cubs	--	--	1 disappear 8 June	3 disappear 9 June
1261	--	--	2/cubs	no young	--	--	2 disappear 13 June	--
1267	--	--	2/2.5yr	2/3.5yr	--	--	all season	2 separated 19 May
1269	--	--	3/cubs	2/yrlg	--	--	all season	2 disappear 17 May
1278	--	--	2/cubs	no young emerge den		--	--	all season --
1287	--	--	--	2/yrlg	--	--	--	all season
1294	--	--	--	2/cubs/MM	--	--	--	2 disappear 15 July
1298	--	--	--	2/cubs/MF	--	--	--	all season
1307	--	--	--	2/2.5yr/MF	--	--	--	all season
1310	--	--	--	1/2.5yr/M	--	--	--	1 disappear 31 July
1320	--	--	--	2/cubs/MM	--	--	--	all season

sow and were assumed dead. One radio-collared yearling (#1225) was killed by another bear in late June 1983. This apparent mortality represents a 58.9% mortality rate among the cubs and yearling cohorts in 1983. The 1984 survival data for young bears were similar to 1983, with 13 of 24 young bears (cubs and yearlings) wither died or disappeared from the maternal sow and were assumed dead (54.2%) mortality rate). The 1985 mortality rate for cubs and yearlings was 45.0% with 18 of 40 young bears either dying or disappearing from the maternal sow (Fig. 2). Causes for the high mortality rate among cubs and yearlings during 1983-1985 are undetermined. Other adult bears are suspected in this mortality, however no direct evidence exists to support this hypothesis.

One capture-related mortality occurred during 1985 when bear 1228 died on 16 June during the immobilization procedure. This bear apparently died as a result of a reaction to the immobilizing drug M99. Five other mortalities occurred during 1985 (Fig. 2). Bears 1202 (a 19.5-year old female) and 1225 (a 10.5-year old male) died during the late fall or early winter of 1984-1985. Sow 1202 was discovered dead on 25 April. An autopsy revealed 2 near term fetuses. This sow had apparently fallen into a steep canyon and had succumbed to cold temperatures. Bear 1225 was found frozen in the lagoon ice in Camden Bay in April. This bear had apparently walked onto the newly frozen lagoon during early fall, broken through the ice, and drowned. Bear 1311 (a 2.5-year old male) disappeared from the maternal sow on 31 July and was presumed dead, although the 2 year old cub might have been able to survive. Bears 1220 (a 13.5-year old female) and 1293 (a 3.5-year old male) were killed by hunters.

Breeding season normally extends from May through approximately 10 July, with peak of breeding occurring during June. Observations of pairs in 1985 were common during this period (Fig. 3), and pairs observed after late July were probably short-term reassociation of siblings and/or family groups. Sexual maturity in females evidently occurs at 6.5 years of age, with 9 of 33 females with young producing cubs at 7.5 years of age (Table 4). Three females produced cubs when 6.5 years of age. The loss of young bears (cubs and yearlings) noted previously that occurs early in the summer often results in rapid recycling of the maternal females into the breeding cycle. Eight different females lost cubs or yearlings in one year and produced another litter of cubs the following year (Table 4).

Population Characteristics

Conclusions based on data presented here are preliminary and contingent upon further analyses. Because arctic brown bears are generally solitary, wide-ranging, and have low population densities, accurate population estimates and density calculations require intensive capture programs coupled with detailed movements and home range use data collected over a 4 or 5 year period. Similarly, parameters describing population dynamics and productivity, especially litter size, reproductive interval, and survival of young must be recorded for more than 3 years in order to be accurate (Reynolds 1980, Reynolds and Hechtel 1983).

<u>Age and Sex Structure</u>. The age and sex of 172 captured and 66 associated unmarked bears (Table 5) indicates a relatively young age structure. In the 3.5 to 11.5-year old age classes, 95 bears are represented by 49 males and 46

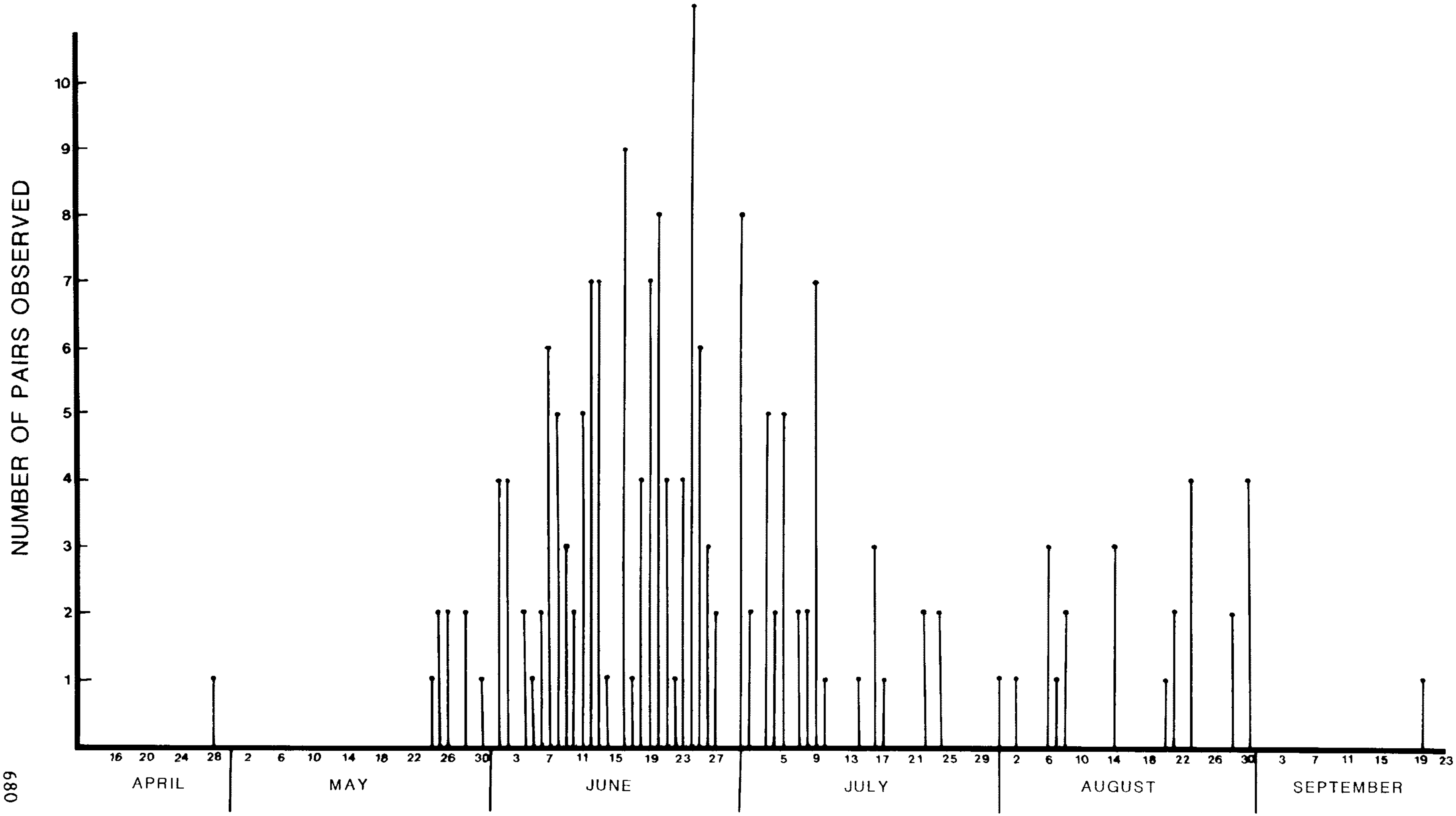

Fig. 3. Chronology of observations of brown bear pairs in the northeast portion of the Arctic National Wildlife Refuge, Alaska, 1985.

Table 4. Age of earlies observed reproduction and known reproductive history for 33 female brown bears in the northeastern portion of the Arctic National Wildlife Refuge, 1982-1985.

Bear #	Cementum age-1985	Reproductive Status 1982	1983	1984	1985	Age at earliest reproduction
1182	18.5	2 cubs	2 yrlgs	none	- -	15.5
1185	21.5	2 yrlgs	2-2 yr	2-3 yr	Dead	17.5
1189	8.5	none	none	none	1 cub	8.5
1190	10.5	2 cubs	2 yrlgs	3 cubs	Dead	7.5
1193	11.5	none	2 cubs	2 yrlgs	- -	9.5
1197	11.5	2 yrlgs	2 yrlgs	2-2 yr	2 cubs	7.5
1202	19.5	3 yrlgs	3-2 yr	3-3 yr	Dead	15.5
1206	10.5	none	none	1 cub	3 cubs	9.5
1208	10.5	2 cubs	2 yrlgs	none	none	7.5
1212	16.5	none	1 cub	2 cubs	3 cubs	14.5
1213	15.5	1-2 yr	1-3 yr	1-4 yr	Dead	10.5
1217	15.5	milk, no cubs	1 cub	2 cubs	2 cubs	13.5
1220	13.5	1-3 yr	1-4 yr	2 cubs	1 yrlg	7.5
1227	16.5	2-2 yr	2-3 yr	unknown	3 yrlgs	11.5
1230	10.5	none, no milk	none	2 cubs	1 yrlg	9.5
1236	10.5	- -	2 yr	none	none	6.5
1239	10.5	- -	2 yrlgs	2-2 yr	3-3 yr	7.5
1245	16.5	- -	2 yrlgs	1-2 yr	3 cubs	13.5
1247	20.5	- -	milk, no cubs	2 cubs	2 cubs	19.5
1248	12.5	- -	1-3 yr	2 cubs	2 yrlgs	7.5
1252	9.5	- -	1 yrlg	1-2 yr	1 cub	6.5
1257	10.5	- -	1 yrlg	none	none	7.5
1260	12.5	- -	none, no milk	1 cub	3 cubs	11.5
1261	8.5	- -	- -	2 cubs	none	7.5
1267	11.5	- -	- -	2-2 yr	2-3 yr	8.5
1269	11.5	- -	- -	3 cubs	2 yrlgs	10.5
1278	9.5	- -	- -	2 cubs	none	8.5
1287	8.5	- -	- -	- -	2 yrlgs	7.5
1294	14.5	- -	- -	- -	2 cubs	14.5
1298	10.5	- -	- -	- -	2 cubs	10.5
1307	10.5	- -	- -	- -	2-2 yr	9.5
1310	8.5	- -	- -	- -	1-2 yr	6.5
1320	20.5	- -	- -	- -	2 cubs	20.5

females. However, the 12.5 and older age classes contained only 41 bears (20 males and 21 females). This age structure would indicate an apparently stable or increasing population. These data are biased towards those bears that frequent the coastal plain and adjacent foothills of ANWR. Bears were only captured along the edges of more mountainous terrain and the central mountains were no searched to capture bears for this study.

Reproductive Biology. Reproductive rates for brown bears are dependent upon the following measures of reproductive biology: age at first production of young, length of the productive life for females, average litter size, and length of the reproductive cycle or reproductive interval, (Craighead et al. 1974, Bunnell and Tait 1980, 1981). Arctic brown bears have low reproductive rates (Reynolds, 1980). Because the proportion of females with offspring in arctic populations is low and reproductive cycles may be 6 years or longer (Reynolds and Hechtel 1983), accurate measures of reproductive rates require long-term observations. As mentioned earlier, the reproductive history of female brown bears in ANWR (Table 3 and 4) indicates a rapid recycling of females into the breeding cycle, when young cubs are lost early in the breeding season.

Interaction Between Brown Bears and Prey Species

Brown bears were observed in the vicinity of caribou (Rangifer tarandus) on 340 different occasions during June-August 1982-1985. In a majority of these instances, caribou did not react to bears nor did bears react to caribou. Bears

Table 5. Age and sex structure of brown bears and associated young captured in the Arctic National Wildlife Refuge, 1982-1985.

Age by cementum (yr)	Number of bears: Age at capture 1982			Age at capture 1983			Age at capture 1984			Age at capture 1985		
	M	F	Unk	M	F	Unk	M	F	Unk	M	F	Unk
0.5	2	2	12	0	0	4	7	2	17	8	3	3
1.5	3	0	4	2	0	12	0	0	2	2	0	2
2.5	1	1	-	1	5	2	0	0	5	2	4	3
3.5	4	1	-	0	1	-	1	0	-	2	0	-
4.5	5	0	-	1	0	-	2	0	-	4	3	-
5.5	2	3	-	0	1	-	0	0	-	4	1	-
6.5	5	1	-	1	0	-	1	1	-	1	3	-
7.5	0	4	-	0	1	-	1	1	-	4	1	-
8.5	0	2	-	0	3	-	0	1	-	1	2	-
9.5	0	0	-	0	1	-	0	0	-	1	1	-
10.5	1	1	-	1	2	-	1	2	-	0	5	-
11.5	1	0	-	1	1	-	2	0	-	0	1	-
12.5	0	2	-	2	0	-	1	0	-	4	1	-
13.5	1	2	-	0	0	-	0	0	-	0	1	-
14.5	0	0	-	0	1	-	0	0	-	2	1	-
15.5	0	1	-	0	0	-	0	0	-	0	0	-
16.5	0	1	-	0	0	-	0	0	-	0	2	-
17.5	1	0	-	0	0	-	0	0	-	0	0	-
18.5	1	1	-	1	1	-	0	0	-	0	0	-
19.5	0	0	-	1	0	-	0	0	-	1	1	-
20.5	1	0	-	1	0	-	0	0	-	0	2	-
21.5	0	0	-	0	0	-	0	0	-	1	0	-
22.5	0	0	-	0	0	-	0	0	-	0	0	-
23.5	0	0	-	0	1	-	0	0	-	0	0	-
24.5	0	0	-	0	0	-	0	0	-	0	0	-
Totals	28	22	16	12	18	18	16	7	24	37	32	8
		66			48			47			77	

were observed chasing caribou on 28 occasion during June 1982-1985. The of these chases resulted in a successful kill in 1985. Bears were observed feeding on caribou carcasses on 72 occasions during 1982-1985. For those instances when the age of the carcass was discernable, 31 were adults and 22 were calves. Caribou did not react to nearby bears unless the bear attempted a chase. These observations indicate the bears utilize caribou as a seasonal food source during June and early July. This use appears to be limited to the time when caribou are present on the coastal plain and adjacent foothills. Preliminary analysis of bear movement data indicate that bears shift their activity areas to the coastal plain when caribou are present. Detailed analysis of concurrent bear and caribou movement patterns in the study area will clarify this temporal and spatial relationships between the two species.

Bears were observed in the vicinity of moose (Alces alces) in mountainous habitats on 28 occasions during 1982-1985. Three unsuccessful chases were observed and moose easily outdistanced the pursuing bear. An unmarked bear was observed feeding on a moose calf during June 1985. Moose were seldom observed on coastal plain habitats and represent an occasional food source in mountainous terrain.

Muskoxen (Ovibos moschatus)were observed in the vicinity of brown bears on 32 occasions during 1982-1985. One unsuccessful chase was observed and bears were observed feeding on a muskox carcass on 3 occasions. Muskoxen are widely distributed on the coastal plain of ANWR and are a potential food source for bears.

Denning

Radio-collared bears were monitored to determine approximate dates of emergence from winter dens (Table 6). Six bears were out of their dens by 29 April, an additional 5 bears by 19 May, and all bears were out of their dens by early June. Inclement weather curtailed aerial monitoring of radio-collared bears, however the general pattern of early emergence by males and non-parturient females and later emergence of females with new cubs (Quimby 1974, Ruttan 1974, Harding 1976) was apparent.

Table 6. Approximate dates of emergence from winter dens for 37 radio-collared brown bears in the Arctic National Wildlife Refuge, 1985.

Bear #	Date first observed out of den	Den type	Associated bears number/age/sex/bear #
1056	26 May	dug	none
1182	28 May	dug	none
1188	28 April	dug	none
1189	26 May	cave	1/cub
1197	25 May	cave	2/cubs
1204	25 May	dug	none
1205	25 May	dug	none
1208	25 May	dug	none
1210	25 May	dug	none
1212	26 May	dug	3/cubs
1214	25 May	dug	none
1217	25 May	dug	2/cubs
1220	26 May	dug	1/yrlg
1223	25 May	dug	none
1226	28 May	dug	none
1230	17 May	dug	1/yrlg
1232	26 May	dug	none
1235	28 May	dug	none
1236	29 April	dug	none
1239	28 April	dug	2/3 yr
1245	24 May	dug	3/cubs
1246	29 April	dug	none
1247	19 May	dug	2/cubs/MF/1285,1286
1251	28 May	dug	none
1252	2 June	dug	1/cub
1257	25 May	dug	none
1259	19 May	cave	none
1260	25 May	dug	3/cubs
1261	19 May	dug	none
1263	24 May	cave	none
1264	28 April	dug	none
1267	29 April	1/2 snow, 1/2 dug	2/3 yr
1269	17 May	cave	2/yrlg
1278	26 May	dug	none
1281	2 June	dug	none
1282	25 May	dug	none
1283	6 June	dug	none

Den sites of 32 radio-collared bears and 5 unmarked bears were inspected in late May 1985 and physical characteristics of each den were measured. Each den was revisited in July 1985 and the vegetational and soil characteristics of the den site were sampled. All dens were located in foothills and mountainous terrain except 3 dens which were located in coastal plain tundra habitats (Table 7). Elevations of all den sites averaged 963.7 $\pm$ 64.7 m (SE) with a range of 29-1954 m. Dens located in mountainous terrain (n = 31) averaged 1077.1 $\pm$ 53.9 m (SE), while dens located in foothills terrain (n = 3) averaged 580.0 $\pm$ 135.2 m (SE). Three dens located in tundra habitats averaged 175 $\pm$ 103.4 m (SE). Average elevation of den sites recorded during 1983 and 1984 in the same study area (Garner et al. 1983, 1984) and to den sites recorded by Reynolds et al. (1976) along the Canning River. Den sites were must common in the middle and upper slope positions (n = 16 and 13 respectively), while the lower 1/2 slope was less common with 7 dens. These results are in contrast to 1984 when dens were equally

Table 7. Physical characteristics of 37 den sites used by brown bears during the winter of 1984-1985 in the northeastern portion of the Arctic National Wildlife Refuge, Alaska.

					Elevation (m)			Slope		Den status	
		Date inspected				Valley		position			
Den #	Bear #	1985	(%) Slope	Aspect	Den	Floor	Crest	(1/3)	Topography	May & June 1985	July 1985
85-1	1261	10 June & 26 July	77	212	695	341	854	upper	mountains	intact	collapsed
85-3	1267	21 May & 29 July	44	118	1075	927	1226	mid	mountains	intact	collapsed
85-4	1205	21 May & 19 July	34	174	957	622	976	upper	mountains	intact	intact
85-5	1203	31 May & 27 July	76	142	750	625	926	mid	mountains	intact	intact
85-6	1202	31 May & 27 July	71	154	838	625	926	upper	mountains	intact	intact
85-6a	unmarked	31 May & 27 July	71	154	841	625	926	upper	mountains	intact	intact
85-7	1247	31 May & 21 July	66	120	787	567	835	upper	mountains	collapsed	collapsed
85-9	1259	21 May & 25 July	61	107	988	570	1082	upper	mountains	intact	collapsed
85-10	1269	05 June & 23 July	43	145	988	433	1268	mid	mountains	collapsed	collapsed
85-11	1264	17 May & 26 July	56	148	957	756	1021	upper	mountains	collapsed	collapsed
85-12	1208	-- 23 July	67	149	1516	1079	1793	mid	mountains	--	collapsed
85-13	1056	-- 23 July	64	117	1363	984	1834	mid	mountains	--	collapsed
85-14	1212	01 June & 22 July	72	127	1216	1165	1988	lower	mountains	partially collapsed	collapsed
85-15	1182	-- 20 July	47	98	1560	1465	1640	mid	mountains	--	collapsed
85-16	1220	04 June & 20 July	62	156	1651	1497	1744	mid	mountains	partially collapsed	partially collapsed
85-17	1283	29 May & 28 July	62	210	122	113	125	upper	tundra	collapsed	collapsed
85-19	1282	17 May & 23 July	56	140	918	720	1140	mid	mountains	intact	intact
85-20	1239	17 May & 25 July	56	179	1244	1110	1366	mid	mountains	partially collapsed	collapsed
85-22	unmarked	-- 25 July	61	175	1531	1123	1954	mid	mountains	--	partially collapsed
85-23	1233	10 June & 28 July	53	170	1012	939	1256	lower	mountains	partially collapsed	partially collapsed
85-25	1223	10 June & 26 July	44	346	360	311	616	lower	foothills	collapsed	collapsed
85-27	1252	-- 28 July	55	217	926	882	1290	lower	mountains	--	partially collapsed
85-28	1189	-- 24 July	60	199	853	678	1283	lower	mountains	--	partially collapsed
85-29	1235	-- 24 July	68	143	1207	868	1480	mid	mountains	--	collapsed
85-31	1260	10 June & 26 July	64	26	854	591	918	upper	mountains	collapsed	collapsed
85-32	1217	22 July	48	258	1086	992	1290	upper	mountains	--	partially collapsed
85-33	1246	31 May & 19 July	50	174	893	720	1220	mid	mountains	intact	intact
85-34	1245	30 May & 21 July	66	153	991	860	1622	lower	mountains	collapsed	collapsed
85-35	1210	-- 20 July	64	200	1954	1786	2256	mid	mountains	--	partially collapsed
85-36	1204	31 May & 27 July	71	93	872	625	926	upper	mountains	intact	intact
85-37	unmarked	-- 21 July	49	210	868	540	1305	mid	mountains	--	partially collapsed
85-38	1214	31 May & 27 July	15	159	375	375	378	lower	tundra	partially collapsed	collapsed
85-39	1263	01 June & 21 July	51	77	854	457	927	upper	mountains	intact	intact
85-40	1236	21 May & 23 July	66	97	826	579	863	upper	foothills	partially collapsed	collapsed
85-42	1188	-- 24 July	57	176	554	255	667	upper	foothills	--	partially collapsed
85-46	unmarked	-- 25 July	104	73	1145	729	1713	mid	mountains	--	collapsed
85-47	unmarked	-- 27 July	31	96	29	26	33	mid	tundra	--	collapsed

distributed among the 3 slope positions (Garner et al. 1985) and to 1983 when no den sites were recorded in the upper 1/3 slope position (Garner et al. 1984).

Twenty-four dens were inspected in late May and early June 1985 and 11 dens were intact, including 7 rock caves, while 6 were partially collapsed and 7 were totally collapsed (Table 7). In July, all dug dens were partially collapsed or totally collapsed except 1 den. One den was a snow den with a bed of vegetation at ground level. This den was located in a small snow-filled creek in coastal plain habitats. No reuse of dug dens was documented during the study and the majority of dug dens were collapsed by late July. The incidence of collapsed dens in July supports Pearson's (1975) and Reynold's (et al. 1974) conclusions that soil depth and moisture content (re. frozen top soil) are important factors in den site selection by northern brown bears. All den sites were well drained and located on slopes ranging from 15-104% ($\bar{x}$ = 58.4 ± 2.5% SE).

Aspects of den sites (Table 7) were examined using circular statistics (Batschelet 1981, Zar 1984). Aspects were concentrated in a southeast direction (Fig. 4), with a mean aspect of 146° (95% C.I., 128°-164°) with an angular dispersion of 48°. Aspects were not uniformly distributed in all directions (Raleigh's test; Z=15.6, P<0.001) and were strongly oriented in a southeast direction (mean aspect = 146°; V-test, u=3.58, p<0.001). Reynolds et al. (1976) reported that 47 of 52 dens (90%) were located on southerly slopes along the Canning River. These data are also in close agreement with aspects (mean aspect = 145°) of 29 dens examined in 1983 (Garner et al. 1984) and 46 dens examined in 1984 (Garner et al. 1985). These data indicate that bear dens in the northeastern Brooks Range are located on slopes with aspects strongly oriented in a southeasterly direction. These slopes are warmer and are normally free of snow earlier than northern facing slopes. Bears may be selecting southeastern facing slopes for the earlier warming trend; however, other edaphic factors may also be influencing this selection (i.e. permafrost depths, etc.)

During October and early November 1985, den sites of 66 radio-collared and 4 unmarked bears were recorded during den surveys. Distribution of these dens were 63 in mountainous terrain, 4 in foothills terrain, and 3 in coastal plain terrain (Fig. 5). In general, all radio-collared bears captured on coastal plain or foothills habitats denned south of their capture sites (Figs. 1 and 5). Chronology of denning indicated that 36 bears were denned by 16 October, while an additional 30 bears were denned by the end of October and 4 additional bears denned in early November (Table 8). Incidence of denning in early November in 1985 was similar to 1983 when 3 of 46 bears denned in early November (Garner et al. 1984). Snow cover was moderate and temperature was mild throughout October. In 1984, 21.9% of the radio-collared bears denned in early November (Garner et al. 1985).

Elevations and aspects of the 70 fall den sites were estimated from 1:63,360 scale topographic maps (Table 8). Average estimated elevation was 809 ± 38 m (SE) and is similar to the average elevations of the 37 measured den sites in summer 1985. Estimated aspects for these 70 fall dens are depicted in Fig. 6. In general, estimated aspects of the 70 dens show a wider dispersion than the 37 den sites visited during summer 1985 (Figs. 4 and 6). However, the southeast and southwest quadrants contained a majority of the estimated aspects of den sites (29 and 24 respectively).

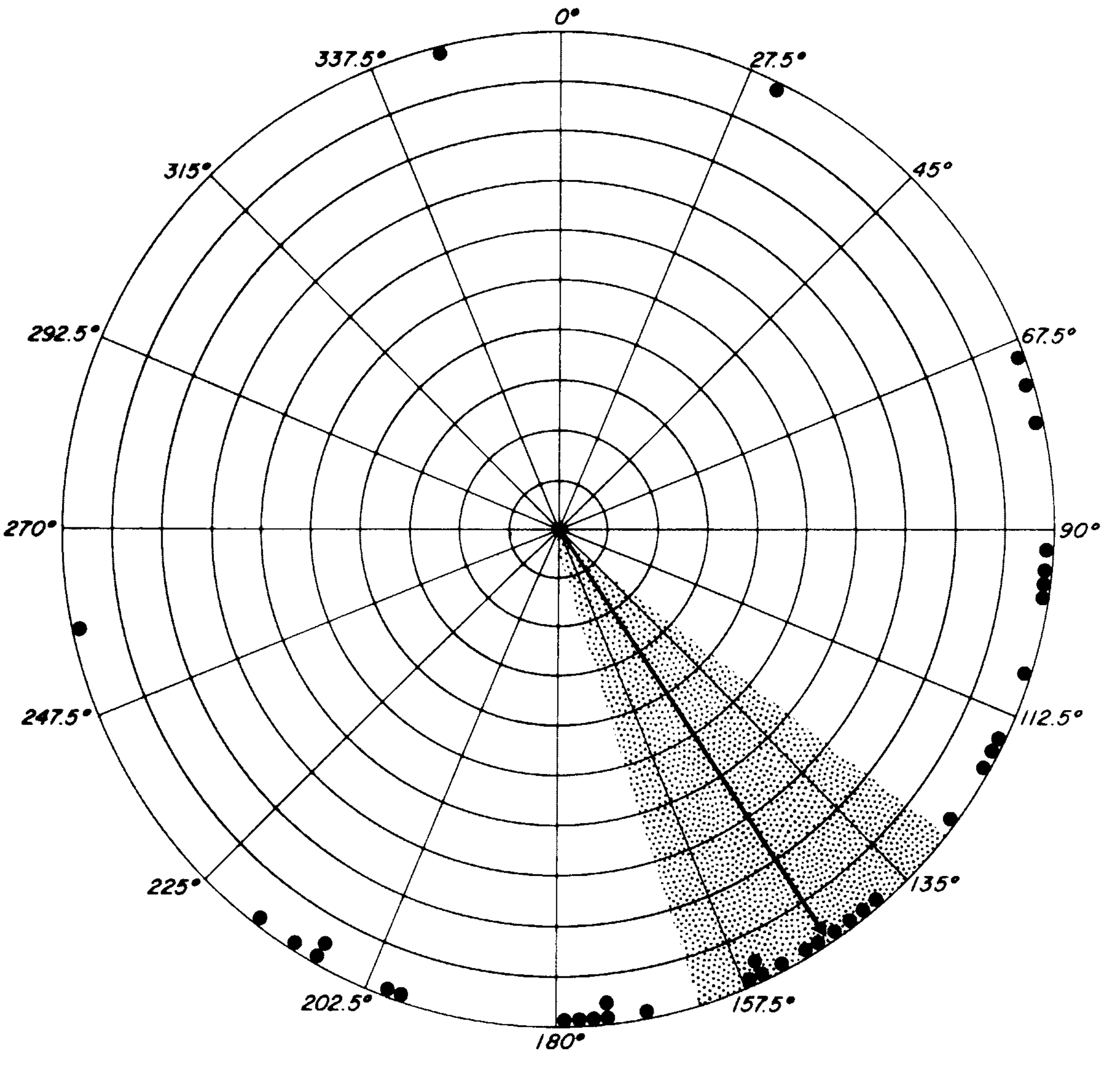

Fig. 4. Aspects, mean aspect (arrow), and 95% confidence interval (shaded area) of 46 bear dens used during winter 1983-1984 on the Arctic National Wildlife Refuge, Alaska.

Table 8. Fall denning characteristics of 70 brown bears in the northeastern portion of the Arctic National Wildlife Refuge, 1985.

Bear #	Reproductive Status	Terrain	Date observed denned	Estimated aspect	Estimated elevation(m)
1056	male	mountainous	13 Oct	82°	975
1072	male	mountainous	13 Oct	122°	1036
1182	probable breeder	mountainous	21 Oct	158°	1173
1189	probable breeder	mountainous	16 Oct	170°	655
1194	male	mountainous	22 Oct	256°	808
1206	3 cubs	mountainous	12 Oct	118°	692
1208	probable breeder	mountainous	13 Oct	8°	914
1210	probable breeder	mountainous	21 Oct	196°	1676
1212	probable breeder	mountainous	21 Oct	231°	1250
1214	immature female	coastal plain	21 Oct	140°	152
1216	probable breeder	mountainous	13 Oct	127°	1250
1217	2 cubs	mountainous	15 Oct	149°	792
1223	male	mountainous	22 Oct	216°	518
1226	male	mountainous	20 Oct	192°	320
1227	3 - 1.5 year old	mountainous	16 Oct	234°	381
1230	probable breeder	mountainous	16 Oct	268°	792
1232	male	mountainous	24 Oct	185°	1082
1233	male	mountainous	11 Oct	88°	899
1235	immature female	mountainous	20 Oct	110°	762
1236	probable breeder	foothills	20 Oct	230°	594
1237	immature female	mountainous	21 Oct	129°	1173
1239	probable breeder	mountainous	22 Oct	184°	930
1245	3 cubs	mountainous	12 Oct	116°	914
1246	male	mountainous	20 Oct	154°	686
1247	2 cubs	mountianous	20 Oct	94°	792
1248	2 - 1.5 year old	mountainous	22 Oct	177°	381
1251	male	mountainous	16 Oct	145°	808
1252	probable breeder	mountainous	22 Oct	118°	1113
1254	male	mountainous	21 Oct	270°	930
1257	probable breeder	mountainous	13 Oct	226°	1509
1258	probable breeder	mountainous	13 Oct	271°	975
1259	probable breeder	mountainous	20 Oct	156°	914
1260	probable breeder	mountainous	16 Oct	233°	472
1261	probable breeder	mountainous	11 Oct	136°	564
1263	male	mountainous	20 Oct	286°	732
1264	male	foothills	22 Oct	204°	472
1267	probable breeder	mountainous	4 Nov	63°	747
1269	probable breeder	mountainous	12 Oct	275°	853
1275	male	mountainous	16 Oct	205°	503
1278	probable breeder	mountainous	20 Oct	156°	518
1281	male	mountainous	5 Nov	163°	1311
1282	probable breeder	mountainous	13 Oct	133°	884
1283	male	coastal plain	2 Nov	256°	152
1284	male	mountainous	5 Nov	210°	716
1287	2 - 1.5 year old	mountainous	12 Oct	346°	884
1288	immature female	mountainous	12 Oct	289	1005
1289	immature female	mountainous	12 Oct	125°	1173
1290	male	mountainous	13 Oct	72°	1128
1291	male	mountainous	13 Oct	258°	1280
1292	probable breeder	mountainous	22 Oct	92°	701
1294	probable breeder	mountainous	12 Oct	270°	1082
1297	probable breeder	mountainous	13 Oct	143°	1280
1298	2 cubs	mountainous	22 Oct	146°	960
1301	probable breeder	mountainous	12 Oct	88°	808
1302	male	coastal plain	21 Oct	89°	91
1303	male	mountainous	15 Oct	140°	1036
1305	male	mountainous	22 Oct	186°	655
1307	2 - 2.5 year old	mountainous	15 Oct	257°	960
1310	probable breeder	foothills	22 Oct	148°	472
1312	immature female	mountainous	15 Oct	7°	442
1313B	male	mountainous	20 Oct	160°	853
1314	male	mountainous	6 Oct	286°	610
1315	male	mountainous	20 Oct	225°	930
1319	probable breeder	mountainous	7 Oct	241	716
1320	2 cubs	foothills	20 Oct	230°	366
1323	immature female	mountainous	10 Oct	134°	914
UM1	---	mountainous	12 Oct	67°	838
UM3	---	mountainous	16 Oct	281°	503
UM4	---	mountainous	16 Oct	122°	518
UM5	---	mountainous	20 Oct	220°	655

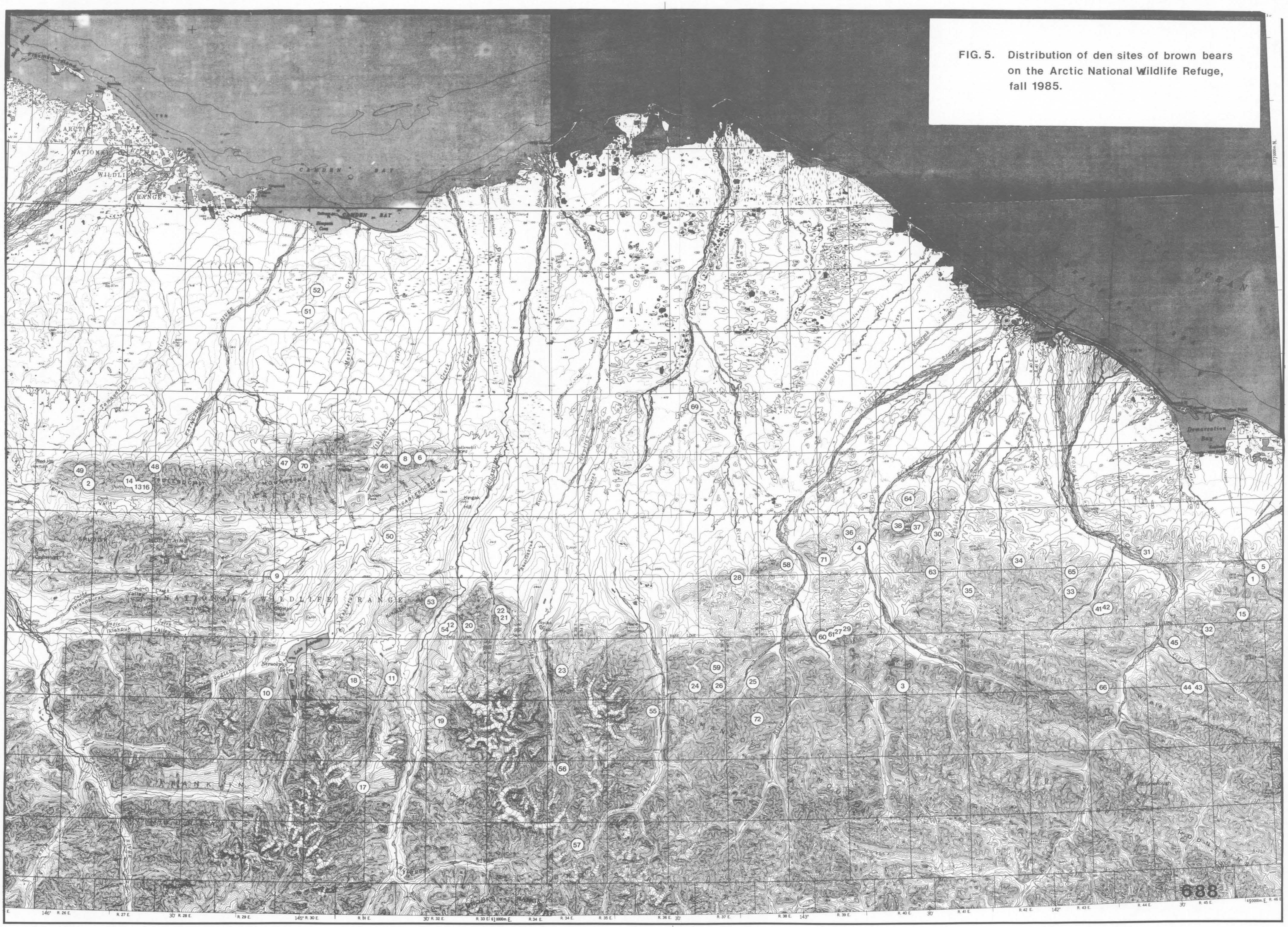

FIG. 5. Distribution of den sites of brown bears on the Arctic National Wildlife Refuge, fall 1985.

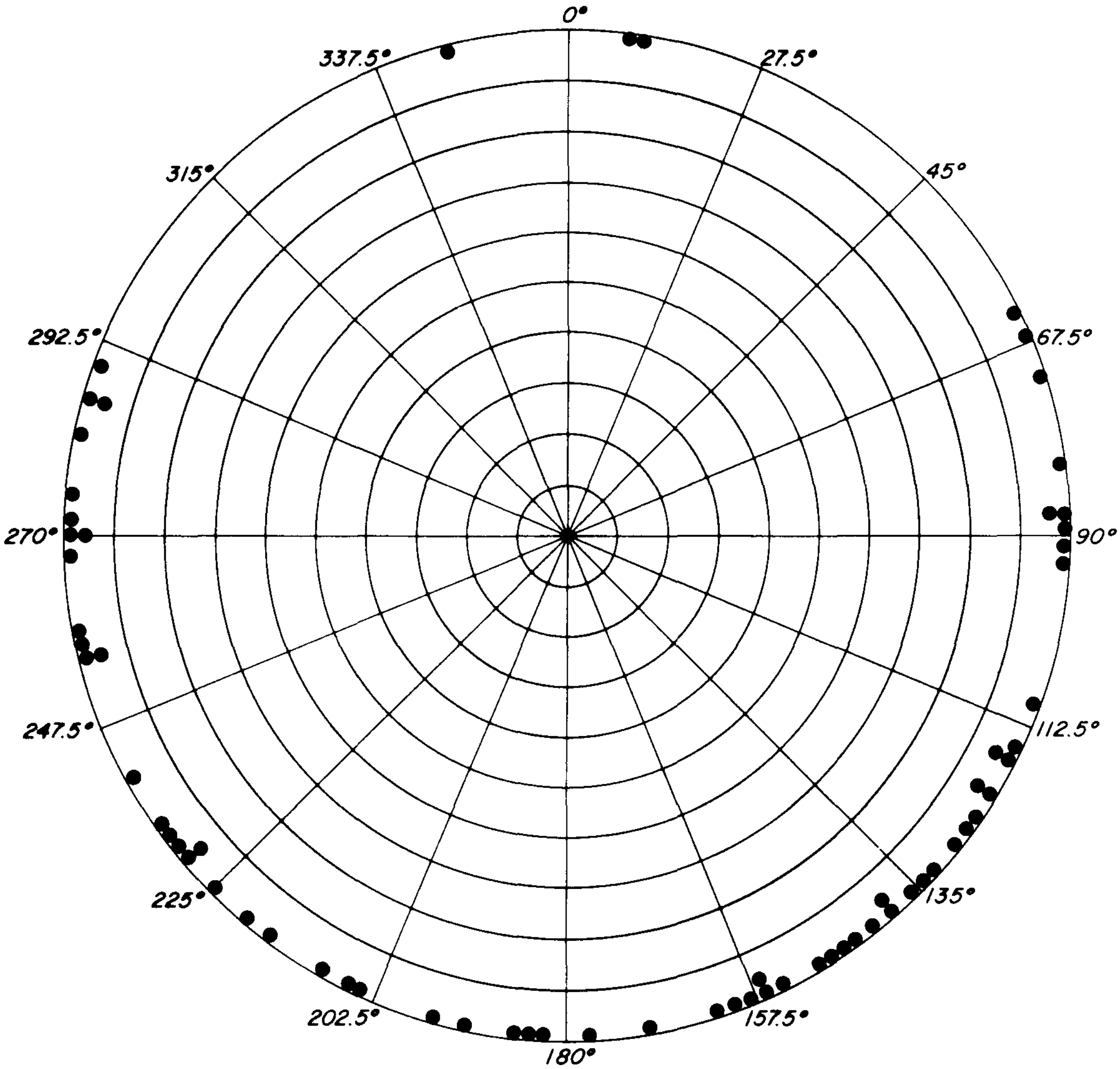

Fig. 6. Estimated aspects of 70 bear den sites located on the Arctic National Wildlife Refuge in October 1985.

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ANWR Progress Report Number FY86-7

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

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Key Words: wolf, movements, northeastern Brooks Range, Arctic National Wildlife Refuge, reproduction, rabies, den sites.

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

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Abstract: Twenty six wolves were captured and radio collared in 1984 and 1985 on the Arctic National Wildlife Refuge. These wolves included members of 8 packs and 11 lone wolves. Average weights were 43.1 kg for males and 36.7 kg for females with the average age being 2-3 years old. Only 5 wolves were 4 years old and older. Activity areas were delinieated for all packs as some packs had insufficient data to accurately define territories. These activity areas were non-overlaping. Only 1 wolf pack had a large scale seasonal shift in areas used. Formation of new packs and long-distance movements were common. One wolf had a documented movement of 770 km, the longest recorded movement in Alaksa. Wolf densities were 1/726 km^2 in 1984 and 1/686 km^2 in 1985 for an area of 24,700 km^2. Litter sizes averaged 3.0 and 4.2-4.75 in 1984 and 1985 respectively. Over-summer pup survival was related to pack size; more pups survived in larger packs. This was in contrast to other studies where pup survival and pack size were unrelated. After wolves had left, den sites were visited, scats were collected, and dens were mapped. Mortality (natural and human induced) was 35% of the fall population. Rabies was documented in the wolf population in the spring on 1985. It is believed that rabies in the wolf population in the arctic is more common than previously thought and may be cyclic in conjunction with outbreaks of rabies in the Arctic fox (*Alopex lagopus*) population.

ANWR Progress Report No. FY85-7

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

Wolves (Canis lupus) are found throughout the state of Alaska and are year round residents of the Arctic National Wildlife Refuge (ANWR). Locations from sightings on ANWR indicate that wolves roam throughout the northeastern Brooks Range and utilize most habitats of the area. Although wolves range primarily in the mountains and arctic foothills, the coastal plain is used extensively by some wolves in early summer with use decreasing after caribou (Rangifer tarandus) have left the area. Data specific to numbers, movements, and prey relationships of wolves on ANWR are limited. Potential impacts from potential oil and gas exploration and development include displacement of parturent female caribou from traditional areas, shifts in territories used by wolves in response to movements of prey species, increased contact between wolves and humans, and increased access to previously remote areas. This report summarizes data colleted during the first two years of a study that was initiated in 1984. The objectives of this study were:

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

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

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

4. Document predatory behavior and social interactions of selected study wolves during the denning season. (This objective was addressed in a secondary study conducted by H. Haugen as part of a Master of Science program through the University of Alaska, Fairbanks).

Methods and Materials

The study area included the coastal plain, adjacent foothills and mountains of the Arctic National Wildlife Refuge and extended south to the continental divide in the Brooks Range, east into Canada and west past the Canning River as necessary to follow movement of collared wolves. A detailed description of the area was presented in the Initial Report - Baseline Study of the ANWR coastal plain (U.S. Fish and Wildlife Service 1982).

Field work was based at Barter Island and extended from 28 April to 8 November 1984, and from 25 March to 25 October 1985. Radio-tracking flights were also conducted on an intermittent basis during winter months. Wolves were captured between 19 May and 5 July 1984 and between 6 April and 24 August 1985 using a Bell 206B Jet ranger helicopter. Fixed-wing aircraft were used to locate wolves and direct the helicopter and capture crew to capture sites.

The drug M99 (Etorphine, 1 mg/ml, D-M Pharmaceuticals) was injected using a Cap-Chur Rifle, 3 cc syringes, and low power charges (Palmer Chemical and Equipment Co., Douglasville, GA). All animals recovered after the antidote M 50-50 (Diprenorphine, 0.2 mg/ml, D-M Pharmaceuticals) was administered at 1.5 times the dosage of M-99. Two-thirds of the M 50-50 dosage was administered intravenously through the cephalic vein in the front leg with the remaining one-third intramuscularly in the rump to offset potential recycling effect of etorphine. Captured animals were measured, weighed, ear-tagged, and fitted with a collar containing a radio transmitter (Telonics, Inc. Mesa, Az). Rectal temperatures were taken using a digital thermometer at the time of immobilization and at periodic intervals during processing. Photographs were taken of the entire animal with detailed photographs of the teeth to be used to confirm age estimates. In addition, blood was drawn from the brachial artery using vacutainers (Bectian-Dickinson, Rutherford, NJ) for seriological study by Alaska Department of Fish and Game (ADF&G) personnel.

Active wolf dens were inspected following abandonment by the pack. The area immediately surrounding each den was searched and all scats and bones were collected. Scat analyses were conducted by the Composition Analysis Laboratory, Colorado State University, Fort Collins, Colorado, and the results were presented by Weiler and Garner 1987. Dens were mapped, measured and photographed at ground level and aerially.

Radio relocations of wolves were plotted on 1:63,360 scale topographic maps. Radio relocations were also digitized and the Map Overlay and Statistical System (MOSS) was used to generate maps, movement vectors, and distances. Activity areas used by wolves were determined by plotting radio locations on 1:250,000 scale maps and subjectively encircling the locations. This area represented a subjective interpretation of the area used by wolves based on radio locations, tracks, and topographical features of the area. Due to limited data on some animals and, in some cases, only 1 collared animal per pack, these areas are not intended as a measurement of territory size and are for discussion of relative movements and areas used by collared wolves.

Results and Discussion

Capture

Twenty-six wolves were captured and radio-collared in the northern portion of ANWR (11 in 1984 and 15 in 1985). Collared wolves included members of 8 packs and 11 lone wolves Four of these 11 are believed to have been members of a fragmented pack). Another pack consisting of 2 wolves was located but the wolves were killed by local hunters prior to denning. All den sites with the exception of the 1984 Sadlerochit pack were located.

Capture efforts were conducted during 28 April to 4 May (no captures) and 5 to 8 July (2 captures) 1984 and 6 to 8 April (3 captures) and 30 April to 1 May (3 captures) 1985. Subsequent capture efforts were opportunistic when wolves were located during survey of capture efforts on other projects. In 1984, most wolves were located during caribou surveys; in 1985 most wolves were located during bear capture and bear denning projects.

Dark colored wolves were more readily sighted than gray colored wolves. This was true for initial sightings and also while radio-tracking wolves and maintaining visual contact with wolves until capture. This contrasts with reports by Ballard et al. (1981) where gray wolves were more easily observed, however, this difference may be the result of the more open, treeless tundra and mountain habitats of ANWR.

Wolves were initially captured using 2.5 cc of M-99, but this dosage was increased to 2.75 cc and again to 3.0 cc after several wolves were not fully immobilized or attempted to escape when approached. No problems were encountered with wolves that were injected with 3.0 cc of M-99 initially. Recovery of wolves after the antagonist M 50-50 was administered intravenously averaged 83 sec with times ranging from 35 sec to 210 sec. Two wolves had M 50-50 injected intramuscularly and recovered in 10 min and 21 min respectively, while 1 wolf recovered before the antagonist was administered and had to be physically restrained while work was completed. It was not uncommon (5 of 26, 19%) for wolves to convulse once after being immobilized. One wolf, a lactating female, experienced four convulsions and an attempt was made to calm her down. According to directions, 2.0 cc of acepromazine maleate (Ayerst Lalso, New York) was administered. After the antagonist (M 50-50) was injected this wolf took a long time to recover (2:30 min.). Although it recovered from the initial drugging, the wolf was so sedated that it had difficulty walkking and remained bedded where captured. This wolf had fully recovered by the following morning, although it had remained at the capture site throughout the night until the effects of the acepromazine subsided.

The combination of spotter plane and helicopter for capture worked very well for wolf capture. Wolves on open tundra and in treeless valleys were highly maneuverable and often had to be chased with the helicopter until they tired before being tranquilized. The spotter plane maintained visual contact with the darted wolf while the helicopter landed some distance from the animal. This method allowed the wolf an opportunity to stop running and calm down prior to the drug taking effect.

Wolves can become overheated during capture efforts in summer due to warm temperatures and length of the chase. Several wolves had temperatures of 41.1°C. When temperatures were elevated, animals were placed on snow or in water until temperatures declined to 39.4°C before being processed. One wolf was immobilized on aufeis and her temperature dropped from 39.9°C to 35.9°C in 16 mins. The wolf's body temperature returned to normal (38.4°c) faster than expected based on experience with brown bears in the same area.

Physical Characteristics

Adult males from most areas average 43-45 kg, while adult females average 36-39 kg (Mech 1970). Wolves captured on ANWR during 1984-1985 (Table 1) averaged 43.1 kg for males (N=15) and 36.7 kg for females (N=9). However, captures occurred between May and August, a time of year considered by Seal and Mech (1983) as a period of weight loss in wolves. Seal and Mech (1983) and Peterson et al. (1984) showed seasonal variation in weights of wolves and suggested this variation was due to reduced food intake. Stephenson (pers. comm.) suggested that prey species are less fat at this time of year. One wolf (a 4-year old male), which was captured twice on ANWR, weighed 52.2 kg in July and 55.8 kg the following April. Although wolves on ANWR were at the lower end of Mech's scale (1970), their

Table 1. Physical measurements of wolves captured during 1984 and 1985 on the Arctic National Wildlife Refuge, Alaska.

Wolf No.	Date of Capture	Sex	Color	Est. age (yrs.)	Weight lb/kgs	Body (cm)	Tail (cm)	Heart girth(cm)	Upper canine(mm)	Lower canine(mm)	Reproductive condition
1984											
1	19 May	M	Dark brown	1	84/38.1	128	46	76	26.1	26.1	Testes withdrawn
2	2 June	F	Tawny	3	85/38.6	121	43	70	25.5	22.5	No evidence of breeding or suckling
3	5 June	M	Gray	1-2	87/39.5	131	45	75	27.8	25.6	
4	25 June	M	Black	2-3	100/45.4	137	46	71	28.5	27.9	Not fully distended
5	25 June	M	Gray	3-4	94/42.7	121	46	79	31.8	26.9	
6	26 June	F	Dark brown	2	72/32.7	114	40	68	28.8	25.4	No evidence of breeding or suckling
7	27 June	M	Brown	3	99/44.9	140	46	78	28.5	25.8	
8	27 June	F	Brown	2-3	88/39.9	117	42	77	27	25.5	No evidence of breeding or suckling
9	30 June	F	Gray	2-3	88/39.9	134	48	83	24.3	23.5	No evidence of breeding or suckling
10	5 July	M	Gray	4	115/52.2	142	49	80	32.6	27.7	Testes - left L-41mm W-22.2mm
11	5 July	F	Dark	6-8	65/29.5	117	45	59	R - 18.4 L - 26.4	R - 23.8 L - 24.2	Has been suckling; L 11.4 ; W 8.3; Lactating
1985											
12	6 Apr.	M	Gray	1-2	95/43.1						
10	7 Apr.	M	Gray	5	123/558						
13	7 Apr.	F	Gray	3-4	80-90 est	133	48		27.4	25.3	No evidence of breeding or suckling
14	7 Apr.	F	Gray	2-3	96/43.6	175	51		26.2	25.0	No evidence of breeding or suckling
15	1 May	F	Gray	1	78/35.4	108.5	53.6	69.2	25.3	24.1	No evidence of breeding or suckling
16	1 May	M	Black	5-7	102/463	121.5	50	82.5	30.3	27.2	Distended
17	1 May	M	Black	3	??	123	50	79.8	30.0	28.2	Distended
18	17 May	F	Dark Brown	1-2	70/31.8	117	50	70.5	20.1	14.4	No evidence of breeding or suckling
19	19 June	M	Brown	3-4	77/35	118	52	70	29.4	26.8	Distended
20	25 June	F	Brown	3-4	86/39	124	46	70	30.8	27.7	Suckling
21	27 June	M	Gray	1-2	94/42.7	126	46	70	22.6	20.7	Distended
22	1 July	M	Black	2-3	97/44	118	37	74	30.6	28.2	
23	1 July	M	Black	2-3	93/42.2	127	42	70.5	29.3	27.1	
24	3 July	M	Gray	4-5	94/42.7	125	48.5	75	27.4	26.0	
25	23 Aug.	M	Gray	2	96/43.6	130	53.5	69.5	29.15	26.7	Not fully distended
26	24 Aug.	M	Black	2-3	96/43.6	126	53	73	26.8	25.4	Not fully distended

average weights were almost 3 kg heavier than wolves captured on the Kenai Peninsula, Alaska during the same time periods. Kenai wolves averaged 40.3 kg for males and 33.2 kg for females (Peterson et al. 1984).

Age Structure

In 1984 ANWR wolves averaged 2.6 - 3.2 years of age while in 1985 they averaged 2.7 - 3.5 years of age (Table 1). Only 5 wolves were estimated to be 4 years old or older (Table 1). This age structure may not reflect the true age structure of the population due to biases created by the capture efforts. Most wolves were captured opportunisticly. Seven of 11 wolves in 1984 and 10 of 26 wolves altogether were captured on the coastal plain. Two of these were estimated at 3-4 years of age while the remainder were less than 3 years of age. There is some evidence that younger and dispersing wolves may utilize the coastal plain more than older wolves (see movements and dispersals). Older wolves may have been more adept at avoiding aircraft as a result of experiences with aerial hunting in the past. Wolves at or near a den site were intentionally avoided during capture efforts. Therefore, older animals, especially breeding females, active in rearing pups near the den site would not have been captured. However, in 1984 and 1985 , 40.7% and 54.5% respectively of the estimated minimum fall population was collared. The age structure is therefore considered a useful indicator of relative composition of the adult wolf population.

Fritts and Mech (1981) commented on the apparent greater susceptibility of females to being trapped. On the Kenai Peninsula, wolves captured during summer trapping were also composed mainly of females (7M, 19F) (Peterson et al. 1984), but wolves captured using aerial darting techniques during winter had a larger proportion of males (13M, 9F), although Peterson et al. (1984) determined that this ratio was not significantly different from 50:50. Wolves darted on ANWR included more males (16M, 10F) (X^2=1.38, 0.25<P<0.1). If uncaptured alpha females, are included, the sex ratio becomes 16M:15F, 50:50 (X^2=0.32, 0.75<P<0.5). It is not known how many of the captured wolves were alpha males. If males from packs where there is doubt about which animal was the alpha male are added, then the sex ratio remains the same as that of captured wolves.

The significance of the apparent greater proportion of males in the ANWR wolf population is not known, although, methods employed while capturing wolves on ANWR may have been biased toward taking males and lone wolves or dispersing animals may have been more readily detected and captured. Eleven (8M, 3F) wolves were captured which were not associated with packs. Four of these were believed to be part of a fragmented pack and 4 others either joined packs or were associated with other wolves at a later date.

Color

Wolves on ANWR ranged in pelage color from light tawny (almost white) to black. Among captured wolves, the most common pelage color was gray (17), followed by brown (13), black (5), and tawny (4). In 96 miscellaneous sightings of wolves, the proportions of colors were similar to captured wolves with gray (56), brown (17), black (17), tawny (5) and white (1). Dark brown wolves often appeared black from aircraft, while light colored wolves appeared to be white. It is likely that during miscellaneous sightings, some brown wolves were recorded, as black. One white wolf was recorded, but it may have been a light tawny color. Gray wolves usually had dark markings and many had a dark crescent shaped patch across the top of the shoulders. Brown wolves often had faces and lower legs that tended toward black with a light colored crescent shaped patch across the top of the shoulders. Tawny wolves were light colored with a light tan-gray along the back and down the sides, fading to almost white on the belly. The Canning pack (all gray's) was the only pack whose members were all the same color.

Pack/Wolf History

Prior to this study, only 3 wolf packs had been documented on ANWR. Active packs had been seen on the Canning and Kongakut Rivers, and a pack had also been observed on the Hulahula River until 1977, when Chapman (1978) documented an outbreak of rabies. In 1984, 4 active packs were documented on ANWR (Canning, Sadlerochit, Aichilik, and Kongakut). In 1985, only 1 pack from 1984 was still active while 4 new packs were located (Canning, Hulahula, Egaksrak, Drain Creek, and Malcolm).

<u>Canning Pack</u>.

Wolves have denned in this portion of the Canning River since 1972 (Quimby 1974). Another den site that apparently was used in recent years was located in 1984. On 15 March 1984, 5 gray wolves were observed on the Canning River several km north of the Marsh Fork junction and the 1984 den site. It is likely that this was the same pack that denned on the Canning that year. Observations of the den were difficult to obtain due to heavy willow growth around the den. No pups were observed and few pup scats were found after the wolves abandoned the den in late June-early July (Haugen 1985). It is believed that this pack failed to raise any pups in 1984.

On 26 June 1984 a small tawny colored wolf was located 6 to 8 km north of the den site, but was not captured. A large gray male (#10) was located and captured at the same location on 5 July. This wolf was located 3 times between 7 July and 7 August, alone on the Marsh Fork. The Canning pack was never located after it left the den and wolf #10 was not found in 1984 after 7 August despite several extensive searches of the area and areas farther south.

On 2 April 1985, wolf #10 was again located on the Canning River, traveling with a smaller gray wolf. Four gray wolves were found on the Marsh Fork on 7 April (#10 and 3 unmarked). Two of the unmarked grays were captured and were both females (#13, a 3-4 year old and #14, a 2-3 year old). The fourth wolf which was not captured was also believed to be a female. Wolf #10 was located with wolves #13 and #14 on 11 April and alone on 26 April. This wolf was not relocated again. Although transmitter failure is the most probable cause, the wolf was never observed at the den site.

Wolves #13 and #14 were located on the upper Canning River on 25 April 1985. On 31 May, #14 was in the vicinity of the old den site, while #13 remained at the upper Canning location. Wolf #13 was located 4 times between 31 May and 19 June at the same location indicating a possible second den site. On 25 June it was seen at the lower den with an unmarked gray, and on 30 June, it was found dead approximately 2.5 km from the lower den. Cause of death was undetermined, but necropsy results indicated that a possible cause was viral pnemonia or bronchitis. The upper Canning site, 26.5 km south of the lower den and was visited on 8 July. The den was a single hole in a bank and no scats or evidence of pups in the den were found. Placental scars showed that #13 had had at least one pup.

Wolf #14 was located 6 times between 31 May and 21 July 1985 with all locations being at or in the vicinity of the lower den. Six locations between 21 July and 20 August were all at the den site, but the den was not visited until after it was not occupied. On 28 July, observers at the den saw an adult unmarked gray with one pup, a short distance upriver from the den. The carcass of wolf #14 was removed from the den on 23 August. The wolf had apparently been dead for 2-3 weeks and had a large number of porcupine quills were protruding from the muzzle and face. Neither the unmarked adult or the pup were located after 28 July.

Sadlerochit Pack.

No reports of a wolf pack in this area were previously recorded, although tracks of wolves were observed and the area was frequented by local residents hunting for wolves.

The Sadlerochit pack was first observed hunting caribou on 6 March 1984 and contained 8 wolves, 7 dark and 1 gray. Several days later 3 wolves from this pack were shot by local hunters.

In the summer of 1984, the Sadlerochit had 3 adult members. On 26 June 1984 a brown 2-year old female (#6) was captured and a brown 6 to 8 year old lactating female (#11) was captured on 5 July. A third wolf, a large gray male, eluded capture twice. The pack utilized the area on and near the Sadlerochit River until late July. In late July and early August the pack expanded their range to include the Canning River and Cache and Eagle Creek. On 7 August a lone wolf pup was observed following an adult caribou in Ignek Valley. The pup was first observed with the pack on 29 August. The 1984 den site was never located although an old den site, possibly from the previous year was found. This pack probably denned in this area for at least two years prior to 1984.

In mid-October 1984 a black wolf had joined the pack while the young female (#6) moved east to the Okpilak River. Wolf #6 was located 5 times between 15 October and 6 November. All sightings were on the Okpilak River with the exception of the 3 November location when the wolf was east of the Jago River near a caribou carcass. The remainder of the pack continued to use the Sadlerochit area. Between 8 November 1984 and 5 March 1985 the pack was located 3 times.

On 16 March 1985, wolf #11 and an unmarked dark wolf were shot by local hunters. Two other wolves (dark and gray) were observed running away. A grey, 2-3 year old male, wolf #12, was captured on the Sadlerochit River on 6 April 1985. This wolf died 2 weeks later of rabies. It is not known if this wolf was a member of the Sadlerochit pack. No other wolves or sign of the pack was found during 1985.

Hulahula Pack.

There were at least 2 historical den sites known on the Hulahula River. In 1977, Chapman (1978) documented the death of at least 6 of 10 members of a pack due to rabies. Spindler (1982, unpublished data, ANWR files) reported hearing pups howling and seeing a lactating female in July 1982. This is the only known report of wolf sightings in the area since 1977, although tracks were sometimes seen along the river. The Hulahula den found in 1985 was 37.5 m south of an old den site which was extensively developed and had been used repeatedly although not in recent years.

After leaving the Sadlerochit pack, wolf #6 stayed in an area adjacent to an area used by its parent pack throughout the winter. On 20 March 1985, wolf #1 (from the Aichilik pack) was shot in this area. At the time, it was with another wolf, possibly #6. On 18 May 1985 wolf #6 was located at a den, although no ohter wolves were seen in the area. Wolf #6, possibly bred by wolf #1 prior to its death, remained at the den, throughout June. The first pup was observed on 13 June. On 15 July, #6 was seen with 2-3 pups downstream from the den while 2 other pups were seen at the den. On 22 July, another adult gray wolf was seen at the den with wolf #6 and 4-5 pups, for the first time since #1 was shot. An observer at the den on 25 July reported a golden eagle perched on the bank above the den. About 45 min later, a pup was heard to yelp several times as if being hurt, but neither the eagle nor the pup could be located. Both adults and 4 pups were at the den on 2 August but the den was abandoned by early August. On 23 August a gray 2 year old male (#25) was captured on the Canning River approximately 58 km west of the Hulahula den site. By 9 September, #25 had joined the Hulahula pack, which was now 6 members as another pup had been lost. During the winter this pack gradually moved back into the area previously used by the Sadlerochit pack. Beginning in May 1986, radio relocations indicated that wolf #25 had shed the collar. However, when the collar was retreived, it had been cut and wolf #25 had probably been shot. The pack, containing #6 reoccupied the 1984 Sadlerochit den site in 1986.

Aichilik Pack

No previous reports of wolves in this area were known, but the development of the den site, first located on 12 June 1984, indicated that either this pack had existed for several years prior to 1984 or that the site was a historical site that was used by the pack when it moved into the area.

The Aichilik pack consisted of 7 wolves in 1984 - 3 dark brown, 1 black and 3 gray, including the breeding female. This pack reared 4 pups in 1984 but the den site was not occupied in 1985. Both collared wolves (a 1-year old male, #1, and a 2- to 3-year old female #8) used the coastal plain in the vicinity of the Aichilik River extensively during the month of June. Wolf #1 traveled east into Canada between 4-17 July and then returned to the vicinity of the Aichilik River. Wolf #8 traveled east as far as the Kongakut River on 23 July and then returned to the Aichilik River area. Both of these movements were probably due to the wolves searching for caribou, as the caribou migration had reached the mountains near the Upper Firth and Kongakut Rivers by this time and few caribou remained on the coastal plain area. Both wolves were usually alone when they were relocated. Only once after the pack left the den site was either collared animal found with the pack. Due to poor flying conditions, the pack was located only once, between August and November, on 17 October. On 17 November, wolf #8 was tracked near Double Mountain, on the Sheenjek River. However the wolf was not visually observed and it is unknown if she was alone or with the pack.

Wolf #1 was not located again until 20 March 1985 when it was shot while accompanied by another wolf near the Hulahula River. The other wolf is believed to have been wolf #6. Wolf #8 was located on Juniper Creek west of the Canning

River on 4 April 1985. This wolf has not been located since, despite extensive searches in the area between the Canning and the Sagavanirktok Rivers.

A pack of 5 wolves was observed on the Jago River on 30 April 1985, and the following day wolves #15 (gray 2 year old female) and #16 (black 5-6 year old male) were captured. Wolf #18 (brown, 2 year old female) was captured in the same area after being located with #15 on 17 May. Wolf #16 was found dead approximately 14.5 km upriver the same day. Tracks in the snow indicated that wolf #16 had been with 3-4 other wolves, but these animals could not be followed as they moved into a narrow side drainage. Wolf #16 tested positive for rabies. Wolf #15 was located near the old Aichilik den on 18 June with a brown wolf, and again on 19 June when the brown wolf (4 year old male) was captured (#19). Wolf #24 was captured in the same area on 3 July. All these wolves (except #24) were associated at one time or another and all were thought to be members of the Aichilik pack. It is probable that other members of this pack died from rabies as did wolf #16. It's believed that this pack did not den in 1985 and the pack may have fragmented after the death of 1 or more members.

Wolves #15, 18, 19, and 24 all used the same general area which included the Jago and Aichilik Rivers. Wolves #15 and 19 used the coastal plain between the 2 rivers as well as the mountains, while #18 and 24 were not relocated on the coastal plain. In late July, wolf #15 began traveling with wolf #19. They were together until last located on 22 October 1985. Wolf #18 was located 14 times between 17 May and 23 July 1985 when interference on her frequency interfered with attempts to relocate her. She was found on 3 May 1986 near Itkillik Lake approximately 270 km SW of her last location. Wolf #24 was located 9 times between 3 July and 20 October. At this time it had crossed the divide of the Brooks Range and was located on the upper Sheenjek River. When next located, on 9 March 1986, this wolf was on the Hulahula River near an historical den site. On 4 April it was in the same general area and back near the old den site on 5 June. An active den in the area was suspected.

Egaksrak Pack

No reports of wolves in this area were known. The den site was a first year den with a simple structure. It is not known how long this pack had existed, but the pack size indicated that it had existed for several years. It is possible that the pack existed in 1984 and was not detected even though numerous surveys of the river were conducted. It is also possible that wolf #2 (see Malcolm pack) was a member of this pack, although it was never tracked to a den or observed with other pack members.

This pack consisted of 5 adults, which raised 5 pups in 1985. A lactating 3-4 year old female (#20) was captured on 25 June 1985. The den was first located on 5 July. Wolves abandoned the den in early August. Wolf #20 was located 18 times between 25 June and 24 October. When wolf #20 was away from the den (before abandonment) she was always alone. However, after abandoning the den, she was always with the pack. In general, all locations of wolf #20 and associated sightings of the pack were on the Egaksrak River. Three wolves (believed to be part of the pack) were observed on a side drainage of the Kongakut River. The pack was located once on the Kongakut River on 26 September and once on the Aichilik River (east fork) on 15 October. On 4 December, the signal of wolf #20 was heard (but not located) near the September location on the Kongakut River. Although it is difficult to determine the pack's use of the

Kongakut River, it seems likely the pack used part of the area on the west side of the Kongakut that overlapped part of the 1984 Kongakut pack's territory. The Kongakut pack did not den in 1985. In June 1986, wolf #20 was located on the Aichilik River and the pack apparently occupied the 1984 Aichilik den site.

Drain Creek Pack

This pack had probably existed for a number of years. Tracks of wolves in this area of the upper Kongakut were commonly seen and discovery of the pack and den in 1985 only confirmed earlier suspicions.

The Drain Creek pack consisted of 6 wolves and raised 4 pups in 1985. On 1 July 1985, 2 black 2-3 year old males (#22 and 23) were captured. The den was located on 7 July and pups were first observed at that time. Wolves #22 and #23 were located 17 and 15, times respectively, between 1 July and 24 October. Until early September, both wolves were usually alone, although they were often in the same general area. In September, the wolves were usually with other members of the pack, with #23 often being accompanied by several of the pups. The whole pack was never observed together. The wolves were usually in the Drain Creek and upper Kongakut River area and extending into the upper Firth River and Mancha Creek areas. The pack was still in the Drain Creek area in December and appeared to have remained in the vicinity throughout the winter. The pack denned in the same site in 1986.

Kongakut Pack.

This pack has existed since at least the mid-1970's. The den site has been used most years since 1975 and is well known to people familiar with the area.

This pack consisted of 6 wolves which reared 2 pups in 1984 at a den site that was used in previous years. A graduate study at the den site was conducted by H. Haugen (Haugen 1985). On 27 June, Haugen reported seeing several wolves of the Kongakut pack traveling up one of the tributary drainages of the Kongakut River. This drainage was searched and a brown, 3-year old male (wolf #7) was located and captured. Between 27 June and 28 July this wolf was located 5 times. In each case, the wolf was alone and on the Kongakut River. This wolf then disappeared and was not located until 20 September. At this time it was in the vicinity of the Bell River in Canada, a movement of over 193 km from its last location. On 6 December it was again located in the mountains west of Aklavik, Canada, a subsequent movement of approximately 64 km. This last movement coincided with the northeast movement of caribou into the area around Aklavik. Wolf #7 was not located again until April 1986 when it was shot approximately 113 km west of Tuktoyaktuk, Northwest Territories, near the Kugalik River. This wolf had moved of over 240 km from its last December 1984 location and was with 4 other wolves when it was shot. Haugen reported 2 brown wolves frequenting the Kongakut den. After wolf #7 was captured, Haugen reported that the 1 brown wolf never returned to the den. Although it is possible that #7 was not a member of the Kongakut pack, Haugen's observations suggested that it was.

On 30 June, wolf #9 (gray, 2- to 3-year old female) was captured on the Kongakut River. Wolf #9 was located 6 times between 30 June and 13 August and was alone and on the Kongakut River each time. During this time, Haugen observed this wolf visiting the den on 5 occasions. On 19 September, it was located on Aspen Creek in Canada and had moved back to the den site on 28 October. When next located, on 8 November, it was on a tributary of the Kongakut River approximately 19 km south of its last location. Wolf #9 was never located with the pack after they left the den.

Two pups from the Kongakut pack were seen alone 6 km north of the den on 19 July, this was the first observation of pups alone and away from the den site. During a moose survey on 31 October, a pack of wolves, consisting of 3 adults and 2 pups, was found in a small drainage on the west side of the Kongakut River. These wolves probably belonged to the Kongakut Pack. This is the only sighting of the pack after it left the den site.

Wolf #9 was next located on 2 April 1985 near the Kongakut den site. On 3 April it was in the same location with another gray wolf, on 5 April it was at the den and the den was dug out. Wolf #9 was found dead on 27 April and was found to be rabid. During the summer, the remains of another gray wolf was found at the den site. Cause of death could not be determined but it is probable that it was the gray which was observed with #9 and possibly was rabid also. The Kongakut pack was never found in 1985 and the den site remained unused. In June 1986, several wolves were observed at the den site and it appears that a pack had denned there again.

Malcolm Pack

The Malcolm pack was formed by 2 lone wolves (#2 and #17) in 1985 and raised 2 pups. Wolf #2 was a 3-year old, tawny colored female that was captured on 2 June 1984. This wolf was located 14 times between 2 June and 17 June, each time it was alone and on the coastal plain or in the foothills. On 19 July it was located with a gray wolf with which it was found 3 more times including 25 June when the gray was captured. The gray wolf (#5) was a 3- to 4-year old male. The two wolves were located together 5 times between 26 June and 4 July, but had separated on 6 July. Between 17 July and 28 July 1985, wolf #2 traveled to the south side of the Brooks Range and was near Conglomerate Mountain which is approximately 106 km southwest of its last location. Located again on 11 September, wolf #2 was found back on the northside of the Brooks Range on the Kongakut River and was still in the same general area, on 29 October, but was with a black wolf. Wolf #2 was still with the black wolf on 7 November, but had traveled east and was on the Firth River, approximately 40 km into Canada and 106 km from its last location. The pair was still together on 2 April 1985 in the same area. On 27 April and 1 May they were near the foothills between the Kongakut and Clarence Rivers and the black (4-year old male #17) wolf was captured. The pair then moved into Canada and denned on the Malcolm River. The female produced 4-5 pups but only 2 survived to den abandonment in early August. The pack stayed in the same area it had been using, but was located near the Trail River on 16 October with only 1 pup, approximately 45 km southeast of their previous most southern location. The wolves were back on the Malcolm River on 24 October. On 12 March 1986 the signal from #17 was heard but not located in the Old Crow flats, roughly 200 km southwest of their center of their area of activity in 1985. In 1986 wolf #2 was denned at the same site and 2 other adult gray wolves were observed there. The fates of #17, her mate, and their last surviving pup are unknown.

Old Man Creek Pack.

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

Wolf #3.

Wolf #3 was a gray 1- to 2-year old male. It was captured on 5 June 1984. It was located 18 times between 5 June and 13 August. Wolf #3 stayed east of the Kongakut River until 9 June when it moved west. Between 6 June and 21 June it utilized the coastal plain between the Aichilik and Kongakut Rivers. On 25 June it had moved east, was located in Canada, south of Clarence Lagoon and was near the Clarence River on 27 June. These last 2 locations coincide with the movements of large concentrations of caribou as they started leaving the ANWR coastal plain (Whitten et al. 1985). Wolf #3 then moved west and was on the coastal plain near the Aichilik and Egaksrak River between 8 July and 13 August. This wolf was not located again until January 1985 when it was shot by a local hunter west of the mouth of the Kugarak River near Selawik, Alaska, approximately 770 km from its last known location. At the time it was in good condition and no other wolves were observed in the area.

Wolf #4.

Wolf No. 4 was a black, 2-3 year old male which was captured on 25 June 1984 on the Clarence River. This wolf was found on the coastal plain between the Clarence River and Craig Creek from 25-28 June. When located on 17 July it had moved approximately 61 km southeast to the Firth River, Canada, and was still at this location on 29 July 1984. It was next located on 28 August near Ammerman Mountain approximately 112 km southwest of its last location. On 22 and 27 September, wolf #4 was with a gray wolf in the vicinity of Ammerman Mountain and a radio fix on 15 November showed it was still in the same general area. It was not located again until 14 October 1985 when it was with 2 other wolves, at a moose kill, approximately 230 km southwest of its last location. On 20 October it was still in the area but has not been located since then.

Wolf #5.

Wolf #5 was a 3- to 4-year old gray male. The first sighting was on 19 June 1984 when it was with wolf #2. It was observed 3 times between 14 June and 24 June running with wolf #2 and was captured on 25 June. Wolf #5 was located 5 times with wolf #2 between 26 June and 4 July. On 6 July it was separated from wolf #2 and remained alone and in the same general area between 6 and 9 July. After the location on 9 July it left the area and was not found again until 8 November when it was located on the Ivishak River with 4 other wolves, a move of approximately 217 km southwest from the last location. The wolves with wolf #5 were very wary of the airplane and may have been exposed to aerial hunting, while wolf #5 seemed unconcerned with the aircraft. This differential behavior suggested that wolf #5 may have recently joined this pack or may have previously been a member but had habituated to aircraft during tracking flights. Wolf #5 was located dead on 30 April 1985 on the Ribdon River, in the vicinity of Elusive Lake approximately 50 km west of its last location. Tracks in the snow indicated that several wolves had been with wolf #5 with the possibility of a fight in which #5 was killed. Testing confirmed that wolf #5 was rabid.

Wolf #21.

Wolf #21 was a gray 1-2 year old male and was captured on the Clarence River on 27 June 1985. Immediately after release the signal became very weak indicating either transmitter failure or possibly a broken antenna. It was found on 7 July with another gray wolf on the Firth River approximately 77 km southeast of the capture point. Contact was lost until a radio fix on 9 March 1986 put the wolf on the Sheenjek River near Little Brushman Mountain. This was approximately 157 km southwest of its last location. This wolf has not been located since.

Wolf #26.

Wolf #26 was a black, 2-3 year old male which was captured on 24 August 1986. This wolf was captured on the coastal plain near the Aichilik River. It was located in the same area on 28 August but on 18 September it had moved into the mountains and was near Mount Chamberlin, a move of approximately 80 kms. On 24 September it was back on the coastal plain near its previous locations. On 7 October it was located 103 km west near the Canning River and was in the same area on 21 October with a gray wolf. This wolf was not located again until 5 June 1986 when it was found dead on the Sadlerochit River. Cause of death is unknown.

Territories and Movements

Areas utilized by wolf packs on ANWR tended to be non-overlapping (Fig. 1 & 2). Packs tended to center activities in and along major river drainages during spring, summer, and fall. It has become evident that movements of 1 or 2 wolves from a pack during the denning season may not reflect the movements of the pack. Although some radio collared wolves were frequently observed with other members of the pack, other radio collared wolves were always alone except when at the den site. In these cases, mapping of radio relocations would show the area used by that particular wolf, which may not be representative of the area or territory utilized by the whole pack. Although data for some packs (i.e. Sadlerochit, Hulahula, Malcolm) is sufficient to show territories, data for other packs probably is not. Therefore these use areas are referred to an activity areas.

In the Northwest Territories of Canada (Kuyt 1972) and northwestern Alaska (Stephenson 1979, James 1983), wolves tend to seasonally shift their ranges in correspondence with seasonal migration of caribou (Rangifer tarandus). In the northeastern Brooks Range (ANWR), these seasonal shifts in resident pack territories due to caribou movements have not been detected. Winter data (November to April) are scarce. However, surveys flown for relocation of caribou have failed to locate any collared pack animals in areas of overwintering caribou. Although several lone and dispersing wolves traveled south in conjunction with caribou, they failed to return with caribou the following year. Limited radio tracking data indicates that these wolves joined with other wolves and/or packs and remained in that area rather than following caribou migrations north. These data suggest that wolves belonging to resident north slope packs are using the same or possibly expanded summer ranges and remain near or north of the continental divide during winter. Alternate food sources would include year round resident prey such as Dall sheep (Ovis dalli) and moose (Alces alces), and in the Sadlerochit mountain area to the west, scattered groups of caribou from the Central Arctic herd. Limited tracking data for the Sadlerochit pack during winter 1984-1985 and the Egaksrak, Drain Creek, and Malcolm packs in winter 1985-1986 supports this hypothesis. The Canning pack was the only pack that appeared to have a large scale seasonal shift in territories. Contact was lost with the pack in both years (1984-1985) after abandonment of the den. Although it is apparent that the pack has a seasonal shift in territories, the location of the winter use area is unknown.

During the 1984-1985 ANWR study, 26 wolves were captured of which 7 were lone wolves. Another 4 wolves were not associated with a pack, but were thought to be former members of a pack that disintegrated after at least 1 and possibly several members of the pack died from rabies (see section on disease). Five animals associated with packs at the time of their capture later dispersed. In 1984, 9 of 11 captured wolves were either captured on the coastal plain or used the coastal plain area while caribou were present. Eight of the nine were 3-years old or less. All of these wolves later dispersed either from the area or from their associated packs. In 1985, only animals were captured on the coastal plain, with both being lone wolves. Another 4 animals were believed to have been members of a pack that broke up. All of these animals later dispersed. Two have used the coastal plain extensively while 1 was captured too late in the season to access use of the coastal plain. All wolves using the coastal plain were 3-years old or less. Wolves associated with packs were captured in the mountains and were with the packs at the beginning of the 1986 denning season. Although data are limited, they suggest that wolves using the coastal plain during the time caribou are calving are either lone wolves or young and/or dispersing wolves from packs denning on ANWR. When discussing wolf predation on the calving grounds of the Kaminuriak caribou herd, Miller and Broughton (1974) suggested that the behavior of the wolves indicated that much of the predation was by young animals. This theory, if correct, would be of major significance for any future assessment of the impact of wolf predation on calving caribou. A study stressing only denning wolves would be biased against detailing calf predation.

Dispersing wolves have been known to travel over great distances. Fritts (1983) documented a movement of 886 km for a wolf from Minnesota, while Ballard et al. (1983) reported a dispersal in Alaska of 732 km by 2 wolves. One of the ANWR study wolves traveled from the Kongakut River area of the coastal plain to an area between Ambler and Selawik where it was killed by a trapper. This is a distance of approximately 770 km from its last location and 826 km from its known farthest eastward location (Fig. 3). This distance represents the longest recorded movement in Alaska. The fate of dispersing wolves on ANWR is presented in Table 2 and Fig. 4.

Two wolves (1 pack member and 1 lone wolf) dispersed from the area and followed caribou movements to the south and into Canada. The lone wolf (a 2-3 year old male #4) was captured in June 1984 near the U.S.-Canada border. By mid-July it had moved 61 km southeast into Canada. At the end of August it was 112 km southwest of the last location and was with a large gray wolf. It stayed in the area of line Kongakut until at least mid-November 1984, when contact was lost. These movements corresponded to general caribou movements at the time and caribou were in the immediate area each time the wolf was

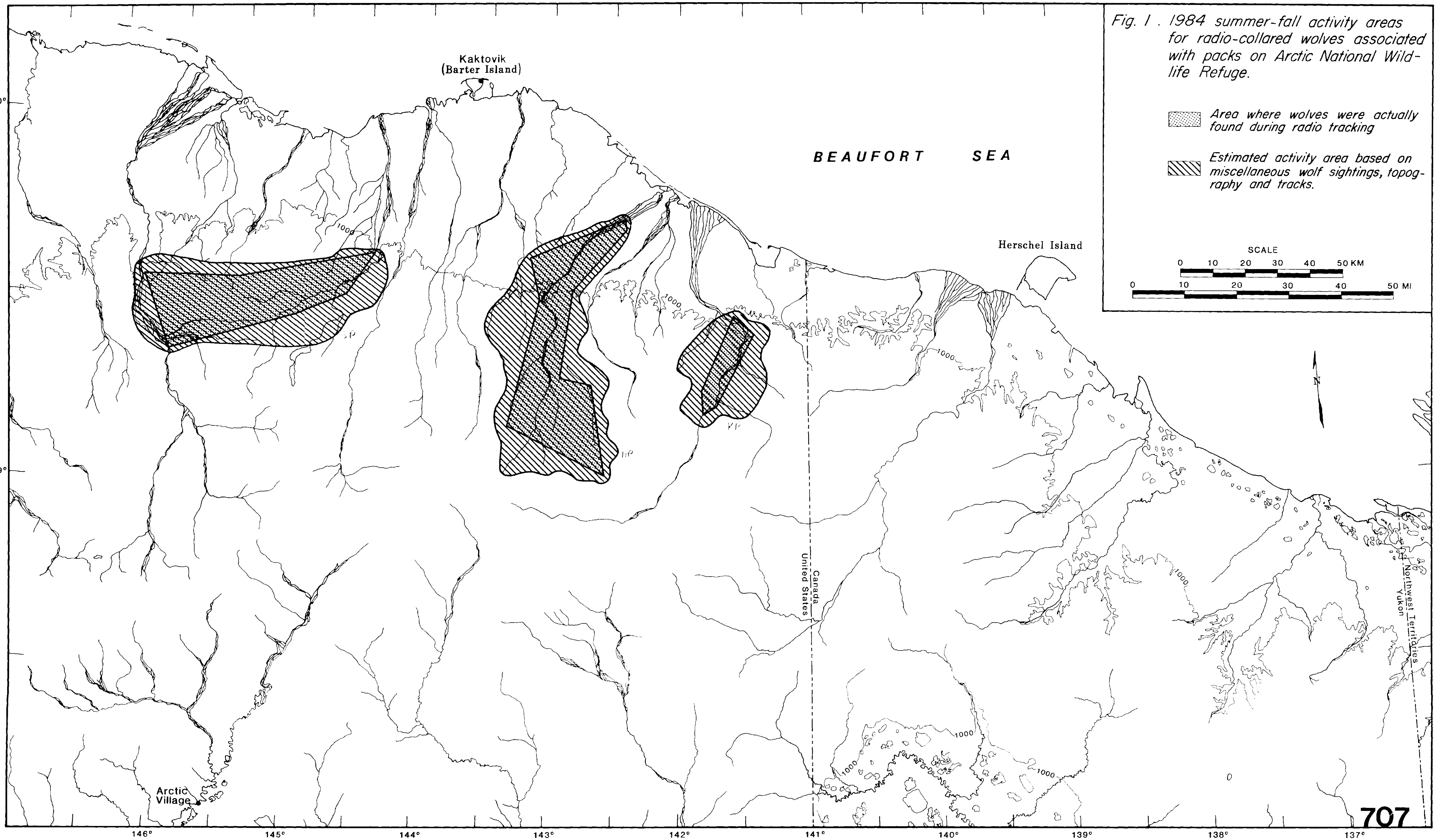


Fig. 1. 1984 summer-fall activity areas for radio-collared wolves associated with packs on Arctic National Wildlife Refuge.

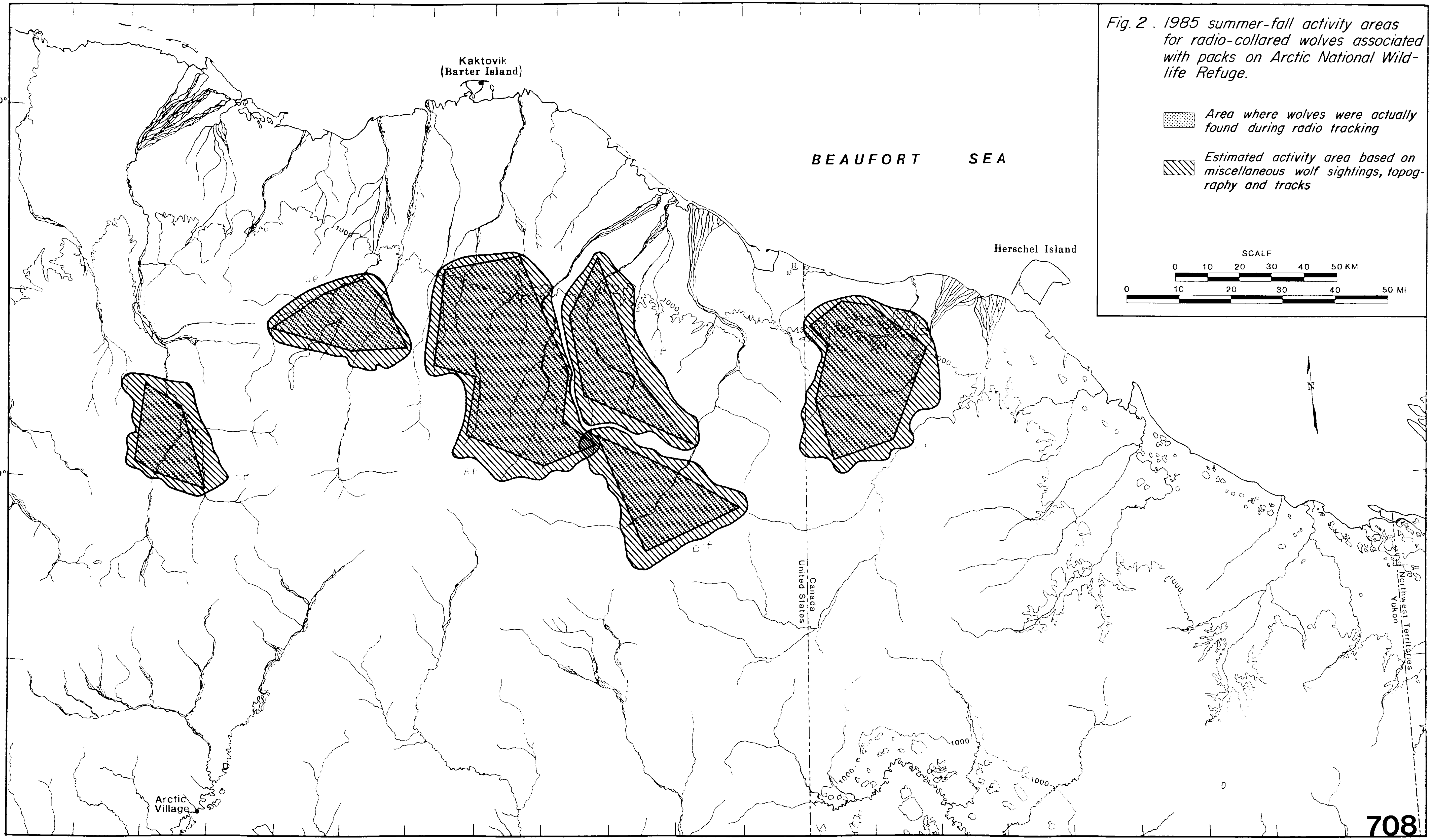


Fig. 2. 1985 summer-fall activity areas for radio-collared wolves associated with packs on Arctic National Wildlife Refuge.

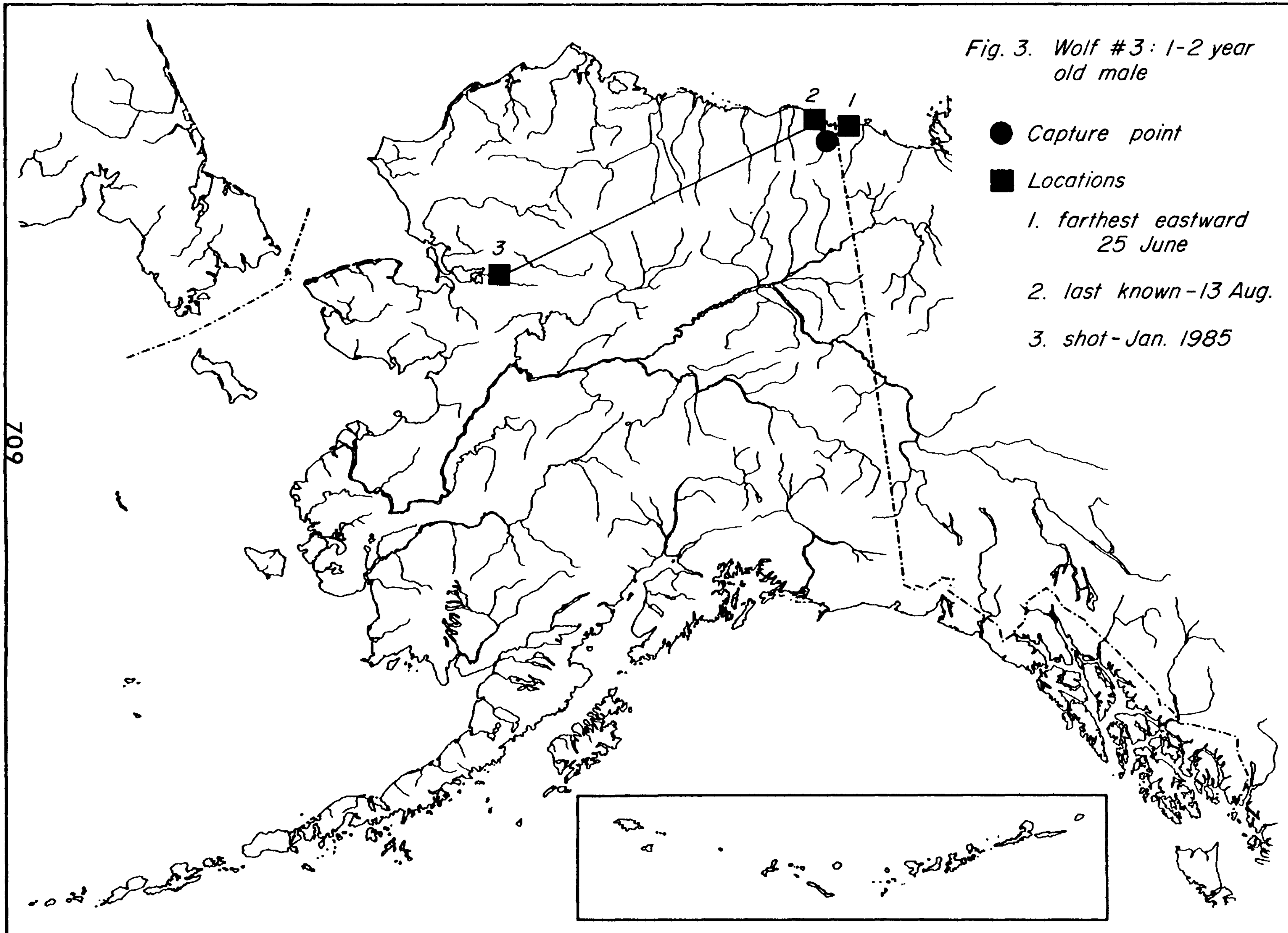


Fig. 3. Wolf #3: 1-2 year old male

Table 2. Sex, age, and fate of lone and dispersing wolves on Arctic National Wildlife Refuge during 1984-1985 (Numbers correspond to numbers on Fig. 4).

Wolf No.	Sex	Age	Fate
1	M	1	Separated from Aichilik pack and joined wolf #6 in early 1985, shot in late March 1985.
2	F	3	Joined wolf #5 in June 1984, seperated in July and joined wolf #17 in October and these wolves formed Malcolm pack in 1985.
3	M	1-2	Lost contact on ANWR in August 1984 - Shot near Selawik in June 1985.
4	M	2-3	Dispersed to south side of Brooks Range in July 1984 - found with 2 unmarked wolves near Ft. Yukon in October 1985.
5	M	3-4	Joined wolf #2 in June 1984, separated and dispersed to the west in July, found with Ivishak pack in November 1984 - found dead of rabies in April 1985 on the Ribden River.
6	F	2	Separated from Sadlerochit pack October 1984, joined wolf #1 in early 1985. After wolf #1 was shot, wolf #6 denned, becoming the Hulahula Pack. She was joined by unmarked wolf in July 1985, and they were joined by wolf #25 September 1985.
7	M	3	Separated from Kongakut pack in July 1984, dispersed east into Canada in August 1984. Last found near Aklavik, Canada in December 1984. Shot in April 1986 approximately 113 km east of Tuktoyaktuk, Northwest Territories.
8	F	2-3	Separated from Aichilik pack in late 1984 or early 1985. Last found on Juniper Creek west of Canning River in April 1985.
9	F	2-3	Separated from Kongakut pack September 1984 - Found dead of rabies in April 1985.
12	M	1-2	Captured 6 April 1985, - Found dead of rabies on 25 April 1985.
13	F	3-4	1 of 2 breeding females in Canning pack, denned but failed to raise pups and found dead of unknown causes on 30 June 1985.
17	M	3	Joined wolf #2 in October 1984, and they formed Malcolm pack in 1985.
18	F	1-2	Believed to be associated with the Aichilik pack, captured in May 1985. Dispersed south and lost contact in July 1985.
21	M	1-2	Captured 27 June 1985, located along Firth River on 7 July 85, last located on Sheenjek River in March 1986.
25	M	2	Captured on Canning River August 1985, joined wolf #6 in Hulahula pack in September 1985.
26	M	2-3	Captured in August 1985. Traveled west across coastal plain in October 1985 and joined unmarked wolf near Canning River. Found dead June 1986 (unknown causes).

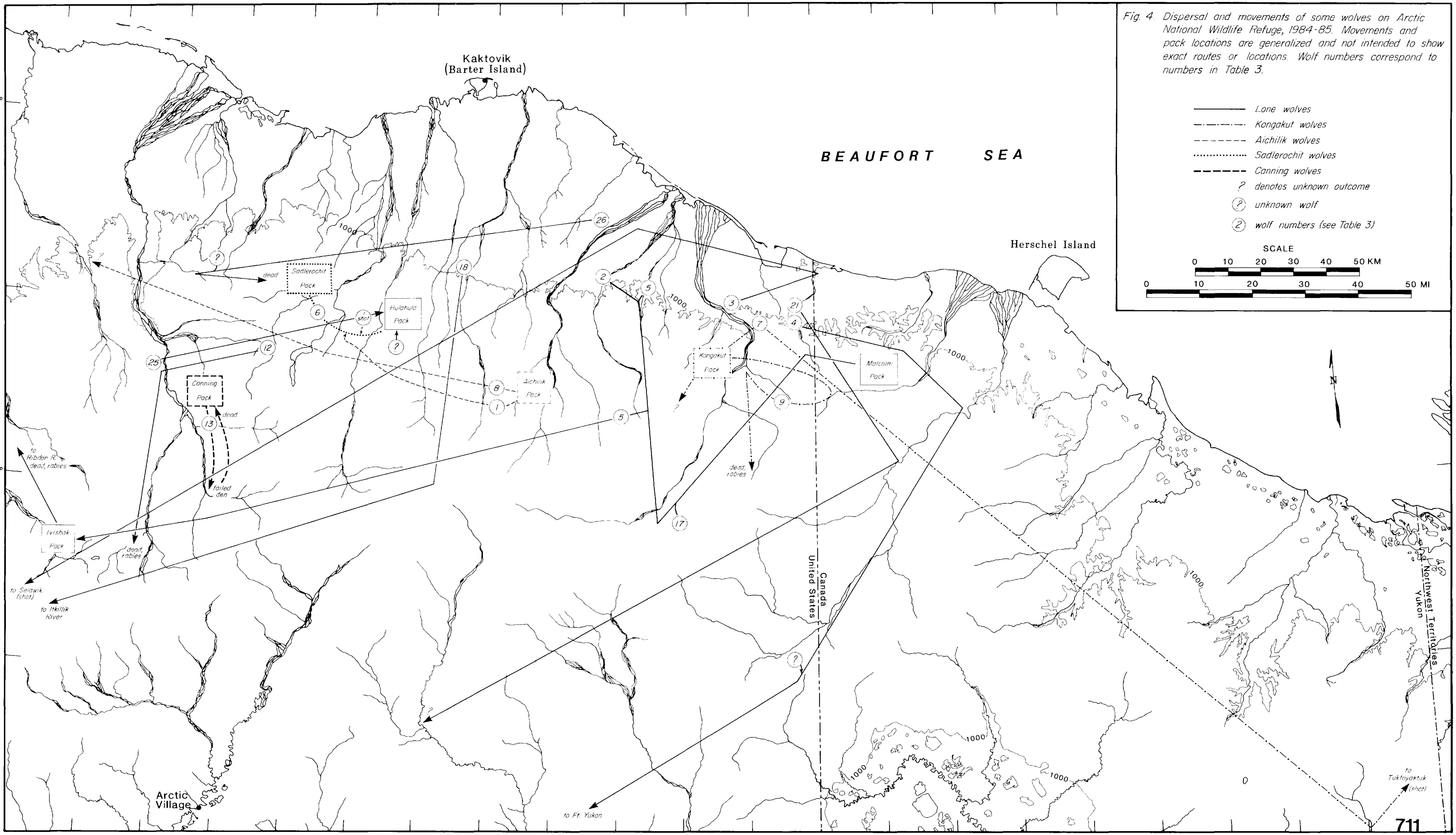


Fig. 4. Dispersal and movements of some wolves on Arctic National Wildlife Refuge, 1984-85. Movements and pack locations are generalized and not intended to show exact routes or locations. Wolf numbers correspond to numbers in Table 3.

located. This wolf was last located in October 1985, approximately 240 km southwest of the November 1984 location.

The other wolf was a member of the Kongakut pack and was a 3-year old male (#7). This wolf was captured in June 1984 and remained in the general area of the Kongukut River until late July. At this time contact was lost and not reestablished until late September when the wolf was in Canada, an eastward movement of 193 km from its last location. In early December it was 64 km northeast of its September location. Again movements corresponded to caribou movements at the time and caribou were in the immediate area each time it was located. This wolf was shot in March 1986, approximately 113 km east of Tuktoyaktuk, N.W.T., in the Kugalik River Area.

Density

Wolf densities in North American populations range from 1 wolf/7.8 km^2 to 1 wolf/520 km^2 (Table 3). Estimated fall densities in the northeastern Brooks Range were 1 wolf/726 km^2 and 1 wolf/686 km^2 for 1984 and 1985 respectively. These estimated densities are for an area of approximately 24,700 km^2 (9500 $mi.^2$), bordered on the west by the Canning River, the Malcolm River on the east, the continental divide of the Brooks Range on the south, excluding the Joe and Mancha creek drainages, and on the north by the Beaufort Sea. If the coastal plain, where no den sites were documented, is excluded from the estimates, densities increase to 1 wolf/497 km^2 and 1 wolf/469 km^2 for 1984 and 1985 respectively. These densities are minimum estimates of wolf density based on the actual number of known wolves in the area (Table 4).

Productivity

A few captive wolves have reached sexual maturity in 1 year (Medjo and Mech 1976), but nearly all females reach puberty by 22 months (Packard et al. 1983). Wolves in packs usually would not breed until older. The probability of a female breeding depends on her social rank within the pack (Zimen 1976), while the probability of copulation and successful reproduction is higher for adults than 22-month old females (Packard et al. 1983).

Average litter size reported by Mech (1970) is 4.0 - 6.5. In the northcentral Brooks Range, average litter size for 43 litters was 5.2 (Stephenson and Johnson 1972). In 1984-1985, 9 packs attempted to raise 10 litters of pups on ANWR. Although there were only 8 packs, 1 pack denned in both years and the same pack attempted multiple litters in 1985. In 1984 litter sizes for 2 packs averaged 3.0, while litter size in 4 packs averaged 4.2 - 4.75 in 1985. These litter sizes are based on the number of pups observed outside the den in early summer and may be inflated due to 3 litters having an unknown number of pups which are not included (Table 4).
They also do not include the second litter in the Canning pack which had an unknown number of pups. The breeding female (#13) died of undetermined causes and examination of placental scars showed that she had a least 1 pup that year. These limited data indicate that wolves in the northern portion of ANWR have litters that are at or below the average litter sizes reported elsewhere.

Mech (1977) reported low litter sizes and related it to nutritional stress, however it is not known if nutritional stress was a factor in the ANWR litter sizes. Rausch (1967) found that the production of ova by multiparous females

Table 3. Reported densities for North American wolf populations (adapted from Stephenson 1975a).

Location	Area (km^2)	Density (km^2/wolf)	Source
Michigan:			
Isle Royale,	544	18-26	Mech 1966 Jordan et al. 1967
Minnesota	6,449	26	Olson 1938
Minnesota	10,619	44	Stenlund 1955
Minnesota	10,886	28[a]	Mech 1973
Minnesota	1,857	24	Van Ballenberghe et al. 1975
Alaska:			
Southeast	19,425	65-104	Atwell et al. 1963
Coronation Island	78	8[b]	Merriam 1964
South central (Unit 13)	51,800	129.5	Rausch 1967
Mt. McKinley N.P.	5,180	129.5	Murie 1944
Mt. McKinley N.P.	3,885	62-108.8	Haber 1968
Brooks Range Northwestern			
Northern foothills	--	390	Stephenson and James 1982
Northern and western areas	--	520	Stephenson and James 1982
National Petroleum Reserve Alaska			
Average	--	520	Stephenson 1979
Southern portions	--	130	Stephenson 1979
North Central			
Spring 1971	9,324	320	Stephenson 1975[b]
Spring 1973	9,324	194	Stephenson 1975[b]
Canning River area			
Spring 1973	4,196	596	Quimby 1974
Fall 1973	4,196	181	Quimby 1974

Table 3. Continued.

Location	Area (km^2)	Density (km^2/wolf)	Source
Canada:			
Western Canada	10,878	225-288[c]	Cowan 1947
Saskatchewan	--	103.6-215	Banfield 1951
Algonquin Park, Ontario	2,590	26	Pimlott et al. 1969
Ontario	25,900	259-518	Pimlott et al. 1969
Northwest Territories	1,243,200	155-311	Kelsall 1957
Northwest Territories	995	18[d]	Kuyt 1972
Baffin Island	4,662	311	Clark 1971
Manitoba-Saskatchewan	3,300	20.2-36[d]	Parker 1973
Manitoba-Saskatchewan-Northwest Territories	282,310	518[e]	Parker 1973

[a] Average for 2 winters, 1971-72 and 1972-73.
[b] Artificial situation; four wolves stocked.
[c] Maximum abundance on winter range.
[d] Temporary concentration of wolves on winter range of Kaminuriak caribou herd.
[e] Total year round range of Kaminuriak caribou herd.

Table 4. Numbers of adult wolves and pups in the northeastern portion of Arctic National Wildlife Refuge, 1984-1985.

Wolf Group	Number of adults	Number pups at den	Number pups surviving to fall
1984:			
Lone wolves	5	--	--
Canning River[a]	5(est.)	?	0(?)
Sadlerochit River	4	at least 1	1
Aichilik River	7	4	4
Kongakut River	6	2	2
Totals	27	7	7
Fall Totals	27		7
1985:			
Lone wolves	5	--	--
Canning River North[b]	4	at least 1	1
Canning River South[c]	-	at least 1	0
Hulahula River[d]	3	4-5	3
Egaksrak River	5	5	5
Drain creek	6	4	4
Malcolm River[e]	2	4-5	1
Totals	27	19-21	14
Fall Totals[f]	22		14

[a] Haugen (1986) believed this pack was unsuccessful in raising young in 1984.
[b] This pack had only 1 surviving adult by late summer.
[c] Attempted second den in Canning River pack - had at least 1 pup based on placental scars.
[d] One adult did not join this pack until late summer, possibly in September.
[e] These animals were lone wolves in 1984, but denned in Canada in 1985.
[f] Fall totals are lower than total numbers due to death and emigration.

was greater than that of first time breeders. In 1984 the only known age breeding female (Sadlerochit pack) was 6-8 years old, and had an unknown number of pups while successfully raising only 1. In 1985, 3 known age breeders were 3, 4, and 3-4 years old. These wolves were members of the Hulahula, Malcolm, and Egaksrak packs and had 4-5, 4-5, and 5 pups respectively. Two wolves were known first time breeders, while the status of the Egaksrak female was unknown. These data indicate that differences between first time breeders and multiparous wolves was not the cause for low litter sizes in northeastern Alaska. In Alaska, Rausch (1967) reported that in arctic areas wolves shed fewer ova and implanted fewer fetuses than other areas of the state.

Survival rates for pups from birth to 5 - 10 months of age vary widely with survival rates for unexploited populations rangeing from 6 - 43%, while exploited populations range from 20 - 88% (Mech 1970). Exploitation seems to stimulate both reproduction and survival of pups, at least until their first winter (Mech 1970). Increased mortality rates in wolf litters has been reported in cases where food supplies were limited or declined (Kuyt 1972, Mech 1977). On ANWR, over-summer survival rates were 100% for 1984, and 68-76% for 1985, for those packs with known litter size. A recalculation of numbers presented by Rausch (1967) for wolves in arctic Alaska, using methods outlined by Mech (1970), results in a survival rate of 72% for pups. A similar recalculation of Chapman's (1977) data using data from the Brooks Range in Alaska results in a survival rate of 85%. These survival rates are comparable to previously reported rates for arctic Alaska. If an average litter size of 4 (calculated from ANWR packs) is used for packs with unknown litter size, the estimated survival rate is 50% for 1984 and 56% for 1985. These rates are lower than previous estimates for arctic Alaska and comparable to those reported by Van Ballenberghe et al. (1975) and Fritts and Mech (1981) for wolves in Minnesota. Overall, smaller litter sizes and lower survival rates indicate a lower productivity for wolves in the northeastern Brooks Range.

A total of 21 pups were raised during 1984-1985, with 15 (71%) being raised by the 4 packs with 5 or more adult members. Packs with less than 5 members (includes 1984 Canning pack and 1985 Canning second litter) successfully raised only 6 pups out of 6 possible litters. If an average litter size of 4 is attributed to packs with unknown litter sizes, estimated over-summer survival rates for packs with less than 5 adults becomes 23-25%, while large packs had an estimated survival rate of 100%. There was no significant difference in the number of pups produced between packs with greater than 5 members and those with less then 5 members ($X^2 = 1.274$, $0.90 < P < 0.95$). There was, however, a significant difference in the number of pups surviving to Fall ($X^2 = 11.8$, $P < .005$). Pup survival was related to pack size, with survival increasing with increasing pack size ($Y_i = 0.1598 + 0.1372X_i$; $R^2 = 0.788$, $F = 14.63$, $0.02 < P < 0.01$; Yi = % pups surviving, Xi = number of adults in pack). This is in contrast to Peterson et al. (1984), where pup survival and pack size were unrelated. Harrington et al. (1983) found that when prey was relatively abundant and the wolf population was increasing, pack size and December litter size were positively correlated. Zimen (1976) suggested that optimal pack size is ultimately derived from prey size. Factors influencing pack and prey size, such as the number of hunting members, replacements for wolves that are killed or injured, and advantages and disadvantages for a pack with fewer or more members, results in an optimal pack size when deer are the primary prey of 6-10 animals and 8-12 animals when moose are the primary prey (Zimen 1976). Dall sheep (<u>Ovis dalli</u>) are the smallest of the large mammals available as prey species for wolves in northern Alaska and are similar in size to white-tailed deer (Odocoileus virginianus). Thus the concept of optimal pack size when applied to current data on wolves on ANWR, would suggest that packs with fewer than 5 adult members cannot utilize available prey as effectively or raise young as successfully as large packs.

Habitat

Wolves were originally circumpolar in distribution and habitat included all Northern Hemisphere types except tropical rain forest and arid deserts (Mech 1970). Wolves are found throughout the state of Alaska. Location information from sightings on ANWR indicate that wolves roam throughout the northeastern Brooks Range and utilize most habitats of the area. Data from the 1984-1985 ANWR study shows that wolves range primarily in the mountains and arctic foothills of the Brooks Range. This may be due to the presence of year round prey sources such as Dall sheep and moose, and the terrain on the coastal plain may render them more vulnerable to harvest (Stephenson pers. comm.). Some wolves use the coastal plain extensively in early summer with use decreasing sharply once caribou have left the area.

Den Sites

Den sites of wolves in arctic Alaska usually are found on moderately steep southern exposures where the soil is well drained and unfrozen during summer (Stephenson 1974). Land forms such as banks, escarpments, dunes, kames, and moraines are often associated with wolf dens (Stephenson 1974). The dens of 7 of the 8 packs followed on ANWR were located. All dens were along rivers with general exposures being southeast to southwest (Table 5).

Four of 8 dens were located on river banks with 3 others on old river banks that are now part of the river terrace. The Egaksrak den (Fig. 5 Plate 1) was located along the river bottom, in the bank of a dry channel. Measurements to water were unavailable for the dens mapped by Haugen (Canning - Fig. 6, Plate 2, Kongakut - Fig. 7, Plate 3), but water was available at all sites within 50 m. As a result of all dens being along banks and elevated above the river bottoms, visibility of the surrounding area was generally good and unobstructed. However, this was variable and ranged from being able to see the immediate area (Egaksrak den) to being able to see for miles in both directions along the river (Drain Creek - Fig. 8, Plates 4-5, Malcolm - Fig. 9, Plate 6). Soil analysis and depth of permafrost at sites was not collected. Most sites, with the exception of the Egaksrak den, appeared to be in sandy soil and were well drained. The Egaksrak den, located in an old river channel, appeared to be susceptible to flooding in wet years. Chapman (1977) noted the flooding of similar dens that were located along rivers. The Canning, Aichilik (Fig. 10, Plate 7), and Kongakut dens were established dens that had prior use. All others were apparently first year sites. All 3 established dens showed evidence (numerous smaller holes and tunnels) of use by foxes, although foxes (Vulpes vulpes) have been observed only at the Aichilik site and many of the holes at the others may have been made by pups. In 1984, wolves were observed on the Canning River at a possible den site which was not used and later was used by red foxes. The Hulahula (Fig. 11-12, Plate 8) was the only first year site to have evidence of prior use by foxes and appeared to be an enlarged fox den. A dead red fox was observed at the den shortly after the wolf started digging at the site and 2 fox skulls were found there when the den was visited in August. Ground squirrel (Spermophilus undulatus) holes were at all sites except for the Drain Creek den which had no evidence of either ground squirrels or foxes.

Table 5. Locations and exposures at den sites in northeastern Alaska, 1984-1985.

Wolf Pack	General location	Exposure of den entrances[a]
1984:		
Canning North	River bank	155°-240°
Aichilik	Cut bank on river terrace	85°-95°
Kongakut	Mound on river terrace	Natal 110°-115°; whelping 270°-280°
1985		
Canning North	River bank	155°-240°
Canning South	Cut bank on river terrace	240°-250°
Hulahula	River bank	210°-215°
Egaksrak	River bottom	250°-270°
Drain Creek	High river bank	East den 180°; West den 175°-180°
Malcolm	High river bank	180°

[a] All bearings are true and were estimated from U.S.G.S. topographical maps.

All established dens had at least 1 distinct chamber while all others consisted of a single hole and chamber in which the chamber was often the same size as the hole or slightly larger. A similar description of dens was reported by Peterson et al. (1984). Two den sites were found for the Drain Creek pack. The "east" den had tracks around it, but no other sign of use and it seems unlikely that it was used except possibly by the pups.

The Malcolm den contained the remains of 8 caribou calf leg bones (Plate 9). Remains of prey in dens is rarely observed but was reported by Kelsall (1960) and Lawhead (1983), although Lawhead stated that the remains in his dens may have resulted from use by other animals such as foxes. Den sites characteristics were in general agreement with those reported for dens in other areas of Alaska.

Although wolves have been known to den on the coastal plain west of ANWR (Stephenson 1975b), no dens have been located on the ANWR coastal plain even though suitable habitat for denning appears to be present.

Mortality

Numerous naturally occurring processes influence mortality and population numbers of wolves. In utero mortality has been reported by Rausch (1967), but the causes of such mortality were undetermined. Post-parturition mortality factors such as canine distemper, rabies, malnutrition, parasites, cannibalism, predation by

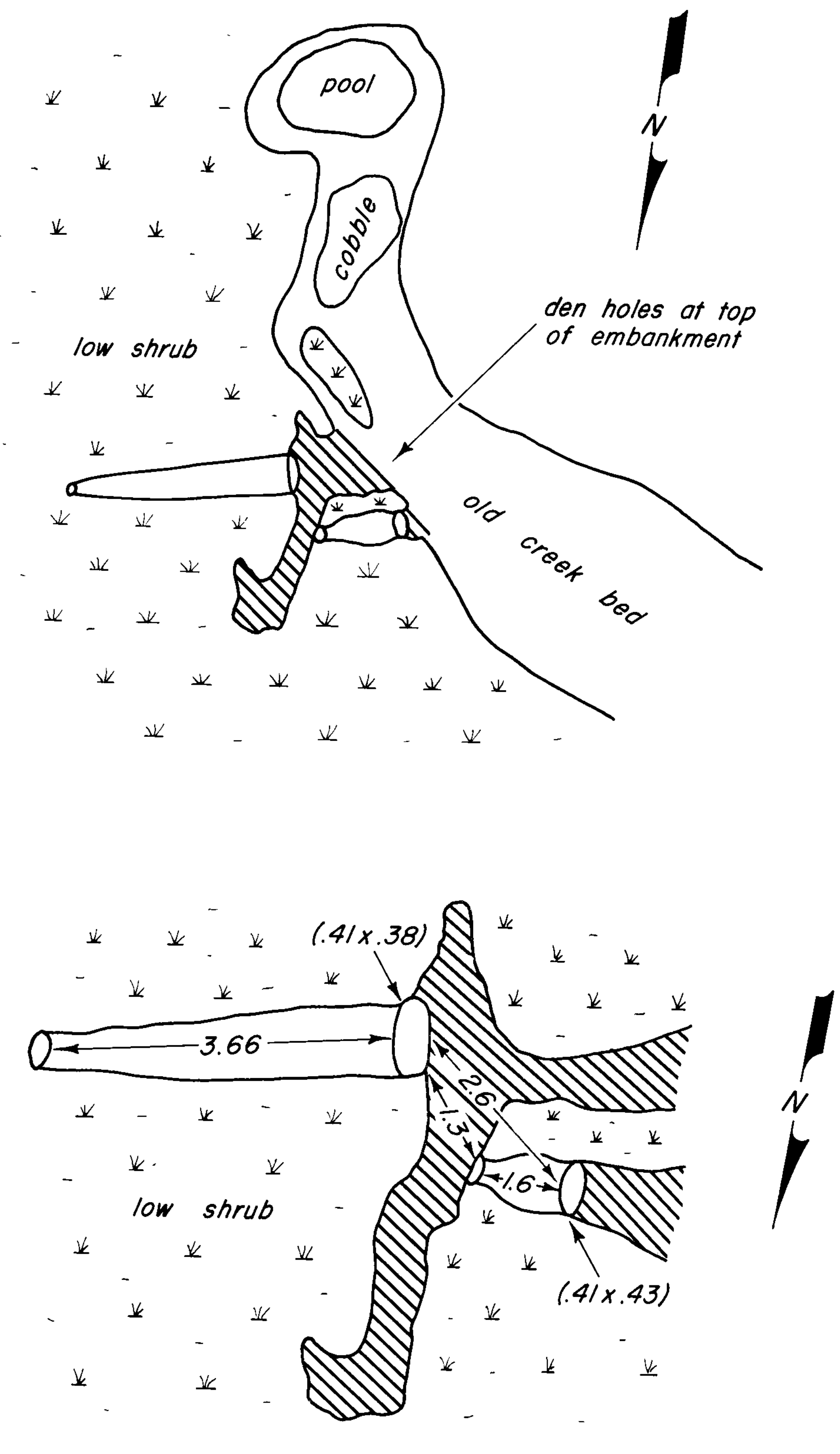


FIG. 5. EGAKSRAK RIVER DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1985.

PLATE I. EGAKSRAK RIVER DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1985.

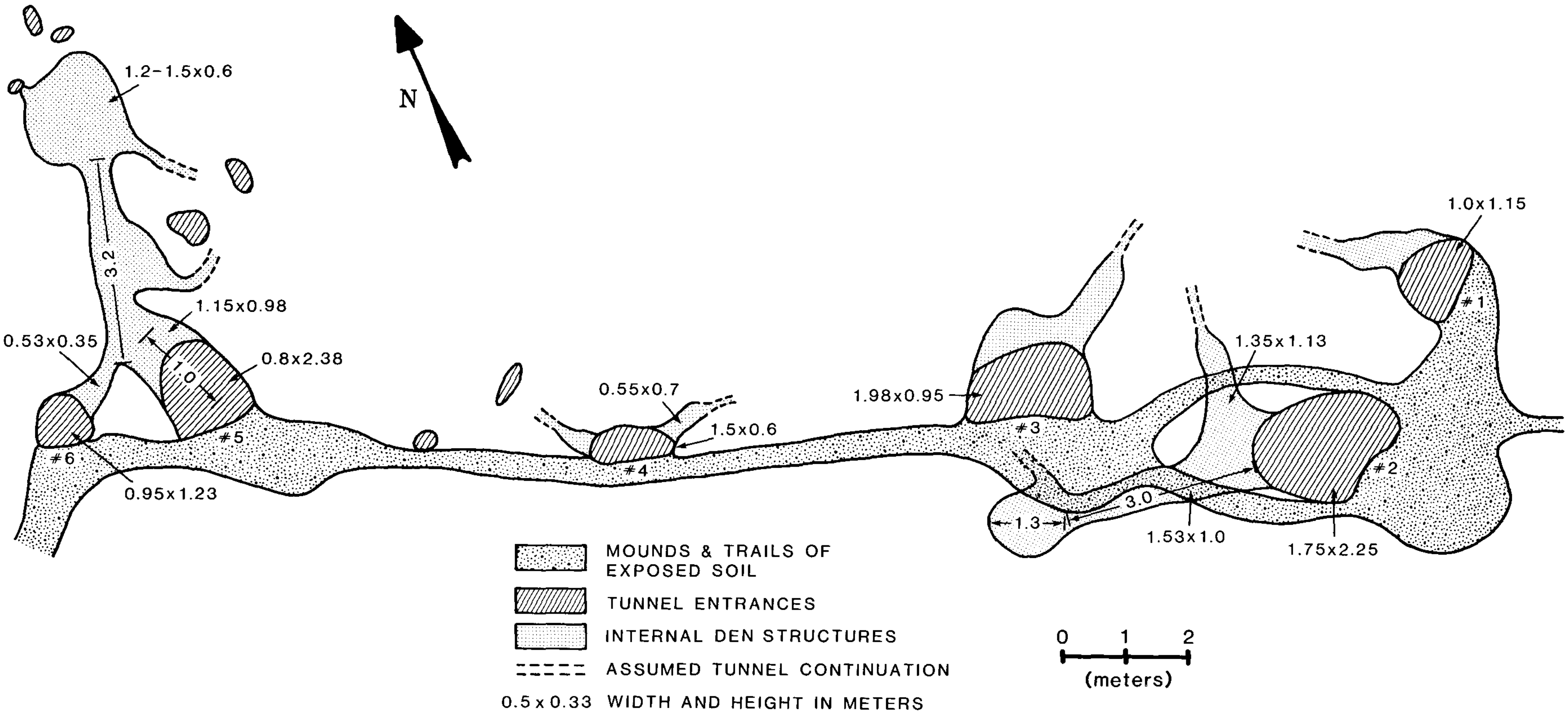


FIG. 6. DETAIL OF THE NATAL DEN AT THE CANNING RIVER DEN SITE ON THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1984. FROM HAUGEN 1985.

PLATE 2. CANNING RIVER DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1985.

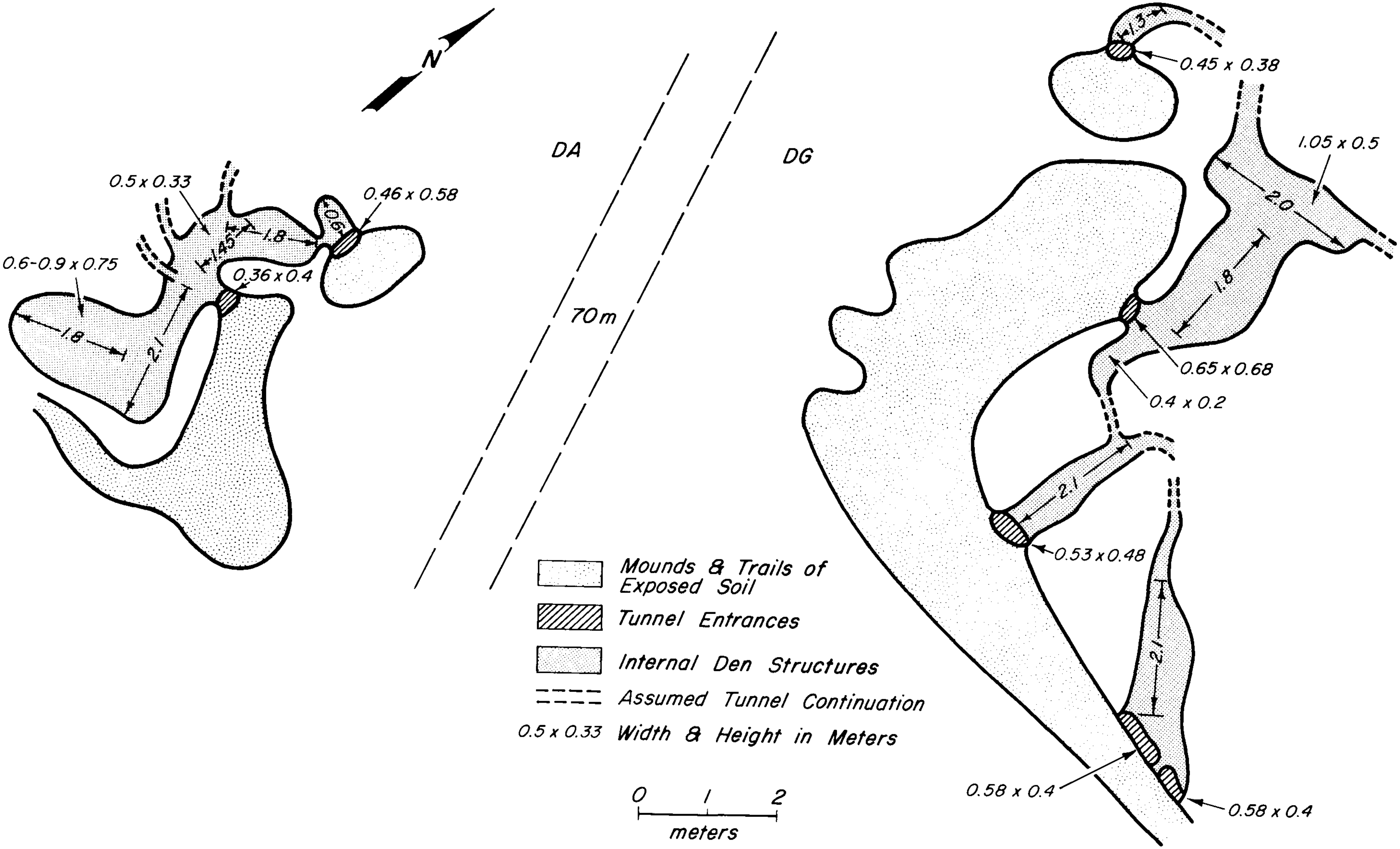
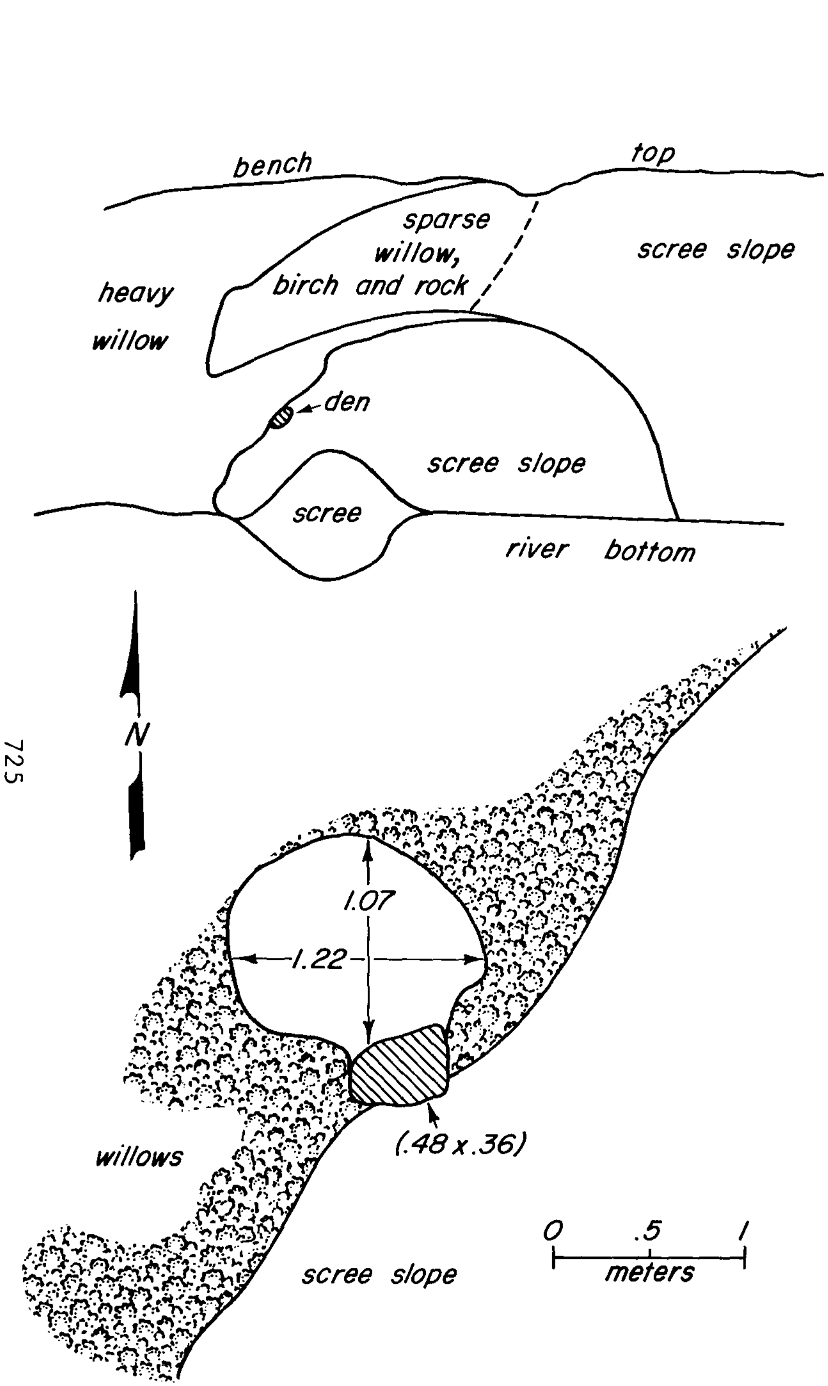
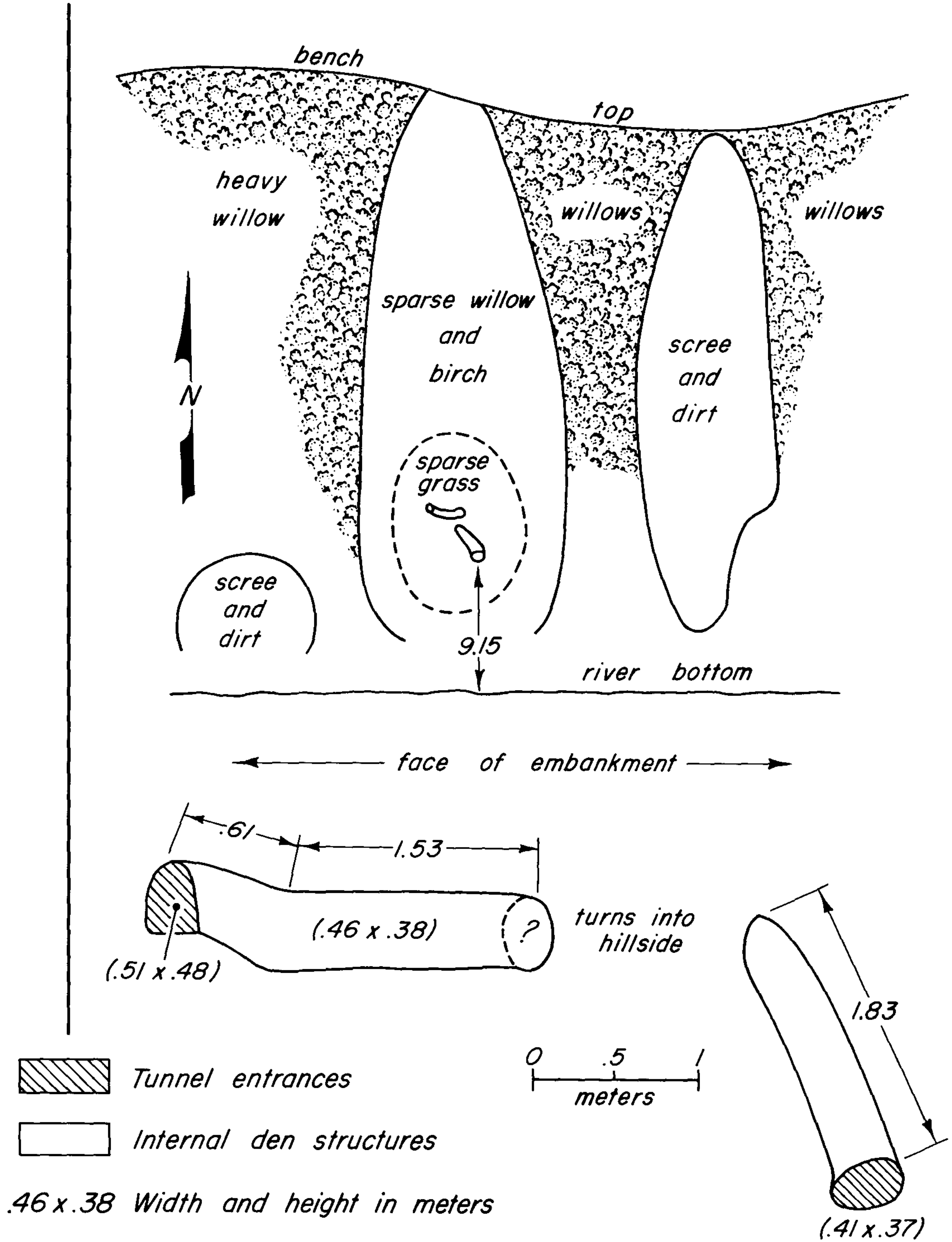


Fig. 7. Detail of the Natal (DA) and Secondary (DG) Dens at the Kongakut Den Site on the Arctic National Wildlife Refuge, Alaska, 1984. From Haugen 1985.

PLATE 3. KONGAKUT RIVER DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1984.



WEST DEN



EAST DEN

PLATE 4. DRAIN CREEK WEST DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1985.

PLATE 5. DRAIN CREEK EAST DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1985.

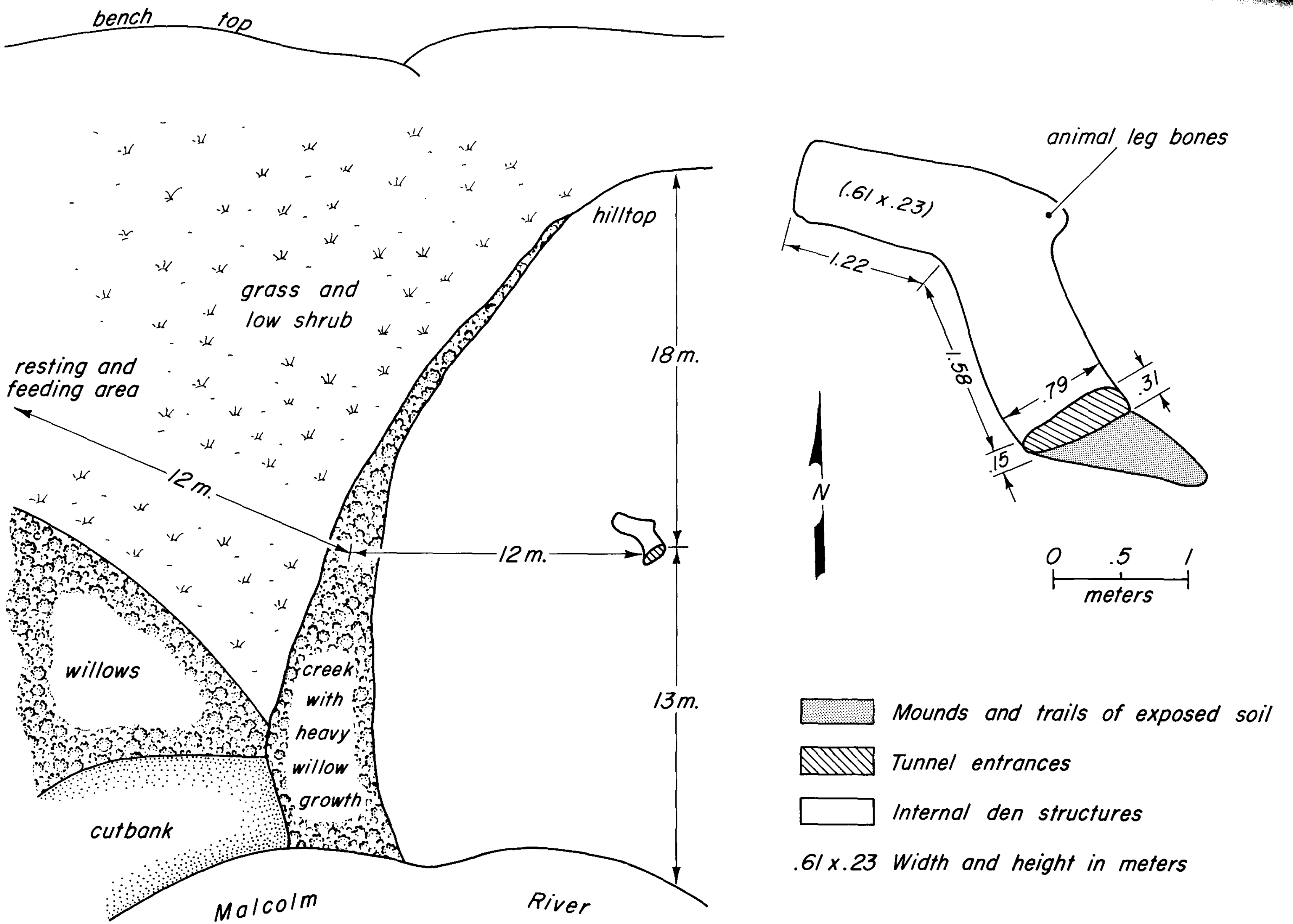


FIG. 9. MALCOLM RIVER DEN SITE, YUKON TERRITORY, CANADA, 1985.

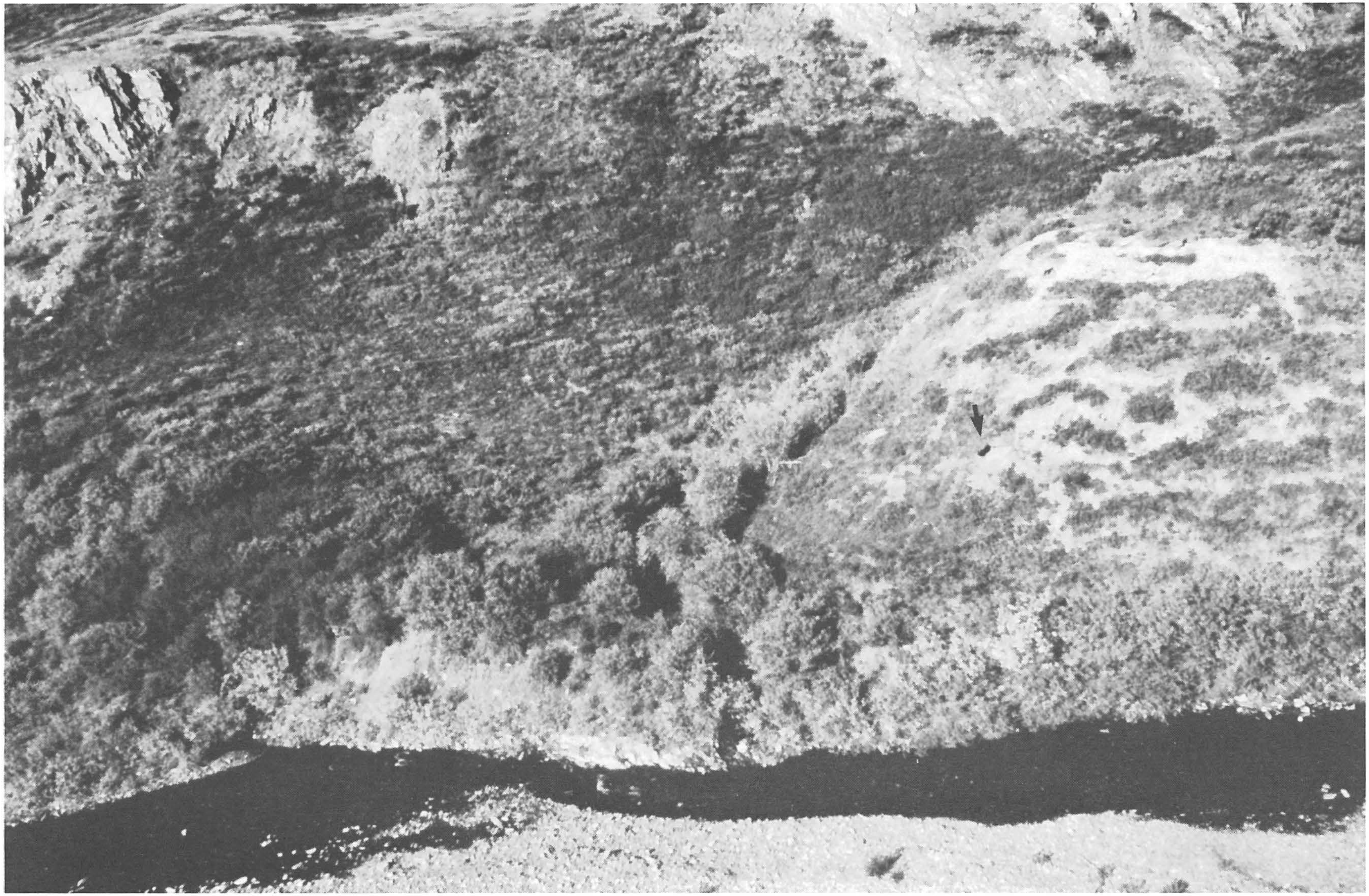


PLATE 6. MALCOLM RIVER DEN SITE, YUKON TERRITORY, CANADA, 1985.

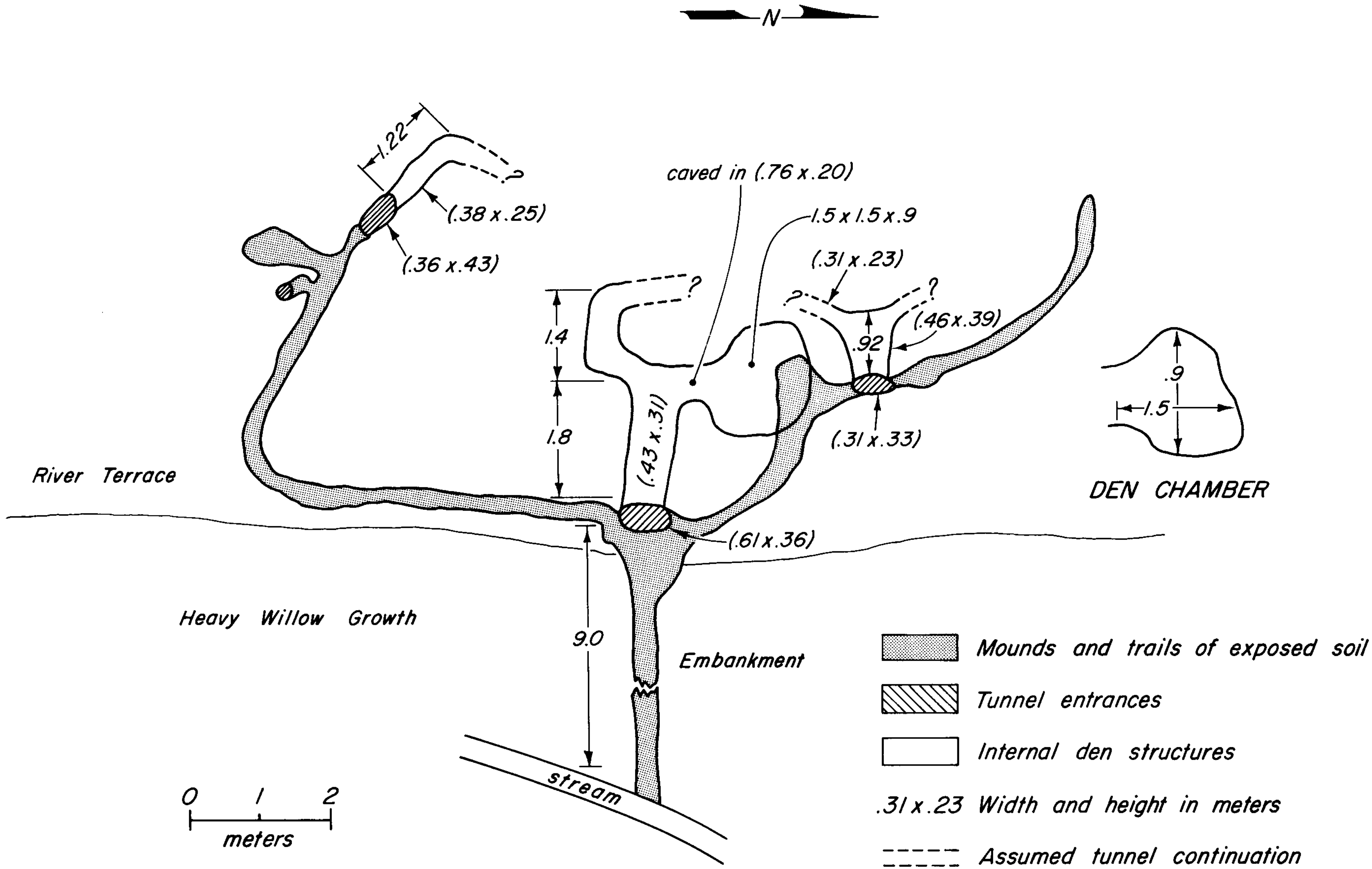


FIG. 10. AICHILIK RIVER DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1984.

PLATE 7. AICHILIK RIVER DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1984.

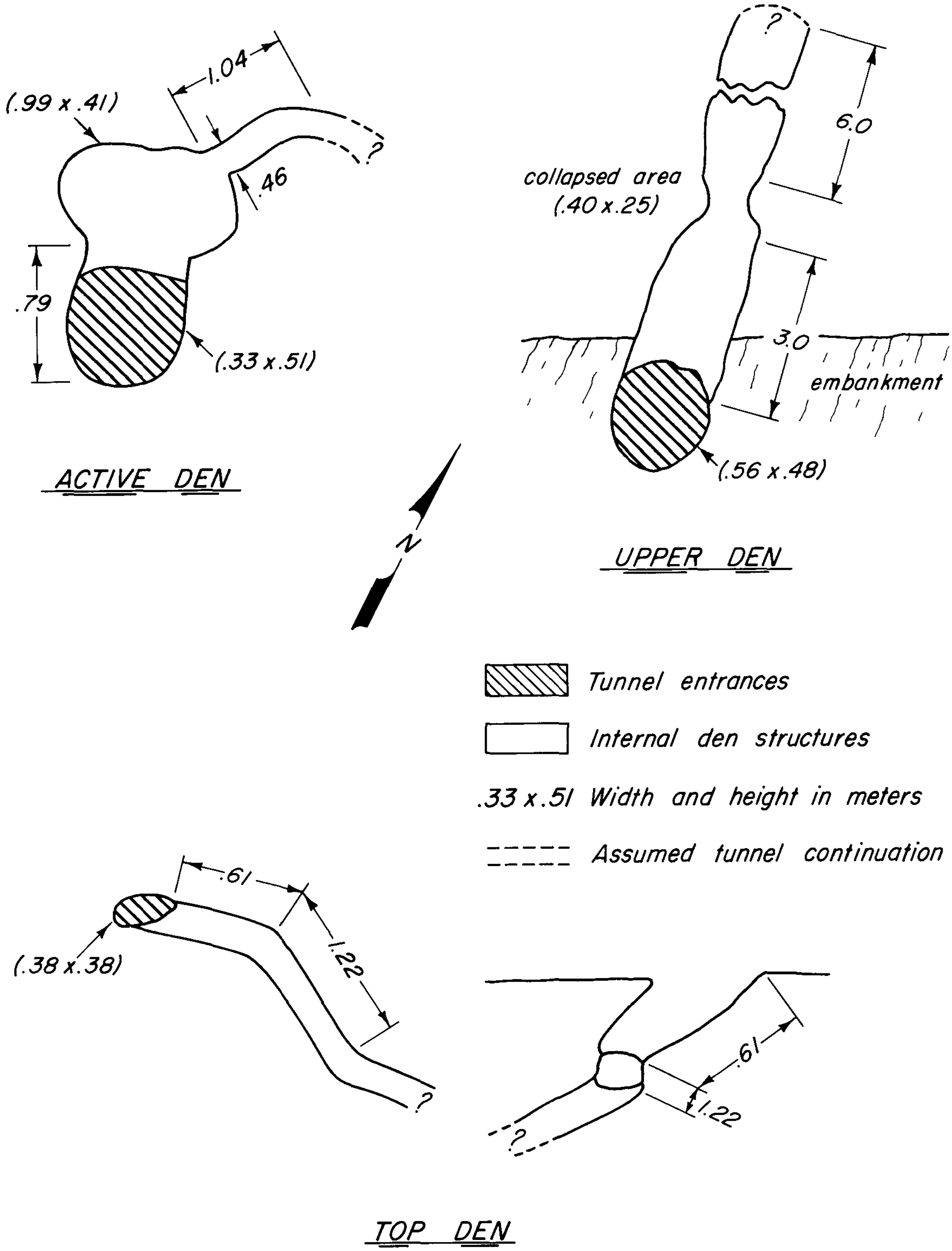


FIG. 11. HULAHULA RIVER DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1985.

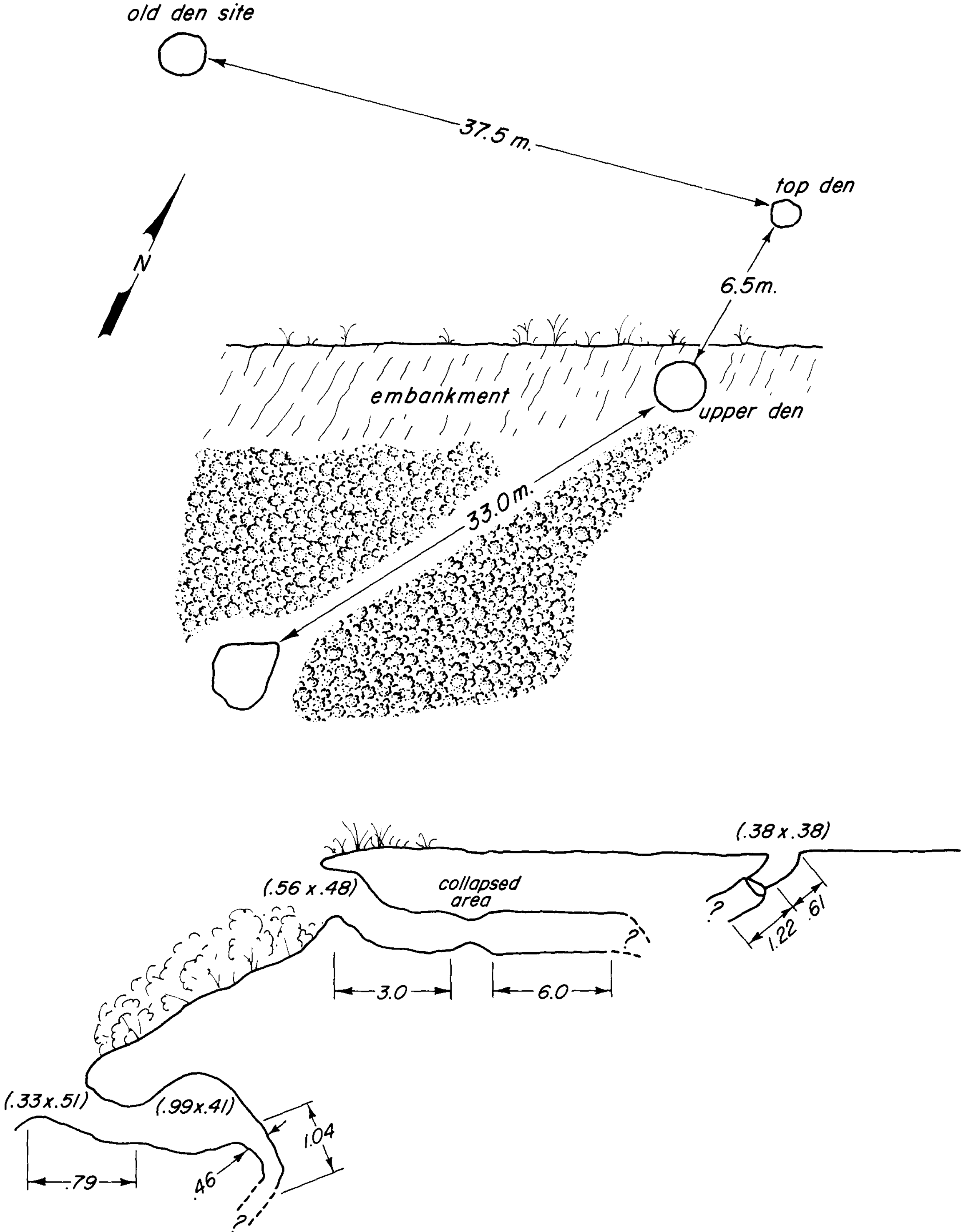


FIG. 12. HULAHULA RIVER DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1985.

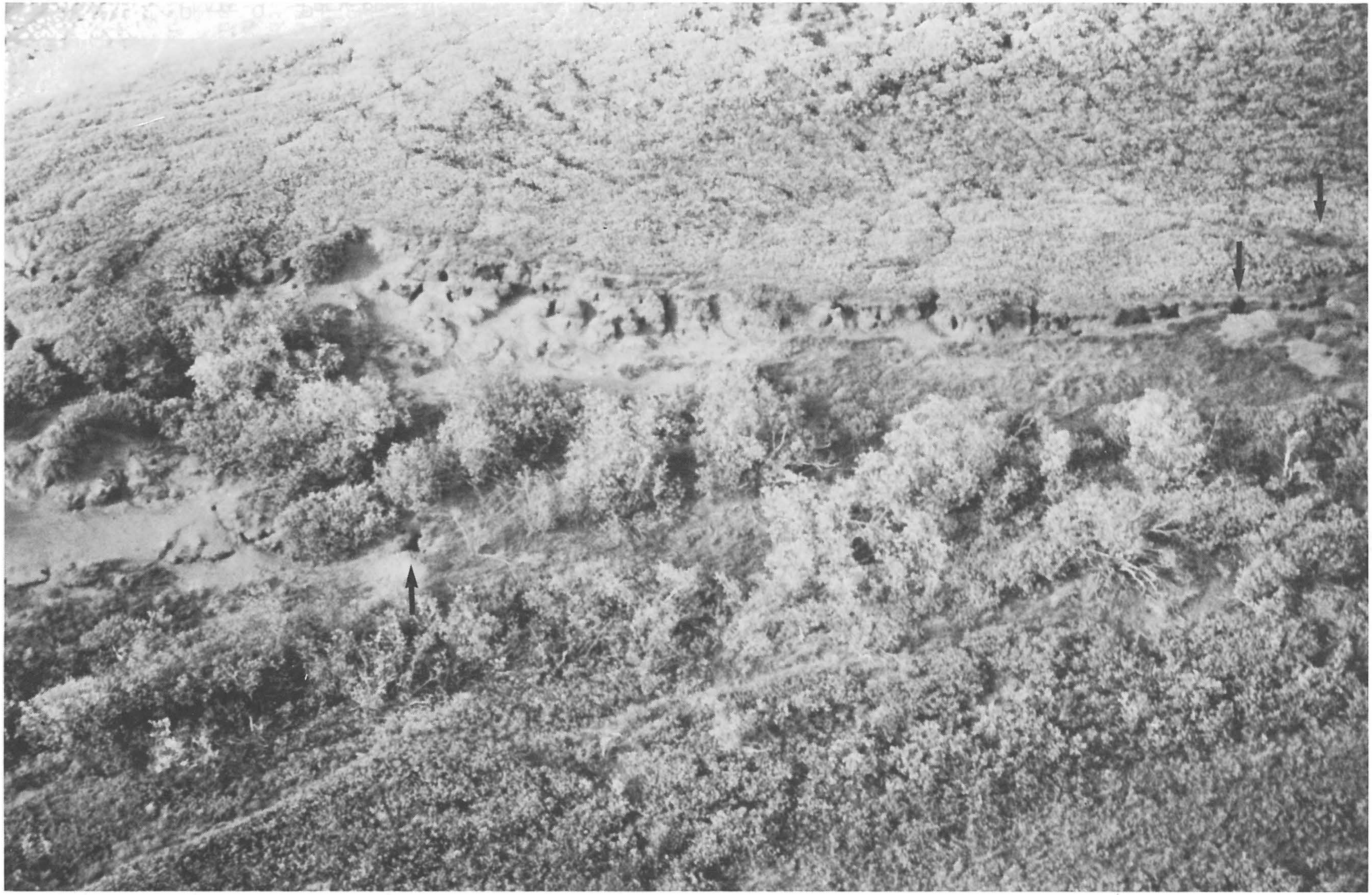


PLATE 8. HULAHULA RIVER DEN SITE, ARCTIC NATIONAL WILDLIFE REFUGE, 1985.

PLATE 9. PREY REMAINS FROM THE MALCOLM RIVER DEN, YUKON TERRITORY, CANADA, 1985.

golden eagles (Aquila chrysaetos), brown bears (Ursus arctos), porcupine quill infection, and accidents (Murie 1944, Mech 1970, Kuyt 1972, Stephenson and Johnson 1972, Chapman 1977 and 1978) influence wolf populations. Certain social mechanisms such as stress, competition, and subordination also function to control wolf populations (Mech 1970, Zimen 1976, Packard et al. 1983).

Disease

Periodic outbreaks of rabies are well documented in arctic foxes (Alopex lagopus), which are also known to be the principle vector of rabies in arctic areas (Rausch 1958, Kantorovich 1964, Syuzyumova 1967). The highest numbers of cases and peaks in the outbreaks occur during the winter months (Kantorovich 1964, Syuzyumova 1967, Ritter pers. comm.). In Alaska this occurs from January to April with peaks in February (Ritter pers. comm.). Large numbers of arctic foxes were observed by local residents along the coast of ANWR in early winter 1984. During the winter of 1984-1985 an epizootic of rabies occurred with cases of rabies in both arctic and red foxes being documented from a number of areas across the coastal plain of northern Alaska (L. Dalton, D. Ritter pers. comm.).

Rabid wolves in Alaska have been rarely recorded. Chapman (1978) documented the death of at least 6 of the 10 members of a wolf pack on the Hulahula River due to rabies. Between April and July 1985, 9 wolves were found dead on ANWR (Fig. 13). Five of the 9 tested positive for rabies with 2 undetermined but probable, and 2 were negative. The 5 rabid animals were found between 7 April and 17 May. Three of the 5 were found during a 4 day period over a distance of approximately 265 km. Two wolves were found dead 16 and 20 days after capture, which indicate that these animals were in the incubation period at the time of capture or became exposed immediately afterward. Rabies is thought to be the cause of the break up of the Aichilik pack. Wolf #5 was found dead (confirmed rabid) and tracks in the snow indicated a possible fight with several other wolves. The pack that #5 had been observed with was never located again and the den in that area which had been active for several years was not used (R. Armstrong pers comm.). One wolf (#12) travelled approximately 96 km in 19-20 days (from capture to when it was found dead). This wolf traveled through the middle of the Canning packs territory and although there is no indication that it came in contact with the pack, an unmarked rabid wolf was found along the route probably traveled by #12. Wolf #9 was found dead due to rabies approximately 26 km from den it had dug and where it had been located the three previous times. Tracks in the snow indicated it was traveling away from the den site at the time.

Rabies in the wolf population on ANWR probably originated with arctic foxes. Thus, it is believed that rabies in wolves in arctic Alaska is much more common than previously thought and outbreaks may occur in cycles in conjunction with outbreaks among arctic foxes. The proximity of the mountains to the coastline in northeastern Alaska and northwestern Canada as compared to other arctic areas, results in closer proximity to arctic foxes. Wide ranging wolves may serve as one vector in the spread of the disease. Dogs have been known to shed rabies virus in saliva up to 7 days before the appearance of signs of illness (Jonesco and Teodasiu 1928, as cited by Bell 1975). Rabies may function as a population regulation mechanism in this area, although a decrease in wolf densities was not apparent. It is possible, as stated by Chapman (1978) that dispersing wolves and subsequent reproduction could mask the effects of the disease. However, the

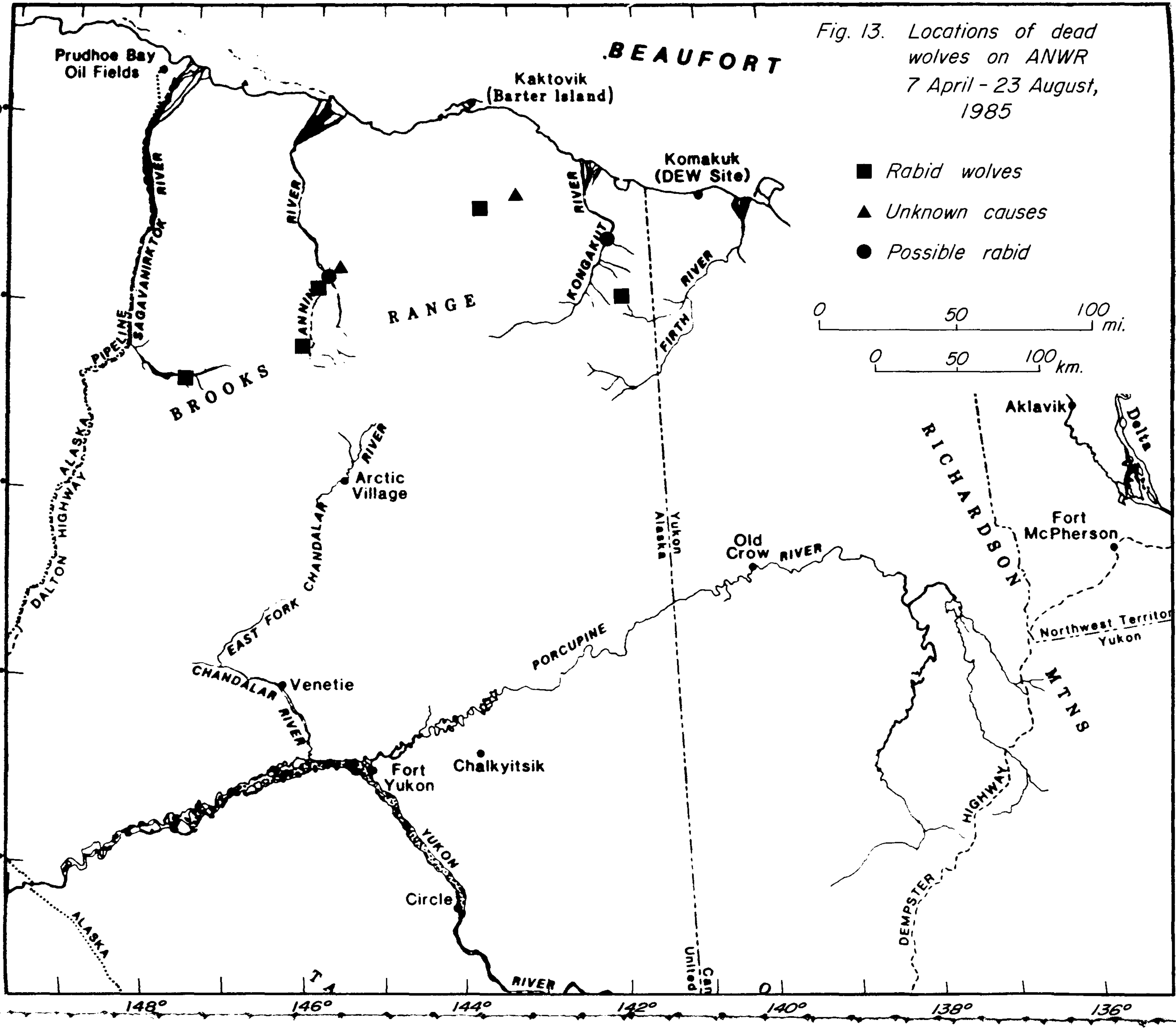


Fig. 13. Locations of dead wolves on ANWR 7 April - 23 August, 1985

relatvely low density of wolf den sites may be a result of previous outbreaks of rabies.

Two wolves were thought to have rabies but not diagnosed due to advanced decomposition of the carcasses. One was found at the Kongakut River den site and was believed to have been associated with 1 of the wolves which was confirmed rabid. The other wolf was found in the Canning River den. This wolf had a large number of porcupine quills in the face and muzzle area of the head as has been commonly reported in rabid foxes and wolves. However, MacDonald (1980) stated that canine distemper may mimic rabies. Foxes having canine distemper sometimes show aggressive behavior resembling that of rabid animals (Helmboldt and Jungherr 1955; Habermann et al. 1958, as cited by Rausch 1958). Carbyn (1982) also indicated unusual behavior may be due to encephalitic implications brought on by distemper. Canine distemper therefore cannot be ruled out as the possible cause of death in this wolf.

Two wolves where found on 19 and 30 June 1985 and were negative for rabies. One was an unmarked wolf while the other was a member of the Canning River pack. Causes of death were undetermined, but necropsy results indicated that a possible cause was viral pneumonia or bronchitis which may have been precipitated by canine distemper.

Blood was drawn from wolves for seroligical study by the Alaska Department of Fish and Game (ADFG). Serum was tested for brucellasis, tularemia, infectious canine hepatitis, canine distemper, canine parvovirus, leptospirosis, and rabies. At present, results from 16 wolves have been received. Wolf #3 (1-2 year old male) had evidence of previous exposure to brucellosis and tularemia and wolf #13 (3-4 year old female) hadevidence of exposure to tularemia. Since testing is incomplete, these results are given as general information. However, it is interesting to note that wolves #12 and #16 showed no evidence of rabies even though these wolves were found dead (positive for rabies) 16 and 20 days after capture. In 1985, 9 of the 12 documented mortalities were due to disease. This represents a mortality of 26% of the known 1984 fall population.

Human Induced Mortality

In the past, human activity has often had negative consequences for wolves. The extirpation of wolves from extensive areas of North American and Eurasia has been directly associated with human settlement activities. Predator control and bounty programs using guns, traps, and poison effectively removed wolves from major agricultural areas of the U.S. and Canada. Government sponsored aerial hunting and poisoning of wolves during the 1940's and 1950's greatly reduced wolf populations in some areas of Alaska (Rausch and Hinman 1977). Wolf populations in many of these areas have since recovered. Wolves were relatively abundant on the north slope of Alaska prior to aerial wolf hunting and predator control activities, which became intensive in this area in the early to mid-1950's (Stephenson per. comm.). Between 1952 and 1958 more than 1500 wolves were killed on the north slope of the Brooks Range (Harbo and Dean 1983). In 1962 it was recognized that wolf numbers on the north slope were depressed and an annual bag limit of 2 wolves was imposed. In 1968, the Alaska Department of Fish and Game abolished bounties on wolves except for a few areas in southwest Alaska. Aerial hunting of wolves on the north slope was banned in 1970.

Human induced mortality on ANWR is the result of harvest by local residents, trapping, sport hunting, and illegal aerial hunting. Illegal aerial hunting is probably more common south of the Brooks Range, occurring only sporadically north of the Brooks Range. Few wolves are taken by sport hunters due to the fact that hides are usually not prime at the time most sport hunting for moose and Dall sheep occurs. Most harvest of wolves occurs from local residents using snowmobiles. In past years the extent of this harvest was unknown because most hides are used locally and therefore were usually not sealed. During 1984-1985, 10 wolves were harvested (7 in 1984, 3 in 1985). All 10 wolves were taken by local residents of which 2 were reported but not confirmed, and 2 were taken illegally after the season closed. Human harvest in 1985 was 9% of the 1984 fall populations, while the total known mortalities (human and natural) in 1985 represented 35% of the 1984 fall population.

Conclusions

Wolves on ANWR are part of a dynamic population in which dispersal and formation of new packs are common. Overall pup production was low compared to other areas and pup survival was related to pack size. Lone wolves and dispersing wolves appear to use the coastal plain during caribou calving while pack wolves utilize the mountains and foothills more heavily. Dispersing wolves may travel great distances and may follow caribou. Although some animals followed caribou south, none returned north when the caribou did. All packs, except the Canning River pack, appeared to be resident packs and stayed in the same areas during winter as in summer. Packs did not show a season shift in territories in conjunction with caribou movements. An outbreak of rabies in 1985 occurred in both foxes and wolves. It is believed that rabies is more common than previously thought and may possibly function as a population regulating mechanism. Outbreaks may occur in conjunction with outbreaks among arctic foxes. To understand the basic ecology of this population (territories, movements, and prey interrelationships), additional data are needed; including winter movements, winter food habies, and the availability and numbers of prey species at various times of the year.

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FOOD HABITS OF DENNING WOLVES ON THE ARCTIC NATIONAL WILDLIFE REFUGE

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

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Food habits of denning wolves on the Arctic National Wildlife Refuge

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Abstract: Wolf (canis lupis) scats were collected at 6 den sites during 2 denning seasons. Results were compared to 2 other den sites where scats had been collected previously. Prey items found in adult scats are presented as percent composition of prey consumed. Prey items found in pup scats are presented as frequency of occurance and are compared to adults scats using a similarity index. Caribou (Rangifer tarandus) was the major prey species overall and was the primary food item for all but 2 packs in which moose (Alces alces) was the the primary prey species. Two packs had shifts between moose and caribou as the primary prey in successive years. Dall sheep (Ovis dalli) were important prey in selected drainages. Non-ungulates comprised less than 2% of the prey consumed in all but 2 packs. Non-ungulates comprised 6.29% of prey consumed in the Hulahula pack, and 18.8% in the Canning pack, of which 16.9% was ground squirrels. Kulcynski's similarity index indicated that prey items used by pups and adults had a high percent similarity in all packs, ranging from 69.7% to 86.8% with a similarity index of 82.7% of all packs combined. Wolf packs on the Arctic National Wildlife Refuge (ANWR) utilized all 3 large ungulates (caribou, Dall sheep, moose) to a greater extent than has been reported for other areas of arctic Alaska and Canada. This appears to be due to the greater availability of moose and sheep in this area. Pack size and the annual variation in availability of prey species are important factors determining use of prey species.

Food Habits of denning wolves on the Arctic National Wildlife Refuge.

In 1984, a study was initiated on the Arctic National Wildlife Refuge (ANWR) to document the seasonal movements of wolves and associated packs and to determine seasonal food habits of wolves as well as the seasonal availability of potential prey within the ranges of study wolves. Data on movements of wolves and wolf packs were presented by Weiler et al. (1987). Food habits of wolves during the denning seasons were determined by analysis of scats collected at den sites. The results of scat collection at 6 den sites during 2 denning seasons (1984 and 1985) are presented in this report.

Methods and Materials

Scats were collected at and around den sites in late August, after wolves had abandoned the sites. Individual scats were placed in whirl paks, numbered and recorded as either pup or adult. Scats were classified as adult or pup based on the scat size, with pup scats being less than 2.5 cm in diameter (Stephenson and Johnson 1972). Analyses of scats was performed by the Composition Analysis Laboratory, Colorado State University, Fort Collins, Colorado (see Appendix item 1). Prey items were recorded by frequency of occurrence and volumetric proportion (ocular estimate). Volumetric proportions of a prey item was used to calculate estimates of the actual weight (kg) of prey consumed using the regression equation developed by Floyd et al. (1978). Using the equation $Y = .38 + .02x$ (x = average live weight of prey, and Y = kilograms prey consumed per scat), Y was multiplied by the volumetric proportions (number of scats) to calculate the number of kilograms consumed for each prey item. This weight (K_3) was then divided by the total weight of all prey items to calculate the percent composition of prey consumed. Since formulas described by Floyd et al. (1978) were derived from yearling and adult wolves, prey items in pup scats are shown as frequency of occurrence only.

Live weights of a prey species are influenced by many factors such as age, sex, composition of the population, condition, and geographic area. Sources for live weights of prey species (Appendix Table 1) used in calculating estimates of weight of prey consumed, are listed in Appendix item 2. Relative frequency of occurance of prey items was used to calculate Kulcynski's similarity index (Oosting 1956) between pup and adult scats. All observations of prey distribution, unless cited, were based on observations made while flying surveys for various projects.

Results and Discussion

A total of 811 scats were collected at 6 den sites (1 site in 1984 and 5 in 1985). An error in numbering of the scats resulted in 43 scats being unusable and a total of 768 scats were analyzed. There were 411 adult scats and 355 pup scats, of which 140 (34%) and 146 (41%) respectively, contained more than 1 food item.

Percent composition of prey consumed by adult wolves is shown in Figure 1. Also, results from the Canning den 1984, and Kongakut den 1983 and 1984 (Haugen 1987) are shown for comparison. Frequency of occurrance in pup and adult scats and volumetric proportion and percent composition of prey species in adult scats are detailed in Appendix Tables 2-5.

Food Habits

Canning River Pack. Scats at the Canning den were collected in 1984. Therefore scats collected in 1985 represent the summer's diet of wolves at the den site. Caribou comprised more than 4 times the percentage of prey consumed in the diet than any other single food item and over 3 times the percentage of all other prey combined (Fig. 1). General observations made while conducting radio tracking flights showed caribou to be scarce in the area. Surveys in April and October 1985 showed 51 and 15 moose respectively in the drainage around the den site, (Garner unpublished data, ANWR files), however, moose were not represented in the scats collected. A major shift from moose to caribou occurred from 1984 to 1985, at a time when observations of prey species in the area would have indicated otherwise. Change in pack size may be a possible explanation of this change in food items. In 1984 Haugen (pers. comm.) estimated that there were 5 adults wolves in the pack. In 1985 the pack consisted of 4 adults (1 male, 3 females), with all but 1 female being radiocollared. Contact with the male was lost in late April and this wolf was never observed at the den again. Two of the females attempted to raise litters of pups in separate dens. One female failed to raise pups, abandoned the den and died shortly afterward of unknown causes. The 1 non-breeding female died in late July. As a result, during the denning period there was only 1 wolf which was able to hunt until the whelping bitch was able to leave the pups at the den and start hunting. Since single wolves are rarely successful in preying upon adult moose (Stephenson 1978), the change in food habits in 1985 may have been due to a decline in pack size rather than a change in available prey.

Sheep comprised only 6.0% and 2.5% of prey consumed in 1984 and 1985 respectively (Fig. 1). Current data on Dall sheep numbers and distribution in the Canning River drainage are lacking. The last survey in the area of the den was conducted in 1979 (Smith, unpublished report ANWR files). This survey showed low numbers of sheep occurring approximately 19 km south of the den site. The percentage of prey consumed for non-ungulate species (18.8%) was much higher than any other den site, which is mainly due to a much higher percentage (16.9%) of ground squirrels in the diet. This again may be due to the reduced pack size.

Hulahula River Pack. This den site was a first year site used by a first time breeder, so scats were assumed to reflect the summers food habits. At the time of denning, the whelping bitch was the only member of the pack. She was joined by a large gray adult in mid-July. The Hulahula wolves diet contained higher proportion of Dall sheep (35%) than any other pack (Fig. 1). This was not unexpected as sheep are common in the area and are often observed on the mountain slopes directly behind and across the river from the den site. The den site itself lies almost in the center of a square formed by four sheep licks (Smith, unpublished report, ANWR files). Sheep surveys in 1986 counted 201 sheep in the area of the den site, (Garrett, unpublished data ANWR files). Sixty percent of the prey consumed were caribou although caribou were not commonly observed in the immediate area. In 1985, caribou were present in the rolling hills between

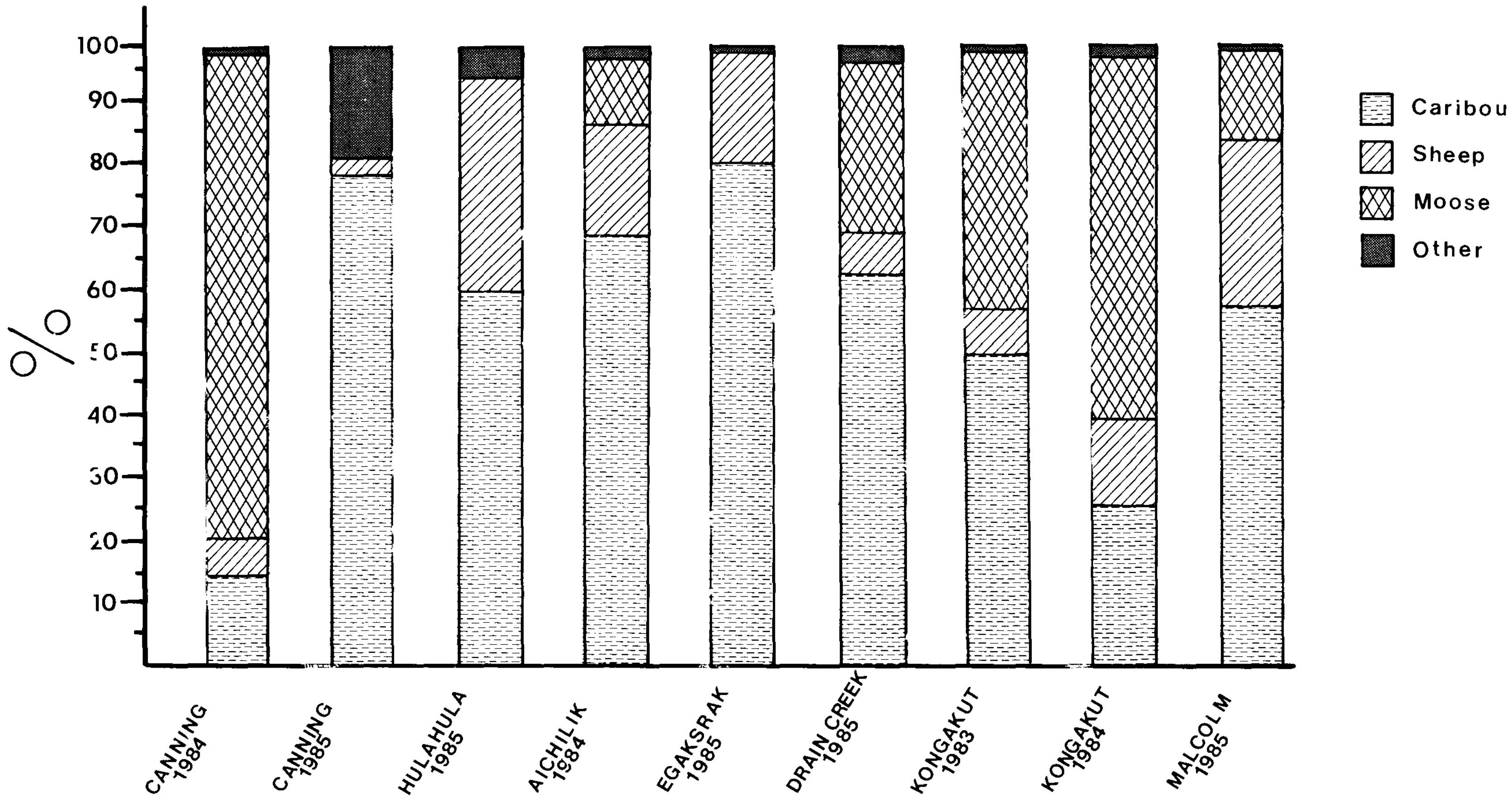

Fig.1. Percent composition of prey consumed by adult wolves in wolf packs during the denning season on the Arctic National Wildlife Refuge.

Lake Schrader and the Sadlerochit River, however, this distribution did not occur until just before the wolves abandoned the den site. It is possible that the wolves were concentrating efforts on small numbers of caribou that may have been scattered throughout the area. Neither Dall sheep lamb nor caribou calf were recorded in the scats collected at this den site. Non-ungulates comprised 6.29% of prey consumed.

Aichilik River Pack. Scats from the Aichilik pack were collected in 1984. This pack did not den in 1985. The extensive development of the den site would indicate that this den was used previously to 1984 and therefore scats collected at the site probably represent at least 2 denning seasons. Caribou accounted for 67.9% of the prey consumed with sheep and moose being 17.9% and 11.6%, respectively (Fig.1). Caribou were abundant in the area, especially 4 to 5 weeks after calving, when movement of caribou into the foothills and mountains occurred. General observations on sheep and moose show that sheep are common in the mountains south of the den while moose are scarce. Surveys in April 1984 showed 12 moose in the vicinity of the den site (Garner, unpublished data, ANWR files). Non-ungulate prey were 1.5% of prey consumed.

Egaksrak River Pack. This den site was probably a first year site based on development of the den and scats were assumed to represent 1 denning season. Caribou and sheep comprised 79.4% and 19.8% of prey consumed respectively (Fig. 1). Sheep were fairly common in the area especially in mountains south of the den site. Caribou were available throughout the denning season especially in mid to late May and then again 4-5 weeks after calving. The Egaksrak den site was located in an area that is usually traversed by caribou both upon arrival and departure from the calving grounds on the coastal plain area of ANWR. Moose surveys in April 1984 showed 12 moose in the Egaksrak River drainage (Garner, unpublished data, ANWR files), although moose was not represented in adult scats. Non-ungulates were 0.58% of the diet.

Drain Creek Pack. Development of the Drain Creek den indicated that it was a first year den site. Although another site was found a short distance away, no scats were found there. It is assumed that the scats collected represented 1 denning season.

Caribou, sheep, and moose accounted for 62.5%, 6.9%, and 26.9% of the prey consumed respectively. Non-ungulates comprised 1.9% (Fig. 1). The Drain Creek den site was located in an area in which all 3 large ungulates were commonly observed. Caribou migrated through the area in large numbers both on their way to and from the coastal plain calving grounds. In 1985 caribou were still in the area in December, and may have remained in this area all winter (Whitten pers. comm.). Sheep are common in the area but numbers may vary from year to year. No current estimates of sheep in the drainage are available but ground surveys (Spindler, unpublished report ANWR files) showed 166 sheep in the area in 1982 and over 800 sheep in the area in 1978. There are at least 8 mineral licks in the area (Smith, unpublished data ANWR files), with 1 lick about 2.4 km from the den site. Moose are common in the area and up to 8 moose were observed directly in front of the den during scat collections. Moose surveys in April and October 1985 showed 28 and 33 moose in Drain Creek respectively (Garner, unpublished data, ANWR files). Only 1 moose calf was observed during the October survey and it was hypothesized that the wolves may have preyed heavily on calves around the den area, but moose calf remains were not detected in the scats.

Malcolm Pack. This den site was a first year den dug by a first time breeder. Scats are assumed to represent 1 denning season. Prey species smaller than ground squirrels were not found in the scats. Caribou represented the largest proportion of prey consumed at 57.5% (Fig. 1). Caribou were numerous around the den throughout most of the summer. On several occasions the wolves were observed at the den site and up to 200 caribou (cows and calves) were only several hundred meters away, resting on gravel bars. Caribou calves were not detected in the scats although 9 leg bones from caribou calves were found in the den. The presence of sheep in the scats was unexpected as sheep are rarely observed in the area and are generally thought to not be present except south and west of the den site. General observations show that moose are uncommon in the area although survey data are not available for this area. Non-ungulate prey comprised .06% of prey consumed.

Kongakut Pack. Data on food habits for the Kongakut wolf pack are taken from Haugen (1987). The Kongakut wolf pack utilized all 3 major prey species in both years. A shift in the primary prey occurred from caribou in 1983 to moose in 1984 (Fig. 1). This shift in the primary prey was unexpected as moose are rarely observed in the vacinity of the den site. During moose surveys in October 1983 and April and October 1984 (Martin, unpublished data ANWR files) no moose were observed in the area around the den site. A review of Haugen's field notes, recorded during observations at the den site in 1984, show that while caribou were frequently observed, no moose were seen. Non-ungulate prey accounted for 1.03% and 1.49% of the prey consumed in 1983 and 1984 respectively.

All Packs Combined. In 1984, only 3 historical den sites were known in 3 river drainages. It was hypothized, based on previous surveys and observations that the prey base for each of those packs would be different. For example, the Canning pack would utilize moose, the Hulahula pack would utilize sheep, and the Kongakut pack would have a more balanced use of all 3 major prey species. Scat analyses showed that this did not occur, at least during the denning season. All packs, with the exception of the Canning and Kongakut packs in 1984, utilized caribou more than any other species. Sheep were the second most common prey species, while moose were utilized very little (with the exception of those packs listed above). Small percentages of muskoxen (Ovibus moschatus) were found in scats from 4 of the 6 packs. Although muskoxen have been sighted in areas frequented by the packs, the small amounts shown in summer scats probably represent scavanging or possible returns to old kills made during winter. Kuyt (1972) also found small frequency of occurrence of muskoxen in wolf scats in Canada, and felt that wolves did not prey heavily on muskoxen. Non-ungulates comprised a very small percentage of prey consumed for all packs except the 1985 Canning pack, where ground squirrels comprised almost 17% of the prey consumed (Appendix Table 2).

The percent kilograms consumed for wolf packs combined was used to estimate the number of individual prey species utilized during the 1985 denning season. One of the most critical factors in such calculations is the consumption rate used. Consumption rates from 1.1 to 6.3 kg/wolf/day have been reported in literature (Mech 1977). Holleman and Stephenson (1981) estimated comsumption rates for 4 packs in the Brooks Range at 2.6 - 3.0 kg/wolf/day, using radiocesium as an indicator. Ballard et al. (1981) used 3.6 kg/wolf/day, a reported rate at which wolf pack populations should remain stable. Using a consumption rate of 3.6

kg/wolf/day, wolf packs on ANWR would consume the following estimated numbers of large ungulates during the denning season: 67 caribou, 7 caribou calves, 22 sheep, 3 lambs, and 3 moose (Appendix Table 6). The numbers are used as a general indicator of possible impacts on prey species. Since these consumption rates were products of winter food habit studies on wolves, they may not be applicable to wolf packs during summer. These calculations also reflect the inherent bias of using scats collected at dens as a indicator of summer food habits.

Food habits shown by scat analysis are specific for that pack during the period of time during which seats were collected. Only 2 packs (Canning and Kongakut) had scats collected in successive years. Both packs had shifts in the major prey species utilized (Fig. 1). The change in the Canning packs' diet may have been due to a change in pack size while the change in the Kongakut packs diet can not be explained by distributions of prey species or pack size. Although the results of scat analysis are specific to conditions for year and/or season, it is difficult to determine if they are representive of the pack's use of prey species in general (ie. over a number of years). Long term trends could be determined by further scat analysis over the next several years. The extensive use of caribou by wolf packs on ANWR would indicate that the use of alternative prey species is not as great as previously thought. However, the importance of alternative prey may increase during winter when most caribou have left the area.

Food items of wolves on ANWR as determined by scat analysis generally agree with results reported in other studies in northern Alaska and Canada (Kuyt 1972, Stephen and Johnson 1972, Stephensen 1975, James 1983). Caribou were the major food item in Canada (Kuyt 1972) followed by birds and microtines. The area studied had low numbers of moose and no sheep. Stephensen (1975) had a high frequency of occurrence of small mammals (microtines and ground squirrel) although caribou were the major food item. Sheep were common in some areas while moose were apparently uncommon. Stephensen and Johnsen (1972) found caribou and sheep as the primarly food items. Caribou abundance varied in some areas while moose were not present. Ground squirrels were the most prevalent small mammal. In northwestern Alaska, James (1983) found caribou to be the prevalent food item while ground squirrels were second. Moose and sheep were apparently uncommon in most areas frequented by those wolf packs. Large ungulates (primarily caribou) were the major food item found in these studies. It appears that differences in species utilized and the extent of that utilization may be due to geographical and seasonal variation in availability of prey species.

Pup Scats

Prey species found in pup scats were compared to those found in adult scats within the pack using Kulcynski's similarity index (Oosting 1956).

All packs showed a high percent similarity with a range from 65.6 to 86.8% (Table 1). This interpretation is subjective as the index is qualitative. However, the range of percentages of the index (21%) appears to be narrow, considering the wide range in the numbers of scats collected at various den sites.

Table 1. Kulcynski's similarity index between pup and adult wolf food habitats during the denning season on the Arctic National Wildlife Refuge, Alaska. 1985.

	Wolf Pack						
	Canning	Hulahula	Aichilik[a]	Egaksarak	Drain Creek	Malcolm	All
Adult (n)	86	16	158	69	88	24	411
pup (n)	5	174	36	79	16	45	355
% Similarity	69.7%	78.6%	86.8%	65.6%	78.6%	75.1%	82.7%

[a] scats collected in 1984.

The Hulahula den appeared to be an enlarged fox den. The observation of a dead fox outside the den, the 2 fox skulls found at the den and the large numbers of pup scats collects suggest the possibility that some of the pup scats collected at this site may have been fox scats. The similarity index of 78.6% for the Hulahula pack along with the lack of any extreme differences between the occurrance of food items in adult and pup scats (Appendix Table 3 and 5), indicate that if fox scats were present, they were few in numbers and did not greatly influence the overall food habitats as indicated by scat analysis.

Conclusion

Large ungulates were the major food item for wolves in the northeastern Brooks Range. Caribou were the dominant food item for all wolf packs in 1985. Moose and sheep appear to be more readily available to wolves on ANWR than on other study areas in northern Alaska and Canada and all were utilized to some extent by wolves. In some years, moose may be the most important prey (eg. Canning and Kongakut 1984). Sheep appear to be important in selected drainages. Annual variation in availability of species, and in pack size may be determining factors as to which species is preyed upon to the greatest extent.

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APPENDIX

ANWR Progress Report Number FY86-19

Appendix Item 1. Procedure for analyses of wolf fecal samples

1. Preserve samples - freeze or oven dry.

2. Place preserved individual fecal pellets in 4 x 8" marked nylon or 100% polyester bags, closing the top tightly with a new rubberband.

3. Record bag and samples identification on data sheets.

4. Place 10 - 20 bagged samples into a gallon jar, fill jar with water and 2 tablespoons laundry detergent, cover and let soak for about 24 hours.

5. Pour the softened samples into washing machine and wash and rinse until the rinse water is clear.

6. Spin out the excess water. Inspect bags to insure that they are still tightly sealed.

7. Dry in clothes dryer using a dryer sheet type fabric softener to remove the static.

8. Match bags to data tags.

9. Pour sample onto tray. Remove hair and place into paper sack, noting color, texture and identification if known. After all hair is removed, sort through remaining material, identifying and recording items found.

10. Identify teeth by matching with reference materials.

11. Make slides of subsamples of the hair, mounting them with nail polish. Identify hair by matching to reference materials.

12. Record all identification on data sheets.

13. Make summary tables.

Appendix Item 2. Determination of average prey weights.

1. Caribou

Sources: Jim Davis, Alaska Department Fish and Game.

<u>Adults</u>: Little information is available on adult weights of the Porcupine Caribou Herd (PCH), however it was felt that animals would be comparable in size to caribou from the Western Arctic herd from which weight data are available.

<u>Calves</u>: Although wolves utilize caribou calves on the coastal plain, most caribou are available to the majority of wolves when the caribou begin to move into the foothills and mountain areas and on migration routes. This normally is when calves are 4-6 weeks of age. Weight gain for caribou calves is approximately 0.45 Kg/day. Weight data on ANWR calves shows calves average 7.0 kg at 3 days of age (Whitten et al. 1984). Calves at 5 weeks of age would weigh approximately 23.0 kg.

2. Moose

Source: Wayne Regelin, Alaska Department Fish and Game.

Moose weigh from about 400 kg in the spring to 450 kg in late summer. James (1983) used 404 kg for an average moose weight in northwestern Alaskan and it was felt that this weight would be suitable for northeastern Alaska. Calves weigh about 9 kg at birth and about 72.5 kg in mid-August. Weight gain is close to 1 kg/day with a weight of 47 kg at 6 weeks of age.

3. Sheep

Source: Stephenson (1978), Wayne Heimer, Alaska Department of Fish and Game.

Lambs weigh 2.7-3.6 kg at birth and 13.6-22.6 kg by mid August. A weight of 14.0 was used as an average.

4. Muskoxen

Source: Lent (1978).

Average weights of muskoxen were 172 kg for females to 269 kg for males. 181.5 kg was used as an average weight.

5. Snowshoe hare

Source: Ballard et al. (1981).

6. Microtines

Source: Ballard et al. (1981).

Appendix Item 2. Cont.

7. Marmot

Source: Bart and Grossenheider (1964).

Weights were from 3.6 to 9 kg. A midrange of 6.8 kg was used.

8. Ground squirrel

Source: James (1983).

9. Birds

Most birds eaten were assumed to be chicks or fledglings of small passerines or ptarmigan (Lagopus spp.).

10. Waterfowl

Source: Bellrose (1980).

Waterfowl remains that appeared in scats at den sites were assumed to be from birds frequenting rivers in the mountains and foothills as opposed to birds utilizing the coastal plain. On ANWR this includes Harlequin ducks (Histrionicus histrionicus) and red-breasted mergansers (Mergus serrator) with weights ranging from 0.55 kg to 0.86 kg, with 0.7 kg used as a midrange.

11. Fish

Source: Robin West, U.S. Fish & Wildlife Service.

Fish generally available in rivers are grayling (Thymallus arcticus) and arctic char (Salvelimus alpinus). Weight of these fish vary greatly and an average weight of 1 kg was used.

Appendix Table 1. Average live weights of prey species.

Prey species	Weight (Kg)[a]
Caribou (*Rangifer tarandus*)	
Adult	104.00
Calf	23.0
Dall sheep (*Ovis dalli*)	
Adult	54.5
Calf	14.0
Moose (*Alces alces*)	
Adult	404.0
Calf	47.0
Muskoxen (*Ovibos moschatus*)	181.5
Snowshoe hare (*Lepus americanus*)	1.8
Microtines (*Lemmus* and *Microtus*)	0.1
Alaska marmot (*Marmot broweri*)	6.8
Arctic ground squirrel (*Spermophilus undulatus*)	0.7
Birds	0.1
Waterfowl	0.7
Fish	1.0

Appendix Table 2. Percent composition of prey consumed by adults in wolf packs on Arctic National Wildlife Refuge.

Prey species	Canning 1984[a] (131)[b]	Canning 1985 (56)	Hulahula 1985 (16)	Aichilik 1984 (158)	Egaksrak 1985 (69)	Drain Creek 1985 (88)	Kongakut[a] 1983 (73)	Kongakut[a] 1984 (142)	Malcolm 1985 (24)
Caribou	17.42	78.29	58.66	67.90	79.42	62.46	58.10	31.80	57.50
adult	13.88	75.30	58.66	67.40	75.76	62.46	37.79	23.92	57.50
calf	3.54	2.79	-	0.50	3.66	-	20.31	7.88	-
Dall Sheep	5.97	2.55	35.00	17.89	19.84	6.90	10.20	12.53	26.20
adult	5.22	1.35	35.00	17.50	19.36	6.90	5.40	8.54	26.20
lamb	0.75	1.20	-	.39	.48	-	4.80	3.99	-
Moose	75.41	-	-	11.60	-	26.86	34.97	54.18	15.70
adult	69.09	-	-	11.60	-	26.30	31.09	47.56	15.70
calf	6.32	-	-	-	-	0.56	3.88	6.62	-
Muskox	-	0.33	-	1.2	0.15	1.89	-	-	-
Ground Squirrel	0.56	16.87	0.48	0.39	0.34	0.36	0.29	0.76	0.60
Marmot	-	0.28	-	0.18	0.23	-	-	-	-
Snowshoe hare	-	1.54	3.28	0.43	-	1.49	-	-	-
Microtine	0.28	0.02	2.44	0.37	-	-	0.08	0.49	-
Mustella	0.05	-	-	-	-	-	0.66	0.10	-
Birds	0.05	0.12	0.09	0.08	-	0.03	-	0.12	-
Waterfowl	-	-	-	-	0.01	-	-	-	-
Fish	0.02	-	-	0.05	-	-	-	0.02	-
Arthropods	-	-	-	-	-	-	-	-	-

[a] from Haugen 1987
[b] number of scats

Appendix Table 3. Percent frequency of occurrence of prey species occurring in adult scats collected at den sites on the Arctic National Wildlife Refuge.

Prey Item	Canning 1985 (56)[a]	Hulahula 1985 (16)	Aichilik 1984 (158)	Egaksrak 1985 (69)	Drain Creek 1985 (88)	Malcolm 1985 (24)	Total all scats (411)
Caribou							
adult	75.0	37.5	63.3	59.4	65.9	58.3	63.5
calf	0.7	--	1.9	10.0	--	--	3.2
Dall sheep							
adult	3.6	43.7	27.8	28.8	14.8	50.0	23.1
lamb	5.4	--	1.9	1.7	--	--	1.7
Moose							
adult	--	--	5.1	--	10.2	12.5	4.9
calf	--	--	--	--	1.1	--	0.2
Muskox	3.6	--	0.6	1.7	1.1	--	1.2
Ground squirrel	17.9	12.5	12.7	3.4	10.2	12.5	11.2
Marmot	3.6	--	5.1	1.7	--	--	2.7
Snowshoe hare	12.5	12.5	8.2	--	12.5	--	8.0
Microtines	1.8	50.0	8.9	--	--	--	5.6
Mustella	--	--	0.6	--	--	--	0.2
Birds	12.5	6.3	6.9	--	3.4	--	5.1
Waterfowl	--	--	--	--	--	--	--
Fish	1.8	--	4.4	1.7	--	--	1.9
Arthropods	--	12.5	3.1	5.1	3.4	4.2	3.6

[a] number of scats.

Appendix Table 4. Volumetric proportion (ocular estimate) of prey species occurring in adult scats collected at den sites on the Arctic National Wildlife Refuge.

Prey Item	Canning 1985 (56)[a]	Hulahula 1985 (16)	Aichilik 1984 (158)	Egaksrak 1985 (69)	Drain Creek 1985 (88)	Malcolm 1985 (24)
Caribou	40.89	5.60	93.88	48.03	53.83	12.59
adult	36.89	5.60	91.93	42.08	53.83	12.59
calf	4.00	-	1.95	5.95	-	-
Dall sheep	3.30	5.60	41.85	19.00	9.95	9.60
adult	1.10	5.60	39.85	18.00	9.95	9.60
lamb	2.20	-	2.00	1.00	-	-
Moose	-	-	4.60	-	7.49	1.00
adult	-	-	4.60	-	6.59	1.00
calf	-	-	-	-	0.90	-
Muskoxen	0.10	-	1.00	0.05	1.00	-
Ground squirrel	5.15	0.29	3.35	1.20	1.95	0.80
Marmot	0.65	-	1.20	0.60	-	-
Snowshoe hare	4.45	1.85	3.45	-	7.60	-
Microtines	0.05	1.50	3.25	-	-	-
Mustella	-	-	0.10	-	-	-
Birds	0.40	0.05	0.74	-	0.15	-
Waterfowl	-	-	-	0.05	-	-
Fish	-	-	0.40	-	-	-
Arthropods	0.01	0.11	0.18	0.70	0.03	0.02

[a] number of scats.

Appendix Table 5. Percent frequency of occurrence of prey species occurring in pup scats collected at den sites on Arctic National Wildlife Refuge.

Food Item	Canning 1985 (5)[a]	Hulahula 1985 (174)	Aichilik 1984 (36)	Egaksrak 1985 (79)	Drain Creek 1985 (16)	Malcolm 1985 (45)	Total all scats (355)
Caribou							
adult	100.0	36.8	66.7	87.0	56.0	57.8	55.5
calf	--	--	--	1.3	--	--	0.3
Dall sheep							
adult	20.0	29.3	38.9	7.6	25.0	15.5	23.4
lamb	--	--	--	--	--	--	--
Moose							
adult	--	0.6	11.0	6.3	18.8	22.0	6.5
calf	--	--	--	--	--	--	--
Muskox	--	0.6	--	--	--	2.0	0.6
Ground squirrel	60.0	25.9	19.4	13.9	12.5	8.9	20.3
Marmot	--	9.8	11.0	1.3	--	2.0	6.5
Snowshoe hare	--	20.0	8.0	1.3	--	4.4	11.5
Microtine	--	25.9	5.6	--	--	--	13.2
Mustella	--	0.6	--	--	--	--	0.3
Birds	--	8.6	8.0	1.3	--	--	5.4
Waterfowl	--	--	2.8	1.3	--	--	0.6
Fish	--	--	2.8	--	--	--	0.3
Arthropods	--	11.5	2.8	2.5	--	6.7	7.3

[a] number of scats.

Appendix Table 6. Estimated number of kilograms of prey consumed and numbers of individual prey consumed by adult wolves[a] on Arctic National Wildlife Refuge as extrapolated from scat analyses and wolf population estimates for a 92 day period (mid-May through mid-August) in 1985.

Prey	Vol. proportion of prey species occuring in combined wolf packs	% kg of consumed by wolves	Est. kg[b] of prey consumed	Est. number of prey consumed
Caribou				
adult	151.00	70.35	6989.97	67.20
calf	10.00	1.60	158.97	6.90
Sheep				
adult	44.25	12.30	1222.13	22.40
lamb	3.20	3.90	38.75	2.80
Moose				
adult	7.59	12.16	1208.20	3.00
calf	0.90	0.23	22.85	0.50
Muskox	1.15	0.87	86.44	0.50
Ground Squirrel	9.39	0.70	69.55	99.40
Marmot	1.25	0.12	11.92	1.80
Snowshoe Hare	13.90	1.09	108.30	60.20
Microtines	1.55	0.11	10.93	109.30
Birds	0.60	0.04	3.97	39.40
Waterfowl	0.05	0.00	0.30	0.43

[a] estimated wolf population = 30
[b] based on a rule of 3.6 kg/wolf/day

ANWR Progress Report Number FY86-1

A MICROTINE RODENT POPULATION INCREASE IN 1985 ON THE COASTAL PLAIN OF THE ARCTIC NATIONAL WILDLIFE REFUGE, WITH NOTES ON PREDATOR DIVERSITY

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Key words: Microtine rodents, *Lemmus sibericus*, *Microtus oeconomus*, population density, predation, Arctic National Wildlife Refuge, north slope, Arctic-Beaufort

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A microtine rodent population increase in 1985 on the coastal plain of the Arctic National Wildlife Refuge, with notes on predator diversity.

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Abstract: During a short trapping program in mid-summer 1985, evidence was gathered that suggested an increase in microtine rodent densities on the coastal plain of the Arctic National Wildlife Refuge. Population densities were an order of magnitude higher than those estimated for 1983 and 1984. Snowfall in the winter of 1985 was greater than in the previous two winters. Peak densities probably occurred in the early spring of 1985, with most of this peak likely the result of successful winter reproduction by Lemmus sibericus (brown lemming). Two of the three study areas showed evidence of spring Lemmus peaks, and these areas also had a corresponding high diversity of microtine predators. At the time of trapping, the third area had a higher total microtine density, due to high densities of Microtus oeconomus (tundra vole), but did not have the predator diversity of the other two areas.

A microtine rodent population increase in 1985 on the coastal plain of the Arctic National Wildlife Refuge, with notes on predator diversity.

A short trapping program was conducted between 27 July and 8 August 1985, to examine densities and demographic status of microtine rodent populations at 3 sites on the coastal plain (Fig.1). Two of the 1985 study areas (Tamayariak and Niguanak) were chosen because of the anomalously high densities of brown bears (Ursus horribilis) associated with them. These bears were apparently preying extensively on microtines (Garner et al. 1987). The third study area (Marsh Creek) was selected because it was in a similar position on the coastal plain, but without high concentrations of brown bears. Brown bears normally tend to move out from the foothills and onto the coastal plain in June and July to occupy calving and post-calving areas used by caribou (Rangifer tarandus) (Garner et al. 1985). After calving and movement of caribou from the coastal plain, brown bears have usually returned to foothills habitats. In 1985, however, calving occured earlier than usual and caribou began to leave the coastal plain earlier (Whitten et al. 1987), but concentrations of brown bears remained high in the calving and post- calving areas throughout July. Brown bears in the foothills have been observed preying on microtines (Phillips 1984, Babcock 1984), although these cases of predation appeared to be occasional and opportunistic.

Analysis of skulls from raptor and jaeger pellets collected from the Okpilak and Katakturuk study areas of 1983 and 1984 (Fig. 1), strongly suggested that fluctuations in microtine densities had occurred at these sites. The fluctuations appeared to be largely attributable to peaks of Lemmus and Dicrostonyx groenlandicus (collared lemming) population densities (Babcock 1985). The trapping effort in the current study concentrated on habitats not typically used by Dicrostonyx.

Methods

At each study area an 8 X 12 (96 station) live-trapping grid was surveyed using compass and chain, and spacing between grid points was 10 m. The effective trapped area for each grid was approximately 1 ha. A large size (7.6 x 7.6x 23 cm) folding Sherman live-trap was placed in a microtine runway within 2 m of each grid point and these traps were moved to other nearby runways periodically through the trapping period. Traps were stuffed with available sedges as insulation and were not baited. These grids were checked at 4 to 6 h intervals throughout the 2 day (48h) trapping periods. Animals were marked by toe clipping, demographic information was taken, and each animal was released at the grid point where it was captured. These methods differ slightly from those of the previous summers' trappings (Babcock 1984), in that the trapped area was smaller and the duration of the trapping period was shorter. Otherwise, all techniques were identical. During each trapping period at each area, the presence of all obligate and facultative microtine predators was noted.

Chi-squared statistics were calculated on contingency table data for species composition and numbers of microtines on the 3 trapping grids. Cochran's Q test (Zar 1984) was used to test for differences in the diversity of

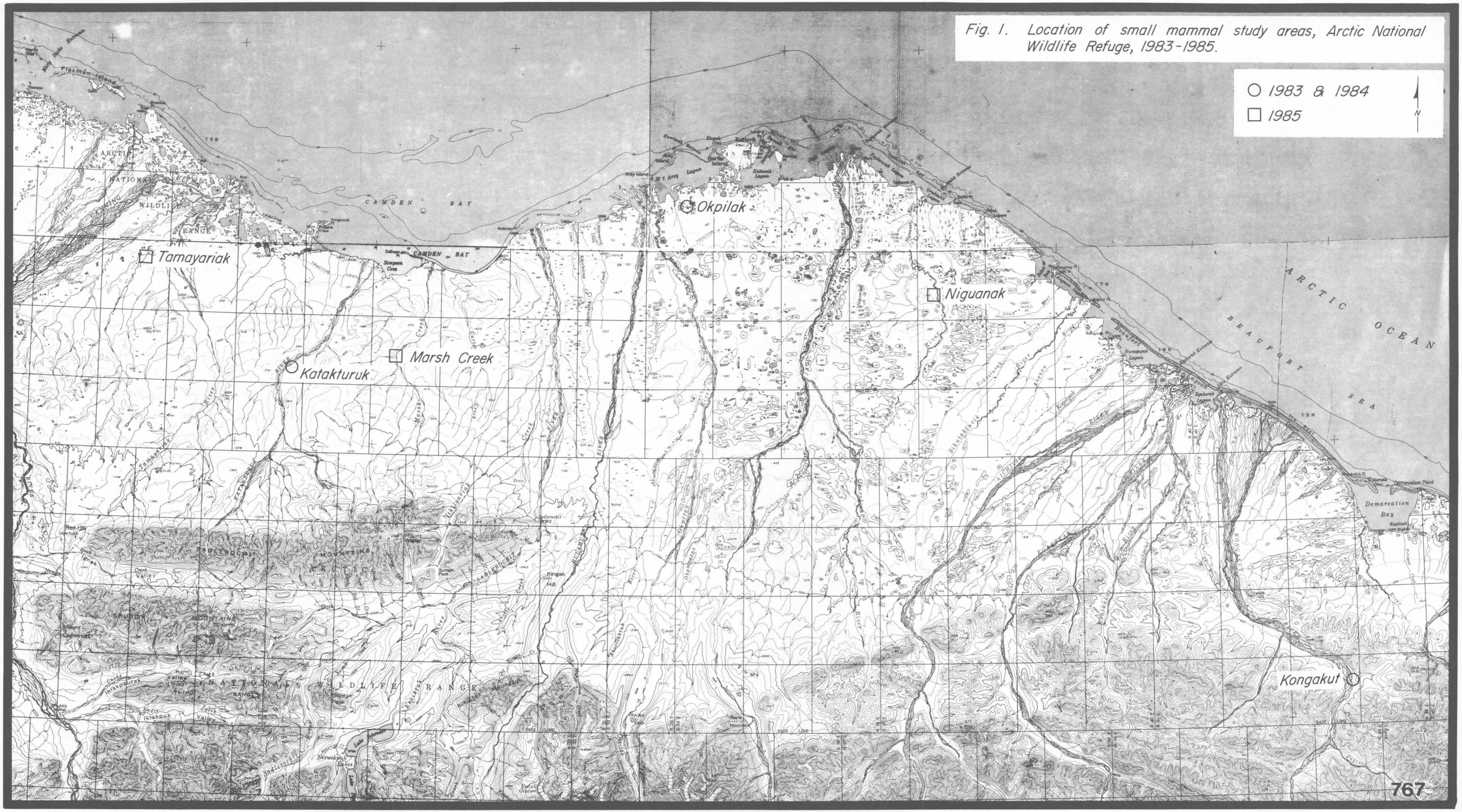

Fig. 1. Location of small mammal study areas, Arctic National Wildlife Refuge, 1983-1985.

microtine predators between the areas. The value of the Q statistic is unaffected by cases where presence or absence is noted for all locations, so such cases may be dropped from the calculation.

Results and Discussion

Similar total numbers of microtines were captured on all 3 of the live-trapping grids (Table 1), but the Marsh Creek area had a significantly different proportion of Lemmus sibericus and Microtus oeconomus (X^2=10.999, 0.001 < P < 0.005). Lemmus populations at both Tamayariak and Niguanak did not appear to be actively increasing; no reproductive females were caught at Tamayariak (Fig. 2). At Niguanak the number of reproductive males was much higher than the number of reproductive females. The sex ratio of all Lemmus captured in the 3 areas combined was signficantly skewed towards males (6 males: 1 female, X^2=7.142, 0.005 < P < 0.01), and recruitment of juvenile, non- reproductive Lemmus into these populations appeared to be very low. Capture weights reinforce the use of simple reproductive indicators for dividing all populations into discreet demographic classes (Fig. 3). None of the 3 Lemmus population samples were composed of proportions of males and females that would indicate increasing densities. The demographic make-up of the Tamayariak and Niguanak populations resemble those reported for Lemmus populations in a decline phase following a density peak (Batzli 1975).

Table 1. Numbers of individuals captured on 1 ha live-trapping grids.

	Numbers of individuals captured			
Location	Lemmus	Microtus	Total microtines	Total mustelids
Tamayariak	5	6	11	3
Niguanak	8	7	15	1
Marsh Creek	1	19	20	0

Populations of Microtus oeconomus had a normal sex ratio, and all showed recruitment of juveniles and evidence of reproduction and population density increase (Fig. 2,3), even though at Tamayariak and Niguanak the total number of Microtus were not significantly different from the number of Lemmus (Table 1).

Densities of microtines on all study grids in 1985 (Table 2) were higher than those recorded at different areas during the previous 2 summers (Babcock 1984, 1985). Trapping procedures for 1983 and 1984 did not follow exactly the same protocol as the 1985 survey, but rough density comparisons can be made for both Lemmus and Microtus. The total numbers of microtines were less in 1983 and 1984, and the proportion of Lemmus was also lower than in 1985 (Table 2). During the winter of 1984-1985, snowfall on the coastal plain was higher than that of the previous 2 winters (Felix et al. 1987).

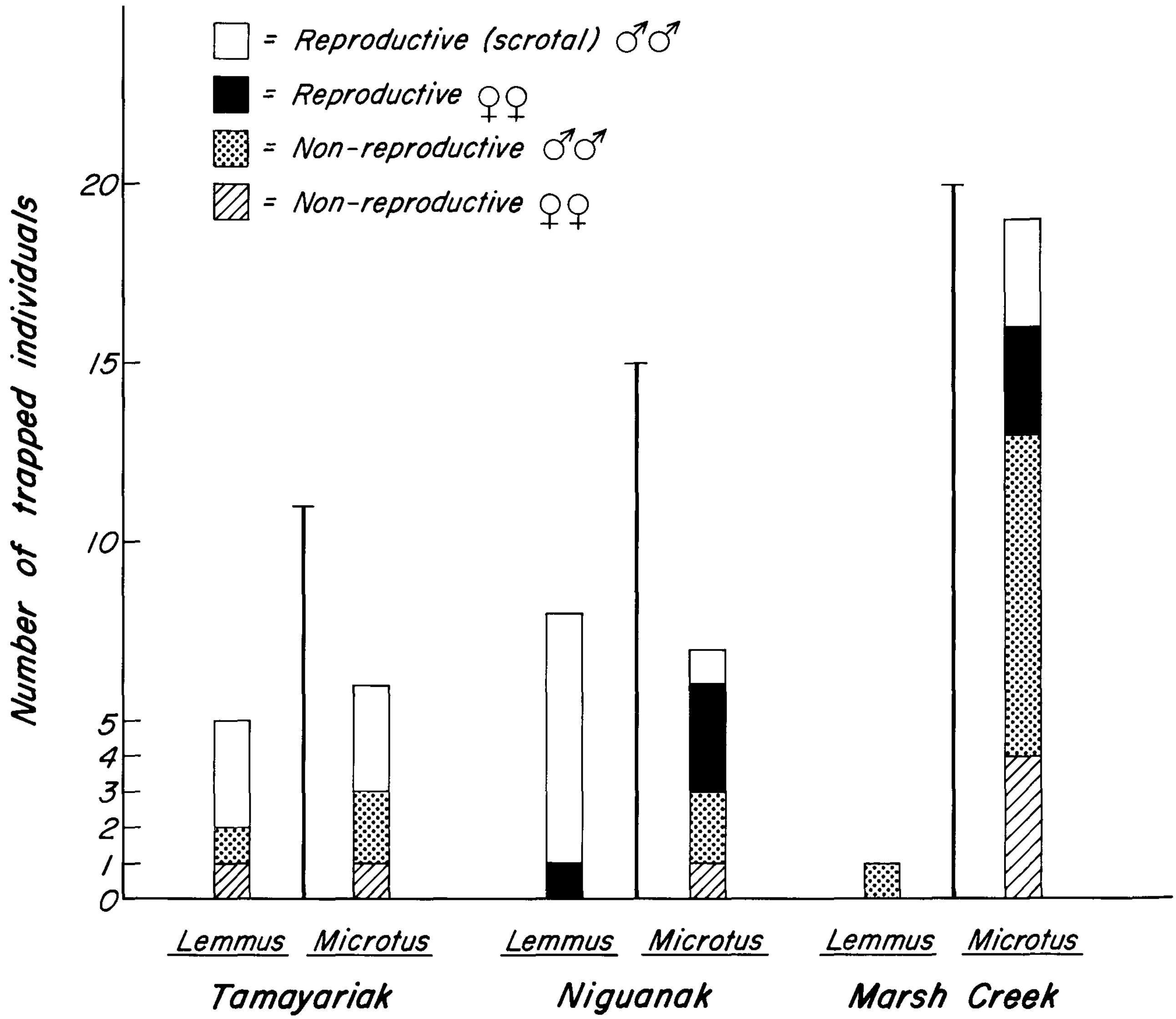

Fig. 2. Demographic composition of trapped populations of Lemmus and Microtus from the three study areas.

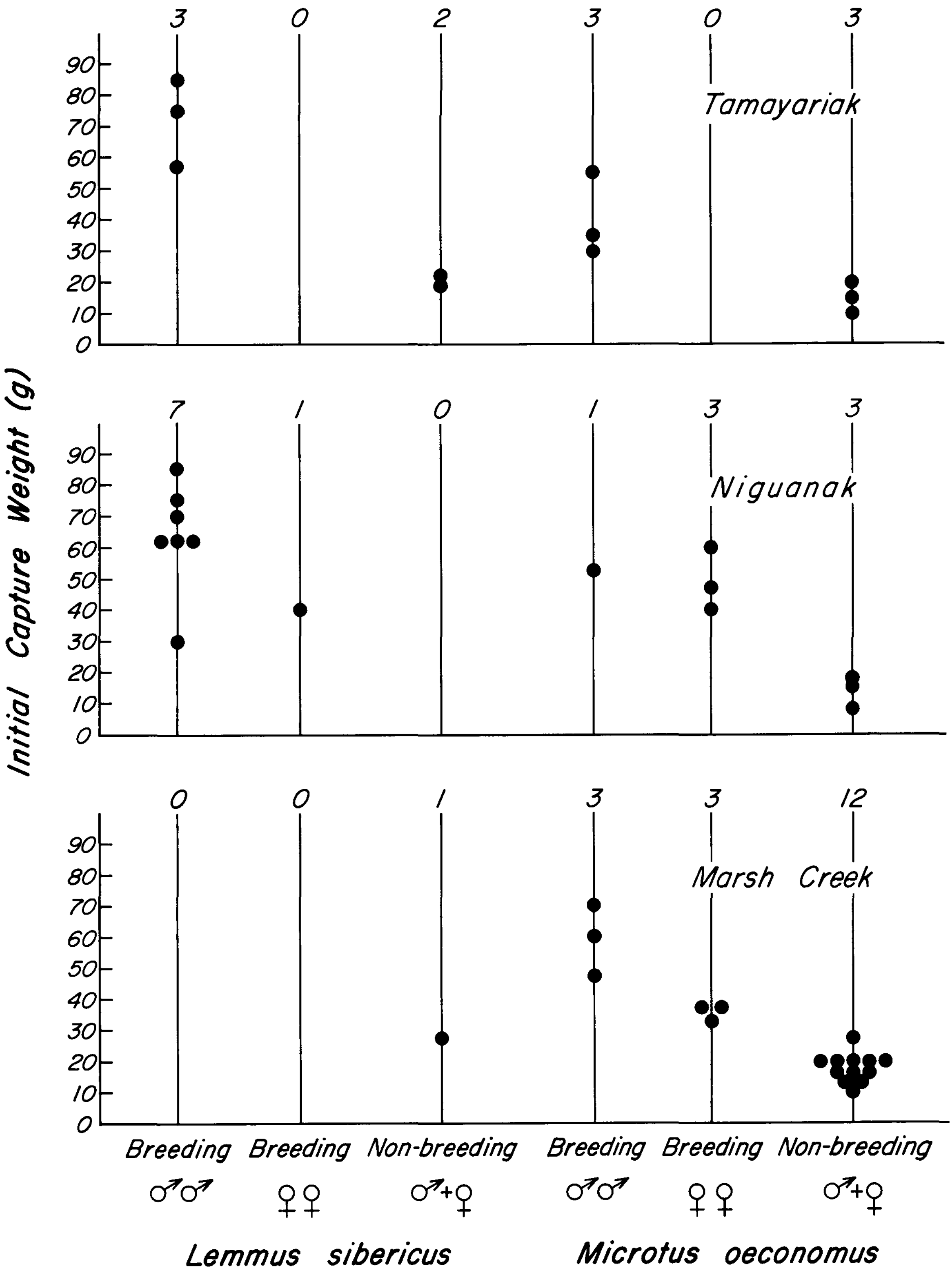

Fig. 3. Initial capture weight distributions among demographic classes within Lemmus and Microtus populations at the three study areas.

MacLean et al. (1974) correlated greater accumulations of snow and the associated increase in insulation effects with increased winter reproductive success in Lemmus populations at Barrow. Comparison of these density estimates (Table 2) with those reported by Batzli (1975) for other arctic locations is difficult because of the variety of trapping and estimation techniques that were used: at the time of the current trappings, densities were about five times lower than peak densities recorded for Barrow, eastern Siberia and northern Finland, but the 1985 ANWR trappings were done on what appeared to be post-peak populations.

Table 2. Number of trappable individuals per ha in 1983, 1984, and 1985. The 1983 and 1984 values are means of two trapping periods per location. Individual values for Dicrostonyx are not shown.

Year	Snow fall[a]	Time of trappings		Density of trappable individuals		
				Lemmus	Microtus	All microtines
1983	86mm	July and	Katakturuk	0.5/ha	6.5/ha	7.2/ha
		August	Okpilak	------	1.7/ha	3.4/ha
		Mean	0.2/ha	4.1/ha	5.3/ha	
1984	48mm	July and	Katakturuk	------	1.2/ha	1.2/ha
		August	Okpilak	0.2/ha	1.7/ha	2.0/ha
		Mean	0.1/ha	1.5/ha	1.6/ha	
1985	106mm	28 July	Tamayariak	5.0/ha	6.0/ha	11.0/ha
		8 August	Niguanak	8.0/ha	7.0/ha	15.0/ha
			Marsh Ck.	1.0/ha	19.0/ha	20.0/ha
			Mean	4.7/ha	10.7/ha	15.3/ha

[a]*winter accumulation in mm equivalent of water, measured at Barter Island (Felix et al. 1986).

Members of the genus Lemmus are active winter breeders, and peak densities are typically seen in the early spring following successful winter reproduction. Microtus spp. have a later age of first reproduction and are not as active in breeding during winter (Batzli 1975), so most density increase for this genus must therefore take place in the snow-free months. Conditions of good snow accumulation and adequate food favor winter reproduction by both Lemmus and Microtus, but Lemmus is better able to capitalize on these conditions.

Although no trapping was done in the early spring of 1985 when peak population densities would have been expected, there was much indirect evidence for such a peak. Signs of intense grazing were seen in scattered pockets at the Tamayariak and Niguanak areas. Pomarine jaegers (Stercorarius pomarinus) and snowy owls (Nyctea scandiaca) bred and nested successfully on the coastal plain for the first time in at least 2 years (Spindler et al. 1984, Miller et al. 1985). These birds are considered to be obligate microtine predators during the breeding season, and nesting densities and fledging success are dependent on an abundance of microtines

(Pitelka et al. 1955). Other avian microtine predators also bred at the 3 study areas (Table 3). Three different ermine (Mustela erminea) were caught on the Tamayariak grid and a single least weasel (Mustela nivalis) was caught on the Niguanak grid. Mammalian predators were seen more commonly at the Tamayariak and Niguanak areas, but were not observed during trapping at Marsh Creek (Table 3). Marsh Creek had significantly lower overall predator diversity, based on the number of species of predators observed during the trapping period at each area (Cochran's Q test, Q=10.57, $P < 0.05$).

Table 3. Observed presence (+) or absence (-) of microtine predators during the trapping period at each study area.

	Study area		
Predator species	Tamayariak	Niguanak	Marsh Creek
Brown bear (Ursus horribilis)	+	+	-
Wolf (Canis lupus)	+	+	-
Arctic fox (Alopex lagopus)	-	+	-
Ermine (Mustela erminea)	+	+	-
Least weasel (Mustela nivalis)	-	+	-
Snowy owl (Nyctea scandiaca)	-	+	-
Pomarine jaeger (Stercorarius pomarinus)	+	+	-
Short-eared owl (Asio flammeus)	+	+	+
Parasitic jaeger (Stercorarius parasiticus)	+	+	+
Long-tailed jaeger (Stercorarius longicaudus)	+	+	+

It appears that the Tamayriak and Niguanak areas had at least locally high Lemmus densities in spring 1985. These high densities may have caused an influx of specialized avian predators such as pomarine jaegers, snowy owls and short-eared owls (Asio flammeus), and increase in the density and reproductive success of least weasels and ermine. High Lemmus densities seem to be a key factor in attracting predators, since at Marsh Creek, where there was little sign of a Lemmus peak, avian and mammalian predators of microtines were neither as common nor as diverse as at the other areas. There is no apparent explanation for the lack of a brown lemming peak at Marsh Creek.

Use of microtines by facultative predators such as brown bears and wolves (Canis lupus) may be the result of prey switching (Murdoch 1969) after the emigration of calving caribou out of the area around Tamayariak and

Niguanak. Caribou of the Porcupine herd calved heavily around the Niguanak area (Whitten et al. 1986), and there was very light calving by caribou of the Central Arctic herd in the Tamayariak area. This activity was also likely the primary reason that bears were attracted to the 2 areas. A similar situation has been seen with lynx (Lynx canadensis) in Newfoundland where they began taking caribou calves more heavily in years of low hare (Lepus americanus) abundance (Bergerud 1971). Such switching only in certain years would likely be more common in areas where prey species cycle or fluctuate. The direction of switching, from the cyclic prey species as in Newfoundland or to the cyclic species as seen on ANWR must depend largely on the energetic cost/benefit ratio incurred by the predator. Only in certain years, and at specific locations, would the use of microtines by bears be more energetically beneficial than following the caribou out of the calving and post-calving grounds, or returning to vegetation food resources in the foothills region.

Acknowledgement

Thanks to G. Garner and H. Reynolds for bringing this study to my attention. G. Garner arranged logistic support and provided valuable comments on the results. M. McWhorter assisted with the 1985 trappings. K. Butters provided transportion between locations.

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Appendix IV

FISH

Appendix IV FISH

Contents Page

Fairbanks Fishery Resources Progress Report Number FY86-1

FISHERIES INVESTIGATIONS IN BEAUFORT LAGOON, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1985

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Key Words: Arctic char, Arctic cisco, movements, distribution, Beaufort Lagoon, Arctic National Wildlife Refuge

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9 May 1986

Fisheries invesitgations in Beaufort Lagoon, Arctic National Wildlife Refuge, Alaska, 1985.

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Abstract: Arctic char (Salvelinus alpinus), Arctic cisco (Coregonus autumnalis), fourhorn sculpin (Myoxocephalus quadricornis) and Arctic flounder (Liopsetta glacialis) were the major fish species captured by fyke nets in Beaufort Lagoon, Alaska from July 7 to August 9, 1985.

Arctic char ranged from 68 to 817 mm fork length and exhibited a bi-modal length frequency distribution. Juvenile char in the 151-200 mm length group comprised 19% of those captured and measured. These were mostly age 3 year smolts. Adult char between 400 and 500 mm comprised 30% of those captured and measured. These lengths correspond to ages 6 to 9 years. Eighty percent of the Arctic char were captured at the inside barrier island station. Most of these were moving in a westerly direction. Two periods of char abundance were observed. The first occurred in early July; 92% of the char were $\geq$ 350 mm. The second peak occurred after July 30. Forty-five percent of these char were less than 350 mm fork length. In the 1985 sampling period 1,262 Arctic char were tagged with Floy anchor tags. Recapture information is presented.

Arctic cisco ranged from 90 to 493 mm in length. Most (72%) were in the length group 351 to 400 mm; which corresponds to ages 7-13 years. Ninety percent of the Arctic cisco were captured at the inside barrier island station and 70% of these fish were moving in a westerly direction. Peak movement of cisco in Beaufort Lagoon occurred in early and mid-July. Arctic cisco captured in Beaufort Lagoon were longer than those reported from the Prudhoe Bay area.

INTRODUCTION

Fisheries investigations were conducted in Beaufort Lagoon, Arctic National Wildlife Refuge (ANWR) to determine use by anadromous and marine species. The objectives were to determine relative abundance, distribution, movements, and age and growth characteristics of the major fish species. The 1985 study was conducted to supplement and assist the interpretation of data collected from the area during the 1984 field season (West and Wiswar 1985). The major fish species utilizing the lagoon include Arctic char (Salvelinus alpinus), Arctic cisco (Coregonus autumnalis), fourhorn sculpin (Myoxocephalus quadricornis), and Arctic flounder (Liopsetta glacialis).

These investigations are part of a series of fish and wildlife studies provided for by the Alaska National Interest Lands Conservation Act (ANILCA) in which a comprehensive and continuing inventory and assessment of the fish and wildlife resources of the coastal plain was mandated.

STUDY AREA

Beaufort Lagoon (69°52'N, 142°15'W) is located approximately 60 km southwest of Barter Island (Fig. 1). The lagoon borders the Arctic coastal plain and is separated from the Beaufort Sea by a long, narrow barrier island. The Aichilik and Egaksrak Rivers are major rivers flowing into the lagoon. Traditional names for smaller embayments within Beaufort Lagoon are Nuvagapak Lagoon on the west side of the Aichilik River delta and Egaksrak Lagoon on the east. All sampling was confined to Nuvagapak Lagoon.

The nearshore waters are influenced by a northwesterly longshore current and wind patterns associated with storms (Truett 1981). The entrances to Beaufort Lagoon are near Angun Point and the Aichilik River delta. Beaufort Lagoon is described as a limited exchange lagoon (Hachmeister and Vinelli 1984) where the flow of nearshore waters is restricted from entering the lagoon by the barrier islands.

Most of Beaufort Lagoon is covered with fast ice during the winter months. The open water season usually runs from late June until September or October. In June, snow melt runoff enters the lagoon from the rivers and accelerates breakup in the lagoon. Waters inside the lagoon tend to be warmer and less saline than offshore waters during the summer months due to the freshwater intrusions being retained within the lagoon by the barrier islands.

The width of Beaufort Lagoon varies from 0.3 km. to approximately 2.0 km. Water depths are up to 3.6 meters over an organic-mud substrate. The shoreline of the barrier island is comprised of sand and small-size gravel.

METHODS

Sampling was conducted from July 7 to August 9, 1985 at 3 of the locations (Fig. 2). The stations were also sampled during the 1984 investigation (West and Wiswar 1985) and included three habitat types: nearshore mainland (Sta. 2); mid-lagoon (Sta. 3); and inside barrier island (Sta. 4). At stations 2

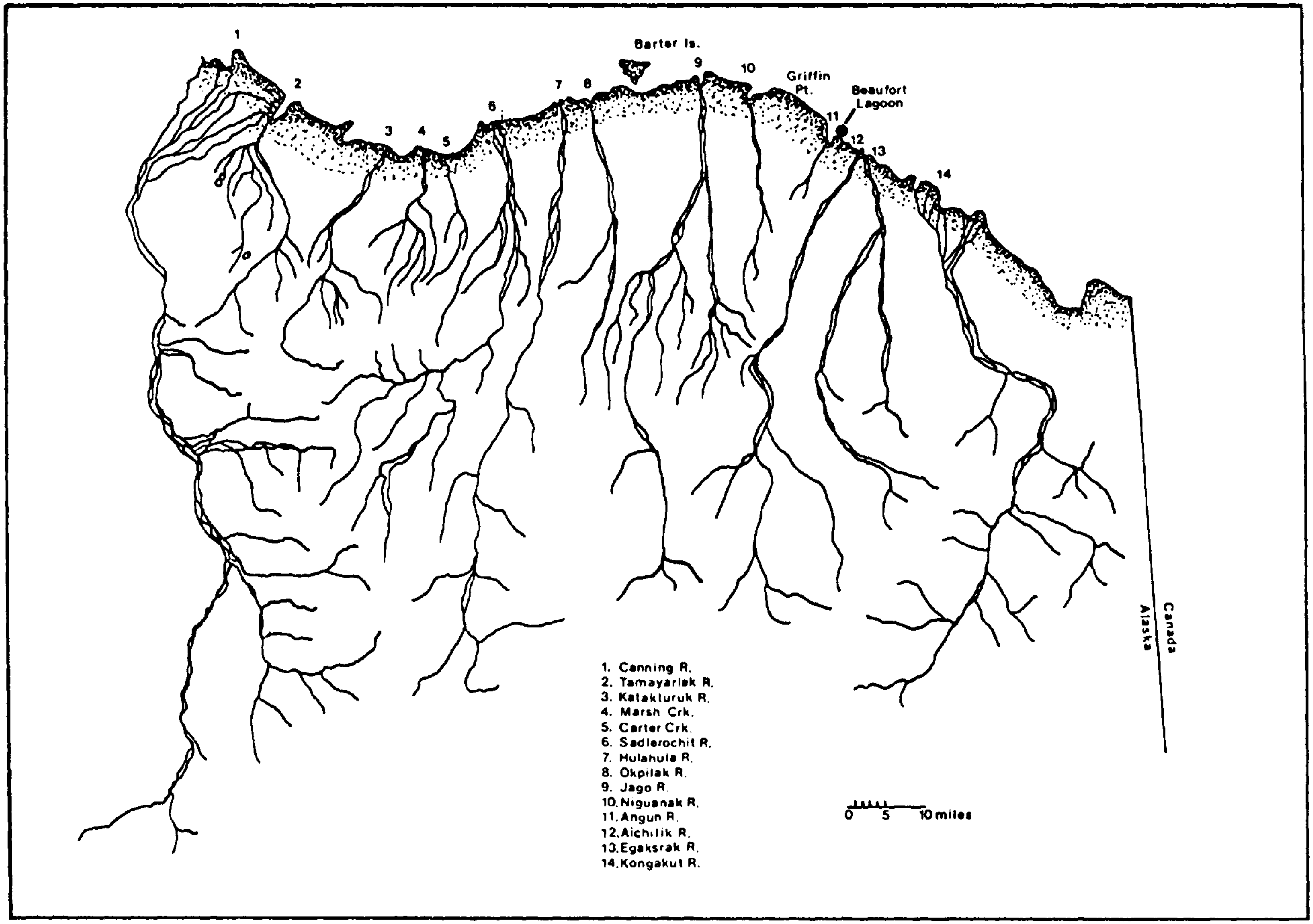

Figure 1. Major rivers on the north slope in the Arctic National Wildlife Refuge, Alaska.

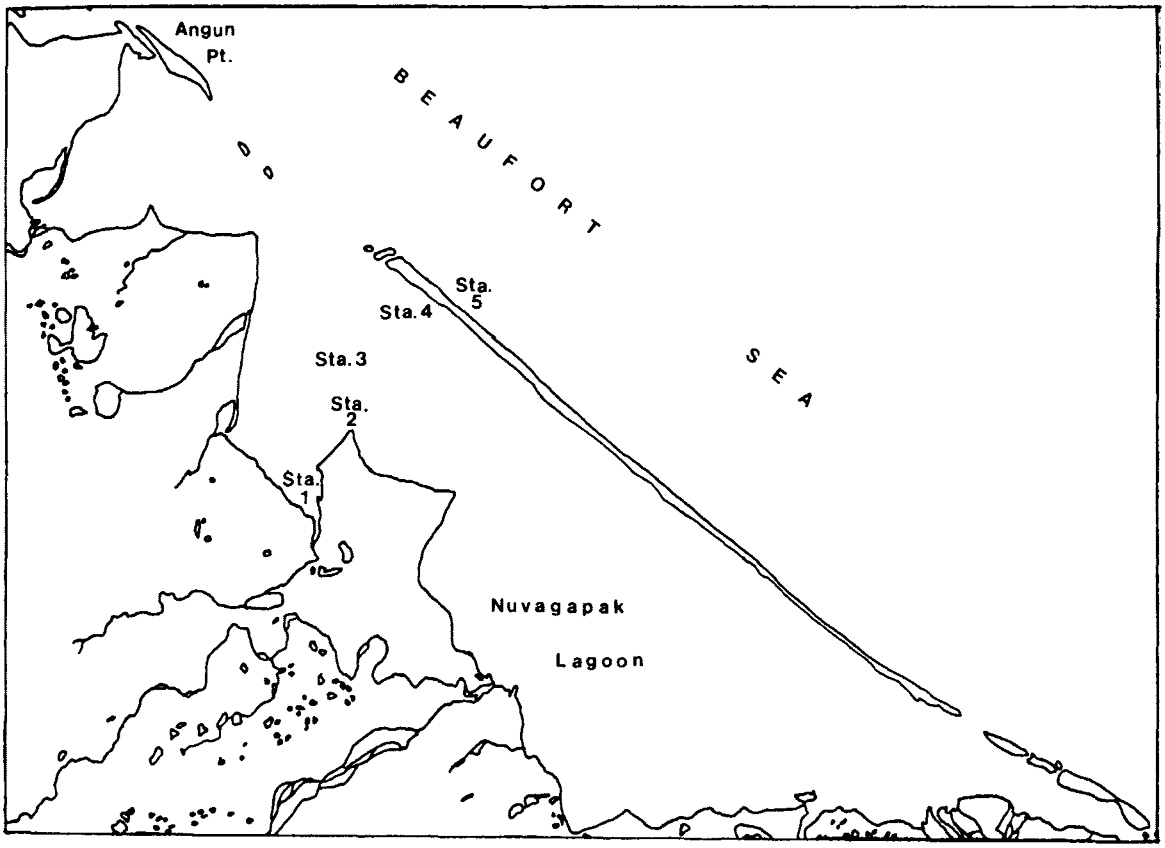

Figure 2. Sampling stations, Beaufort Lagoon, Alaska, 1985. Stations 2 and 4 were fyke net stations operated July 7 to August 9; station 3 was an experimental gillnet site fished July 22 - 29, 1985. Station 1 was an experimental gillnet site fished in June, July and August 1984.

and 4, dual trap, directional fyke nets with 61 m (200 ft.) leads and 15.25 m (50ft.) wings were employed. The leads extended perpendicularly from shore and the traps set in water less than 1.2 m (4 ft.) deep. A 38.1 x 1.8 m (125 ft. X 6 ft.) monofilament experimental gill net with five panels of 12.7, 25.4, 38.1, 50.8, and 63.5 mm (0.5, 1.0, 1.5, 2.0 and 2.5 inch) bar mesh was used at Station 3. The net was weighted and set near the bottom of the 3.6 m deep water column. The gill net station was operated from July 22-29 only.

Access to Beaufort Lagoon was by chartered fixed-wing aircraft from Barter Island. A Mark III Zodiak inflatable raft with a 15 hp outboard motor was used to set and check nets. Nets were checked once daily except during extremely poor weather conditions.

Fork lengths of fish were measured to the nearest millimeter. Weights of fish were estimated to the nearest gram using Pesola spring scales with ranges of 0-250 g, 0-500 g and 0-2000 g. A coefficient of condition (K) was calculated using the equation:

$$K = \frac{\text{weight (g)} \times 10^5}{\text{length (mm)}10^3}$$

Numbered Floy FD-67 anchor tags were implanted in Arctic char and Arctic cisco to aid in determining fish movements.

Arctic char ages were determined from otoliths. Otoliths were cleaned in a solution of Photo-flo and read under reflected light or ground on 400 grit sandpaper and read under transmitted light with a Bauch and Lomb dissecting scope at 3-7 power. Arctic cisco scales were mounted on gummed cards and pressed against acetate with a hydraulic press to form impressions. Impressions were magnified (40 and 70x) with a Bell and Howell microfiche reader to identify annuli. Arctic cisco otoliths were broken, burned and coated with cedar wood oil. Annuli were counted under 10-70x magnificaton with a Bausch and Lomb dissecting microscope.

Water temperature was measured with a standard centigrade stick thermometer. Salinity was measured with a YSI model 33 T-S-C meter.

RESULTS and DISCUSSION

Nine species of fish were caught in Beaufort Lagoon (Table 1). Four species were anadromous: Arctic char, Arctic cisco, least cisco and rainbow smelt. The four marine species found were fourhorn sculpin, Arctic flounder, saffron cod and an unidentified species of eelpout. Arctic grayling was the only freshwater species caught.

Arctic char were the most numerous fish caught, comprising 43% of the total catch and 83% of the anadromous species caught. Fourhorn sculpin ranked second in the catch (37%) and comprised 77% of the marine species caught. These were followed by Arctic flounder and Arctic cisco at 10% and 8% of the total catch, respectively. Arctic char and fourhorn sculpin were also the most numerous fish caught in Beaufort Lagoon in 1984 (West and Wiswar 1985).

Table 1. Summary of fish species and numbers caught, Beaufort Lagoon, July and August 1985.

Species	Station 2 Fyke Net	Station 3 Gill Net	Station 4 Fyke Net	Total
Arctic char (*Salvelinus alpinus*)	433	1	1727	2161
Arctic cisco (*Coregonus autumnalis*	41	26	341	408
Fourhorn sculpin (*Myoxocephalus quadricornis*)	1487	4	365	1856
Arctic flounder (*Liopsetta glacialis*)	453	0	68	521
Unidentified juvenile cisco (*Coregonus* sp.)	18	0	2	20
Saffron cod (*Eleginus gracialis*)	25	0	4	29
Prickleback (*Stichaeidae*)	0	0	7	7
Rainbow smelt (*Osmerus mordax*)	0	0	1	1
Arctic grayling (*Thymallus arcticus*)	1	0	7	8
	2458	31	2522	5011

Griffiths (1983) reported that Arctic char and Arctic cisco comprised only 7 and 8 % of the total fish caught in Beaufort Lagoon in 1982. Fourhorn sculpin and Arctic flounder were the most numerous fish species caught in Beaufort Lagoon that year representing 57 and 27 percent, respectively, of the total number. This study was conducted only from July 25 to August 5, 1982 and sampling stations differed from the 1984 and 1985 studies.

Arctic char

Eighty percent of the Arctic char captured in Beaufort Lagoon were taken at the inside barrier island fyke net station (Sta. 4) (Fig. 2). Arctic char moving in a westerly direction at this station accounted for 68% of the total catch. Arctic char moving easterly at the nearshore mainland fyke net station (Sta. 2) had the second highest capture rate with 15% of the total char caught. Only 1 char was captured at the mid-lagoon station (Sta. 3) after 167.5 hrs. of gill net fishing.

In 1984 the inside barrier island fyke net station accounted for 88% of the Arctic char captured utilizing the same location and methods (West and Wiswar 1985). The majority of those char (98%) were captured during July 24-30. The mid-lagoon station (Sta. 3) was fished for 44.5 hours during July 25-27, 1984 and 89.5 hours during August 20-24, 1984 capturing only one Arctic char.

A total of 1,262 Arctic char were tagged in Beaufort Lagoon in 1985; of those 29 (2.3%) were recaptured within the lagoon during the summer sampling period. In addition one char tagged in Beaufort Lagoon in 1984 was recaptured, two char tagged at Fish Hole #2 on the Hulahula River in 1983, and two char tagged by LGL near the Sagavanirktok River delta in 1982. Arctic char tagged at Beaufort Lagoon in 1985 were also recaptured by subsistence fishermen at Griffin Point (n=2) (Fig. 1) and Bernard Spit at Barter Island (n=3). A char tagged in Beaufort Lagoon in August 1984 was also recaptured off Bernard Spit in July 1985.

Based on recapture information use of the lagoon by char ranged from 1 to 33 days. This is assuming that those fish did not leave the lagoon between the time of tagging and recapture. The mean time was 6.7 days between initial tagging and recapture. Eight fish (28%) were recaptured 10 to 33 days after being tagged.

Twenty-one char tagged moving westerly at the inside barrier island station (Sta. 4) were recaptured within the lagoon. Of these, 13 (62%) were recaptured at the initial tagging site, 6 (29%) were recaptured while moving easterly at the same station, and 2 were recaptured at the nearshore mainland station (Sta. 2) 4 and 5 days later. One char tagged at Station 1 in 1984 was recaptured in 1985 at Station 2. The two stations are only 0.3 km apart.

Daily catch-per-unit-effort (CPUE) of Arctic char was highly variable over the sampling period. The mean CPUE for 3 day time periods at Station 4 was taken and plotted (Fig. 3). In general it appears that the peak movement occurred in early July and after July 30. The earlier peak was dominated by adult char with 92% of the catch being over 350 mm in length. The second peak was strongly influenced by immmature char, especially first year smolts. Forty-five percent of the catch during the second peak (July 30-Aug 1) were 350 mm in length or less. Twenty-two percent of the total were between 151 and 200 mm. Similar trends were also observed during the 1984 sampling at Beaufort Lagoon.

A storm on July 27 from the northwest blew the Sta. 4 trap down sometime early that day. It was not reset until the evening of July 29. Also, the Sta. 2 trap was not considered operating for a 33 hr. period for the same reason. There was no apparent correlation between char CPUE and salinity or water temperature.

The length of Arctic char captured in Beaufort Lagoon ranged from 68-817 mm and exhibited a bi-modal distribution. Juvenile char between 151-200 mm in length comprised approximately 19% of those captured and measured; adult Arctic char between 400-500 mm comprised 30% (Fig. 4).

Fish ages determined from otoliths ranged from 2 to over 15 years. The age-specific length, weight, condition and sex ratio is presented in Table 2. Juvenile Arctic char in the length class 151-200 mm correspond to 3 year old fish. Those char measuring between 401-500 mm correspond to year classes 6-9. Although there were no 6 year old char aged in the 1985 sample, they were included in this length group in 1984 (West and Wiswar 1985).

The largest annual increment in length, 149 mm, was between the ages 4 and 5. This may not characterize the population as a whole as the sample size was low.

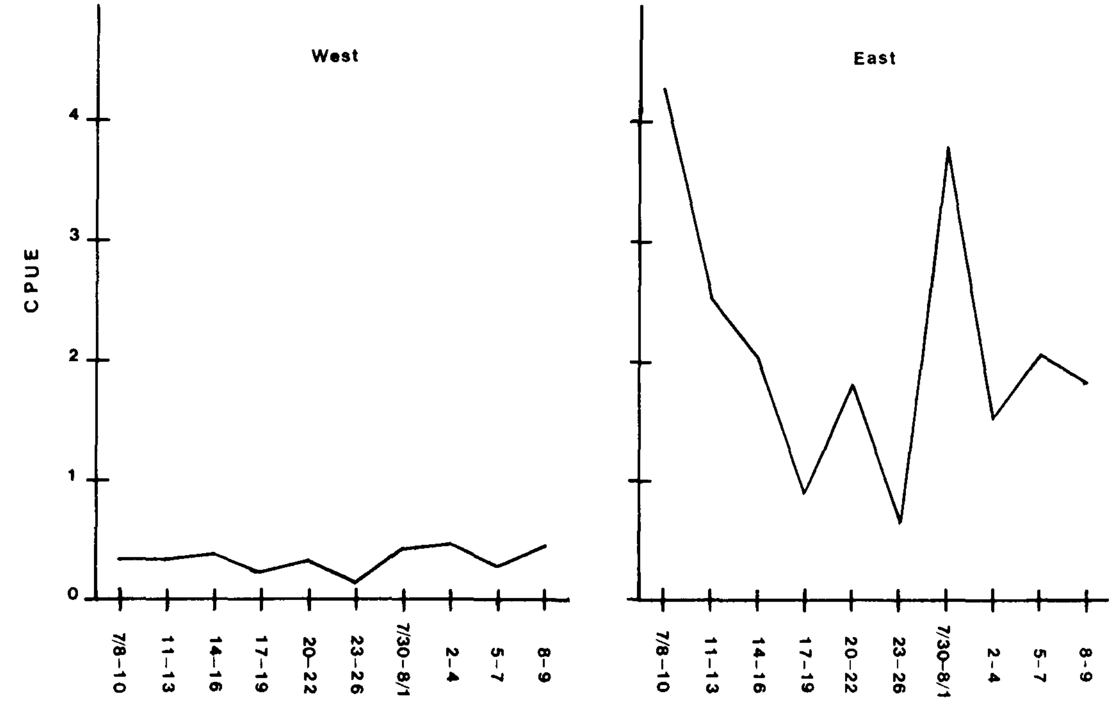

Figure 3. Catch rate of Arctic char at the inside barrier island fyke net station (Sta. 4), Beaufort Lagoon, Alaska, July and August 1985. CPUE = average number of fish caught per hour. West facing trap catches fish moving east, and vice versa.

Table 2. Age-specific length, weight, and condition for Arctic char, Beaufort Lagoon, Alaska, July and August 1985. Age determined from otoliths.

Age	n	Fork Length (mm) Mean	Fork Length (mm) Range	S.D.	Weight (g) Mean	Weight (g) Range	S.D.	Condition Factor K
2	3	110.2	103-117	7.1	10.8	7.8-12.8	2.6	0.77
3	5	189	156-211	20.2	52.2	28.1-71.8	17.2	0.79
4	1	221	---	---	89.5	---	---	0.83
5	3	370	366-373	3.6	354.6	343.5-373.6	16.7	0.70
6	-	---	---	---	---	---	---	----
7	3	475.3	469-481	6.0	706.3	563-854	145.5	0.66
8	1	506	---	---	1163	---	---	0.90
9	2	498	458-538	56.6	1049	880-1218	239.0	0.85
10	4	596.3	567-622	24.6	1882	1628-2238	294.7	0.88
11	3	578	549-610	30.6	1672.7	1318-2063	373.	0.86
12	-	---	---	---	---	---	---	----
13	-	---	---	---	---	---	---	----
14	-	---	---	---	---	---	---	----
15	1	817	---	---	4820	---	---	0.88
	26							

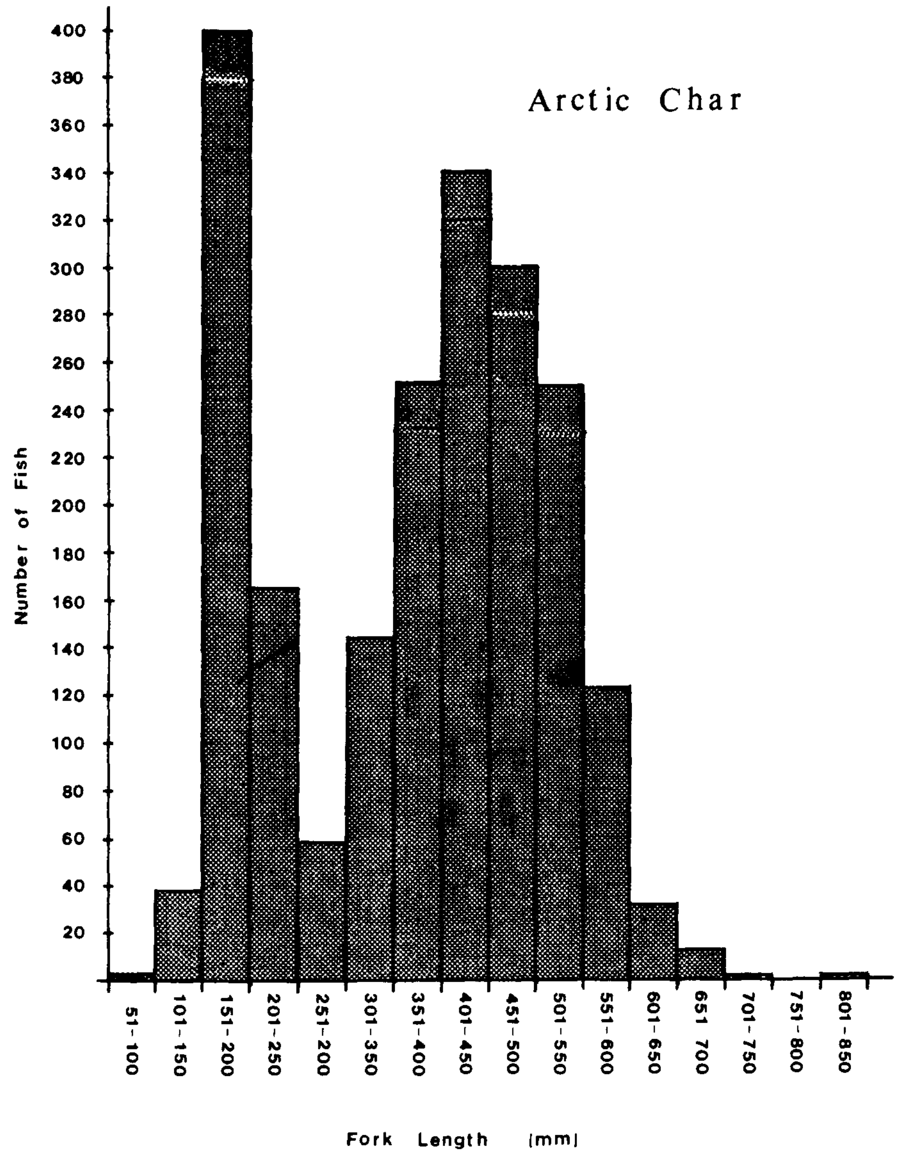

Figure 4. Length frequencies of 2,122 Arctic char captured with fyke nets, Beaufort Lagoon, Alaska, July and August 1985.

The dominant length groups and corresponding age classes were similar in Beaufort Lagoon in 1984 and 1985. In other studies across the Beaufort Sea coastline (Yoshihara 1973, Griffiths et al. 1975, Griffiths et al. 1977) the dominant length classes were also in the 400-500 mm range; however, in Simpson Lagoon, Craig and Haldorson (1981) found Arctic char over 500 mm to dominate the gill net captures of adult char. The overall age-specific lengths of char from Beaufort Lagoon fall within the range reported for ANWR coastal lagoons (Roguski and Komarek 1972), the Sagavanirktok River delta (Yoshihara 1972), Nunaluk Lagoon, Y.T. (Griffiths et al. 1975) and Simpson Lagoon (Craig and Haldorson 1981) (Fig. 5).

Arctic cisco

Ninety percent of the Arctic cisco captured by fyke net in Beaufort Lagoon were from the inside barrier island station (Sta. 4). The east facing trap captured 70% of the total and the west facing trap collected 20% indicating primarily a westerly movement in that area of the lagoon. Although the catch from Station 2 was low by comparison, 95% of the juvenile Arctic cisco (n=18) were collected here. In 1984, the fyke net results where comparable with this years results (West and Wiswar 1985). Station 4 accounted for 85% of the Arctic cisco with the east facing trap capturing about 80% of the total.

At the mid-lagoon gill net station (Sta. 3) 26 Arctic cisco were taken during a 167.5 hour effort (mean CPUE=0.15). The mid-lagoon station was fished from July 22-29, 1985. The catch results from the gill net station at mid-lagoon were higher in July 1984 with a mean CPUE of 0.70 Arctic cisco per hour between July 25 and 27.

A total of 320 Arctic cisco were tagged in Beaufort Lagoon in 1985. No recaptures were made within the lagoon. One recapture was reported from the lower reaches of the Colville River in mid-October 1985 (Larry Moulton, pers. comm. 1985).

Daily CPUE of Arctic cisco was variable. Using the data from Station 4 fyke net, peak movements appeared to be between early and mid-July (Fig. 6). Similar to the data shown for Arctic char at the east trap of Sta. 4, a second peak occurred after July 30. In 1984, the highest CPUE for Arctic cisco at this site occurred on July 28.

At the nearshore mainland station (Sta. 2), Arctic cisco were captured moving in a westerly direction on only 2 (6%) of the 32 days the trap was fishing and moving in an easterly direction on 10 days (31%).

The length of Arctic cisco captured in Beaufort Lagoon ranged from 90-493 mm. Seventy-two percent of the Arctic cisco measured (n=378) were in the 351-400 mm size class (Fig. 7). Juvenile cisco, those less than 170 mm, comprised only 5% of the sample. Arctic cisco from 170 to 325 mm were not caught.

Arctic cisco ages, determined from otoliths (n=52), ranged from 7 to 13 years and correspond to fork length measurements from 345 to 430 mm. Age-specific length data are presented in Table 3. The ages corresponding to the predominant length classes are 8, 9 and 10 (Fig. 7). Within these age classes, females comprised about 47% of the sample. Age estimates derived

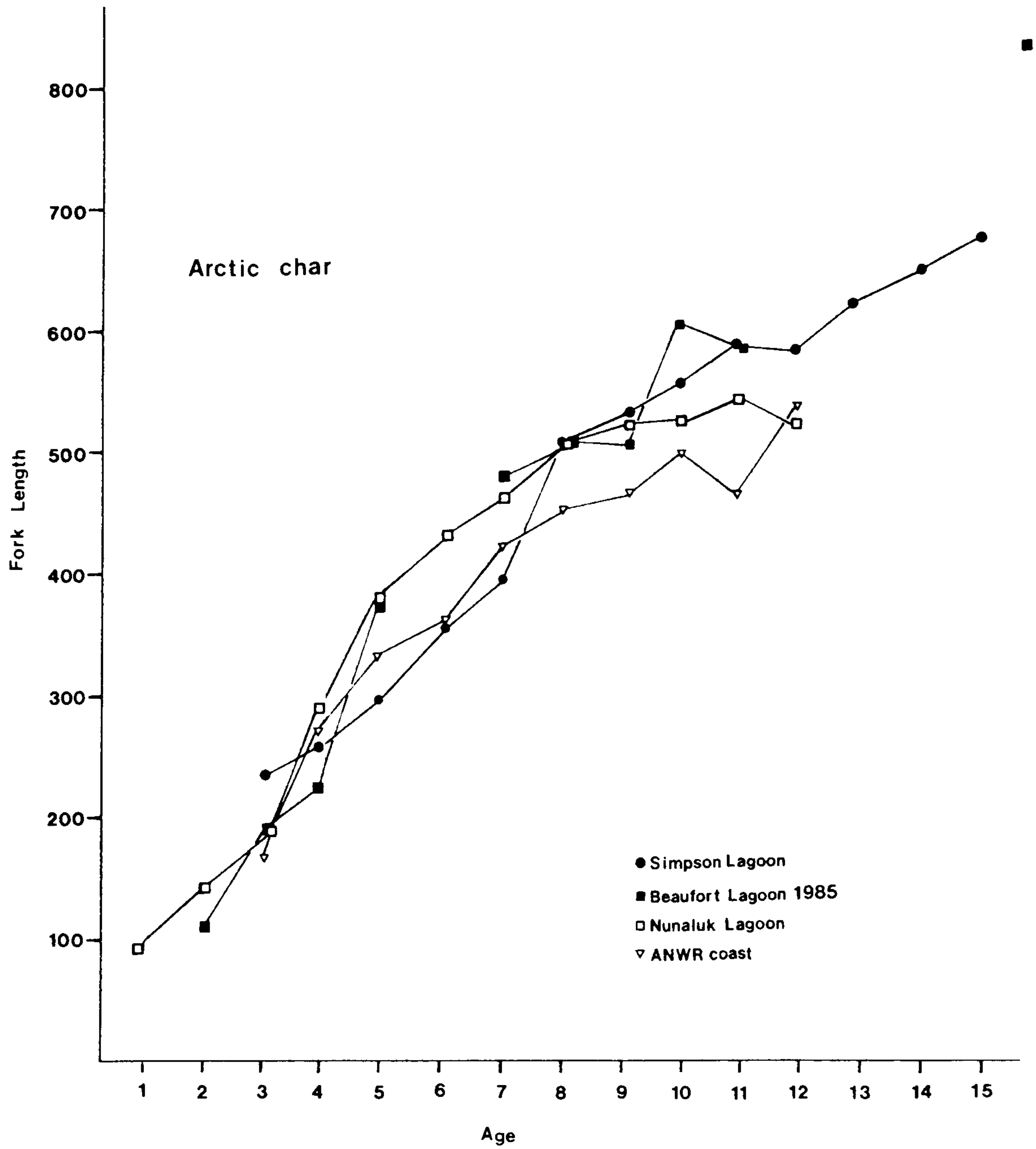

Figure 5. Comparison of age-specific length for Arctic char from coastal areas of the Beaufort Sea. Beaufort Lagoon data from this report; Simpson Lagoon - Craig and Haldorson 1981; Nunaluk Lagoon - Griffiths et al. 1975; ANWR coast - Roguski and Komarek 1972.

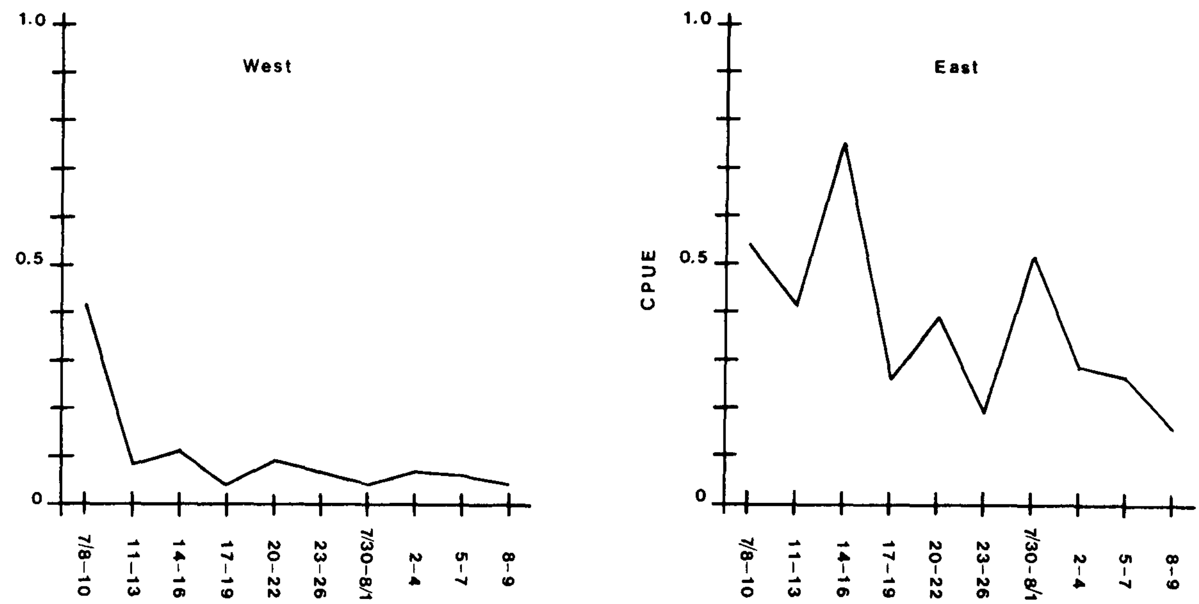

Figure 6. Catch rate of Arctic cisco at the inside barrier island fyke net station (Sta. 4), Beaufort Lagoon, Alaska, July and August 1985. CPUE = average number of Arctic cisco caught per hour. East facing trap captures fish moving in a westerly direction, and vice versa.

from otoliths were compared with age estimates from scales. Otolith age estimates were an average of 1.7 years older than those estimates from scales (Corley 1985). Arctic cisco age information presented by West and Wiswar (1985) are based on scale readings. Otoliths from these samples (n=84) were later read and the results also demonstrated an average 1.7 year higher age estimate with otoliths compared to scales (Table 4).

The largest annual increment in length, 21.9 mm, was between ages 7 and 8. The growth increment between ages 9 and 10 showed a decrease rather than an increase probably because of slow growth and an inadequate sample size.

The predominant length group for Arctic cisco captured during 1984 ranged from 351-400 mm. These fish corresponded to age classes 7, 8 and 9 years.

Arctic cisco from Beaufort Lagoon collected in 1984 and 1985 were longer than those captured in Simpson Lagoon and the Colville River delta (Craig and Haldorson 1981), between Harrison Bay and Brownlow Point (Bendock 1979) and those from the Sagavanirktok River delta (Griffiths et al. 1983). For age classes 7 through 10, Beaufort Lagoon Arctic cisco were 14-32 mm longer than those from Simpson Lagoon in 1977 (Fig. 8).

Table 3. Age-specific length, weight, condition and sex ratio for Arctic cisco, Beaufort Lagoon, Alaska, July and August 1985. Ages determined from otoliths.

Age	n	Fork Length (mm) Mean	Fork Length (mm) Range	Fork Length (mm) S.D.	Weight (g) Mean	Weight (g) Range	Weight (g) S.D.	Condition Factor $\overline{K}$	Sex Ratio % Females
7	9	362.6	345-380	12.5	543.2	431-680	81.4	1.15	44
8	13	384.5	365-411	13.8	551.5	437-710	86.0	0.97	46
9	13	391.0	371-426	15.6	635.2	434-850	133.9	1.02	53
10	7	386.9	368-411	14.8	582.9	487-700	85.2	1.00	42
11	1	400.0	---	---	619.0	---	---	0.97	0
12	7	418.1	406-446	13.2	722.3	600-851	77.1	0.99	57
13	2	417.0	404-430	18.4	717.0	697-737	28.3	0.99	50
	52								

Table 4. Age-specific length, weight, condition and sex ratio for Arctic cisco, Beaufort Lagoon, Alaska, summer 1984. Ages determined from otoliths.

Age	n	Fork Length (mm) Mean	Fork Length (mm) Range	Fork Length (mm) S.D.	Weight (grams) Mean	Weight (grams) Range	Weight (grams) S.D.	Mean Condition Factor ($\overline{K}$)	Sex Ratio % Females
6	2	330.5	294-367	51.6	438.5	282-595	221.3	1.16	0
7	31	371.2	331-408	14.5	603.7	425-775	91.7	1.17	39
8	23	381.1	329-411	15.8	645.0	464-895	106.8	1.16	70
9	12	400.1	369-420	21.6	718.6	460-1120	168.2	1.11	67
10	10	404.4	364-438	25.1	739.5	530-995	168.0	1.11	60
11	4	412.0	401-432	13.8	850.0	690-1050	150.8	1.21	100
12	1	481.0	---	---	655.0	---	---	0.59	100
13	1	429.0	---	---	870.0	---	---	1.10	100
	84								

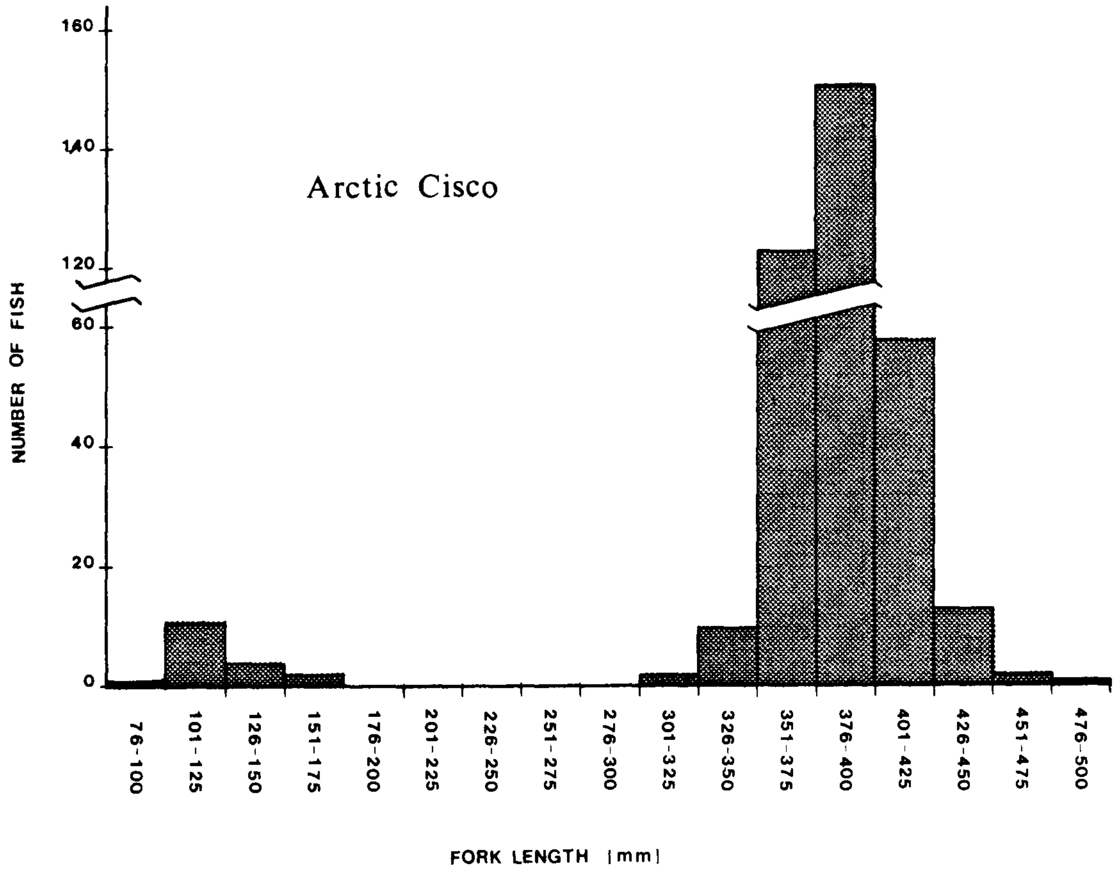

Figure 7. Length frequencies of 378 Arctic cisco captured in Beaufort Lagoon, Alaska, July and August 1985.

Fourhorn sculpin

Eighty percent of the fourhorn sculpin captured in Beaufort Lagoon were from the nearshore mainland station (Sta. 2). Differences between the counts of westerly and easterly moving sculpins were not as pronounced as those for anadromous species. Sculpins moving in a westerly direction at Station 2 accounted for about 50% of the total catch and those moving easterly 30%. At Station 4 the differences between westerly and easterly movements were slight, 9 and 11%, respectively. The catch from the mid-lagoon gill net station was only 4 sculpin. In 1984, Station 2 accounted for 67% of the sculpin caught by fyke net (West and Wiswar 1985).

The CPUE for fourhorn sculpin at Station 2 was variable on a day-to-day basis. The CPUE for approximate 3 day periods is shown in Figure 9. A period of peak movement was evident in early July, a second occurred after July 28, and a third peak was recorded around August 8 and 9. At Station 4, catch rates were low and fairly even up to about August 5 where an increase was seen followed by a decline.

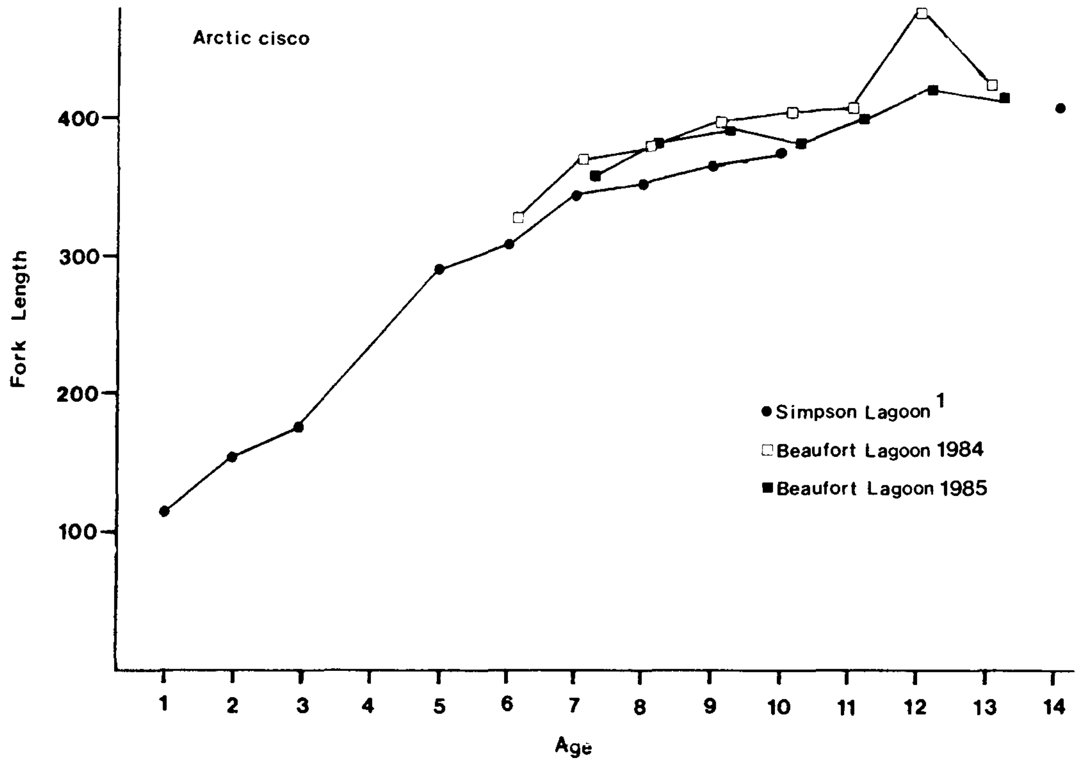

Figure 8. Comparison of age-specific length for Arctic cisco, Alaskan Beaufort Sea coast. 1 = Craig and Haldorson 1981.

The length of fourhorn sculpin observed in Beaufort Lagoon ranged from 16-285 mm. For those fish captured by fyke nets the range was 38-285 mm. By this capture method the dominant length group was 51-75 mm (Fig. 10). On July 24, 1985 young-of-the-year fourhorn sculpin measuring 16-19 mm were observed over a sandy substrate near Station 4.

Sculpin ages estimated from otoliths ranged from 3 to 8 years (Table 5). Lengths from those sculpins aged ranged from 118-267 mm. For those fish age 4 and over, females comprised about 65%. The female ratio of the older sculpins was also high in the 1984 sample.

From the age-specific length data collected in 1984 (West and Wiswar 1985) the 51-75 mm length group, dominating the 1985 catch, was probably comprised of fish primarily 1 and 2 years old. The largest annual growth increment observed for sculpins in 1985 was between ages 4 and 5. Fourhorn sculpin from Beaufort Lagoon in 1985 averaged about 20 mm longer than those from the same age classes in Simpson Lagoon, 1977 (Craig and Haldorson 1981), 35 mm longer than those from Kaktovik, Alaska (Griffith et al. 1977) and almost 80 mm longer than those from Nunaluk Lagoon, Yukon Territory (Griffith et al. 1975) (Fig. 11).

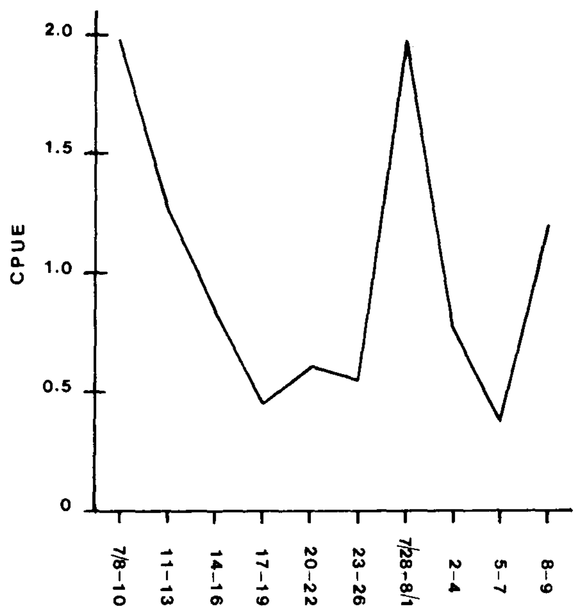

Figure 9. Catch rate of fourhorn sculpin at the nearshore mainland station (Sta. 2) Beaufort Lagoon, Alaska, July and August 1985. CPUE = average number of fourhorn sculpin caught per hour.

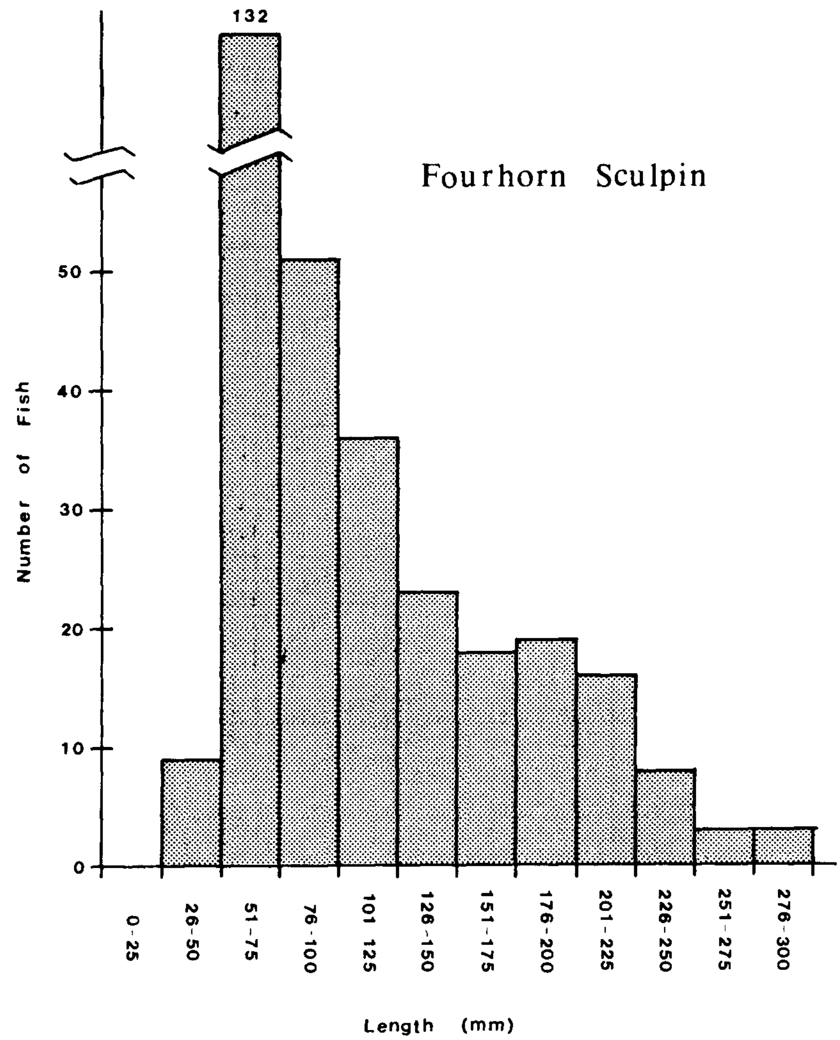

Figure 10. Length frequencies of 318 fourhorn sculpins captured by fyke nets in Beaufort Lagoon, Alaska, July and August 1985.

Table 5. Age-specific length and weight information for fourhorn sculpin, Beaufort Lagoon, Alaska, July and August 1985. Ages determined from otoliths.

		Fork Length (mm			Weight (g)		
Age	n	Mean	Range	S.D.	Mean	Range	S.D.
3	4	139.6	118-155	14.2	23.1	13.8-39.9	12.4
4	8	185.6	163-207	13.6	61.2	34.5-91.8	17.4
5	3	210.7	208-213	2.5	95.5	91.2-99.8	4.3
6	3	226.7	224-231	3.8	119.7	100.8-139.5	19.4
7	6	249.3	242-264	8.5	165.3	147.5-181.6	12.2
8	1	267.0	---	---	168.0	---	---
	25						

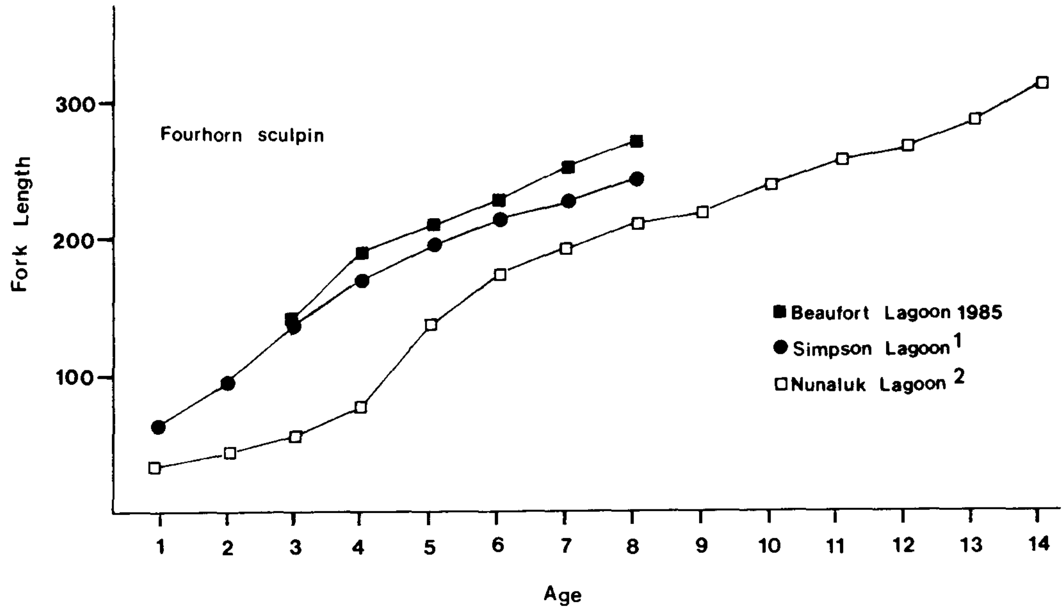

Figure 11. Comparison of age-specific length of fourhorn sculpins, Beaufort Sea coast. 1 = Craig and Haldorson 1981. 2 = Griffiths et al. 1975.

Water temperature and salinity

Temperature and salinity measurements from Beaufort Lagoon are presented in Table 6 for the period July 21 to August 9, 1985. Salinity was fairly constant from July 21-26 (range 4.0 - 4.9 °/oo), both in and outside the barrier island, Stations 4 and 5, respectively (Fig. 2). After a period of strong winds from the northwest on July 26-27 salinity increased and became more variable. Overall, salinity ranged from a low of 4 °/oo at Station 4 on July 25 to a high of 15.7 °/oo at Station 5 on July 29. The lowest temperature recorded was 2.0°C outside the barrier island (Sta. 5) on August 5. The highest water temperature recorded was 9°C inside the barrier island (Sta. 4) on July 2 and August 9. The mean temperature at Stations 4 and 5 between July 21 and August 9 was 7.2 and 4.2°C, respectively. Corresponding mean salinities were 6.5 and 7.5°/oo.

Table 6. Water temperature and salinity, Beaufort Lagoon, Alaska, July 21-August 9, 1985.

Sampling	Temperature (°C)			Salinity (°/oo)		
Date	Sta. 3	Sta. 4	Sta. 5	Sta. 3	Sta. 4	Sta. 5
7/21/85	-	5.0	4.5	-	4.5	4.6
7/22	-	8.0	5.0	-	4.2	4.6
7/23	-	8.0	4.5	-	4.1	4.3
7/24	8.5	8.0	4.5	4.1	4.0	4.3
7/25	8.5	8.0	4.5	4.1	4.1	4.5
7/26	7.0	8.2	3.0	7.4	4.3	4.9
7/27	9.0	5.0	4.0	6.2	8.9	11.1
7/28	7.0	9.0	3.0	10.0	5.1	15.7
7/29	-	7.0	6.0	-	9.7	11.3
7/30	-	8.4	5.0	-	6.3	10.6
7/31		8.0	3.0	-	7.0	6.5
8/1	-	8.5	4.0	-	6.2	7.0
8/2	-	8.5	4.0	-	6.4	7.1
8/3	-	-	-	-	6.9	6.5
8/4	-	4.5	4.0	-	8.2	8.2
8/5	-	4.5	2.0	-	7.5	7.0
8/6	-	5.5	3.0	-	8.4	6.8
8/7	-	6.5	4.5	-	8.0	7.7
8/8	-	7.0	5.0	-	7.9	8.2
8/9	-	9.0	8.0	-	9.0	9.0

CONCLUSION

Arctic char and Arctic cisco were captured primarily along the lagoon side of the barrier island of Beaufort Lagoon in 1984 and 1985. The utilization of this habitat type by these species has also been reported in Simpson Lagoon (Craig and Haldorson 1981).

Utilization of the mid-lagoon by Arctic char is considered to be low based on captures at Station 3. A comparison of CPUE for this station with the inside barrier island or nearshore mainland is difficult due to different capture techniques (variable mesh gill net vs. fyke net); however, a comparison with Station 1 in 1984 (a gill net located near the mainland shoreline) demonstrates a higher CPUE at that station. Overall, only 2 char were caught in 1984 and 1985 with a combined effort of 301.5 hours fishing at the mid-lagoon (Sta. 3) sample site. Arctic cisco showed higher use of the mid-lagoon area than Arctic char for both years based on CPUE of gill net captures. Arctic cisco showed a preference towards the mid-lagoon over the nearshore station (Sta. 1) in July 1984. In 1984, CPUE for Arctic cisco was higher at all stations in July than in August.

The small number of tagged Arctic char recaptured at Beaufort Lagoon makes conclusions about their movement speculative. Two char recaptured at Beaufort Lagoon in 1985 were originally tagged near the Sagavanirktok River delta in 1983. These fish may be from that river system, or could have been Canning River or Hulahula River fish. Tagged Arctic char from the Canning and Huluhula Rivers have been recovered form the Prudhoe Bay area. As no Arctic char tagged in the Canning River [554 Arctic char tagged in summer 1981 and 1982 (Smith and Glesne 1983)] have been recaptured east of that drainage it appears more likely that these were Hulahula River char. Based on recaptures in Beaufort Lagoon and tag returns from the subsistence fishery at Barter Island it is suspected that Arctic char utilizing Beaufort Lagoon are comprised primarily of char from the Hulahula River and rivers east of the lagoon.

The high incidence of Arctic char captured in the east facing trap of the fyke net stationed at the lagoon side of the barrier island (Sta. 4) indicates a strong westerly movement. Many of the fish may exit the lagoon between the west end of the island and Angun Point. Two char tagged on the same day at the same station at Beaufort Lagoon were recaptured at Bernard Spit off Barter Island a day apart suggesting that some schooling may occure. Arctic char moving in small schools of 10-20 fish have been reported by Griffiths et al. (1975) off Nunaluk Spit, Y.T.

Arctic char movements within the lagoon may consist of a counter-clockwise pattern close to the barrier island shoreline. The fish captured moving in a westerly direction at Station 4 inside the barrier island were the fish that comprised the greater number of recaptures. Most of these recaptures (62%) occurred at this same station (Sta. 4) one to 33 days later ($\overline{x}$ = 10.3 days) and 29% were recaptured at this station while moving east. Most recaptures at Station 4 West occurred within 2 days of initial capture. This may indicate that char once reaching the west end of the lagoon start moving east with little time milling at any one site. The furthest easterly movement may include a great distance along the barrier islands, or Arctic char may spend more time milling at the east end of the lagoon before continuing west again.

Arctic cisco appear to be widely dispersed within the lagoon, utilizing mid-lagoon areas as well as the nearshore areas; whereas, Arctic char were found to be concentrated in areas close to the barrier island or mainland shores. The period of peak movement through Beaufort Lagoon for Arctic cisco occured during the month of July. These Arctic cisco are probably stocks from the Mackenzie River, N.W.T. (Gallaway et al. 1983). The occurrence of larger size classes of Arctic cisco along the ANWR coastline (Roguski and Komarek 1972; West and Wiswar 1985; and this report) compared to the western Beaufort Sea may indicate that there is some stock separation during the summer along the coast and possibly these stocks overwinter in different locations as well. Of the 52 adult Arctic cisco examined in Beaufort Lagoon in 1985, none were going to spawn in the upcoming fall.

No tagged Arctic cisco were recaptured within the lagoon or reported by the subsistence fishery at Barter Island; however, one cisco was recaptured in the Colville River delta. There is still a large gap in the existing information on Arctic cisco distribution between Beaufort Lagoon and Prudhoe Bay. Even with the extensive sampling effort in Prudoe Bay since the early 1980's, the larger size cisco have not been reported there with the frequency they have along the ANWR coastline. Distribution throughout the year of all age classes of the potentially different Arctic cisco stocks should receive a high priority for future regional fisheries studies.

ACKNOWLEDGEMENTS

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FALL MOVEMENTS AND OVERWINTERING OF ARCTIC GRAYLING IN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1985

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Key words: Arctic grayling, movements, overwintering, Arctic National Wildlife Refuge

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Fall movements and overwintering of Arctic grayling in the Arctic National Wildlife Refuge, Alaska, 1985.

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Abstract: Radio transmitters were surgically implanted in 38 Arctic grayling (*Thymallus arcticus*) from three north slope drainages in the Arctic National Wildlife Refuge, Alaska in July and August 1985. These fish were tracked periodically by air until late December 1985. Radio-tagged grayling began their migration to overwintering locations in August and were at or near those sites by early September. Grayling from the Tamayariak River were relocated in the lower mainstem of the Canning River and lower Canning River delta. Grayling from Itkilyariak Creek were relocated in the Sadlerochit River near its confluence with the Itkilyariak, below Sadlerochit Springs in the main river, along the Kekiktuk River, and in Schrader Lake. Grayling from the Akutoktak River were relocated at Fish Holes #1 and #2 on the Hulahula River, near the mouth of the Hulahula River, near the confluence of the Okpilak and Akutoktak Rivers, and in the Okpilak River where it emerges from the foothills. The signals from three radio-transmitters implanted in fish in 1984 were also received during 1985 tracking periods.

INTRODUCTION

Arctic grayling (Thymallus arcticus) during summer months are distributed throughout the Arctic National Wildlife Refuge in tundra streams (Smith and Glesne 1982, Daum et al. 1984, West and Wiswar 1985). Flowing water becomes scarce by late November and the habitat available to Arctic grayling is restricted to springs and deeper pools. A radio telemetry project was initiated in 1984 to determine fall movements and identify overwintering locations of grayling. In 1985, this method was used again to confirm multi-year use of the overwintering locations. Three river drainages on the west side of the refuge were examined: the Tamayariak River, Sadlerochit River/Itkilyariak Creek, and Okpilak/Akutoktak Rivers.

METHODS

The Tamayariak and Akutoktak Rivers and Itkilyariak Creek are tundra streams (Craig and McCart 1974b) and have been described by Smith and Glesne (1982) and Daum et al. (1984). These rivers are tributaries to mountain streams (Craig and McCart 1974b) and do not flow directly to the Beaufort Sea. The Tamayariak River shares a large delta with the Canning River (Fig. 2). Itkilyariak Creek and Akutoktak River are tributaries to the Sadlerochit and Okpilak Rivers, respectively (Figs. 1, 3 and 4).

Telonics radio transmitters were surgically implanted in grayling. The characteristics of the transmitters were:

life expectancy = 90 days
mean weight = 14.8 g
mean length = 48 mm
mean width = 14 mm
pulse rate = 34 pulses per minute.

Arctic grayling selected for transmitter implantation were not less than 355 mm in fork length. Grayling were captured by angling and anesthetized in tricaine methanesulfonate (MS-222). Transmitters were surgically implanted through a small incision anterior to the pelvic girdle. The whip antenna was threaded under the pelvic girdle with the aid of a surgical needle and allowed to trail behind the fish. The incision was closed with 7 to 10 stitches from a 2/0 suture. Fish were immediately placed in shallow backwaters for recovery; most resumed posture within 7 minutes.

Transmitters were implanted in 9 grayling in the lower 10 km of the Tamayariak River between August 28 and 29, in 14 grayling on Itkilyariak Creek (near its confluence with the Sadlerochit River) between August 22 and 26, and in 15 grayling on the Akutoktak River between July 26 and 29.

Aerial tracking using a Cessna 185 outfitted with wing-mounted "H" antennas and a Telonics scanner-receiver was conducted periodically (at 3-6 week intervals) between August and December 1985. Altitudes varied from 300 to 1500 feet. Locations were plotted on USGS 1:250,000 topographic maps and distances were measured using a map wheel.

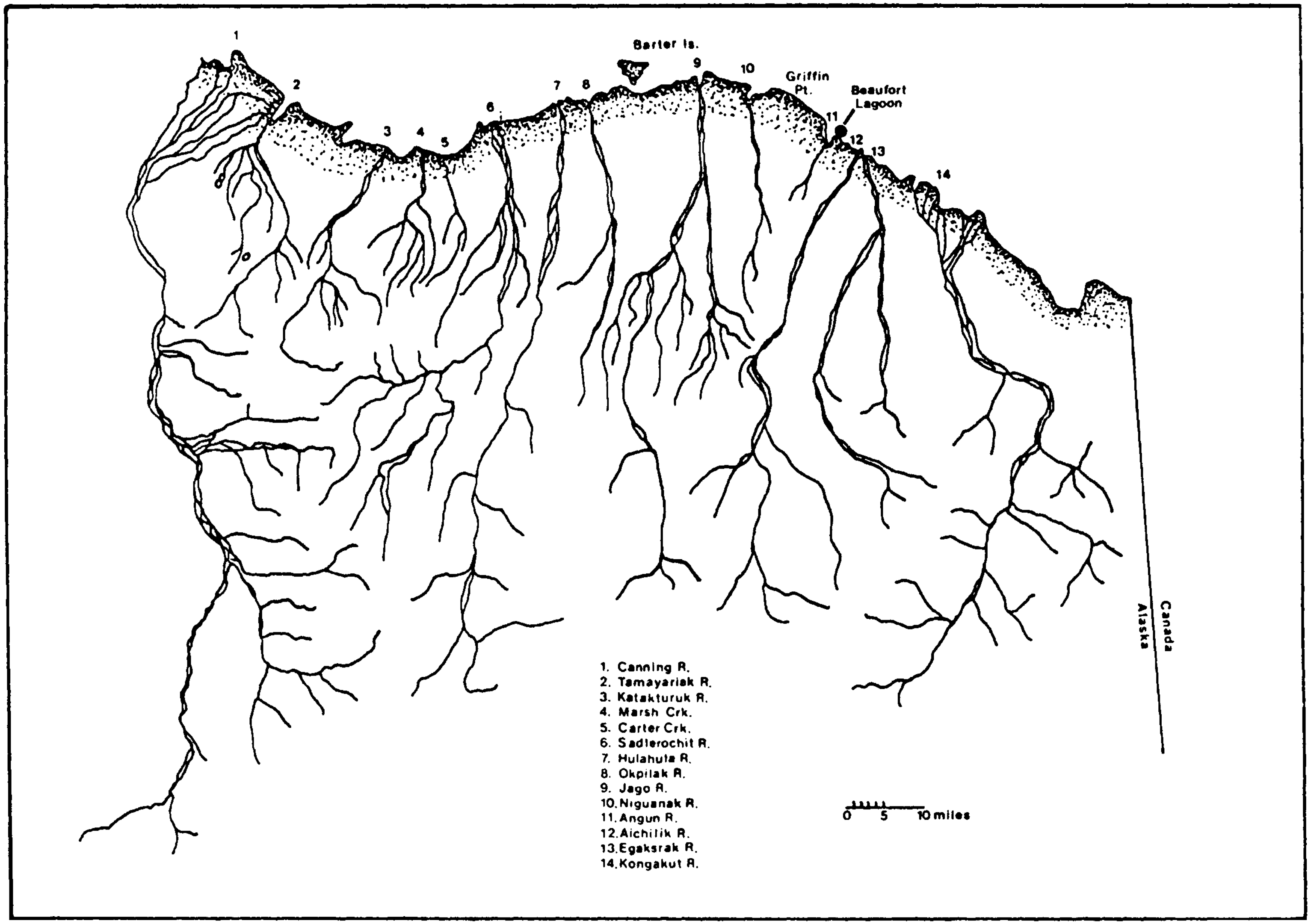

Figure 1. Major rivers on the north slope in the Arctic National Wildlife Refuge, Alaska.

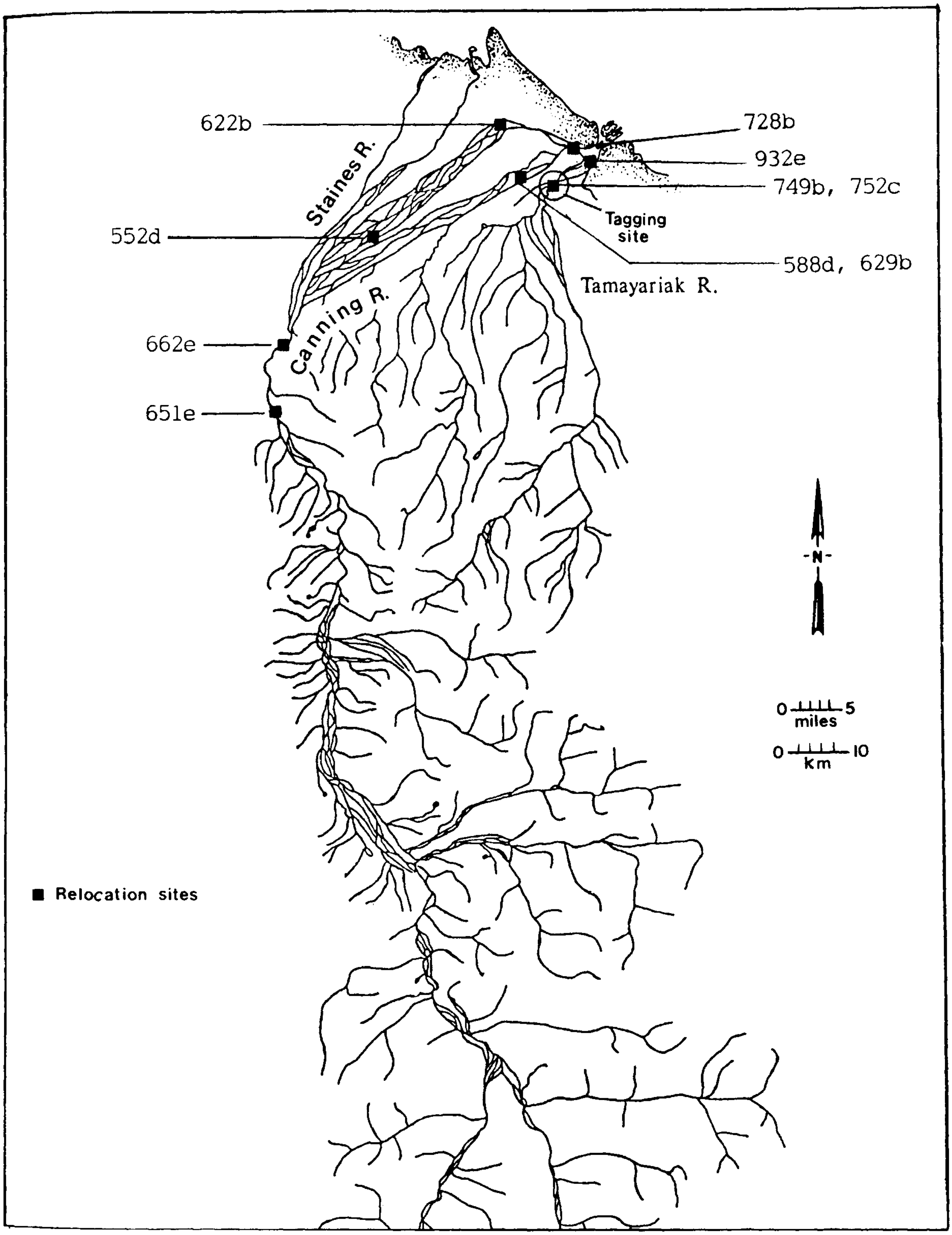

Figure 2. Tagging site and last known relocation sites of 10 radio-tagged Arctic grayling, Tamayariak and Canning Rivers, Alaska, 1985. Tracking periods: a = August, b = September, c = October, d = Novemeber, e = December. Information on individual fish and transmitter frequencies is given in Table 1.

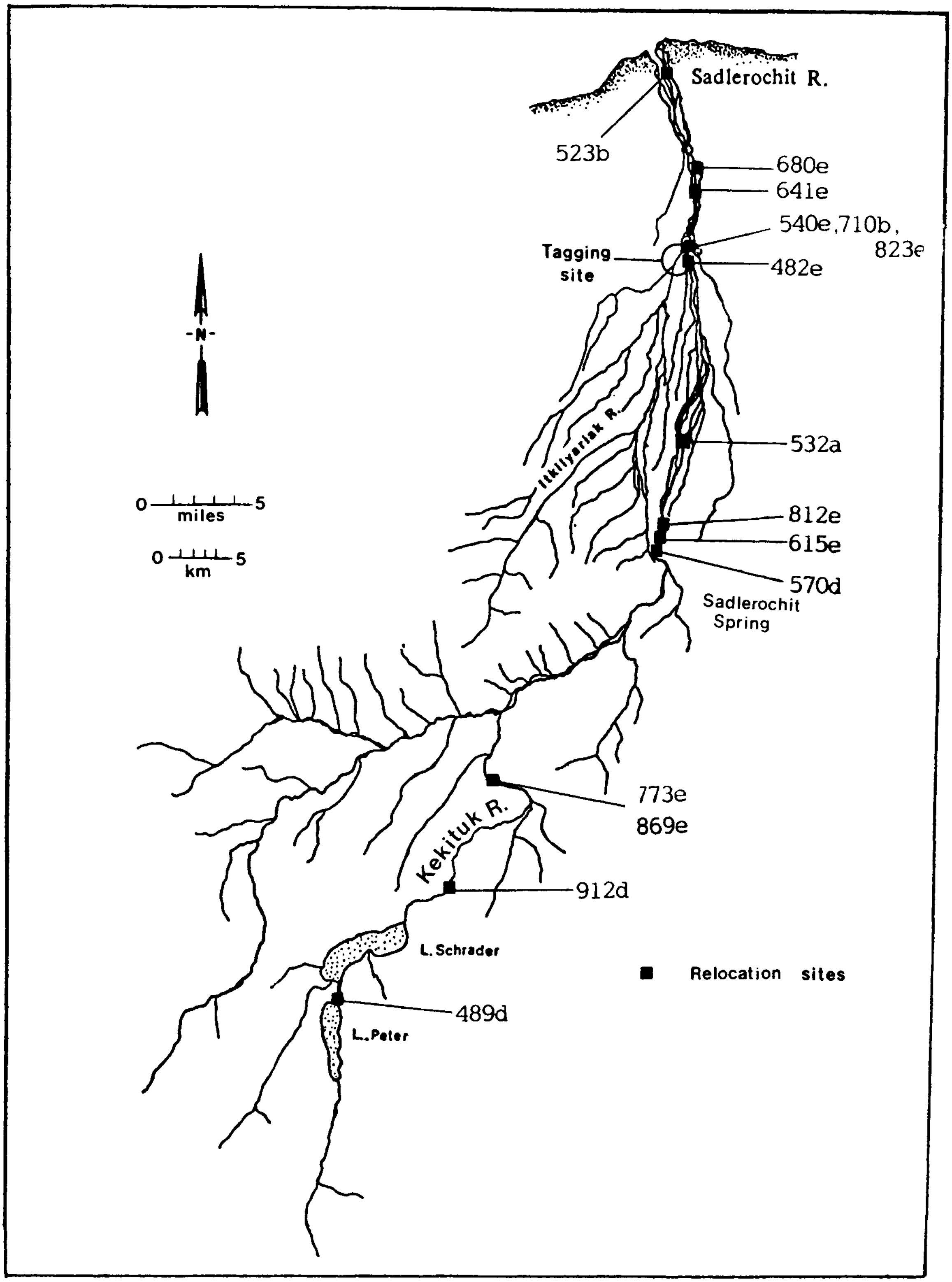

Figure 3. Tagging site and last known relocation sites of 15 radio-tagged Arctic grayling, Sadlerochit River, Alaska, 1985. Tracking periods: a = August, b = September, c = October, d = Novemeber, e = December. Information on individual fish and transmitter frequencies is given in Table 1.

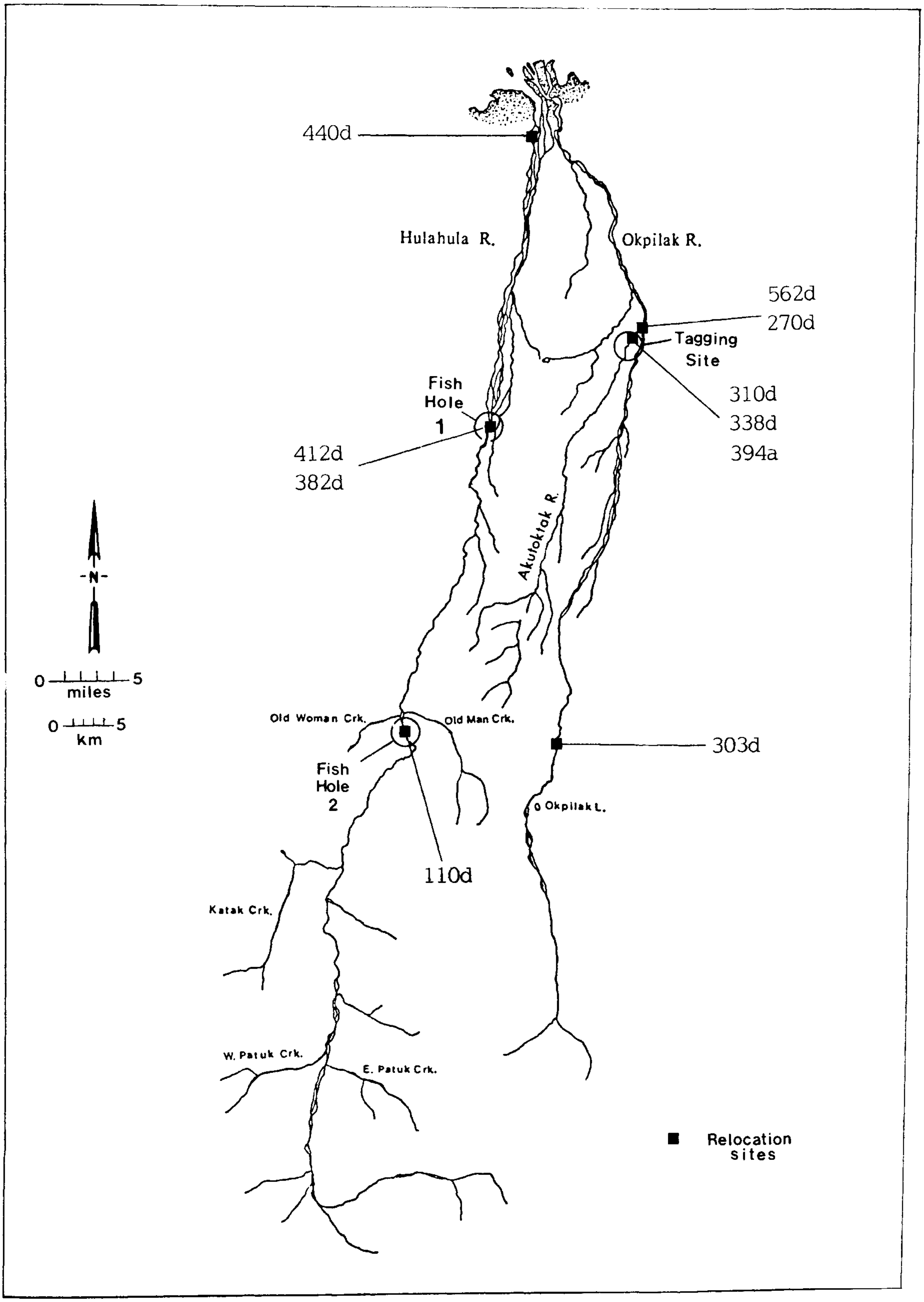

Figure 4. Tagging site and last known relocation sites of 10 radio-tagged Arctic grayling, Okpilak and Hulahula Rivers, Alaska, 1985. Tracking periods: a = August, b = September, c = October, d = Novemeber, e = December. Information on individual fish and transmitter frequencies is given in Table 1.

RESULTS

Thirty-eight Arctic grayling ranging in length from 355-433 mm were surgically implanted with radio transmitters (Table 1). Surgery time ranged from 5.5 to 15 minutes (mean = 8.9 minutes).

Only 5 grayling were not relocated. These 5 fish were from the Okpilak/ Akutoktak River drainage. Tracking success varied: 25 grayling (66%) were relocated in September, 17 (45%) in October, and 23 (61%) in November. In December only the lower Canning and Sadlerochit River drainages were flown due to poor visibility over the other rivers. Of the 23 fish tracked on these two drainages, 12 (52%) were relocated.

Canning/Tamayariak Rivers

All 9 Arctic grayling implanted with radio transmitters in the Tamayariak River were relocated on August 30, 1 to 2 days after transmitters were implanted (Table 1). There was little (less than 6 km) or no change in location from the release sites. By mid-September, four fish had moved to the lower Canning River, travelling between 9-20 km .

Three grayling were relocated on October 7 in the main channel of the Canning River just above the Staines River fork. Flowing water was still visible in the main channel of the Canning River at this time. Total migration distance from release site was about 45 km (Table 1), the longest recorded in this drainage. By the beginning of November flowing water was visible only at spring areas. Grayling were again found in the main channel of the Canning River below the Staines River fork and two were found in the east channel of the lower Canning River near the delta. On December 20, 3 grayling were located. These fish had moved little from their November locations. Overwintering locations appear to be distributed in the lower 5 km of the Canning and Tamayariak Rivers and in the main channel of the Canning, extending from the Staines River fork upstream approximately 10 km (Fig. 2).

Two grayling implanted with transmitters in the Tamayariak last year (August 1984) were located in the lower Canning and Tamayariak Rivers during this year's tracking (Table 1, Fig. 2). This was the first reception of radio signals from these fish since their release. Both fish were equipped with transmitters manufactured by Advanced Telemetry Systems (ATS), Minnesota, U.S.A.

Sadlerochit River/Itkilyariak Creek

All 14 Arctic grayling implanted with transmitters in Itkilyariak Creek were relocated by aerial tracking on August 29, 3 to 7 days after their release (Table 1). Eight fish remained in Itkilyariak Creek and moved little (less than 5 km) or no distance. The other six fish were distributed in the Sadlerochit River, moving 10-19 km upstream from the confluence of Itkilyariak Creek. One grayling tagged with an ATS transmitter in August 1984 was also relocated on August 29, 1985 near the confluence of the Sadlerochit River and Itkilyariak Creek. Four more grayling had migrated out of the Itkilyariak before the September 12 tracking. One fish moved up the Sadlerochit River into the Kekiktuk River, a distance of about 48 km. Two fish moved upstream in the Sadlerochit River about 14 km, and one grayling moved downstream 13 km. Three of the six grayling that started upstream migrations in August continued upstream 16-26 km beyond their previous locations. The October 7 tracking, revealed grayling had moved little from the previous month's location. The greatest movement recorded was 11 km upstream. Grayling remained in the Sadlerochit River within 10 km of the Itkilyariak Creek confluence, in the Sadlerochit River adjacent to Sadlerochit Springs, and the lower Kekiktuk River. The distribution of fish in November and December was similar to the October distribution with one notable exception: one grayling was relocated in the small stream between Peters and Schrader Lakes (Fig. 3).

Okpilak/Akutoktak Rivers
Nine grayling implanted with transmitters in this system were relocated on August 28, 34 to 37 days after tagging (Table 1). Five of these fish remained in the Akutoktak River or near its confluence with the Okpilak River. One migrated upstream approximately 40 km towards Okpilak Lake and 3 moved down the Okpilak River to the mouth and into the Hulahula River. The fish in the Hulahula River were found between the lower portion near the mouth and Fish Hole #1, river kilometer 32 (Fig. 4). Total migration distance was between 36 and 62 km from the release sites. The locations of grayling in September, October, November, and December were essentially the same as in August with two exceptions. One grayling which had not been detected in September was found in Fish Hole #2 on the Hulahula River (river kilometer 68) in October and November. The total migration distance was approximately 98 km from its release site. The grayling that migrated towards Okpilak Lake moved an additional 6 km upriver to just below the lake's outlet by October but was found 10 km downstream from the lake in November.

DISCUSSION

The results of this study indicate that Arctic grayling had begun their movements to overwintering sites by early September. Movements of grayling have been observed in other north slope streams to occur in August and September (Craig and Poulin 1974, Tripp and McCart 1974).

The mainstem of the Canning River from the confluence of the Staines River and upstream approximatetly 10 km is an overwintering area that has been utilized by grayling at least two consecutive years. Deep pools (greater than 2 m) were located in this area in August 1981 with the aid of a fathometer (Smith and Glesne 1983). Aerial surveys conducted in 1972 1nd 1973 identified this area, the east channel of the Canning River delta, and the area near the confluence of the Canning and Tamayariak Rivers as possible overwintering locations (Craig and McCart 1974a). The latter two were also identified by this study and in 1984 (West and Wiswar 1985). There are no perennial springs associated with these areas and it is suspected that deep pools provide the overwintering habitat.

Radio telemetry was used to identify overwintering locations of Arctic char on the Canning River from 1981 to 1983 (Smith and Glesne 1983, Daum et al. 1984). The overwintering locations found to be utilized by Arctic char included the deeper pools previously identified in August 1981. Fisheries investigations conducted during the Arctic Gas pipeline surveys in November 1973 (Ward and Craig 1974) caught Arctic grayling under the ice at an overwintering site identified by Smith and Glesne (1983).. It is likely that the Canning River contains more Arctic grayling overwintwring habitat than this study identified.

Overwintering locations on the Sadlerochit River that were utilized both years by radio-tagged grayling include much of the mainstem above the aufeis field, Peters and Schrader Lakes, and sections along the Kekiktuk River. The sites along the mainstem are probably marginal deep pools. No springs are known to this area. Overwintering habitat in the upper reach of Kekiktuk River is probably influenced by year-round overflow from Schrader Lake, while the lower section it is probably deep pools. The mainstem of the Sadlerochit River near Sadlerochit Springs was identified as a possoble overwintering location by Craig and McCart (1974a). Several fish were in this area in 1985 (Fig. 3, fish 570, 615 and 812). Sadlerochit Springs is located on a terrace above the Sadlerochit River floodplain and is geographically isolated from it. Water from the spring may perculate up into the main river to influence the site; however, deep pools along this reach of the Sadlerochit River are probably a more important feature.

Grayling from the Okpilak River drainage moved into the neighboring Hulahula River to overwinter as was observed in 1984 (Fig. 4). Grayling were found at Fish Hole #1 (32 km from the mouth) and Fish Hole #2 (68 km from the mouth). These sites are influenced by year-round flowing springs and are important overwintering sites for Arctic char as well. A third site on the Hulahula River about 6 km upstream from the mouth was identified in this study. No springs are associated with this area. The potential overwintering locations on the Okpilak River near its confluence with the Akutoktak River maybe marginal deep pools. On-the-ground-surveys during the tagging period did not reveal any deep pools or springs in this area. The fish found in this area may not have recovered adequetly from surgery to take their normal migration. Only one grayling tagged from the Okpilak River migrated upstream (Fig. 4, fish 303) in the river. This fish was relocated 10 km below Okpilak Lake. The lake probably does not contribute to overwintering habitat of stream resident fish. Overflow from the lake during the summer months is low and no flow was observed during the winter tracking. The trauma of surgey may have interfered with normal migratory behavior.

All relocations where little, no, or only downstream movements were recorded must be carefully reviewed. Some sites may prove to be actual overwintering sites while others may have been dead fish held in place by channel structures. On-the-ground checks will be attempted in the future to verify some of the questionable locations.

Table 1. Movements of radio-tagged Arctic grayling in drainages of the north slope of the Arctic National Wildlife Refuge. Tam. R. = Tamayariak River, Itk. Cr. = Itkilyariak Creek, Aku. R. = Akutoktok River.

Tag #	Date of Implant	Fork Length (mm)	Sex	Surgery Time (min)	Initial Location	Movement (km) Aug 21,28-30	Sep 12-13	Oct 7,10	Nov 6-7	Dec 20
Canning and Tamayariak Rivers					Tam. R.					
552	8/29/85	394	M	11.0	8	0	–	46	11	–
588	8/29/85	418	F	11.0	7	0	–	–	17	–
622	8/29/85	381	F	11.0	7	0	19	–	–	–
629	8/29/85	367	F	8.5	7	0	15	–	–	–
651	8/28/85	356	F	10.5	7	0	–	45	6	8
662	8/28/85	406	M	8.5	7	4	32	6	0	0
702	8/28/85	413	F	9.5	7	–	–	–	–	–
752	8/29/85	433	M	9.0	8	0	0	0	–	–
932	8/29/85	392	F	9.0	7	4	7	–	5	0
728*	8/18/84	410	M	14.0	7	–	13	–	–	–
749*	8/18/84	387	F	11.0	7	–	0	–	–	–
Sadlerochit River and Itkilyariak Creek					Itk. Cr.					
482	8/24/85	374	M	14.0	1	10	5	0	0	0
489	8/26/85	375	F	15.0	2	0	51	–	31	–
523	8/22/85	361	M	8.0	1	0	16	–	–	–
532	8/24/85	363	M	9.5	1	20	–	–	–	–
540	8/25/85	365	M	9.5	1	0	0	3	–	–
570	8/25/85	355	F	10.0	1	11	7	–	10	–
615	8/25/85	364	M	10.0	1	0	16	12	0	0
641	8/23/85	370	M	9.5	4	10	0	0	–	0
680	8/23/85	372	M	9.5	4	0	11	–	14	0
773	8/23/85	369	M	10.0	3	32	19	4	0	0
812	8/22/85	365	M	8.5	1	1	21	–	3	0
823	8/23/85	373	M	9.0	3	3	0	0	0	0
869	8/25/85	355	M	10.0	1	22	–	31	–	0
912	8/25/85	360	F	9.0	1	17	28	–	21	0
710*	8/03/84	375	M	17.0	2	0	0	–	–	–

Table 1. (Continued)

Tag #	Date of Implant	Fork Length (mm)	Sex	Surgery Time (min)	Initial Location	Movement (km) Aug 21,28-30	Sep 12-13	Oct 7,10	Nov 6-7	Dec 20
Okpilak and Akutaktak Rivers					Aku. R.					
110	7/28/85	368	-	6.5	2	-	-	125	0	
270	7/27/85	360	-	7.0	1	1	0	-	0	
303	7/28/85	370	M	5.5	2	44	3	4	10	
310	7/26/85	368	-	8.0	1	0	0	0	0	
333	7/27/85	397	M	8.0	1	-	-	-	-	
338	7/28/85	380	M	6.0	2	0	0	0	0	
370	7/26/85	385	-	7.0	1	-	-	-	-	
382	7/27/85	395	-	8.0	1	57	10	0	0	
394	7/26/85	407	-	8.0	1	0	-	-	-	
412	7/28/85	385	M	5.5	2	69	1	0	0	
430	7/27/85	368	F	9.0	1	-	-	-	-	
440	7/28/85	355	F	6.0	2	39	1	-	0	
460	7/26/85	382	-	9.0	1	-	-	-	-	
470	7/29/85	360	M	9.0	3	-	-	-	-	
562	7/29/85	365	M	8.0	3	0	1	2	0	

1 = Initial location is distance (km) from river mouth.
* Advanced Telemetry Systems (ATS) - transmitters from 1984 study that were still emitting a signal.
All other transmitters were Telonics.

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Fairbanks Fishery Resouces Progress Report Number FY86-3

AGE, GROWTH, DISTRIBUTION AND SUMMER FEEDING HABITS OF ARCTIC FLOUNDER IN BEAUFORT LAGOON, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA, 1985

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Key words: Arctic flounder, distribution, summer feeding habits, Beaufort Lagoon, Arctic National Wildlife Refuge

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Notes on the age, growth, distribution and summer feeding habits of Arctic flounder in Beaufort Lagoon, Arctic National Wildlife Refuge, Alaska, 1985.

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Abstract: Arctic flounder (*Liopsetta glacialis*) was the second most abundant species captured in Beaufort Lagoon in July and August 1985, and comprised 10% of the total number of fish captured in the lagoon. They ranged in length from 55-298 mm with the length interval 126-150 mm predominating. These fish were primarily 3 and 4 years old. Arctic flounder were most numerous at the nearshore mainland sampling station. Numbers of Arctic flounder captured were generally low and constant throughout July and August. A marked increase in catch began in mid-August. The major prey item during the summer was the amphipod *Gammarus setosus*. Isopods and polychaetes were also preyed upon.

INTRODUCTION

In concurrence with Section 1002(c) of the Alaska Natural Interest Lands Conservation Act (ANILCA) to provide baseline information on the fish and wildlife on the Arctic coastal plain, Arctic flounder (Liopsetta glacialis) were collected to determine their age and growth, distribution within the lagoon, and feeding habits. Arctic flounder are an abundant marine species inhabitating Beaufort Lagoon during summer months. They remain in the nearshore coastal waters during winter (Morrow 1980). Because of their abundance and tendency to remain nearshore, Arctic flounder may prove to be a good indicator species for future monitoring in the area facing development. Concurrent with this report, baseline histopathological and contaminant studies on this species is included in Fairbanks Fishery Resources Progress Report Number FY86-4 (West 1986).

STUDY AREA

Beaufort Lagoon (69°52'N, 142°15'W) is located approximately 60 km southwest of Barter Island (Fig. 1). The lagoon borders the Arctic coastal plain and is separated from the Beaufort Sea by a long, narrow barrier island. The Aichilik and Egaksrak Rivers are major rivers flowing into the lagoon. Traditional names for smaller embayments within Beaufort Lagoon are Nuvagapak Lagoon on the west of the Aichilik River delta, and Egaksrak Lagoon on the east side. All sampling was confined to Nuvagapak Lagoon.

The nearshore waters are influenced by a northwesterly longshore current and wind patterns associated with storms (Truett 1981). The entrances to Beaufort Lagoon are near Angun Point and the Aichilik River delta. Beaufort Lagoon is described as a limited exchange lagoon (Hachmeister and Vinelli 1984) where the flow of nearshore waters is restricted from entering the lagoon by the barrier islands.

Most of Beaufort Lagoon is covered with fast ice during the winter months. The open water season usually runs from late June until September or October. In June, snow melt runoff enters the lagoon from the rivers and accelerates breakup in the lagoon. Waters inside the lagoon tend to be warmer and less saline than offshore waters during the summmer months due to the freshwater intrusions being retained within the lagoon by the barrier islands.

The width of Beaufort Lagoon varies from 0.3 km (0.2 mi.) to approximately 2.0 km (1.2 mi.). Water depths are up to 3.7 m (12 ft.) deep over an organic-mud substrate. The shoreline of the barrier island is comprised of sand and small-size gravel.

METHODS

Fish sampling was conducted at Beaufort Lagoon, Alaska, at three stations and included three habitat types (Fig. 2): nearshore mainland (Station 2); mid-lagoon (Station 3); and inside barrier island (Station 4). Two fish sampling methods were used: 1) dual trap, directional fyke nets with 61 m (200 ft.) leads and 15.25 m (50 ft.) wings extended perpendicularly from shore (Stations 2 and 4), and 2) 38.1 m (125 ft.) monofilament experimental gill net

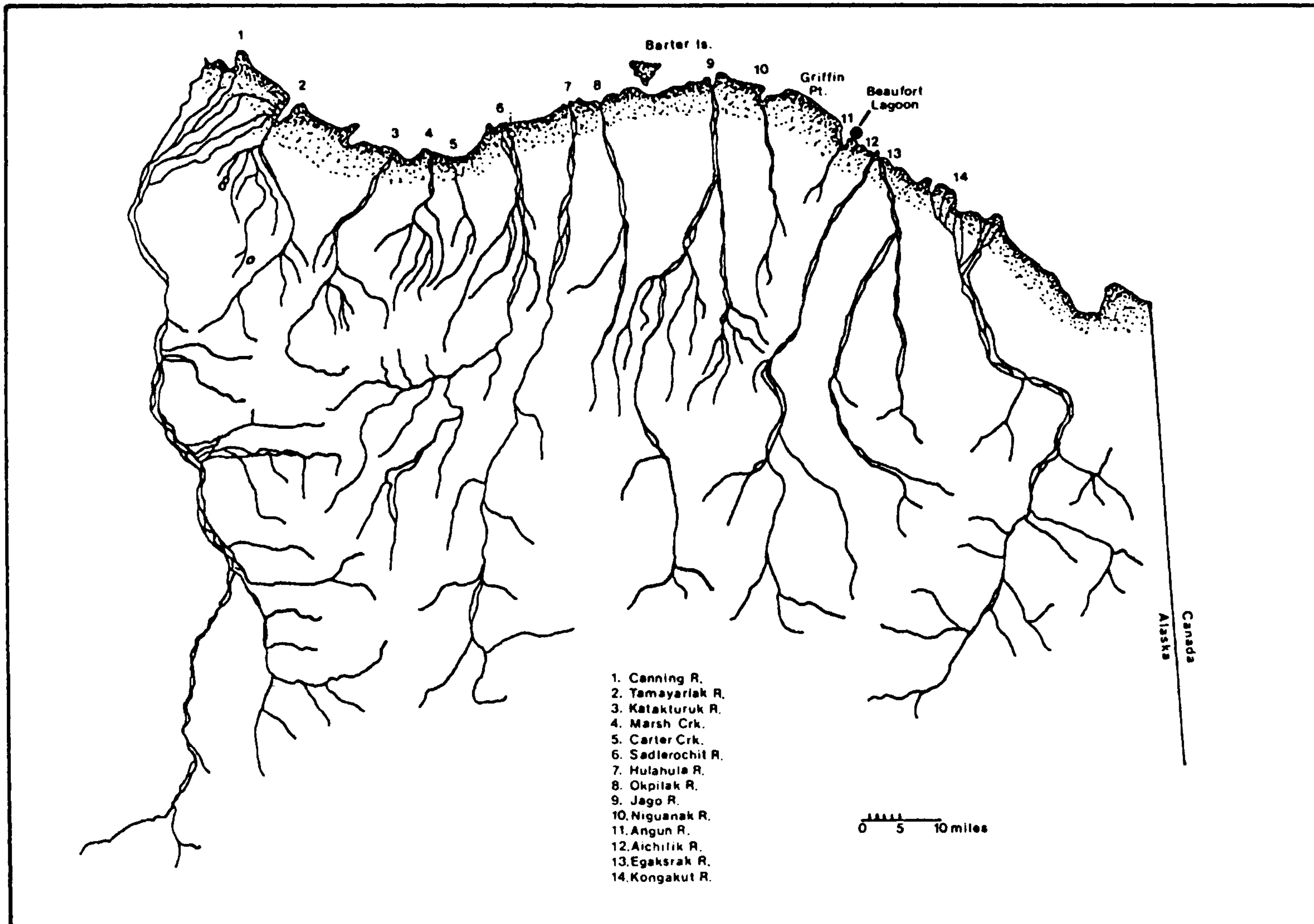

Figure 1. Major rivers on the north slope in the Arctic National Wildlife Refuge, Alaska.

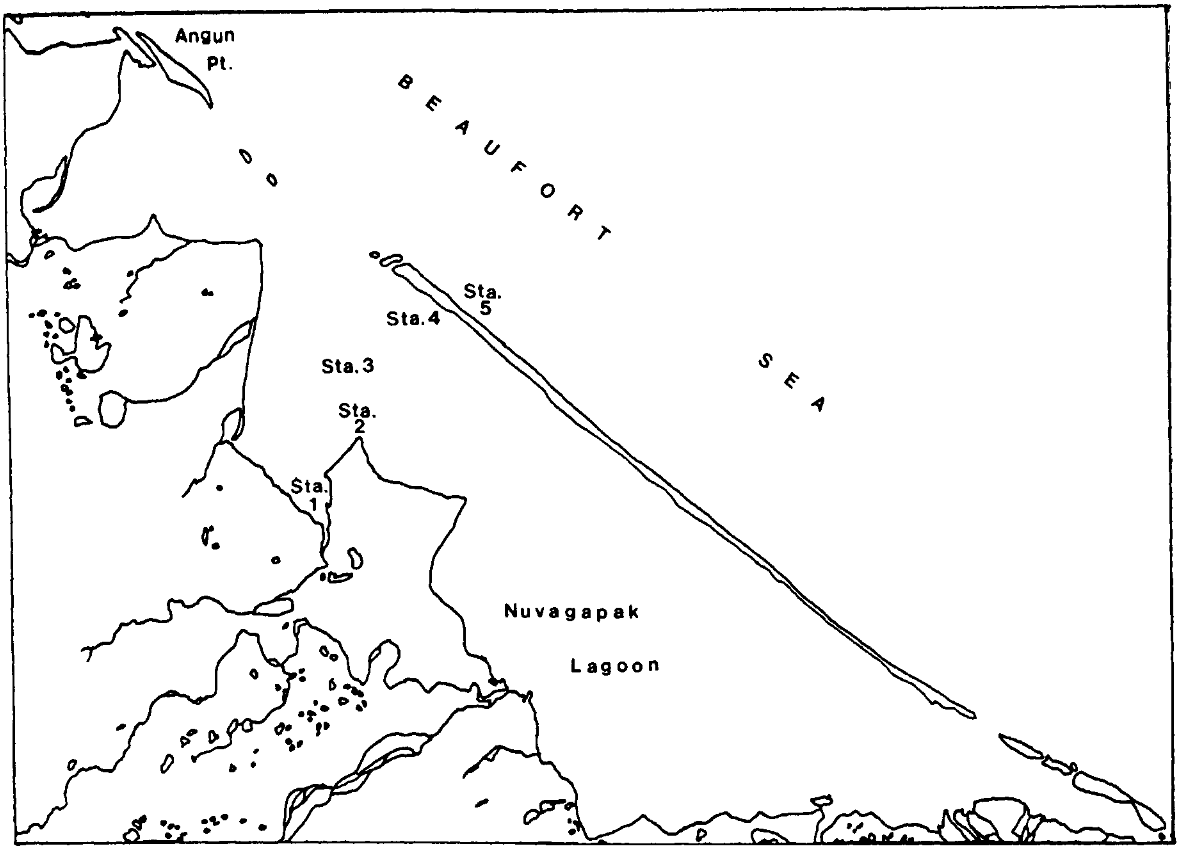

Figure 2. Sampling stations, Beaufort Lagoon, Alaska, 1985. Stations 2 and 4 were fyke net stations operated July 7 to August 9; station 3 was an experimental gillnet site fished July 22 - 29, 1985.

with 5 panels of 12.7, 25.4, 38.1, 50.8, and 63.5 mm (0.5, 1.0, 1.5, 2.0, and 2.5 inch) bar mesh. The two fyke net stations were operated from July 7 to August 9, 1985 and the gill net station from July 22-29, 1985. Fork lengths of fish were measured to the nearest millimeter (mm). Weights of fish were determined by using a Pesola spring scale with a range of 0 to 250 g or an Ohaus balance accurate to 0.1 g.

Ages were determined from otoliths. Otoliths were cleaned in Kodak Photo-Flo 200 and read under a Bausch and Lomb dissecting scope, 3-7x.

Fish esophagi and stomachs were excised and preserved in formalin or iso-propanol and contents were later removed and stored in iso-propanol. Prey items were separated by taxa. The prey items were analyzed by using a modification (West and Wiswar 1985) of the Index of Relative Importance (IRI) developed by Pinkas et al. (1971).

IRI = % Frequency of Occurence (% Number + % Volume).

RESULTS AND DISCUSSION

Arctic flounder comprised 10% of the total number of fish captured in Beaufort Lagoon during July and August 1985. Arctic char (Salvelinus alpinus) and fourhorn sculpin (Myoxocephalus quadricornis) were the most numerous species comprising 43% and 37%, respectively, of the total catch (Wiswar and West 1986). Arctic flounder were second only to fourhorn sculpin (Myoxocephalus quadricornis) as the most abundant marine species caught.

Length frequencies

Arctic flounder captured in Beaufort Lagoon by fyke net ranged in length from 55 mm to 298 mm. The fish from the 101-125 mm and 126-150 mm length intervals were the most frequent in Beaufort Lagoon (Fig. 3). These lengths correspond to the 3 and 4 year age class flounder (Table 1). Griffiths (1983) reported Arctic flounder between 80 and 120 mm to dominate the catch in Angun and Beaufort Lagoons in a short survey conducted between July 25 and August 5, 1982. In a survey along the western Beaufort Sea coast from Point Barrow to Harrison Bay Schmidt et al. (1983) found over 80% of the Arctic flounder catch was under 200 mm. Arctic flounder captured in Simpson Lagoon (Craig and Haldorson 1981) were larger, with the predominant length group represented by fish greater than 180 mm.

Age and growth

The age-specific length, weight and sex ratio for Arctic flounder collected from Beaufort Lagoon is presented in Table 1. In 1985 age classes 3 and 4 were dominant in the fyke net catch. The oldest flounder, a female, was age 9 and measured 298 mm. Weights ranged from 11.5 g for age 4 fish to 346.7 g for age 9 fish. No females were found under age 5. Female flounder dominated (79%) age classess 6-9 years.

In Beaufort Lagoon in 1984 (West and Wiswar 1985) the age classes 3 and 4 were also dominant in the fyke net catch. Bendock (1979) reported age 10 to predominate between Harrison Bay and Flaxman Island in 1975 and 1976 during the open water season. Andriyashev (1954) reported different age classes

Table 1. Age specific length, weight, and sex ratio for Arctic flounder, Beaufort Lagoon, Alaska, July-August 1985 (n=38).

		Total length(mm)			Weight (g)				Sex Ratio
Age	n	mean	range	S.D.	mean	range	S.D.	n	Female:Male
4	6	135.3	94-174	29.3	31.9	11.5-65	20.5	0[a]	-
5	18	163.5	125-195	17.0	55.8	19.2-96.1	19.9	15[b]	1:2.7
6	10	202	185-216	10.6	112.0	69.2-161	27.6	10	4:1
7	2	220.5	220-221	0.7	155.0	150-160	7.1	2	1:1
8	0								
9	2	276.5	255-298	30.4	287.4	228-346.7	83.6	2	1:0

a Sex was not determined.
b Sex was not determined for 3 of the fish aged.

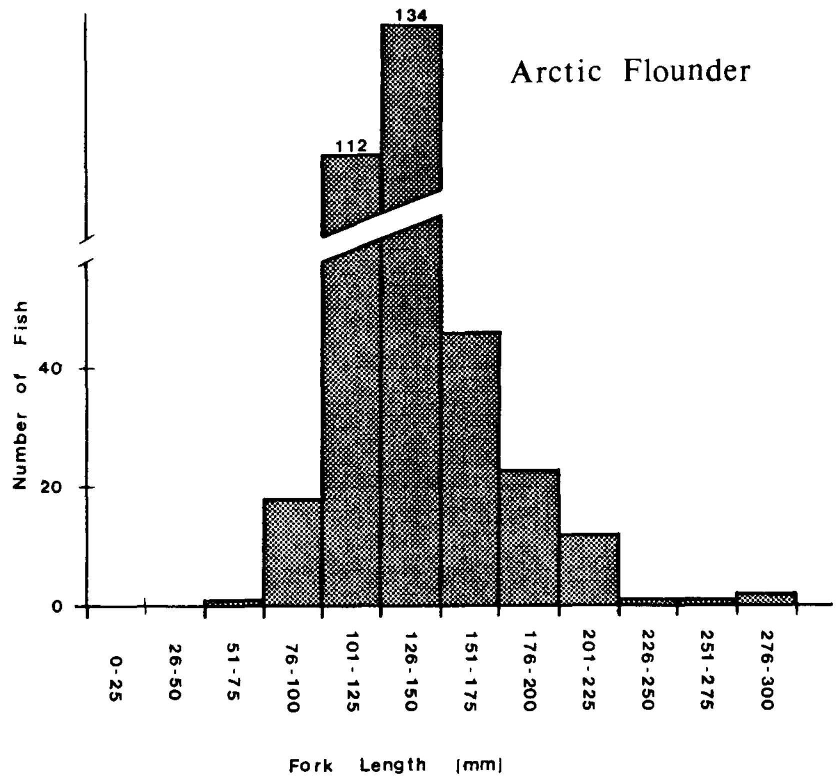

Figure 3. Length frequencies of 350 Arctic flounder captured with fyke nets, Beaufort Lagoon, Alaska, July and August 1985.

predominating in different regions and different times of the year off the Siberian coast. The predominant age class(es) reported from different areas may also be dependent on gear type. Arctic flounder have been reported up to age 19 in Nunaluk Lagoon Y.T. (Griffiths et al. 1975); however, other studies have shown the maximum age to range from 9 to 12 years along the Siberian coast (Andriyashev 1954), Kaktovik Lagoon, Alaska, (Griffiths et al. 1977), and between the Canning and Colville Rivers (Bendock 1979).

Few studies have reported age-specific length of Arctic flounder. In Nunaluk Lagoon, Yukon Territory (Griffiths et al. 1975) age classes 4 and 5 flounder had larger mean lengths than those from Beaufort Lagoon, but age class 6 and above were smaller (Fig. 4). This same comparison also holds for Arctic flounder from Kolgueu Island, U.S.S.R. (Andriyeshev 1954).

Distribution within the lagoon

Arctic flounder were most numerous at the nearshore mainland station (Sta. 2) during this study where 87% of the total number were caught. Arctic flounder moving in a westerly direction accounted for 56% of the total catch; almost twice that of those moving east (31%). At the barrier island station (Sta. 4) the difference in the percent of the catch between flounder moving east and

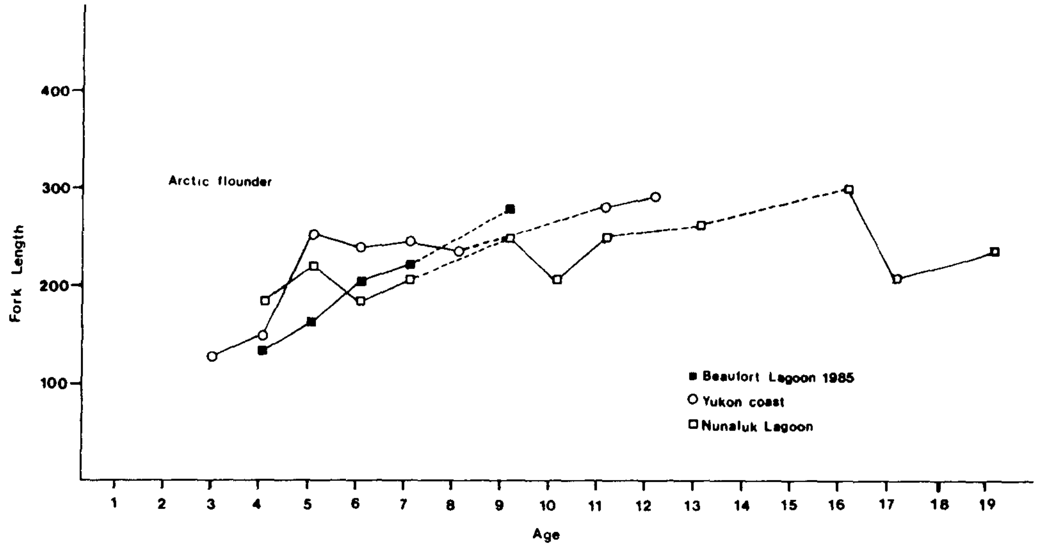

Figure 4. Comparison of age-specific length of Arctic flounder captured in Beaufort Lagoon, Alaska, 1985 with other Beaufort Sea coastal areas; Yukon coast (Kendal et al. 1975), Nunaluk Lagoon, Y.T. (Griffiths et al. 1975). Line hashed to indicate missing age groups in sample.

west was slight and total numbers were low. In 1984 the Station 2 fyke net also received a major portion of the catch, 63% (West and Wiswar 1985). No Arctic flounder were captured at the mid-lagoon gill net station (Sta. 3), probably more due to gear type than sampling location.

The catch-per-unit-effort (CPUE) (Table 2) of Arctic flounder caught per trap/hour moving westerly at the nearshore mainland showed the greatest variation ranging from 0.11 - 2.11 . The highest CPUE occured during the period of August 8-9, the last period sampled. Generally the CPUE at this station was below 0.30 fish/trap-hr. The CPUE at the west trap at this station was less variable and ranged from 0.05 - 0.35 fish/trap-hr. No discernible peak periods of abundance were observed except for the marked increase on August 8-9 at the nearshore mainland station.

Table 2. Catch-per-unit-effort of Arctic flounder in fyke nets, Beaufort Lagoon, Alaska, July and August 1985.

Nearshore Mainland (Station 2)			Lagoon Side of Barrier Island (Station 4)		
Dates	West trap*	East trap*	Dates	West trap*	East trap*
7/8-10	0.21	0.27	7/8-10	0.09	0.02
11-13	0.21	0.14	11/13	0.03	0.01
14-16	0.35	0.19	14-16	0.11	0.01
17-19	0.05	0.29	17-19	0.03	0.03
20-22	0.19	0.29	20-22	0.00	0.01
23-26	0.23	0.43	23-26	0.06	0.03
7/28 - 8/81	0.23	0.27	7/30 - 8/1	0.03	0.02
8/2-4	0.21	0.34	8/2-4	0.10	0.07
5-7	0.13	0.11	5-7	0.04	0.04
8-9	0.34	2.11	8-9	0.08	0.19

* West trap caught fish moving east; east trap caught fish moving west.

Feeding habits

Thirty-nine Arctic flounder collected from Beaufort Lagoon in 1985 were examined to determine summer feeding habits. Fifteen of the stomachs examined were empty. The amphipod Gammarus setosus was the most important prey item followed by isopods and polycheates (Fig. 5). The amphipod comprised the largest percent of prey items and was found in over 50% of the stomachs containing prey items. Isopods and mysids appeared in about one-third of the stomachs (Table 3).

The food habits of Arctic flounder in Beaufort Lagoon are similar to those reported from other areas along the Beaufort Sea coast (Bendock 1979, Griffiths et al. 1975, Craig and Haldorson 1981). In Simpson Lagoon, Arctic flounder fed heavily on the amphipod Onisimus sp. which was reported to be the most abundant food source in the lagoon (Griffiths and Dillinger 1980). In Beaufort Lagoon, the amphipod Gammarus setosus appears very abundant based on stomach analysis of other fish species (West and Wiswar 1985). Arctic flounder showed less variation in their diets than the other species examined from Beaufort Lagoon (West and Wiswar 1985).

The fyke net traps were checked approximately every 24 hours. The long retention time probably accounted for the high number of empty stomachs (38%). The retention time may also bias the results by overemphasizing the importance of G. setosus in the diet. The size of G. setosus lends them capable of passing through the mesh of the trap as well as the mouth of the trap, while other organisms such as polychaetes and isopods may not do so as readily. Feeding while in the traps cannot be discounted as any small organisms in the trap could be prey items.

Table 3. Prey items of Arctic flounder, Beaufort Lagoon, Alaska, July and August 1985.

Prey item	% N	% V	% FO	IRI
Amphipoda				
Gammarus setosus	73	44	54	6318
other	3	9	17	204
Isopoda	13	15	38	1064
Polychaeta	10	8	13	234
Mysidacea	1	5	8	48
Unidentified material	-	19	21	398

Total number of prey items = 301
Number of stomachs with contents = 24
%N = aggregate percent number of prey
%V = percent mean volume
%FO= percent frequency of occurence
IRI= Index of Relative Importance

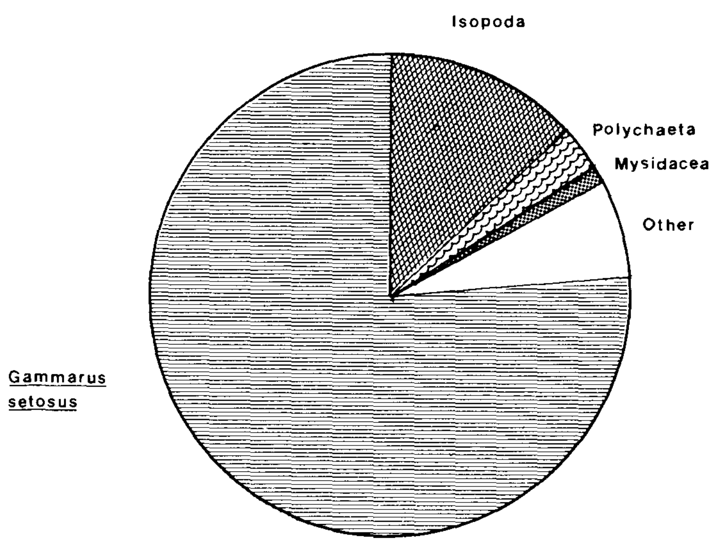

Figure 5. Comparison of IRI values of major prey items of Arctic flounder, Beaufort Lagoon, Alaska, July and August 1985.

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BASELINE HISTOPATHOLOGICAL AND CONTAMINANT STUDIES OF FOUR ARCTIC FISH SPECIES IN BEAUFORT LAGOON, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

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Key Words
Arctic char, Arctic cisco, Arctic flounder, fourhorn sculpin, parasites, histopathology, contaminants, Beaufort Lagoon, Arctic National Wildlife Refuge

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15 April 1986

Baseline histopathological and contaminant studies of four Arctic fish species in Beaufort Lagoon, Arctic National Wildlife Refuge, Alaska.

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Abstract:

Four Arctic fish species were studied at Beaufort Lagoon, Arctic National Wildlife Refuge, Alaska in 1984 and 1985 as part of baseline fish and wildlife studies prior to potential oil and gas development. Arctic char (*Salvelinus alpinus*), Arctic cisco (*Coregonus autumnalis*), Arctic flounder (*Liopsetta glacialis*), and fourhorn sculpin (*Myoxocephalus quadricornis*) were examined for histopathological abnormalities and parasites and were analyzed for 10 heavy metals, and 16 aliphatic and 15 aromatic hydrocarbons. Overall condition and health of the fish were good and disease rates appeared low. Arctic flounder were found to be the least infected of the 4 species with histopathological lesions and parasites. Contaminant levels were generally low or below detection except for arsenic which was elevated in all 4 species. The most common parasite observed was a cestode *Bothrimonus sturionis* which was found in the digestive tract of specimens in all species examined and occurred in 100% of the Arctic char and 96% Arctic cisco samples.

INTRODUCTION

The Alaska National Interest Lands Conservation Act (ANILCA) of 1980 provided for inventory and assessment of fish and wildlife on the coastal plain of the Arctic National Wildlife Refuge (ANWR). Section 1002(c) of the ANILCA specifically required baseline studies to assess fish and wildlife population sizes and distribution, determine location and carrying capacity of habitats, and assess impacts of human activities, especially those related to oil and gas exploration and development. As part of other coastal fish investigations (West and Wiswar 1984) a baseline health study was initiated in 1984 and continued through 1985. The objectives of this study were to examine common fish species for parasites, histological abnormalities, overall condition, and background levels of selected heavy metals and hydrocarbons. This information was deemed important both in assessing existing population health and as a base to measure effects of future development in the area. Similar investigations have been conducted in recent years: diseases (McCain et al. 1978); parasites (Mudry and McCart 1976; Craig and Haldorson 1980); contaminants (West 1982).

Four of the most common species found in the ANWR coastal lagoons were chosen for study. These include Arctic char (*Salvelinus alpinus*), Arctic cisco (*Coregonus autumnalis*), Arctic flounder (*Liopretta glacialis*), and fourhorn sculpin (*Myoxocephalus quadricornis*). The Arctic char and Arctic cisco are anadromous species important to the local subsistence fishery. They are mid-water column feeders; whereas, the Arctic flounder and fourhorn sculpin, both of which inhabit brackish or nearshore marine waters year around, are primarily bottom feeders (Morrow 1980).

STUDY AREA

The study was conducted at Beaufort Lagoon (Figure 1) approximately 60 km southeast of Barter Island, Alaska (Lat. 69° 52'N, Long. 142° 15'W). A field camp was established at Nuvagapak Point, the location of an abandoned military Distant Early Warning (DEW) Line Camp.

Beaufort Lagoon is described as a limited exchange lagoon (Hachmeister and Vinelli 1983) where the flow of nearshore waters is restricted due to the barrier island system. The lagoon is ice-covered much of the year with break-up evident usually in late June and new ice formation beginning in late September to early October. During the ice-free months the water is brackish but is influenced greatly by the large freshwater input from major rivers to the east. Salinities are low in June, 2 to 3 ppt, increasing as the summer progresses, reaching approximately 12 to 15 ppt by late August (West and Wiswar 1984).

Arctic char and Arctic cisco enter the lagoon system in mid- to late June to begin feeding intensively on epibenthic invertebrates along the open leads. Fourhorn sculpin are abundant throughout the thaw season but Arctic flounder tend only to become abundant as summer progresses (Griffiths 1983; West and Wiswar 1984). The amphipod *Gammus setosus* appears to be the most important single prey species to Arctic char and Arctic flounder in Beaufort Lagoon and were also found to be important, to a lesser degree, in the diet of Arctic cisco and fourhorn sculpin, (West and Wiswar 1984; Wiswar 1985).

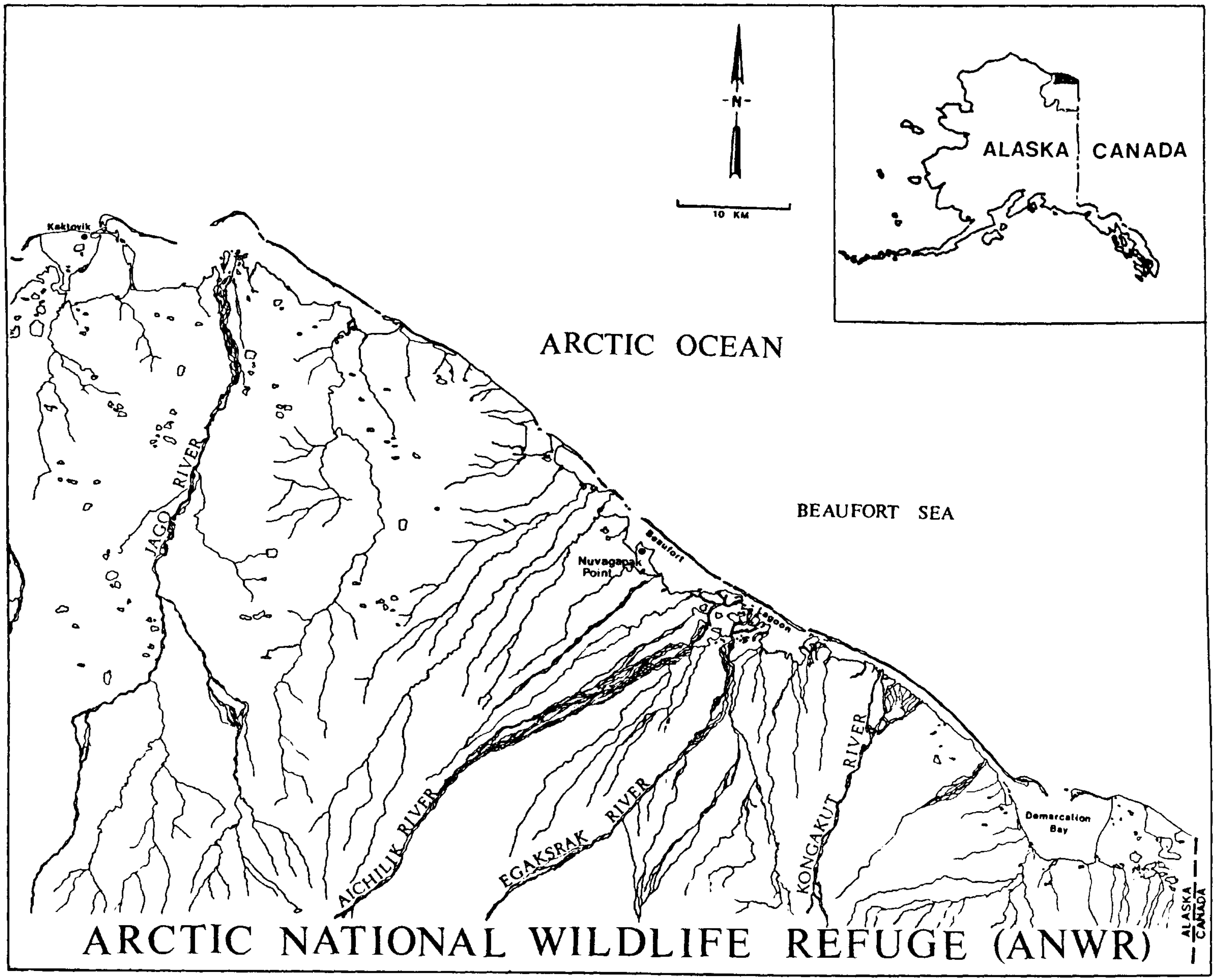

Figure 1. Location of Beaufort Lagoon, Arctic National Wildlife Refuge, Alaska.

Arctic waters such as Beaufort Lagoon typically have short food chains and low species diversity. Schell (1983) describes Beaufort Sea estuarine food webs as dependent on allochthonous carbon from ice algae and phytoplankton supplemented by peat and vegetative detritus, an ecosystem which may have delays of several thousand years between primary production and consumer use. The most abundant wildlife species found at Beaufort Lagoon in summer are oldsquaw ducks (Clangula hyemalis) which use the area for feeding on the abundant epibenthic invertebrates and as a refuge for molting (Spindler and Meehan 1984).

Human use of the Beaufort Lagoon area is limited. The military no longer uses the facilities at Nuvagapak Point, but since a landing strip and buildings remain, the area has been used in recent years for staging for oil and gas exploration activities and biological studies. The area has also been used by Native people for traditional subsistence hunting and fishing activities (Jacobson and Wentworth 1982).

METHODS

Fish were caught by either directional fyke nets or experimental gill nets. The fyke nets employed were shore-based with a 61.00 m lead, 15.25 m wings, and dual 1.22 m by 1.53 m traps. Gill nets were 38.13 m long by 1.83 m deep with equal lengths of 1.27, 2.54, 3.81, 5.08, and 6.35 cm bar mesh. Only live fish freshly removed from the nets were used for all health study examinations.

Samples for histopathological and contaminant analyses were collected between July 23 and August 28, 1984. Parasite examinations were made between July 7 and August 9, 1985.

Histopathological

A sample size of 30 fish per species was chosen based on the method described by Ossiander and Wedemeyer (1973) to detect at least a 10% disease incidence in a population of 100,000 or more fish with a 95% confidence level. Tissues were excised in the field using surgical instruments. Samples were taken of gill, heart, skin, muscle, kidney, spleen, liver, gonad, and digestive tract and preserved in Bouin's solution. The samples were then sent to the U.S. Fish and Wildlife Service National Fishery Research Center, Seattle, Washington where they were transferred to histological grade alcohol. The tissues were then embedded in paraffin, sectioned, and stained with Harris' hematoxylin and eosin and May-Grunwald Giemsa (Yasutake and Wales 1983). Gram and periodic acid Schiff stains were used when needed. Photomicrographs were taken of the prepared tissues using a Zeiss Photomicroscope III.

Contaminants

Five each of Arctic char, Arctic cisco, Arctic flounder, and fourhorn sculpin were collected for analysis of 10 heavy metals and five of each species (except 3 fourhorn sculpin) were collected for analysis of 16 aliphatic and 15 aromatic hydrocarbons. Fish were killed using a teflon-coated scalpel by making a single incision in the head while removing otoliths for ageing. After weighing and measuring the fish, they were carefully wrapped in non-annealed aluminum foil, tagged, placed in clean zip lock plastic bags, and put on ice. All samples were frozen within 3 days of the time of capture. Frozen samples were then shipped with dry ice to Analytical Bio-Chemistry

Laboratories, Inc., Columbia, Missouri for heavy metals analysis and to Hazleton Laboratories America, Inc., Madison, Wisconsin for hydrocarbons analysis.

Fish were ground whole for all determinations. Individual preparation and digestion techniques are available upon request.

Heavy metals analyzed for included lead, barium, cadmium, chromium, copper, zinc, arsenic, mercury, nickel, and vanadium. Atomic absorption spectroscopy was employed in the determinations of lead, cadmium, nickel, vanadium, arsenic, and mercury. A graphite furnace was used for lead, cadmium, nickel, and vanadium; whereas, hydride generation was used for arsenic and an automated cold vapor technique was employed for mercury. Instrumentation included a Perkin-Elmer 305B spectrophotometer with background correction, an HGA-2100 graphite furnace accessory, an MHS-10 hydride generation system, and a Technicon Auto-Analyzer. Table 1 summarizes the various instrumental parameters used for the atomic absorption spectroscopy.

Barium, copper, chromium, and zinc were determined by inductively coupled argon plasma spectroscopy. Instrumentation used for these determinations included a Jarrell-Ash Series 800 Atom Comp equipped with a digital PDP8/a computer with dual floppy disks. A forward power of 1.0 kw was used with the emission signal taken 15 mm above the load coil. The sample was introduced into the plasma through a fixed cross-flow nebulizer at a rate of 1.4 ml/minute which was kept constant through the use of a peristaltic pump. The sample, coolant, and plasma gas flows were 250 ml, 22.5 1, and 600 ml per minute respectively. Background correction on one side of each analytical line was accomplished through the use of a spectrum shifter. A two-point standardization was employed for each element using standards of 0.0 and 10.0 ppm.

Each value reported is the average of at least 3 determinations. Metals detection limits were 0.01 μg/g.

Duplicate heavy metals analyses were conducted on randomly chosen samples and recovering information was gathered using certified value reference tissues to assume compliance with the U.S. Environmental Protection Agency Good Laboratory Practice Standards; Toxic Substances Control Act (40 CFR 792).

Analysis of fish for petroleum-derived hydrocarbons was undertaken using a modification of procedures described by Gay et al. (1980). Capillary column gas chromatography was employed in the determinations of 16 aliphatic and 15 aromatic hydrocarbons (listed in Table 2 along with information on the standards used in the analyses).

Separation of the aliphatic and aromatic hydrocarbons was performed on silicar columns. Aliphatics were eluted using 80 ml of pentane followed by elution of aromatics with 100 ml of methylene chloride. Individual fractions were reduced to 1 ml, transferred into iso-octane and analyzed on a Hewlett Packard 5730A gas chromatograph with J & W fused silica capillary columns set up as follows:

Dimensions 30 MX 0.322 mm i.d.
Liquid phase: DB-5
Film thickness: 0.25 μ

Carrier gas: helium at 1.5 to 2.0 ml/minute

Table 1. Instrumental parameters for atomic absorption spectrophotometry analysis of heavy metals in fish samples from Beaufort Lagoon.

ELEMENT:	LEAD	CADMIUM	ARSENIC	MERCURY	NICKEL	VANADIUM
Monochrometer Slit Width (nm):	0.7	0.7	0.7	0.7	0.2	0.7
Wavelength Monitored (nm):	283.3	228.8	193.7	253.7	232.0	318.4
Lamp Power or Current:	10 watts	5 watts	7 watts	15 ma	20 ma	20 ma
Signal Expansion to Recorder	3x	2x	ABS	2x	3x	10-30x
Concentration of Standards Used for Method of Additions:	0.0, 0.02, 0.04ppm	0.0, 0.002, 0.04ppm	0.0, 0.02, 0.04ppm	-	0.0,0.03, 0.06ppm	0.0, 0.03 0.06ppm
Concentration of Standards Used for Reference Curve:	-	-	-	0.20ppb	-	-
Furnace Dry Temperature and Time:	95°C 30sec	95°C 30sec	-	-	95°C 30sec	95°C 22sec
Furnace Char Temperature and Time:	700°C 30sec	250°C 30sec	-	-	1000°C 30sec	1500°C 20sec
Furnace Atomize Temperature and Time:	2700°C 4 sec	2100°C 4 sec	-	-	2700°C 5 sec	2750°C 11 sec

Table 2. Hydrocarbons analyzed for Beaufort Lagoon fish samples and information on standard source and purity used in the analyses.

Aliphatic Hydrocarbons	Source*	Lot Number	Purity (%)
Decane	EPA	E-000236	99+
Undecane	Aldrich	1528BL	99
Dodecane	Chem Service	9-30K	99
Tridecane	EPA	E-000239	99+
Tetradecane	EPA	E-000240	99+
Pentadecane	EPA	E-000241	99+
Nonylcyclohexane	Pfalty & Bauer	N13990	99
Hexadecane	EPA	E-000309	99+
Heptadecane	Aldrich	1908EL	99
Pristane	Aldrich	1922EL	96
Plytane	Aldrich	G800225	99+
Octadecane	Aldrich	2406HL	97
Nonadecane	EPA	E-000244	99+
Eicosane	EPA	EC-319-01	99+
Heneicosane	EPA	EC-386-01	99+
Docosane	EPA	E-000245	99+

Aromatic Hydrocarbons	Source*	Lot Number	Purity (%)
Naphthalene	Chem Service	6-64	99
Acenaphthylene	Chem Service	6-203	95
Acenaphthene	Chem Service	7-58E	99+
Fluorene	Chem Service	6-202	98
Phenanthene	Chem Service	9-19P	99
Anthracene	Chem Service	6-203	98+
Fluoranthene	Chem Service	10-25B	98
Pyrene	Chem Service	6-205	99+
Benzo (a) anthracene	Aldrich	1224-EL	99
Chrysene	Chem Service	4-142	97
Benzo (b) fluoranthene	Chem Service	2-40B	98
Benzo (k) fluoranthene	Chem Service	2-25B	98
Benzo (a) pyrene	Aldrich	031497	98
1,2,5,6-Dibenzanthene	Chem Service	10-25B	97
Benzo (g,h,i) Perylene	Aldrich	0421A5	98.4

*addresses of chemical standard sources available upon request.

Inlet: 18740B in splitless mode
    Injection temperature: 250°C
    Delay: 40 seconds
    Injection volume: 4.9 µl
    Pressure: 13 psi
    Septum purge: 1.5 to 20 ml/minute
Detector: flame ionization
    Temperature: 300°C
    Range: 1
    Attenuation: 16
    Hydrogen flow: 30 ml/minute
    Air flow: 240 ml/minute
Oven Temperature:
    Initial hold: 90°C for 4 minutes
    Gradient: 4°C (aromatics); 8°C (aliphatics) per minute to 300°C
    Final hold: 300°C for 8 minutes

Due to variations between injections using capillary inlet systems, 20 µg of 2-fluorobiphenyl were added to each aliphatic extract and 12 µg of dotriacontane were added to each aromatic fraction as injection interval standards. Compounds detected were quantitated using a standard curve based on peak area ratios (area of compound per area of interval standard) vs. concentration. Integration and computation were performed on a Hewlett Packard 3356 Laboratory Automation System.

Detection limits for both aliphatic and aromatic hydrocarbons were 0.10 µg/g. Quality control was performed on the hydrocarbon samples by running one sample duplicate, one sample recovery, one reagent blank, one reagent method check recovery, two tuna control sample recoveries, and one tuna control sample blank. Recoveries were performed by spiking a sample with 1 ml of the 100 µg/ml mixed standard prior to the saponification step.

Because of high levels of arsenic discovered in the 1984 fish samples, 3 replicate water samples were taken each inside and outside the barrier islands at Beaufort Lagoon in 1985. These samples were taken in acid rinsed Nalgene 1-liter bottles and preserved with .2 ml of concentrated pure nitric acid. The samples were kept dark and on ice and then shipped to Northern Testing Laboratories, Inc., Fairbanks, Alaska for analysis. Procedures followed Standard Methods (APHA-AWWA-WPCF 1980). A 95% confidence interval for results was established through repetitive analyses.

Parasites

Twenty-five each Arctic char, Arctic cisco, Arctic flounder, and fourhorn sculpin were examined for macro parasites at Beaufort Lagoon in 1985. In addition, one Arctic grayling (Thymallus articus) was examined. The histopathological examinations conducted in 1984 included microscopic examination of tissues for parasites. Methods for examination and preservation of larger external and internal parasites followed Hoffman (1967).

Fish were killed by pithing. Gross examinations were made of gills, fins, skin, eyes, brain, pseudobranch, stomach, intestine, liver, gall bladder, spleen, pyloric caeca, heart, kidney, gonads, gas bladder, visceral cavity, and muscle using a Bausch and Lomb 3X hand lens. External examination was made first, followed by the viscera, and finally the muscle (accomplished by making diagonal cuts every 4 cm through the body). The lumen and gut were inverted and pyloric caeca projections individually split and inverted to make accurate counts of tapeworms.

Parasites were counted and representative specimens were weighed using a RCBS Model 505 precision scale (± 0.0065 g) and then preserved. Trematodes, cestodes, and acanthocephala were preserved in warm 10% formalin. Nematodes, copepods, and isopods were preserved in warm 70% alcohol. Identifications in the field were made under a Bausch and Lomb 10-70X dissecting microscope with the aid of host-parasite lists (Margolis and Arthur 1979; Moles 1982) and keys (Bykhouskaya-Pavlouskaya et al. 1964; Hoffman 1967). Verification of identifications and identification of unknown samples was accomplished through the assistance of several renowned fish parasitologists (See acknowledgement).

Condition and Ageing

Fish were measured using a plastic WILDCO measuring board and fork lengths were recorded to the nearest mm. Weights of fish taken in 1985 for parasite examinations were taken on an OHAUS balance (± 0.10 g) after fish were drip dried for one minute. All other weights were taken with Pesola spring scales (± 1.0g). A coefficient of condition (K) was calculated following Carlander (1969) using the equation:

$$K= \frac{\text{Weight X } 10^5 (g)}{\text{Fork Length}^3 (mm)}$$

A condition factor was determined for all fish collected for histopathological, contaminant, and parasite examination. In addition, 27 separate Arctic cisco were examined for condition in 1985. Age was determined by otoliths except for the 1984 Arctic cisco samples where scales were used. Arctic cisco otoliths were taken in 1985 and were aged by the U.S. Fish & Wildlife Service, National Fisheries Research Center in Seattle following methods similar to Williams and Bedford (1974) in which the otoliths are broken and burned. Arctic char, Arctic flounder, and fourhorn sculpin otoliths were ground when necessary with 320 grit wet sandpaper and read in a solution of Photo-Flo with a Bausch and Lomb 10-40X dissecting microscope using reflected light. Hyaline zones were counted as described by Jearld (1983).

RESULTS

Histopathological

The histopathological examinations were accomplished under contract to the Seattle National Fisheries Research Center. A complete account of the histopathological survey was compiled in an unpublished report (Goldberg et al. 1985). The results are summarized in Table 3.

Arctic flounder was the "cleanest" fish of the four species examined. Small aneurisms in the gill lamellae were observed in 27% of the flounder samples. The gill epithelium was separated from the lamellae in 10% of the 30 fish in the sample. Congested spleens were observed in 6% of the flounder examined. Excess mucus, hyperplasia of the gill epithelium, inflamed stomach tissue, and a skin ulcer were each found in separate single cases. The skin ulcer was localized but had extended invasion with collagenous connective tissue and

Table 3. Histopathological abnormalities and percent of occurrence in four fish species from Beaufort Lagoon, Alaska.

Arctic Flounder	
*Gill aneurisms	27%
*Excess mucus in gills	3%
Hyperplasia of gill epithelium	3%
*Congested spleen	6%
Hermaphroditism	3%
Localized inflammation, stomach	3%
Skin ulcer	3%
*Gill epithelium separated from lamellae	10%
Arctic Char	
*Gill aneurisms	13%
Gill edema	3%
Helminth, trematode in gill	3%
*Congested spleen	13%
*Congested liver	3%
Helminth, cestode in digestive tract	30%
Helminth, trematode in digestive tract	10%
Nematode in digestive tract	3%
Intestine, granuloma	3%
Hypoplasia of spleen	3%
Fatty liver	3%

*Possible artifact caused during sampling

Table 3. Continued.

Arctic Cisco	
*Gill aneurisms	6%
Hyperplasia of gill epithelium	3%
*Gill epithelium separated from lamlelae	6%
Fatty liver	3%
Helminth, cestode in digestive tract	17%
Helminth, trematode in digestive tract	3%
Granuloma, kidney	6%
Granuloma, spleen	3%
Coccidian protozoan, testis	3%
Localized inflammation, gut mesentery	3%
Fourhorn Sculpin	
*Gill aneurisms	3%
Trichodina in gill	43%
Ichthyophthirius - like protozoan in gills	3%
Epitheliocystis in gill	3%
Fatty liver	3%
*Congested liver	3%
*Congested heart	3%
*Congested kidney	3%
Megalocytic Hepatosis, liver	40%
Helminth, trematode in digestive tract	3%
Helminth, cestode in digestive tract	6%
Kidney tubule degeneration	3%
Kidney tubules swollen	3%
Localized inflammation between muscle bundles	3%
*Congested spleen	3%
Granuloma, kidney	3%

*Possible artifact caused during sampling numerous inflammatory cells underneath, but it did not exhibit any etiological agent. One hermaphroditic flounder was also discovered (Goldberg et al. 1986).

Thirty percent of the Arctic char examined contained cestodes in the lumen tissue sections where they caused no apparent histological damage to the digestive tract. Other parasites observed in char during histopathological examinations included small trematodes in the digestive tract of 10% of those examined, 1 trematode in the gill of a single fish, and 1 nematode in the muscularis of the intestine of another fish. The trematodes caused no apparent histological damages but the nematode was surrounded by an inflammed tissue area. Congested spleens were observed in 13% of the Arctic char examined. Gill aneurisms were also noted in 13% of the samples. Single cases were observed each for gill edema, congested liver, granuloma in the intestine, hypoplasia of the spleen, and a fatty liver.

As with Arctic char, Arctic cisco were found to possess cestodes (17%) and a trematode (3%) in the digestive tracts causing no apparent harm. Gill aneurisms and gill epithelium separated from lamellae were observed in 2 cases but may have been artifacts caused during sampling. A granuloma was seen in the kidney of each of 2 Arctic cisco and in the spleen of one fish. One example each of fatty liver, localized inflammation in the gut mesentery, and hyperplasia of gill epithelium was also observed. A single cisco was found to have a coccidian protozoan parasite infection in the testis. The parasite consisted of a basophilic body with a nucleus containing a single round basophilic nucleolus. The parasite displaced the germinal cysts within the seminiferous tubule thereby sterilizing the fish in those tubules posessing the parasite. In the single case examined, however, the density of the parasite did not appear sufficient to influence the fertility of the fish.

Fourhorn sculpin appeared to be relatively free of helminth parasites. Helminth infections were seen in two separate fishes. Fourhorn sculpin, however, were heavily parasitized on the gill by Trichodina. A single Ichthyophthirius - like protozoan was also seen in the gills. One observation of possible epitheliocystis was made. This disease is caused by rickettsiae, encompassing the orders Rickettsiales and Chlamydiales (Buchanan and Gibbons 1974). Gill aneurisms were found in one sculpin. An idiopathic lesion was found in a single fourhorn sculpin kidney. In another sample some of the kidney tubules were swollen; the kidney from another fish was congested. A granulomatous area on the periphery of the kidney was seen in 1 sculpin. Single cases of congested heart, congested spleen, fatty liver, congested liver, and inflammation between muscle bundles were also observed. Forty-three percent of the fourhorn sculpins examined displayed signs of Megalacytic Hepatosis (MH) with pleomorphic nuclei. This is a liver condition characterized by an increase in hepatocyte diameters and their nuclei.

Contaminants

Mean concentrations, range of values, and standard deviations for contaminants found in the fish tissues are reported by species for heavy metals, aliphatic hydrocarbons, and aromatic hydrocarbons in Tables 4 to 6, respectively.

Arctic char had the lowest overall metal concentrations but the highest total tissue hydrocarbon levels of the 4 species analyzed (Table 7). Fourhorn sculpin displayed just the opposite, having the highest heavy metal concentrations and the lowest hydrocarbon levels. Arctic cisco ranked second for both metals and hydrocarbons of the 4 species and Arctic flounder ranked

Table 4. Concentrations of heavy metals in whole ground fish from Beaufort Lagoon, Alaska, 1984. Results are expressed as micrograms of contaminant per gram of tissue (µg/g).

	Lead	Barium	Cadmium	Chromium	Copper
Arctic Char (n=5)					
Mean Value	*0.01	0.21	*0.02	*0.01	1.50
Range	*0.01-0.02	0.14-0.25	*0.01-0.03	*0.01-0.02	1.30-1.70
Std. Deviaiton	0.004	0.043	0.008	0.004	0.158
Arctic Cisco (n=5)					
Mean Value	0.03	0.51	*0.01	*0.01	1.01
Range	0.01-0.04	0.42-0.67	*0.01-0.02	*0.01-0.03	0.92-1.10
Std. Deviation	0.011	0.102	0.004	0.009	0.083
Arctic Flounder (n=5)					
Mean Value	*0.03	0.41	*0.01	0.13	1.10
Range	*0.01-0.07	0.21-0.66	*0.01-0.02	0.06-0.20	0.92-1.30
Std. Deviation	0.024	0.187	0.004	0.051	0.152
Fourhorn Sculpin (n=5)					
Mean Value	0.07	1.42	0.04	0.16	2.64
Range	0.06-0.09	0.69-2.80	0.02-0.04	0.08-0.22	1.90-3.90
Std. Deviation	0.011	0.843	0.009	0.058	0.792

Table 4. Continued.

	Zinc	Arsenic	Mercury	Nickel	Vanadium
<u>Arctic Char</u>					
(n=5)					
Mean Value	20.94	0.92	0.04	0.06	0.10
Range	16.40-22.80	0.50-1.40	0.03-0.05	0.01-0.13	0.04-0.14
Std. Deviation	2.589	0.448	0.008	0.055	0.042
<u>Arctic Cisco</u>					
(n=5)					
Mean Value	26.48	1.01	0.03	0.06	0.11
Range	20.70-34.80	0.74-1.40	0.02-0.05	0.01-0.14	0.05-0.16
Std. Deviation	5.893	0.261	0.013	0.049	0.040
<u>Arctic Flounder</u>					
(n=5)					
Mean Value	22.12	0.75	0.02	0.11	*0.09
Range	19.80-23.80	0.51-1.10	0.02-0.04	0.03-0.20	*0.01-0.17
Std. Deviation	1.678	0.240	0.009	0.070	0.074
<u>Fourhorn Sculpin</u>					
(n=5)					
Mean Value	23.92	0.71	0.02	0.14	*0.19
Range	20.10-27.70	0.54-0.84	0.01-0.03	0.08-0.23	*0.01-0.60
Std. Deviation	3.216	0.113	0.007	0.067	0.240

*Means "less than" where the true value is below the normal detection limit. Mean values and standard deviations were calculated using values at the detection limit; therefore, in cases where one or more replicate sample(s) were below detection, the reported mean values are slightly high and standard deviations are slightly low.

Table 5. Concentrations of aliphatic hydrocarbons in whole ground fish from Beaufort Lagoon, Alaska, 1984. Results are expressed as micrograms of contaminant per gram of tissue (μg/g).

	Decane	Undecane	Dodecane	Tridecane	Tetradecane
Arctic Char (n=5)					
Mean Value	0.28	1.53	*0.10	*0.10	*0.10
Range	*0.10-0.67	0.69-3.19	*0.10	*0.10	*0.10
Std. Deviation	0.232	1.016	0	0	0
Arctic Cisco (n=5)					
Mean Value	0.25	1.45	*0.10	*0.10	*0.10
Range	*0.10-0.57	*0.10-3.29	*0.10	*0.10-0.12	*0.10
Std. Deviation	0.190	1.225	0	0.009	0
Arctic Flounder (n=5)					
Mean Value	0.54	2.71	*0.10	*0.10	*0.10
Range	*0.10-0.77	*0.10-4.19	*0.10	*0.10	*0.10
Std. Deviation	0.261	1.579	0	0	0
Fourhorn Sculpin (n=5)					
Mean Value	0.17	1.05	*0.10	*0.10	*0.10
Range	*0.10-0.30	0.47-1.89	*0.10	*0.10	*0.10
Std. Deviation	0.115	0.745	0	0	0

Table 5. Continued.

	Pentadecane	Nonylcyclohexane	Hexadecane	Heptadecane	Pristane
Arctic Char (n=5)					
Mean Value	0.15	*0.10	*0.10	0.12	14.52
Range	*0.10-0.19	*0.10	*0.10	*0.10-0.18	7.01-27.43
Std. Deviation	0.036	0	0	0.36	7.815
Arctic Cisco (n=5)					
Mean Value	0.31	*0.10	*0.10	0.13	4.05
Range	0.17-0.56	*0.10	*0.10	*0.10-0.22	0.37-6.34
Std. Deviation	0.149	0	0	0.053	2.261
Arctic Flounder (n=5)					
Mean Value	*0.10	*0.10	*0.10	0.12	0.11
Range	*0.10	*0.10	*0.10	*0.10-0.18	*0.10-0.14
Std. Deviation	0	0	0	0.036	0.018
Fourhorn Sculpin (n=5)					
Mean Value	0.12	*0.10	*0.10	*0.10	0.38
Range	*0.10-0.17	*0.10	*0.10	*0.10	0.11-0.91
Std. Deviation	0.040	0	0	0	0.456

Table 5. Continued.

	Octadecane	Phytane	Nonadecane	Eicosane	Heneicosane	Docasane
Arctic Char (n=5)						
Mean Value	*0.10	*0.10	*0.10	*0.10	*0.10	*0.10
Range	*0.10	*0.10	*0.10	*0.10	*0.10	*0.10
Std. Deviation	0	0	0	0	0	0
Arctic Cisco (n=5)						
Mean Value	*0.10	*0.10	*0.10	*0.10	*0.10	*0.10
Range	*0.10	*0.10	*0.10	*0.10	*0.10	*0.10
Std. Deviation	0	0	0	0	0	0
Arctic Flounder (n=5)						
Mean Value	*0.10	*0.10	*0.10	*0.10	*0.10	*0.10
Range	*0.10	*0.10	*0.10	*0.10	*0.10	*0.10
Std. Deviation	0	0	0	0	0	0
Fourhorn Sculpin (n=5)						
Mean Value	*0.10	*0.10	*0.10	*0.10	*0.10	*0.10
Range	*0.10	*0.10	*0.10	*0.10	*0.10	*0.10
Std. Deviation	0	0	0	0	0	0

*Means "less than" where the true value is below the normal detection limit. Mean values and standard deviations were calculated using values at the detection limit; therefore, in cases where one or more replicate sample(s) were below detection, the reported mean values are slightly high and standard deviations are slightly low.

Table 6. Concentrations of aromatic hydrocarbons in whole ground fish from Beaufort Lagoon, Alaska, 1984. Results are expressed as micrograms of contaminant per gram of tissue (μg/g).

	Naphthalene	Acenaphthylene	Acenaphthene	Flurorene	Phenanthrene
<u>Arctic Char</u>					
(n=5)					
Mean Value	*0.10	*0.10	*0.10	*0.10	*0.10
Range	*0.10	*0.10	*0.10	*0.10	*0.10
Std. Deviation	0	0	0	0	0
<u>Arctic Cisco</u>					
(n=5)					
Mean Value	-	-	-	-	-
Range	-	-	-	-	-
Std. Deviation	-	-	-	-	-
<u>Arctic Flounder</u>					
(n=5)					
Mean Value	*0.10	*0.10	*0.10	*0.10	*0.10
Range	*0.10	*0.10	*0.10	*0.10	*0.10
Std. Deviation	0	0	0	0	0
<u>Fourhorn Sculpin</u>					
(n=5)					
Mean Value	*0.10	*0.10	*0.10	*0.10	*0.10
Range	*0.10	*0.10	*0.10	*0.10	*0.10
Std. Deviation	0	0	0	0	0

Table 6. Continued.

	Anthracene	Fluoranthene	Pyrene	Benzo(a)anthracene	Chrysene
Arctic Char (n=5)					
Mean Value	*0.10	0.13	0.31	*0.10	*0.10
Range	*0.10	*0.10-0.18	0.12-0.63	*0.10	*0.10
Std. Deviation	0	0.044	0.197	0	0
Arctic Cisco (n=5)					
Mean Value	-	-	-	-	-
Range	-	-	-	-	-
Std. Deviation	-	-	-	-	-
Arctic Flounder (n=5)					
Mean Value	0.19	0.12	0.45	*0.10	*0.10
Range	*0.10-0.29	*0.10-0.17	0.28-0.55	*0.10	*0.10
Std. Deviation	0.088	0.032	0.115	0	0
Fourhorn Sculpin (n=5)					
Mean Value	*0.10	*0.10	*0.10	*0.10	*0.10
Range	*0.10	*0.10	*0.10	*0.10	*0.10
Std. Deviation	0	0	0	0	0

Table 6. Continued.

	Benzo (b) fluoranthene	Benzo (k) fluoranthene	Benzo (a) pyrene	Dibenz (a,h) anthracene	Benzo (g,h) perylene
<u>Arctic Char</u> (n=5)					
Mean Value	0.12	0.11	*0.10	*0.10	0.24
Range	*0.10-0.18	*0.10-0.16	*0.10	*0.10	*0.10-0.81
Std. Deviation	0.036	0.027	0	0	0.318
<u>Arctic Cisco</u> (n=5)					
Mean Value	-	-	-	-	-
Range	-	-	-	-	-
Std. Deviation	-	-	-	-	-
<u>Arctic Flounder</u> (n=5)					
Mean Value	*0.10	0.12	*0.10	*0.10	*0.10
Range	0.09-*0.10	*0.10-0.18	*0.10	*0.10	*0.10
Std. Deviation	0	0.036	0	0	0
<u>Fourhorn Sculpin</u> (n=5)					
Mean Value	*0.10	0.11	*0.10	*0.10	*0.10
Range	0.09-*0.10	*0.10-0.12	*0.10	*0.10	*0.10
Std. Deviation	0.006	0.012	0	0	0

*Means "less than" where the true value is below the normal detection limit. Mean values and standard deviations were calculated using values at the detection limit; therefore, in cases where one or more replicate sample(s) were below detection, the reported mean values are slightly high and standard deviations are slightly low.

third for both. Considering total aromatic hydrocarbons alone, however, flounder had the highest concentrations (although not significantly different from char, $p < 0.05$) (see Table 7).

Arsenic was the only contaminant that appeared high relative to results of similiar recent studies of various fish species in Northern Alaska (Table 8). The only results that were similar were for those of Arctic grayling taken in the Kantishna Hills mining area of Denali National Park which had high levels of arsenic in many of the mined streams (West and Deschu 1984).

Analysis of seawater samples from Beaufort Lagoon showed a significant difference ($p < 0.05$) for total arsenic concentration inside the barrier islands compared to just outside the barrier islands (mean value inside was 27.333 µg/l, n=3; mean value outside was 9.33 µg/l, n=3; individual sample standard deviations ranged from 0.002 to 0.005).

Nevertheless, arsenic concentrations within Beaufort Lagoon were still far below what is normally considered toxic to saltwater aquatic life (EPA 1980). The arsenic levels found in the fish, however, are high enough to be considered as an increased health risk if consumed in quantity. EPA (1980) provides that the following concentrations of arsenic when consumed in aquatic organisms will result in incremental increase of cancer risk over the individuals lifetime: 0.175 µg/l = 10^{-5} increased risk, 0.01 µg/l = 10^{-6} increased risk, and 0.002 µg/l = 10^{-7} increased risk. Such values are approximate and dependent on a number of factors; however, a further examination of arsenic concentration in Beaufort Sea fishes, especially those of value to subsistence, sport, and commercial fisheries, may be warranted.

Macro-Parasites

Arctic char generally had more taxa and numbers of macro-parasites than the other fish species examined. Arctic cisco were second, followed by fourhorn sculpin. Sculpins had more variety of parasites than ciscos but these parasites were found much less frequently. Arctic flounder rarely were observed to be a host to parasites and had only two identified taxa present.

The most common parasite observed in the Beaufort Lagoon fish samples was the adult cestode (tapeworm) Bothrimonus sturionis. These cestodes were observed in 25 (100%) of the Arctic char examined and 24 (96%) of the Arctic cisco. Only 4 (16%) of the fourhorn sculpin and 3 (12%) of the Arctic flounder possessed Bothrimonus sturionis.

The average number of B. sturionis found in Arctic char was 96 worms with a range of 1 to 685. For Arctic cisco, the average was 38 with a range of 0 to 270 worms. The size of these cestodes varied greatly but the average wet weight of 1,053 taken from char was 0.012 g/worm and 0.008 g/worm from a sample of 539 B. sturionis taken from cisco.

The second most commonly observed parasites were copepods attaching to the fins, gills, mouth, or pseudobranch. All of the parasitic copepods observed were of the genus Salmincola, but several species appeared to be present and were difficult to identify. Salmincola edwardsii was positively identified in char, but other copepods observed in char more commonly resembled S. carpionis or S. extensus. Those in Arctic cisco appeared to be primarily S. extensus but a positive identification was not made. Attachment in char was observed primarily in gills or mouth while fins were the most common attachment site in

Table 7. Ranking of metal and hydrocarbon contaminant levels among four fish species from Beaufort Lagoon, Alaska. Contaminant concentrations are expressed in µg/g.

	Arctic Char	Arctic Cisco	Arctic Flounder	Fourhorn Sculpin
Total *Mean Heavy Metal Concentration and 95% Confidence Intervals (All 10 Metals Combined)	23.81 ±4.03	29.26 ±7.76	24.77 ±2.99	29.31 ±6.41
Total *Mean Heavy Metal Concentration and 95% Confidence Intervals (Less Zinc and Copper)	1.37 ±.73	1.77 ±.59	1.55 ±.79	2.75 ±1.60
Total *Mean Heavy Metal Concentration and 95% Confidence Intervals (Less Zinc)	2.87 ±.92	2.78 ±.69	2.65 ±.97	5.39 ±2.55
Ranking for Mean Heavy Concentrations (1 is high)	4	2	3	1
Total *Mean Hydrocarbon Concentrations and 95% Confidence Intervals (Aliphatics and Aromatics)	19.61 ±11.71	-	6.66 ±2.60	4.18 ±3.44
Total *Mean Aromatic Hydrocarbon Concentration and 95% Confidence Interval	1.91 ±.75	-	1.98 ±.33	1.51 ±.05
Total *Mean Aliphatic Hydrocarbon Concentration and 95% Confidence Interval	17.70 ±10.96	7.29 ±4.66	4.68 ±2.27	2.67 ±3.39
Ranking for Mean Hydrocarbon Concentration (1 is high)	1	2	3	4

*Total mean concentrations were calculated using values at detection limits although many actual values were below detection; therefore, the totals given above are higher than actual total concentrations and the confidence limits are narrower than the true, unknown limits. Refer to Tables 1 and 2 for a complete listing of metals and hydrocarbons in the analyses.

Table 8. Total arsenic levels in whole fish from Northern Alaska.

Species	Location	Sample Size	Mean Total Arsenic (µg/g)	Reference
Broad Whitefish (Coregonus nasus)	Teshekpuk Lake	6	0.05	West 1982
Arctic Grayling	Teshekpuk Lake	5	< 0.05	West 1982
Longnose Sucker (Catastomus catastomus)	Colville River	7	0.10	West 1982
Arctic Grayling	Itkalukrok Cr.	5	0.01	Metsker et al. 1984
Arctic Grayling	Kantishna Area	9	0.73	West and Deschu 1984
Arctic Grayling	Canning River	5	0.05	Metsker et al. 1984
		- Results This Study -		
Arctic Char	Beaufort Lagoon	5	0.92	-
Arctic Cisco	Beaufort Lagoon	5	1.01	-
Fourhorn Sculpin	Beaufort Lagoon	5	0.71	-
Arctic Flounder	Beaufort Lagoon	5	0.75	-

cisco. Nine (36%) of the char examined had Salmincola and 19 (76%) of the cisco; whereas, none were observed in Arctic flounder or fourhorn sculpin. Two parasitic isopods were found in a single fourhorn sculpin attached to the gills.

The most common parasites observed in fourhorn sculpin were nematodes (Anisakis simplex) attached to the viscera of 7 (28%) of the sculpins examined. Three cases each (12%) of adult cestodes (Eubothrium crassum and Bothriocephalus scorpii) in the lumen or intestine were also observed.

The only parasites found in Arctic flounder other than Bothrimonus sturionis were juvenile Acanthocephala found loosely attached to the liver in 3 (12%) of the fish sampled. This parasite appeared to be Corynosoma sp. The adults of this organism are found in pinnipeds.

Many of the small cysts observed on char and cisco viscera appeared to be Diphyllobothrium sp. plerocercoids (intermediate stages) but species identification was not possible.

Appendix 1 provides a complete account of numbers and species of macro-parasites identified for each fish sample in Beaufort Lagoon. Table 9 is a summary of the macro-parasites observed.

Of the Arctic grayling captured at Beaufort Lagoon in 1985, one was examined for parasites. The fish was a 359 mm (FL), 420 g female with good physical apearance. She was feeding on amphipods and mysids. She had three copepods (Salmincola sp.) attached to gill filaments, 89 small Bothrimonus sturionis in the lumen, and an additional 23 B. sturionis in the intestine.

Condition

Sample numbers, dates of collection, fork lengths, weights, condition values, ages, and sex of all fish samples are provided in Appendix 2. The mean condition value for Arctic char was 0.875 (n = 65, S.D. = 0.143). For Arctic cisco the mean condition value was 1.089 (n = 65, S.D. = 0.145). Arctic flounder and fourhorn sculpin had mean condition values of 1.334 (n = 69, S.D. = 0.241) and 0.920 (n = 63, S.D. = 0.187) respectively.

Condition in all species was highly variable, possibly in response to a wide variety of environmental and physiological factors such as length of active feeding period in the lagoon system, age, and reproductive status. Multiple regression (Zar 1974) analyses demonstrated no significant correlations ($p < 0.01$) between combinations of contaminant levels, numbers of parasites, and condition factors (dependent variable). Significance was based on the slope of the regression line. Sampling date and condition factors were significantly correlated ($r = 0.75$, $p < 0.01$) for Arctic cisco, but not for the other species examined. Figure 2 illustrates the trend in increasing condition for Arctic cisco throughout the summer sampling periods.

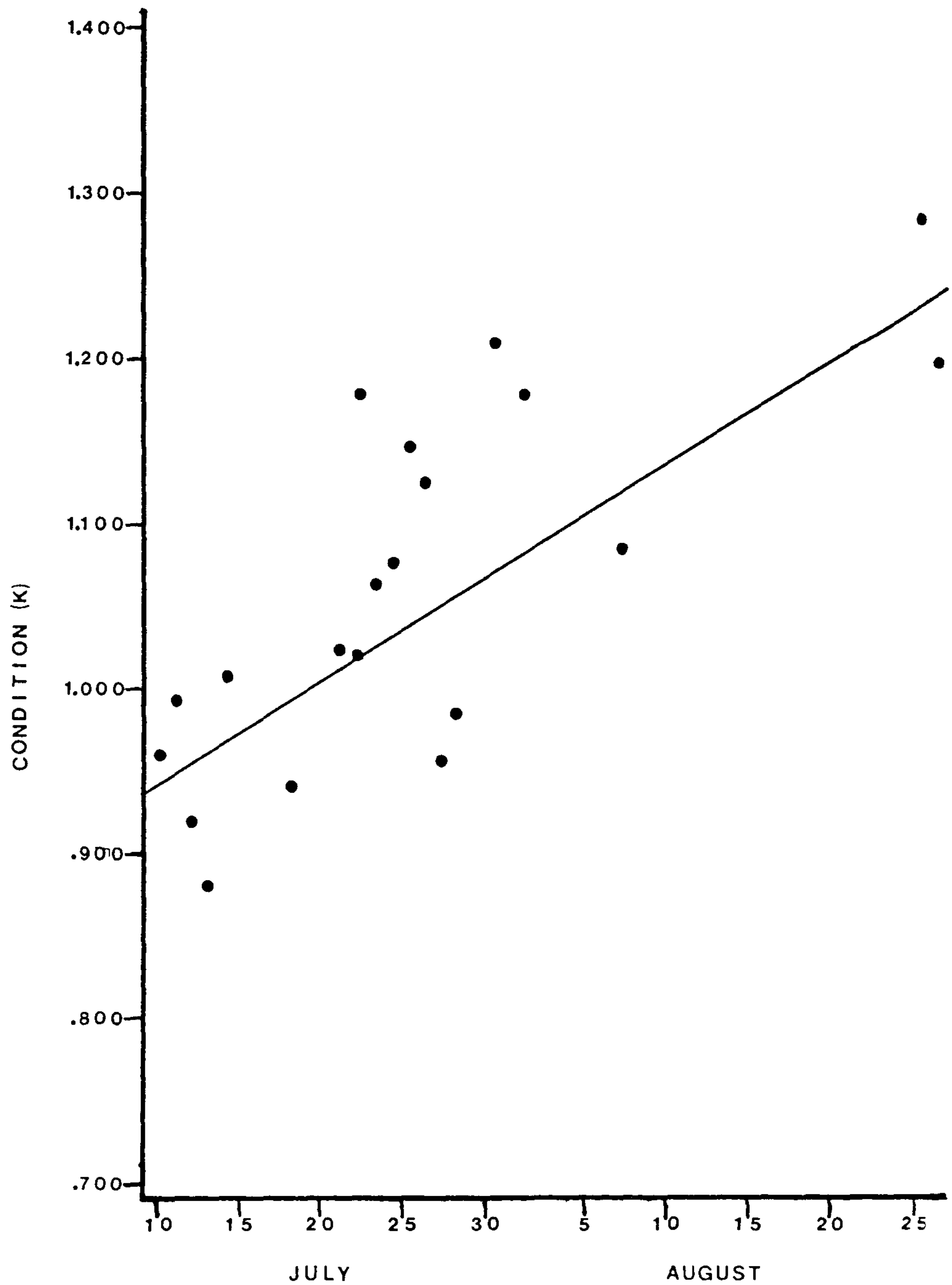

Figure 2. Mean condition values (K) for Arctic cisco by time, Beaufort Lagoon, Alaska (n = 93).

Table 9. A summary of macro-parasites observed in Beaufort Lagoon fish samples.

Arctic Char		
(Adult Cestode)	*Bothrimonus sturionis*	digestive tract
(Larval Cestodes)	*Triaenophorus crassus*	in muscle
	Triaenophorus nodulosus	pyloric caeca
	Diphyllobothrium sp.	liver and viscera
(Larval Trematodes)	unidentified intermediate stages	on viscera
(Adult Nematoda)	Cystidicola sp. (probably *C. farionis*)	swim bladder
(Copepoda)	*Salmincola edwardsii*	pseudobranch
	Salmincola sp.	fins, gills, pseudobranch, and mouth
Arctic Cisco		
(Adult Cestode)	*Bothrimonus sturionis*	digestive tract
(Larval Cestode)	*Diphyllobothrium* sp.	on pyloric caeca
(Adult Trematode)	unidentified	on gonads
(Adult Nematoda)	unidentified	in stomach
(Copepoda)	*Salmincola* sp.	fins, gills, and pseudobranch
Fourhorn Sculpin		
(Adult Cestodes)	*Eubothrium crassum*	intestine
	Bothriocephalus scorpii	digestive tract
	Bothrimonus sturionis	digestive tract
(Adult Nematoda)	*Anisakis simplex*	on stomach mesentary
	Hysterothylacium sp.	in gut
(Acanthocephala)	unidentified larvae	on stomach mesentary
(Isopoda)	unidentified adult	on gills
Arctic Flounder		
(Adult Cestode)	*Bothrimonus sturionis*	digestive tract
(Acanthocephala)	probably *Corynosoma* sp.	on liver

DISCUSSION

Histopathological examinations resulted in observations of a number of idiopathic tissue changes present at low frequencies. These included congestion in the spleen, heart, kidney, and liver; gill aneurisms; epithelial separation from the gill lamellae, hyperplasia of the gill epithelium, and excess mucus in gills. Some of the observed changes may have resulted from trauma during capture.

The fewest lesions were found in Arctic flounder. The single skin ulcer observed had large amounts of connective tissue suggesting it was chronic in nature. No bacteria were observed and only one sample had Trichodina in the gills.

Arctic char demonstrated no histological damage in the digestive tract as result of their heavy helminth parasite infestation. There was an inflammatory tissue response to a nematode in one case. One granuloma was seen in the intestine of a single fish perhaps indicating chronic host response to parasites, bacteria, or other factors. One example of hyperplasia of the spleen was also seen for Arctic char. Malins et al. (1982) observed up to 25% of the Pacific tomcod (Microgadus proximus) and Pacific staghorn sculpin (Leptocottus armatus) in samples from Puget Sound to contain similar lesions.

No histopathological damage was associated with the cestode infestation in the digestive tract of Arctic cisco. Granulomas were found in the kidneys of two different fish but most of the lesions observed in Arctic cisco were found in a single sample.

Nearly half the fourhorn sculpins examined were infested with Trichodina; however, no histopathological damage was observed in the gills. Usually this protozoa is harmless attaching to the gill epithelial cells of marine fishes and feeding on particles in the water and cellular debris (Lom 1970). One-third of the sculpins demonstrated signs of Megalocytic Hepatosis, a lesion which has been associated with hepatotoxic changes induced in vertebrates by chemicals (McCain et al. 1982). This condition may be normal for fourhorn sculpins and samples from the species should be taken elsewhere for comparison before conclusions as to the cause of this histological "change" can be drawn. One sculpin had a highly vacuolated fatty liver. This also may be within the normal intraspecific variations to be expected. The single occurrences each of an idiopathic kidney lesion, swollen kidney tubules, and a localized inflammation between muscle bundles could not be linked to any particular cause.

The heavy metals analyses were relatively simple and the results were close to expected except for arsenic. The primary source of arsenic for fish is organoarsenic compounds synthesized lower in the food chain (Lunde 1972). Because the arsenic is most likely being picked up from feeding on zooplankton and was found at elevated levels in all the fish samples and species examined, it appears as though the arsenic "contamination" may be widespread. However, since the arsenic levels were found to be significantly higher inside the barrier island at Beaufort Lagoon compared to outside the island, the source of arsenic may be one or more of the major river drainages in the Eastern Beaufort Sea which influence the nearshore water quality.

The baseline metals values should provide good background information to monitor potential marine drilling contamination. Barium in particular has been suggested as a good indicator metal because of the high barite content in most drilling muds (Chow 1976). Other indicators such as chromium and zinc may prove valuable depending on the types of muds used.

A major interference occurred in the analysis of two aliphatic hydrocarbons, decane and undecane. Major peaks appeared for these compounds in all samples analyzed, including the blank, indicating reagent-associated contamination. All sample values were corrected for this contamination, but due to the large amount of contamination relative to the amount present in the samples, the values obtained are of questionable accuracy.

The analysis showed pristane as the largest and most frequent aliphatic contaminant. Pristane was present in all char samples at levels ranging from 7 to 27 μg/g, all but one cisco between 3.5 and 6.3 μg/g, and all fourhorn sculpins between 0.11 and 0.91 μg/g. The flounder were "clean" except for one sample which contained pristane at 0.14 μg/g. Gay et al. (1980), noted that pristane accumulated more than any other compound in their study and also pointed out that branched aliphatics have been demonstrated to selectively accumulate in marine organisms.

Pentadecane was the second most common aliphatic hydrocarbon compound. It appeared in all Arctic cisco samples at levels between 0.17 and 0.56 μg/g and all but one char between 0.14 and 0.19 μg/g. The tuna used for the laboratory control contained more aliphatic compounds than any of the arctic species and all of the levels in the control, except pristane, were higher than in the study samples.

Analysis of the aromatic fractions were more difficult than the aliphatics. All but one cisco sampled contained large interference that rendered analysis by capillary gas chromatograph impossible. It is likely that this interference was due to biogenic compounds such as carotenoids and steroids which will elute with polycylic aromatic compounds during the silicar separation. The one cisco that had little interference associated with it was captured in July. The remaining samples were captured in August and had noticeably increased their body condition (Figure 2) which was evident in the large deposits of visceral fat. Future efforts may need to be modified to include a sample cleanup by gel permeation chromatography to eliminate interference of this nature.

The fish samples overall were relatively free of most aromatic hydrocarbons. Pyrene was shown to be the largest and most frequent aromatic contaminant and was confirmed by mass spectroscopy. It appeared in all char and flounder samples at levels between 0.12 and 0.63 μg/g. All fourhorn sculpin were "clean". Anthracene and fluoranthene were found in 4 of the 5 flounder samples at levels ranging from 0.10 μg/g to 0.29 μg/g while 2 of 5 char contained fluoranthene at this level.

Chromatograms of the fish hydrocarbon samples showed a large number of unidentified peaks eluting with the aromatic fraction. These peaks could have been due to pesticide compounds, PCBs, polycyclic aromatic sulfur heteracycles, or low-level biogenic compounds. None of these compounds were analyzed for in this study. Nitrogen heterocycles were removed by washing the extracts with 3N HCI, but this would not affect the sulfur compounds. Vassilaros et al. (1982) found fairly high levels of sulfur heterocycles in the fish they studied and suggested from the data some degree of sulfur-selective accumulation in the fish or the aquatic ecosystem. Recent analyses of water and soil around Beaufort Lagoon and other abandoned military sites on the North Slope have evinced high levels of PCBs. U.S. Army Corp of Engineers data show up to 19.7 µg/g as AROCLOR 1254 in a soil sample near the facility at Beaufort Lagoon. A liquid sample from the facility at Bullen Point (approximately 210 km west of Beaufort Lagoon along the coast) contained 136.6 µg/g as AROCLOR 1254. The possibility of PCB contamination may therefore be high and sampling of this contaminant in local fish should be undertaken.

Many documents of parasite infestation records for various fish species exist for Arctic areas in Alaska, Canada, and the U.S.S.R. Some of the parasites found in this study appear to be new accounts of fish hosts or range extensions for parasites. Mudry and McCart (1976) in studying Metazoan parasites of Arctic char from the North Slope of Canada and Alaska, found 14 species consisting of 1 monogean, 4 degeneans, 4 cestodes, 2 nematodes, 1 acanthocephalan, and 2 copepods. One parasite was described as a new species (Bulbodacnitis alpinus; Mudry and McCart 1974), 3 were new North American host records, and all of the localities sampled were range extensions of the parasites found. Of note is their identification of parasites also found in char at Beaufort Lagoon in this study, Bothrimonus sturionis at 1 site and Salmincola edwardsii and/or S. carpionis infecting char at 5 of the 11 sites they sampled.

Craig and Haldorson (1981) found 3 parasites in Arctic cisco in their studies in Simpson Lagoon, near Prudhoe Bay. The primary species present was Diplocotyle olrikii, a species considered to be synonymous with Bothrimonus sturionis by some researchers (Margolis and Arthur 1979). It appears likely that the two are indeed the same species, at least as considered in the Simpson Lagoon work and this study. Craig and Haldorson (1981) found the cisco captured in mid to late summer in the lagoon had 84-92% infection rates with D. olrikii/B. sturionis; whereas none were found in the November samples. This indicates an annual cycle of infection in lagoons initiated in the spring by fish feeding on infected zooplankton. This thought is reinforced by Bauer (1970) who reported that this species infected fish in marine waters but died once the host entered freshwater. This short infection period may help explain why the parasite appears to do no long term harm to its host species. Burt and Sandeman (1969) provide a good summary of B. sturionis/D. olrikii taxonomy and biology and list other Alaska host records. Other host records provided by Margolis and Arthur (1979) for this species include Arctic char from the Eastern Arctic, Labrador, and Manitoba and fourhorn sculpin from the Eastern Arctic.

Copepod infestations have been reported by Margolis and Arthur (1979) in Arctic char in Labrador, Northwest Territories, and Yukon Territory (Salmincola edwardsii) and in Labrador, Northwest Territories, Quebec, and Yukon Territory (S. carpionis). Alaskan records include S. edwardsii in Arctic char (Dunagan 1957), S. extensus in Coregonus sp. (Wilson 1908), and S. carpionis in Arctic char (Mudry and McCart 1976).

The cestodes Bothriocephalus scorpii and Eubothrium crassum have both been reported in fourhorn sculpins from Canada (Margolis and Arthur 1979) and the nematode Cystidicola farionis has been identified in Arctic char from Alaska (Pennell et al. 1973).

All the other parasites besides those specifically mentioned that were identified to species from this study are found in parasite-host records from Alaska or Canada, but were generally found in different fish species than this study (Moles 1982; Margolis and Arthur 1979).

CONCLUSIONS

The histopathological examinations indicated that parasite and pathological tissue changes occur in at least 10% of the general population of each of the four species (Arctic char, Arctic cisco, Arctic flounder, and fourhorn sculpin). A number of the observed changes (e.g. gill epithelial separation, aneurisms, and liver and spleen congestion) could have resulted from trauma associated with capture. Arctic flounder had the least number of abnormalities of the 4 species examined. Fourhorn sculpin had heavy infestations of the protozoan Trichodina. Although this parasite is generally harmless, high infestations have been reported to cause mortalities in fish (Sindermann 1980).

Further histological examinations focusing on fish reproduction may prove useful in monitoring should oil development occur in the area in the future. Scott et al. (1980) and Scott et al. (1981) in histopatholocial studies of fish gonads near petroleum production sites and control sites in the Gulf of Mexico found little evidence morphologically of toxic effects from exposure to petroleum. The researchers did find, however, acidophillic cells, chromatophores, and leucocytic foci more often in fish ovaries from specimens collected in the vicinity of petroleum production platforms than in those from control sites. A baseline study of the reproductive cycle of the four species examined in this study in Beaufort Lagoon might also be valuable for future monitoring to help identify changes as result of development.

Futher sampling is also recommended for contaminants. Sampling for arsenic should be undertaken to determine its source(s) by sampling water in lagoons along the coast and from major rivers entering the Beaufort Sea. Testing for arsenic in fish muscle tissues rather than whole ground fish should also be undertaken to determine the level of arsenic normally available when consumed. Accompanying these analyses should be a chemical analysis of the arsenic to determine if it is in a form readily absorbed by man. Analysis of fish tissues for PCBs and pesticides is also recommended to determine if these contaminants are present.

The heavy metal and hydrocarbon tissue analyses should be repeated periodically if development begins in the area. Every third year during exploration and every second year during production should be adequate to monitor the contaminant levels in the local fish populations.

The overall health of the Beaufort Lagoon fish appears good. The parasite infestations seem to be in the range of what normally might be expected for a wild fish population. The parasites for the most part don't appear to be adversely affecting fish health. The most commonly found parasite, Bothrimonis sturionis is also probably the most aesthically displeasing as these tapeworms were quite obvious and often filled much of the digestive tract of their hosts. There is no indication, however, that B. sturionis can be transmitted to man. Some of the other parasite species present less frequently may be of concern to public health. The Diphyllobothrium sp. may be transmittable to man. Hoffman (1967) reports D. latrum has developed in man in the United States and Canada. Bauer (1970) reports D. dendriticum, a species also known to infect man, is present in cisco in the U.S.S.R. Larval Anisakis nematodes, found in the fourhorn sculpin, have also been reported to cause acute abdominal syndrome in man (Hoffman 1967). To avoid risk of any parasite infections, the viscera should be discarded and the meat thoroughly cooked. Smoking or freezing may kill the parasites depending on temperature and the particular parasite species tolerance.

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Appendix 1. Results of individual fish examinations for parasites at Beaufort Lagoon, Alaska.

Sample Number*	Date	Number, Location, and Identification of Parasites**
AC-373-BL85	7/11/85	(8) *Salmincola* sp. on gills; (1) *Salmincola* sp. on vomer; 5 cysts attached to visceral mesentary; (61) *Bothrimonus sturionis* in lumen.
AC-599-BL85	7/13/85	(51) Cysts on pyloric caeca; (96) *B. sturionis* in lumen; (34) *B. sturionis* in intestine
AC-771-BL85	7/15/85	(2) *Salmincola* sp. on gills; (2) *Salmincola* sp. on pseudobranch; (1) *Salincola* sp. on tongue; (1) *Triaenophorous nodulosus* in stomach; (65) B. sturionis in lumen and intestine
AC-772-BL85	7/15/85	(5) *Salmincola* sp. on gills (217) cysts on pyloric caeca; (1) *Triaenophorus nodulosus* in stomach; (70) *B. sturionis* in digestive tract
AC-780-BL85	7/15/85	(1) *Cystidicola* sp. in swim bladder; (3) *B. sturionis* in intestine; (157) *B. sturionis* in lumen
AC-781-BL85	7/15/85	(3) *Salmincola* sp. on gills; (1) *Salmincola edwardsii* on pseudobranch; (2) cestodes in stomach; (264) *B. sturionis* in lumen
AC-782-BL85	7/15/85	(72) *B. sturionis* in lumen
AC-798-BL85	7/16/85	(1) *Salmincola edwardsii* on pseudobranch; (126) cysts on pyloric caeca; (4) *B. sturionis* in lumen
AC-800-BL85	7/16/85	(2) *Diphyllobothrium* sp. in liver; (2) cysts in kidney; (215) *B. sturionis* in digestive tract
AC-801-BL5	7/16/85	(1) cyst in kidney; (116) cysts on pyloric caeca; (81) *B. sturionis* in lumen; (4) *B. sturionis* in intestine
AC-802-BL85	7/16/85	(3) *Salmincola edwardsii* on pseudobranch; (3) *Salmincola* sp. on gills; (39) *B. sturionis* in lumen
AC-820-BL85	7/16/85	(33) *B. sturionis* in lumen
AC-821-BL85	7/16/85	(26) *B. sturionis* in lumen
AC-822-BL85	7/16/85	(53) *B. sturionis* in lumen
AC-823-BL85	7/16/85	(3) *B. sturionis* in lumen
AC-838-BL85	7/17/85	(19) *B. sturionis* in lumen
AC-839-BL85	7/17/85	(2) cysts in kidney; (18) *B. sturionis* in lumen
AC-840-BL85	7/17/85	(18) *Triaenophorus crassus* in muscle; (16) *B. sturionis* in lumen
AC-847-BL85	7/17/85	(1) Nematode loose in viscera; (2) cysts in kidney; (26) *B. sturionis* in intestine; (93) *B. sturionis* in lumen
AC-852-BL85	7/17/85	(1) *B. sturionis* in lumen
AC-1841-BL85	8/6/85	(1) *Salmincola* sp. on vomer; (1) cyst on stomach; (12) *B. sturionis* in intestine; (81) *B. sturionis* in lumen
AC-1842-BL85	8/6/85	(119) cysts on pyloric caeca; (1) *Triaenophorus crassus* in muscle; (1) cyst in kidney; (13) *B. sturionis* in lumen

Appendix 1. Continued.

Sample Number*	Date	Number, Location, and Identification of Parasites**
AC-1843-BL85	8/6/85	(1) Salmincola sp. on tongue; (5) Salmincola sp. on gills; (56) cysts on pyloric caeca; (1) cyst in kidney; (74) B. sturionis in digestive tract
AC-1844-BL85	8/6/85	(1) Salmincola edwardsii on pseudobranch; (27) B. sturionis in lumen
AC-1845-BL85	8/6/85	(16) B. sturionis in lumen; (112) B. sturionis in intestine
ACi-057-BL85	7/10/85	(2) Salmincola sp. on pelvic fins; (1) encapsulated egg case on ova; (4) Bothrimonus sturionis in lumen
ACi-067-BL85	7/11/85	(14) B. sturionis in intestine; (5) B. sturionis in lumen
ACi-077-BL85	7/11/85	(1) cyst on pyloric caeca; (7) Salmincola sp. on pelvic dorsal, and pectoral fins; (5) B. sturionis in lumen
ACi-095-BL85	7/12/85	(3) Salmincola sp. on dorsal, pelvic, and pectoral fins; (6) B. sturionis in intestine; (9) B. sturionis in lumen
ACi-096-BL85	7/12/85	(1) Salmincola sp. on pelvic fin; (39) B. sturionis in lumen; (94) B. sturionis in intestine
ACi-097-BL85	7/12/85	(36) cysts on pyloric caeca; (107) B. sturionis in intestine; (163) B. sturionis in lumen
ACi-098-BL85	7/12/85	(1) Salmincola sp. on pelvic fin; (31) B. sturionis in lumen; (88) B. sturionis in intestine
ACi-099-BL85	7/13/85	(1) cyst on pyloric caeca; (1) Salmincola sp. on dorsal fin; (5) B. sturionis in lumen
ACi-100-BL85	7/13/85	(2) Salmincola sp. on pelvic fin
ACi-101-BL85	7/13/85	(2) Salmincola sp. on pectoral and pelvic fins; (29) B. sturionis in intestine; (52) B. sturionis in lumen
ACi-102-BL85	7/13/85	(1) B. sturionis in lumen; (1) B. sturionis in intestine
ACi-104-BL85	7/14/85	(6) cysts on pyloric caeca; (16) B. sturionis in digestive tract; (1) nematode in stomach
ACi-105-BL85	7/14/85	(11) B. sturionis in lumen; (1) B. sturionis in intestine

Appendix 1. Continued.

Sample Number*	Date	Number, Location, and Identification of Parasites**
ACi-106-BL85	7/14/85	(2) Salmincola sp. on dorsal and pelvic fins; (4) cysts on pyloric caeca; (24) B. sturionis in lumen; (18) B. sturionis in intestine
ACi-107-BL85	7/14/85	(1) cyst on spleen; (1) B. sturionis in lumen
ACi-174-BL85	7/18/85	(1) Salmincola sp. on pelvic fin; (14) cysts on pyloric caeca; (3) cysts on gall bladder; (11) B. sturionis in lumen
ACi-175-BL85	7/18/85	(12) cestodes encysted in liver, pyloric caeca, and stomach wall; (1) Salmincola sp. on dorsal fin; (4) B. sturionis in digestive tract
ACi-176-BL85	7/18/85	(3) Salmincola sp. on pelvic, dorsal, and pectoral fin; (1) B. sturionis in intestine
ACi-357-BL85	8/7/85	(1) Trematode on gonads; (1) Salmincola sp. on pelvic fin; (3) cysts on pyloric caeca; (2) tiny unidentified parasites on liver; (32) B. sturionis in digestive tract
ACi-358-BL85	8/7/85	(1) Salmincola sp. on pelvic fin; (6) B. sturionis in intestine; (18) B. sturionis in lumen
ACi-359-BL85	8/7/85	(1) Salmincola sp. on pelvic fin; (40) B. sturionis in lumen; (13) B. sturionis in intestine
ACi-360-BL85	8/7/85	(2) Salmincola sp. on pelvic fin; (3) cysts in kidney; (3) cysts on intestine; (34) B. sturionis in digestive tract
ACi-361-BL85	8/7/85	(3) cysts in kidney; (12) B. sturionis in lumen; (1) B. sturionis in intestine
ACi-362-BL85	8/7/85	(1) Salmincola sp. on pelvic fin; (2) B. sturionis in lumen; (16) B. sturionis in intestine
ACi-363-BL85	8/7/85	(1) Salmincola sp. on pelvic fin; (17) B. sturionis in lumen; (22) B. sturionis in intestine
AF-001-BL85	7/8/85	"clean"
AF-002-BL85	7/8/85	"clean"
AF-004-BL85	7/9/85	(7) loose egg sacs on intestine from unidentified parasite
AF-005-BL85	7/9/85	"clean"
AF-006-BL85	7/9/85	"clean"

Appendix 1. Continued.

Sample Number*	Date	Number, Location, and Identification of Parasites**
AF-007-BL85	7/9/85	"clean"
AF-008-BL85	7/9/85	"clean"
AF-009-BL85	7/9/85	"clean"
AF-010-BL85	7/9/85	"clean"
AF-025-BL85	7/10/85	"clean"
AF-030-BL85	7/10/85	"clean"
AF-032-BL85	7/10/85	"clean"
AF-036-BL85	7/11/85	"clean"
AF-054-BL85	7/12/85	"clean"
AF-059-BL85	7/13/85	"clean"
AF-118-BL85	7/18/85	(4) *Bothrimonus sturionis* in digestive tract
AF-119-BL85	7/18/85	(6) Acanthocephalans on liver
AF-949-BL85	8/6/85	"clean"
AF-962-BL85	8/8/85	"clean"
AF-963-BL85	8/8/85	(1) cyst on gas bladder; (2) *B. sturionis* in intestine
AF-965-BL85	8/8/85	(5) *B. sturionis* in intestine; (5) Acanthocephala on liver and viscera
AF-966-BL85	8/8/85	"clean"
AF-968-BL85	8/8/85	(1) Acanthocephalan on viscera
AF-969-BL85	8/8/85	"clean"
AF-970-BL85	8/8/85	"clean"
FS-012-BL85	7/8/85	"clean"
FS-013-BL85	7/8/85	(1) *Anisakis simplex* in visceral mesentary
FS-014-BL85	7/8/85	(2) *A. simplex* in viscera mesentary
FS-039-BL85	7/9/85	(1) *A. simplex* on stomach
FS-040-BL85	7/9/85	(3) cysts on pyloric caeca; (1) *A. simplex* on stomach; (1) *Bothriocephalus scorpii* in lumen
FS-041-BL85	7/9/85	(3) Isopods on gills; (1) *A. simplex* loose in viscera
FS-042-BL85	7/9/85	"clean"
FS-131-BL85	7/9/85	"clean"
FS-131-BL85	7/9/85	"clean"
FS-132-BL85	7/9/85	(8) *Bothriocephalus scorpii* in digestive tract
FS-261-BL85	7/11/85	"clean"
FS-327-BL85	7/12/85	(1) cyst on intestine; (2) *Bothrimonus sturionis* in lumen; (7) *Hysterothylacium* sp. in digestive tract
FS-388-BL85	7/13/85	"clean"

Appendix 1. Continued.

Sample Number*	Date	Number, Location, and Identification of Parasites**
FS-436-BL85	7/13/85	(22) cysts in liver; (1) A. simplex loose in viscera
FS-437-BL85	7/13/85	(1) cyst on pyloric caeca; (1) Eubothrium crassum in digestive tract
FS-607-BL85	7/17/85	"clean"
FS-610-BL85	7/17/85	(2) Acanthocephalans on stomach
FS-615-BL85	7/17/85	(6) B. sturionis in intestine
FS-1579-BL85	8/6/85	(2) A. simplex in visceral mesentary; (1) Eubothrium crassum in intestine; (4) B. sturionis in lumen; (1) Hysterothylacium sp. in lumen
FS-1788-BL85	8/9/85	"clean"
FS-1789-BL85	8/9/85	"clean"
FS-1790-BL85	8/9/85	"clean"
FS-1791-BL85	8/9/85	"clean"
FS-1792-BL85	8/9/85	(1) Eubothrium crassum in intestine
FS-1793-BL85	8/9/85	(2) unidentified parasites in pyloric caeca; (7) Acanthocephala on intestine; (2) Eubothrium crassum in intestine

*AC = Arctic Char; ACi = Arctic cisco; AF = Arctic flounder; FS = fourhorn sculpin

**Counts of parasites are accurate; identification of large groups of parasites (greater than 10) were based on subsamples. This only applied to Bothrimonus sturionis and it is likely in some cases that similar size cestodes or trematodes occasionally got overlooked when entangled with masses of B. sturionis.

Appendix 2. Sample numbers, dates of collection, fork lengths, weights, condition factors, ages, and sex of fish samples from Beaufort Lagoon, Alaska.

Sample Number*	Date	Fork Length (mm)	Weight (g)	Condition (K-value)	Age**	Sex
Histopathological Samples						
AC-056-BL84	7/24/84	410	660	.958	6+	F
AC-057-BL84	7/24/84	456	860	.907	7+	F
AC-059-BL84	7/25/84	494	1150	.954	7+	F
AC-060-BL84	7/25/84	519	1125	.805	7+	F
AC-061-BL84	7/25/84	491	1125	.950	6+	F
AC-064-BL84	7/25/84	505	1300	1.009	8+	F
AC-069-BL84	7/26/84	377	475	.886	5+	M
AC-070-BL84	7/26/84	510	1265	.954	8+	F
AC-071-BL84	7/26/84	384	525	.927	6+	F
AC-072-BL84	7/26/84	468	980	.956	7+	F
AC-073-BL84	7/26/84	420	650	.877	7+	M
AC-074-BL84	7/26/84	484	875	.772	7+	F
AC-075-BL84	7/26/84	505	1200	.932	7+	F
AC-076-BL84	7/26/84	340	305	.776	5+	M
AC-077-BL84	7/26/84	328	290	.822	4+	M
AC-078-BL84	7/26/84	295	204	.787	4+	F
AC-079-BL84	7/26/84	517	1225	.886	8+	F
AC-081-BL84	7/26/84	521	1440	1.018	7+	F
AC-082-BL84	7/26/84	302	245	.889	5+	M
AC-084-BL84	7/27/84	299	230	.860	4+	M
AC-085-BL84	7/27/84	505	1150	.893	6+	M
AC-086-BL84	7/27/84	432	750	.930	7+	M
AC-087-BL84	7/27/84	445	760	.862	7+	M
AC-088-BL84	7/27/84	335	300	.798	5+	F
AC-089-BL84	7/27/84	478	950	.870	7+	F
AC-091-BL84	7/27/84	301	250	.917	4+	M
AC-092-BL84	7/27/84	367	410	.829	5+	F
AC-093-BL84	7/27/84	533	1325	.875	8+	M
AC-094-BL84	7/27/84	506	1225	.946	7+	F
ACi-016-BL84	7/24/84	399	725	1.141	7+	F
ACi-017-BL84	7/24/84	371	650	1.273	6+	M
ACi-018-BL84	7/24/84	366	585	1.193	5+	M
ACi-019-BL84	7/24/84	350	485	1.131	5+	M
ACi-020-BL84	7/24/84	378	550	1.018	6+	F
ACi-023-BL84	7/24/84	392	615	1.021	6+	F
ACi-025-BL84	7/25/84	384	630	1.113	6+	F
ACi-026-BL84	7/25/84	449	1120	1.237	8+	F
ACi-027-BL84	7/25/84	391	675	1.129	7+	M
ACi-028-BL84	7/25/84	389	690	1.172	6+	F
ACi-030-BL84	7/25/84	390	700	1.180	6+	F

Appendix 2. Continued.

Sample Number*	Date	Fork Length (mm)	Weight (g)	Condition (K-value)	Age**	Sex
ACi-031-BL84	7/26/84	401	640	1.070	7+	F
ACi-032-BL84	7/26/84	389	660	1.121	7+	M
ACi-033-BL84	7/26/84	420	800	1.080	8+	M
ACi-034-BL84	7/26/84	369	560	1.051	6+	M
ACi-037-BL84	7/26/84	356	500	1.108	5+	M
ACi-038-BL84	7/26/84	432	1050	1.302	8+	F
ACi-039-BL84	7/26/84	389	710	1.206	6+	M
ACi-040-BL84	7/26/84	372	460	.894	7+	M
ACi-041-BL84	7/26/84	361	550	1.170	5+	M
ACi-042-BL84	7/26/84	362	510	1.290	6+	M
ACi-048-BL84	7/26/84	379	700	1.026	6+	F
ACi-049-BL84	7/26/84	420	760	1.024	8+	F
ACi-050-BL84	7/26/84	384	580	1.175	6+	F
ACi-051-BL84	7/26/84	371	600	1.085	6+	F
ACi-052-BL84	7/26/84	381	600	1.104	7+	M
ACi-054-BL84	7/26/84	408	750	.933	7+	F
ACi-055-BL84	7/26/84	377	500	1.141	6+	F
ACi-056-BL84	7/26/84	378	665	1.231	6+	F
ACi-057-BL84	7/26/84	378	820	1.518	6+	F
AF-001-BL84	7/27/84	143	35	1.197	4+	M
AF-002-BL84	7/27/84	115	21	1.381	4+	M
AF-003-BL84	7/28/84	210	185	1.998	5+	M
AF-005-BL84	7/28/84	114	20	1.350	4+	M
AF-006-BL84	7/28/84	151	40	1.162	4+	M
AF-007-BL84	7/28/84	104	15	1.333	3+	M
AF-008-BL84	7/29/84	125	27	1.382	4+	M
AF-009-BL84	7/29/84	115	20	1.315	4+	M
AF-010-BL84	7/29/84	110	15	1.127	3+	M
AF-011-BL84	7/29/84	122	30	1.652	4+	M
AF-012-BL84	7/29/84	135	34	1.382	4+	M
AF-013-BL84	7/29/84	136	29	1.153	4+	M
AF-014-BL84	7/29/84	109	20	1.544	3+	M
AF-015-BL84	7/30/84	130	29	1.320	4+	M
AF-016-BL84	7/30/84	125	9	.461	4+	M
AF-017-BL84	8/22/84	148	48	1.141	5+	M
AF-018-BL84	8/22/84	135	32	1.301	4+	M
AF-019-BL84	8/22/84	138	39	1.484	4+	M
AF-020-BL84	8/22/84	113	21	1.455	4+	M
AF-021-BL84	8/22/84	124	28	1.469	4+	M
AF-022-BL84	8/22/84	106	13	1.092	4+	M
AF-023-BL84	8/22/84	137	33	1.283	4+	M
AF-024-BL84	8/22/84	191	97	1.392	5+	M
AF-025-BL84	8/22/84	131	48	2.135	4+	M
AF-026-BL84	8/23/84	138	34	1.294	4+	M

Appendix 2. Continued.

Sample Number*	Date	Fork Length (mm)	Weight (g)	Condition (K-value)	Age**	Sex
AF-027-BL84	8/23/84	138	33	1.256	4+	M
AF-028-BL84	8/23/84	125	28	1.434	4+	M
AF-029-BL84	8/23/84	121	23	1.298	4+	M
AF-030-BL84	8/23/84	116	20	1.281	4+	M
AF-031-BL84	8/23/84	114	17	1.147	4+	M
FS-002-BL84	7/25/84	101	8	.776	2+	M
FS-003-BL84	7/25/84	99	7	.721	2+	M
FS-004-BL84	7/26/84	119	11	.653	2+	M
FS-007-BL84	7/26/84	96	8	.904	2+	M
FS-008-BL84	7/26/84	114	8	.540	2+	M
FS-009-BL84	7/26/84	134	22	.914	3+	M
FS-010-BL84	7/26/84	219	108	1.028	4+	F
FS-013-BL84	7/27/84	230	113	.929	5+	F
FS-014-BL84	7/27/84	121	12	.677	3+	M
FS-015-BL84	7/27/84	100	8	.800	2+	M
FS-018-BL84	7/27/84	153	52	1.452	4+	M
FS-019-BL84	7/27/84	139	28	1.043	3+	M
FS-020-BL84	7/27/84	111	12	.877	2+	M
FS-021-BL84	7/27/84	88	6	.880	2+	M
FS-022-BL84	7/27/84	184	55	.883	4+	F
FS-023-BL84	7/27/84	159	38	.945	3+	M
FS-026-BL84	7/27/84	103	6	.549	2+	M
FS-029-BL84	7/28/84	122	16	.881	3+	M
FS-032-BL84	7/29/84	222	109	.996	5+	M
FS-033-BL84	7/29/84	228	104	.877	5+	M
FS-034-BL84	7/29/84	102	8	.754	2+	M
FS-039-BL84	7/29/84	79	3	.608	2+	M
FS-040-BL84	7/29/84	97	8	.877	2+	M
FS-041-BL84	7/29/84	110	11	.826	2+	M
FS-042-BL84	7/29/84	123	15	.806	3+	M
FS-043-BL84	7/29/84	206	79	.904	4+	F
FS-045-BL84	7/29/84	154	38	1.040	3+	M
FS-047-BL84	7/29/84	195	72	.971	4+	F
FS-048-BL84	7/29/84	259	180	1.036	7+	F
FS-050-BL84	7/30/84	161	40	.958	4+	M
Heavy Metals Samples						
AC-413-BL84	7/30/84	408	1180	1.737	7+	F
AC-414-BL84	7/30/84	489	1120	.958	7+	F
AC-415-BL84	7/30/84	381	550	.994	6+	M
AC-416-BL84	7/30/84	476	1015	.941	7+	F
AC-417-BL84	7/30/84	490	1220	1.037	7+	F

Appendix 2. Continued.

Sample Number*	Date	Fork Length (mm)	Weight (g)	Condition (K-value)	Age**	Sex
ACi-164-BL84	7/30/84	399	895	1.409	7+	F
ACi-165-BL84	7/30/84	389	775	1.317	6+	F
ACi-166-BL84	7/30/84	429	870	1.102	9+	F
ACi-167-BL84	7/30/84	378	562	1.041	6+	F
ACi-168-BL84	7/30/84	381	603	1.090	6+	M
AF-032-BL84	8/23/84	202	113	1.371	6+	M
AF-033-BL84	8/23/84	211	178	1.895	6+	F
*** AF-034-BL84	8/23/84	136	36	1.431	4+	M
and AF-035-BL84	8/23/84	118	24	1.460	4+	M
AF-036-BL84	8/24/84	198	118	1.520	6+	M
*** AF-037-BL84	8/24/84	131	33	1.468	4+	M
and AF-038-BL84	8/24/84	120	26	1.505	4+	M
FS-051-BL84	7/30/84	179	58	1.011	4+	F
FS-052-BL84	7/30/84	173	53	1.024	4+	F
FS-053-BL84	7/30/84	136	24	.954	3+	M
FS-054-BL84	7/30/84	179	59	1.029	4+	F
FS-063-BL84	7/30/84	169	41	.849	4+	M
Hydrocarbons Samples						
AC-425-BL84	7/30/84	350	393	.917	5+	F
AC-427-BL84	7/30/84	394	554	.906	6+	M
AC-428-BL84	7/30/84	386	507	.882	6+	F
AC-429-BL84	7/30/84	464	830	.831	7+	M
ACi-169-BL84	7/30/84	381	705	1.275	6+	M
ACi-183-BL84	8/25/84	329	464	1.303	5+	M
ACi-184-BL84	8/25/84	331	456	1.257	5+	M
ACi-186-BL84	8/26/84	294	282	1.110	4+	M
ACi-187-BL84	8/26/84	385	728	1.276	6+	F
*** AF-039-BL84	8/24/84	143	44	1.505	4+	M
and AF-040-BL84	8/25/84	108	21	1.667	3+	M
AF-041-BL84	8/25/84	180	90	1.543	5+	M
AF-042-BL84	8/25/84	176	82	1.596	5+	M
AF-043-BL84	8/25/84	186	87	1.352	5+	M
*** AF-044-BL84	8/25/84	133	35	1.488	4+	M
and AF-045-BL84	8/25/84	123	31	1.666	4+	M
FS-064-BL84	7/30/84	172	47	.924	4+	M
FS-065-BL84	7/30/84	310	279	.937	10+	F
FS-240-BL84	8/25/84	249	208	1.347	7+	F

Appendix 2. Continued.

Sample Number*	Date	Fork Length (mm)	Weight (g)	Condition (K-value)	Age**	Sex
Parasite Samples						
AC-373-BL85	7/11/85	817	4820	.884	15+	M
AC-599-BL85	7/13/85	481	563	.563	7+	M
AC-771-BL85	7/15/85	538	1218	.871	9+	F
AC-772-BL85	7/15/85	586	1652	.821	10+	F
AC-780-BL85	7/15/85	476	854	.791	7+	F
AC-781-BL85	7/15/85	610	2063	.909	11+	M
AC-782-BL85	7/15/85	567	1628	.893	10+	M
AC-798-BL85	7/16/85	622	2238	.930	10+	F
AC-800-BL85	7/16/85	575	1637	.861	11+	M
AC-801-BL85	7/16/85	469	702	.680	7+	M
AC-802-BL85	7/16/85	458	880	.916	8+	F
AC-820-BL85	7/16/85	211	72	.764	3+	F
AC-821-BL85	7/16/85	156	28	.740	3+	F
AC-822-BL85	7/16/85	188	50	.751	3+	M
AC-823-BL85	7/16/85	110	12	.840	2+	F
AC-838-BL85	7/17/85	184	46	.738	3+	F
AC-839-BL85	7/17/85	371	347	.679	5+	F
AC-840-BL85	7/17/85	373	374	.720	5+	M
AC-847-BL85	7/17/85	366	344	.701	5+	F
AC-852-BL85	7/17/85	117	13	.799	2+	F
AC-1841-BL85	8/6/85	610	2010	.886	10+	M
AC-1842-BL85	8/6/85	549	1317	.797	11+	F
AC-1843-BL85	8/6/85	506	1163	.898	8+	F
AC-1844-BL85	8/6/85	221	90	.829	4+	F
AC-1845-BL85	8/6/85	196	65	.869	3+	F
ACi-057-BL85	7/10/85	446	851	.959	12+	F
ACi-067-BL85	7/11/85	404	697	1.057	13+	M
ACi-077-BL85	7/11/85	430	737	.927	13+	F
ACi-095-BL85	7/12/85	411	691	.995	10+	M
ACi-096-BL85	7/12/85	404	598	.907	9+	F
ACi-097-BL85	7/12/85	374	434	.830	9+	F
ACi-098-BL85	7/12/85	358	431	.939	7+	M
ACi-099-BL85	7/13/85	377	437	.816	8+	F
ACi-100-BL85	7/13/85	387	535	.923	8+	F
ACi-101-BL85	7/13/85	407	578	.857	9+	F
ACi-102-BL85	7/13/85	376	488	.918	8+	M
ACi-104-BL85	7/14/85	415	713	.998	12+	F
ACi-105-BL85	7/14/85	400	619	.967	11+	F
ACi-106-BL85	7/14/85	388	502	.859	10+	F
ACi-107-BL85	7/14/85	377	646	1.206	7+	F
ACi-174-BL85	7/18/85	417	728	1.004	12+	F
ACi-175-BL85	7/18/85	416	675	.938	12+	M

Appendix 2. Continued.

Sample Number*	Date	Fork Length (mm)	Weight (g)	Condition (K-value)	Age**	Sex
ACi-176-BL85	7/18/85	382	489	.877	8+	M
ACi-357-BL85	8/7/85	408	724	1.066	12+	M
ACi-358-BL85	8/7/85	362	517	1.090	7+	M
ACi-359-BL85	8/7/85	389	654	1.111	8+	M
ACi-360-BL85	8/7/85	345	480	1.169	7+	M
ACi-361-BL85	8/7/85	419	765	1.040	12+	F
ACi-362-BL85	8/7/85	371	517	1.012	9+	M
ACi-363-BL85	8/7/85	356	498	1.104	7+	M
AF-001-BL85	7/8/85	152	44	1.256	5+	M
AF-002-BL85	7/8/85	145	35	1.145	5+	M
AF-004-BL85	7/8/85	160	49	1.206	5+	M
AF-005-BL85	7/8/85	133	24	1.033	4+	M
AF-006-BL85	7/8/85	141	28	.999	5+	F
AF-007-BL85	7/8/85	114	15	.999	4+	M
AF-008-BL85	7/8/85	125	19	.983	5+	M
AF-009-BL85	7/8/85	138	29	1.103	4+	M
AF-010-BL85	7/9/85	194	96	1.316	5+	F
AF-025-BL85	7/10/85	175	62	1.161	5+	M
AF-030-BL85	7/10/85	217	129	1.259	6+	F
AF-032-BL85	7/10/85	166	58	1.264	5+	M
AF-036-BL85	7/11/85	211	122	1.296	6+	F
AF-054-BL85	7/12/85	185	69	1.093	5+	F
AF-059-BL85	7/13/85	164	52	1.179	5+	F
AF-118-BL85	7/18/85	196	79	1.044	6+	M
AF-119-BL85	7/18/85	298	347	1.310	9+	F
AF-949-BL85	8/6/85	195	107	1.446	6+	F
AF-962-BL85	8/8/85	159	47	1.164	4+	M
AF-963-BL85	8/8/85	159	50	1.234	5+	M
AF-965-BL85	8/8/85	207	131	1.478	6+	F
AF-966-BL85	8/8/85	176	79	1.444	5+	M
AF-968-BL85	8/8/85	192	87	1.232	6+	F
AF-969-BL85	8/8/85	172	65	1.283	5+	M
AF-970-BL85	8/8/85	170	60	1.219	5+	M
FS-012-BL85	7/8/85	191	67	.967	4+	F
FS-013-BL85	7/8/85	267	168	.883	8+	F
FS-014-BL85	7/8/85	231	101	.818	6+	M
FS-039-BL85	7/9/85	207	92	1.035	4+	F
FS-040-BL85	7/9/85	264	165	.895	7+	M
FS-041-BL85	7/9/85	208	96	1.062	5+	F
FS-042-BL85	7/9/85	199	74	.933	4+	M
FS-131-BL85	7/9/85	213	91	.944	5+	M
FS-132-BL85	7/9/85	247	158	1.047	7+	F
FS-133-BL85	7/9/85	224	140	1.241	6+	F

Appendix 2. Continued.

Sample Number*	Date	Fork Length (mm)	Weight (g)	Condition (K-value)	Age**	Sex
FS-261-BL85	7/11/85	186	60	.929	4+	F
FS-327-BL85	7/12/85	243	148	1.028	7+	F
FS-388-BL85	7/13/85	155	40	1.071	3+	M
FS-436-BL85	7/13/85	182	60	.995	4+	M
FS-437-BL85	7/13/85	225	119	1.042	6+	M
FS-607-BL85	7/17/85	242	182	1.281	7+	F
FS-610-BL85	7/17/85	182	45	.750	4+	M
FS-615-BL85	7/17/85	163	35	.797	4+	F
FS-1579-BL85	8/6/85	245	165	1.123	7+	F
FS-1788-BL85	8/9/85	127	14	.659	3+	F
FS-1789-BL85	8/9/85	137	25	.972	3+	M
FS-1790-BL85	8/9/85	118	14	.840	3+	M
FS-1791-BL85	8/9/85	276	58	1.057	4+	F
FS-1792-BL85	8/9/85	211	100	1.062	5+	F
FS-1793-BL85	8/8/85	255	175	1.057	7+	M

*AC = Arctic char; ACi = Arctic cisco; AF = Arctic flounder; FS = fourhorn sculpin

**1984 Arctic cisco aged by scales; all other samples aged by otoliths.

***Pooled samples for contaminant analysis (2 fish treated as 1 sample).

Appendix 2. Continued.

Sample Number*	Date	Fork Length (mm)	Weight (g)	Condition (K-value)	Age**	Sex
FS-261-BL85	7/11/85	186	60	.929	4+	F
FS-327-BL85	7/12/85	243	148	1.028	7+	F
FS-388-BL85	7/13/85	155	40	1.071	3+	M
FS-436-BL85	7/13/85	182	60	.995	4+	M
FS-437-BL85	7/13/85	225	119	1.042	6+	M
FS-607-BL85	7/17/85	242	182	1.281	7+	F
FS-610-BL85	7/17/85	182	45	.750	4+	M
FS-615-BL85	7/17/85	163	35	.797	4+	F
FS-1579-BL85	8/6/85	245	165	1.123	7+	F
FS-1788-BL85	8/9/85	127	14	.659	3+	F
FS-1789-BL85	8/9/85	137	25	.972	3+	M
FS-1790-BL85	8/9/85	118	14	.840	3+	M
FS-1791-BL85	8/9/85	276	58	1.057	4+	F
FS-1792-BL85	8/9/85	211	100	1.062	5+	F
FS-1793-BL85	8/8/85	255	175	1.057	7+	M

*AC = Arctic char; ACi = Arctic cisco; AF = Arctic flounder; FS = fourhorn sculpin

**1984 Arctic cisco aged by scales; all other samples aged by otoliths.

***Pooled samples for contaminant analysis (2 fish treated as 1 sample).

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Fisheries Investigations on the Kongakut River, Arctic National Wildlife Refuge, Alaska, 1985

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Key Words
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Fisheries investigations on the Kongakut River, Artic National Wildlife Refuge, Alaska, 1985.

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Abstract:

Fishery investigations were undertaken on the Kongakut River of the Arctic National Wildlife Refuge (ANWR) in Alaska during June and July 1985. Arctic char (*Salvelinus alpinus*) and Arctic grayling (*Thymallus arcticus*) were the only fish species found. Spawning age grayling and young-of-the-year grayling fry appeared to be distributed throughout the study area. Juvenile char ages 0+ through 4+ and ripening adults were abundant in middle and lower reaches of the watershed. Adult non-spawning char apparently had left the system for the summer, entering Beaufort Sea lagoons to feed. The Kongakut River possesses good water quality typical of undeveloped non-glacial arctic streams. Twenty-two macroinvertebrate taxa were collected in surber samples: Chironomidae, Nemouridae, and Oligochaeta were the most abundant. Both diversity and density of invertebrates were low, probably due to the location of most of the sampling sites in mountain streams.

INTRODUCTION

For years, recreational users of the Arctic National Wildlife Refuge (ANWR) have been turning in glowing reports about the fishing along the Kongakut River. Long before the arrival of backpackers, river-rafters and pilots, the Kongakut River was well-known to the Inupiaq Eskimos for its fishing holes and for the access it provided to the mountains for hunting and trapping. On the coast, a portion of the Kongakut River delta just south of Siku Island was considered an important whitefish (Coregonus sp.) fishing area (Jacobson and Wentworth 1982). Commercial whalers of the last century and early 1900's found the river useful as a main travel route to their winter sheep hunting grounds (Jacobson and Wentworth 1982).

Despite all of the favorable mention the Kongakut has received, little scientific information regarding its fisheries has been reported. In light of increasing recreational use of the area, this void prompted a reconnaissance of the fishery resources of the Kongakut River drainage.

The goals of this study were to describe the habitat and aspects of the life histories of Arctic char (Salvelinus alpinus) and Arctic grayling (Thymallus arcticus) within the Kongakut River system. The objectives were:

1) to identify spawning and rearing areas and mid-summer distribution of char and grayling;
2) to describe age and growth charcteristics;
3) to delineate physical and chemical characteristics of the river and selected tributaries;
4) to determine species composition of benthic invertebrates.

STUDY AREA

The Kongakut River is in the eastern part of the ANWR on the north slope of the Brooks Range (Fig. 1). It originates at about 1,460 m in the Davidson Mountains at the Continental Divide and flows east, then north, to the Beaufort Sea, a distance of approximately 177 km. On 1:250,000 USGS quadrangle maps the river is a fifth order stream (Strahler 1957) at the mouth with a drainage area of 4,002 square km. Investigations of the river took place from sampling site 1, about 11 km from the headwaters, to sampling site 10 at Baseline Creek, about 45 km from the mouth of the Kongakut at the Beaufort Sea.

According to Wahrhaftig's (1965) classification of Alaska, the river runs through three different physiographic zones: the Arctic Mountain province, the Arctic Foothills province and the Arctic Coastal Plain. Most of the Kongakut drainage is in the Arctic Mountain province. In the headwaters, weather-resistant metasedimentary rock predominates. To the north is a narrow east-west belt of the Lisburne Formation consisting of Mississippian limestone and dolomites (Hobbie 1962). Springs and aufeis formations are often associated with the Lisburne Limestone group (Craig and McCart 1974) and are prevalent along the Kongakut River. The southern margins of the Arctic Foothills province were glaciated during the Pleistocene and glacial debris covers portions near the mountains (Detterman 1974). Permafrost may extend to depths as great as 275 m (Wiggins and Thomas 1962) and has a significant

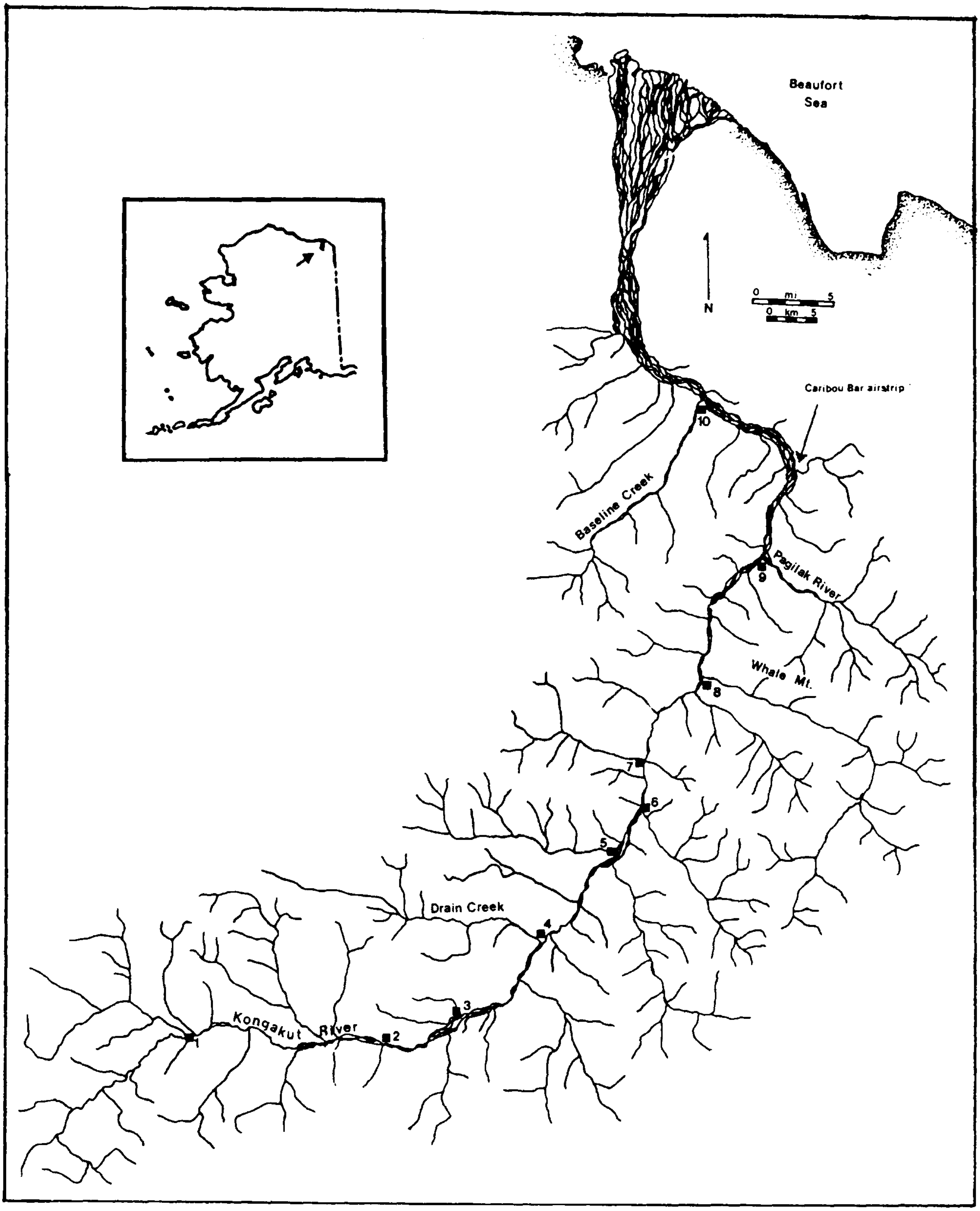

Fig. 1. The Kongakut River drainage with locations of sampling sites 1-10. Inset shows drainage location in Alaska.

effect on soils. The soils of the Arctic Coastal Plain province tend to lack well-defined soil horizons, to be slightly acidic and to be low in nutrients. Dark colored mineral soils (mollisols), which are neutral to slightly alkaline, predominate in the Arctic Foothills province (Wiggins and Thomas 1962). Only the upper few inches of the tundra mat thaws during summer and though it is highly absorbent, once saturated, run-off is total and additional rain flows immediately to streams. This sudden change in water volume in conjunction with an abundance of unconsolidated sand and gravel produces braiding (Detterman 1974) which is extensive in the Kongakut River.

MATERIALS AND METHODS

Access to the uppermost sampling site (see Fig. 1) was provided by helicopter. A 4-person crew conducted the study, moving downstream via inflatable rubber rafts. Camp sites were selected in advance based on inferences made from USGS 1:63,360 maps of the area.

Stream length, stream orders and drainage areas were measured from USGS 1:250,000 maps. Stream orders were determined using the method of Strahler (1957). Aufeis locations and approximate thicknesses were recorded to indicate possible Arctic char spawning areas.

Stream flow (discharge or runoff) was measured using a Marsh-McBirney velocity meter and a standard wading rod. Velocities were measured at approximately 0.6 of total depth (ft) and braided-channel flows were combined to obtain total flow. Total flow was calculated using the formula:

$$Q = \sum_{i=1}^{n} \sum_{i=1}^{k} W \times D \times V$$

where n = number of channels
k = number of cells
W = width of cell (ft)
D = mean depth (ft) of cell
V = mean velocity (ft/sec) of cell
(modified from Simon 1981)

Other stream characteristics measured were water temperature, conductivity, pH, total alkalinity, and total hardness. A Hach Mini-pH meter, model 17200, and a Hach Mini-Conductivity meter, model 17250, were used for the analysis. Both were temperature-adjustable thus values given for pH and conductivity are for those temperatures listed in Table 1. Total alkalinity and total hardness were measured in mg/l as $CaCO_3$ using Hach prepared chemicals and a Hach hand-held digital titrator. All measurements were taken at least twice; mean values are reported in Table 1.

Five replicate aquatic macroinvertebrate samples were collected in riffles at each site with a 1000-micron mesh surber sampler to depths of 10 to 15 cm. One kick sample was taken at each site. All samples were preserved in approximately 10% formalin in Whirl-Pak bags. Organisms were identified to family level whenever expertise allowed. Representative chironomid larvae were mounted in CMCP-10 media and identified when possible to sub-family. The following identification keys were used: Pennak 1978, Bryce and Hobart 1972, Oliver et al. 1978, and Merritt and Cummins 1984. Percent frequency of occurrence and percent composition are based on total number of individuals from all samples (Table 2). The mean, standard deviation, standard error and sampling precision were calculated for density of organisms at each sampling station (Table 3).

Minnow traps were baited with commercially prepared roe. Experimental monofilament gillnets consisted of four 305 cm panels with 2.5, 3.8, 4.1, and 5.4-cm bar meshes.

Fork length was recorded to the nearest mm for all fish. In addition, all mortalities were weighed wet to the nearest divisions of 0-250 g, 0-500 g, 0-2000 g, and 0-5000 g Pesola spring scales. Scales and otoliths (sagittae) were removed from Arctic grayling for ageing. Otoliths and digestive tracts were removed from Arctic char for ageing and food habits studies. Digestive tracts were preserved in approximately 5% formalin in Whirl-Pak bags in the field, then later dissected and the food items transferred to vials of isopropyl alcohol. Scales and otoliths were stored cleaned and dried in envelopes.

Otoliths were cleared in Photo-Flo 200 and ground on one side on fine 400 grit sand paper to enhance the clarity of age marks. They were viewed against a dark background with a dissecting microscope. The hyaline rings were counted starting with the first hyaline zone outside the dark centrum. Two independent ageings were made on each otolith. A third ageing was done in those cases of discrepancies between the first two determinations.

Fish caught with angling gear were measured to the nearest millimeter (fork length) and marked with numbered Floy FD-67 anchor tags.

A coefficient of condition (K) was calculated for char and grayling using the following formula:

$$K = \frac{(\text{Weight in g}) \times 10^5}{(\text{Fork length in mm})^3}$$

RESULTS

Physical and chemical characteristics

Physical and chemical data are summarized in Table 1. Mean conductivity and mean alkaliniity were highest (mean total hardness was high) at site 2, a small spring. These same characteristics were lowest at sampling site 7, which was located on a small tributary flowing east out of the Romanzof Mountains. The pH ranged from 6.4. at the uppermost sampling site to 7.7, measured at sampling site 10 on Baseline Creek.

We were unable to obtain flow in the main channel Kongakut River below sampling site 4. Channels flowing beneath large aufeis fields were unmeasureable. Heavy rainfall limited flow measurements to smaller tributaries that could be waded.

Macroinvertebrates

Table 2 lists the 22 macroinvertebrate taxa that were identified in the surber

Table 1. Physical and chemical characteristics of water at sampling sites, Kongakut River, June and July 1985. Conductivity meter was temperature-adjustable therefore values given are for these temperatures specified.

Sampling site	Location	Date	Approx. elevation (m)	Water temp. (°C)	pH	Conductivity (umhos/cm)	Total alkalinity (mg/l as $CaCO_3$)	Total hardness (mg/l as $CaCO_3$)	Flow (cms)
1 river	Table Mt. D-4 T6S, R38E, Sec. 12	6/22	855	7.0	6.4-6.5	240	73	116	9.70
trib				5.8	6.8	225	91	81	0.26
2 river	Table Mt. D-3 T6S, R40E, Sec. 12	6/24	700	7.3	6.4-6.5	285	100	116	11.56
trib				10.4	6.6-7.0	395	168	130	-
3 river	Table Mt. D-4 T5S, R41E, Sec. 35	6/25	630	5.5	6.8-6.9	260	-	-	-
trib				7.3	6.6-7.0	333	104	158	0.29
4 river	Demarc. Pt. A-2 T5S, R42E, Sec. 3	6/26	560	-	-	-	-	-	8.45
Drain Ck				6.7	6.7-6.8	320	84	138	0.87
5 trib	Demarc. Pt. A-2 T4S, R42E, Sec. 10	6/28	510	5.0	6.9-7.0	345	106	166	0.10
6 trib	Demarc. Pt. A-2 T3S, R43E, Sec. 36	6/29	480	4.8	6.8-6.9	175	66	103	0.67
7 trib	Demarc. Pt. A-2 T3S, R42E, Sec. 12	6/30	440	5.0	7.0-7.1	55	17	28	3.18
8 river	Demarc. Pr. B-2 T2S, R43E, Sec. 15	7/01	380	5.3	7.3	155	-	-	-
trib				2.9	7.1-7.3	128	54	72	0.06
9 Pagilak River	Demarc. Pt. B-1 T1S, R44E, Sec. 8	7/01	300	6.6	7.0-7.1	220	68	96	11.41
10 Baseline Creek	Demarc. Pt. C-2 T2N, R42E, Sec.24	7/03	185	11.3	7.5-7.7	318	88	134	9.42

Table 2. Macroinvertebrate taxa collected in surber samples, Kongakut River and tributaries, June and July 1985.

- Platyhelminthes
  - Turbellaria
    - Tricladia
      - Planaridae
- Annelida
  - Oligochaeta
- Arthropoda
  - Crustacea
    - Amphipoda
      - Gammaridae
  - Arachnoidea
  - Hydracarina
  - Insecta
    - Ephemeroptera
      - Baetidae
      - Heptageniidae
    - Plecoptera
      - Nemouridae
      - Capniidae
      - Perlodidae
      - Leuctridae
    - Trichoptera
    - Diptera
      - Chironomidae
        - Orthocladiinae
      - Ceratopogonidae
      - Simulidae
      - Tipulidae
      - Culicidae
      - Ephydridae
    - Coleoptera
      - Curculionidae
      - Hydrophilidae
    - Hemiptera
      - Mesoveliidae
    - Collembola

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samples. Table 3 gives densities of macroinvertebrates (organisms/m^2) and the number of taxa identified for each sampling site. Densities ranged from 6.5 organisms/m^2 to 400 organisms/m^2 with the greatest density occurring at sampling site 2, a spring. The largest number of taxa was found at sampling site 3, which was on a small tributary of the Kongakut. Percent species composition and percent frequency of occurrence are listed in Table 4. Chironomid larvae dominated both frequency of occurrence (they were found in 92 percent of all samples) and percent composition (33 percent of the total number of invertebrates collected were Chironimid larvae). Orthocladiinae was the only sub-family identified in the sub-sample of chironomids. Although greater numbers of less abundant taxa were found in kick samples, the taxa obtained by this method were the same as those picked from surber samples.

Fish distribution and abundance

Arctic char

Juvenile Arctic char were distributed throughout the study area and were either captured or observed in both the main channel and tributary streams. All juvenile Arctic char were captured with baited minnow traps (Table 5). Although the greatest effort (87.0 hrs) was expended at sampling site 1, no fish were captured with minnow traps; however, juvenile or small resident Arctic char were observed at that site. CPUE for minnow traps ranged from 0 fish/trap-hr (sites 1,4,6) to 1.16 fish/trap-hr at Pagilak River, site 9 (Table 5). CPUE for minnow traps tended to increase down-stream despite high, turbid water conditions resulting from heavy rains during July. Juvenile and young-of-the-year (YOY) Arctic char were observed or captured in backwater areas, behind boulders in fast water, and along the edges of fast-flowing water in the main

Table 3. Density (organisms/m^2) and number of taxa of macroinvertebrates at sampling sites, Kongakut River and tributaries, June and July 1985.

Sampling Station	Sample Size	Mean # Organisms/m^2	Standard Deviation	Standard Error	% Precision	Number of Taxa
1 River	5	155	81.1	36.3	23.4	7
1a Trib	5	7	9.6	4.3	61.4	2
1b Trib	5	271	251.5	112.5	41.5	7
2 River	5	93	64.4	28.8	31.0	5
2 Trib	5	400	300.3	134.3	33.6	4
3 Trib	5	207	107.5	48.1	23.2	12
4 River	5	50	16.3	7.3	14.6	9
4 Drain Ck	5	56	32.6	14.6	26.1	8
5 Trib	5	24	24.5	11.0	45.8	2
6 Trib	5	58	22.3	10.0	17.2	7
7 Trib	5	88	35.2	15.7	17.8	8
8 Trib	5	41	23.2	10.4	25.4	4
9 Pagilak R	5	105	101.6	45.4	43.2	6
10 Baseline Ck	5	84	74.2	33.2	39.5	9

Table 4. Frequency of occurrence of major macroinvertebrate taxa and percent composition of surber samples, Kongakut River and tributaries, June and July 1985; A = adult; P = pupae; N = nymph; L = larvae.

Taxon		Percent frequency of occurrence	Percent composition
Planaridae		7.1	0.5
Oligochaeta		35.7	13.0
Gammaridae		50.0	8.4
Arachanoidea		7.1	0.1
Hydracarina		14.3	0.3
Insecta			
Ephemeroptera	N	(42.8)	(8.4)
Baetidae	N	7.1	0.1
Heptegeniidae	N	42.8	8.3
Plecoptera	A	(14.3)	(0.1)
	N	(35.7)	(23.0)
Nemouridae	N	42.8	20.0
Capniidae	A	7.1	0.4
	N	14.3	0.3
Perlodidae	N	14.3	0.4
Leuctridae	N	14.3	0.1
Trichoptera	L	7.1	0.1
Diptera	A	(78.6)	(2.8)
	P	(57.1)	(1.5)
	L	(100.0)	(35.0)
Chironomidae	A	28.6	0.5
	L	92.8	33.0
Ceratopogonidae	P	7.1	0.1
Simulidae	L	14.3	0.7
Tipulidae	A	14.3	0.5
	P	14.3	0.3
	L	28.6	1.2
Culicidae	P	50.0	4.8
Ephydridae	L	21.4	0.3
Coleoptera	L	14.3	0.3
Collembola	A	7.1	0.1
Hemiptera	A	21.4	0.4

Table 5. Fish sampling summary by gear type, Kongakut River, June and July 1985. AC = Arctic char, GR = Arctic grayling, CPUE = catch-per-unit-effort. One juvenile Arctic char was captured with a dip net at station 5.

Sample Site	Minnow Traps		Gill Net		Angling	
	Effort (hrs)	CPUE (per trap)	Effort (hrs)	CPUE (per net)	Effort (hrs)	CPUE (per person)
1	87.0	0.00	11.25	0.00	2.5	0.00
2	25.5	0.08 AC	12.75	0.31 GR	not attempted	
3	60.0	0.08 AC	11.5	0.09 GR	1.75	0.57 AC 1.14 GR
4	48.0	0.00	not fished		4.35	3.45 AC 0.46 GR
5	not fished		not fished		not attempted	
6	54.0	0.00	not fished		1.25	1.60 AC 1.60 GR
7	52.0	0.31 AC	11.3	0.00	1.75	4.00 AC 1.71 GR
8	56.0	0.93 AC	not fished		not attempted	
9	48.5	1.16 AC	24.5	0.00	0.70	1.43 GR
10	42.75	0.75 AC	8.5	0.12 GR	not attempted	

channel and tributary streams. Glova and McCart (1974) reported young char in similar habitats in the Firth River.

Adult Arctic char were captured via angling at sampling sites 3-7 (Table 5). Although 11.25 and 12.75 gill-net hours and 2.5 and 1.75 angling-hours were expended at sampling sites 1 and 2 respectively, no Arctic char adults were captured nor were any observed. At least 2 Arctic char escaped from the gill net at site 3. Highest angling CPUE (4.0 adults/angler-hr) was at sampling site 7 (Table 5). Adult Arctic char were present below and in the channels running through the large aufeis field located at sampling site 3. Adults were observed in a pool in Drain Creek (site 4) near the confluence with the main channel. They were captured in deep pools, in deep, fast riffles, and at the confluence of tributary streams and the Kongakut River.

Eleven Arctic char were marked with Floy tags at sampling site 4 (the confluence of the Kongakut and Drain Creek) and four were marked at sampling site 7. Fork lengths ranged from 525 mm to 682 mm. Weights were not taken from fish that were released (Table 7).

Arctic grayling

YOY Arctic grayling were observed throughout the study area. The portion of the Kongakut River which flows through the Arctic coastal plain was not sampled. We observed grayling in slow-moving margins of stream channels and occassionally in isolated pools in both the main channel of the Kongakut River and tributary streams. No juvenile Arctic grayling were captured at any of the sampling sites.

Adult Arctic grayling were captured at most sampling sites. Adults were captured with gill nets and by angling. The highest gill net CPUE was at sampling site 2 with 0.31 adults caught per net per hour (Table 5). The habitat at sampling site 2 was a backwater area with a mud bottom. Arctic grayling adults were captured with angling gear at all sites except 1 and 5. Although 2.5 hours were spent angling at sampling site 1, no adult grayling were captured. One adult was observed in a pool in a tributary stream. Angling was not attempted at the small tributary stream at sampling site 5. Highest angling CPUE (1.74 adults/angler-hr) was at sampling site 7 (Table 5).

Seven Arctic grayling were marked with Floy tags. One was marked at site 1, two at site 4 one at site 6, two at site 7, and one at site 9. Fork lengths ranged from 303 mm to 380 mm (Table 7).

Age and growth

Arctic char

Thirty-nine of the 45 pairs of otoloiths collected from Arctic char were aged (Table 6). Six pairs of otoliths were unreadable; these were from juveniles and were malformed. Summer growth beyond the last annulus was observed in all otoliths examined.

Juvenile fish ranged from age 1 to age 4 (Table 6). Most juveniles were age 1 and 2 with mean fork lengths of 98 mm and 131 mm respectively. The modal length class for juvenile Arctic char was 100-149 mm (Fig. 2).

Ten adult Arctic char were aged from otoliths. Ages 7 through 10 were represented with age 8 fish predominating (Table 6). Age 8 fish had the longest mean fork length (603 mm), the heaviest mean weight (2,069 g) and the highest mean coefficient of condition (0.94). All of the adult Arctic char captured had maturing gonads and we judged that they would spawn in the fall. Seven of the 10 fish were females. Based on the description by Craig and McCart (1974), all adult fish were from an anadromous stock. The modal length class was 600-649 mm (Fig 2).

Arctic grayling

Nine pairs of Arctic grayling otoliths were aged. Summer growth beyond the last annulus was observed in all otoliths. Otolith-ages ranged from 5 through 8 with age 8 fish predominant (Table 5). Mean fork lengths ranged from 268 mm (age 5) to 313 mm (age 8) and mean wet weights ranged from 185 g to 281 g,

Table 6. Age-specific fork lengths (mm), wet weights (g), female:male ratios and coefficients of condition (K) for 39 Arctic char and 9 Arctic grayling, Kongakut River, June and July 1985.

Species	Age	Sample size	Mean fork length (mm)	Mean weight (g)	Range	K	Sex ratio F:M
Arctic char	1	13	98		86-114mm		
	2	12	131		118-141mm		
	3	3	141		111-160mm		
	4	1	150				
	7	2	514	1185	512-516mm 1120-1250g	0.87	2:0
	8	4	603	2069	574-620mm 1750-2600g	0.94	2:2
	9	3	553	1525	535-565mm 1175-1700g	0.89	3:0
	10	1	655	2600		0.93	0:1
Arctic grayling							
	5	1	268	185		0.96	1:0
	6	2	267	178	265-268mm 175-180g	0.93	--
	7	2	327	343	316-337mm 325-360g	0.98	0:2
	8	4	313	281	298-337mm 240-320g	0.92	3:1

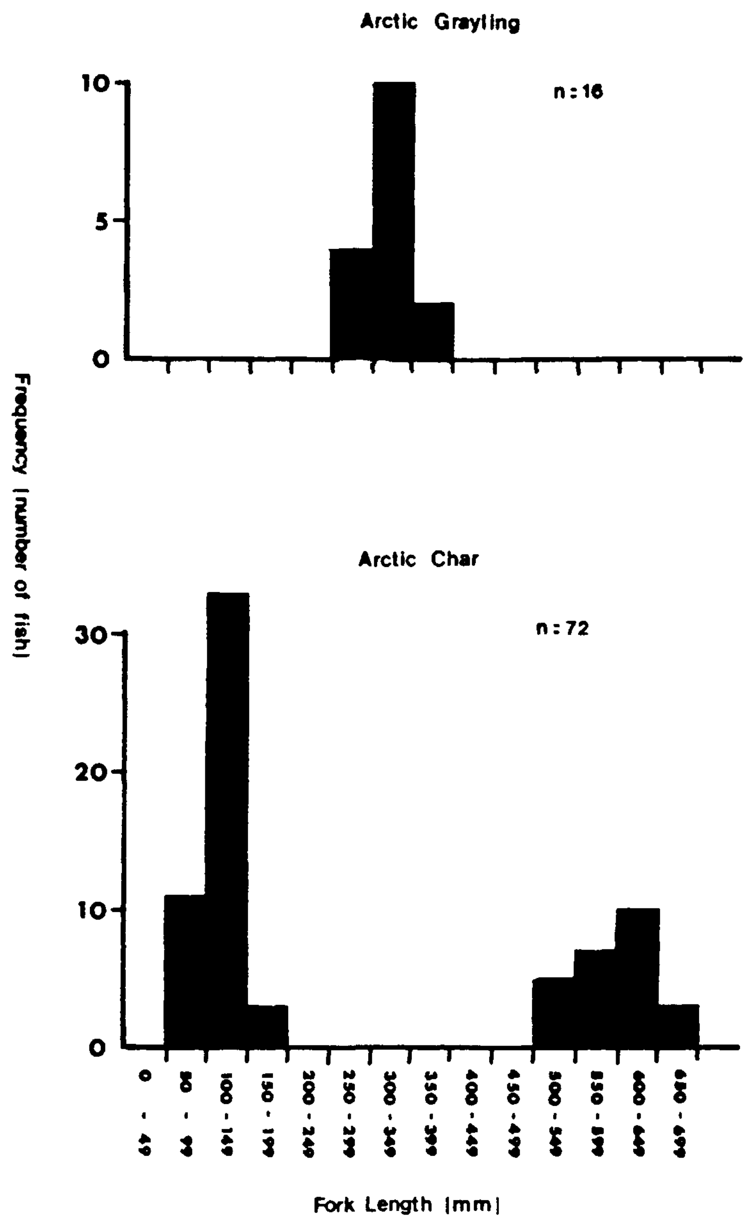

Figure 2. Length frequencies of Arctic char and Arctic grayling, taken from the Kongakut River, June and July 1985.

Table 7. Capture locations, fork lengths, sex and tag numbers of Arctic char and Arctic grayling taken and released in the Kongakut River, June-July 1985.

Sampling site	Date	Fork length (mm)	Sex	Tag Number (yellow)
		Arctic char		
4	6-25-85	648	M	003751
		621	F	003752
		609	F	003753
		577	-	003754
		525	-	003755
	6-26-85	682	M	003756
		640	M	003757
		574	F	003758
		560	F	003759
	6-27-85	610	F	003761
		574	F	003763
7	6-29-85	644	-	003766
		608	F	003767
		688	-	003769
	6-30-85	535	F	003770
		Arctic grayling		
3	6-25-85	318	-	003800
4	6-25-85	303	-	003760
		312	-	003762
6	6-28-85	361	-	003764
7	6-29-85	307	-	003765
		335	-	003768
9	7-01-85	380	-	003771

respectively (Table 5). Mean coefficient of condition was highest (0.98) for two 7-year-old male Arctic grayling (Table 5). Fork length range was also largest (346-337 mm) for age 7 fish. The modal length class was 300-349 mm (Fig. 2).

DISCUSSION

Weather is an important consideration when reviewing the information gathered in this study. An early break-up on the eastern North Slope was followed by a period of cold weather and little precipitation. By June, temperatures were quite warm but still little precipitation had fallen. For the first five days of the study (June 21-26) the Kongakut River water level was dropping. This situation explains the apparent loss of flow between sampling stations 2 and 4 (Table 1). After it began to rain (June 27) the water level rose every night. Stream flow on the average peaks in mid-June in the Arctic slope region (Feulner et al. 1971). The 1985 summer peak for the Kongakut was probably later, in early July while we were on the river. Instantaneous and average flows have been measured for many of the rivers and streams of the ANWR, but comparisons are not possible because measurements have been taken at different times of the year.

In general the selected chemical characteristics measured in the Kongakut River and tributaries were typical of undeveloped streams of the North Slope (Ward and Craig 1974, Smith and Glesne 1982, Glesne and Deschermeier 1984.) The high values for conductivity, alkalinity, and hardness collected at sampling site 2 were in accordance with values obtained for other springs in the ANWR (Ward and Craig 1974, Glesne and Deschermeier 1984). The apparent downstream decrease for these characteristics is most likely due to increased runoff in streams as a result of rain.

Both macroinvertebrate density and number of taxa were low for most sites. This was probably due to the location of most of the sampling sites on mountain streams. Glesne and Deschermeier (1984) summarized the classification systems of Craig and McCart (1974a) and Harper (1981) to produce the following definition of a "mountain stream": these streams exhibit low stream order and high gradient; flow regimes are highly variable; riparian vegetation is sparse; turbidity and suspended sediments are higher than in spring or tundra streams; and with the exception of deep pools, streams freeze to the bottom in winter. Great fluctuations in environmental conditions of mountain streams limit diversity.

Slack et al. (1979) found in the north-flowing Atigun River (in the Brooks Range) the distribution and diversity of benthic invertebrates were consistent with the hypothesis that aquatic biological communities are related to stream order. Craig and McCart (1974a) found a significant correlation between invertebrate densities and stream flow. Neither of these relationships were observed in this study. However, the finding of greatest macroinvertebrate density at a spring site is in agreement with the results of Glesne and Deschermeier (1984).

Species composition at sampling sites was similar to that of benthic communities in other Arctic streams (Craig and McCart 1974a). An attempt was made to identify Chironomid larvae to the sub-family level in order to establish which functional groups could be found at particular sites. Representative larvae were examined and all were identified as members of the sub-family Orthcladinae, which includes a wide variety of functional groups. Other studies have reported up to five sub-families of Chironomid larvae from Arctic streams (Oliver et al. 1978, Slack et al. 1979, Glesne and Deschermeier 1984). The absence of other sub-families in this survey may be due to different rates of larval development and emergence.

Fish distribution and abundance were difficult to determine in some areas downstream of sampling site 3 due to high turbid water, the result of heavy rain. The uppermost site on the Kongakut at which fish (both char and grayling) were taken was sampling site 2 (Fig. 1), approximately 100 km from the mouth. Furniss (1975) reported spawning anadromous char were abundant in August in both the main river and in tributaries between 65 and 120 km from the mouth. It appears that the upper limits of char distribution on the Kongakut River are the second-order tributaries which join the Kongakut about 120 km from the mouth.

The lowest sampling site on the river at which grayling and char were caught during this survey was sampling site 10 (Fig. 1). In the delta region downstream from this site, juvenile char have been collected during November from areas influenced by springs (Craig and McCart 1974b). Concentrations of fish have been observed in open water there in April. Char may share these areas with grayling during winter. Summer distribution of both species in the lower portion of the Kongakut remains unclear.

Spawning areas of anadromous Arctic char are associated with springs (Glova and McCart 1974, Johnson 1980, Smith and Glesne 1983, Daum et al. 1984). Spring water overflow during winter results in large ice formations called aufeis, which may be used as clues indicating nearby char habitat (Craig and McCart 1974a). On the Kongakut River, the distribution of Arctic char was associated with the distribution of aufeis (Fig. 5). Boulder-strewn gravels of the type typically used for spawning redds were evident near aufeis fields at site 3 and between sites 7 and 8. Spawning sites for grayling were not observed, but the abundance of YOY grayling throughout the drainage suggests many of the tributaries may be used as spawning areas. Juvenile grayling ages 1 - 4 were neither captured nor observed; therefore, it was not possible to determine rearing habitat for grayling this age.

Age-specific fork lengths for char and grayling from the Kongakut and other North Slope drainages are depicted in Figs. 3 and 4. The mean size of char aged 2 to 4 appears to be smaller than those taken from other streams. The mean size of older char (ages 7 to 10) from the Kongakut seems to be greater than that of the fish from the Hulahula and Firth Rivers. Small sample sizes prevent us from drawing general conclusions about growth rates in the Kongakut.

Residual char — non-anadromous stream residents (usually males) — were not collected in the samples. Char of this life history type have been taken from the Canning, Hulahula, and the Aichilik Rivers. Though they have not been reported they most likely exist in small numbers in the Kongakut as well.

Also absent from samples were char of ages 5 and 6. The sample size may have been too small to encompass all age groups. Another possible explanation for

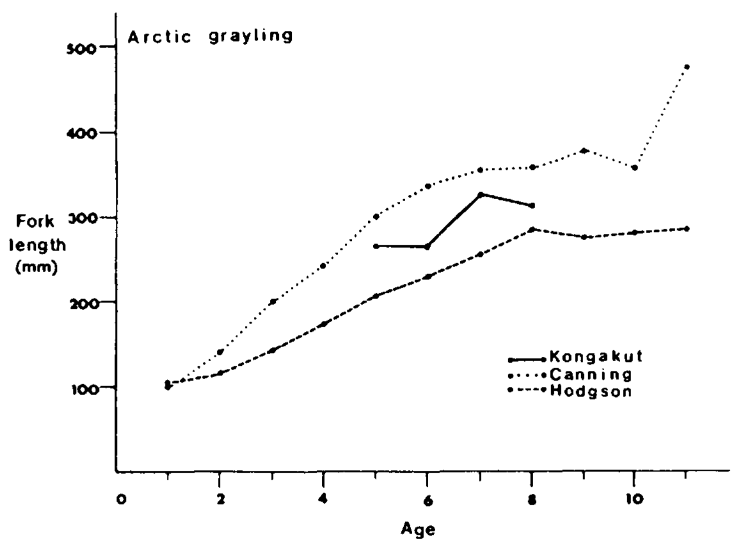

Fig. 3. Age-specific (based on otoliths) mean fork lengths of Arctic grayling from three river systems. Hodgson Creek data from Bain (1974); Canning River data from Smith and Glesne (1983); Kongakut River data, this study.

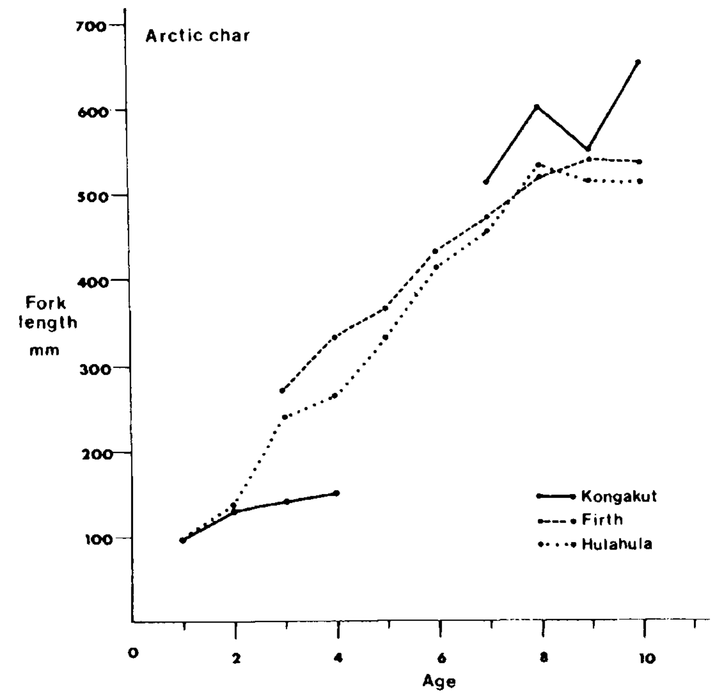

Fig. 4. Age-specific (based on otoliths) mean fork lengths of Arctic char from three river systems. Firth River data from Glova and McCart (1974); Hulahula River data from Smith and Glesne (1983); Kongakut River data, this study.

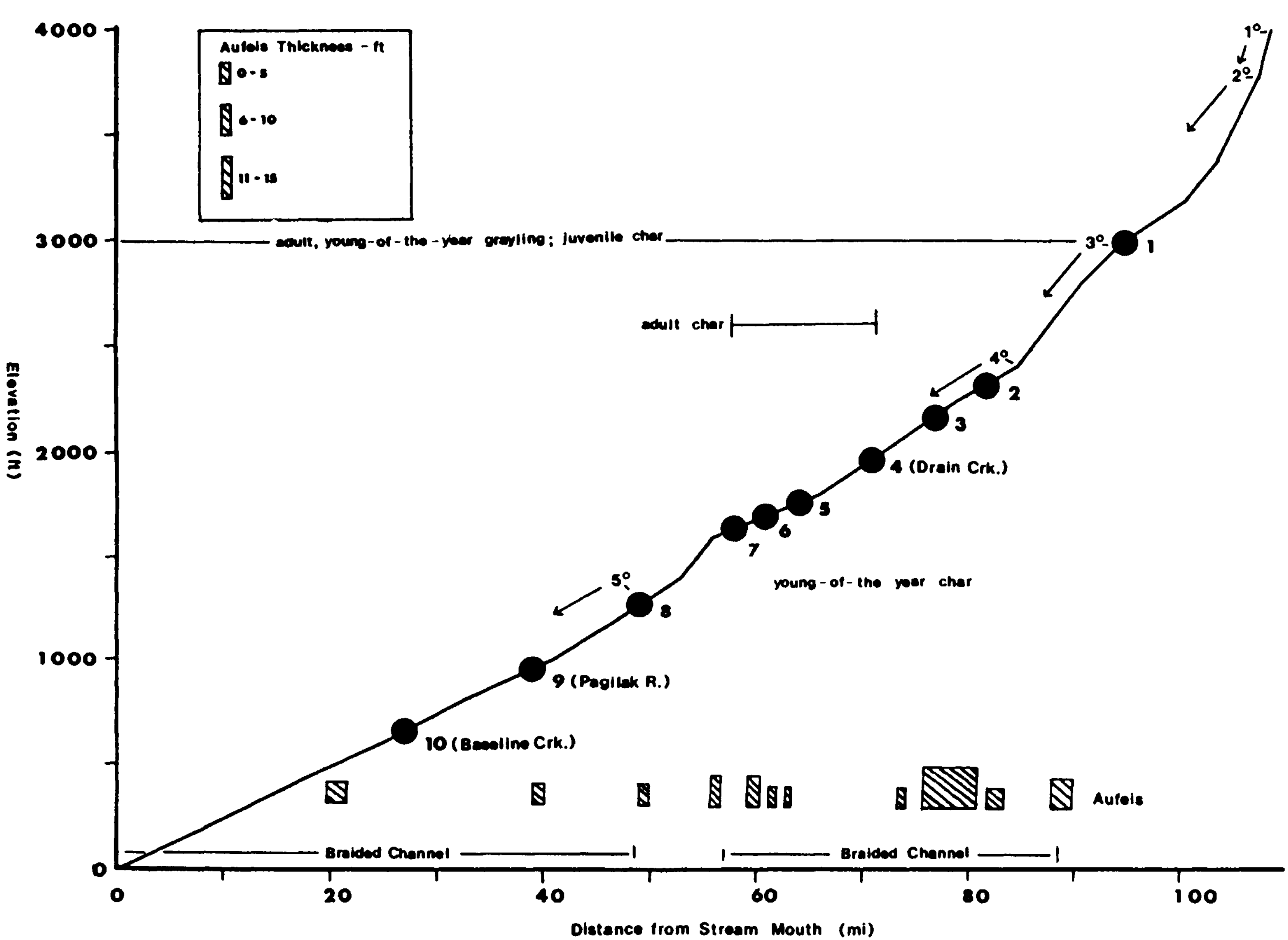

Figure 5. Arctic char and Arctic grayling distribution, extent of aufeis, stream order, and location of braided channels in relation to elevation and distance (miles) from the mouth of the Kongakut River.

the absence of 5 and 6 year olds is they had not begun their migration into freshwater. Older, mature adult char migrate upstream first; the size of the migrants decreases as the run continues. A third possibility is fish seven years and older (in spawning condition) did not leave the system that May, or if they did, spent a very short time at sea.

RECOMMENDATIONS

1. Specific spawning areas need to be identified. Annual surveys are recommended to establish baseline spawning populations prior to oil and gas development.

2. Identified spawning areas need to be ground-checked to document habitat characteristics (spring locations, flow, relative macroinvertebrate abundance, water chemistry, etc.), to obtain size and extent of spawning areas (via mapping), to obtain relaive abundance estimates of both adults and juveniles, to obtain spawning sex ratios, to obtain spawning and nonspawning population ratios, and to examine fish for tags from other studies.

3. A larger sample size needs to be collected to adequately describe growth, to assess mortality and to describe age distribution and sex ratios of char and grayling.

4. No juvenile Arctic grayling were captured during this study. A special attempt should be made to identify their distribution, relative abundance, and food habits.

7. Stream gaging stations and portable weather stations should be erected at the lowermost portion of each subdrainage and at spring origins to adequately describe flow regimes.

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THE FRESHWATER FOOD HABITS OF JUVENILE ARCTIC CHAR IN STREAMS IN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

Key Words
Food habits, Arctic char, Arctic National Wildlife Refuge

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The freshwater food habits of juvenile Arctic char in streams in the Arctic National Wildlife Refuge, Alaska.

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Abstract:

Juvenile Arctic char (Salvelinus alpinus) were collected from the Canning, Hulahula, Aichilik, and Kongakut Rivers in the Arctic National Wildlife Refuge in Alaska between 1982 and 1985. Stomachs were removed from 189 fish and examined for content. Chironomids were the most commonly found prey organism. Plecopterans were second overall except in samples from the Canning River in which Ephemeropterans were more commonly found.

INTRODUCTION

The Fairbanks Fishery Resources Office has conducted baseline survey and inventory studies of the fishery resources of the North Slope of the Arctic National Wildlife Refuge (ANWR) since 1981 under the direction of Sec. 1002(c) of the Alaska National Interest Lands Conservation Act of 1980. Arctic char (Salvelinus alpinus) were sacrificed during these studies for age and growth information and digestive tracts were often removed to learn food habits of fish in the study streams. Some of the char collected could not be aged; however, it is assumed that all char examined for this report were juveniles (under 5 years), based on length comparisons with fish of known ages taken from the same streams at the same time of year.

Four life history types have been described for North Slope Arctic char (McCart 1980): one anadromous form and 3 non-anadromous forms. The non-anadromous forms have been categorized as stream-residents [stream-resident char have also been referred to as "residual Arctic char" (Craig 1977a)], lake-residents or spring-residents. The juveniles examined for this report were either anadromous, stream-resident, or spring-resident char; due to the difficulty of differentiating between these types during the juvenile stage, only those char taken from Shublik Spring (a tributary to the Canning River) are of known type. No separation between stream-resident and anadromous juveniles was made for this analysis.

The objective of this study was to provide baseline information concerning food habits of juvenile Arctic char from streams on the North Slope of the ANWR.

METHODS

Juvenile Arctic char were taken from the Canning River in 1982, from the Aichilik River in 1982 and 1983, from the Hulahula River in 1983, and from the Kongakut River in 1985 (Fig. 1). The sampling sites are described in detail in Smith and Glesne (1983), Daum et al. (1984), and Deschermeier et al. (1987). Fish were collected with a variety of gear: hook and line, electroshocker, minnow traps, gillnets, and seines (Table 1). Table 1 gives the date and location of the sampling sites on each river, the sample sizes, the number of fish collected, and the number of empty stomachs.

Both whole fish and separate digestive tracts were preserved in the field in solutions of approximately 10% formalin. The fork lengths of whole fish measured after preservation were adjusted for shrinkage (Parker 1963). Stomach contents were removed from formalin and transferred to isopropyl alcohol before examination.

Keys used for identification of organisms comprising stomach contents were Oliver et al. (1978), Pennak (1978), and Merritt and Cummins (1984). Organisms were viewed with a 1-7x Bausch and Lomb dissecting scope and a Bausch and Lomb microscope (10-40x).

Sample sizes were insufficient for statistical testing, therefore stomach contents were not analyzed in detail. Relative biomass of food organisms was

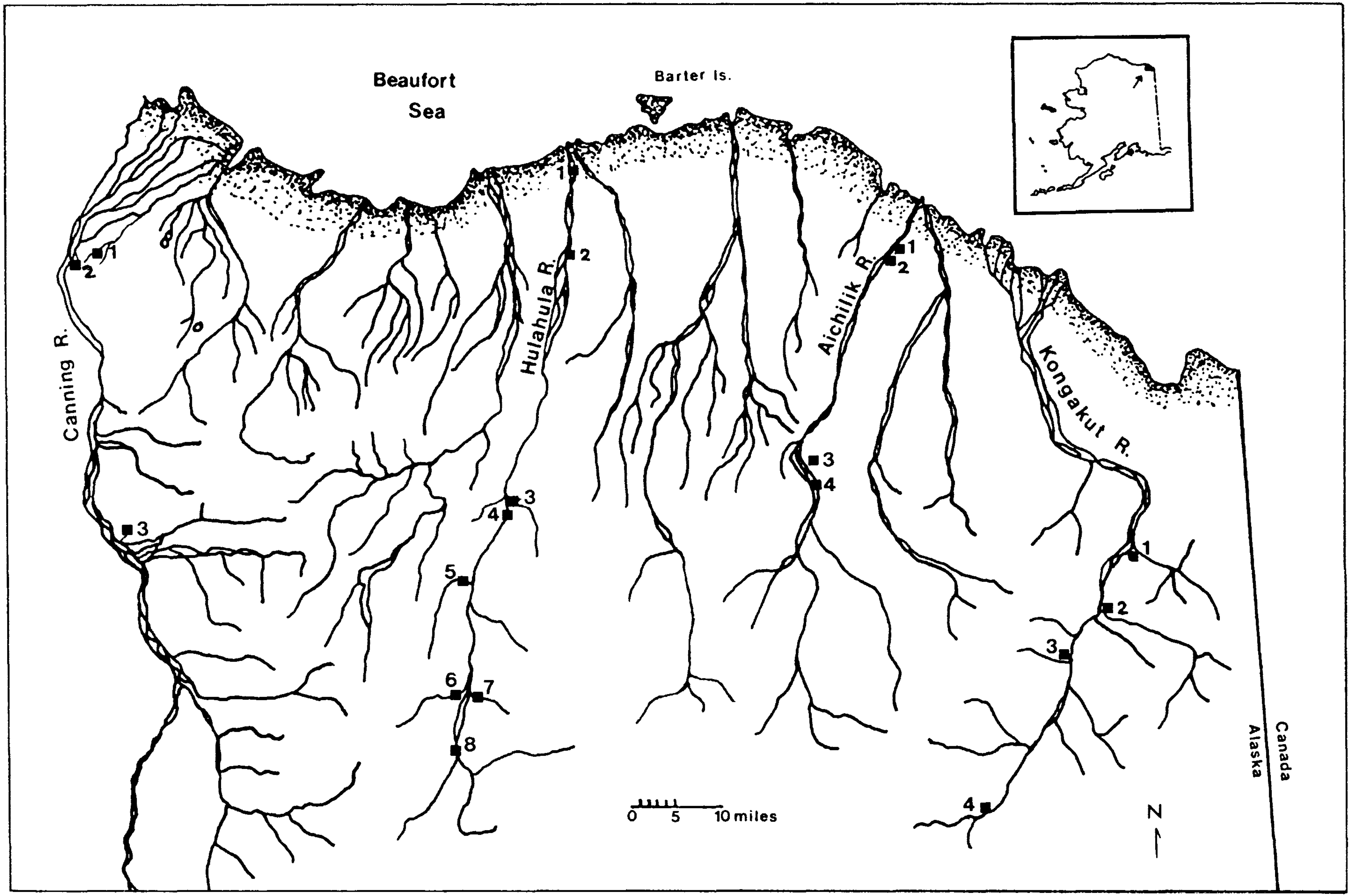

Figure 1. Collection sites on four river drainages in the Arctic National Wildlife Refuge, Alaska. Table 1 gives sampling dates and location names for each number on the map.

Table 1. Dates of fish sampling, gear type used, fork length range of fish collected, number of Arctic char stomachs collected and the number of empty stomachs, August 1982 - July 1985, Arctic National Wildlife Refuge, Alaska; ES = electroshocker, MT = baited minnow traps, S = seine, GN = gill-net, A = angling.

Figure 1 Location	Sampling site no.	Sampling date	Gear type	Fork length range (mm)	Number of stomachs collected	Number of empty stomachs
Canning River						
Coastal trib.	1	8-4-82	ES	57 - 155	7	0
Coastal trib.	2	8-2-82	ES	83 - 151	15	0
		8-9-82	MT	77 - 136	4	0
		8-10-82	MT	85 - 106	2	0
		8-11-82	ES	60 - 136	3	0
		8-12-82	MT	135	1	0
		8-14-82	MT	128 - 140	3	1
Shublik Spring	3	9-19-82	ES	45 - 158	9	0
					44	1
Hulahula River						
Near mouth	1	8-8-83	S	64	1	0
	1	8-31-83	S	66 - 72	4	1
Lower river	2	7-16-83	ES	78	1	0
Old Man Creek	3	7-16-83	ES	65 - 110	13	0
Fish hole II	4	8-15-83	ES	45 - 93	3	0
	4	9-19-83	MT	51 - 131	12	3
Katuk Creek	5	7-16-83	ES	69 - 136	13	0
W. Patuk Creek	6	7-15-83	ES	106 - 185	22	1
E. Patuk Creek	7	7-15-83	ES	99 - 136	7	1
Grasser Strip	8	8-13-83	ES	174 - 218	2	0
					78	6

Table 1 continued

Figure 1 Location		Sampling date	Gear type	Fork length range (mm)	Number stomachs collected	Number stomachs empty
Aichilik River						
	1	7-4-83	ES	117 - 178	7	0
	2	7-3-83	ES	118 - 182	5	0
	3	7-4-83	ES	74 - 171	15	8
	4	9-20-82	MT	117 - 131	2	0
			GN	125	1	0
			A	107	1	0
		9-21-82	MT	70 - 108	3	0
			GN	113 - 120	2	0
					36	8
Kongakut River						
	1	7-2-85	MT	73 - 153	18	5
	2	7-1-85	MT	86 - 141	10	3
	3	6-29-85	MT	149 - 160	2	0
	4	6-24-85	MT	101	1	0
					31	8
Totals					189	23

Table 2. Stomach contents of juvenile Arctic char from four drainages of the Arctic National Wildlife Refuge, Alaska, 1982 - 1985; A = adult, P = pupae, L = larvae, N = nymph. Results are given as percent frequency of occurrence and percent compostion of stomach items. Empty stomachs were not included in the calculations.

Organism		Canning River		Hulahula River		Aichilik River		Kongakut River	
		% Freq.	% Comp.	% Freq.	% Comp.	% Freq.	% Comp.	% Freq.	% Comp.
Unidentified Diptera	A	48.8	2.6	50.0	0.7	53.6	0.8	12.5	0.6
	P	16.3	1.3	11.0	0.2	17.9	0.1	12.5	0.6
	L			0.5	*	3.6	*	4.2	0.2
Chironomidae	P	58.1	8.5	29.2	1.0	53.6	1.3	8.3	0.4
	L	93.0	74.6	98.6	92.0	92.9	88.0	91.7	86.0
Tipulidae	L	4.7	0.1	27.8	*	10.7	*	41.2	3.6
Simulidae	P	18.6	0.5						
	L	30.2	2.9	15.3	0.2	28.6	1.4		
Empididae	L	9.3	0.1	22.2	*	3.6	*	16.7	2.1
Psychodidae	L	2.3	0.1	1.4	*				
Plecoptera	N	23.3	0.5	62.5	5.0	53.6	2.3	29.2	2.3
Ephemeroptera	N	55.8	6.5	27.8	0.6	28.6	3.9	16.7	1.3
Coleoptera	A	13.9	0.3	6.9	*	17.9	0.1	8.3	0.6
	L	7.0	0.1	6.9	*	25.0	0.6	4.2	*
Trichoptera	L	25.6	1.3	2.8	*				
Hemiptera	A			9.7	*	14.3	0.1		
Collembola	A	2.3	*	6.9	*	7.1	*		

Table 2 continued

Organism	Canning River % Freq.	Canning River % Comp.	Hulahula River % Freq.	Hulahula River % Comp.	Aichilik River % Freq.	Aichilik River % Comp.	Kongakut River % Freq.	Kongakut River % Comp.
Amphipoda					7.1	1.3		
Hydracarina	16.3	0.3	1.4	*	3.6	*	4.2	0.2
Araneae			6.9	*	7.1	*		
Nematoda	9.3	0.1	13.9	0.1	14.3	0.1	4.2	0.2
Unidentified terrestrial insects	9.3	0.1	19.4	0.1	10.7	*		
Fish	2.3	n	2.8	n			16.7	n
Sample size	43		73		26		24	
Total number of organisms		6,207		42,874		23,438		472

* = Items that constituted less than 0.1 % of the composition.
n - Fish were not included in calculation of percent composition.

Table 3. Stomach contents of juvenile Arctic char, by length group, from four drainages in the Arctic National Wildlife Refuge, Alaska, 1982 - 1985. Results are given as percent frequency of occurrence and percent composition of stomach items. Fish captured in minnow traps and those with empty stomachs were not included in the analysis.

Organism		40 - 99 mm % Freq.	40 - 99 mm % Comp.	100 - 149 mm % Freq.	100 - 149 mm % Comp.	150 - 221 mm % Freq.	150 - 221 mm % Comp.
Unidentified Diptera	A	30.8	0.6	62.1	0.7	70.8	1.0
	P	15.4	0.3	12.1	0.4	4.2	*
	L			1.7	*	16.7	*
Chironomidae	P	26.9	1.5	39.7	0.7	54.2	3.4
	L	88.5	80.2	98.2	93.0	95.8	86.2
Tipulidae	L	7.7	*	29.3	0.1	16.7	*
Simulidae	P	3.8	0.1	5.2	*	4.2	*
	L	23.1	3.3	24.1	0.5	25.0	0.7
Empididae	L	3.8		27.6	0.1	8.3	
Psychodidae	L					4.2	*
Plecoptera	N	38.5	9.3	53.4	2.0	54.2	4.9
Emphemeroptera	N	61.5	4.2	17.2	1.4	41.7	2.5
Coleoptera	A			13.	*	20.8	0.1
	L	3.8	*	10.3	*	37.5	0.5
Trichoptera	L	3.8	0.1	10.3	0.1	16.7	0.2
Hemiptera	A			6.9	*	20.8	0.1
Collembola	A	3.8	*	5.2	*	16.7	*
Amphipoda				3.4	0.7	4.2	*
Hydracarina				5.2	*	29.2	0.1
Araneae		3.8	*	3.4	*	16.7	*
Nematoda		7.7	0.1	10.3	0.1	25.0	0.2
Unidentified terrestrial insects		3.8	0.1	20.7	0.1	33.3	0.1
Fish				3.4	n	4.2	n
Sample size		26		58		24	
Total organisms			4,296		43,694		27,312

* = Items that constituted less than 0.1 % of the stomach contents.
n - Fish were not included in the calculation of percent composition

not taken into account, nor was there an attempt to identify the contribution of micro-organisms, detritus or plant material in the diet of the juvenile Arctic char examined for this report.

Stomach contents are listed in terms of percent frequency of occurrence and percent composition of all stomachs combined. In Table 2, results are grouped by the drainage from which fish were taken; in Table 3, results are grouped by arbitrarily determined size classes.

RESULTS

Dipteran larvae of the family Chironomidae comprised the overwhelming majority of the diet of almost all fish examined, in terms of both frequency of occurrence and percent composition. Only 2 of 166 fish examined contained other organisms in greater number; these two char (from the lower Aichilik River) were full of amphipods. Adult dipterans also occurred frequently but comprised a small proportion of the diet. The frequency of occurrence of dipteran adults increased with an increase in size class.

The next most frequently eaten organisms appeared to be Plecopteran (stonefly) nymphs, except in the fish from the Canning River, in which Ephemeropteran (mayfly) nymphs were found more frequently and made up a greater portion of the total contents.

Seven char from three drainages had remains of fish in their stomachs. These remains were presumed to be Arctic grayling (Thymallus arcticus) young-of-the-year, based on their sizes. The smallest char, from the Kongakut River, was 118 mm long and weighed 10 g, and had recently eaten 2 grayling each 18 mm long.

The stomach contents of the spring-resident char differed slightly from those of fish from the main Canning River. They contained many Trichoptera larvae and larvae of the dipteran family Psychodidae. These organisms were found only in stomachs of fish from Shublik Spring and in a few fish from the Hulahula River.

DISCUSSION

The stomach contents of juvenile Arctic char from four drainages flowing into the Beaufort Sea appear to be similar to those examined in other studies (Bain 1974, Craig 1977a, b, c). Dipteran larvae, primarily Chironomids, constituted the greatest portion of the diet.

Although these char appeared to rely greatly on Chironomid larvae as a food source, there were many other insect and invertebrate orders represented in stomach samples. It was not difficult to judge that Chironomids dominated in both numbers and biomass; however, the contribution of other organisms to the diet of juvenile char is not apparent when merely reviewing the tables presented in this report. McCart (1980) discussed the inadequacies of describing food habits using data expressed in the form of percent frequency of occurence and percent composition. Despite the drawbacks to this system, it was chosen as the style of analysis and presentation because it has been used by other researchers who have reported char food habits (Grainger 1953, Bain 1974, Craig 1977a, b, c, Sparholt 1985) and thereby allows gross comparisons to be made between fish from different areas.

Most unfairly represented in terms of contribution to the diet were the stonefly and mayfly nymphs which were found in the majority of stomachs. These organisms varied greatly in size : many of the char stomachs contained large nymphs in small numbers. The data describing these stomach contents showed that whereas either mayfly or stonefly nymphs may have occurred quite frequently, they comprised a small percent of the numbers of organisms composing the diet in general. This should not mislead readers to believe that they were an unimportant component of the diet. Most other organisms were more satisfactorily represented in Tables 2 and 3 than stonefly and mayfly nymphs.

Ephemeropterans were found in greater frequency than plecopterans only in stomachs of the fish from the Canning River. The difference is most likely due to the varying time of emergence of the nymphs in the areas in question, rather than an actual preference of char for mayfly nymphs on the Canning.

Johnson (1980) and McCart (1980) describe char as opportunistic feeders. The variety of organisms and the differences in composition of stomach contents of char from different drainages in this study are indications that their classification is likely true for the juvenile char from streams of the North Slope of the Arctic National Wildlife Refuge.

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